

Oct. 24, 1939.

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2,177,079

AUTOMATIC TELEPHONE SYSTEM

Filed June 19, 1936

8 Sheets-Sheet 1

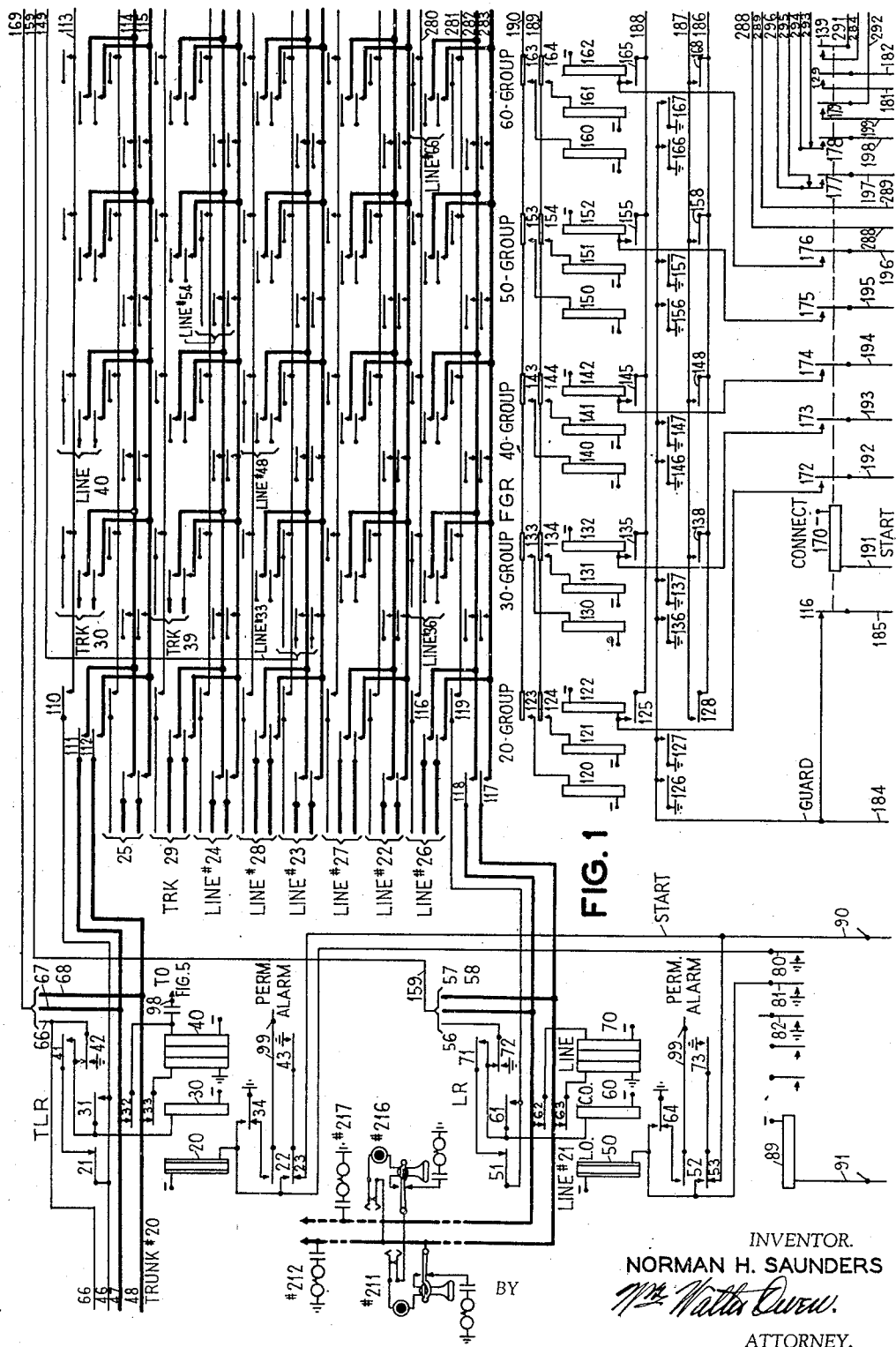


FIG. 1

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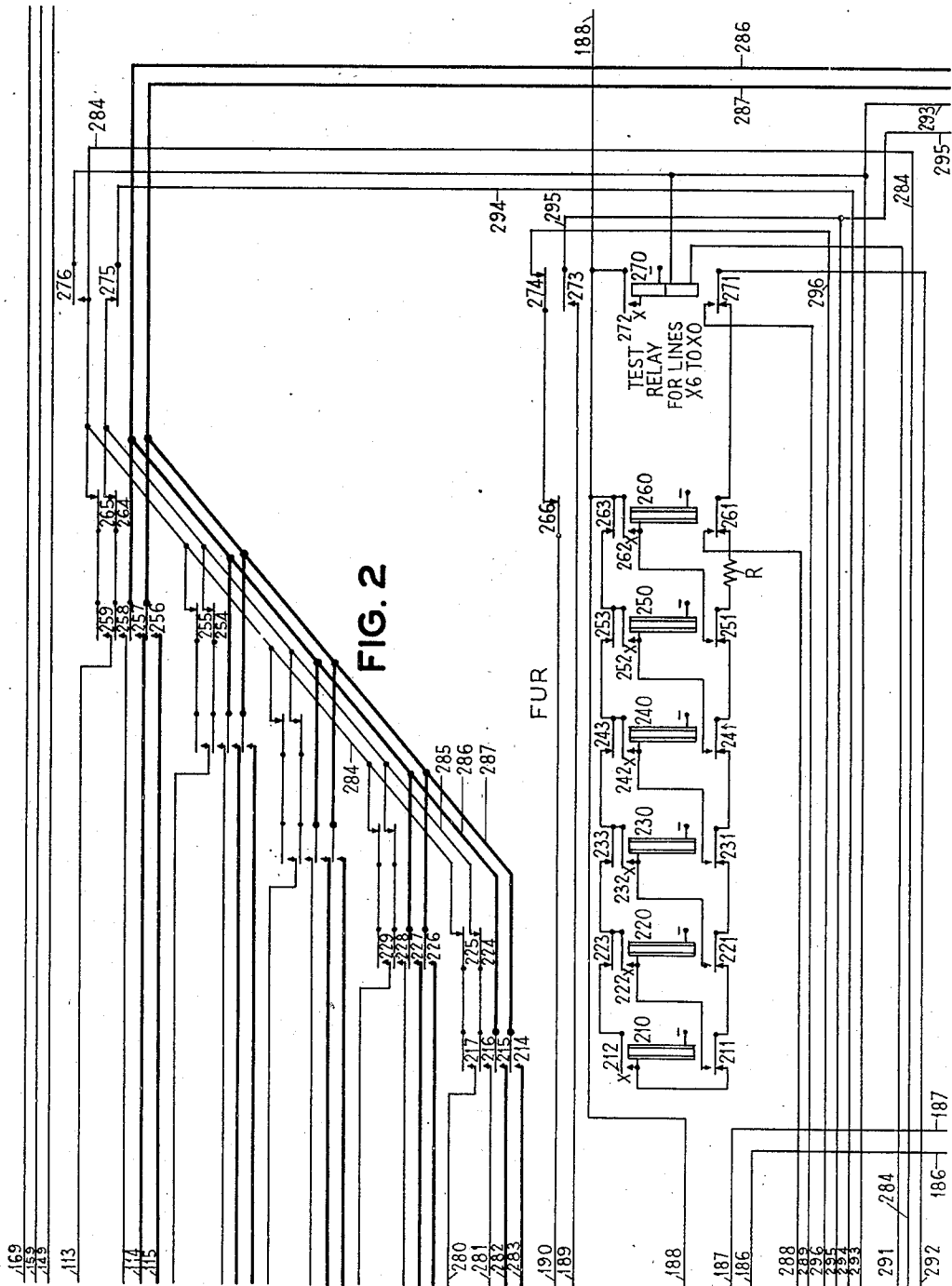
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8 Sheets-Sheet 2



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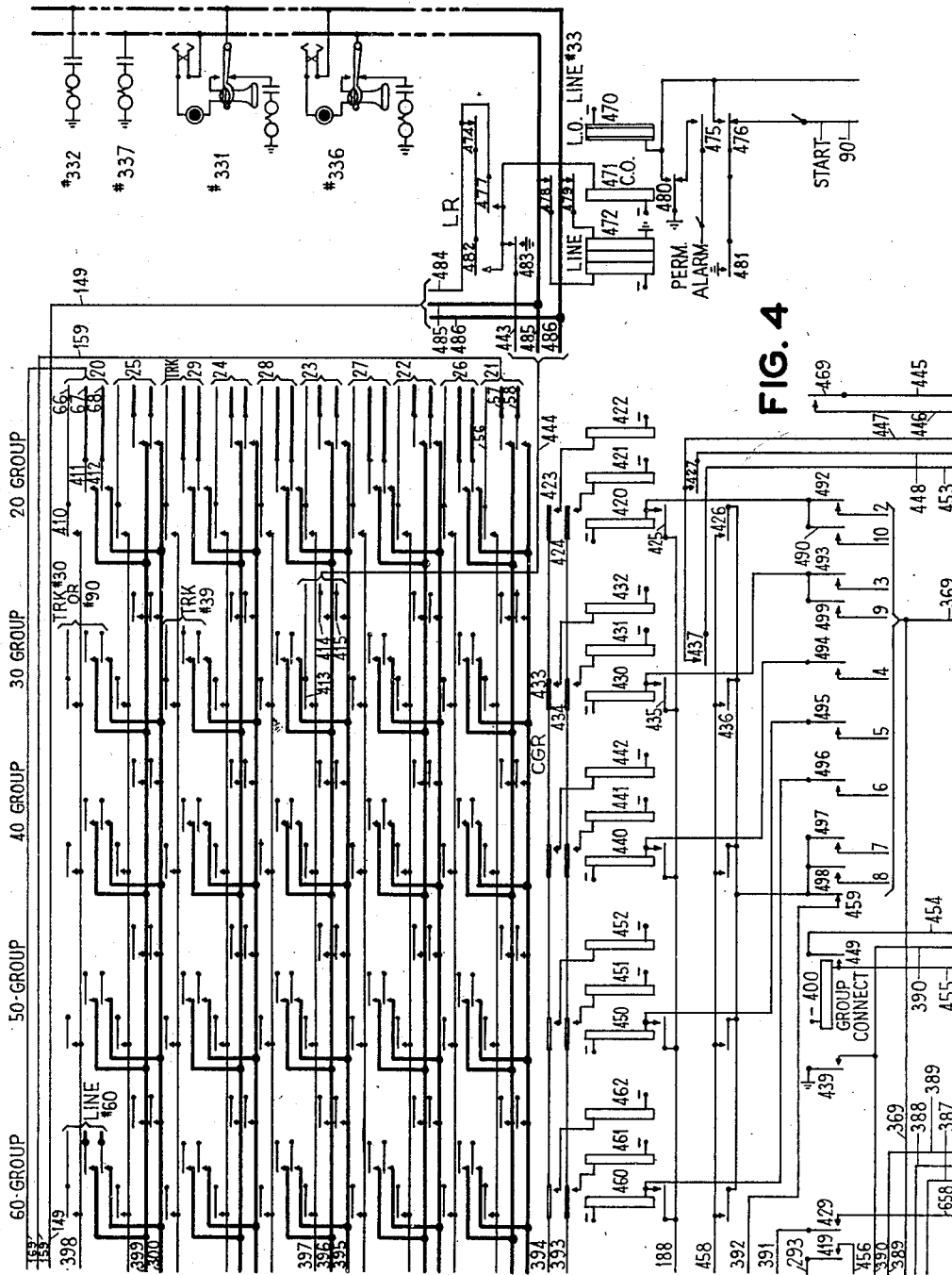


FIG. 4

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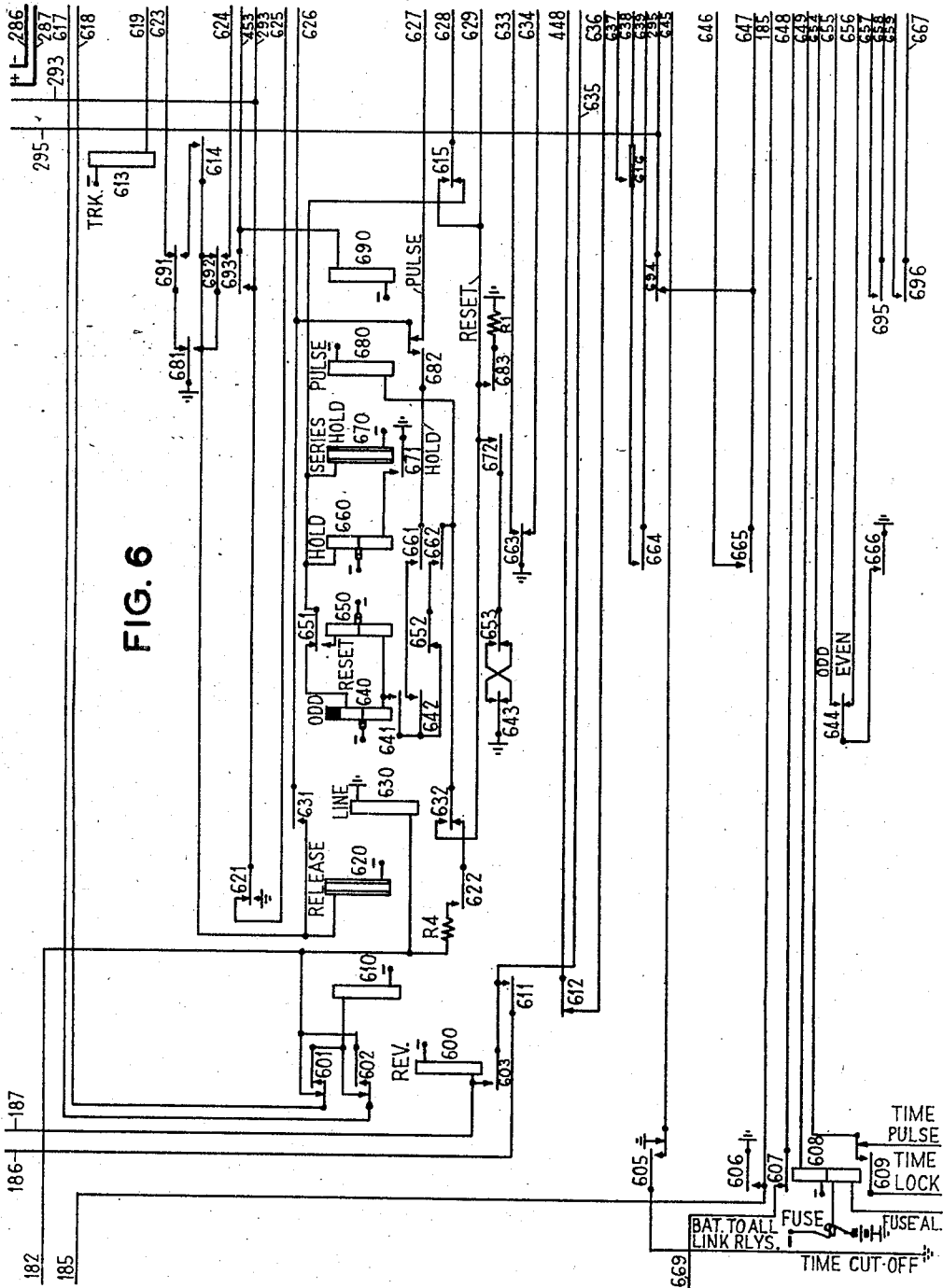
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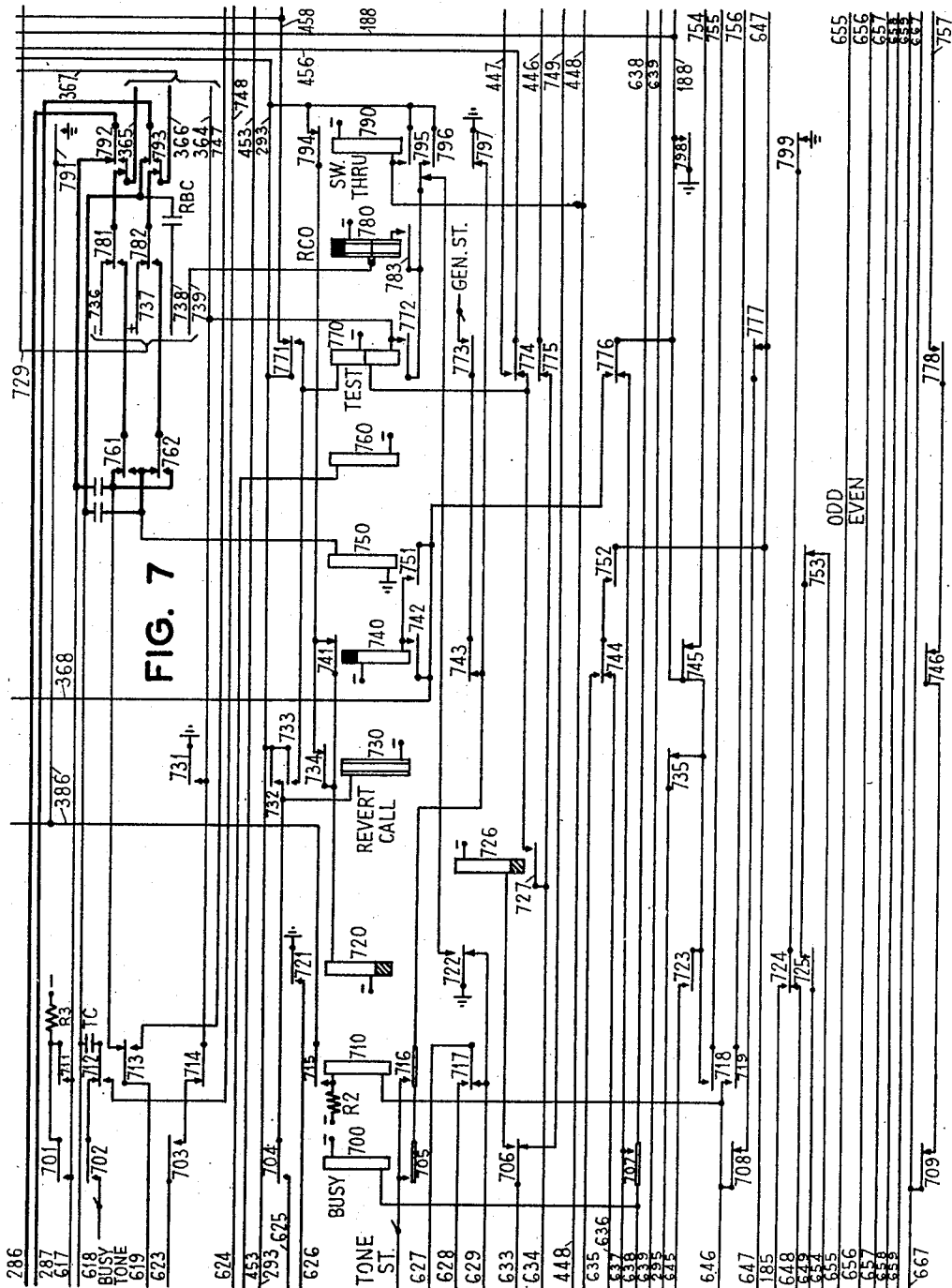
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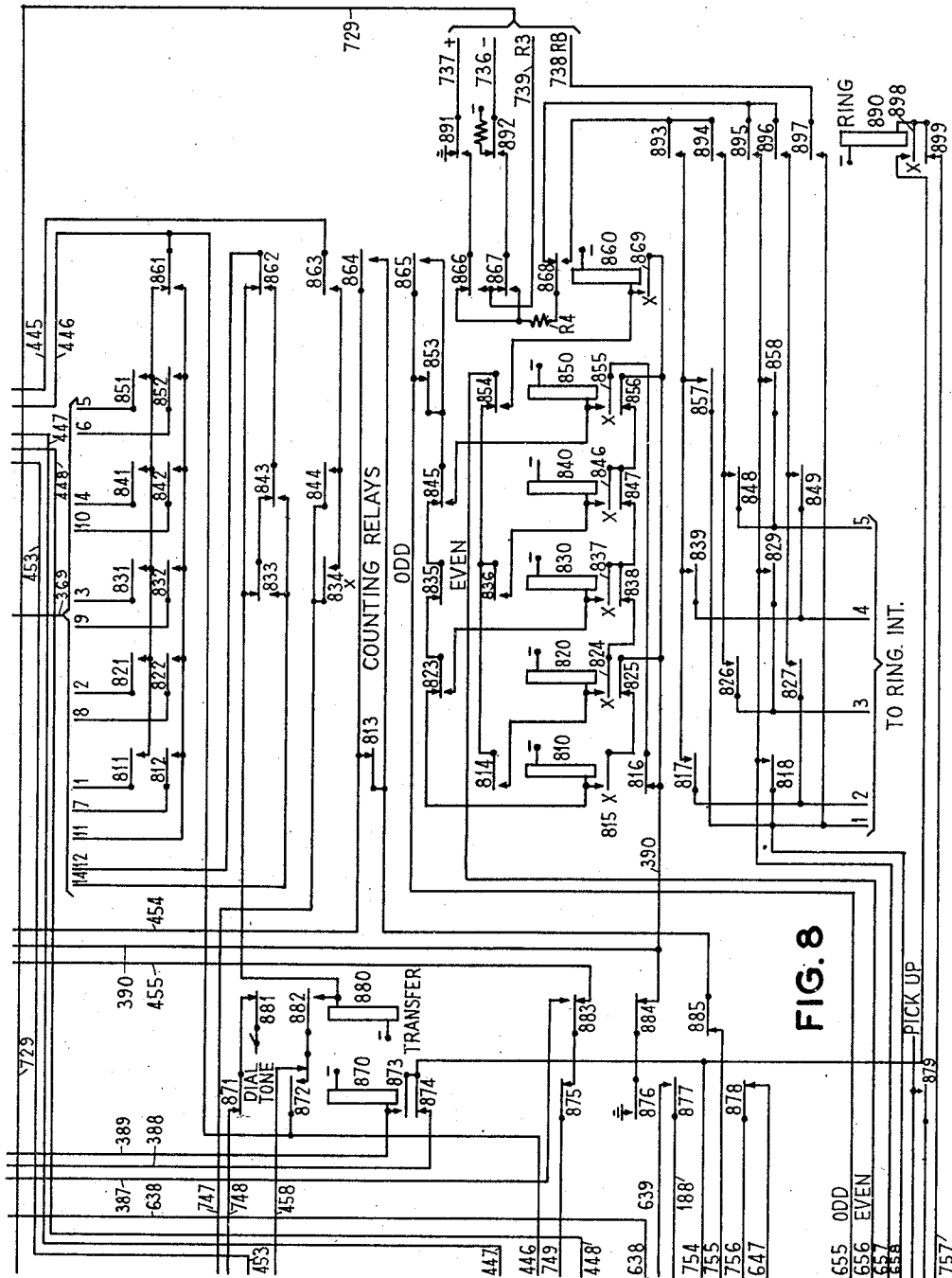
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2,177,079

AUTOMATIC TELEPHONE SYSTEM

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Application June 19, 1936, Serial No. 86,046

32 Claims. (Cl. 179—18)

This invention relates in general to automatic telephone systems, but more in particular to small systems suited for installation in towns or villages. An automatic telephone system of this type is generally known as a community automatic exchange or C. A. X., and may have a capacity of about fifty lines, more or less. Usually the lines are party lines having either bridged or grounded ringing circuits over which such subscribers are signalled by means of code ringing. Provisions are made also for trunking calls to and from distant exchanges. The object of the present invention is to provide a novel and improved all-relay community automatic exchange of the foregoing character and which may be considered as an improvement on the system disclosed in Patent No. 2,023,239, issued to John E. Ostline on December 3, 1935.

One of the features of the invention relates to the semi-directive all-relay finder having improved testing circuits whereby the finder unit relays test two lines simultaneously in the calling group.

Another feature relates to an improved testing circuit whereby the connector unit relays are each used for testing one of two lines in the called group dependent upon the unit digit dialled.

Another feature relates to an improved subscriber's line circuit having a shunt field line relay and a lockout relay.

A further feature relates to an improved lockout feature which is operative in case the finder fails to find the calling line potential, due to an open marking circuit and in which other links are prevented from attempting connection with this line as long as the line circuit is in its calling condition.

These and other features of the invention will be apparent from the foregoing detailed description of the invention.

Referring now to the drawings, comprising Figs. 1 to 8, inclusive, there is shown by means of the usual circuit diagrams sufficient of the apparatus in an automatic telephone system to enable the invention to be readily understood.

Fig. 1 shows a group of finder group relays FGR for connecting the line conductors and test conductors of the various groups of lines and trunk lines to one of the finder connector all-relay links. The lines are divided into five groups of ten lines each and are designated as the 20, 30, 40, 50, and 60 group. Relays 122, 132, 142, 152, and 162 operatively connect the test conductors of their respective groups to the link circuit shown. Relays, such as relays 120—121,

130—131, 140—141, 150—151, and 160—161, are for connecting the line conductors of their respective groups to the link circuit. In the lower left-hand corner of Fig. 1 is shown the line circuit LR of the first line in the 20-group. A plurality of sub-stations such as 211, 212, 216, and 217 are diagrammatically shown connected to this line. As will be seen, the line conductors of this line, or line 21, terminate in contacts 117 and 118 in the 20-group. The line conductors and called test conductor extend by way of a three-conductor cable 159 to the outgoing end of the link wherein these conductors terminate in contacts on the connector group relays in the 20-group. In the upper left-hand corner of Fig. 1 is shown the trunk line circuit TLR for trunk line 20. This trunk line terminates in contacts 110, 111, and 112 of the finder-group relays 121 and 122. The trunk line conductors are also connected to the outgoing end of the link in a manner similar to that described for line 21 by way of three-conductor cable 169. Lines 22, 23, 24, 25, 26, 27, and 28 and trunk lines 29 and 30 terminate in contacts controlled by the finder group relays of the 20-group. The trunk lines and subscribers' lines in the 30-group and other groups are connected in a similar manner. The connect relay 170 in the lower portion of Fig. 1 operatively connects this particular link to the common apparatus of Fig. 5.

Fig. 2 shows a group of finder unit relays FUR for connecting the line of any group to the control circuits in the link.

Fig. 3 shows a group of connector unit relays CUR for connecting the link circuit to any particular called line in any called group as determined by the operated connector group relay. The lower portion of Fig. 3 shows a unit-connecting relay 370 for connecting the connector unit relays to the link circuit.

Fig. 4 shows a group of connector group relays CGR for connecting the outgoing end of the link to any line in any group. In the right-hand end of Fig. 4 is shown the line circuit of line 33, and a plurality of substations thereon. Line 33 is connected to the link as shown diagrammatically by the three conductor cables 149 and 444. All of the trunk lines and all of the subscriber's lines in all of the groups terminate in the outgoing end of the link in the manner illustrated by line 33. A group-connect relay 400 is shown in the lower portion of Fig. 4 for operatively connecting the link circuit to the connector group relay.

Fig. 5 shows an all-relay allotter for preselect-

ing an idle link. In the upper left-hand corner of Fig. 5 are shown the link-selecting relays LSR which control the selection of an idle link and the operation of the connect relay 170 shown in the lower portion of Fig. 1. The right-hand portion of Fig. 5 shows the common group-start relays which control the operation of the finder group relays shown in Fig. 1. In the lower left-hand corner of Fig. 5 is shown the allotter control relay ACR, which control different functions to be described hereinafter. Each group of lines has a start conductor such as start conductor 90 extending from each group of line circuits to a terminal such as the terminal 20. The start conductor of the 30 group, corresponding to start conductor 90 of the 20-group, would terminate in terminal 30 and the remaining start conductors of the other groups would terminate in the correspondingly numbered terminals. Each group of lines also has a common lock-out relay such as relay 89 in Fig. 1 and which is controlled over a conductor such as conductor 91 by the group-start relay.

Fig. 6 shows a group of relays in the control circuit of the link.

Fig. 7 shows another group of relays in the control circuit of the same line.

Fig. 8 shows a further group of relays in the same link and includes the digit-counting relays.

Throughout the drawings numerous types of relays, well known in the automatic telephone art are shown. Slow-to-operate relays are shown having a full black upper section. Slow-to-release relays are shown having a cross-hatched lower section, and vertical lines or sleeves. In Fig. 5 relay 597 has a weighted vibrating armature 598 which vibrates on deenergization of the relay between the two make contacts.

Although only substations having their ringers grounded for divided or grounded ringing have been illustrated in the drawings, it will be understood that substations having their ringers bridged across the line conductors may also be operated over the circuits shown.

Briefly the operation of this system is as follows: when a calling subscriber initiates a call the test conductor of the calling line is marked with calling potential and the corresponding group-start relay is operated to energize the proper finder group control relay in an idle link previously selected by the allotter. The operation of the finder group control relays connects all of the test conductors of all the lines in the calling group to the finder unit relays which now operate successively, each relay testing two lines simultaneously until the marked calling line is found.

When the calling line is found the allotter is operated to preselect another idle link and the calling line is connected to the control equipment of the link in use. The first digit transmitted by the calling subscriber operates the counting relays to operate the corresponding connector group control relay which connects all of the test conductors of the called group to the connector unit relays of the link. The second digit reoperates the counting relays to operate the corresponding connector unit to connect the test conductor of the called line to the link control circuit. Each connector unit relay is used for connecting up two of the test conductors of two of the lines dependent upon the unit digit dialled. The third digit reoperates the counting relays to select the ringing code. If the called line is idle, a ringing relay in the link connects the

selected ringing conductor to transmit the selected ringing code to the called line.

In incoming trunk calls the operation is the same as just described with the exception that the local talking bridges in the link are disconnected and the link is switched straight through to the trunk line. The link is then held from the trunk line. In outgoing trunk calls the calling line is found and connected to the link in the same manner as just described and in response to dialling a single digit, designating a trunk call, the corresponding connector group relay connects the test conductors of this line group to the connector unit relays and a portion of these latter relays then successively operate in a hunting operation to search for an idle trunk in this group. When an idle trunk is found the link switches straight through cutting off the local talking bridges.

Having given a general description of the operation a detailed description will now be given. It will now be assumed that one of the subscribers on line 21 initiates a call. When the subscriber removes his receiver the circuit is completed for energizing the shunt field line relay 70 as follows: from ground through the left-hand winding of shunt-field line relay 70, contact 63, over the calling loop to contact 62, and through the right-hand winding to negative battery. It should possibly be mentioned at this time that the shunt field line relay 70 will operate only when the line conductors of line 21 are short-circuited and will not operate in case either one or both lines become grounded. A shunt field relay, as is well known, has its two windings wound in opposition onto iron cores which are connected together so that it is necessary for both windings to be simultaneously energized before the relay operates its armature and contacts. Shunt field line relay 70, upon energizing, at contact 71 connects marking potential extending from negative battery through the winding of cut-off relay 60 to contacts 119 of finder group relay 122. At front contact 72 relay 70 connects direct ground to test conductor 56 to busy this line and at contact 73 grounds the common start conductor 90 to cause the energization of common group-start relay 552 in Fig. 5.

Group-start relay 552, upon energizing, at front contact 562 prepares a point in the circuit for finder group relay 122, at contact 572 prepares a point in the circuit to the common lock-out relay 89 of the 20-line group, at contact 577 completes a circuit by way of contact 543 for energizing relay 551, at contact 578 completes its own locking circuit to grounded start conductor 90, and at contacts 579 to 582, inclusive, opens the circuits to the remaining group start relays to prevent their operation. Relay 551, upon energizing, at contact 544 grounds conductor 192 to prepare a circuit for energizing relay 122, at contact 545 opens a point in the original energizing circuit of relay 552, now maintained energized over its locking circuit, and at contacts 546 to 549, inclusive, opens further points in the circuit to the remaining group-start relays to prevent the operation of these group-start relays in case a line in another group should initiate a call. At contact 559 relay 551 prepares a point in the locking circuit for relay 594, at contact 560 maintains the all-link busy relay 592 in operated position, at contact 561 completes the circuit for operating the connect relay 170, at contact 570 prepares circuits for relays 595 and 596 and operates relay 597, and at contact 571 prepares a

point in the circuit to relays 502 and 594. Relay 597 is energized from ground at armature 570 by way of contact 575 to negative battery through the winding of relay 597. Relay 597, upon operating, attracts its weighted armature 598 thereby connecting ground at armature 570 through 598 and 599 and the winding of relay 596 to battery. Relay 596 energizes and at contact 569 completes the circuit for energizing slow-to operate relay 595 from this same ground at contact 570. After an interval relay 595 energizes and at contact 559 shunts contact 569 and at contact 576 completes the circuit from grounded armature 570 for energizing relay 593. Slow-to operate relay 593, upon energizing, at contact 575 opens the original circuit of relay 597. Relay 597 accordingly deenergizes and releases its weighted armature 598 to cause this armature to vibrate between its two make contacts, while the contact 599 is opened. Relay 596 deenergizes when its circuit is opened at 599, but relay 595, due to its slow release characteristics, is maintained in operated position as long as the vibrations of weighted armature 598 are of sufficient amplitude to engage with the make contacts on either side thereof.

The circuit for energizing connect relay 170 may be traced as follows: from ground by way of contacts 589, 588, 561, 574, 507, to start conductor 191 and thence through the winding of connect relay 170 to negative battery. At contact 116, connect-relay 170 disconnects conductor 185 from the guard conductor 184, at contact 172 connects the grounded conductor 192 to relay 122 to cause the latter relay to operate, at contacts 172 to 176, inclusive, prepares circuits to the other finder group relays, at contact 177 prepares a point in the circuit to finder group relay 120, at contact 178 prepares a point in the test circuit for the first five lines of a group and for test relay 557, at contact 179 prepares a point in the hunting circuit for the finder-unit relays, at contact 129 completes a circuit for operating relay 558 in series with link line relay 630, and at contact 139 prepares a point in the test circuit for the last five lines in a group and for relay 270.

Finder group relay 122, upon energizing, at its upper contacts connects up the test leads of all the lines in the 20-group, at contact 123 prepares a point in the circuit to relay 120, at contact 124 prepares a point in the circuit to relay 121, at contact 125 prepares its own locking circuit to conductor 188, and at contact 128 prepares a point in the circuit to reverse battery relay 600. The circuit for energizing line relay 630 in series with relay 558 may be traced as follows: from ground through the winding of line relay 630, conductor 182, contact 129, conductor 181, and through the winding of relay 558 to battery. At contact 583 relay 558 prepares a point in the test circuit for relay 557 and at contact 584 completes the hunting circuit for the finder unit relays and operates relay 210.

Line relay 630, upon energizing, at contact 631 completes a circuit for energizing release relay 620 as follows: from ground at back contact 722, back contact 717, conductor 627, normally closed contacts controlled by armature 682, conductor 626, contact 631, and through the winding of release relay 620 to negative battery. At front contact 632 line relay 630 completes a circuit for energizing the pulse relay 680 as follows: from ground by way of back contact 722, conductor 629, front contact 632, and through the winding of

pulse relay 680 to battery. At front contact 621 release relay 620 grounds conductor 293 and completes a circuit by way of contacts 794, 741 and 734 in multiple, through the winding of relay 720 to negative battery. Pulse relay 680, upon energizing, at contacts 681 completes a further circuit for holding release relay 620 in operated position by way of back contact 692, at contact 682 opens the original energizing circuit of release relay 620, and at contact 683 connects multiple ground through resistance R1 to the reset conductor 629 to maintain itself in operated position when the ground at back contact 722 is disconnected from reset conductor 629.

Relay 720 energizing, and at contact 721, grounds conductor 626 to maintain release relay 620 in operated position. At contact 722 relay 720 opens the original circuit of relays 680 and 620 and relay 680 is now maintained in operated position through contact 683 and the resistance R1 to ground. At front contact 722 relay 720 prepares a point in the locking circuit for test relay 770 and ring-cut-off relay 780, at contact 723 connects direct ground at the normally closed springs controlled by contact 605 to conductors 754, 295, 188, and 388, and also completes the circuit for operating relay 710. At contact 724 relay 720 disconnects one of the multiple grounds from the all-link-busy conductor 669, and at front contacts thereof grounds conductor 185 to maintain ground on the guard lead 184 when connect relay 170 deenergizes, and at contact 725 completes the circuit for operating relay 608.

The circuit for energizing relay 710 may be traced as follows: from grounded conductor 645 by way of 723, 735, 295, 694, 647, 777, 708, and through the winding of relay 710 and resistance R2 to negative battery. At contact 711 relay 710 connects battery through resistance R3 in shunt of relay 610 by way of conductor 617 and contact 602, at contact 712 connects up dial tone, at contact 713 prepares a point in the circuit to relay 613, at 715 prepares a point in the circuit by means of which relay 710 is later on short circuited, at contact 716 starts the tone machine over the tone start circuit, at 717 prepares points in the circuits to relay 660 and 670, at 718 prepares a point in the locking circuit of relay 400, and at contact 719 completes its own locking circuit. This locking circuit may be traced from grounded conductor 645 by way of 723, 735, 295, 694, 647, 878, 756, and 719. The circuit for energizing the time cut-off relay 608 may be traced as follows: from grounded time pulse lead, through the normally closed springs controlled by contact 609 and thence by way of 654, 753, 725, 649, and through the upper winding of relay 608 to battery. At contact 605 relay 608 connects the grounded time-cut-off conductor to conductor 645 in place of direct ground, at 606 grounds conductor 185, at 607 opens a further point in the circuit for ground all-links-busy conductor 669, and at 609 completes a locking circuit for itself from grounded time-lock conductor over its previously traced circuit.

The finder unit relays FUR are slightly slow to operate as well as release on account of the resistance R included in their energizing circuit, and each finder unit relay on operating closes its "X" contact first. The finder unit relay 210 is energized in response to the operation of relay 558 as follows: from ground by way of 584, 587, 199, 179, 292, back contact 271, 261, re-

distance R, 251, 241, 231, 221, 211, and through the winding of relay 210 to battery. Relay 210 at "X" contacts 212 locks itself to grounded conductor 188 through contacts 223, 233, 243, 253, and 263. At contact 217 relay 210 prepares the test circuit for the sixth line in the calling group, at 216 prepares the test circuit for the first line in the calling group, at contacts 214 and 215 prepares the line connections for either line 21 or line 26, at contact 211 opens its original energizing circuit, at front contact 211 completes the circuit for operating the second finder unit relay 220.

If the calling line is not line 21 or 26, then relay 220 energizes after an interval over the same circuit as traced for relay 210 except that in this case the circuit for relay 220 extends through front contact 211. At contact 222 relay 220 locks to grounded conductor 188, at 229 prepares the test circuit for line 27 in the calling group, at 228 prepares the test circuit for line 22 in the calling group, at contacts 226 and 227 prepares the line connections for lines 22 and 27 of the called group, at contacts 224 and 225 opens the test circuit to the first and sixth lines of the calling group, at 223 opens the locking circuit of the first finder unit relay 210 which deenergizes after an interval, at 221 opens its original circuit, and at front contact thereof closes the circuit for the third finder unit relay 230.

The finder unit relays 230 to 250, inclusive, operate in sequence as above described until the called line is found or until relay 260 is energized in case the link fails to find the calling line. Each finder unit relay on operating locks, opens the preceding relay circuit to cause its deenergization, disconnects the test leads closed by the preceding relay, and connects the test leads for the next two lines.

In case the link fails to find the marked calling potential of the calling line, then relay 260 is energized by relay 250. At 262 relay 260 locks to grounded conductor 188, at 264 and 265 opens the test leads to the fifth and tenth lines of the calling group, at 266 opens the circuit to finder group relay 120 to prevent its operation, at 263 opens the locking circuit of relay 250 which deenergizes, at back contact 261 opens the hunting circuit to the finder unit relays, and at front contact 261 closes the circuit for operating the 20-group lockout relay 89 as follows: from ground by way of 584, 587, 199, 179, 292, back contact 271, front contact 261, conductor 288, 572, conductor 91, and through the 20-group lockout relay 89 to negative battery. At contact 80, relay 89 completes the circuit for operating the lockout relay 20 of trunk No. 20, at contact 81 completes the circuit for operating lockout relay 50 of line 21, and at other similar contacts closes circuits to the lockout relays in the line circuits of the 20-group. Lockout relay 20 at contact 21 opens the circuit to the cut-off relay 30 to prevent a call on this trunk line from marking contact 110 with calling potential, and at contact 22 grounds the permanent alarm lead 99 to bring in an alarm. Lock-out relay 50 at contact 51 disconnects calling potential from contact 119, at 52 likewise grounds permanent alarm conductor 99 to bring in an alarm, and at contact 53 disconnects ground from the start lead 90 to cause the deenergization of the 20-group start relay 552 in Fig. 5, and at front contact 53 completes a locking circuit for itself from

grounded contact 73 as long as the line relay 10 is maintained in operated position.

Group-start relay 552 deenergizes and at contact 562 opens the original circuit of relay 122 which is now held in operated position over grounded conductor 188. At 572 relay 552 opens the circuit to the common 20-group lockout relay 89 which releases, and at 577 opens the circuit to relay 551 which likewise deenergizes. At contact 80 relay 89, upon deenergizing, opens the circuit of lockout relay 20 which deenergizes and in a similar manner at its other contacts releases the lockout relays in all the line circuits of group 20 in case the line relay of such circuits are not operated. At contact 81 relay 89 also opens the original circuit of lockout relay 50, but this relay is now locked in operated position due to the energized condition of line relay 70. Therefore as long as line relay 70 is maintained in operated position the lockout relay 50 is held operated to remove the calling battery potential from contact 119 at contact 51. At contacts 545 to 549, inclusive, relay 551, upon deenergizing, prepares the start circuits to the group-start relays, at 560 disconnects multiple ground from the all-link-busy relay 592, at 561 opens the circuit to connect relay 170 which deenergizes, and at 570 opens the circuit to relays 593 and 595.

Connect relay 170, upon deenergizing, at 116 connects grounded conductor 185 to guard lead 184 to operate link selecting relay 502 in series with relay 594 to cause the latter to preselect the next idle link. At contacts 172 to 176, inclusive, opens the circuit to the finder group relays, at 178 opens the point in the prepared circuit to test relay 557, at 179 opens the hunting circuit to the finder unit relays, at 129 opens the circuit to relays 558 and 630, and at 139 opens the prepared circuit to relay 270. Relay 558 deenergizes when its circuit is opened by relay 170 to open a further point in the circuit of test relay 557 at contact 583 and at contact 584 opens a further point in the hunting circuit of the finder unit relays.

Line relay 630 deenergizes when its circuit is opened by connect relay 170, and at contact 632 opens the circuit of pulse relay 680 and at 631 opens one of the circuits for release relay 620. Pulse relay 680, upon deenergizing, when its circuit is opened, at 681 opens the circuit of release relay 620, which accordingly deenergizes after an interval. Relay 620 at 621 disconnects ground from conductor 293 and releases relay 720. Shortly after its circuit is opened slow-to-release relay 720 deenergizes and at contact 723 disconnects ground from conductors 754, 388, 188, and 295 to cause the release of relays 122, 260, and 710. At contact 725 relay 720 opens the circuit of relay 608 which likewise deenergizes. Relay 710, upon deenergizing, at contact 711 disconnects the battery through resistance R3 from in shunt of relay 610, at 712 disconnects dial tone, and at 716 opens the tone-start circuit. Finder group relay 122, upon deenergizing, at its upper contact opens the test circuit to the lines in the 20-group, and at contacts 123 and 124 opens the prepared circuit to relays 120 and 121. Relay 260 deenergizes and restores its contacts to normal. Time cut-off relay 608, upon deenergizing, at contact 605 disconnects the grounded time cut-off lead and substitutes direct ground, at 606 disconnects ground from conductor 185 and therefore ground from the guard lead 184, and at 607 again grounds the all-link busy conductor 669. Link selecting relay 502 is energized in series

with the upper winding of relay 594 in response to the deenergization of relay 170 over the following circuit: from ground at contact 606 before relay 608 deenergizes, conductor 185, contact 116, guard lead 184, contact 510, upper winding of link-selecting relay 502, and through the upper winding of relay 594 to battery. At 513 relay 502, upon energizing, closes the start circuit to the connect relay of the second link over conductor 191' if the second link is idle, at 516 closes the circuit to the third link-selecting relay 503 if the second link is busy, at 517 locks in series with relay 591, and at 518 opens the locking circuit of relay 501. Relay 594 energizes in series with relay 502 and deenergizes when relay 608 deenergizes or when relay 501 deenergizes. Relays 593 and 595 deenergize shortly after the release of relay 551. The link has now been released, line No. 21 is locked out of service, as long as line relay 70 is in energized position, and the allotter has selected the next idle link.

Returning now to the operation of the finder unit relays and since line 21 is the calling line, the operation of the finder unit relay 210 therefore at contact 216 completes the test circuit for operating the cut-off relay 60 of the calling line in series with the test relay 557 as follows: from ground by way of contact 583 through the upper winding of test relay 557, and thence by way of 198, 178, 294, 275, 285, 224, 216, 281, 119, 51, 71, and through the winding of cut-off relay 60 to battery. At contact 585 test relay 557 completes the circuit for operating finder group relay 120 as follows: from ground by way of 585, 197, 177, 296, 274, 266, 190, 123, and through the winding of relay 120 to battery. At contact 586 relay 557 maintains 551 in operated position, and at front contact 587 completes a locking circuit through its lower winding from grounded armature 584. At back contact 587 relay 557 opens the hunting circuit before the next, or in this case, the second finder relay can fully operate. Test relay 557 is fairly fast to operate and therefore opens the circuit to the second finder unit relay before it can operate to close its "X" contact. Cut-off relay 60, upon energizing, at 61 locks itself independent of contacts 51 and 71, at 62 and 63 disconnects the shunt-field line relay 70, and at contact 64 operates the lockout relay 50. Lockout relay 50 at 51 opens the original circuit of cut-off relay 60, at 52 prepares a point in the alarm circuit, and at 53 opens the start circuit and releases the group-start relay 552 if no other line in this group is calling. Shunt-field line relay 70 deenergizes in response to the operation of the cut-off relay 60, and at contact 72 disconnects direct ground from conductor 56 and connects ground from the link to guard this line in the connector end of the link.

Before proceeding with the description, and in order to more fully describe the simultaneous testing of two lines in a group, it will be assumed that at the time finder unit relay 210 is operated that line No. 26 instead of line No. 21 is the calling line. In case line 26 is the calling line, then test relay 270 is energized in series with the cut-off relay of the calling line over the following circuit: from grounded conductor 293, through the lower winding of test relay 270, conductor 291, contact 139, conductor 284, contacts 225 and 217, conductor 280, contact 116, test conductor of calling line 26, through the normally closed contacts on the associated lockout relay through the closed line relay contacts and through the winding of the cut-off relay of line 26 to negative

battery. At contact 272 relay 270 locks to grounded conductor 188, at contact 276 connects the grounded conductor 293 to the winding of the cut-off relay of line 26, at 275 opens a point in the test circuit to test relay 557, at 274 opens a point in the circuit to finder group relay 120 to prevent its operation, at 273 completes the circuit for energizing finder group relay 121, at back contact 271 opens the hunting circuit to prevent operation of the next finder unit relay, in this case relay 220, and at front contact 271 maintains relay 551 operated from ground by way of 584, 587, 199, 179, 292, 271, 289, and thence over the previously traced circuit to relay 551. The cut-off relay of the line No. 26 operates and locks, disconnects the line relay which deenergizes, operates the lock-out relay and opens the start circuit to start-relay 552 in a manner similar to that described for line 21. The circuit for operating the finder group relay 121 may be traced as follows: from grounded conductor 295, contact 273, conductor 189, contact 124 and through the winding of relay 121 to battery. At its upper contacts finder group relay 121 connects the line conductors of the last six lines in this group to the finder unit relays. Since relay 210 is operated conductors 282 and 283 are connected to the link line conductors 286 and 287 by way of contacts 215 and 214. From the foregoing description it will be seen that the finder unit relay 210 simultaneously tests lines 21 and 26. In a similar manner the finder unit relays 220, 230, 240, and 250 likewise simultaneously test for two lines in the calling group.

In this case, since line No. 21 is the calling line, then finder group relay 120 is energized as previously described to connect the line conductors of the calling line to the link conductors 286 and 287 at contacts 117 and 118. The link line relay 630 is maintained energized over the following subscriber's loop as follows: from the calling loop by way of 117 and 118, 282 and 283, 215 and 214, 286 and 287, back contacts 792 and 793, conductors 617 and 618, contact 711 and resistance RC to negative battery in multiple with negative battery through the winding of relay 610 and normally closed contact 602, and through the normally closed contacts 601 and the winding of line relay 630 to ground. The closure of contact 117 also connects dial tone to the calling line as follows: from dial tone source by way of 881, 871, 748, 712, through the tone condenser TC to conductor 618, and thence back over the previously traced circuit to contact 117 and the calling line. At contact 126 finder group relay 120 connects ground to the guard lead of 184 to operate relay 502 in series with relay 594 to cause the allotter to preselect the next idle link.

The circuit for energizing link selecting relay 502 in series with relay 594 may be traced from grounded guard conductor 184, 510, upper winding of relay 502, and upper winding of relay 594 to battery. At 590 relay 594 completes a locking circuit for itself through its lower winding to grounded contact 550, at 573 opens one of the multiple ground connections to the all-link-busy relay 592 to cause the deenergization of this relay if all the links are busy, at 574 reoperates relay 597, and at back contact 574 opens the circuit to connect relay 170 to cause the latter relay to deenergize. Link-selecting relay 502 at 513 prepares the circuit for the connect relay of the second link, at 514 opens a point in the circuit to the guard conductor 184'' of the third link, at 515 prepares a point in the circuit from the guard

lead of the second link for relay 597, at 516 connects the guard lead 184' of the second link to the upper winding of link selecting relay 503 to cause the energization of this relay if the second link is busy, at 517 locks itself in series with relay 591, and at 518 opens the locking circuit of link-selecting relay 501 to cause this latter relay to deenergize. Relay 501 energizes and at contact 507 opens a further point in the circuit to connect relay 170 of the first link. At 508 connects the guard lead 184' of the second link to contact 567, at 509 disconnects the guard lead 184 of the first link from contact 567, at 510 opens the original circuit of relays 502 and 594, at 511 opens a point in its own locking circuit, and at 512 closes a point in the locking circuit for relay 506. If the subsequent links are busy their guard conductors 184', 184'', etc., are grounded and cause the link-selecting relays 503, 504, etc., to operate in succession until an idle link is selected. Assuming that the second link is idle, then link selecting relay 502 energizes and relay 501 deenergizes to permit the deenergization of relay 594.

If no other line in the 20-line group is calling then group-start relay 552 deenergizes when ground is removed from common start conductor 90. At 562 relay 552 opens a point in the original circuit for finder group relay 122 now locked to grounded conductor 188. At 572 opens the circuit to common lockout relay 89, at 577 opens the original circuit to relay 551 now held in operated position from ground at contact 586, at contact 578 opens a point in its own locking circuit, and at contacts 579 to 582, inclusive, prepares the circuit to the remaining group-start relays. Relay 597 reoperates in response to the operation of relay 594 to cause the reoperation of relay 596 and to maintain relay 595 in operated position. At the lower contact of relay 596 the locking circuit of relay 594 is opened whereupon the latter relay deenergizes. At 573 relay 594 reconnects ground to the all link busy relay 592, at front contact 574 opens the circuit to relay 597 which now vibrates its armature 598, and at back contact 574 completes the circuit for the connect relay of the second link over start conductor 191'. Armature 598 of relay 597 now vibrates causing the release of relay 596 and holds relay 595 in operated position for a certain time interval dependent upon the operated condition of relay 551.

Connect relay 170 deenergizes in response to the operation of relay 594, and at 116 connects grounded conductor 185 to guard conductor 184 to maintain the link busy. At contacts 172 to 176, inclusive, relay 170 disconnects the finder group relays, at 177 disconnects grounded conductor 197 from conductor 296 and connects the grounded conductor 295 to conductor 296 to hold relay 120 in operated position. At contact 178 relay 170 disconnects ground extending through the upper winding of test relay 557 from conductor 294 and connects grounded conductor 293 to conductor 294 to hold the cut-off relay 60 energized and to maintain line 21 busy. At contact 179 relay 170 opens the hunting circuit for operating the finder unit relays, at 129 opens the circuit to relay 558, but the link line relay 630 is now held over the calling loop, and at 139 opens a point in the circuit to relay 270. Relay 558 deenergizes and at 584 opens the locking circuit of test relay 557. Test relay 557 deenergizes and at its contact 586 opens the circuit of relay 551. Relay 551 deenergizes, and at contacts 656 to 549, inclusive, prepares the start circuit for the group-start relays. At 560 relay 551 removes

the multiple ground from the all-link-busy relay 592, at 561 opens the circuit to the connect relay, at 570 opens the circuit to relays 593 and 595, and at 571 opens the circuit to relay 594. Relay 593 deenergizes after an interval and at 575 prepares the circuit for relay 597. Relay 595, upon deenergizing, at 559 opens a point in its own circuit, and at 576 opens a point in the circuit to relay 593.

The foregoing operations have all taken place in response to the initiation of a call and when the calling subscriber hears dial tone such subscriber then dials the digits necessary to connect with and ring the desired called line. Line relay 630 follows the pulses transmitted and deenergizes for each pulse. Line relay 630 deenergizes on the first pulse and at 631 opens a multiple circuit to release relay 620, which, however, is maintained in operated position during the pulsing period. At front contact 632 relay 630 opens the circuit to pulse relay 680, which deenergizes and at back contact 632 closes the priming circuit to assist in reenergizing link line relay 630 over the subscriber's loop. This priming circuit may be traced through the resistance R4, contact 622 and back contact 632, through the winding of relay 680. The resistance R4 is of sufficient resistance to prevent the operation of relays 630 and 680 but primes line relay 630 so that it responds to the impulses over the subscriber's loop. Pulse relay 680 deenergizes and at 681 temporarily opens the circuit to slow-to-release relay 620, and at 682 disconnects ground from the hold lead and grounds the pulse lead.

On each odd pulse ground on the pulse lead closes the circuit to relays 640, 660, and 670. On each even pulse ground on the pulse lead closes 650, 660, and 670. The circuit for energizing relays 640, 660, and 670 may be traced as follows: from grounded contact 721, conductor 626, normally closed contacts controlled by contacts 682, pulse lead 627, front contact 717, conductor 628, back contact 615, and in multiple through the windings of series hold relay 670, the upper winding of hold relay 660, and by way of contact 651 through the upper winding of relay 640. At contact 661 hold relay 660 prepares a point in the hold circuit for relay 640 and a point in the energizing circuit of relay 650, at 662 also prepares a holding circuit for relay 640 and for relay 650, at front contact 663 completes the circuit for operating the group-connect relay 400, at 665 prepares a new holding circuit for relay 710, and at 666 grounds contacts 644. Series hold relay 670, upon energizing, at 671 completes a holding circuit through the lower winding of hold relay 660, and at 672 prepares a new circuit for relay 680. Odd relay 640, upon energizing, at contact 641 prepares a hold circuit through its lower winding as well as the energizing circuit for the lower winding of relay 650, at 642 connects the hold conductor through the lower windings of relays 640 and 650, at 643 prepares a new circuit for the relay 680 and relays 640 and 650, and at 644 ground the odd conductor to energize the first counting relay 810.

At the end of the first pulse line relay 630 is reenergized over the subscriber's loop and is assisted in its operation due to the previously mentioned priming circuit including the resistance R4. At contact 631 relay 630 recloses the circuit to slow-to-release relay 620 before it has had sufficient time to release, at back contact 632 opens the priming circuit and at front contact 632 closes the circuit for pulse relay 680, relay 75

650, and completes the circuit for holding relay 640. The circuit for pulse relay 680 may be traced as follows: from ground by way of 643, 653, 672, 632, relay 680 to battery. Pulse relay 680 reenergizes, and at 681 recloses the circuit to release relay 620, at 682 grounds the hold conductor to hold relays 640 and 650, and disconnects ground from the pulse lead 627 to open the original energizing circuit of relays 640, 670, and 680. Relay 670, due to its slow-release characteristics, is maintained energized during the impulsing period. At 683 pulsing relay 680 again completes its own locking circuit through resistance R1. The circuit for operating reset relay 650 is as follows: from grounded contact 643, 653, 672, 632, 662, 652, 641, and through the lower winding of relay 650 to negative battery. Relays 640 and 650 are likewise held in operated position by way of contacts 641, 642, and 661 to the hold conductor which is now grounded over 682, 626, and 721. Relay 650, upon energizing, at back contact 651 opens the original energizing circuit of relay 640 which is now held through its lower winding, at front contact 651 prepares a holding circuit for its upper winding, at 652 opens a point in the original circuit and the holding circuit of relay 640, and at 653 opens the energizing circuit of relay 680, but the latter relay is now held operated through its own contacts 683.

At the start of the second pulse line relay 630 is deenergized over the loop circuit. At 632 line relay 630 opens the locking circuit of pulse relay 680 and re-establishes the priming circuit. Pulse relay 680 deenergizes, and at 682 disconnects ground from the hold lead, thereby opening the holding circuit of relay 640 and also grounds the pulse lead to maintain the series hold relay 670 and 660, as well as 650 energized. Odd relay 640 deenergizes after an interval and at contacts 641 and 642 opens the circuit through the lower winding of relay 650 which is now held in operated position over its upper winding. At 643 relay 640 prepares a new circuit for reenergizing pulse relay 680, and at 644 disconnects ground from the odd conductor and grounds the even conductor to operate counting relay 820.

At the end of the second pulse line relay 630 is reenergized over the subscriber's loop to again complete the circuit to hold release relay 620 in energized position at contact 631, and at 632 completes the circuit for reenergizing the pulse relay 680. This circuit may be traced as follows: from ground, back contact 643, front contact 653, 672, 632, and through the winding of pulse relay 680 to battery. At 682 relay 680 again grounds the hold lead without effect at this time since the relay 640 is in deenergized position, and at the normally closed contacts controlled by contact 682 disconnects ground from the pulse lead to restore relay 650. Relay 650 at 651 reestablishes the original circuit of relay 640, at 652 prepares a point in the holding circuit for relays 640 and 650, and at 653 prepares the circuit for pulse relay 680.

At the start of the third pulse line relay 630 again deenergizes and opens pulse relay 680 which releases. At 682 pulse relay 680 reestablishes the circuit for relays 640, 660, and 670. Relay 640 reenergizes to prepare the circuits for relays 650 and 680, and at contact 644 grounds the odd conductor to operate the third counting relay 830. At the end of the third pulse line relay 630 and pulse relay 680 are reoperated and relay 650 is reenergized. At the start of the fourth pulse

line relay 630 and pulse relay 680 deenergize and cause the deenergization of relay 640. Relay 640 at contact 644 grounds the even conductor to operate the fourth counting relay 840.

In the same manner as just described relays 640 and 650 are energized on each odd pulse and deenergized for each even pulse for the remaining pulses. At contact 644 each energization of odd relay 640 grounds the odd lead to cause the energization of the succeeding odd counting relay and on each deenergization of odd relay 640 contact 644 grounds the even lead to energize the succeeding even counting relay.

The counting relays are shown in Fig. 8 and comprise relays 810 to 860, inclusive. These counting relays are adjusted so that their locking contacts marked with an "X" are first to operate to close the locking circuit of such relays. When the odd conductor is grounded in response to the first odd pulse counting relay 810 is energized by way of contacts 853, 845, 835, and 823. At 811 relay 810 prepares the circuit over the No. 1 conductor of cable 369, at 813 opens the locking circuit of connect relay 400 if only one pulse is transmitted, at 814 connects the even conductor to the second counting relay 820, at 815 locks itself by way of contacts 825 and conductor 390 which was grounded in response to the operation of the group-connect relay 400 in Fig. 4, as will be subsequently described, and at 818 connects the No. 1 ring conductor to contact 895.

In response to the even pulse, the even conductor is grounded to energize the second counting relay 820 by way of contacts 854 and 814. At 821 relay 820 prepares a connection to the No. 2 conductor of cable 369, at 823 connects the third counting relay 830 to the odd conductor, at 824 locks itself to grounded conductor 390 by way of contacts 838, 847, and 856, at 825 opens the locking circuit of the first counting relay 810 which accordingly deenergizes and at 827 connects the No. 2 ring conductor to contact 896.

In response to the third pulse the odd pulse conductor is again grounded and this time completes the circuit for energizing the third counting relay 830 by way of contacts 853, 845, and 823. At 831 relay 830 prepares the circuit for the No. 3 conductor of cable 369, at 835 opens its original energizing circuit after completing its locking circuit at contact 837, at 836 prepares the circuit for relay 840, at 837 completes its own locking circuit by way of contacts 847 and 856 to grounded conductor 390, at 838 opens the locking circuit of the second counting relay 820 which deenergizes, and at 829 connects the No. 3 ring conductor to contact 895.

In response to the fourth pulse the even pulse conductor is grounded the second time to cause the energization of the fourth counting relay 840 by way of contacts 854 and 836. At 841 relay 840 prepares the circuit over the No. 4 conductor of cable 369, at 845 prepares the circuit for the fifth counting relay 850, at 846 locks to grounded conductor 390 by way of contact 856, at 847 opens the locking circuit of the third counting relay 830 which deenergizes, and at 849 connects the No. 4 ring conductor to contact 896.

In response to the fifth impulse the odd pulse conductor is grounded the third time to complete the circuit for the fifth counting relay 850 by way of contacts 853 and 854. At 851 relay 850 prepares the circuit over the No. 5 conductor of cable 369, at 853 opens its original energizing circuit after completing its locking circuit at contact 855, at 854 prepares the circuit for the

sixth counting relay 860, at 855 locks itself by way of contact 816 to grounded conductor 390, at 856 opens the locking circuit of counting relay 840 which deenergizes, and at 858 connects the

5 No. 5 ring conductor to contact 895.

In response to the sixth pulse transmitted from the calling line the even pulse conductor is grounded a third time to complete the operation of the sixth counting relay 860 by way of front

10 contact 854. At contact 861 relay 860 prepares the circuit for the No. 6 conductor of cable 369 by way of contact 852, at 862 prepares a point in the circuit to relay 880, at 863 prepares a point in the circuit to relay 613, at 864 shunts contacts

15 813, at 865 prepares a new circuit for reenergizing the first counting relay 810, at contacts 866, 867, and 868 prepares the circuit for reversing the application of ringing current to the called line, and at 869 locks itself to grounded conductor 390.

In response to the seventh pulse the odd pulse conductor is grounded a fourth time to cause the reoperation of the first counting relay 810 by way of 865, 845, 835, and 823. At 812 relay 810

25 prepares a point in the circuit to the No. 7 conductor of cable 369, at 814 prepares the circuit to the second counting relay 820, at 815 locks itself, at 816 opens the locking circuit of the fifth counting relay 850 which accordingly deenergizes, and at 817 connects the No. 2 ring conductor to contact 893.

In response to the eighth pulse the even pulse conductor is grounded a fourth time to energize relay 820 by way of contacts 854 and 814. At

35 822 relay 820 prepares the connection for the No. 8 conductor of cable 369, at 823 prepares the circuit for the third counting relay 830, at 824 locks itself, at 825 releases the first counting relay 810, and at 826 connects the No. 3 ring conductor to contacts 894.

In response to the ninth pulse the odd pulse conductor is grounded a fifth time to reenergize the third counting relay 830 over the previously traced circuit. At 832 relay 830 connects the

45 No. 9 conductor of cable 369, at 833 prepares a point in the circuit for relay 340 if this is the first digit transmitted by the calling subscriber, at 834 prepares a point in the circuit for relay 613 if this is the first digit transmitted by the calling subscriber, at 835 opens its original circuit after locking at contact 837, at 836 prepares a circuit for the fourth counting relay 840, and at 839 connects the No. 4 ring conductor to contact 893.

In response to the tenth pulse the even pulse conductor is grounded the fifth time to energize the fourth counting relay 840. At 842 relay 840 prepares the circuit over the No. 10 conductor in cable 369, at 843 prepares a point in the circuit to relay 340 if the digit just dialled is a first digit, at 844 operates relay 613 in case this digit is a first digit, at 845 prepares the circuit for the fifth counting relay 850, at 846 locks itself, at 847 releases the third counting relay 830, and at 848

55 connects the No. 5 ring conductor to contact 894.

Group-connect relay 400 is energized in response to the energization of relay 660 over the following circuit. From ground by way of front contact 663, back contact 706, 749, 875, 883, 455, and through the winding of group-connect relay

70 400 to battery. At 419 connect relay 400 connects grounded conductor 293 to conductor 456, at 429 prepares a point in the circuit to connector unit relay 350, at 439 prepares the locking circuit for the counting relays by grounding conductor

390, at 449 completes the locking circuit for itself, at 459 prepares a point in the circuit to transfer relay 880, at contacts 490 to 498, inclusive, connects the connector group relays to the counting relay contacts, and at 469 prepares a point in the circuit to relay 613 in case the first digit dialled is either 9 or 0.

After each digit dialled by the calling subscriber line relay 630 and pulse relay 680 are held in energized position for a sufficient length of time to cause the deenergization of slow-to-release series hold relay 670, since the energization of pulse relay 680 disconnected ground from the pulse conductor. Series-hold relay 670 therefore deenergizes shortly after each impulsing period and at 671 opens the holding circuit of series-hold relay 660, which likewise deenergizes. At 661 and 662 relay 660 causes the release of relays 640 and 660 if the same should be energized, at front contact 663 opens the original energizing circuit of relay 400 which is now maintained in operated position over its locking circuit, at back contact 663 grounds the contact 861 to operate the connector group relay prepared dependent upon the last counting relay energized, and at 666 disconnects ground from the even and odd conductors to prevent further impulsing to the counting relays. The locking circuit for the group-connect relay 400 may be traced as follows: from grounded conductor 645 by way of

30 contacts 723, 718, 755, 885, 813 (or 864), conductor 454, contact 449, and through the winding of relay 400 to battery.

In case the first digit dialled by the calling subscriber is 1, which in this case is considered a preliminary impulse, counting relay 810 is energized and at contact 813 opens the locking circuit of group connect relay 400 so that this relay will deenergize when relay 660 deenergizes in order to cause the release of the operated counting relay. In case the first digit dialled is 2, 3, 4, 5, or 6, then counting relay 820, 830, 840, 850, or 860 is operated, and when relay 660 deenergizes to ground contact 861 a circuit is completed for operating the corresponding connector group relay or relays 420, 430, 440, 450, or 460. In case the first digit dialled is 9, then relays 430 and 613 are operated when relay 660 deenergizes. If the first digit is 0, then relays 420 and 613 are operated in response to the deenergization of relay 660 as will be more fully described in connection with trunk calls.

Assuming now that line No. 33 is being called by the calling subscriber, then the first and second digits are 3 and 3, respectively, after which the ringing digit is dialled. In this case counting relay 830 is operated and when relay 660 deenergizes after the impulsing period for the first digit connector-group relay 430 is energized over the following circuit: from ground by way of back contact 663, conductor 634, 775, 446, 861, 831, conductor 3 of cable 369, 493, and through the winding of connector group relay 430 to negative battery. At its upper contacts connector group relay 430 connects the test leads of all the lines in the 30-group to the test conductors extending to the connector unit relays, at 433 prepares the circuit for connector group relay 432, at 434 prepares a circuit for connector group relay 431, at 435 completes its own locking circuit to grounded conductor 188, and at 436 completes the circuit for operating relay 880. This circuit may be traced as follows: from ground by way of 621, 293, back contact 771, 458, 436, 459, 392, 311, 321, 331, 341, 351, conductor 12 of cable 369, back 75

contact 862, and through the winding of transfer relay 880 to battery. At contact 881 transfer relay 880 disconnects dial tone from the calling line, at 882 completes its own locking circuit from grounded conductor 458, at back contact 883 opens the original energizing circuit of relay 400, at front contact 883 prepares a point in the circuit to connect relay 370, and at 885 opens the locking circuit of group connect relay 400, which deenergizes. At contact 429 relay 400 opens a point in the circuit to relay 360, at 439 disconnects ground from conductor 390 to open the locking circuit of the operated counting relay, in this case relay 830, at 459 opens the original circuit of transfer relay 880 now locked in operated position, at contacts 492 to 499, inclusive, opens the circuit to the connector group relays, and at 469 opens a point in the circuit to relay 613.

The calling subscriber may now dial the second digit, or digit 3. Relays 630, 680, 640, 650, 660, and 670 are operated as previously described to cause the operation of counting relay 830. At front contact 663 relay 660, upon energizing in response to the second digit, completes the circuit for energizing connect relay 370 as follows: from ground, front contact 663, 633, 706, 749, 875, front contact 883, 387, and through the winding of unit connect relay 370 to battery. Relay 370 energizes, and at 383 locks itself by way of 388, 874, 754, 745, and 723 to grounded conductor 645. At contacts 371 to 375, inclusive, prepares circuits for the connector unit relays 310 to 350, inclusive, and at contacts 376 to 380, inclusive, prepares other circuits for these same connector unit relays. At contact 381 relay 370 prepares a point in the circuit to relay 360, at 384 prepares a circuit to relay 870, and at 385 grounds conductor 390 to provide a locking circuit for the operated counting relays.

After the second digit 3 has been transmitted by the calling subscriber relays 670 and 660 deenergize as before, and relay 660 at front contact 663 opens the original energizing circuit of connect relay 370, and at back contact 663 completes the circuit for energizing connector unit relay 330 as follows: ground, back contact 663, conductor 634, 775, 446, 861, 831, conductor 3 of 369, 373, and through the winding of connector unit relay 330 to battery. At contact 338 relay 330 prepares a point in the test circuit for line No. 38 only when connector unit relay 330 is energized at the same time as relay 360. At 337 relay 330 connects the test lead 443 of line 33 to test relay 770. At contacts 335 and 336 connects the line conductors 366 and 365 of the link to conductors 395 and 396, at 334 completes the circuit for energizing relay 870, at 333 opens the locking circuit to relay 320 if operated, at 332 locks itself to grounded conductor 188, at back contact 331 opens the original energizing circuit of relay 880, and at front contact prepares a point in the trunk-hunting circuit which is used only in case three trunks are included in one group.

The circuit for energizing relay 870 may be traced as follows: from ground by way of contact 334, by way of 384, 389, and through the winding of relay 870 to battery. At 871 relay 870 opens a further point in the dial tone circuit, at 872 transfers the locking circuit of relay 880 to the back contact 663, at 763 completes its own locking circuit to grounded conductor 754, at 874 opens the locking circuit of connect relay 370 which deenergizes, at 875 opens a further point in the original circuit of relay 370, at 876 prepares a point in the locking circuit for the

counting relays, at 877 prepares a point in the circuit to relay 700, at 879 prepares a point in the circuit to ring relay 330, and at 878 opens the locking circuit of relay 710, but this latter relay is held operated by way of 708, 777, 694, 735, and 723, to grounded conductor 645. Unit connect relay 370 deenergizes when its locking circuit is opened and at contacts 371 to 381 disconnects the connector unit relays. At 373 relay 370 opens a further point in its own locking circuit, at 384 opens a point in the original circuit of relay 870 now locked in operated position, and at 387 disconnects ground from conductor 390 to release the operated counting relay 830.

The foregoing description describes the operation of the connector unit relays for the first five lines in the called group. The operation of the connector unit relays for a line in the last five of a group is slightly different. In order to describe this operation it will be assumed for the time being, that the second digit dialled is 8 instead of three. In this case it will be remembered that counting relays 820 and 860 are operated in response to dialling digit 8. Now, when relay 660 deenergizes after the second digit connector unit relays 330 and 360 are operated. The circuit for operating relay 360 may be traced as follows: from ground by way of back contact 663, 634, 775, 446, front contact 861, conductor 11 of cable 369, contact 381, and through the winding of relay 360 to battery. Relay 360, upon energizing, at back contact 363 disconnects the link test lead 364 from the test contacts of the first five lines in the group, and at front contact 363 connects the link test conductor 364 to the test contacts of the last five lines in the called group. At back contact 362 relay 360 opens the circuit prepared for connector group relay 432, at front contact 362 prepares a point in the circuit for connector group relay 431, and at 361 locks to grounded conductor 188. The circuit for energizing connector unit relay 330 is the same as that previously described up to contact 861, and thence through its front contact by way of contact 822 since counting relay 820 is operated with counting relay 860, over conductor 8 of cable 369, contact 378, and through the winding of connector unit relay 330 to battery. At contact 332 relay 330 locks to grounded conductor 188 by way of back contact 343 and 353, at 338 connects the link test conductor 364 to the test lead of line 38. At 335 and 336 prepares the line connections, and at 334 operates relay 870 as before. Relay 870, upon energizing, causes the release of unit connect relay 370, and the deenergization of the operated counting relays 820 and 860. Unit connect relay 370 deenergizes and releases the counting relays 820 and 860 by disconnecting ground from conductor 390. The operation from this point on is the same for line 38 as for line 33.

Assuming now that line No. 33 has been connected with, the calling subscriber may now dial the ringing digit to selectively ring the desired subscriber on this line. In case ringing digit 1 is dialled, then ringing current will extend from the ring lead No. 1 from the ringing interrupter (not shown) over the positive line to signal subscriber No. 331. Relays 630, 680, 640, 650, 660, and 670 are operated in response to the ringing digit, as previously described. In this case, since digit 1 is dialled, then counting relay 810 is operated as before. Relay 660, upon energizing for the third digit or ringing digit, at back contact 663, opens the locking circuit of relay 880 which deenergizes. At 664 relay 660 completes the circuit for oper-

ating relay 700 as follows: from grounded conductor 188 by way of 877, 639, 646, 638, and through the winding of busy relay 700 to battery. At 665 relay 660 completes a new holding circuit for relay 710 as follows: from grounded conductor 645 by way of 723, 735, 295, 694, 665, 646, and through the winding of relay 710 and the resistance R2 to negative battery. Relay 880 deenergizes in response to the operation of relay 660 and at 884 connects grounded contact 876 to conductor 390 to provide a locking circuit for the counting relays. Busy relay 700, upon energizing, at 701 shunts the winding of relay 610 by connecting battery through resistance R3 thereto, and at 702 prepares a point in the busy tone circuit, at 703 prepares a point in the circuit for grounding conductor 364 in case the call is a reverte call, and at 704 prepares a point in the circuit for reverte relay 730, at 705 connects multiple ground to the tone-start lead, at 706 completes the circuit for operating relay 726 by way of conductor 633 and front contact 663, at 707 completes its locking circuit by way of back contact 776 and grounded conductor 188, at 708 opens one of the circuit holding relays 710 in energized position, and at 709 opens a point in the circuit to ring relay 890. Relay 726 energizes and at 727 prepares a point in the test circuit for test relay 770. Counting relay 810 is energized in response to the ringing digit 1, and at 818 prepares the ringing connection.

After the last pulse of the ringing digit relays 660 and 670 release as previously described. At front contact relay 660 opens the circuit to the slow-to-release relay 726, and at back contact 663 completes the test circuit for test relay 770 and cut-off relay 471 in case the called line is idle, and at 665 opens the holding circuit of relay 710 which accordingly deenergizes.

If line 33 is busy, then the test lead 443 of the called line will be grounded to short circuit test relay 770 to prevent its operation over the following circuit: from ground by way of back contact 663, conductor 634, contact 727 of the slow-to-release relay 726, through the lower winding of test relay 770, link test conductor 364, back contact 363, conductor 349, contact 337, conductor 397, contact 413, test conductor 443, to busy ground at the called busy line. After an interval, slow-to-release relay 726 deenergizes and at 727 opens the test circuit through the lower winding of test relay 770 to prevent the seizure of line 33 in case it should become idle. Relay 710 deenergizes in response to the release of relay 660, and at 712 completes the busy tone circuit which may be traced as follows: from busy tone source, by way of 702, 712, tone condenser TC, back contact 793, conductor 287, contact 214, conductor 283, contact 117, to the calling line loop. At back contact 713 relay 710 prepares a point in the circuit to relay 613, at 714 prepares a point in the circuit for grounding test conductor 364 on a reverting call, at 716 removes one of the multiple ground connections from the tone start lead, at 717 connects the pulse lead to the reset lead to prepare a circuit for reoperating relay 680 if the circuit to line relay 630 is again interrupted for a reverting call, and at 718 disconnects ground from conductor 755. When the subscriber hears the well known busy tone such subscriber will replace his receiver and release the apparatus in a manner more fully described hereinafter.

If line 33 is idle then test relay 770 is not short circuited and is operated in series with the cut-off relay 471 of the called line as follows;

from ground by way of back contact 663, conductor 634, contact 727, through the lower winding of test relay 770, test conductor 364, back contact 363, conductor 349, contact 337, conductor 397, contact 413, conductor 443, back contact 483, and through the winding of cut-off relay 471 to battery. At 771 test relay 770 completes a locking circuit through its upper winding of grounded conductor 293, at 772 connects direct ground from front contact 722 over the link and called line test conductor to hold the cut-off relay and the called line busy, at 773 connects ground to the generator start lead to start the ringing machine, at 775 disconnects ground from conductor 446, at back contact 776 opens the locking circuit of busy relay 700 which deenergizes, at front contact 776 completes the circuit for operating the connected group relay 432 or 431, dependent upon the operated condition of relay 360, at 777 opens a point in the circuit of relay 710 to prevent its reenergization in response to the release of relay 700, and at 778 prepares a point in the circuit to ring relay 890. Relay 700, upon deenergizing, at 701 disconnects the battery shunt from around the winding of relay 610 to allow this relay to operate over the calling subscriber's loop, at 702 disconnects the busy tone from the calling line, at 705 disconnects ground from the tone start lead to stop the tone machine, and at 709 connects the pick-up lead to ring relay 890.

Cut-off relay 471 of the called line, upon energizing, at 477 connects the grounded test conductor 443 to test conductor 484 to busy this line in the finder end of the link, at 478 and 479 disconnects the shunt-field line relay 472, and at 480 operates lockout relay 470. In this case, since finder unit relay 360 is not operated, then the connector group relay 432 is operated in response to the operation of test relay 770 over the following circuit: from grounded conductor 645, by way of 723, front contact 776, conductor 368, back contact 362, conductor 394, contact 433, and through the winding of connector group relay 432 to battery. At contacts 414 and 415 relay 432 connects the line conductors of the link to the line conductors 485 and 486 of the called line.

At the beginning of each ringing cycle the ringing machine grounds the pick-up lead 659 momentarily and now operates ring relay 890 as follows: from grounded pick-up lead by way of contact 879, conductor 667, 709, 746, 778, 757, 899, and through the winding of ring relay 890 to battery. Ring relay 890 energizes, and at its "X" contact 898 completes its own locking circuit before opening contact 899. At contacts 891 and 895 relay 890 connects the No. 1 ring conductor to the positive line 486 of the called line, at 892 connects the negative line of the called line to the ring-cut-off relay 780, at 897 completes the ringback tone circuit to the calling line, and at its remaining contacts prepares the ringing circuit for connection to the remaining ringing leads in case other ringing digits are dialed. Interrupted grounded generator connected to ring conductor No. 1 now extends by way of 818, 895, 868, 866, 891, 737, 782, 366, 335, 395, 415, 486, and through the switch-hook and ringer of the first five subscribers' lines in this group to ground. The proper ringing code is transmitted over this circuit to signal the called subscriber at 331. The ring back circuit to the calling subscriber may be traced from ring conductor No. 1 by way of 897, 738, ring-back condenser RBC, 793, through the operated contacts on the finder unit and finder group relays to the calling line conductor,

In case the ringing digit is six or more, then counting relay 860 is energized and the ring leads 1 to 5 are connected, dependent upon the other counting relays energized, to the negative line conductor of the called line by way of front contact 867, while the positive line conductor of the called line is connected to the ring-cut-off relay 780 by way of front contact 866 and conductor 739. The remaining subscribers on the called line, having their ringers connected to the negative line conductor, are selectively signalled in a manner apparent from the foregoing description.

When the called subscriber answers the ring-cut-off relay 780 is energized over the called line loop over the previously traced ringing circuit and thence back over negative line conductor 485, contact 414, conductor 396, contact 336, conductor 365, contact 781, conductor 736, contact 892, back contact 867, conductor 739, and through the upper winding of ring-cut-off relay 780 to negative battery. Ring-cut-off relay 780 energizes over the above traced circuit, and at "X" contacts 783 completes its locking circuit to grounded contact 722. At contacts 781 and 782 ring-cut-off relay opens the ringing circuit and completes the circuit for operating relays 750 and 613 over the called line loop.

Relay 750, upon energizing in series with relay 613 over the called loop, at 751 completes the circuit for operating slow-to-operate relay 740 by way of 776 and grounded conductor 188. At 752 relay 750 prepares a point in the circuit for the reverse relay 600, and at 753 opens the locking circuit of relay 608 which releases. Relay 613 is energized over the called loop and performs no useful function at this time except to feed talking battery along with relay 750 to the called line. Cut-off relay 608, upon deenergizing, at contact 605 disconnects the time-cut-off ground and substitutes direct ground to the link to prevent disconnection of this link when the time-cut-off ground is removed. This time cut-off ground is effective to release the link in case the link has not reached talking condition within a predetermined time. Relay 740, upon energizing, at 741 removes the shunt from around contact 734, at 742 completes its own locking circuit, at 743 disconnects ground from the generator start lead to stop the ringing machine, at 744 completes the circuit for operating the reverse relay 600, at 745 disconnects ground from conductor 754 to release relays 870 and 890, and at 746 opens a point in the original circuit of ring relay 890. The circuit for operating the reverse relay 600 may be traced as follows: from grounded conductor 645 by way of 723, 735, 295, 694, 647, 752, 744, 635, 611, 186, 128, 187, and through the winding of relay 600 to battery. It should possibly be mentioned at this time that contacts such as contacts 128, 138, 148, 158, and 168 are provided for each group of lines in case such lines require reverse battery supervision for operating a meter or other purposes. At contact 603 relay 600 completes its own locking circuit to 635, and at contacts 601 and 602 reverses battery back over the calling line loop to operate a meter for coin collect or to give supervision if required. Ringing relay 890 deenergizes in response to the operation of relay 740 and opens the ringing and ring-back connections to the ringing machine. Relay 870 deenergizes in response to the operation of relay 740, and at contact 876 disconnects ground from conductor 390 to unlock the operated counting relay to cause the release of the same. The connection between the calling line 21 and line 33 is now completed over

the heavy talking conductors including conductors 286 and 287, back contacts 761 and 762, front contacts 781 and 782, and conductors 365 and 366.

Release

When the called subscriber replaces his receiver the called line loop is opened and relays 750 and 613 deenergize. At 751 relay 750 opens the original circuit of relay 740 now locked energized, at 752 opens the circuit to relay 600 which releases and reverses battery, and at 753 reoperates relay 608. Relay 608 energizes and locks as previously described, and at 605 disconnects ground and substitutes the time-cut-off ground so as to automatically release the link after a predetermined time if the calling subscriber fails to hang up.

When the calling subscriber replaces his receiver relays 610 and 630 deenergize. At 631 relay 630 disconnects one multiple ground from release relay 620, and at 632 releases relay 680. At 681 relay 680, upon deenergizing, opens the circuit of slow-to-release relay 620 which deenergizes after an interval. At 621 relay 620 disconnects ground from conductor 293, opens the circuit to relays 720 and 770, removes the busy-ground from the calling line, and causes the release of cut-off relay 660. Test relay 770 deenergizes when its locking circuit is opened by relay 620, and at 772 disconnects ground from conductor 364 and test lead 443 of the called line, thereby opening the circuit of the cut-off relay 471 to free the called line. At contact 776 relay 770 opens the locking circuit of relay 740 which releases and also opens the circuit to the operated connector group relay 431 or 432 which thereupon deenergizes. Slow-to-release relay 720, upon deenergizing, at 722 opens the locking circuit of ring-cut-off relay 780 which releases, and at 723 disconnects grounded conductor 645 from conductor 295 to release finder group relay 120, disconnects ground from conductor 188 to release the operated connector group relay 430, the operated connector unit relay 330 (relay 360 if operated), the operated finder unit relay 210 (270 if also operated), and finder group relay 122. At front contact 724 relay 720 removes one of the multiple ground connections from the guard lead 184, and at back contact 724 opens the locking circuit of the time-cut-off relay 608 which deenergizes. Time-cut-off relay 608 deenergizes, disconnects a multiple ground from guard lead 184 at 606, and at 607 grounds the all-link-busy conductor 559 to maintain the all-link-busy relay 592 energized. Finder group relay 120, upon deenergizing, at contact 126 disconnects ground from the guard lead 184 to make this link available for use on other calls. Relays 120, 122, 210, (270 and 360 if operated), 330, 430, and 432 deenergize and disconnect the calling and called lines from the link. Relay 740 and the remaining link relays now restore to their normal position. The cut-off relays 60 and 471 of the calling and called lines deenergize when their circuits are opened to open the circuits to their associated lockout relays 60 and 470, which likewise deenergize after an interval providing the associated line relays 70 and 452 do not operate when the cut-off relays release. All of the apparatus is now restored to normal position and may be used on subsequent calls.

Reverting calls

In order to describe the operation which takes place in a reverting call, it will be assumed that subscriber 216 on line 21 desires to call another

subscriber on his own line or subscriber 211. In response to the initiation of a call an idle link is connected to line 21 by the operation of the finder relays 120, 122, and 210 as previously described. In response to dialing digits 2 and 1, the connector relays 420 and 310 are operated in a manner apparent from the foregoing description. In response to dialing the ringing digit 1 the called line is tested for its idle or busy condition, and the ringing lead is selected by counting relay 810. Since this call is a reverting call, then the line will test busy with the result that test relay 770 is short circuited and does not operate, and busy tone is transmitted to the calling line as previously described. The calling subscriber replaces his receiver when he hears the busy tone to cause the release of relays 610 and 630. Line relay 630, upon deenergizing, at 632, opens the circuit of relay 680 which likewise deenergizes. Relay 680, upon deenergizing, at front contact 681 opens the circuit of slow-to-release relay 620 and at back contact 681 completes a holding circuit for holding the cut-off relay 60 of the calling line because relay 700 is still in energized position and because the test relay 770 did not operate. Ground is connected to the test lead 56 of the calling line because in this case the calling and called lines are the same. The circuit for holding the cut-off relay 60 in energized position may be traced as follows: from ground by way of back contact 681, back contact 691, 623, 703, 714, 364, back contact 363, conductor 349, contact 317, upper test contact of connector group relay 420 for line 21, conductor 56 of cable 159 to the calling and called line circuit, back contact 72 and through the winding of cut-off relay 60 to battery. This same ground also maintains relay 720 in operated position and operates reverting relay 630 as follows: from ground over the previously traced circuit to the cut-off relay 60 and thence by way of contact 61, contact 119, conductor 281, contact 216, contact 224, conductor 285, 275, 294, 178, 293, contact 794, contacts 734 and 741 in multiple and through the winding of relay 720 to battery.

Relay 720 is maintained energized over this circuit and when release relay 620 deenergizes this same ground continues by way of back contact 621, conductor 625, contact 704 and through the winding of reverting call relay 730 to operate relay 730. At contact 731 reverting call relay 730, upon operating, connects direct ground to link test conductor 364 to hold the cut-off relay 60, and slow-to-release relay 720 operated, at 732 completes a locking circuit for itself independent of contact 704, and at 733 connects grounded conductor 293 through the upper winding of test relay 770 to cause this latter relay to operate, at 734 opens the shunt around contact 741, and at 735 disconnects ground from conductor 295 to release finder group relay 120.

Finder group relay 120 accordingly deenergizes and at contacts 117 and 118 disconnects the line from the finder end of the link, and at 126 removes one of the multiple grounds from the guard lead 184. Test relay 770, upon energizing, at 771 locks itself to grounded conductor 293, at 772 connects ground at armature 722 to conductor 364, at 773 starts the ringing machine, at back contact 776 causes the release of relay 700, and at front contact 776 grounds conductor 368 to operate connector group relay 422.

Busy relay 700 deenergizes when its circuit is opened by relay 770. At 702 relay 700 opens the busy-tone circuit, at 703 opens a point in the

original circuit used on the reverting call, at 704 opens a point in the original energizing circuit of reverting call relay 730 now locked in energized position, at 705 disconnects ground from the tone start lead, and at 709 prepares the circuit for ring relay 890. Connector group relay 422 energizes and at its upper contacts connects the link to conductors 57 and 58 of line 21 to prepare the ringing circuit. Ringing relay 890 energizes when the pick-up conductor PU is grounded and connects No. 1 ring conductor to the positive line 58 as follows: from ringing conductor 1, by way of 818, 895, 868, resistance R4, 866, 891, 737, 782, 366, 315, to the lower contact of connector group relay 422, conductor 58 of cable 159, and over the positive line conductor of line 21 to the ringers connected thereto. The proper code ring or the proper generator is connected over this circuit to selectively ring subscriber 211.

When the called party answers, or in case the calling party should be the first to answer, the ring-cut-off relay 780 is operated to disconnect the ringing circuit, and relays 750 and 613 are operated over the line loop as previously described. Relays 608, 890, and 870 release, and relays 740 and 600 operate as previously described, except in this case when relay 740 operates the circuit to relay 720 is opened at contact 741 to cause the release of relay 720. At 723 relay 720, upon deenergizing, disconnects ground from conductor 188 to release relays 740, 420, 422, 310, and 122. At contact 725 relay 720 opens the circuit of time-cut-off relay 608, at 724 removes the multiple ground from guard lead 184, at 722 relay 720 disconnects the multiple ground from link test lead 364 extending by way of contact 772, and opens the locking circuit of ring-cut-off relay 780 which accordingly deenergizes. At contact 723 relay 720 disconnects ground from conductor 188 to cause the release of the finder relays 122 and 210 and the connector relays 310 and 420, and the release of relay 740. The finder and connector relays deenergize and open the locking circuit of the reverting call relay 730 and the locking circuit of test relay 770 as well as the circuit of the cut-off relay of the calling and called line. Time-cut-off relay 608, upon deenergizing, at 606 removes ground from the guard lead 184, and at 607 grounds the all-link busy conductor 669. All of the relays in the links are now in released position and the link may be used on other calls.

When the cut-off relay 60 deenergizes contacts 62 and 63 close the circuit for energizing the shunt-field line relay 70 over the line loop, at front contact 64 momentarily opens the circuit to lockout relay 50 and at back contact 64 grounds the permanent alarm conductor 99. Line relay 70 energizes over the subscriber's loop, at 72 grounds test conductor 56 to mark this line as busy in the connector end of the link, and at 73 maintains the locking circuit of lockout relay 50. The talking battery for both subscribers is taken through both windings of the line relay 70. When both subscribers replace their receivers after conversation then line relay 70 deenergizes to disconnect ground from conductor 56 to free the line at contact 72 and at 73 opens the circuit to lockout relay 50. Lockout relay 50 deenergizes to open the alarm circuit at 52, at 51 prepares a point in the circuit for marking the line as a calling line, and at 53 prepares a point in the start circuit.

Trunk calls

Two groups of trunks are accessible to the link circuit, one group reached by dialling the digit 0, while the other is a group of ring-down trunks reached by dialling the digit 9 for the first digit. In case the calling subscriber 211 desires to call one of the trunks in the first group, then such subscriber will dial the digit 0. In response to the initiation of the call an idle link is connected with line 21, and in response to dialling digit C counting relays 840 and 860 are energized as previously described. It will be remembered at this time that relays 50, 60, 120, 122, 210, 630, 620, 660, 670, 680, 720, 710, 608, and 400 are also energized. Now, when relay 660 deenergizes after the impulsing period said relay at back contact 663 grounds contact 861 as previously described, and since counting relays 840 and 860 are in energized position at this time because of the digit 0 being dialled, the following circuit is completed for energizing connector group relay 420 and relay 613. Relay 420 is energized from ground by way of front contact 861, contact 842, No. 10 conductor of cable 369, contact 490, and through the winding of relay 420 to battery. The circuit for energizing relay 613 may be traced as follows: from ground by way of back contact 663, conductor 634, contact 775, conductor 446, contact 469 of the operated group connect relay 400, conductor 445, contact 863, contact 844, conductor 747, front contact 713, conductor 619, and through the winding of relay 613 to battery.

Relay 420, upon energizing over the above-traced circuit, at its upper contacts connects the test lead of the lines in the 20-group to the test contacts of the finder unit relays, at 424 prepares the circuit for connector group relay 421, at 425 locks itself to grounded conductor 188, and at 426 completes the circuit for energizing connector-unit relay 340. This circuit may be traced as follows: from ground by way of front contact 621, conductor 293, back contact 771, conductor 458, contact 426, contact 459, conductor 392, through back contacts 311, 321, 331, 341, and 351, to conductor 12 of cable 369, front contact 862, front contact 843, through conductor 14 of cable 369, and through the winding of connector unit relay 340 to battery.

Relay 613, upon energizing over the above-traced circuit, at 616 completes the circuit for energizing busy relay 700 and connector unit relay 360. The circuit for energizing relay 360 may be traced as follows: from grounded conductor 645 by way of 723, 188, back contact 776, 637, 616, 638, contact 429, conductor 391, and through the winding of finder unit relay 360 to battery. Since the ground is connected to conductor 638 as just traced, the busy relay 700 is energized in multiple with relay 360. At contact 701 relay 700 connects a multiple battery shunt to relay 610, at 702 prepares a part of the busy-tone circuit, at 705 maintains the tone-start lead grounded, at 707 locks itself independent of contact 616, at 708 opens one of the multiple circuits holding relay 710, and at 709 opens a point in the circuit to ring relay 890.

Connector unit relay 360, upon energizing over the above-traced circuit, at 361 locks itself to grounded conductor 188, at 362 prepares a point in the circuit to connector group relay 421, and at 363 transfers the test lead 364 from conductor 349 to 359. Connector unit relay 340, upon energizing over the above-traced circuit, at "X" contact 432 locks itself to grounded conductor 188 by way of contact 353, at back contact 341

opens its own original energizing circuit, at front contact 341 completes the circuit for the next connector unit relay 350, and at 348 completes a circuit over the test lead of trunk No. 29 in series with the test relay 770. If this trunk is busy, then ground on the test lead of trunk No. 29 short circuits relay 770 as follows: from ground on the test lead of trunk 29, through the upper operated test contact of relay 420 of trunk 29, over the link conductor to contact 348, conductor 359, front contact 363, conductor 364, through the lower winding of test relay 770, back contact 774, conductor 456, contact 419, conductor 293, to ground at front contact 621. Test relay 770 therefore is not energized since the trunk 29 is busy. The next connector unit relay 350 is operated after an interval over the following circuit: from ground by way of front contact 621, conductor 293, back contact 771, conductor 458, contact 426, contact 459, conductor 392, back contacts 311, 321, and 331, front contact 341, and through the winding of relay 350 to battery. At "X" contact 352 relay 350 locks to grounded conductor 188, at 353 opens the locking circuit of relay 340 which deenergizes, at front contact 351 prepares a point in the circuit for short-circuiting relay 710, at 358 completes the test circuit over the test lead of trunk No. 20 in series with the test relay 770, and at 355 and 356 prepares the line connection.

If trunk No. 20 is busy, then ground on the test lead of trunk No. 20 short circuits test relay 770 over a circuit similar to that previously traced for trunk 29. Relay 710 is now short circuited over the following circuit: from grounded conductor 645 by way of 723, 735, 295, 694, 647, 878, 756, 719, through the winding of relay 710, contact 715, conductor 386, front contact 351, back contacts 341, 331, 321, and 311, over conductors 392, 459, 426, 458, back contact 771 to grounded conductor 293. At 712 relay 710, upon deenergizing, completes the busy tone circuit, at 713 opens the circuit of relay 613 which deenergizes, at 716 disconnects multiple ground from the tone start lead, and at 718 opens the locking circuit of relay 400, which relay releases and restores the operated counting relays. In response to receipt of busy tone the calling subscriber hangs up and releases the connection as previously described.

In case trunk No. 20 is idle, then test relay 770 energizes in series with cut-off relay 30 as follows: from grounded conductor 293, contact 419, conductor 456, back contact 774, through the lower winding of test relay 770, link test conductor 364, front contact 363, contact 358, conductor 398, test contact 410, test conductor 66 included in cable 169, back contact 42 and through the winding of cut-off relay 30 to battery. Test relay 770, upon operating over the above-traced circuit, at front contact 771 locks itself to grounded conductor 293, and at back contact 771 opens the circuit to the next connector unit relay to prevent its operation if the last operated connector unit relay is not the last relay in the group; or opens the short circuit previously traced for relay 710 if the last operated connector unit relay in the group is operated. At contact 772 relay 770 connects ground by way of front contact 722 and 772 to the test lead 364 to hold the cut-off relay 30 and to busy trunk 20. At contact 773 test relay 770 grounds the generator start lead, at back contact 774 opens its original energizing circuit only after closing its locking circuit, at front contact 774 prepares the circuit

for relay 790, at 775 opens the original circuit of relay 420 and 613 to cause the release of the latter relay, at 776 operates connector group relay 421, and at 778 prepares a point in the circuit to ring relay 890.

The circuit for operating connector group relay 421 may be traced as follows: from grounded conductor 645 by way of 723, front contact 776, conductor 368, front contact 362, conductor 393, contact 424, and through the winding of relay 421 to battery. At contacts 411 and 412 relay 421 connects the link line conductor to conductors 67 and 68 of trunk 20, and at contact 427 completes the circuit for operating switch-through relay 790. This circuit may be traced as follows: from ground by way of front contact 621, conductor 293, contact 419 of connect relay 400, conductor 456, front contact 774, conductor 447, contact 427, conductor 448, and through the winding of switchthrough relay 790 to battery. At contact 791 switchthrough relay 790 short circuits relay 710 to cause the deenergization of this relay, and at contacts 792 and 793 connects the calling line conductors directly through to connect with the trunk line conductors 67 and 68 by way of conductors 399 and 300. At contact 793 relay 790 also opens the circuit to line relay 630, at 794 opens the circuit to relay 720, at 795 locks itself to grounded conductor 293, at 796 connects grounded conductor 293 to link test conductor 364 by way of 772, at 797 disconnects ground from the tone-start and generator-start leads, at 798 places a multiple ground on the lead 188 to hold the finder and connector relays operated, and at 799 removes a multiple ground from the guard lead 184.

Line relay 630 deenergizes in response to the operation of the switchthrough relay 790, and at 631 removes the multiple ground from release relay 620, and at 632 releases relay 680. The toll repeater (not shown) operates in the well-known manner when the calling loop is connected over conductors 67 and 68 and 47 and 48, and in response to this connection returns ground back over conductor 66 to busy this trunk and hold the cut-off relays 30 and 60 and relays 770 and 790 over the following circuit: from grounded conductor 66 included in cable 169, contact 410, conductor 398, contact 358, front contact 363, conductor 364, contact 772, and thence by way of contacts 796 and 795 for locking the switch through relay 790, and by way of conductor 293 and front contact 771 for locking test relay 770.

Relay 710 deenergizes when the short circuit is completed around its winding by the operation of switch-through relay 790 to open a further point in the circuit to relay 613 at contact 713, and at contact 718 opens the circuit of connect relay 400 which deenergizes. Pulse relay 680, upon deenergizing at 681, opens the circuit of slow-to-release relay 620, which accordingly deenergizes. Relay 720 deenergizes in response to the operation of switch-through relay 790, at 723 disconnects one of the multiple ground connections from conductor 188 now grounded at contact 798, and at 725 opens the locking circuit of time cut-off relay 608 to deenergize the same. Relay 613, upon deenergizing, at 616 opens the locking circuit of relay 700 and the original energizing circuit of relay 360. Group-connect relay 400, upon deenergizing, at contact 429 opens the circuit of relay 700 which releases, at 419 opens the original energizing circuit of switch-through relay 790 now locked to ground extending from

the toll repeater, at 439 disconnects ground from conductor 390 to release the operated counting relays, and at 492 to 498 disconnects the connector group relays from the counting relays. After an interval relay 620 deenergizes, and at contact 621 disconnects the multiple ground from conductor 293, which conductor, however, is now grounded from the toll repeater over the circuit previously traced. Time-cut-off relay 608 deenergizes, and at 606 removes the multiple ground from guard lead 184. Relay 700, upon deenergizing, at 703 disconnects a multiple ground from link test conductor 364 now grounded from the toll repeater, and at contact 704 prevents the operation of reverting call relay 730.

The calling line loop is now connected straight through the link to the toll repeater and the remainder of the connection is set up in the well known manner. The talking circuit between the calling subscriber and the toll repeater may be traced as follows: from the calling line conductors by way of 117 and 118, 282 and 283, 215 and 214, 286 and 287, front contacts 792 and 793, conductors 365 and 366, contacts 356 and 355, conductors 399 and 300, contacts 411 and 412, conductors 67 and 68, and over conductors 47 and 48 to the toll repeater. Talking battery is supplied from the toll repeater to the calling line. The talking bridges in the local link have been disconnected in response to the operation of the switch-through relay 790.

The release of the link is controlled from the repeater since the repeater connects ground to conductor 66. When the toll repeater is released after conversation ground is disconnected from conductor 66, thereby opening the circuit of cut-off relay 30, relay 770, relay 790, and cut-off relay 60 to release the same. Test relay 770, upon deenergizing, at front contact 776 opens the circuit to connector group relay 421, which deenergizes. Switch through relay 790, upon deenergizing, at contact 798 disconnects ground from conductor 188 to release relays 120, 122, 210, 360, 350, and 420, and at 799 grounds the all-link busy conductor 669. Finder group relay 120, upon deenergizing, at contacts 117 and 118 disconnect the calling line from the link, and at 126 disconnects ground from the guard lead 184 to free the link. Finder group relay 122, upon deenergizing, at 119 disconnects the test lead of the calling line from the link. The connector relays 360, 350, 420, and 421 deenergize and disconnect the trunk from the link. Cut-off relay 30, upon deenergizing, at 34 opens the circuit to lock-out relay 20 which releases, and cut-off relay 60 deenergizes to cause the release of the lockout relay 50 as previously described.

In case the calling subscriber desires to extend a call to the second group of trunks, which in this case are ring-down trunks, such subscriber will dial the digit 9. The link is operated as previously described and counting relays 830 and 860 are operated in response to digit 9. As previously described relay 660 deenergizes after the impulsing period and at back contact 663 completes the circuit for operating connector group relay 430 and link relay 613 as follows: from ground by way of back contact 663, conductor 634, back contact 775, conductor 446, to contact 861 where the circuit divides, one branch extending by way of front contact 861, contact 832, conductor 9 of cable 369, contact 499, and through the winding of connector group relay 430 to battery; and the other branch extending from conductor 446 by way of contact 469, conductor 445, 75

contact 863, contact 834, conductor 747, front contact 713, conductor 619, and through the winding of relay 613 to battery. Connector group relay 430, upon energizing, at its upper contacts connects the test leads of the trunk lines and lines in the 30-group to the connector unit relays, at 434 prepares a point in the circuit for relay 431, at 435 locks itself to grounded conductor 188, and at 436 completes the circuit for operating the first of the trunk hunting finder unit relays 340. At contact 616 relay 613 completes the circuit for operating relays 700 and 360, as previously described. The energization of relay 700 accomplishes the same functions as previously described. Relay 360 at 361 locks itself to grounded conductor 188, at 362 prepares the circuit of relay 431, and at 363 transfers the test lead as previously described. The circuit for operating the first trunk hunting connector unit relay 340 may be traced as follows: from grounded conductor 293, back contact 771, conductor 458, contact 436, contact 459, conductor 392, back contacts 311, 331, 341, and 351, conductor 12 of cable 369, front contact 862, back contact 843, front contact 833, conductor 14 of cable 369, and through the winding of relay 340 to battery. Relay 340 energizes over the above-traced circuit and at contact 342 locks itself to grounded conductor 188 by way of contact 353. At contact 348 connects the test lead of trunk 39 in series with the test relay 770, and at contact 341 completes the circuit for the second trunk hunting connector unit relay 350. If trunk No. 39 is busy, then ground is connected to the test conductor of this trunk with the result that test relay 770 is short circuited, as previously described. The second trunk hunting connector unit relay 350 energizes after an interval in case test relay 770 does not operate and at 352 locks itself to grounded conductor 188. At contact 353 relay 350 opens the circuit to relay 340 which deenergizes, at front contact 351 prepares the short circuit for relay 710, and at 358 connects the test relay 770 in series with the test conductor of trunk No. 30.

If the trunk is idle then test relay 770 energizes in series with the cut-off relay of trunk 30 over the following circuit: from grounded conductor 293, contact 419 of group connect relay 400, conductor 456, back contact 774, through the lower winding of test relay 770, link test conductor 364, front contact 363, conductor 359, contact 358, conductor 398, through the upper contact of connector group relay 430 to the test conductor of trunk No. 30, thence through the winding of the cut-off relay associated with trunk 30 to battery. At back contact 771 test relay 770 disconnects ground from conductor 458 to open the hunting circuit for operating the connector unit relays and at front contact 771 completes a locking circuit through its upper winding to grounded conductor 293. At contact 776 relay 770 completes the following circuit for operating connector group relay 431 from ground by way of conductor 645, 723, front contact 776, conductor 368, front contact 362, conductor 393, contact 434, and through the winding of relay 431 to battery. Relay 431 at its upper contacts connects the link line conductors to the trunk line conductors and at 437 completes the circuit for operating relay 690. This circuit may be traced as follows: from grounded conductor 293 by way of 419, 456, front contact 774, conductor 447, contact 437, conductor 453, and through the winding of relay 690 to battery. At 691 relay 690 prepares a point in the circuit for holding

relay 620, at 692 completes a circuit for operating relay 760 by way of grounded contact 681 and conductor 624, at 693 locks itself to grounded conductor 293, at 694 opens the circuit to relay 710 which deenergizes, and at 695 and 696 prepares the ringing circuit.

Relay 710, upon deenergizing, at 713 releases relay 613 and at 718 releases group connect relay 400. Group connect relay 400, upon deenergizing, at 419 opens the original circuit of relay 690 now locked in operated position, at 429 opens the circuit of relay 700 which deenergizes, at 439 disconnects ground from conductor 390 to release the operated counting relays, and at contacts 492 to 498 disconnects the connector group relays from the counting relays. Relay 760, upon energizing, at contacts 761 and 762 reverses the connection of relays 613 and 750 to contacts 781 and 782 on the ring-cut-off relay 780. Relay 700, upon deenergizing, at 705 disconnects ground from the tone start lead, at 701 removes the battery shunt from around the winding of relay 610 which now operates over the calling subscriber's loop, and at 709 connects the ring relay 890 to the pick-up lead.

When the pick-up lead is grounded by the ringing machine, ring relay 890 is energized and locks in the same manner as previously described. Ring relay 890, upon energizing, at 897 completes the ring-back circuit for the calling line, and at 895 completes the ringing circuit as follows: from No. 1 ring conductor, conductor 658, contacts 695, conductor 657, contact 895, back contact 868 since counting relay 860 is deenergized by this time, resistance R4, back contact 866, front contact 891, conductor 737, back contact 782, conductor 366, contact 355, conductor 300, upper contact of connector group relay 431 associated with the positive line conductor of trunk 30 over the positive line conductor of trunk 30 through the ring-down equipment associated with this trunk back to negative line conductor and the upper contact of relay 431, conductor 399, contact 356, conductor 365, back contact 781, conductor 736, front contact 892, back contact 867, conductor 739, and through the upper winding of ring-cut-off relay 780 to battery. The ring-down apparatus in the trunk operates and causes the operation of the ring cut-off relay 780 over the previously traced ringing circuit. At 783 ring-cut-off relay completes its own locking circuit to ground at front contact 722, at back contacts 781 and 782 disconnects the ringing circuit and connects the ring-down trunk to relays 615 and 750.

Relays 750 and 613 are now energized in series over the heavy talking conductors and the bridge at the ring-down trunk. At contact 614 relay 613 prepares a point in the circuit to release relay 620 to place the release of the link under control of the trunk. Relay 750 at 751 completes the circuit for operating relay 740, and at 735 causes the release of the time cut-off relay 608. Relay 740, upon operating, at 742 locks itself to grounded conductor 188, at 743 disconnects ground from the generator start to stop the ringing machine, and at 745 opens the locking circuit of ring relay 890 to release the latter relay. Talking battery is furnished to the calling line through relays 610 and 630.

After conversation, and assuming that the calling subscriber is the first to release, then relays 610 and 630 deenergize. At 631 relay 630 opens the circuit to slow-to-release relay 620, and at 630 opens the circuit to pulse relay 680. 75

Pulse relay 680 deenergizes, at front contact 681 opens the circuit to relay 760, and at back contact 681 completes a circuit for maintaining relay 620 in operated position as follows: from ground, back contact 681, front contact 691, contact 614, and through the winding of release relay 620 to battery. Relay 620 is therefore maintained in operated position to maintain the link in operated position. Relay 760 deenergizes in response to the release of relay 681 and at contacts 761 and 762 reverses battery through the windings of relays 613 and 750 over the trunk conductors for supervisory purposes to signal the operator.

When the operator releases from the ring-down trunk relays 613 and 750 deenergize. Relay 750 at 653 reoperates the time-cut-off relay 608 to again connect the grounded time-cut-off conductor to the link. Relay 613, upon deenergizing, at 614 opens the circuit to release relay 620. Relay 620 deenergizes after an interval, and at front contact 621 disconnects ground from conductor 293 to free the calling line and release the cut-off relay, and to cause the deenergization of relays 690, 720, and 770.

In case the operator is the first to disconnect then relays 750 and 613 deenergize. Relay 750 at 753 connects the time-cut-off ground so as to release the link after a predetermined time in case the calling line fails to hang up. When the calling line hangs up, the link is released as previously described.

The operation of this link when it is seized by a toll repeater over conductors 66, 46, 47, and 48 of trunk 20, for example, is the same as that previously described for a local subscriber making a call. In this case, however, the toll repeater after the first pulse of the first digit of the called number, opens lead 47 to open the circuit to relay 610 while negative battery is connected to conductor 48 for operating relay 630. Relay 610 is not operated at this time in order to prepare a circuit for the switchthrough relay 790. After ringing and when the called subscriber answers ring-cut-off relay 780 energizes and locks, and transfers the called loop to relays 750 and 613 which operate as previously described. Relay 750 causes the operation of relay 740 and releases relays 608, 870, and 890 as before, and at 752 completes the circuit for operating switchthrough relay 790 before slow-to-operate relay 740 operates. This circuit may be traced as follows: from grounded conductor 645, contact 723, contact 735, conductor 295, contact 694, conductor 647, contact 752, back contact 744, conductor 636, contact 612, conductor 448, and through the winding of switchthrough relay 790 to battery. Switchthrough relay 790, upon operating, at 795 locks itself to conductor 293, at contacts 792 and 793 switches the trunk straight through to the called line and releases relay 630, 750, and 613. At 794 relay 790 opens the circuit to relay 720 which accordingly deenergizes, at 796 provides a new holding circuit for relays 770 and 780, at 797 disconnects ground from the generator start lead, at 798 grounds conductor 188 to hold the finder and connector relays. Relays 750, 613, 630, 680, 620, and 720 release as previously described, and the ground extending back from the toll repeater over conductor 66 now holds the link relays 770, 780, and 790 in operated condition as previously described. The talking battery for the called subscriber is furnished from the toll repeater.

When the toll repeater is released ground is disconnected from the conductor 66 to release the

cut-off relay of the called line, the cut-off relay of the trunk line, and relays 770, 780, and 790 whereupon the link is released as previously described, and in addition, in this case the deenergization of switchthrough relay 790 releases the finder and connector relays and relay 740.

In case the link is held in its non-talking condition, due to failure of the calling line to dial the required digit, due to failure of the calling line to hang up in response to a busy tone, due to failure of the calling party to hang up when the called party does not answer or after the called party hangs up, or due to failure of either party to answer a reverting call, the link is automatically released after a predetermined time by the disconnection of ground from the time-cut-off lead. At regular intervals after a call has been initiated, the timing equipment (not shown), momentarily disconnects ground from the time-cut-off lead. If the link is not in talking position at this time, (with relay 608 released,) then the disconnection of ground from the time-cut-off lead also disconnects ground from conductors 645 and 188 to release the finder, the connector, and the link relays in a manner apparent from the foregoing description.

In case the fuse for supplying battery to the link relay should blow, then the time-cut-off relay 608 is energized over the fuse-alarm lead. At 608 time-cut-off relay 608 grounds the guard lead 184 of this link to make it busy and at 607 removes the multiple ground from the all-link-busy conductor 669. An alarm relay (not shown) is energized in series with relay 608 to operate an alarm. When the fuse is replaced relay 608 releases:

When all the links are busy, all of the multiple ground connections are disconnected from conductor 669 to cause the deenergization of the all-link-busy relay 592. All-link-busy relay 592 deenergizes when ground is removed from conductor 669 and when relay 594 operates at the time the last link is taken into use. This last circuit of relay 592 is opened at contact 573. All-link-busy relay 592, upon deenergizing, at front contact 589 opens the circuit to relay 591, opens the start lead and locking winding of the operated link selecting relay 501, and at back contact 589 prepares the circuit for operating relay 597. At contact 543 relay 592 opens the circuit to relay 551 and prepares the circuit to the tone-start lead, and at contact 500 connects the all-link-busy tone to the common lead 98 so that the toll trunk lines will receive busy tone at this time if a call is attempted. Relays 501 and 551 deenergize and the latter relay at contact 569 opens the locking circuit of relay 594. Relay 595 at 576 maintains relay 593 operated and the latter relay at 575 maintains open the circuit of relay 597. Relay 597 continues to vibrate its weighted armature, and releases relay 595 after a predetermined time or at a time when the vibrating contact 598 no longer intermittently engages with its make contacts during vibration. At contact 576 relay 595 opens the circuit of relay 593 and the latter relay at contact 575 reoperates relay 597 and the foregoing cycle continues until an idle link is available. When a link becomes free, ground is connected to the all-link-busy conductor 669, and the all-link-busy relay 592 is energized. At contact 500 relay 592 disconnects the busy tone from conductor 98 at 543 opens the tone-start circuit and prepares the circuit for relay 551, and at 589 closes a circuit through the upper winding of link-selecting relay

501 in series with relay 594. In response to these operations relays 593, 595, 596, and 597 release. Link-selecting relay 501 energizes, at 511 locks in series with relay 591, and at 510 connects the guard-lead 184 to the link-selecting relay 502. Relay 591 energizes in series with relay 501, at back contact 588 opens the circuit through relays 501 and 594, and at front contact 588 prepares the start circuit to start conductor 191. If link No. 1 is busy then ground on the guard lead operates the second link-selecting relay 502 and relay 594 and the allotter selects the first idle one of the links as previously described.

In case the link is seized and fails to operate correctly due to faulty operation, for example, such as failure of the FUR relays, 210, 220, etc., to operate, the call is transferred to another link after a predetermined time. Assuming that relay 210 fails to operate at a time when relays 70, 170, 122, 501, 552, 551, 558, 597, 596, 595, and 593 are operated as previously described. When relay 593 is operated by relay 595, the circuit of relay 597 is opened at contacts 575 whereupon the latter relay releases to vibrate its weighted armature. At contacts 599 relay 597 opens the circuit to relay 596 which deenergizes. When the swing of the weighted spring 598 subsides to a point where it no longer alternately contacts its make springs relay 595 deenergizes. At front contacts 576 relay 595 opens the circuit to relay 593 but before this slow acting relay deenergizes the following circuit is completed for the second link selecting relay and relay 594 in series: ground at contact 570, bank contact 576, contacts 571, 568, 567, 509, 539, and 510, through the upper winding of relay 502 and the upper winding of relay 594. In the same manner as previously described, the operation of relay 594 causes the release of the link and the release of connect relay 170. The allotter now searches for an idle link, as previously described.

Having described the invention, what is considered new and is desired to be protected by Letters Patent will be set forth in the following claims.

What is claimed is:

1. In a telephone system, a group of lines, each line having a pair of talking conductors and a test conductor, a link circuit for interconnecting said lines, means responsive to a line in said group initiating a call for connecting all the test conductors only of said group to said link circuit, a group of relays in said link circuit sequentially operated in response to said connection, and means for simultaneously testing over two of said test conductors in said group in response to the operation of each group relay.

2. In a telephone system, a group of lines, each line having a pair of talking conductors and a test conductor, a link circuit for interconnecting said lines, means responsive to a line in said group initiating a call for connecting all the test conductors only of said group to said link circuit and for marking the test conductor of the calling line, a group of relays in said link circuit sequentially operated in search of said marked test conductor in response to said connection, means for simultaneously testing two lines in said group for said marked conductor in response to the operation of each group relay, and a pair of test relays for stopping further sequential operation of said group relays in response to the operated group relay finding the marked test conductor.

3. In a telephone system, a group of lines, a

link circuit for interconnecting said lines, means responsive to a line in said group initiating a call for marking the calling line, a group of relays in said link circuit sequentially operated in search of the marked calling line in response to the initiation of said call, and means for simultaneously testing two lines in said group for said marked calling line in response to the operation of each group relay.

4. In a telephone system, a group of lines, each line having a pair of talking conductors and a test conductor, a link circuit for interconnecting said lines, means responsive to a line in said group initiating a call for connecting all the test conductors only of said group to said link circuit and for marking the test conductor of the calling line, a pair of test relays either one of which is operated when connected with the marked conductor, and a group of relays in said link circuit sequentially operated to simultaneously connect the test conductors of two lines in said group to said test relays for each group relay operated in response to said connection.

5. In a telephone system, a group of lines, a plurality of link circuits for interconnecting said lines, means responsive to a line in said group initiating a call for selecting an idle link circuit and for marking the calling line, a group of relays in said selected link circuit sequentially operated in search of the marked calling line in response to said selection, a test relay in said selected link circuit and a test relay common to all said link circuits, each of said test relays being connected to a separate line in said group in response to the operation of each group relay to test two lines simultaneously, and means for operating one of said test relays in response to connection with the calling line to stop further sequential operation of said group relays.

6. In a telephone system, a group of lines, a link circuit for interconnecting said lines, means responsive to a line in said group initiating a call for marking the calling line, a group of relays in said link circuit sequentially operated in search of the marked calling line in response to the initiation of said call, a pair of test relays simultaneously connected to a pair of said lines in response to the operation of each group relay to test two lines simultaneously, and means for operating one of said test relays in response to connection with the calling line to stop further sequential operation of said group relays.

7. In a telephone system, a group of lines, a plurality of link circuits for interconnecting said lines, means responsive to a line in said group initiating a call for operating an idle one of said link circuits to search for and connect the calling line to said link circuit, a lockout relay common to said lines operated in case the idle link circuit fails to find the calling line, and a lockout relay individual to the calling line operated by said common relay to prevent other link circuits searching for the calling line as long as said calling line condition persists.

8. In a telephone system, a line, means responsive to said line initiating a call for marking said line with calling potential and starting condition, means responsive to said marked starting condition for finding said calling potential to extend the calling line, a lockout relay individual to said calling line for removing said calling potential and said starting condition when operated, means for operating said relay in response to said second-named means finding and extending the calling line, and means for operating said relay

in case said second-named means fails to find the calling line to prevent other similar means from operating in an attempt to find the calling line.

9. In a telephone system, a plurality of groups of lines, a plurality of links for interconnecting said lines, a group relay in each link for each group of lines, a group of unit relays in each link common to each group of lines, a group start relay for each group of lines, means responsive to a call by a line in one of said groups for directly operating only the group start relay corresponding to the line group of the calling line, means for directly operating the group relay of an idle link corresponding to the line group of the calling line responsive to the operation of said group start relay, and means for thereafter sequentially operating the unit relays in said idle link in search of the calling line to extend the connection.

10. In a telephone system, a plurality of groups of lines, a group start relay for each group of lines, means responsive to a call by a line in one of said groups for operating the group start relay corresponding to the line group of the calling line, means operated responsive to the operation of any group start relay for preventing the operation of other group start relays, a group connect relay operated in response to the operation of said group start relay for connecting the lines of the calling group, and a group of unit relays sequentially operated to search for the calling line in the connected group.

11. In a telephone system, a plurality of groups of lines, a group start relay and a group connect relay for each group of lines, a group of unit relays common to each group of lines, a circuit completed responsive to a call by a line in one of said groups for directly operating only the group start relay corresponding to the line group of the calling line, a circuit completed responsive to the operation of said group start relay for directly operating only the group connect relay corresponding to the line group of the calling line, and means for thereafter operating said unit relays in sequence in search of the calling line to extend the connection.

12. In a telephone system, a plurality of groups of lines, a link for interconnecting said lines, a group relay in said link for each group of lines, a group of unit relays in said link common to said lines, means responsive to a call by a line in one of said groups for directly operating the group relay in said link corresponding to the line group of the calling line, means for sequentially operating the unit relays in search of the calling line, said unit relays being less in number than the number of lines in any one group of lines, and means responsive to the operation of each unit relay for simultaneously testing two lines of the calling group.

13. In a telephone system, a group of lines, a link for interconnecting said lines, a group of unit relays in said link, said unit relays being less in number than the number of lines in said group, and means in said link responsive to a line calling another line for operating only one of said unit relays in case certain lines in said group are called and for operating two of said unit relays in case the other lines in said group are called to connect the calling line to the called line.

14. In a telephone system, a group of lines divided into a first and second sub-group, a link for interconnecting said lines, a group of unit relays in said link equal in number to the num-

ber of lines in a sub-group, means in said link responsive to a line calling a line in the first sub-group for operating the corresponding unit relay to connect the calling line to said called line, a sub-group relay, and means in said link responsive to a line calling a line in the second sub-group for operating the corresponding unit relay and said sub-group relay to connect the calling line to said last called line.

15. In a telephone system, a plurality of groups of lines, a link circuit for interconnecting said lines, a group relay in said link circuit for each group of lines, a group of unit relays in said link circuit common to said lines, means in said link circuit responsive to a line calling another line for operating the group relay and the unit relay in said link circuit corresponding to the called group and line in such group to connect the calling line to said called line, said unit relays being less in number than the number of lines in any one group of lines, and means for operating only one of said unit relays to connect with certain of said lines in the called group and for operating two of said unit relays to connect the other lines of the called group.

16. In a telephone subscriber's line circuit, a shunt-field line relay, a cut-off relay, a lockout relay, two windings on said line relay, said windings being connected to opposite poles of battery, a pair of line conductors extending through normally closed contacts on said cut-off relay and terminating in said windings, said line relay being inoperative when one or both line conductors are grounded but operative responsive to the connection of one line conductor to the other line conductor when the subscriber initiates a call, a circuit for said cut-off relay including normally closed contacts on said lockout relay, and normally open contacts on said line relay, a locking circuit for said cut-off relay excluding said contacts, a circuit for said lockout relay controlled by said cut-off relay, and a locking circuit for said lockout relay controlled by said line relay independent of said cut-off relay.

17. In a telephone subscriber's line circuit, a shunt-field line relay, a cut-off relay, two windings on said line relay, said windings being connected to opposite poles of battery, a pair of line conductors extending through normally closed contacts on said cut-off relay and terminating in said windings, said line relay being inoperative when one or both line conductors are grounded but operative responsive to the connection of one line conductor to the other when the subscriber initiates a call, and means responsive to the operation of said line relay for preparing a circuit for said cut-off relay.

18. In a telephone subscriber's line circuit, a shunt-field relay, two windings on said relay wound in opposition to each other, said windings being connected to opposite poles of battery, a pair of line conductors terminating in said windings, said line relay being inoperative when either winding alone is energized by connection of ground to one or both line conductors, and means responsive to the subscriber initiating a call for connecting one line conductor to the other line conductor to operate said line relay.

19. In a telephone system, a group of lines, a link for interconnecting said lines, a group of unit relays and a sub-group unit relay in said link, each of said unit relays being operative to connect either one of two lines of said group of lines to said link dependent upon the operated or non-operated condition of said sub-group unit

relay, and means responsive to a call to one of said lines for operating said sub-group relay and one of said unit relays, said means also being responsive to a call to another of said lines for operating said one of said unit relays without causing operation of said sub-group unit relay.

20. In a telephone system, a group of lines, a link circuit for interconnecting said lines, and finder means consisting only of relays operative to connect said link circuit to any one of said lines, certain of said relays operated responsive to a line initiating a call, circuits closed by each relay in its operation, and means controlled over the circuits closed by each relay to simultaneously test a plurality of lines to determine which is the calling line.

21. In a telephone system, a group of lines, a link circuit for interconnecting said lines, and finder means consisting only of relays operative to connect said link circuit to any one of said lines, certain of said relays sequentially operated responsive to the initiation of a call over one of said lines, a group of circuits closed by each relay by its operation, and means controlled over the group of circuits closed by each relay to simultaneously test said lines in groups, each including a plurality of lines, thereby to select the calling line.

22. In a telephone system, a group of lines, a plurality of link circuits for interconnecting said lines, each of said link circuits having finder means associated therewith, means responsive to a line initiating a call for selecting an idle one of said link circuits, means included in the finder means associated with said selected link circuit for simultaneously testing a plurality of said lines to determine which is the calling line, and means operated when said last-named means fails to find said calling line for preventing other link circuits from searching for said calling line.

23. In a telephone system, a group of lines, an automatic switch having access to said lines, a group of unit relays and a sub-group unit relay in said switch, said sub-group unit relay being operative between two positions, each of said unit relays being operative to select either one of two lines in said group depending upon the position of said sub-group unit relay, and means operative during the operation of said switch to select one of the lines of said group for causing said sub-group unit relay to operate from one of its two positions to the other and for causing the operation of one of said unit relays, said means also being operative to cause the operation of said one unit relay without causing the operation of said sub-group unit relay during the operation of said switch to select another of said group of lines.

24. In a telephone system, a group of lines, an automatic switch having access to said lines, a group of unit relays and a sub-group unit relay in said switch, each of said unit relays being operative to select either one of two lines in said group dependent upon the operated or non-operated condition of said sub-group unit relay, and means operative during the operation of said switch to select one of said group of lines for causing the operation of said sub-group unit relay and one of said unit relays, said means also being operative to cause the operation of said one unit relay without causing the operation of said sub-group unit relay during the operation of said switch to select another of said group of lines.

25. In a telephone system, a group of lines in-

cluding one line to be selected, said lines being divided into two sub-groups, a switch having access to said lines, a group of unit relays and a sub-group unit relay in said switch, each of said unit relays being operative to select either of two different lines in said group dependent upon the operated or non-operated condition of said sub-group unit relay, and means operative during the operation of said switch to select said one line for causing the operation of said sub-group unit relay and one of said unit relays in the event said one line is included in one of said sub-groups, said means being operative to cause the operation of said one unit relay without causing the operation of said sub-group unit relay in the event that said one line is included in the other of said sub-group.

26. In a telephone system, a group of lines, said group of lines being divided into two sub-groups, a finder switch having access to said group of lines and operative to select a line therefrom, a group of unit relays and a subgroup relay in said finder switch, said subgroup relay being operable between two positions, each of said unit relays being operative to select a line from each of said subgroups depending upon the position of said subgroup relay, means responsive to the initiation of a call on a line in one of said subgroups for causing the operation of the corresponding unit relay and the operation of said subgroup relay to one of its positions, thereby to select the calling line, and means responsive to the initiation of a call on a line in the other of said subgroups for causing the operation of the corresponding unit relay while said subgroup relay occupies its other position, thereby to select the calling line.

27. In a telephone system, a group of lines, said group of lines being divided into two sub-groups, a finder switch having access to said group of lines and operative to select a line therefrom, a group of unit relays and a subgroup relay in said finder switch, each of said unit relays being operative to select either of two lines from said group depending upon the operated or non-operated condition of said subgroup relay, means responsive to the initiation of a call on one of said lines for causing the operation of one of said unit relays and said subgroup relay, thereby to select said one line in the event said one line is in one of said subgroups, and means responsive to the initiation of a call on said one line for causing the operation of said one unit relay without causing the operation of said subgroup relay, thereby to select said one line in the event said one line is in the other of said subgroups.

28. In a telephone system, a group of lines, said group of lines being divided into two sub-groups, a finder switch having access to said group of lines and operative to select a line therefrom, a group of unit relays and a subgroup relay in said finder switch, each of said unit relays being operative to select a corresponding line from each of said subgroups, depending upon the operated or non-operated condition of said subgroup relay, means responsive to the initiation of a call on a line in one of said subgroups for causing the operation of the corresponding unit relay and said subgroup relay, thereby to select the calling line, and means responsive to the initiation of a call on a line in the other of said subgroups for causing the operation of the corresponding unit relay without causing the operation of said subgroup relay, thereby to select the calling line.

29. In a telephone system, a group of lines, said group of lines being divided into two subgroups, a finder switch having access to said group of lines and operative to select a line therefrom, means responsive to the creation of a calling condition on one of said lines for initiating the operation of said finder switch to select the calling line, a group of unit relays and a subgroup relay in said finder switch, each of said unit relays being operative to select a corresponding line from each of said subgroups depending upon the operated or non-operated condition of said subgroup relay, and means for operating said unit relays individually and said subgroup relay, thereby to select the corresponding lines from one of said subgroups, and for operating said unit relays individually without operating said subgroup relay, thereby to select the corresponding lines from the other of said subgroups.

30. In a telephone system, a group of lines, said lines being divided into two subgroups, a finder switch having access to said lines, a group of unit relays and a subgroup relay in said switch, each of said unit relays being operative to select either of two lines of said group depending upon the operated or non-operated condition of said subgroup relay, means responsive to the creation of a calling condition on one of said lines for causing the operation of said subgroup relay only in the event said one line is included in one of said subgroups and for causing the operation of one of said unit relays, thereby to select said one line, and means responsive to the creation of a calling condition on said one line for causing the operation of said one unit relay without causing the operation of said subgroup relay, thereby to select said one line in the event said one line is included in the other of said subgroups.

31. In a telephone system, a number of lines divided into a plurality of groups, each of said groups of lines being divided into two subgroups, a finder switch having access to said number of lines and operative to select a line therefrom,

means responsive to the creation of a calling condition on one of said lines for initiating the operation of said finder switch to select the calling line, a plurality of group relays, a group of unit relays and a subgroup relay in said finder switch, each of said group relays being operative to select a corresponding group of lines from said plurality of groups, each of said unit relays being operative to select a corresponding line from each of the subgroups depending upon the operated or non-operated condition of said subgroup relay, means for operating said group relays individually to select the corresponding groups of lines from said plurality of groups, and means for operating said unit relays individually and said subgroup relay, thereby to select the corresponding lines from one of said subgroups, and for operating said unit relays individually without operating said subgroup relay, thereby to select the corresponding lines from the other of said subgroups.

32. In a telephone system, a group of lines, said lines being divided into two subgroups, a switch having access to said lines and operative to select a line therefrom, a group of unit relays and a subgroup relay in said switch, each of said unit relays being operative to select either of two lines of said group depending upon the operated or non-operated condition of said subgroup relay, a pair of operating circuits for each of said unit relays, means operative during the operation of said switch to select one of said lines for completing one of the operating circuits for the one unit relay which is operative to select said one line, said last named means only being operative in the event said one line is included in one of said subgroups, and means for causing the operation of said subgroup relay and for completing the other operating circuit for said one unit relay, said last-named means only being operative in the event said one line is included in the other of said subgroups.

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