

April 9, 1935.

H. D. MacPHERSON
TELEPHONE EXCHANGE SYSTEM

1,997,195

Filed Dec. 29, 1933

12 Sheets-Sheet 1

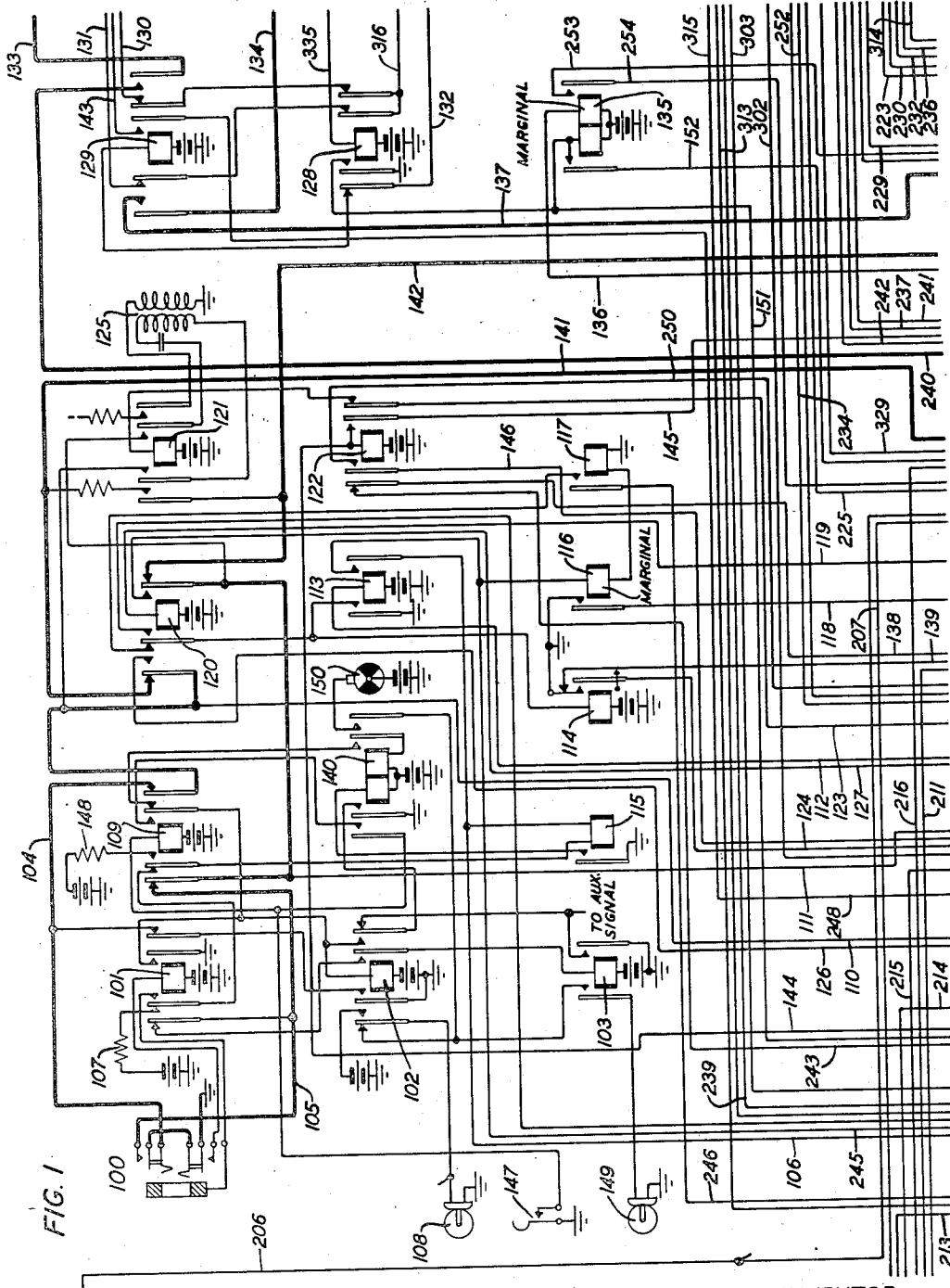


FIG. 1

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12 Sheets-Sheet 2

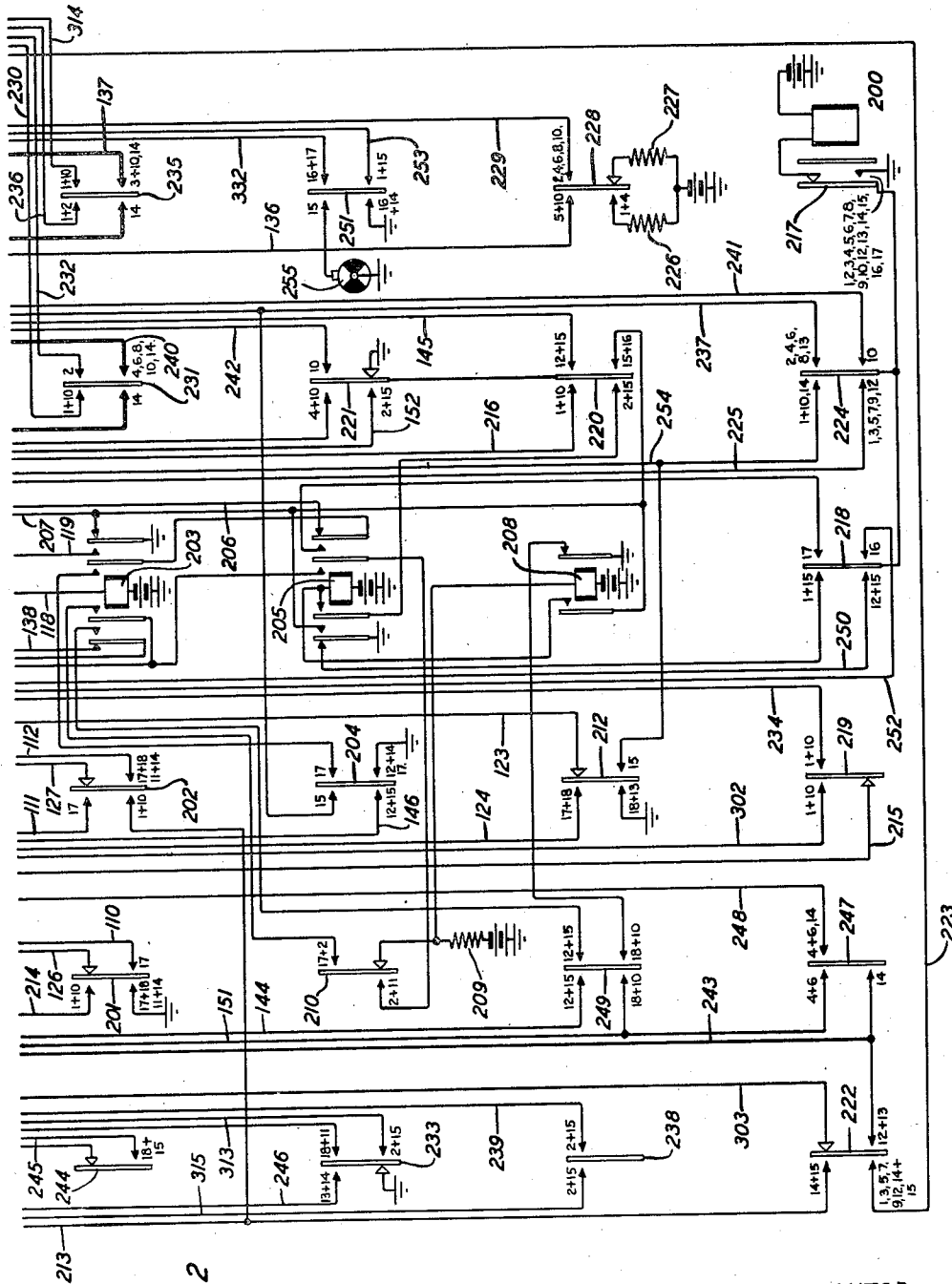


FIG. 2

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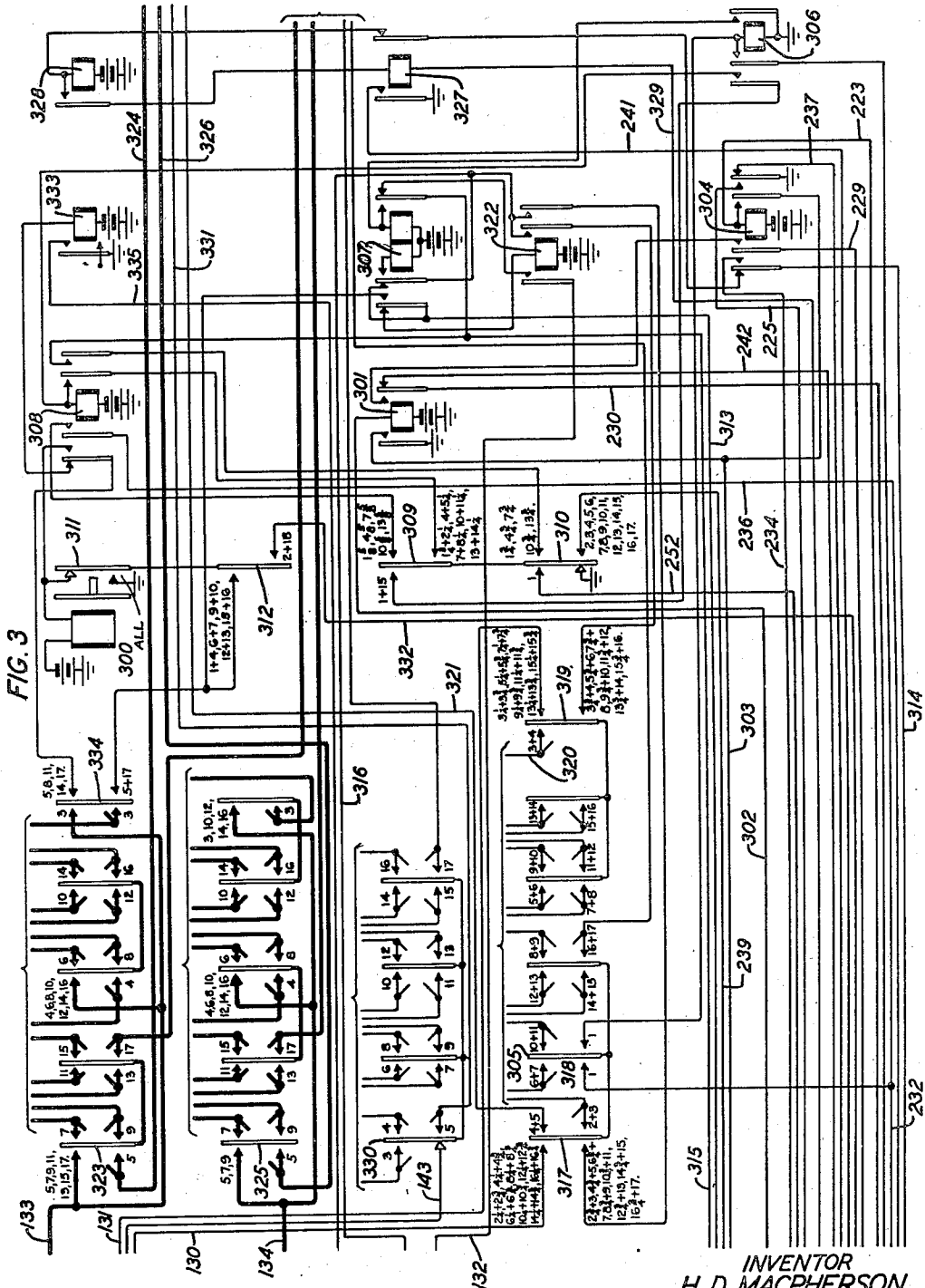
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TELEPHONE EXCHANGE SYSTEM

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12 Sheets-Sheet 3



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12 Sheets-Sheet 4

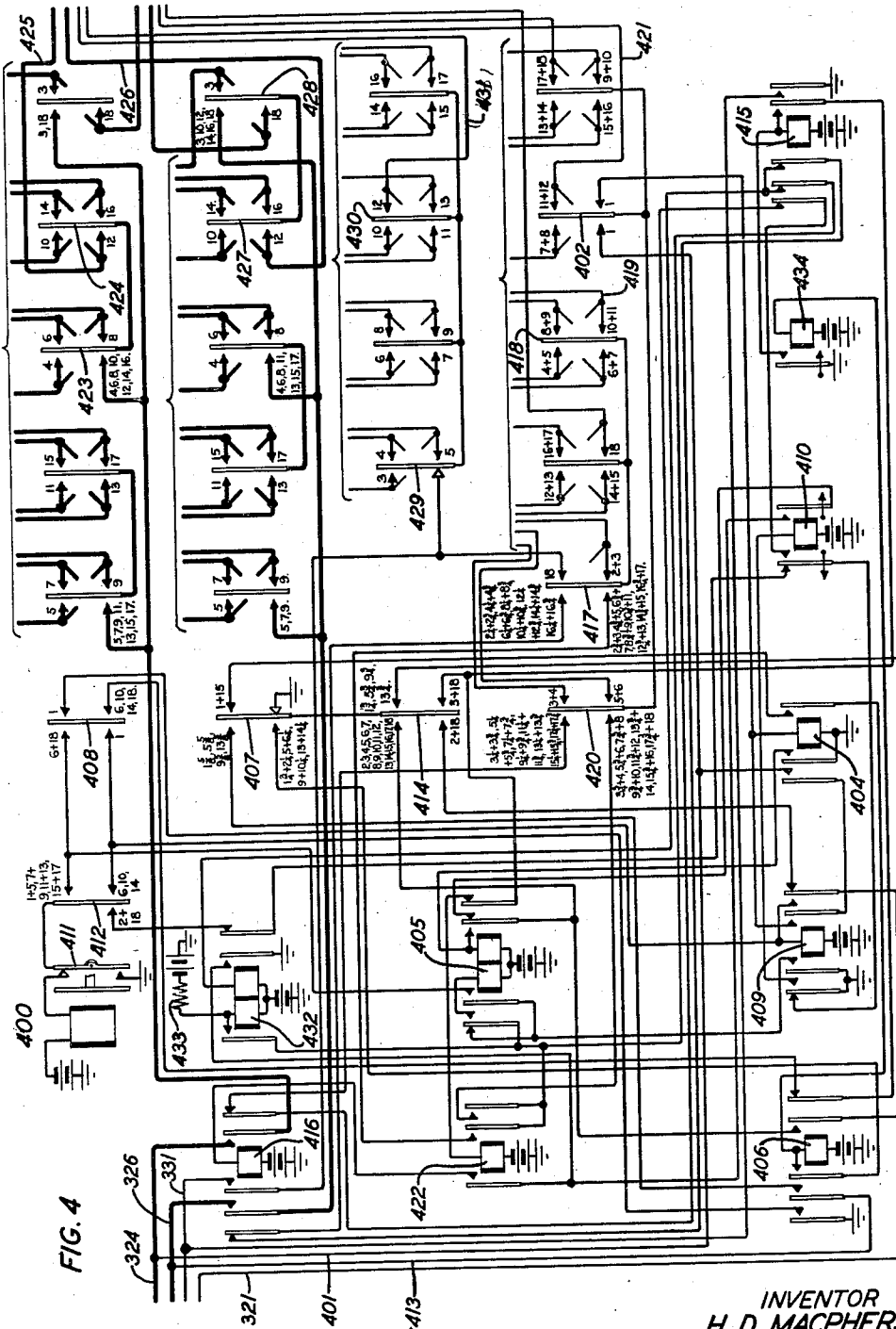


FIG. 4

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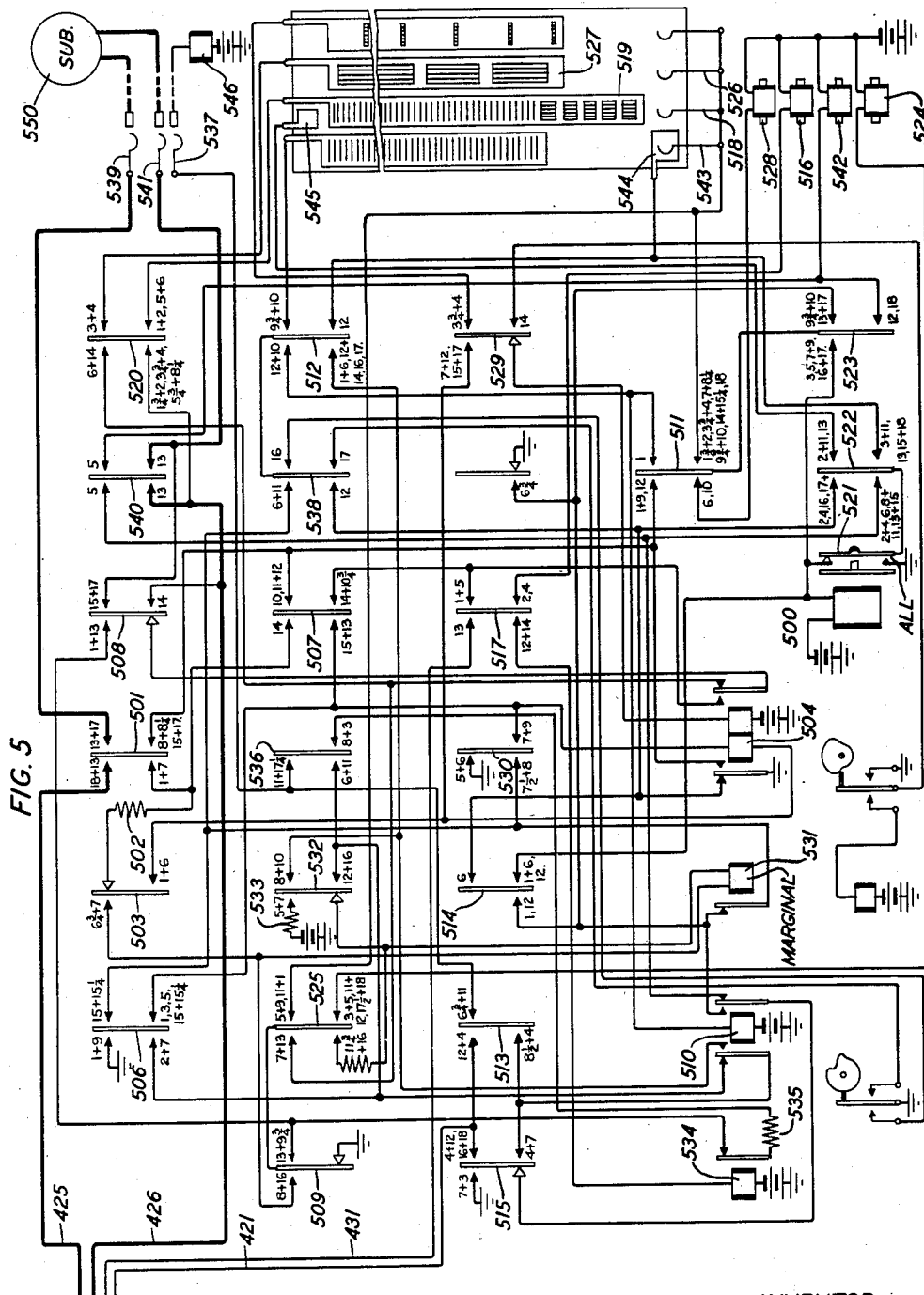
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12 Sheets-Sheet 6

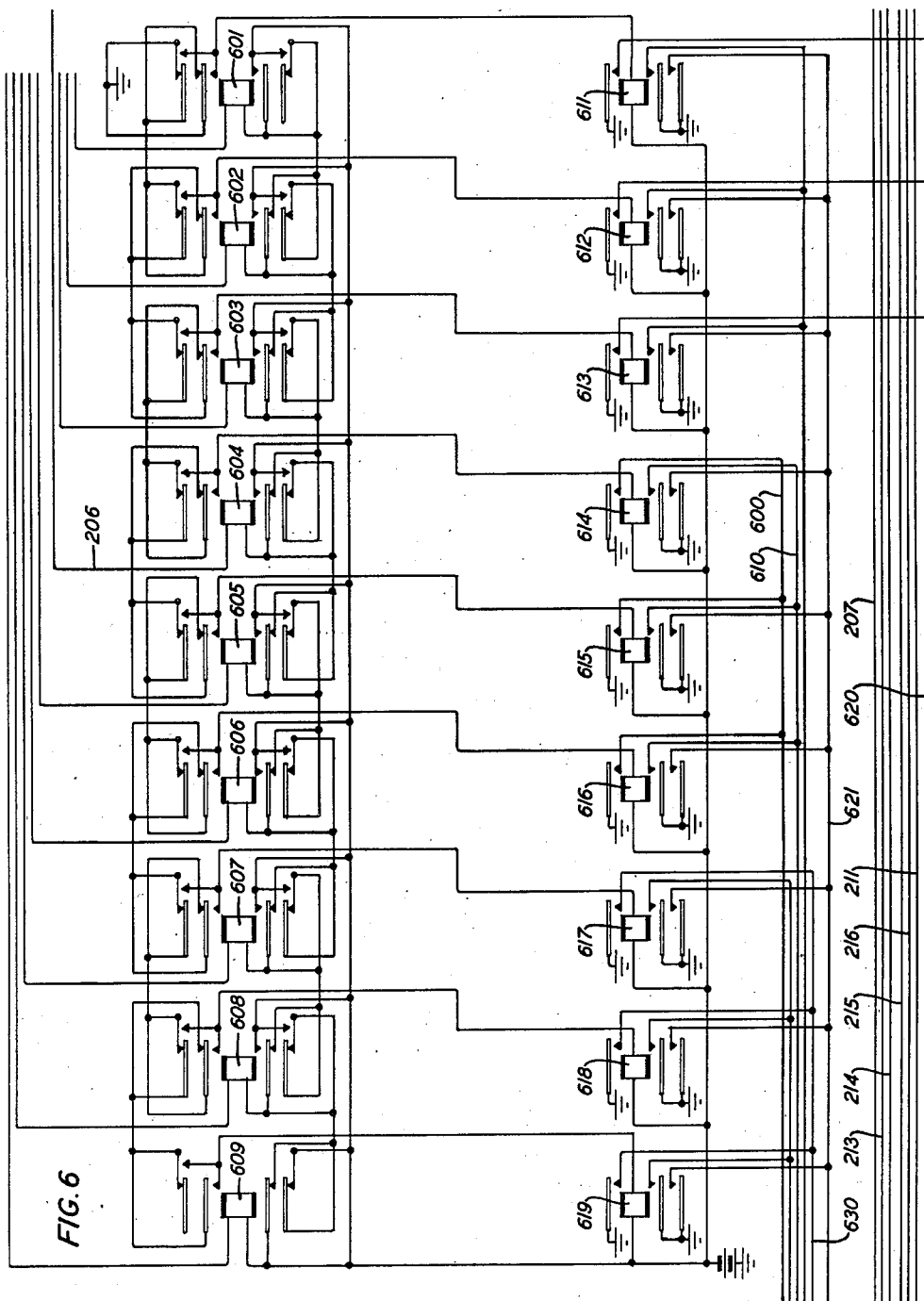


FIG. 6

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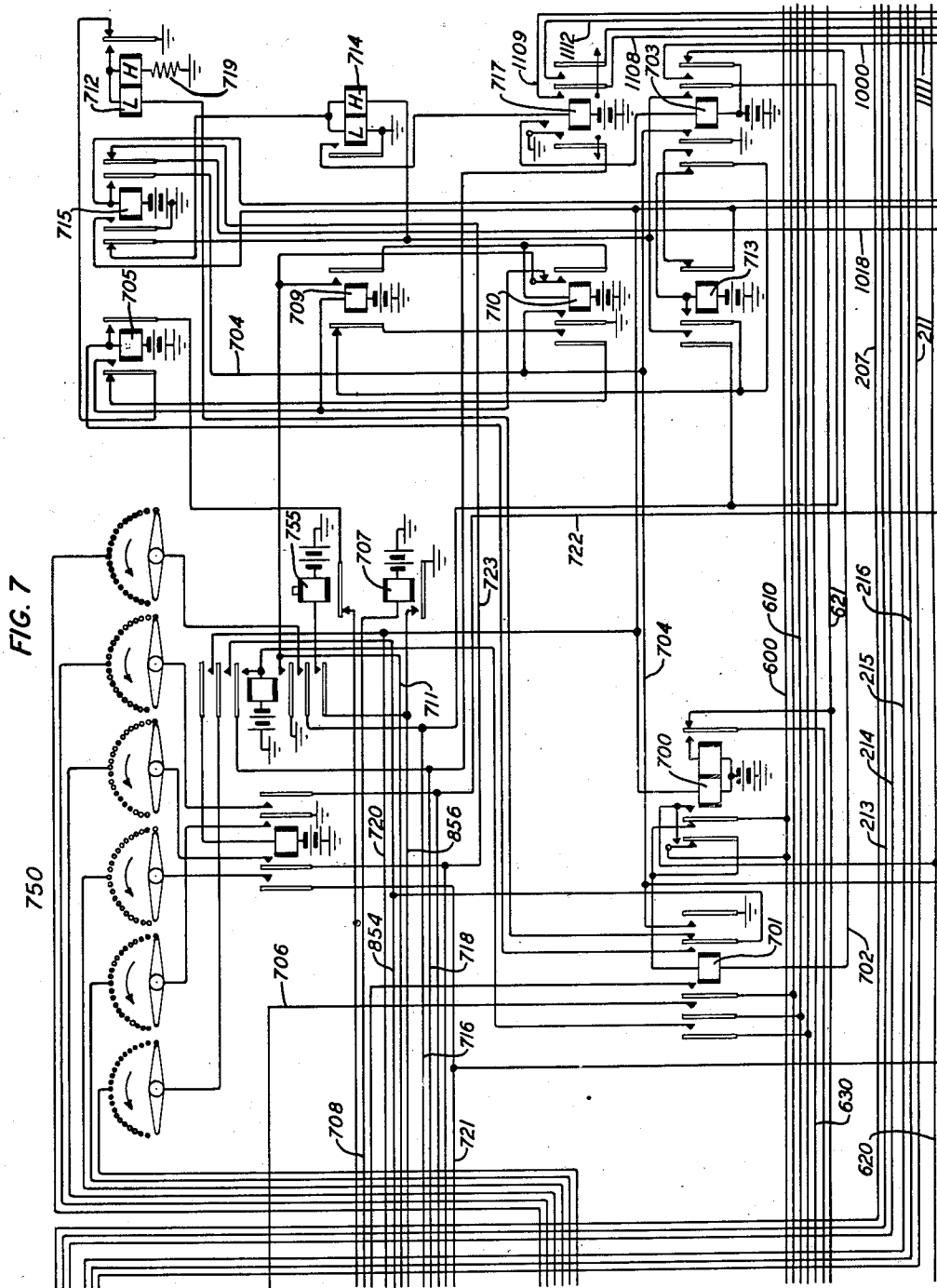
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TELEPHONE EXCHANGE SYSTEM

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12 Sheets-Sheet 7



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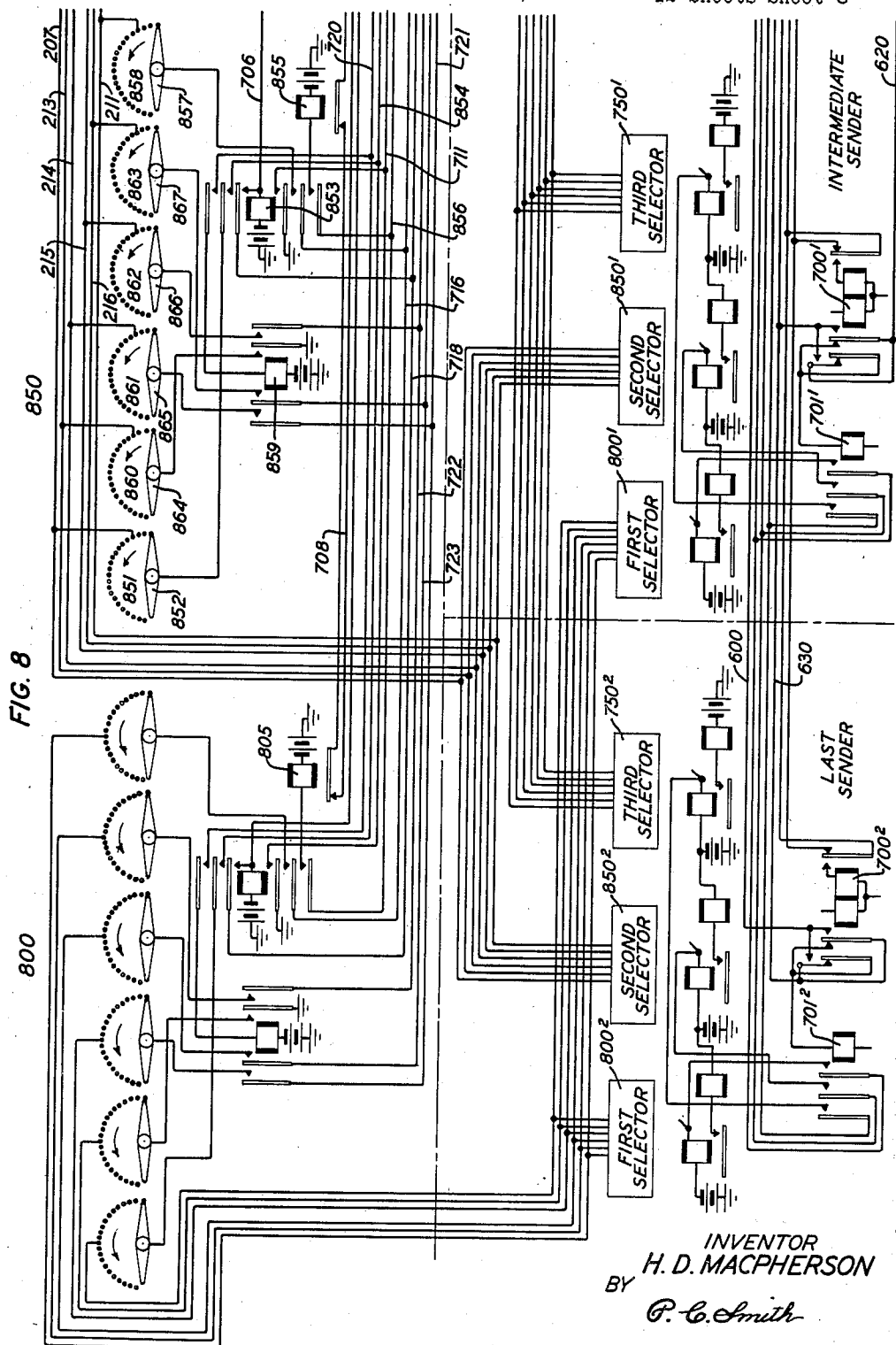
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12 Sheets-Sheet 8



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12 Sheets-Sheet 9

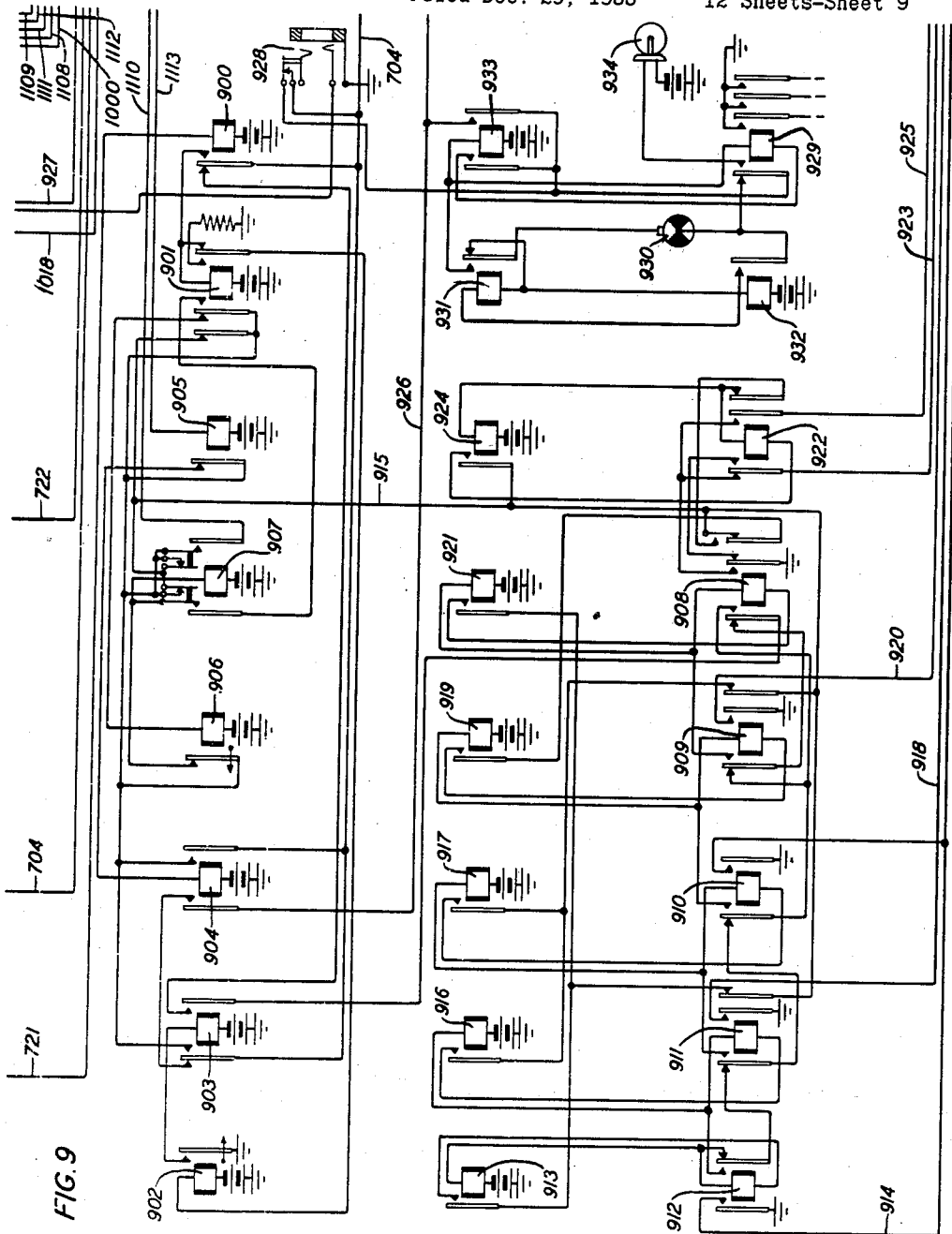


FIG. 9

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TELEPHONE EXCHANGE SYSTEM

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12 Sheets-Sheet 10

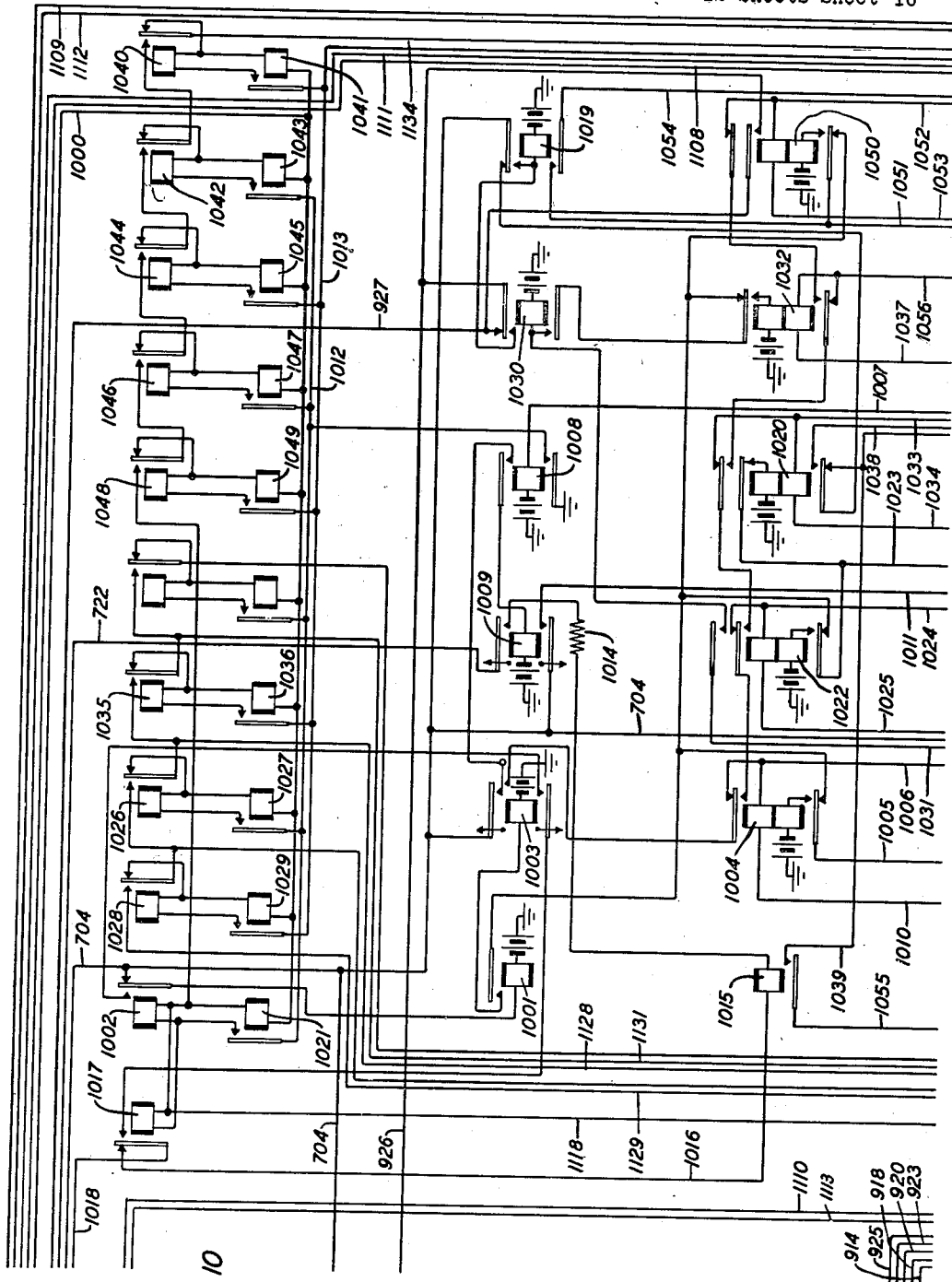


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12 Sheets-Sheet 11

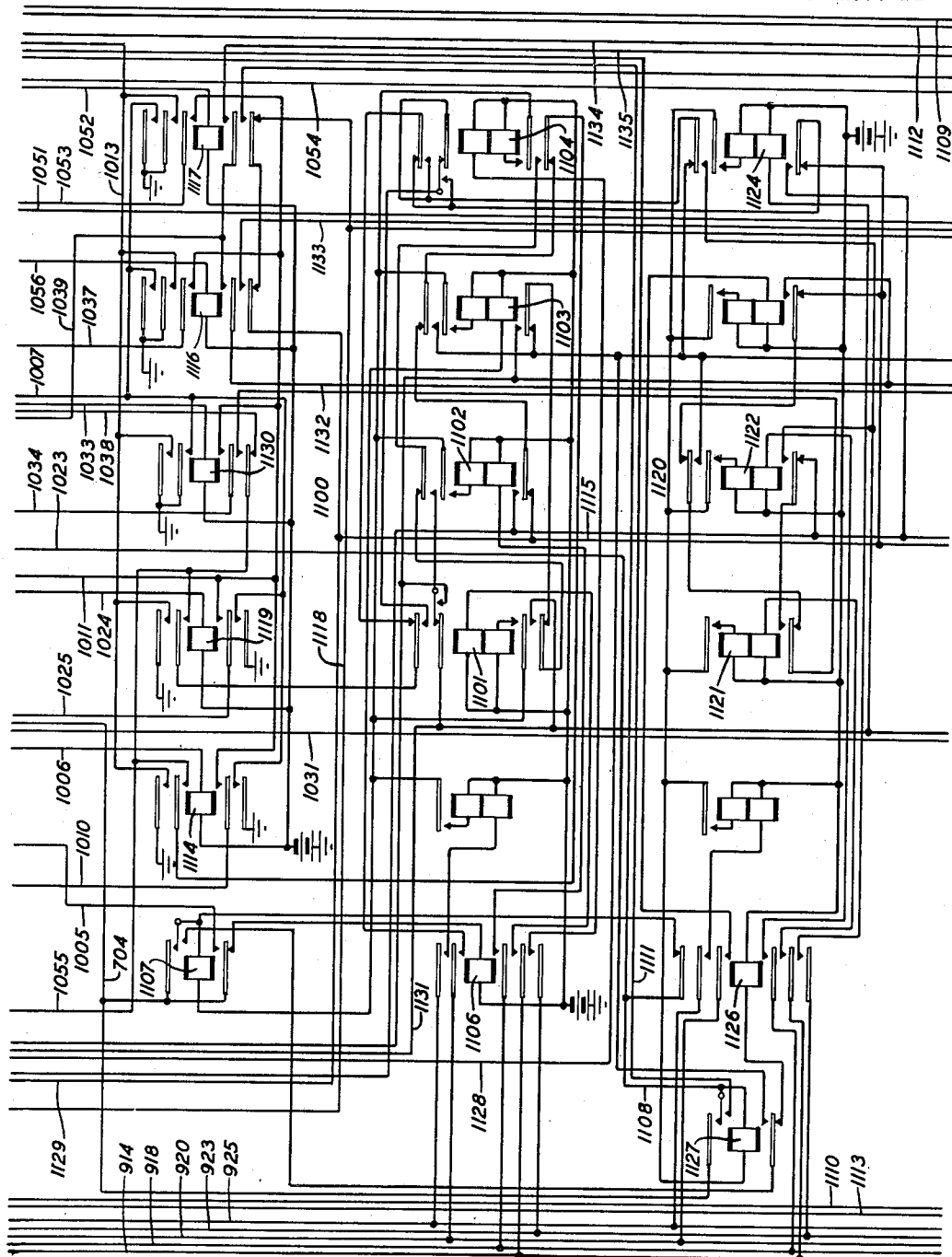


FIG. 11

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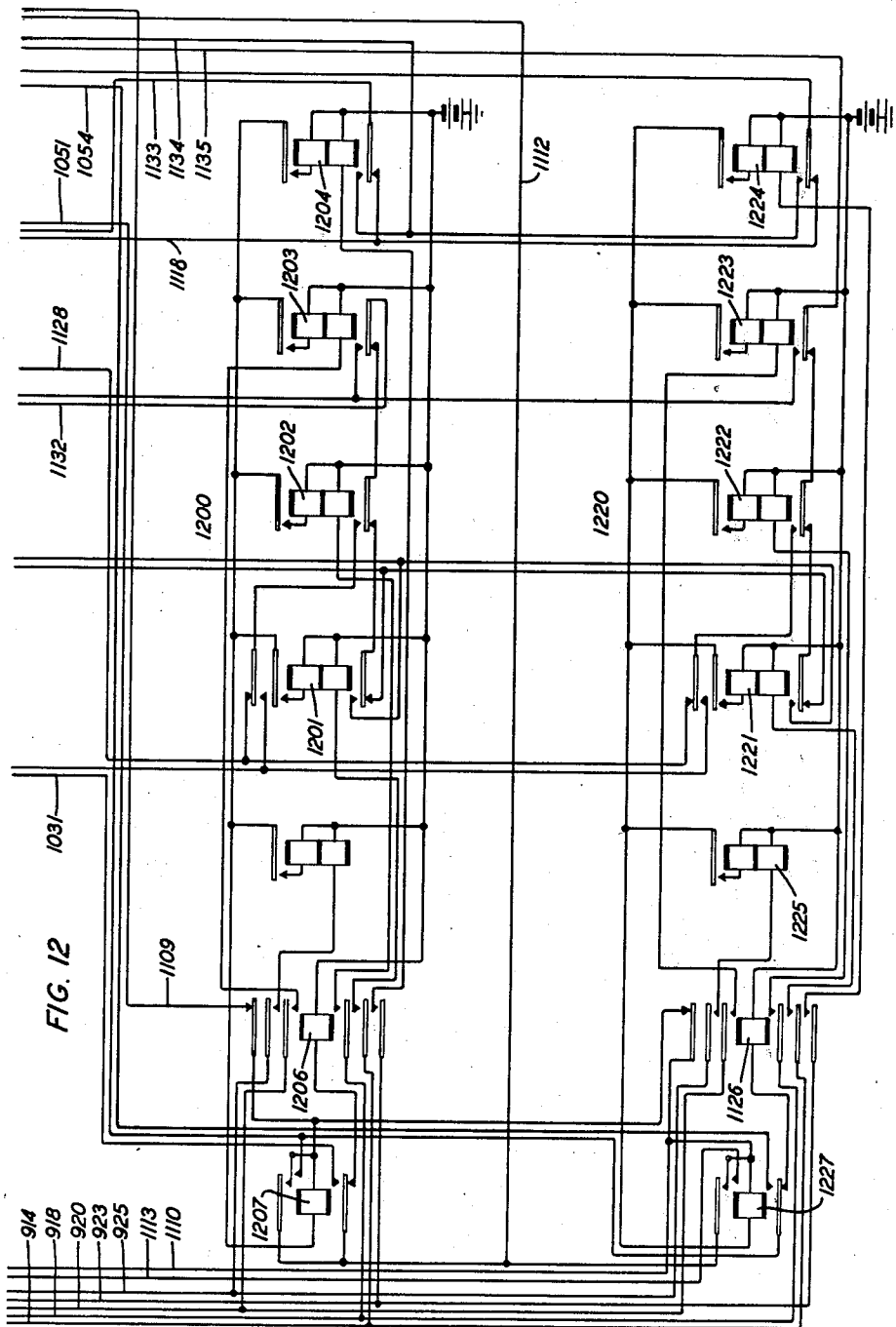
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UNITED STATES PATENT OFFICE

1,997,195

TELEPHONE EXCHANGE SYSTEM

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Application December 29, 1933, Serial No. 704,381

14 Claims. (Cl. 179—175.2)

This invention relates to telephone exchange systems and more particularly to systems in which connections to subscribers' lines are completed by switching apparatus under dial control.

In such telephone systems provisions are made for enabling a test or repair man to establish connections from the test desk of an office to any subscriber's line terminating in the office for the purpose of applying tests to determine the operative condition of the subscriber's line. It is the object of the present invention to improve the apparatus for enabling the establishment of such test connections whereby they may be more effectively and efficiently completed. More particularly it is the object of the invention to provide an efficient register sender common to a plurality of trunks outgoing from the test desk responsive to the dialing of a subscriber's line designation by the test man for setting selector switches to select the subscriber's line in accordance with the designation dialed.

In accordance with the present invention the test desk has access to a plurality of outgoing test trunks each terminating in a first test selector and all having access to a plurality of equivalent register senders. The outgoing trunks are divided into a plurality of subgroups, each subgroup of trunks having a start circuit extending to a start and sequence circuit which is common to all of the trunks and common to the senders. The common start and sequence circuit is provided with as many start relays as there are subgroups of trunks so that on the seizure of a trunk of one of the subgroups the corresponding start relay will be operated. A chain of sequence relays is also provided for insuring that should trunks of more than one subgroup be simultaneously taken for use, but one subgroup start relay will be operated and that one corresponding to the subgroup of trunks whose start circuit appears earliest in the chain of sequence relays. The common start and sequence circuit in turn controls the association of an idle register sender with the trunk taken for use.

Each sender has for this purpose a plurality of trunk finders, each trunk finder having access to a plurality of the subgroups of trunks. For the purposes of illustration, the trunks are divided into nine subgroups, each of which subgroups may comprise a maximum of six trunks and thus each sender may have access to fifty-four trunks. Each sender is therefore provided with three rotary type step-by-step trunk finders, each trunk finder having access to eighteen trunks belong-

ing to three subgroups. For the purpose of adequately handling the traffic the invention has been further illustrated as having three senders, one sender being first choice for serving calls originating on any trunk of three subgroups, the second sender being first choice for serving calls originating on any trunk of three other subgroups and a third sender being first choice for serving calls originating on any trunk of the three remaining subgroups. It will be obvious, however, that where the traffic requirements are more severe additional senders might be employed, each sender being first choice to less than three subgroups of trunks. It will also be obvious that since each finder switch may have access to a maximum of twenty-two trunks that the three finder switches of each sender might have a total access to sixty-six trunks instead of to fifty-four trunks as illustrated and that these trunks might be divided into more than nine subgroups of six trunks each and that the common start and sequence circuit might have more than nine start relays.

Each start relay of the start and sequence circuit controls a start circuit for the sender which is the preference for serving the corresponding subgroup of trunks if such sender is at the time idle, but if the preference sender is at the time busy the start circuit is extended to the next idle sender which is normally the first choice preference to other subgroups of trunks. This is accomplished by extending the start circuits from the common start and sequence circuit to different points in a chain circuit extending over contacts of the make-busy relays of all of the senders.

In addition each start relay of the start and sequence circuit indicates to the sender which is started, which one of its three trunk finder switches should be started to hunt for the calling trunk. Thus, for example, should a trunk of the second subgroup be taken for use, the first sender being the preference for serving trunks of the first three subgroups and this sender be at the time idle, the first of the three finder switches associated with the first sender will be started to hunt for the calling trunk. Had a trunk of the fourth subgroup been taken for use, the second sender being the preference for serving trunks of the fourth to sixth subgroups, this sender being at the time idle, the second of the three finder switches associated with the second sender would be started to hunt for the calling trunk.

The sender is arranged in the well known manner to record each series of impulses dialed thereinto and to set up on register relays the complete

designation of any subscriber's line and with circuits under the control of the registers for controlling the setting of a train of selector switches to complete a connection from the trunk outgoing from the test switchboard to a subscriber's line. In accordance with the present invention, however, provision is made for enabling the immediate release of the sender if a call is abandoned or the sender times out if dialing is not completed within a predetermined interval, provided the sender has not advanced in its selection control functions to a point where it is ready to set the final selector of the train of selector switches. If, however, the sender has started to set the final selector the abandonment of a call or a sender time-out will not cause the immediate release of the sender, but will cause the sender to advance the final selector to tell-tale on the selection control then being exercised, rather than to complete the selection as registered. The final selector upon reaching its tell-tale position will then cause the sender to be released.

For a clearer understanding of the invention reference may be had to the following detailed description in connection with the accompanying drawings in which:

Figs. 1, 2 and 3 taken together show a test trunk first selector for establishing connections to subscribers' lines from a test desk, Fig. 1 showing the test desk end of the test trunk, Fig. 2 showing the control sequence switch of the trunk and Fig. 3 showing the sequence switch type first selector in which the test trunk terminates;

Fig. 4 shows a second selector also of the sequence switch type;

Fig. 5 shows a final selector of the panel type together with the schematic representation of a subscriber's line;

Fig. 6 shows a sender start and sequence circuit common to a plurality of first test trunks, one of which is illustrated in Figs. 1 to 3, inclusive, and common to a group of senders; and

Figs. 7 to 12, inclusive, show one complete sender to which the start and sequence circuit is common and the diagrammatic representation of two other senders.

To completely illustrate the invention Figs. 8, 7, 6, 1, 3, 4 and 5 should be placed in horizontal alignment in the order named with Figs. 9, 10 and 2 beneath Figs. 7, 6 and 1, respectively, Fig. 11 beneath Fig. 10 and Fig. 12 beneath Fig. 11.

The first and second selector switches illustrated in Figs. 3 and 4, respectively, are of the sequence switch type disclosed in Patent No. 1,373,447 granted April 5, 1921 to L. Polinkowsky.

The final selector switch disclosed in Fig. 5 is of the well known panel power driven type but modified for testing purposes. The finder switches shown in Figs. 7 and 8 serve to connect the sender with any one of a main group of test trunks and are of the rotary step-by-step type having no normal position. The test trunks, one of which is disclosed in Figs. 1 to 3, inclusive, are accessible from the cord circuit of a test desk, not shown. This test desk may be similar to that disclosed in Patent No. 1,632,886 granted June 21, 1927 to L. T. Cox.

Initiation of a test call

It will now be assumed that the test man desires to make tests on the subscriber's line schematically illustrated at 550 in Fig. 5 and for that purpose inserts the plug of a test cord of the test desk into the jack of a first test trunk. For es-

tablishing a connection to the office in which the desired line terminates, a main group of fifty-four test trunks divided into nine subgroups of six trunks each is provided. It will be further assumed that the test man plugs into jack 100 of the test trunk shown in Figs. 1 to 3, inclusive, which is in the fourth subgroup of trunks. With the plug in jack 100 an obvious circuit is established for relay 101 which operates, closes an obvious circuit for relay 102, at its outer back contacts disconnects ground and the winding of relay 103 from the tip and ring conductors 104 and 105 of the trunk and at its inner left contact transfers the outgoing sleeve conductor 106 of the trunk from battery through resistance 107 to the conductor of the connected cord circuit over the sleeve of jack 100. Relay 102 upon operating closes the circuit of lamps, such as 108, as signals to other test desks that the trunk is busy, prepares the circuit of relay 103 and prevents the false operation of the auxiliary signaling circuit by opening its right back contact.

The test man having plugged into the jack of the test trunk throws the dialing key of the connected test cord circuit thereby closing a bridge at the cord circuit comprising a polarized relay and a resistance, across the tip and ring conductors of the cord circuit thus establishing a loop circuit over the tip of jack 100, conductor 104, outer right back contact of relay 109, conductor 110, to ground over the lower contacts of cam 201 of sequence switch 200, which is in position 17 when the test trunk is idle, and over the ring of jack 100, conductor 105, outer left back contact of relay 109, conductor 111, upper left and lower right contacts of cam 202, conductor 112 to battery through the winding of relay 113. Relay 113 operates, at its left contact establishing a circuit for relay 114 which in turn operates, and at its right contact completes a circuit from the sleeve of jack 100, left front contact of relay 101, inner left back contact of relay 109, winding of relay 115, right contact of relay 113, windings of relays 116 and 117 in series to ground. Relay 115 operates and closes an obvious circuit through the left winding of relay 140 which operates and locks over its right winding and inner right front contact, inner right back contact of relay 109 to ground at the right front contact of relay 101, and at its inner left front contact closes a locking circuit for relay 102 extending over the outer right front contact and winding of relay 102 to battery. Relay 117 operates without effect at this time and relay 116 operates to establish a circuit extending from battery, winding of start relay 203, conductor 118, contact of relay 116 to ground. Relay 203 operates closing a circuit extending from ground over its outer right front contact, conductor 119 to battery through the winding of relay 120, connects ground over the right contacts of cam 204, inner right contact of relay 203, right back contact of relay 205 to the start conductor 206 which is common to the six test trunks of the subgroup to which the seized trunk belongs, removes ground at its outer right back contact from the test conductor 207 extending to the testing bank of the trunk finder switches of all senders which have access to the trunk to mark the trunk as in a calling condition, and prepares a circuit for relay 208 extending from battery in parallel through resistance 209 and the winding of relay 208, right contacts of cam 210 to conductor 211. Relay 120 operates to perform functions to be described later.

With relay 114 operated a circuit is closed 75

from battery, winding of relay 121, right back contact of relay 122, conductor 123, upper contacts of cam 212, conductor 124 to ground at the alternate contacts of relay 114 as long as sequence switch 200 remains in position 17 and then directly to ground over the lower left contact of cam 212 after the sequence switch advances out of position 18 and until it leaves position 13. Relay 121 upon operating connects tone current from tone coil 125 over its inner front contacts and trunk conductors 104 and 105 to the connected test cord circuit as a signal that selections are in progress, but this tone will be inaudible to the test man while the dial key is operated and ordinarily will not be heard by him at all.

When the common start conductor 206 is grounded through the operation of relay 203 a circuit is completed through the winding of start relay 604 of the common start and sequence circuit, thence over a chain circuit extending through the lower normal contacts of start relays 605 to 609, inclusive, to battery. Each start relay of the group 601 to 609, inclusive, is connected to an individual start conductor corresponding to conductor 206 and is thus individualized to a subgroup of six test trunks, start relay 601 being individualized to the first subgroup of six trunks, relay 602 to the second subgroup of six trunks and so forth. Relay 604 upon operating in response to a calling trunk in the fourth subgroup of trunks locks over its inner lower front contact directly to battery and opens at its lower normal contacts the chain circuit extending over the lower normal contacts of relays 603, 602 and 601 to prevent the operation of any one of these relays should a trunk in any one of the first three subgroups of trunks be thereafter placed in a calling condition. The seizure of a trunk in any subgroup to which start relays 605 to 609 are individualized will, however, cause the operation of the proper one of these relays. Relay 604 also completes a circuit from battery through the winding of relay 614 over the inner upper front contact and upper alternate contacts of relay 604 in parallel, thence over a chain circuit extending through the inner upper and outer upper back contacts in parallel of relays 603, 602 and 601 to ground. At its inner upper and outer upper back contacts relay 604 opens the chain circuit extending through the upper contacts of relays 605 to 609, inclusive, which supply ground to the windings of relays 615 to 619, inclusive, so that should any one of relays 604 to 609 be operated it would not be able to complete the circuit of the corresponding relay in the group 615 to 619, inclusive. This arrangement of relays 601 to 609, inclusive, prevents more than one of relays 611 to 619, inclusive, from operating at a time and therefore prevents more than one sender from hunting at a time.

It will be assumed that the sender disclosed in full in Figs. 7 to 12, inclusive, is the preference sender for any calling trunk in subgroups 4, 5 and 6 and that at the time the start relay 604 operates it is idle and available to serve the calling trunk. When, therefore, relay 614 operates as previously described, it closes a circuit from ground at its upper contact over conductor 600, inner left back contact of the sender make-busy relay 700, winding of start relay 701, conductor 702 to battery over the right back contact of relay 703. Relay 701 operates, connects off-normal ground to conductor 704 for starting the time-out period of the sender as later described and for furnishing holding ground for subse-

quently operated relays of the sender, and prepares a circuit for relay 705. Relay 614 also connects ground over its inner lower front contact, conductor 610, the middle left front contact of relay 701, conductor 706 to battery through the winding of relay 853. Thus the operation of relay 614 of the start circuit has caused the seizure of the preference sender and prepared the proper one 800 of its three associated trunk finders 750, 800 and 850 for operation to hunt for the calling trunk. It is to be noted that finder 800 has access to the first three subgroups of trunks comprising trunks 1 to 18, inclusive, that finder 850 has access to the second three subgroups of trunks comprising trunks 19 to 36, inclusive, and that finder 750 has access to the last three subgroups of trunks comprising trunks 37 to 54, inclusive.

All test trunks to which the finder 850 has access, which are in a non-calling condition, will be marked on the test terminals of arc 851 of finder 850 by ground, and assuming that this finder is at the time standing in the position illustrated, a circuit will be established from ground on the test terminal upon which wiper 852 is standing, middle upper contact of relay 853, conductor 854, inner right front contact of relay 701, winding of relay 705 to battery. Relay 705 will therefore operate and close a circuit for the pulse help relay 707 extending from battery, winding of relay 707, conductor 708, back contacts of stepping magnets 805, 855 and 755, right front contact of relay 705 to ground on the test terminal of arc 851 as previously traced. When relay 853 operated, it closed a circuit which may be traced from battery, winding of relay 709, right normal contacts of relay 710, conductor 711, to ground at the inner, lower front contact of relay 853. Relay 709 operates and extends its operating ground to the winding of relay 710 which upon operating opens the initial operating circuit of relay 709 at its right normal contacts and locks over its right alternate contacts to ground at the inner lower front contact of relay 853. Relay 705 also closes a holding circuit for relay 709 extending from battery, winding of relay 709, left front contact of relay 705 to ground at the back contact of relay 712.

With pulse help relay 707 now operated a circuit is established for the stepping magnet 855 of finder 850 which may be traced from battery, winding of magnet 855, lower contact of relay 853, conductor 856 to ground at the contacts of relay 707. Magnet 855 now operates opening at its contacts the circuit of relay 707 which releases in turn releasing magnet 855 to advance the wipers of finder 850 one step. If, as assumed, the next trunk to which this finder has access is also in a non-calling condition, relay 705 will remain operated again causing the operation of relay 707 and magnet 855 to step the finder another step. In this manner the finder will be advanced until the test wiper 852 engages a test terminal of its arc which is ungrounded denoting a trunk which is in a calling condition. Thus when wiper 852 engages the test terminal to which conductor 207 of the calling trunk is connected no circuit will be effective to reoperate relay 707 and to hold relay 705 operated and relay 705 will therefore release in turn releasing relay 709. With relays 705 and 709 both released and relay 710 operated a circuit is now closed for relay 713 extending from battery, winding of relay 713, left back contact of relay 703, back contact of relay 709, outer left front contact 75

of relay 710, back contact of relay 705 to ground at the back contact of relay 712. Relay 713 operates, locks over its inner left contact, back contact of relay 709, thence as just traced to ground at the back contact of relay 712 and establishes a circuit from ground through the low resistance left winding of relay 714, left back contact of relay 715, outer left contact of relay 713, conductor 716, middle lower contact of relay 853, wiper 857 of finder 850 and the terminal of arc 858 upon which it is resting, conductor 211, inner left front contact of relay 203, right contacts of cam 210 to battery through resistance 209 and the winding of relay 203 in parallel.

Relay 208 of the first test trunk and relay 714 of the sender both operate over this circuit due to the low resistance of the left winding of relay 714. Relay 714 upon operating in turn causes the operation of relay 717 over an obvious circuit. Relay 717 at its left contact closes an obvious operating circuit for relay 703 and a holding circuit for relay 853. The holding circuit of relay 853 may be traced from battery, winding and inner upper front contact of relay 853, conductor 718 to ground at the left contacts of relay 717. Relay 703 upon operating connects ground over its inner left front contact to the sender off-normal conductor 704, connects battery over its outer right front contact to conductor 1000 for furnishing operating battery to the counting relays of the sender, bridges the outer left contact of relay 713 at its inner right contact to maintain the circuit previously traced for relays 208 and 714 after the release of relay 713, opens at its left back contact the initial operating circuit of relay 713 which, however, does not release at this time since it is held operated over its own front contact, and at its right back contact opens the circuit of start relay 701. Relay 701 now releases opening the initial operating circuit of relay 853, disconnecting the winding of relay 705 from the test wiper 852 and establishing a circuit from ground through resistance 719, both windings of relay 712, right back contact of relay 701, conductor 854, middle upper contact of relay 853, test wiper 852 and the terminal of its arc 851 upon which it is resting, conductor 207, front contact of relay 208, winding of relay 205 to battery. Relay 712 operates in this circuit but due to the resistance of the windings of relay 712 relay 205 does not operate at this time. Relay 712 upon operating opens the holding circuit of relay 713 which now releases, and short-circuits resistance 719 and its own right winding, allowing sufficient current to flow over the previously traced circuit through the winding of relay 205 to permit its operation. Relay 205 upon operating connects direct ground over its outer left front contact to conductor 207 thus shunting the left winding of relay 712 and causing relay 712 to release. With relay 712 released, relay 703 operated, and relay 713 released a circuit is closed from battery, winding of relay 859, upper front contact of relay 853, conductor 720 and in parallel therewith from battery through the left winding of sender make-busy relay 700, thence over the right back contact of relay 713, outer left front contact of relay 703, back contact of relay 709, outer left front contact of relay 710, left back contact of relay 705 to ground at the back contact of relay 712. Relays 859 and 700 both operate.

Relay 859 upon operating extends the tip conductor 213, ring conductor 214, fundamental tip conductor 215 and fundamental ring conductor 216 from the test trunk over the terminals of arcs

860, 861, 862 and 863 and the associated wipers 864, 865, 866 and 867 to the sender, and relay 700 upon operating extends conductor 600 over its left front contacts in parallel to conductor 620 which is the start conductor extending from the start and sequence circuit to the intermediate sender which is the normal preference for serving any calling trunk in the first three subgroups of trunks. Should any trunk in the fourth, fifth or sixth subgroups of trunks be in a calling condition, the operation of any one of relays 614, 615 or 616 will now apply ground to conductor 600 and thence as traced to conductor 620, or if any trunk in the first, second or third subgroups of trunks be in a calling condition the operation of any one of relays 611, 612 or 613 will apply ground directly to conductor 620. If the intermediate sender, portions of which are schematically illustrated by the dot-dash rectangle in the lower right portion of Fig. 8, is at the time idle the start conductor 620 will be extended over the left back contacts of make-busy relay 700' of that sender to the winding of start relay 701' thereby starting such sender for serving the calling trunk. The trunk finders of this sender are schematically illustrated at 750', 800' and 850'. Should this sender be busy and its make-busy relay 700' be operated then conductor 620 would be further extended over the left front contacts of relay 701' to conductor 630 which is the start conductor extending from the start and sequence circuit to the last sender which is the normal preference for serving any calling trunk in the seventh, eighth and ninth subgroups of trunks. Should any trunk in the fourth, fifth or sixth subgroups of trunks be in a calling condition the operation of any one of relays 614, 615 or 616 will now apply ground to conductor 600 and thence as traced over conductor 620 to conductor 630, or if any trunk in the first three subgroups be in a calling condition the operation of any one of relays 611 to 613, inclusive, will apply ground to conductor 620 and thence as traced to conductor 630, or if any trunk in the last three subgroups be in a calling condition, the operation of any one of relays 617 to 619, inclusive, will apply ground directly to conductor 630. If the last sender, portions of which are schematically illustrated by the dot-dash rectangle in the lower left portion of Fig. 8 is at the time idle, the start conductor 630 will be extended over the outer left back contacts of make-busy relay 700² of that sender to the winding of start relay 701² thereby starting such sender for serving the calling trunk. The trunk finders of this sender are schematically illustrated at 750², 800² and 850².

As a further example, it will be assumed that a trunk in one of the first three subgroups of trunks is in a calling condition and that one of relays 611 to 613 has grounded start conductor 620 and the intermediate sender which is the normal preference for serving trunks of these subgroups is busy and the make-busy relay 700' thereof is operated. Conductor 620 will now be extended to conductor 630 over the left front contacts of relay 700'. If it now be assumed that the last sender which is second choice preference to these subgroups of trunks is also busy, conductor 620 will be further extended over conductor 630, the left front contacts of make-busy relay 700² of the last sender to conductor 600 and thence over the outer left back contacts of make-busy relay 703 of the first sender which is in this case third choice preference to that subgroup of trunks, to start relay 701. Thus it will be apparent that al-

though each sender is the normal preference for serving trunks in certain subgroups it may be employed as a later preference for serving other subgroups of trunks.

It will be recalled that following the connection of the test trunk with the sender through the operation of finder 850, relay 205 of the trunk operated and placed ground on conductor 207. This ground, in addition to shunting down relay 712 of the sender, also marks the trunk unselectable to the trunk finders of other senders and locks relay 205 under the control of relay 208. Relay 205 also at its right back contact removes ground from start conductor 296 thereby causing the release of relays 604 and 614 of the start and sequence circuit and at its outer right front contact establishes a circuit for advancing sequence switch 200 out of position 17 into position 1. This circuit may be traced from battery, winding of the magnet of sequence switch 200, upper contact of cam 217, upper right contact of cam 218, outer right front contact of relay 205, inner right front contact of relay 203, right contacts of cam 204 to ground.

With the sequence switch 200 in position 1, the winding of relay 113 and ground are disconnected from the trunk conductors 105 and 104 and relay 113 releases in turn releasing relay 114. Relay 114 upon releasing opens the circuit of relay 121 at its alternate contacts but relay 121 remains operated over a circuit extending from battery through its winding, right back contact of relay 122, conductor 123 to ground over the upper right and lower left contacts of cam 212 until after sequence switch 200 has passed beyond position 13. A dialing circuit is now closed from the test cord circuit loop over the tip of jack 100, trunk conductor 104, outer right back contact of relay 109, outer left front contact of relay 120, conductor 126, upper contacts of cam 201, conductor 214, wiper 865 of finder 850, outer left contact of relay 850, conductor 721 to battery through the winding of impulse relay 900 and over the ring of jack 100, trunk conductor 105, outer left back contact of relay 109, right front contact of relay 120, conductor 127, upper right and lower left contacts of cam 202, conductor 213, wiper 864, to ground at the inner right contact of relay 850. The current flowing over this circuit is now in such a direction as to operate the polarized relay in the cord circuit loop to extinguish the dialing lamp. Relay 900 operates over the dialing loop in turn closing an operating circuit for relay 901 extending from off-normal ground on conductor 704, front contact of relay 900 to battery through the winding of relay 901. At its right front contact relay 901 establishes an obvious circuit for slow-to-release relay 902 which upon operating causes the operation of relay 903. Relay 903 upon operating establishes a circuit extending from battery, winding of relay 904, back contact of relay 905, left front contact of relay 903 to ground on conductor 704 and relay 904 operates. The sender is now prepared to receive dial impulses.

Digit registration

It will be assumed that the directory number of the line 550 which the test man wishes to test is 1370. The test man will then proceed to dial this number. When he dials relay 900 releases momentarily on each impulse. Between successive digits and after the last digit, relay 900 remains steadily operated. When relay 900 releases on the first impulse of a digit relay 901 also releases but not being fast to operate it may not follow

all of the operations of relay 900 but will stay released or buzz slightly during the return of the dial. After the last impulse of the digit, however, relay 901 will remain operated. Relay 902 being slow to release does not follow the impulses but remains operated until relays 900 and 901 finally release when dialing is completed and the dialing loop is opened. During dialing relay 902 is held operated either over the front contact of relay 901 or over the right back contact of relay 901 and the front contact of relay 900 and maintains relay 903 operated. On the first impulse of each digit which releases relays 900 and 901, the register advance relay 905 operates in a circuit from battery through its winding, inner left back contact of relay 901, left front contact of relay 903, to ground on conductor 704 and being slow to release holds during the impulses of each digit series although relay 901 may intermittently break its circuit. After the last impulse of each digit series when relay 901 operates and stays operated until the first impulse of the next digit series, relay 906 releases and closes the circuit of relay 907. This circuit extends from battery, winding of relay 907, back contact of relay 906, left front contact of relay 903 to ground on conductor 704. Relay 907 upon operating locks over its outer left front contact, inner left front contact of relay 901, left front contact of relay 903 to ground on conductor 704, thus preventing relay 907 from following vibrations of the contacts of relay 906 when it releases. Relay 907 upon operating first closes the register advance circuit which also serves as an initial locking circuit for operated register relays, to be traced later over conductor 1110, and thereafter disconnects ground at its inner normal contacts from conductor 915 to release operated impulse recording relays. Thus any register relays which are operated by these recording relays at the time relay 907 operates will become locked before the recording relays are released.

Considering the assumption that the test man dials the number 1370, relay 900 will release momentarily once in response to the first digit 1, releasing relay 901 and operating relay 906. Upon the release of relay 900 a circuit is now closed from ground on conductor 704, back contact of relay 900, right contact of relay 903, left back contact of impulse recording relay 908, left back contact of recording relay 909, left back contact of recording relay 911, right back contact of recording relay 912 to battery through the winding of recording relay 913. Relay 913 operates and locks in a circuit through its winding and the winding of relay 912 in series, front contact of relay 913, right back contact of relay 911, conductor 915, inner normal contacts of relay 907, left front contact of relay 903 to ground on conductor 704, but relay 912 being shunted does not operate. When relay 900 again operates at the end of the digit impulse, relay 912 operates and since this is the last impulse of the first digit series and relay 900 remains operated for an appreciable interval, slow-to-release relay 906 also releases and causes the operation of relay 907 which opens the locking circuit of relays 912 and 913. However, relay 912 upon operating has extended a circuit from ground at its left contact over conductor 914, middle lower front contact of transfer relay 1106, which operated in a circuit over the back contact of relay 1107 when off-normal ground was first applied to conductor 704, thence through the upper winding of relay 75

1101 of the thousands digit register 1100 to battery. Relay 1101 operates and as soon as relay 907 operates closes a locking circuit for itself extending from battery through its lower winding and inner lower front contact, winding of relay 1107, back contact of transfer relay 1126, conductor 1108, inner right front contact of relay 717, conductor 1109, back contact of transfer relay 1206, back contact of transfer relay 1226, conductor 1110, right front contact of relay 907, left front contact of relay 903 to ground on conductor 704. Thus before relay 907 operates to such an extent as to release recording relays 912 and 913, and in turn open the initial operating circuit of register relay 1101, relay 1101 has become locked.

Transfer relay 1107 operates in the locking circuit of relay 1101 and locks itself in series with register relay 1101 over its upper front contact to ground on conductor 704, opens at its back contact the circuit of transfer relay 1106 which now releases and at its inner upper front contact establishes a circuit from ground on conductor 704, back contact of relay 1127, winding of transfer relay 1126 to battery. The release of transfer relay 1106 disconnects the circuits extending from the contacts of the impulse recording relays from the operating windings of the relays of the thousands register 1100 and the operation of transfer relay 1126 connects these circuits to the operating windings of the relays of the hundreds register 1120. At its upper back contact relay 1126 also opens the initial operating circuit of relay 1107.

In response to the first impulse of the second digit 3, relays 900 and 901 release, reoperating relay 906 and releasing relay 907 and operating recording relay 913 over the previously traced circuit. Relay 912 operates in the locking circuit relay 913 upon the next energization of relay 900 and closes a circuit from ground over conductor 914, the middle lower contact of transfer relay 1126, to battery through the lower winding of relay 1121 of the hundreds register 1120, but since relay 907 is not at the time operated, 1121 does not close an effective locking circuit for itself.

On the next release of relay 900 with relay 912 operated, the impulsing circuit from the back contact of relay 900 is extended as previously traced to the left back contact of relay 911, hence over the right front contact of relay 912 to battery through the winding of impulse recording relay 916. Relay 916 operates and locks in a circuit through its winding and the winding of relay 911 in series, front contact of relay 916, right back contact of relay 909, thence over conductor 915 to ground on conductor 704 as traced, and relay 911 operates in this locking circuit upon the next energization of relay 900. Relay 911 upon operating opens the holding circuits of relays 912 and 913 at its right back contact and these relays now release. Relay 912 upon releasing opens the previously traced circuit through the winding of register relay 1121 which also releases. On the next release of relay 900, the impulsing circuit from the back contact of relay 900 is extended as previously traced to the left back contact of relay 910, thence over the left front contact of relay 911, to battery through the winding of impulse recording relay 917. Relay 917 operates and locks in a circuit through its winding and the winding of relay 910 in series, front contact of relay 917, right back contact of relay 909 to ground on conductor 915. Re-

lay 910 operates in this locking circuit upon the next energization of relay 900. Relay 900 remains operated for an appreciable interval and relay 906 releases in turn causing the operation of relay 907 to open at its inner contact the holding circuit over conductor 915 for the operated recording relays 911, 916, 910 and 917.

Before the release of the recording relays, however, relay 911 upon operating closed a circuit from ground at its right front contact, conductor 918, inner lower contact of relay 1126, lower winding of relay 1122 of the hundreds register 1120 to battery and relay 910 upon operating closed a circuit from ground at its right front contact, conductor 914, middle lower contact of relay 1126, to battery through the lower winding of relay 1121. Relays 1121 and 1122 both operate and close locking circuits for themselves in parallel from battery through their upper windings and front contacts, thence through the winding of relay 1127, conductor 1108, and as previously traced to conductor 1110, thence over the right front contact of relay 907, left front contact of relay 903 to ground on conductor 704. Relay 1127 operates in this locking circuit, locking in series with relays 1121 and 1122 directly to ground on conductor 704 over its upper front contact, opening the operating circuit of transfer relay 1126 at its lower back contact, and closing a circuit extending from ground on conductor 704 over its inner upper front contact, conductor 1111, the outer contact of relay 717, conductor releasing disconnects the operating windings of transfer relay 1206 to battery. Relay 1126 upon releasing disconnects the operating windings of the relays of the hundreds register 1120 from the contacts of the recording relays and the operation of transfer relay 1206 connects the operating windings of the relays of the tens register 1200 to the contacts of the recording relays.

In response to the first impulse of the third digit 7, relays 900 and 901 release, reoperating relay 906 and releasing relay 907. Relay 900 upon releasing also operates recording relay 913 over the previously traced circuit. Relay 912 then operates as previously described upon the next energization of relay 900. In response to the next two impulses dialed, recording relays 911, 916, 910 and 917 operate and relays 912 and 913 release as previously described, relays 910, 911 and 912 closing operating circuits over conductors 914 and 918 and the middle and inner lower front contacts of transfer relay 1206 for relays 1201 and 1202 of the tens register 1200. Since, however, relay 907 is not at this time operated, these register relays do not close effective locking circuits for themselves.

In response to the fourth impulse of this digit, relay 900 again releases and with relay 910 operated closes the impulsing circuit from its back contact, as traced to the left back contact of relay 909, left front contact of relay 910 to battery through the winding of recording relay 919. Relay 919 operates and locks in a circuit through its winding and the winding of relay 909 in series, front contact of relay 919, outer right back contact of relay 903 to ground over conductor 915. Relay 909 operates in this locking circuit upon the next energization of relay 900. Relay 909 upon operating opens the holding circuit of relays 911, 916, 910 and 917 at its right back contact whereupon these relays release, relays 911 and 910 in turn releasing register relays 1201 and 1202. At its right front contact relay 909 also

closes a circuit from ground over conductor 920, inner contact of transfer relay 1206, lower winding of relay 1203 of tens register 1200 to battery. Since, however, relay 907 is not at this time operated, relay 1203 does not close an effective locking circuit for itself.

In response to the fifth impulse, relay 900 again releases and with relay 909 operated, closes the impulsing circuit from its back contact as traced, to the left back contact of relay 908, left front contact of relay 909 to battery through the winding of impulse recording relay 921. Relay 921 operates and locks in a circuit through its winding and the winding of relay 908 in series, front contact of relay 921, right back contact of relay 911 to ground on conductor 915. Relay 908 operates in this locking circuit upon the next energization of relay 900 opening at its outer right back contact the locking circuit of relays 909 and 919 which now release. Relay 909 upon releasing in turn releases the operated register relay 1203. Relay 908 also closes a circuit extending from ground on conductor 915, outer right contacts of relay 908, right back contact of relay 922, to battery through the winding of relay 924. Relay 924 operates and closes a locking circuit for itself extending from battery through its winding and the winding of relay 922 in series, front contact of relay 924 to ground on conductor 915, but relay 922 does not operate in this locking circuit so long as relay 908 remains operated. Relay 908 also closes a circuit extending from ground at its inner right front contact, left back contact of relay 922, conductor 923, lower contact of transfer relay 1206, lower winding of relay 1204 of the tens register 1200 to battery. Relay 1204 upon operating prepares a locking circuit for itself which will be traced hereinafter.

In response to the sixth impulse, relay 900 again releases and with relay 908 operated, closes the impulsing circuit from its back contact as traced to the left front contact of relay 908, left back contact of relay 910, left back contact of relay 911, right back contact of relay 912 to battery through the winding of relay 913. Relay 913 operates and locks in a circuit through its winding and the winding of relay 912 in series, front contact of relay 913, right back contact of relay 911 to ground on conductor 915, and relay 912 operates in this locking circuit upon the next energization of relay 900. Relay 912 also connects ground to conductor 914 thereby closing the previously traced circuit through the lower winding of relay 1201 of tens register 1200 to battery. Since, however, relay 907 is not at this time operated, relay 1201 does not close an effective locking circuit for itself.

In response to the seventh and last impulse of this digit series, relay 900 again releases and with relays 908 and 912 operated, closes the impulsing circuit from its left back contact as traced to the left back contact of relay 911, thence over the right front contact of relay 912 to battery through the winding of relay 916. Relay 916 operates and closes a locking circuit for itself through its winding and the winding of relay 911 in series, front contact of relay 916, right back contact of relay 909, to ground on conductor 915 and relay 911 operates in this locking circuit upon the next energization of relay 900. Relay 911 upon operating opens at its right back contact, the locking circuit of relays 912, 913, 908 and 921 which now release. Relay 908 upon releasing permits relay 922 to operate. Relay 912

upon releasing opens the operating circuit of register relay 1201 which also releases. At its right front contact, relay 911 closes the circuit previously traced over conductor 918 to battery through the winding of register relay 1202 which operates and prepares a locking circuit for itself. Relay 908 upon releasing opens the previously traced circuit over conductor 923 for the register relay 1204, but with relay 922 now operated, the circuit is reclosed from conductor 923 over the left front contact of relay 922 to ground at the inner right and back contact of relay 908 and register relay 1204 reoperates. Thus at the end of the third digit series, relays 1202 and 1204 are the only relays of the tens register 1200 which remain operated.

Relay 900 now remains operated for an appreciable interval whereupon relay 906 releases and relay 907 operates to open at its inner contacts the holding circuit over conductor 915 for the operated recording relays 911, 916, 922 and 924. Before the release of these relays and the consequent opening of the operating circuits of register relays 1202 and 1204 controlled thereby, relays 1202 and 1204 close locking circuits for themselves extending from battery through their upper windings and upper contacts in parallel, winding of relay 1207, back contact of transfer relay 1226, conductor 1110, outer right front contact of relay 907, left front contact of relay 903 to ground on conductor 704. Relay 1207 operates in this locking circuit, locking itself and relays 1202 and 1204 over its upper front contact, conductor 1112, outer right contact of relay 717, conductor 1111, upper front contacts of relay 1127, to ground on conductor 704, opening the operating circuit of transfer relay 1205 at its lower back contact, and closing a circuit from ground on conductor 1112 over its inner upper front contact, the lower back contact of relay 1227 to battery through the winding of transfer relay 1226. Relay 1206 upon releasing disconnects the operating windings of the relays of the tens register 1200 from the contacts of the recording relays and the operation of transfer relay 1226 connects the operating windings of the relays of units register 1220 to the contacts of the recording relays.

In response to the first impulse of the fourth digit zero, relays 908 and 901 release, reoperating relay 906, releasing relay 907 and operating recording relay 913. Relay 912 then operates as previously described upon the next energization of relay 900. In response to the next six impulses, the recording relays operate and release as previously described, so that when relay 900 reoperates at the end of the seventh impulse, recording relays 911, 916, 922 and 924 are operated and circuits are closed by relays 911 and 922 over conductors 918 and 923, the inner lower and lowermost contacts of transfer relay 1226 and the lower windings of relays 1222 and 1224 of the units register 1220 to battery. Relays 1222 and 1224 will therefore be operated to prepare locking circuits for themselves.

In response to the eighth impulse, relay 900 again releases and with relay 911 operated closes the impulse circuit from its back contact, thence as traced to the left back contact of relay 908, left back contact of relay 909, left back contact of relay 910, left front contact of relay 911 to battery through the winding of relay 917. Relay 917 operates and locks in a circuit through its winding and the winding of relay 910 in series, front contact of relay 917, right back contact of relay

909 to ground on conductor 915. Relay 910 operates in this locking circuit on the next energization of relay 900 and closes a circuit from ground at its right contact over conductor 914, the middle lower front contact of transfer relay 1226, to battery through the lower winding of register relay 1221 of the units register 1220. Relay 1221 operates and prepares a locking circuit for itself.

10 In response to the ninth impulse, relay 900 releases and with relay 910 operated closes the impulsing circuit from its back contact thence as traced to the left back contact of relay 908, left back contact of relay 909, left front contact of relay 910 to battery through the winding of relay 919. Relay 919 operates and locks in a circuit through its winding and the winding of relay 999 in series, front contact of relay 919, outer right back contact of relay 908, to ground on conductor 915. Relay 909 operates on the next energization of relay 900, closes the circuit over conductor 920 and the inner upper contact of transfer relay 1226, to battery through the lower winding of relay 1223 of the units register 1220 and opens the locking circuit of relays 911, 916, 919 and 917 at its right back contact. Relays 911, 916, 910 and 917 now release in turn releasing register relays 1221 and 1222.

20 In response to the tenth and last impulse, relay 900 releases and with relay 909 operated, closes the impulsing circuit from its back contact, thence as traced over the left back contact of relay 908, left front contact of relay 909, winding of relay 921 to battery. Relay 921 operates and locks in a circuit through its winding and the winding of relay 908 in series, front contact of relay 921, right back contact of relay 911 to ground on conductor 915. Relay 908 operates in this locking circuit upon the next energization of relay 900 and opens at its right back contact the locking circuit of relays 909 and 919. These relays now release, relay 909 in turn opening the operating circuit of register relay 1223. With relay 922 operated, relay 908 upon operating opens the circuit previously traced over conductor 923 through the operating winding of register relay 1224, whereupon relay 1224 releases. Relay 908 also closes a circuit from ground at its inner right front contact, over the inner right front contact of relay 922, conductor 925, upper front register relay 1225 to battery, thus at the end of the fourth digit series, relay 1225 is the only relay of the units register 1220 which is operated.

50 Relay 900 now remains operated for an appreciable time, whereupon relay 906 releases and relay 907 operates to open at its inner contacts the holding circuit over conductor 915 for the operated recording relays 908, 921, 922 and 924. Before the release of these relays and the consequent opening of the operating circuit of register relay 1225, relay 1225 closes a locking circuit for itself, extending from battery through its upper winding and contact, winding of relay 1227, conductor 1110, outer right front contact of relay 907, left front contact of relay 903 to ground on conductor 704. Relay 1227 operates in this circuit, locking itself and register relay 1225 over its upper front contact, conductor 1112, outer right contact of relay 717, conductor 1111, upper front contacts of relay 1127 to ground on conductor 704, opening the operating circuit of transfer relay 1226 at its lower back contact and closing a circuit from ground on conductor 1112 over its inner upper front contact, conductor 1113

to battery through the winding of relay 1226 upon releasing disconnects the recording windings of the relays of the units register 1220 from the contacts of the recording relays and relay 905 upon operating opens the circuit of relay 904 which now releases.

Setting the test trunk first selector for the two thousands selection

As soon as the first digit dialed has been registered, in the case assumed by the operation and locking of relay 1101 of the thousands register 1100 and relay 1107 has operated as previously described, a circuit is closed for relay 1003 which may be traced from battery, front contact of relay 1001, which operated over the back contact of counting relay 1002 when ground was applied to conductor 704 upon the seizure of the sender, thence over the lower back contact of relay 1004, conductor 1005, lower front contact of relay 1107 to ground on conductor 704. Relay 1003 operates and closes a circuit from ground on conductor 704, inner upper front contact of relay 1103, upper back contact of relay 1004, conductor 1006, winding of transfer relay 1114 to battery. Relay 1114 operates and closes a circuit from ground over its lower front contact, conductor 1007 to battery through the winding of relay 1008. Relay 1008 operates and with relay 1003 operated closes an operating circuit for relay 1009, extending from battery, winding of relay 1009, upper contact of relay 1008, upper contact of relay 1003, to ground on conductor 704. A holding circuit for relay 1114 is now closed from battery, winding of relay 1114, conductor 1006, upper winding of relay 1004, conductor 1010, inner lower front contact of relay 1114, conductor 1011, lower contact of relay 1009 to ground on conductor 704, but relay 1004 being shunted so long as relay 1003 remains operated does not operate at this time.

With relay 1008 operated, ground is connected to conductor 1012 to afford locking ground for certain of the counting relays and ground is connected over the upper contact of relay 1114 to conductor 1013 to afford locking ground for the remainder of the counting relays. A fundamental selection control circuit is now closed from battery, winding of selection control relay 301 of the first or two thousands selector of Fig. 3, conductor 302, left contacts of cam 219, fundamental tip conductor 215, wipers 866 of trunk finder 850, outer right contact of relay 859, conductor 722, upper contact of relay 1009, resistance 1014, winding of stepping relay 1015, conductor 1016, back contact of counting relay 1017, conductor 1018, right back contact of relay 715, conductor 723, inner left contact of relay 859, wiper 867 of finder 850, fundamental ring conductor 216, upper left contact of cam 220 to ground at the lower right contact of cam 221.

Control relay 301 and stepping relay 1015 both operate over this circuit, relay 301 upon operating closing a circuit extending from ground at its left contact, over conductor 303, the upper right and lower left contacts of cam 222, conductor 223 to battery through the winding of relay 304. Relay 304 operates and locks over its inner right contact directly to ground at the left contact of relay 301 and closes a circuit for advancing sequence switch 200 out of position 1 into position 2 which may be traced from battery, magnet winding of sequence switch 200, upper contact of cam 217, lower left contact of cam 224, conductor 225 to ground at the outer

right front contact of relay 304. With sequence switch 200 in position 2 and relays 301 and 304 operated, a circuit is established from battery through resistances 226 and 227 in parallel, lower and upper right contacts of cam 228, conductor 229, inner left front contact of relay 304, right front contact of relay 301, conductor 230, upper contacts of cam 231, conductor 232, lower contacts of cam 305 to ground through the winding of relay 306. Relay 306 operates and locks over conductor 232, independently of the contacts of cam 305, closes at its right front contact an obvious circuit through the right winding of relay 307 thereby operating relay 307 and closes a circuit from battery, winding of relay 308, outer left contact of relay 306, left contact of cam 309 to ground at the lower left contact of cam 310. Relay 307 now closes a circuit for advancing sequence switch 300 which may be traced from battery, winding of the magnet of sequence switch 300, upper contact of cam 311, left contact of cam 312, outer left contact of relay 307, conductor 313 to ground at the lower contacts of cam 233.

At the sender stepping relay 1015 upon operating, with the thousands register relay 1101 operated as assumed to register the thousands digit 1, closes a circuit from ground on conductor 704, back contact of relay 1019, lower back contact of relay 1020, front contact of stepping relay 1015, conductor 1055, inner upper front contact of transfer relay 1114, lower back contact of thousands register relay 1104, upper back contact of thousands register relay 1103, lower back contact of thousands register relay 1102, conductor 1115, lower back contact of transfer relay 1116, lower back contact of transfer relay 1117, conductor 1118, winding of the No. 0 counting relay 1021, conductor 1000 to battery at the outer right contact of relay 703. Relay 1021 operates in this circuit and locks through its winding, and the windings of counting relays 1002 and 1017 in parallel, the front contact of relay 1021 to ground on conductor 1012, but relays 1002 and 1017 being shunted do not operate so long as stepping relay 1015 remains operated.

As sequence switch 300 advances out of position 1 and enters position 1½, ground is applied to the fundamental tip conductor 215 over the right contact of cam 219, conductor 234, the outer left front contact of relay 304, conductor 314, the upper contacts of cam 235, conductor 236, the inner left front contact of relay 308, upper right contact of cam 309, to ground at the lower left contact of cam 310. Relay 301 is held operated from this ground over the upper left contact of cam 219, conductor 302, to battery through the winding of relay 301, but the sender stepping relay 1015 is shunted and released thereby permitting the operation of counting relays 1002 and 1017. With relays 1002 and 1017 both operated, a holding circuit over the tip of the fundamental circuit for relay 1001 is established from ground at the upper right contact of cam 309, thence as traced to the contacts of cam 219, thence as traced to conductor 1018, the front contact of relay 1017, lower front contact of relay 1003, front contact of relay 1002, to battery through the winding of relay 1001. When sequence switch 300 advances out of position 1½, however, relay 1001 releases in turn releasing relay 1003. The fundamental circuit being now opened both at the back contact of relay 1017 and at the upper right con-

tact of cam 309, after sequence switch 300 leaves position 1½, relay 301 then releases. Relay 1003 upon releasing in turn releases relay 1009 and removes the shunt from the upper winding of relay 1004. Relay 1004 now operates in the locking circuit of relay 1114, and upon operating closes a locking circuit for itself extending from battery through its lower winding and lower front contact, conductor 1005, lower front contact of relay 1107, to ground on conductor 704, opens at its lower back contact the operating circuit of relay 1003, and prepares at its upper front contact an operating circuit for transfer relay 1119. Relay 1009 which is slow to release remains operated long enough after its circuit is opened by the release of relay 1003 to insure that relay 1004 will operate and lock. When relay 1009 finally releases, the previously traced operating circuit of relay 1114 is opened and relay 1114 releases, removing ground from conductor 1013 and releasing relay 1008. Relay 1008 upon releasing removes ground from conductor 1012, thus releasing the operated counting relays 1021, 1002 and 1017.

Relay 1017 upon releasing again closes the previously traced fundamental circuit and relay 1002 upon releasing closes the operating circuit of relay 1001 which reoperates. As soon as the hundreds digit has been dialed and registered, as indicated by the operation of relay 1127, a circuit for reoperating relay 1003 is established from battery, winding of relay 1003, front contact of relay 1001, lower back contact of relay 1022, conductor 1023, lower front contact of relay 1127, upper contacts of relay 1107, to ground on conductor 704. Relay 1003 upon operating closes a circuit extending from ground on conductor 704, over its upper front contacts, the upper front contact of relay 1004, the upper back contact of relay 1022, conductor 1024, winding of transfer relay 1119 to battery. Relay 1119 operates and closes a circuit from ground over its lower front contact, conductor 1007 to battery through the winding of relay 1008. Relay 1008 reoperates and with relay 1003 operated closes a circuit for reoperating relay 1009. This circuit may be traced from battery, winding of relay 1009, upper contact of relay 1008, upper contact of relay 1003 to ground on conductor 704. A holding circuit for relay 1119 is now closed from battery, winding of relay 1119, conductor 1024, upper winding of relay 1022, conductor 1025, inner lower front contact of relay 1119, conductor 1011, lower contact of relay 1009 to ground on conductor 704, but relay 1022 being shunted so long as relay 1003 remains operated does not operate at this time. With relay 1008 operated, ground is reconnected to conductor 1012 to afford locking ground for certain of the counting relays and ground is reconnected over the upper contact of relay 1119 to conductor 1013 to afford locking ground for the remainder of the counting relays. The fundamental circuit is now closed at the sender and the sender is prepared to control the next selection.

At the first test selector upon the opening of the fundamental circuit following the completion of the first selection control, relay 301 releases in turn releasing relay 304. Relay 304 upon releasing closes a circuit for advancing sequence switch 200 out of position 2 into position 3. This circuit may be traced from battery, winding of the magnet of switch 200, upper contact of cam 217, upper right contact of cam 224, conductor 237, 75

right back contact of relay 304 to ground. When sequence switch 200 leaves position 2, the holding circuit of relay 306 is opened and this relay releases opening the previously traced operating circuits of relays 307 and 308. Relay 308, however, remains locked over its inner right front contact, the lower contact of cam 309 to ground at the left contact of cam 319 until after sequence switch 300 leaves position 2½, and relay 307 remains locked over its right winding and right front contact, the outer right contact of relay 308 and the upper right and lower left contacts of cam 319 until sequence switch 300 leaves position 1¾. When sequence switch 300 reaches position 2, a new holding circuit is effective for relay 307 extending through its right winding and inner right front contact, over conductor 315, the contacts of cam 238, conductor 239 to ground over the lower contacts of cam 310. When the sequence switch 300 leaves position 2, this holding circuit is opened. Upon leaving position 2½ the holding circuit of relay 308 is opened and relay 308 releases. The first test trunk selector has now been positioned to extend the connection to the line group having access to lines 0 to 1999 and proceeds to hunt for a trunk terminating in an idle second test selector.

As a sequence switch 200 passes through position 2¼ to 2¾, a circuit is established from battery through the left winding and inner left front contact of test relay 307, conductor 316, outer right back contact of relay 128, right back contact of relay 129, conductor 130, upper left and lower right contacts of cam 317, to the sleeve conductor 318 of the first test trunk terminating in a second test selector. If this test trunk is busy, there will be ground on conductor 313 and relay 307 will therefore not release as the sequence switch 300 leaves position 2. With relay 307 operated, the circuit previously traced for advancing sequence switch 300 is maintained and it continues to advance through position 2¾. When it reaches position 3, the holding circuit for relay 307 previously traced over the lower contacts of cam 310 is again established and the sequence switch continues to advance through position 3¼ to 3¾, closing a circuit from battery through the left winding and inner left front contact of test relay 307, conductor 316, inner right back contact of relay 128, left back contact of relay 129, conductor 131, upper contacts of cam 319 to the sleeve conductor 320 of the second test trunk terminating in a second test selector. If this test trunk is also busy there will be ground on conductor 320 and relay 307 will therefore not release after sequence switch 300 leaves position 3. With relay 307 operated the circuit previously traced for advancing sequence switch 300 is maintained and it continues to advance through position 3¾. When it reaches position 4, the holding circuit for relay 307, previously traced over the lower contacts of cam 310, is again established and the sequence switch continues to advance through position 4¼ to 4¾, closing a circuit from battery through the left winding and inner left front contact of test relay 307, conductor 316, outer right back contact of relay 128, right back contact of relay 129, conductor 130, upper contacts of cam 317, to the sleeve conductor 321 of the third test trunk. It will be assumed that this trunk is idle and that therefore there is no ground on conductor 321. Relay 307 now has no holding circuit and releases opening the circuit through the sequence switch magnet to arrest the sequence switch 300 in position 5.

Relay 307 upon releasing immediately connects conductor 321 over the upper contacts of cam 317, conductor 130, right back contact of relay 129, outer right back contact of relay 128, conductor 316, inner left back contact of relay 307, conductor 313, to ground at the lower contacts of cam 233 to mark the selected test trunk as busy and closes an operating circuit for relay 322 extending from battery, winding of relay 322, outer left back contact of relay 307 to ground on conductor 313. Relay 322 upon operating connects permanent busy ground to sleeve conductor 321 over a circuit extending through the upper right and lower left contacts of cam 317, outer right contact of relay 322, inner left back contact of relay 307 to ground on conductor 313 and closes an operating circuit for relay 129 extending from battery, winding of relay 129, left back contact of relay 128, conductor 132, left contact of relay 322, right back contact of relay 307, conductor 315, contacts of cam 238, conductor 239, to ground over the lower contacts of cam 310.

Five hundreds selection

As soon as the fundamental circuit is reclosed at the sender following the completion of the two thousands selection with sequence switch 200 in position 3, the previously traced circuit through the winding of relay 301 and the winding of sender stepping relay 1015 is reestablished and these relays operate. Relay 301 in turn operates relay 304 which locks under the control of relay 301. Relay 304 upon operating closes the previously traced circuit for advancing sequence switch 200 into position 4. With sequence switch 200 in position 4 and relays 301 and 304 operated, a circuit is established from battery through resistances 226 and 227 in parallel, lower and upper right contacts of cam 228, conductor 229, inner left front contact of relay 304, right front contact of relay 301, conductor 230, upper left and lower right contacts of cam 231, conductor 240, outer right front contact of relay 129, conductor 133, left contacts of cam 323, conductor 324, conductor 401, lower contacts of cam 402 to ground through the winding of relay 404. Relay 404 operates, at its inner left front contact closes an operating circuit through the right winding of relay 405 to battery, and closes an operating circuit for relay 406 extending from battery, winding of relay 406, right contact of relay 404 to ground at the right contacts of cam 407.

Relay 406 upon operating establishes a circuit from ground at its outer left contact, over the lower left upper right contacts of cam 403 to battery through the winding of relay 409. Relay 409 upon operating connects the winding of relay 404 over its inner right front contact, the outer left contact of relay 404 to the tip trunk conductor 324 for holding relay 404 operated after sequence switch 400 leaves position 1, closes at its outer left front contact an obvious operating circuit for slow-to-release relay 410 and closes a circuit for advancing sequence switch 400 out of position 1 which extends from battery, winding of the magnet of sequence switch 400, upper contact of cam 411, upper contact of cam 412, inner left front contact of relay 405 to ground at the inner left contact of relay 409. Relay 409 also locks over its outer right front contact to ground on sleeve conductor 321. The second test trunk selector is now in condition to be selectively set from the sender.

At the sender, stepping relay 1015 upon operat-

ing, with the thousands register relay 1101 operated as assumed to register the thousands digit 1 and the hundreds register relays 1121 and 1122 operated as assumed to register the hundreds digit 3, closes a circuit from ground on conductor 704, back contact of relay 1019, lower back contact of relay 1020, contact of stepping relay 1015, conductor 1055, inner upper front contact of transfer relay 1119, upper front contact of register relay 1101, inner upper back contact of register relay 1104, upper back contact of register relay 1124, conductor 1128, back contact of the No. 2' counting relay 1026, winding of the No. 2 counting relay 1027, to battery on conductor 1000. Relay 1027 operates in this circuit and locks through its winding and the winding of counting relay 1026 in series, front contact of relay 1027, to ground on conductor 1012, but relay 1026 being shunted does not operate so long as stepping relay 1015 remains operated.

As sequence switch 400 of the second test selector advances out of position 1 and into position 1½, shunting ground is applied to the fundamental tip conductor 215 over the right contact of cam 219, conductor 234, the outer left front contact of relay 304, conductor 314, the right contacts of cam 235, conductor 137, the outer left front contact of relay 129 conductor 134, the left contacts of cam 325, conductor 326, conductor 413, middle left front contact of relay 406, and the upper left and lower right contacts of cam 407. Relay 301 is held operated from this ground over the upper left contact of cam 219 and conductor 302 and holds relays 304 and 404 operated but the sender stepping relay 1015 is shunted and releases thereby permitting the operation of counting relay 1026 in the locking circuit of relay 1027. As sequence switch 400 advances out of position 1½ the shunting ground is removed from the fundamental tip conductor and sender stepping relay 1015 reoperates and, with counting relay 1026 operated, the previously traced circuit over the front contact of relay 1015 is extended from conductor 1128 over the front contact of counting relay 1026, the back contact of the No. 1' counting relay 1028 to battery, through the winding of the No. 1 counting relay 1029. Relay 1029 operates and locks through its winding and the winding of relay 1028 in series, front contact of relay 1029 to ground on conductor 1013 but relay 1028 being shunted does not operate so long as stepping relay 1015 remains operated.

As sequence switch 400 advances into position 5½ a second shunting ground impulse is connected to the tip fundamental conductor again shunting down the sender stepping relay 1015 whereupon counting relay 1028 operates in the locking circuit of relay 1029. When the sequence switch leaves position 5½ the shunting ground is removed and relay 1015 reoperates. With counting relays 1026 and 1028 now operated the previously traced circuit over the contacts of relay 1015 and conductor 1128 is extended over the front contacts of relays 1026 and 1028, conductor 1129, lower back contacts of transfer relays 1116 and 1117, conductor 1118, winding of the No. 0 counting relay 1021, to battery. Relay 1021 operates and locks in a circuit through its winding, the windings of counting relays 1002 and 1017 in parallel, front contact of relay 1021, to ground on conductor 1012, but relays 1002 and 1017 being shunted do not operate so long as relay 1015 remains operated.

When sequence switch 400 reaches position 6, with relay 406 still operated, a circuit is effective to advance it into position 7 which may be traced from battery, winding of the magnet of the sequence switch, upper contact of cam 411, lower right contact of cam 412, to ground at the outer left contact of relay 406. In position 7 a circuit is established from battery, winding of the magnet of switch 400, upper contact of cam 411, upper contact of cam 412, inner left contact of relay 405, to ground at the inner left contact of relay 409, for advancing the sequence switch out of position 7 toward position 10. As the switch 400 advances through position 9½ a third shunting ground impulse is connected to the tip fundamental conductor again shunting down the sender stepping relay 1015 whereupon counting relays 1002 and 1017 operate in the locking circuit of counting relay 1021. With relays 1002 and 1017 both operated a holding circuit over the tip fundamental circuit for relay 1001 is established from ground at the upper left contact of cam 407, thence as traced to the contacts of cam 219, thence as traced to conductor 1018, the front contact of relay 1017, lower front contact of relay 1003, front contact of relay 1002, to battery through the winding of relay 1001. When sequence switch 400 advances out of position 9½, however, relay 1001 releases in turn releasing relay 1003. The fundamental circuit being now open both at the back contact of relay 1017 and at the upper left contact of cam 407 after sequence switch 400 leaves position 9½, relay 301 then releases. Relay 1003 upon releasing also releases relay 1009 and removes the shunt from the upper winding of relay 1022. Relay 1022 now operates in the locking circuit of relay 1119, closes a locking circuit for itself extending from battery through its lower winding and lower front contact, conductor 1023, lower front contact of relay 1127, upper front contacts of relay 1107, to ground on conductor 704, opens at its lower back contact the operating circuit for relay 1003, prepares at its inner upper front contact an operating circuit for relay 1130, and at its upper front contact closes a circuit for operating relay 1030 if at this time the tens digit has been dialed and registered. This circuit may be traced from battery, winding of relay 1030, upper front contact of relay 1022, conductor 1031, lower front contact of relay 1207, conductor 1112, outer right front contact of relay 717, conductor 1111, upper front contacts of relay 1127, to ground on conductor 704.

Relay 1009 which is slow to release remains operated long enough after its circuit is opened by the release of relay 1003 to insure that relay 1022 will operate and lock. When relay 1009 finally releases the previously traced operating circuit of relay 1119 is opened and relay 1119 releases removing ground from conductor 1013 to release the operated counting relays 1028 and 1029 and to release relay 1008. Relay 1008 upon releasing removes ground from conductor 1012 thus releasing the operated counting relays 1026, 1027, 1021, 1002 and 1017.

Relay 1017 upon releasing again closes the previously traced fundamental circuit and relay 1002 upon releasing closes the operating circuit of relay 1001 which operates. With relay 1030 operated a circuit for reoperating relay 1003 is established from battery, winding of relay 1003, front contact of relay 1001, upper back contact of relay 1032, lower front contact of relay 1030, to ground on conductor 704.

upper front contact of relay 1022, conductor 1031, thence as traced to ground on conductor 704. Relay 1003 upon operating closes a circuit extending from ground on conductor 704, over its upper front contact, the upper front contact of relay 1004, the inner upper front contact of relay 1022, the upper back contact of relay 1020, conductor 1033, to battery through the winding of transfer relay 1130. Relay 1130 operates and closes a circuit from ground at its inner upper front contact, conductor 1007, to battery through the winding of relay 1008. Relay 1008 reoperates and with relay 1003 operated closes the previously traced circuit for reoperating relay 1009. A holding circuit for relay 1130 is now closed from battery, winding of relay 1130, conductor 1033, lower winding of relay 1020, conductor 1034, inner lower front contact of relay 1130, conductor 1011, lower contact of relay 1009, to ground on conductor 704, but relay 1020 being shunted so long as relay 1003 remains operated does not operate at this time. With relay 1008 operated ground is reconnected to conductor 1012 to afford locking ground for certain of the counting relays and ground is reconnected over the upper front contact of relay 1130 to conductor 1013 to afford locking ground for the remainder of the counting relays. The sender is now prepared for controlling the next selection.

Upon the opening of the fundamental circuit at the sender following the five hundreds selection relay 301 at the first test selector releases, in turn releasing relay 304. Relay 304 upon releasing closes a circuit for advancing sequence switch 200 from position 4 to position 5 which may be traced from battery, winding of the magnet of switch 200, upper contact of cam 217, upper right contact of cam 224, conductor 237, to ground at the outer right back contact of relay 304. The release of relays 301 and 304 also opens the circuit of relay 404 at the second test selector and relay 404 releases opening at its right contact the operating contact of relay 406 but relay 406 remains operated over a locking circuit through its winding and inner left front contact to ground over the lower contacts of cam 407 until sequence switch 400 passes through position 10 $\frac{1}{4}$. With relay 406 operated when sequence switch 400 reaches position 10 this sequence switch is advanced into position 11 over a circuit extending from battery, winding of the magnet of switch 400, upper contact of cam 411, lower right contact of cam 412, to ground at the outer left contact of relay 406. In position 9 $\frac{3}{4}$ relay 405 is held operated over its right winding and inner right front contact, the right front contact of relay 406, the upper right contact of cam 414, to ground at the lower right contact of cam 407. When the sequence switch reaches position 10 relay 405 is held operated over its right winding and inner right front contact, the upper left contact of cam 414, to ground at the lower right contact of cam 407. When sequence switch 400 leaves position 10 both of these locking circuits for relay 405 are opened and unless the first trunk of the third group of final selector trunks selected through the operation of switch 400 under the control of the sender is busy relay 405 will release. The second test selector has now been positioned to extend the connection to a group of final selectors which have access to the lines 1009 to 1499 and proceeds to hunt for an idle final selector of this group.

As sequence switch 400 passes through posi-

tions 10 $\frac{1}{4}$ to 11 a circuit is established from battery through the left winding and outer left front contact of test relay 405, inner left back contact of relay 415, left back contact of relay 416, upper left contact of cam 417, lower right contact of cam 418, to the sleeve conductor 419 of the first test trunk of the third group of final selector trunks. If this trunk is busy there will be ground on conductor 419 and relay 405 will therefore not release after sequence switch 400 leaves position 10 but will be held operated from ground on test conductor 419 until after the sequence switch leaves position 11. With relay 405 operated the sequence switch will continue to advance out of position into position 12 over a circuit from battery, winding of the magnet of switch 400, upper contact of cam 411, upper contact of cam 412, inner left front contact of relay 405, to ground at the inner left contact of relay 409. As the sequence switch enters position 11 relay 405 is held operated over its right winding and inner right front contact, the upper left contact of cam 414, to ground at the lower right contact of cam 407. When the sequence switch passes through positions 11 $\frac{1}{4}$ to 11 $\frac{3}{4}$ a circuit is established from battery through the left winding and outer left front contact of test relay 405, middle left back contact of relay 415, right back contact of relay 416, upper left contact of cam 420, upper right contact of cam 402 to sleeve conductor 421. It will be assumed that the second trunk is not in use and that therefore there is no ground on the sleeve conductor 421 thereof. Test relay 405 will now release and open the circuit previously traced for the sequence switch magnet, arresting the sequence switch in position 12.

Relay 405 upon releasing immediately connects sleeve conductor 421 over the upper right contact of cam 402, the upper left contact of cam 420, the right back contact of relay 416, the middle left back contact of relay 415, outer left back contact of relay 405, to ground at the inner left front contact of relay 409 to mark the selected test trunk busy and closes an operating circuit for relay 422 extending from battery, winding of relay 422, outer right back contact of relay 405, lower right contact of cam 414, to ground at the lower right contact of cam 407. Relay 422 upon operating connects permanent busy ground to sleeve conductor 421, over a circuit extending from ground at the inner left contact of relay 409, left back contact of relay 405, outer right contact of relay 422, lower left contact of cam 420, upper right contact of cam 402, the sleeve conductor 421, and closes an operating circuit for relay 416 which extends from battery, winding of relay 416, left contact of relay 422, right contact of relay 410, inner right back contact of relay 405, upper left contact of cam 414, to ground at the lower right contact of cam 407.

Final brush selection

When the fundamental circuit is reclosed at the sender through the release of counting relay 1017 and the reoperation of relay 1009 following the completion of the five hundreds selection, with sequence switch 200 in position 5, the previously traced fundamental circuit through the winding of relay 301 and the winding of sender stepping relay 1015 is reestablished and these relays operate. Relay 301 upon operating in turn operates relay 304 which locks under the control of relay 301. Relay 304 upon operating closes the previously traced circuit for advancing sequence switch 200 into position 6. With se-

quence switch 200 in position 6 and relays 301 and 304 operated a circuit is closed from battery through resistance 227 and the lower right contact of cam 228, and in parallel therewith from battery through the right winding of overflow relay 135, conductor 136 and upper left contact of cam 228, thence over the upper right contact of cam 228, conductor 229, inner left front contact of relay 304, right front contact of relay 301, conductor 220, upper left and lower right contacts of cam 231, conductor 240, outer right front contact of relay 129, conductor 133, left contacts of cam 323, conductor 324, right front contact of relay 416, lower left contact of cam 423, lower left contact of cam 424, conductor 425, left contacts of cam 501, resistance 502, right contacts of cam 503, left winding of relay 504, lower right and upper left contacts of cam 506 to ground. Relay 504 operates in this circuit but relay 135 being marginal does not operate at this time. Relay 504 now closes a locking circuit for itself extending as traced from battery through its left winding, lower contacts of cam 507, right front contact of relay 504, left contacts of cam 508, to ground at the right contacts of cam 509, and closes a circuit for relay 510 extending from battery, winding of relay 510, upper contacts of cam 511, to ground at the left front contact of relay 504. Relay 510 now operates, locks over the left contacts of cam 512, its own left front contact and the left contacts of cam 513 to ground on sleeve conductor 421, and closes a circuit for advancing sequence switch 500 into position 2. This circuit may be traced from battery, winding of the magnet of switch 500, lower contacts of cam 514, right front contact of relay 510, to ground at the left contacts of cam 515. Upon leaving position 1 the initial operating circuits of relays 504 and 510 are opened but these relays remain operated over their locking circuits as traced.

At the sender, stepping relay 1015 upon operating, with the hundreds register relays 1121 and 1122 operated as assumed to register the hundreds digit 3, closes a circuit from ground on conductor 704, back contact of relay 1019, lower back contact of relay 1020, contacts of stepping relay 1015, conductor 1055, lower front contact of transfer relay 1130, lower front contacts of register relays 1121 and 1122, conductor 1131, back contact of the No. 3' counting relay 1035, winding of the No. 3 counting relay 1036, to battery on conductor 1090. Relay 1036 operates in this circuit and locks through its winding and the winding of counting relay 1035 in series, front contact of relay 1036, to ground on conductor 1013, but relay 1035 being shunted does not operate so long as stepping relay 1015 remains operated.

At the final selector with relay 504 operated and sequence switch 500 in position 2 the circuit of the high speed up-drive magnet 516 is closed from battery through the winding of magnet 516, the right contacts of cam 517, the right front contact of relay 504, left contacts of cam 508, to ground at the right contacts of cam 509, and the brush shaft of the final selector is driven upward in a brush selection movement. During this movement commutator brush 518 engages conducting segments of commutator strips 519 intermittently connecting shunting ground to the tip conductor of the fundamental circuit over a path which may be traced from ground, left front contact of relay 504, upper left and lower right contacts of cam 511, brush 518, com-

mutator strip 519, lower contacts of cam 520, conductor 426, lower left contact of cam 427, upper left contact of cam 428, outer left front contact of relay 416, conductor 326, left contacts of cam 325, conductor 134, left front contact of relay 129, conductor 137, the right contacts of cam 235, conductor 314, outer left front contact of relay 304, conductor 234, contacts of cam 219, tip fundamental conductor 215, and thence as traced through the winding of sender stepping relay 1015. On each application of this shunting ground relay 1015 releases but relay 301 of the first test selector is maintained operated.

On the first application of shunting ground and the consequent release of stepping relay 1015, counting relay 1035 operates in the locking circuit of relay 1036. As the commutator brush 518 engages the next insulating segment of commutator strip 519 the shunting ground is removed and sender stepping relay 1015 reoperates and with the counting relay 1035 now operated extends the circuit previously traced to conductor 1131, over the front contact of relay 1035, the back contact of the No. 2' counting relay 1026, to battery through the winding of the No. 2 counting relay 1027 and relay 1027 operates. In a similar manner in response to the further application of shunting ground to the fundamental circuit counting relays 1026, 1029, 1028, 1021, 1002 and 1017 operate in succession. With relays 1002 and 1017 both operated a holding circuit over a tip fundamental conductor is established for relay 1001, from ground over commutator brush 518 and commutator strip 519, thence as traced to the contact of cam 219, thence as traced to conductor 1018, the front contact of relay 1017, lower front contact of relay 1003, front contact of relay 1002, to battery through the winding of relay 1001. When brush 518 thereafter engages the next insulating segment of commutator strip 519 relay 1001 releases, in turn releasing relay 1003. The fundamental circuit being now open both at the back contact of relay 1017 and at commutator strip 519 relay 301 releases, and upon releasing in turn releases relays 304 and 504. Relay 504 upon releasing opens the circuit of up-drive magnet 516 to arrest the upward movement of the final selector brush shaft which has now been advanced to a position preparatory to tripping the fourth brush set of the final selector. Relay 304 upon releasing also closes at its right back contact the previously traced circuit for advancing sequence switch 200 into position 7. Relay 504 upon releasing closes a circuit for advancing the final selector sequence switch into position 3 which may be traced from battery, winding of the magnet of switch 500, upper contact of cam 521, upper left contact of cam 522, to ground at the left back contact of relay 504. With sequence switch 500 in position 3 the circuit of trip magnet 524 is closed from battery, winding of magnet 524, lower right contact of cam 525, to ground at cam 509 preparatory to tripping the selected fourth set of brushes upon the subsequent advance of the final selector brush shaft.

Relay 1003 upon releasing also releases relay 1009 and removes the shunt from the upper winding of relay 1020. Relay 1020 now operates in the locking circuit of relay 1119, closes a locking circuit for itself extending from battery through its upper winding and inner upper front contact, conductor 1023, lower front contact of relay 1127, upper contacts of relay 1107, to ground on conductor 704 and at its upper front contact prepares an operating circuit for transfer relay 1116.

Relay 1009 which is slow to release remains operated long enough after its circuit is opened by the release of relay 1003 to insure that relay 1020 will operate and lock. When relay 1009 finally releases the previously traced operating circuit of transfer relay 1130 is opened and relay 1130 releases removing ground from conductor 1013 to release the operated counting relays 1035, 1036, 1028 and 1029 and releases relay 1008. Relay 1008 upon releasing removes ground from conductor 1012, thus releasing the operated counting relays 1026, 1027, 1021, 1002 and 1017.

Relay 1017 upon releasing again closes the previously traced fundamental circuit and relay 1002 upon releasing closes the operating circuit of relay 1001 which operates. Relay 1001 upon operating with relay 1030 operated closes the previously traced operating circuit for relay 1003 which operates and closes a circuit extending from ground on conductor 704, over its upper front contacts, the upper front contact of relay 1004, the inner upper front contact of relay 1022, the upper front contact of relay 1020, the lower back contact of relay 1032, conductor 1056 to battery through the winding of relay 1116. Relay 1116 operates and closes a circuit through the winding of relay 1008, conductor 1007, to ground at its upper front contact. Relay 1008 now reoperates and with relay 1003 operated closes the previously traced circuit for reoperating relay 1009. A holding circuit for relay 1116 is now closed from battery, winding of relay 1116, conductor 1056, lower winding of relay 1032, conductor 1037, inner upper front contact of relay 1116, conductor 1011, lower contact of relay 1009, to ground on conductor 704, but relay 1032 being shunted so long as relay 1003 remains operated does not operate at this time. With relay 1008 operated ground is reconnected to conductor 1012 to afford locking ground for certain of the counting relays and ground is reconnected over the middle upper front contact of relay 1116 to conductor 1013 to afford locking ground for the remainder of the counting relays. The sender is now prepared for controlling the next or tens selection.

Final tens selection

When the fundamental circuit is reclosed at the sender through the release of counting relay 1017 and the reoperation of relay 1009 following the completion of final brush selection, with sequence switch 200 in position 7, the fundamental circuit is completed through the winding of relay 301 and the winding of sender stepping relay 1015 and these relays reoperate, relay 301 in turn operating relay 304. Relay 304 locks under the control of relay 301 and recloses the previously traced circuit for advancing sequence switch 200 into position 8. With relays 301 and 304 both operated and sequence switch 200 in position 8, the previously traced circuit through the right winding of overflow relay 135 and the left winding of relay 504 of the final selector is established and relay 504 operates, locking itself in a circuit to ground at the right contact of cam 500 as previously described and closing a circuit extending from ground at its left front contact, upper left contact of cam 511, left contact of cam 523, to battery through the magnet winding of switch 500 for advancing sequence switch 500 into position 4. With the sequence switch in position 4, the previously traced circuit for high speed updrive magnet 516 is again closed and the final selector brush shaft is then advanced in a group selection movement.

During the initial portion of this movement with trip magnet 524 operated, the fourth set of brushes is tripped. As the brush shaft continues to advance the commutator brush 526 engages the commutator strip 527 and intermittently connects shunting ground to the fundamental circuit for shunting down the sender stepping relay 1015 and for holding relay 301 operated. Shunting ground is applied over a circuit extending from ground at the left front contact of relay 594, upper left and lower right contacts of cam 511, brush 526, commutator strip 527, upper right and lower left contacts of cam 520, conductor 426, and thence as traced to the sender. Upon the initial closure of the fundamental circuit for final tens selection stepping relay 1015 upon operating, with tens register relays 1202 and 1204 operated as assumed to register the tens digit 7, closes a circuit from ground on conductor 704, back contact of relay 1019, lower front contact of relay 1020, conductor 1038, lower back contact of relay 1130, conductor 1055, contacts of stepping relay 1015, conductor 1039, inner lower front contact of transfer relay 1116, conductor 1132, lower back contact of register relay 1203, lower front contact of register relay 1201, conductor 1128, back contact of the No. 2' counting relay 1026, winding of the No. 2 counting relay 1027 to battery on conductor 1000. Relay 1027 operates and locks through its winding and the winding of relay 1025 in series, front contact of relay 1027, to ground on conductor 1012, but relay 1027 does not operate so long as stepping relay 1015 remains operated.

In response to the first shunting ground from commutator strip 527 and commutator brush 526, relay 1015 releases permitting counting relay 1026 to operate. Counting relays 1029 and 1028 operate in a similar manner in response to the next operation and release of stepping relay 1015. Upon the next energization of relay 1015 with counting relays 1026 and 1028 operated, the circuit previously traced over the contact of relay 1015 to conductor 1128 is extended over the front contacts of counting relays 1026 and 1028, conductor 1129, the lower front contact of transfer relay 1116, conductor 1133, the lower front contact of tens register relay 1204, conductor 1134, back contact of the No. 9' counting relay 1040, winding of the No. 9 counting relay 1041, to battery on conductor 1000. Relay 1041 operates and locks through its winding and the winding of relay 1040 in series, front contact of relay 1041, to ground on conductor 1013. On the next release of stepping relay 1015, relay 1040 operates in this locking circuit. In a similar manner counting relays 1042 to 1049, inclusive, and counting relays 1021, 1002 and 1017 operate on the subsequent operations and releases of stepping relay 1015.

Upon the operation of relays 1002 and 1017 a holding circuit over the tip fundamental conductor is established for relay 1001 from ground over commutator brush 526, commutator strip 527, thence as traced to the contacts of cam 219, thence as traced to conductor 1018, the front contact of relay 1017, lower contact of relay 1003, front contact of relay 1002, to battery through the winding of relay 1001. When brush 526 thereafter engages the next insulating segment of commutator strip 527, relay 1001 releases, in turn releasing relay 1003. The fundamental circuit being now opened both at the back contact of relay 1017 and at the commutator strip 527, relay 301 releases and in turn releases relays 304 and 504. Relay 75

504 upon releasing opens the circuit of updrive magnet 516 to arrest the upward movement of the final selector brush shaft which has now advanced to position the tripped fourth set of brushes beneath the first set of line terminals in the eighth brush group, and closes a circuit for advancing the final selector sequence switch into position 5. This circuit may be traced from battery, magnet winding of sequence switch 500, upper contact of cam 521, upper left contact of cam 522, to ground at the left back contact of relay 504. Relay 304 upon releasing closes at its right back contact the previously traced circuit for advancing sequence switch 200 into position 9.

Relay 1003 upon releasing causes the release of relay 1009 and removes the shunt from the lower winding of relay 1032. Relay 1032 now operates in the locking circuit of relay 1116, closes a locking circuit for itself extending from battery through its upper winding and inner upper front contact, lower front contact of relay 1039, upper front contact of relay 1022, conductor 1031, lower front contact of relay 1207, conductor 1112, outer contact of relay 717, conductor 1111, upper contacts of relay 1127 to ground on conductor 704, and its lower front contact prepares an operating circuit for transfer relay 1117. Relay 1009 which is slow to release remains operated long enough after its circuit is opened by the release of relay 1003 to insure that relay 1032 will operate and lock. When relay 1009 finally releases the previously traced operating circuit of relay 1116 is opened and relay 1116 releases removing ground from conductor 1013 to release certain of the operated counting relays and releases relay 1008. Relay 1008 upon releasing removes ground from conductor 1012 thus releasing the remaining counting relays including relays 1017 and 1002.

Relay 1017 upon releasing again closes the previously traced fundamental circuit and relay 1002 upon releasing closes the operating circuit of relay 1001 which also operates. Relay 1001 upon operating with relay 1022 operated closes an operating circuit for relay 1003 provided that the units digit has been registered as indicated by the operation of relay 1227. This circuit may be traced from battery, winding of relay 1003, contact of relay 1001, lower back contact of relay 1050, conductor 1051, lower front contact of relay 1227, upper front contacts of relay 1207, conductor 1112, outer contact of relay 717, conductor 1111, upper contacts of relay 1127 to ground on conductor 704. Relay 1003 upon operating closes a circuit extending from ground on conductor 704, over its upper contacts, the upper front contact of relay 1004, inner upper front contact of relay 1022, upper front contact of relay 1020, lower front contact of relay 1032, upper back contact of relay 1050, conductor 1052, winding of transfer relay 1117 to battery. Relay 1117 operates and closes a circuit through the winding of relay 1008, conductor 1007 to ground at the upper contact of relay 1117. Relay 1008 reoperates and with relay 1003 operated closes the previously traced circuit for reoperating relay 1009. A holding circuit for relay 1117 is now closed from battery, winding of relay 1117, conductor 1052, upper winding of relay 1050, conductor 1053, inner upper front contact of relay 1117, conductor 1011, lower contact of relay 1009 to ground on conductor 704, but relay 1050 being shunted so long as relay 1003 remains operated does not operate at this time. With relay 1003 operated ground is reconnected to conductor 1012 to afford locking ground for certain of the counting relays and ground is reconnected over the

middle upper front contact of relay 1117 to conductor 1013 to afford locking ground for the remainder of the counting relays. The sender is now prepared for controlling the next or units selection.

Final units selection

When the fundamental circuit is reclosed at the sender through the release of counting relay 1017 and the reoperation of relay 1009, with sequence switch 200 in position 9, the fundamental circuit is completed through the winding of relay 301 and the winding of sender stepping relay 1015 and these relays reoperate. Relay 301 upon operating in turn operates relay 304 which locks under the control of relay 301 and closes the previously traced circuit for advancing sequence switch 200 into position 10. With relays 301 and 304 both operated and sequence switch 200 in position 10, the previously traced circuits through the right winding of overflow relay 135 and the left winding of relay 504 of the final selector are reestablished and relay 504 operates locking itself in a circuit to ground at the right contacts of cam 509 as previously traced, and closing a circuit extending from ground at its left front contact, upper left contact of cam 511, left contact of cam 523 to battery through the magnet winding of switch 500 for advancing sequence switch 500 into position 6. With sequence switch 500 in position 6, the circuit of slow-speed updrive magnet 528 is closed from battery, winding of magnet 528, left contacts of cam 511 to ground at the left front contact of relay 504. The final selector brush shaft is then advanced in a units selection movement.

As the brush shaft advances under the control of up-drive magnet 528, the commutator brush 518 engages the upper portion of commutator strip 519 and intermittently connects shunting ground to the fundamental circuit for shunting down the sender stepping relay 1015 and for holding relay 301 operated. This shunting ground is applied over a circuit extending from ground at the lower contact of cam 509, upper right contact of cam 525, brush 518, commutator strip 519, lower contacts of cam 520, conductor 426 and thence as traced to the sender. Upon the initial closure of the fundamental circuit for final units selection, stepping relay 1015 upon operating, with units register relay 1225 operated, as assumed to register the units digit zero, closes a circuit from ground on conductor 704, back contact of relay 1019, lower front contact of relay 1020, conductor 1038, lower back contact of relay 1130, conductor 1055, contacts of stepping relay 1015, conductor 1039, inner lower front contact of transfer relay 1117, conductor 1135, lower back contact of units register relay 1224, conductor 1118, winding of the No. 0 counting relay 1021 to battery on conductor 1000. Relay 1021 operates and locks in a circuit through its winding, the windings of relays 1002 and 1017 in parallel, front contact of relay 1021 to ground on conductor 1012, but relays 1002 and 1017 do not operate so long as stepping relay 1015 remains operated.

When the commutator brush 518 engages the first conducting segment of commutator strip 519 and thus shunts the winding of stepping relay 1015, this relay releases permitting counting relays 1002 and 1017 to operate. These relays upon operating establish a holding circuit over the fundamental circuit for relay 1001 from ground over commutator brush 518 and commutator strip 519 as previously traced. When brush 518 thereafter engages the next insulating segment of com-

mutator strip 519, relay 1001 releases in turn releasing relay 1063. The fundamental circuit being now open both at the back contact of relay 1017 and at the commutator strip 519, relay 301 releases and in turn releases relays 304 and 504. Relay 504 upon releasing opens the circuit of up-drive magnet 528 to arrest the upward movement of the final selector brush shaft which has now been advanced to position the fourth set of brushes on the bank terminals connected to the desired line 550, and closes a circuit for advancing the final selector sequence switch into position 7. This circuit may be traced from battery, magnet winding of sequence switch 500, right contacts of cam 514 to ground at the left back contact of relay 504. Sequence switch 500 is now advanced into position 9 over a circuit extending from ground on cam 509, upper right contact of cam 525, lower right contact of cam 511, left contact of cam 523 to battery through the magnet winding of switch 500.

Relay 1003 upon releasing causes the release of relay 1009 and removes the shunt from the upper winding of relay 1050. Relay 1050 now operates in the locking circuit of relay 1117, closes a locking circuit for itself extending from battery through its lower winding and inner lower front contact, over conductor 1051, thence as traced to ground on conductor 104. Relay 1009 which is slow to release remains operated long enough after its circuit is opened by the release of relay 1003 to insure that relay 1050 will operate and lock. When relay 1009 does finally release, the previously traced operating circuit of relay 1117 is opened and relay 1117 releases removing ground from conductor 1013 and releasing relay 1008. Relay 1008 upon releasing removes ground from conductor 1012 thus releasing counting relays 1021, 1017 and 1002. Relay 1002 upon releasing closes the operating circuit of relay 1001, but relay 1003 cannot operate now and therefore the fundamental circuit is not reestablished.

It will be assumed that the test first selector is wired for making "no test" calls and therefore immediately after selections are completed and relays 301 and 304 have released, and as the final sequence switch 500 passes through position 7, as previously described, a circuit is completed from ground over the right contacts of cam 221, conductor 242, right back contact of relay 301, conductor 230, upper left and lower right contacts of cam 231, conductor 240, outer right front contact of relay 129, conductor 133, left contacts of cam 323, conductor 324, right front contact of relay 416, lower left contact of cam 423, lower left contact of cam 424, conductor 425, left contacts of cam 501, resistance 502, upper contacts of cam 503, winding of relay 531, left contacts of cam 532 to battery through resistance 533. Relay 531 operates and opens the previously traced locking circuit of relay 510 which now releases and upon releasing closes a circuit from ground, left contacts of cam 515, right back contact of relay 510, lower left contact of cam 522, upper contact of cam 521, to battery through the magnet of switch 500 thus advancing sequence switch 500 into position 12. Thus, relay 504 does not operate as sequence switch 500 passes through position 7½ to 8 since at that time the circuit through its windings in series is opened at the back contact of relay 531 and no test of the called line is therefore made.

The called line is made busy as soon as sequence switch 500 reaches position 8 and until it

leaves position 11 by ground connected over the lower contact of cam 509, upper left contact of cam 525, right back contact of relay 534, left contacts of cam 508, back contact of relay 534, resistance 535, lower contacts of cam 536, left back contact of relay 510, lower left and right contacts of cam 513 to sleeve brush 537 and thence to battery through the winding of the cut-off relay 546 of the called line. The cut-off relay then operates to perform its usual function. Upon reaching position 11 and until the sequence switch leaves position 13 ground is applied to sleeve brush 537 from the lower contact of cam 509, upper left contact of cam 525, right back contact of relay 504, left contacts of cam 508, back contact of relay 534, resistance 535, lower right and upper left contacts of cam 536 to sleeve brush 537 thus maintaining the cut-off relay 546 of the called line operated. When the sequence switch 500 reaches position 12 relay 510 operates in a circuit extending from battery, winding of relay 510, upper left contact of cam 512, lower left contact of cam 538 to ground at the left back contact of relay 504, locks in a circuit through its winding, the left contacts of cam 512, left front contact of relay 510, left contacts of cam 513 to ground on conductor 421, and closes a circuit for advancing sequence switch 500 into the talking position 13. This circuit may be traced from battery, winding of the magnet of switch 500, lower contacts of cam 514, right front contact of relay 510 to ground at the left contacts of cam 515. From position 13 through position 17¼ the sleeve brush 537 is connected over the upper left and lower right contacts of cam 536, resistance 535, back contact of relay 534 to ground at the right contacts of cam 509.

From the time of the release of relay 504 following the completion of units selection until sequence switch 500 leaves position 8¼ a circuit is closed from ground at cam 509, upper left contact of cam 525, left contacts of cam 520, conductor 426, lower left contact of cam 427, upper left contact of cam 428, outer left front contact of relay 416, conductor 326, left contacts of cam 325, conductor 134, left front contact of relay 129, conductor 137, right contacts of cam 235 now in position 10, conductor 314, left back contact of relay 304, back contact of relay 327, winding of relay 328 to battery. Relay 328 operates and locks through its winding and front contact, winding of relay 327, conductor 329 to ground over the upper left and lower right contacts of cam 221. Relay 327 operates in this locking circuit as soon as sequence switch 500 passes beyond position 8¼. Relay 327 upon operating closes a circuit from battery through the magnet winding of sequence switch 200, upper contact of cam 217, lower right contact of cam 224, conductor 241 to ground at the front contact of relay 327 for advancing sequence switch 200 into position 12. Upon leaving position 10 both relays 327 and 328 release.

When sequence switch 200 leaves position 10 the tip and ring conductors 104 and 105 of the first test trunk are disconnected from conductors 214 and 213 extending to the sender at the contacts of cams 201 and 202, and are connected to ground at the lower left contact of cam 201 and to battery through the winding of relay 113 over the right contacts of cam 202. If the dial key of the test cord circuit is still operated, relay 113 will now operate in turn operating slow-to-release relay 114. As the sequence switch leaves 75

position 11 the previously traced circuit through the winding of relay 208 and the winding of relay 714 at the sender is opened. Relay 714 will thereupon release in turn releasing relays 717 and 703. Relay 717 upon releasing releases relay 853 which in turn releases relays 859 and 710. With both relays 703 and 710 released off-normal ground is removed from conductor 704 and all other operated relays of the sender are now released restoring the sender to normal.

When the dial key of the cord circuit is restored, the circuit over the sleeve of trunk jack 100 is immediately opened while the dialing circuit is maintained closed for a moment at the cord circuit. Relays 115, 116 and 117 now release, relay 116 causing the release of relays 203 and 120 in turn. Upon the release of relay 120, relay 113 releases in turn opening the circuit of relay 114. Relay 114 which is slow-to-release releases after an interval and closes a circuit which may be traced from battery, winding of relay 304, conductor 223, lower contacts of cam 222, conductor 243, left back contact of relay 122, conductor 138, left back contact of relay 203, conductor 139 to ground over the normal contacts of relay 114. Relay 304 upon operating closes a circuit from ground at its right front contact over conductor 225, lower left contact of cam 224, upper contact of cam 217 to battery through the magnet of switch 200 for advancing sequence switch 200 into position 13. Relay 304 locks in a circuit through its winding and inner right front contact, conductor 303, right contacts of cam 222, thence as traced to ground at the normal contacts of relay 114 and remains operated until relay 114 again operates.

Relay 117 is now reoperated in a circuit extending over the sleeve of jack 100, inner left front contact of relay 101, inner left back contact of relay 109, winding of relay 115, conductor 106, contacts of cam 244, conductor 245, windings of relays 116 and 117 to ground. Relay 117 upon reoperating closes a circuit from ground at the left contacts of cam 233, conductor 246, contacts of relay 117, inner left back contact of relay 120, winding of relay 114 to battery. Relay 114 now operates opening the circuit of relay 304 which releases. Relay 304 now closes the previously traced circuit over its outer right back contact to battery through the winding of the magnet sequence switch 200 for advancing the sequence switch out of position 13 into position 14. The delay interval introduced by relay 114 is to prevent the talking circuit from being cut through to the called subscriber's line while the dial bridge is closed at the test cord circuit so that conversation which may be going on with the called subscriber if the line is in use can not be disturbed or that ringing on the called line if at the time being conducted will not be interfered with.

If the dial key is restored while the sender is still attached as will usually be the case, relays 109, 203, 120 and 114 will all be normal when sequence switch 200 reaches position 12 following the completion of selections and the sequence switch will therefore advance into position 14 without the delay interposed by relay 114 as just described.

As sequence switch 200 leaves position 13, relay 121 releases and discontinues the application of steady tone current from the first-test selector trunk to the test cord circuit as a signal to the test man that he may proceed to test the called line. The testing path now extends from

the tip of jack 100 over conductor 104, outer right back contact of relay 109, outer left back contact of relay 120, conductor 141, lower contacts of cam 231, conductor 240, outer right front contact of relay 129, conductor 133, thence as traced to conductor 425, upper contacts of cam 501, brush 539 to the tip of the called line, and from the ring of jack 100 over conductor 105, outer left back contact of relay 109, right back contact of relay 120, conductor 142, lower contacts of cam 235, conductor 137, left front contact of relay 129, conductor 134, thence as traced to conductor 426, lower contacts of cam 540, brush 541 to the ring of the called line. Thus, a test path from the test desk to the called line free from all bridges is provided.

If the test man desires to ring the subscriber's bell on the called line, he may do so by the application of ringing current from the test desk, or he may test the functioning of the line circuit by releasing the called line cut-off relay 546 to establish a bridge across the tip and ring conductors of the testing path to cause a linefinder to seize the line. In preparation for the test just mentioned the test man operates a key at the test desk which opens the previously traced circuit through the winding of relay 117 and this relay releases in turn releasing relay 114. With sequence switch 200 in position 14, the release of relay 114 closes a circuit from ground over the normal contacts of relay 114, conductor 139, left back contact of relay 203, conductor 138, left back contact of relay 122, conductor 243, lower left and right contacts of cam 247, conductor 248, inner right front contact of relay 129, conductor 143, lower contacts of cam 330, conductor 331, inner left front contact of relay 416, lower left contact of cam 429, upper right contact of cam 430, conductor 431, left contacts of cam 517, winding of relay 534 to battery. Relay 534 operates and opens the previously traced circuit from ground at the right contacts of cam 509, over sleeve brush 537 to battery through the winding of cut-off relay 546 releasing relay 546. With relay 546 released, the line relay (not shown) of the called line is reconnected to the tip and ring conductors of the line and when a bridge is established at the test desk across the tip and ring conductors of the testing path previously traced, the line relay of the called line functions in the well-known manner to cause a linefinder to be started to hunt for and seize the called line and a sender to be associated with the called line. Upon the association of a sender the usual dial tone is transmitted therefrom to the called line and thence over the testing path to the test desk.

Disconnection

To disconnect the test man may either remove the test cord plug from jack 100 or if he wishes to use the same first test trunk for other tests may momentarily operate the non-locking disconnect key 147. The operation of key 147 causes the operation of relay 109 which locks in a circuit through its winding, the outer left front contact of relay 149, inner right front contact of relay 109 to ground at the right front contact of relay 101 and at its inner left front contact establishes a circuit from battery, resistance 148, winding of relay 115, conductor 106, contacts of cam 244, conductor 245, windings of relays 116 and 117 in series to ground. Relays 115, 116 and 117 operate, relay 115 establishing an obvious circuit through the left winding of relay 140 to hold

relay 140 operated following the opening of its locking circuit by the operation of relay 109, and relay 116 causing the operation of relay 203 which in turn operates relay 120. Relay 120 upon operating opens the circuit of relay 114 at its left back contact and relay 114 releases. A circuit is now closed for operating relay 122 which may be traced from battery, winding of relay 122, conductor 144, upper contacts of cam 249, outer left front contacts of relay 233, conductor 139 to ground over the normal contacts of relay 114. Relay 122 locks through its winding and right front contacts, conductor 145, upper right contact of cam 220 to ground at cam 221, opens the circuit of relay 121 to discontinue the application of steady tone current to the test set if sequence switch 200 has not at the time advanced out of position 13, and closes a circuit for advancing sequence switch 200 into position 15 which may be traced from battery, magnet winding of switch 200, upper contact of cam 217, lower left contact of cam 218, conductor 259, left front contact of relay 122, conductor 146 to ground at the lower contacts of cam 234. When sequence switch 200 reaches position 15, it is advanced into position 16 over a circuit extending from its magnet winding thence as traced to the lower left contact of cam 204, thence over the upper left contact of cam 204, conductor 237, to ground at the right back contacts of the relay 304. Upon leaving position 15, sequence switch 200 opens the circuit of relays 116 and 117 at the contacts of cam 244 thus releasing these relays and in turn releasing relays 203 and 120, opens the locking circuit of relay 122 at the upper right contact of cam 220 thus releasing relay 122, opens the locking circuit of relay 205 at the lower left contact of cam 220 thus releasing relay 205, opens the circuit of relay 322 at the lower contacts of cam 233 thus releasing relay 322, and opens the circuit of relay 129 at the contacts of cam 238 thus releasing relay 129. With sequence switch 200 in position 16 a circuit is closed from ground over the lower left and upper right contacts of cam 251, conductor 332, right contact of cam 312, upper contact of cam 311 to battery through the magnet winding of sequence switch 300 for advancing this sequence switch into its normal position 1. When sequence switch 300 reaches normal, a circuit is established for advancing sequence switch 200 to normal position 17 which may be traced from battery, winding of the magnet of switch 200, upper contact of cam 217, lower right contact of cam 218, conductor 252 to ground at the left contacts of cam 319.

When sequence switch 200 advances beyond position 15, the previously traced circuit through the windings of relays 115, 116 and 117 is opened at the contacts of cam 244 and these relays release, relay 115 upon releasing in turn releasing relay 140. Relay 140 upon releasing releases relay 109, relays 101 and 102 remaining operated so long as the test cord plug is in jack 100. The return of the test first selector to normal also removes ground from sleeve conductor 321 thus releasing relay 409. Relay 409 upon releasing removes ground at its inner left front contact from the sleeve conductor 421 of the final test trunk thus releasing relay 510 in the final selector, and opens the operating circuit of relay 410. Relay 410 being slow to release maintains its operated condition for a sufficient period after the release of relay 409 to close a circuit extending from battery, right winding of relay 432, outer left back contact of relay 415, left front contact of relay

410 to ground at the outer left back contact of relay 409. Relay 432 operates closing a holding circuit for relay 416 extending from battery, winding of relay 416, left contacts of relay 422 to ground at the right front contact of relay 432 for holding relay 416 operated following the release of relay 410, and relay 432 locks over its left winding in parallel with resistance 433 over its left contact, outer right contacts of relay 422, lower left contact of cam 420, upper right contact of cam 402, conductor 421, left contacts of cam 513, left back contact of relay 510, lower contacts of cam 532, winding of marginal relay 531, upper left and lower contacts of cam 509 to ground. Relay 531 now operates in the locking circuit of relay 432.

With relay 510 released and relay 531 operated a circuit is closed for initiating the immediate release of the final selector without waiting for the called subscriber to disconnect. The release of relay 510 closes a circuit for advancing sequence switch 500 out of the talking position 13 into position 16. This circuit may be traced from battery, magnet winding of switch 500, upper contact of cam 521, lower left contact of cam 522, right back contact of relay 510 to ground over the left contacts of cam 515. As the sequence switch passes through positions 15 to 15½ with relay 531 operated, relay 504 can not operate and therefore when it reaches position 16, a circuit is closed from ground at the left back contact of relay 504, over the upper left contact of cam 522, the upper contact of cam 521 to battery through the magnet of switch 500 for advancing sequence switch 500 into position 18. In position 18 the trip magnet 524 is operated in a circuit from battery through its winding, the lower right contact of cam 525 to ground at cam 509 to prevent the brushes from snagging during the return of the brush shaft to normal and a circuit is closed from battery through the winding of down-drive magnet 542, lower contact of cam 523, lower right contact of cam 511, upper right contact of cam 525 to ground at cam 509. In response to the energization of magnet 542, the brush shaft is returned to normal. In its normal position a circuit is closed from ground at cam 509, upper right contact of cam 525, brush 543, normal commutator segment 544, lower right contact of cam 522, upper contact of cam 521 to battery through the magnet of switch 500 thus advancing the sequence switch to normal. As the sequence switch leaves position 16, the circuit previously traced through the winding of relay 531 is opened and relay 531 releases. The final selector is now in normal condition.

From positions 16 to 18 of sequence switch 500, direct ground is maintained on sleeve conductor 421 over the upper contacts of cam 515 to mark the final selector trunk as busy and to hold relay 432 in the second test selector operated. As soon as the final selector reaches normal and its sequence switch 500 leaves position 13, this busy ground is removed and relay 432 releases in turn releasing relay 416. Since at this time relays 409 and 410 are both released, a circuit is closed from ground at the left back contact of relay 409, left back contact of relay 410, right back contact of relay 432, left contact of cam 412, upper contact of cam 411 to battery through the magnet of sequence switch 400 for advancing the sequence switch into normal position. Upon leaving position 18 the circuit of relay 422 is opened and relay 422 releases. All apparatus of the second test selector is now in normal position.

If the test man disconnects from jack 100 after

the completion of a test connection without first operating the disconnect key 147, relay 101 releases, but relay 102 remains locked up since relay 140 is at the time operated. With relay 101 released and relay 102 operated, ground is connected over the inner left front contact of relay 102 and the right back contact of relay 101 to the tip test path and battery through the winding of relay 103 is connected over the inner right front contact of relay 102 and the outer left back contact of relay 101 to the ring test path and should the called subscriber now remove his receiver or an outside man connect his headset across the testing path, relay 103 will operate closing the auxiliary signal circuit at its right contact and connecting the supervisory lamp 149 in a flashing circuit over the left contact of relay 103, the outer right contact of relay 140 to battery through interrupter 150. If the test man now again plugs into jack 100, relay 101 will reoperate releasing relay 103 and effacing the signal. Should the plug of the test cord be removed from jack 100 during the time that relay 115 is normal, relays 101 and 140 will be operated and in order to release the connection, it will be necessary for the test man to operate disconnect key 147, disconnection then proceeding as previously described.

Abandonment of a call

If the test man abandons a call before the tens digit has been registered in the sender, the dialing circuit to the sender will be opened thus permitting relays 900, 901, 902 and 903 of the sender to release. Relay 903 upon releasing closes a circuit from ground on conductor 704, back contact of relay 903, left contact of relay 904, conductor 926, upper back contact of relay 1030 which operates only after the tens digit has been registered, conductor 927 to battery through the winding of sender release relay 715. Relay 715 upon operating locks directly to off-normal ground on conductor 704, at its left back contact opens the short-circuit around the right high resistance winding of relay 714, at its right back contact opens the fundamental circuit and at its inner left front contact establishes a holding circuit for the sender make-busy relay 700. With the high resistance winding of relay 714 now in the circuit previously traced through the winding of relay 208 at the test first selector, relay 208 releases and closes an operating circuit for relay 135 which may be traced from battery, left winding of relay 135, conductor 151, lower contacts of cam 249 to ground at the back contact of relay 208. Relay 135 upon operating locks over its left contact, conductor 152, to ground at the lower contacts of cam 221 and, at its right front contact, closes a circuit for advancing sequence switch 200 into the overflow position 12. This circuit may be traced from ground over the lower contacts of cam 251, conductor 253, right contacts of relay 135, conductor 254, upper left contact of cam 224, upper contact of cam 217 to battery through the magnet of sequence switch 200. When sequence switch 200 reaches position 12, relay 304 is operated in a circuit through its winding, conductor 223, lower contacts of cam 222, conductor 243, left back contact relay 122, conductor 138, back contact of relay 203, conductor 139, normal contacts of relay 114 to ground and relay 304 advances sequence switch 200 into position 13 over a circuit extending from ground at its front contact, conductor 225, lower left contact of cam 224, thence

to battery through the magnet winding of sequence switch 200. As soon as the sequence switch leaves position 12, relay 304 releases and closes a circuit from ground over its right back contact, conductor 237, upper right contact of cam 224, thence to battery through the magnet winding of sequence switch 200 for advancing the sequence switch into position 14. From position 14 it is advanced into the overflow position 15 under the control of overflow relay 135. As the sequence switch 200 passes beyond position 11, the circuit previously traced through the windings of relays 208 and 714 is opened and relay 714 releases in turn releasing relays 717 and 703. The sender is then dismissed in the manner previously described.

With sequence switch 200 in position 15 and overflow relay 135 operated, the circuit of tone relay 121 which was opened when the sequence switch passed beyond position 13 is reestablished and relay 121 is intermittently operated to apply intermittent tone to the test part as a disconnect signal. The circuit for relay 121 may be traced from battery, winding of relay 121, right back contact of relay 122, conductor 123, right contacts of cam 212, conductor 254, right contacts of relay 135, conductor 253, lower right and upper left contacts of cam 251 to ground on interrupter 255. The test man then proceeds to initiate disconnection as previously described.

If the call is abandoned after the tens digit has been registered then the release of relay 903 in the sender closes a circuit from ground on conductor 704, back contact of relay 903, left front contact of relay 904, conductor 926, upper front contact of relay 1030 which operated upon the registration of the tens digit, to battery through the winding of relay 1019. Relay 1019 upon operating opens the circuit previously traced through contacts of the sender stepping relay 1015 so that no further operation of counting relays is possible. When, therefore, the final selector advances in the selective movement which is next initiated thereafter, the sender will fail to be satisfied and the final selector will continue its movement until it reaches the tell-tale position. If at that time the final selector sequence switch 500 is in position 2 and the selector is driven to the tell-tale position during its brush selection movement, relay 504 being operated, a circuit will be closed from ground, left front contact of relay 504, upper left and lower right contacts of cam 511, brush 518, tell-tale segment 545, upper right contact of cam 522, upper contact of cam 521 to battery through the magnet of sequence switch 500, thus advancing the sequence switch to position 3. Upon reaching position 3 with relay 510 normal, a circuit is closed from the magnet winding of sequence switch 500, over the lower left contact of cam 522, the right back contact of relay 510, to ground at the left contact of cam 515 for advancing the sequence switch into position 4. In position 4 with relay 504 still operated the circuit previously traced over the tell-tale segment 545 and the upper right contact of cam 522 is effective for advancing the sequence switch into position 5. From position 5 sequence switch 500 is advanced to position 10 in a circuit extending from battery, winding of the magnet of switch 500, upper right contact of cam 522, segment 545, brush 518, upper right contact of cam 525 to ground at cam 509. Upon reaching position 10 with relay 510 normal the sequence switch is driven into position 12 over a circuit through the lower left contact of cam

522, right back contact of relay 510 to ground at the left contacts of cam 515.

If the final selector is driven to tell-tale during its tens selection movement at which time sequence switch 509 is in position 4, the sequence switch is advanced to position 5 in a circuit from battery through the magnet winding, upper right contact of cam 522, tell-tale segment 545, brush 518, lower right and upper left contacts of cam 511 to ground at the left front contact of relay 504. From position 5 it will then be advanced to position 12 in the manner just described. If the final selector is driven to tell-tale during its units selection movement, it will be driven from position 6 into position 12 in the manner just described. When the sequence switch reaches position 12, relay 510 operates as previously described in connection with a completed call, locks itself to ground on the incoming sleeve conductor 421, and advances sequence switch 500 into position 13. As soon as the sequence switch reaches position 13, a circuit is closed through the magnet of sequence switch 500, upper right contact of cam 522, tell-tale segment 545, brush 518, upper right contact of cam 525 to ground at cam 509 for advancing the sequence switch into position 14.

Since relays 301 and 304 at the test first selector are now held operated over the fundamental circuit from the sender, when sequence switch 500 passes through positions 8 to 8 1/4, a circuit is closed from ground at cam 509, upper right contact of cam 525, lower right and upper left contacts of cam 511, lower right and upper left contacts of cam 501, conductor 425, lower left contact of cam 424, lower left contact of cam 423, inner right front contact of relay 416, conductor 324, left contacts of cam 323, conductor 133, outer right front contact of relay 129, conductor 240, lower right and upper left contacts of cam 231, conductor 230, right front contact of relay 301, inner left front contact of relay 304, conductor 229, upper contacts of cam 228, conductor 136, to battery through the right winding of overflow relay 135. Relay 135 will now receive sufficient current to operate and will lock over its left winding and front contact, conductor 152 to ground at the lower contacts of cam 221, and will advance sequence switch 200 into position 15 as previously described. As sequence switch 200 leaves position 11 the circuit of relay 714 of the sender is opened and the release of the sender proceeds in the manner previously described. Upon reaching position 15, relay 121 is intermittently operated to transmit an intermittent tone signal to the test desk. The test man then proceeds to initiate the release of the connection as previously described.

First test selector goes to overflow

If the first test selector (sequence switch 300) goes to overflow during trunk hunting, test relay 307 will remain operated during the time that the selector tests for an idle second test selector in the selected group, in the case assumed when sequence switch 300 reaches position 5, in which position a test is made of the condition of the last trunk of the first group. Similarly, had the selector been set to test trunks in any of the other groups and found no idle trunk, relay 307 would remain operated when the selector reached any of the positions 8, 11, 14 or 17. In any of these positions with relay 307 operated a circuit is closed for relay 333 extending from battery, winding of relay 333, left back contact of relay 308,

right contacts of cam 334, outer left front contact of relay 307, conductor 313 to ground at the lower contacts of cam 233. Relay 333 upon operating closes an obvious circuit over conductor 335 for overflow relay 123 which operates, opening at its back contacts the connections over conductors 130 and 131 to the sleeve cams of switch 330, and closing a circuit from battery through the left winding of overflow relay 135, to ground at its left front contact. Relay 135 upon operating locks over its left winding and left front contact, conductor 152 to ground at the lower contacts of cam 221 and closes a circuit from ground over the lower contacts of cam 251, conductor 253, right contacts of relay 135, conductor 254, upper left contact of cam 224, to battery through the magnet winding of switch 200 for advancing sequence switch 200 into position 12. As soon as the test man restores the dialing key, sequence switch 200 is advanced to position 14 as previously described in connection with a completed call, and is then advanced into position 15 over the circuit previously traced through the right contacts of overflow relay 135. Upon leaving position 11 the circuit through the winding of relay 200 and the winding of relay 714 of the sender is opened. The sender is then dismissed as previously described. With sequence switch 200 in position 15, relay 121 is intermittently operated to apply intermittent tone to the test desk cord circuit as an overflow signal. The test man then proceeds to initiate disconnection as previously described.

Second test selector goes to overflow or tell-tale

If the second test selector goes to overflow during trunk hunting, test relay 405 will remain operated during the time that the selector tests for an idle final selector trunk in the selected group, in the case assumed when sequence switch 400 reaches position 14 in which a test is made of the condition of the last trunk of the third group. Similarly, had the selector been set to test trunks in any of the other groups and found no idle trunk, relay 405 would remain operated when the selector reached any of the positions 6, 10 or 18. In any of these positions with relay 405 operated, a circuit is established from battery, winding of relay 434, right back contact of relay 406, lower right and upper left contacts of cam 408, inner left front contact of relay 405, to ground at the inner left front contact of relay 409. Relay 434 upon operating closes an obvious circuit for relay 415 which locks over its inner right front contact and the lower right contact of cam 414 to ground at cam 407, opens the test conductors extending over back contacts of relay 416 to the sleeve cams of switch 400, and closes a circuit from ground at its outer right front contact, conductor 331, lower contacts of cam 330, conductor 143, inner right front contact of relay 129, conductor 248, upper contacts of cam 247, conductor 151, to battery through the left winding of overflow relay 135. Relay 135 operates and performs the functions previously described in connection with the overflow condition established at the test first selector.

Should the selector fail to stop in any of its selection movements through failure of relay 404 to release, relay 404 will hold relay 405 operated continuously and will hold relay 406 operated until after sequence switch 400 leaves position 15. With relays 405 and 406 both operated the selector will be advanced into position 18. The circuit for advancing sequence switch 400 through positions 1 to 5, 7 to 9, 11 to 13 and 15 to 17

extends over the upper right contact of cam 412, inner left front contact of relay 405, to ground at the inner left front contact of relay 409, and the circuit for advancing it out of positions 6, 10 and 14 extends over the lower right contact of cam 412 to ground at the outer left contact of relay 406. In position 18 with relay 406 now released, relay 434 operates in turn operating relays 415 and 135. Relay 135 now performs the overflow functions previously described.

If the final selector is driven to a tell-tale position during any of its selective movements, the circuits function in the manner previously described in connection with a call abandoned after the tens digit has been registered.

Sender times out

When the sender is first seized and start relay 701 operates, ground is connected to the off-normal conductor 704 and the sender time-out circuit starts to function in the following manner. With ground connected to conductor 704 a circuit is completed therefrom over the normal contacts of make-busy jack 928, back contacts of timing relay 929, interrupter 930, back contact of timing relay 931, winding of timing relay 932 to battery. Upon the next closure of the contacts of interrupter 930, timing relay 932 operates and locks through the winding of timing relay 931, front contact of relay 932, back contact of timing relay 929 to ground on conductor 704. On the next opening of the interrupter contacts, relay 931 operates in the locking circuit of relay 932 and closes a circuit from ground on conductor 704, back contact of relay 929, contacts of interrupter 930, front contact of relay 931, winding of relay 933 to battery, as soon as the contacts of interrupter 930 again close. Relay 933 operates and locks in a circuit through its winding in series with the winding of relay 929, left contact of relay 933, to ground on conductor 704. When relay 933 operates, which occurs after a period of thirty to sixty seconds following the seizure of the sender, if the tens digit has not been registered and relay 1030 has not operated, a circuit is closed for relay 715 extending from battery, winding of relay 715, conductor 927, upper back contact of relay 1030, conductor 926, right contact of relay 933 to ground on conductor 704. Relay 715 upon operating will then cause the release of the sender and the advance of the test first selector to the overflow position as previously described in connection with an abandoned call. If, however, relay 1030 is operated indicating that the tens digit has been registered, the operation of relay 933 will close a circuit extending from battery, winding of relay 1019, upper front contact of relay 1030, conductor 926, right contact of relay 933, to ground on conductor 704. Relay 1019 upon operating will close an operating circuit for relay 1003, extending from battery, winding of relay 1003, front contact of relay 1001, lower back contact of relay 1050, lower front contact of relay 1019, conductor 1054, upper contacts of relay 1207, conductor 1112, outer right contacts of relay 717, conductor 1111, upper contacts of relay 1127 to ground on conductor 704. Relay 1003 operates in turn operating relay 1009, which closes the fundamental circuit. With relay 1019 operated, the circuit for operating the counting relays under the control of sender stepping relay 1015 is opened at the upper back contact of relay 1019 and, therefore, when the final selector

makes its next selection, the sender will not be satisfied and the final selector will advance to the tell-tale position, establishing the overflow condition at the test first selector as previously described. The sender will then be restored and an intermittent tone signal will be transmitted to the test desk.

After the operation of relay 933 if the sender restores to normal before interrupter 930 again breaks its contacts, ground is removed from off-normal conductor 704, and the timing relays 929, 931, 932 and 933 will restore. If, however, the sender fails to reach the normal, then when the interrupter 930 breaks its contacts, with relay 933 operated, both relays 933 and 929 are held operated in the locking circuit of relay 933 and relay 929 will light the lamp 934 on the sender frame, light the aisle pilot lamp and cause the operation of an alarm signal.

Sender make-busy

If it is desired to remove a sender from service, as for example, when the sender has timed out through faulty operation, a plug having its ring and sleeve contacts short circuited is inserted in make-busy jack 928. With the plug in jack 928, the timing relays 929 and 933 if operated are released, the alarm is silenced, and a circuit is closed from battery, left winding of the sender make-busy relay 700, ring and sleeve of jack 929, and the make-busy plug to ground. With relay 700 operated, the start conductor 600 is disconnected from start relay 701 and is extended to the next sender which is then used to serve the subgroup of first test trunks which have first choice preference to the sender so plugged out. Relay 700 also establishes a circuit from battery through its right winding and right front contact over right back contacts of the make-busy relays 700' and 700² of the other senders, if idle, to conductor 621. If ground is connected to conductor 621 indicating that another sender has been started to hunt for a first test selector trunk through the operation of one of the sequence start relays 611 to 619, and the plug is removed from the make-busy jack 928 or the operating circuit for relay 700 is opened due to the completion of a call, this relay will be held operated over conductor 621 until the sender which is hunting finds a calling test trunk or until all other senders become busy, and their make-busy relays 700' and 700² operate, opening the circuit over conductor 621 through the right winding of relay 700. Thus, holding the make-busy relay 700 operated over conductor 621 prevents the opening of start conductor 600 and the stopping of the sender that may be hunting and starting another sender hunting.

What is claimed is:

1. In a telephone exchange system a plurality of subgroups of trunks and trains of selector switches for extending calls to subscribers' lines, a register sender common to said trunks for controlling the setting of said switches, a plurality of trunk finders for connecting said sender with any one of said trunks, each of said finders having access to different subgroups of trunks, respectively, and means operative upon the initiation of a call on a trunk of any subgroup for starting only that one of said finders which has access to that particular subgroup of trunks.

2. In a telephone exchange system a plurality of subgroups of trunks and trains of selector switches for extending calls to subscribers' lines, 75

a register sender common to said trunks for controlling the setting of said switches, a plurality of trunk finders for connecting said sender with any one of said trunks, each of said finders having access to different subgroups of trunks, respectively, means operative upon the initiation of a call on a trunk of any subgroup for starting only that one of said finders which has access to that particular subgroup of trunks, and means for preventing the starting of more than one of said finders should calls be initiated at the same time on trunks of more than one subgroup.

3. In a telephone exchange system a plurality of subgroups of trunks and trains of selector switches for extending calls to subscribers' lines, a register sender common to said trunks for controlling the setting of said switches, a plurality of trunk finders for connecting said sender with any one of said trunks, each of said finders having access to a different number of said subgroups of trunks, respectively, a sequence relay for each of said subgroups of trunks, a corresponding start relay for each of said subgroups of trunks, said sequence relays being so interrelated with each other and with said start relays that only one sequence relay and the corresponding start relay can be operated at one time in the event that trunks of more than one subgroup are taken for use at the same time, and means controlled by the operated start relay for starting only that one of said finders which has access to the subgroup of trunks corresponding to the operated sequence and start relays.

4. In a telephone exchange system a plurality of subgroups of trunks and trains of selector switches for extending calls to subscribers' lines, a register sender common to said trunks for controlling the setting of said switches, a plurality of trunk finders for connecting said sender with any one of said trunks, each of said finders having access to a different number of said subgroups of trunks, respectively, a start relay for each of said subgroups of trunks operative when any trunk of the corresponding subgroup is taken for use, and a start circuit for each of said finders, any one of said start circuits being closed by the operation of any one of the start relays of the subgroups of trunks to which the particular finder has access.

5. In a telephone exchange system a plurality of subgroups of trunks and trains of selector switches for extending calls to subscribers' lines, a plurality of register senders common to said trunks for controlling the setting of said switches, each of said senders being the normal preference for serving particular ones of said subgroups of trunks, a plurality of trunk finders for each sender for connecting said sender with any one of said trunks, the corresponding finders of said senders having access respectively to said subgroups of trunks, a main start circuit for each sender, an auxiliary start circuit for each finder thereof, and means for closing the main start circuit of a sender, if idle, when a call is initiated on any trunk of the subgroups for which the sender is the preference and for closing the auxiliary start circuit of the finder of that sender which has access to the particular subgroup of trunks in which the calling trunk is located.

6. In a telephone exchange system a plurality of groups of trunks each divided into a plurality of sub-groups and trains of selector switches for extending calls to subscribers' lines, a plurality of register senders common to said trunks for con-

trolling the setting of said switches, each of said senders being the normal preference for serving a particular one of said groups of trunks, a plurality of trunk finders for each sender for connecting said sender with any one of said trunks, the corresponding finders of said senders having access respectively to certain subgroups of said trunks, a main start circuit for each sender, auxiliary start circuits common respectively to the corresponding finders of said senders, and means for closing the main start circuit of a sender, if idle, when a call is initiated on any trunk of a group for which the sender is the preference and for closing the auxiliary start circuit of the finder of that sender which has access to the subgroup of trunks in which the calling trunk is located.

7. In a telephone exchange system a plurality of groups of trunks each divided into a plurality of subgroups and trains of selector switches for extending calls to subscribers' lines, a plurality of register senders common to said trunks for controlling the setting of said switches, each of said senders being the normal preference for serving a particular one of said group of trunks, a plurality of trunk finders for each sender for connecting said sender with any one of said trunks, the corresponding finders of said senders having access respectively to certain subgroups of trunks, a main start circuit for each sender, auxiliary start circuits common respectively to the corresponding finders of said senders, means for closing the main start circuit of a sender when a call is initiated on any trunk of a group for which the sender is the normal preference, means for extending said main start circuit to another of said senders if the preference sender is busy, and means for closing the auxiliary start circuit of the finder of the started sender which has access to the subgroup of trunks in which the calling trunk is located.

8. In a telephone exchange system a plurality of groups of trunks each divided into a plurality of subgroups and trains of selector switches for extending calls to subscribers' lines, a plurality of register senders common to said trunks for controlling the setting of said switches, each of said senders being the normal preference for serving a particular one of said groups of trunks, a plurality of trunk finders for each sender for connecting said sender with any one of said trunks, the corresponding finders of said senders having access respectively to certain subgroups of trunks, a main start circuit for each sender, said start circuits being connected at different points in a chain sequence circuit common to all of said senders, auxiliary start circuits common respectively to the corresponding finders of said senders, means for closing the main start circuit of a sender when a call is initiated on any trunk of a group for which the sender is the normal preference, means including said chain sequence circuit for extending said main start circuit to another sender if the preference sender is busy, and means for closing the auxiliary start circuit of the finder of the started sender which has access to the subgroup of trunks in which the calling trunk is located.

9. In a telephone exchange system a trunk and a train of selector switches for extending calls to subscribers' lines, means for seizing said trunk, a sender having registers, means for associating said sender with said trunk, selection control apparatus in said sender for controlling the selective movements of said switches in accordance with the setting of said registers, a

