

July 27, 1943.

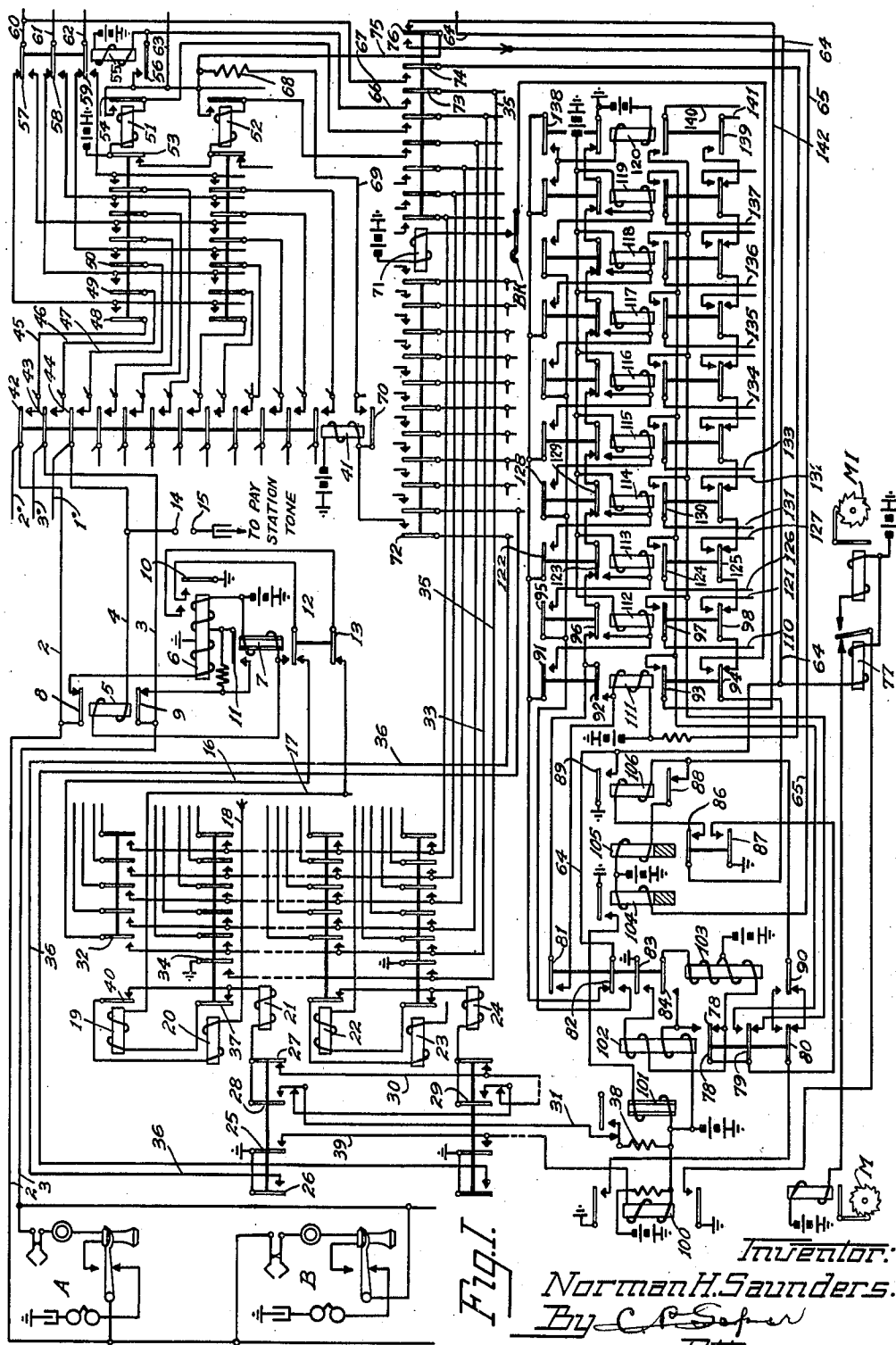
N. H. SAUNDERS

2,325,151

100-LINE ALL RELAY SYSTEM

Filed Dec. 2, 1940

8 Sheets-Sheet 1



July 27, 1943.

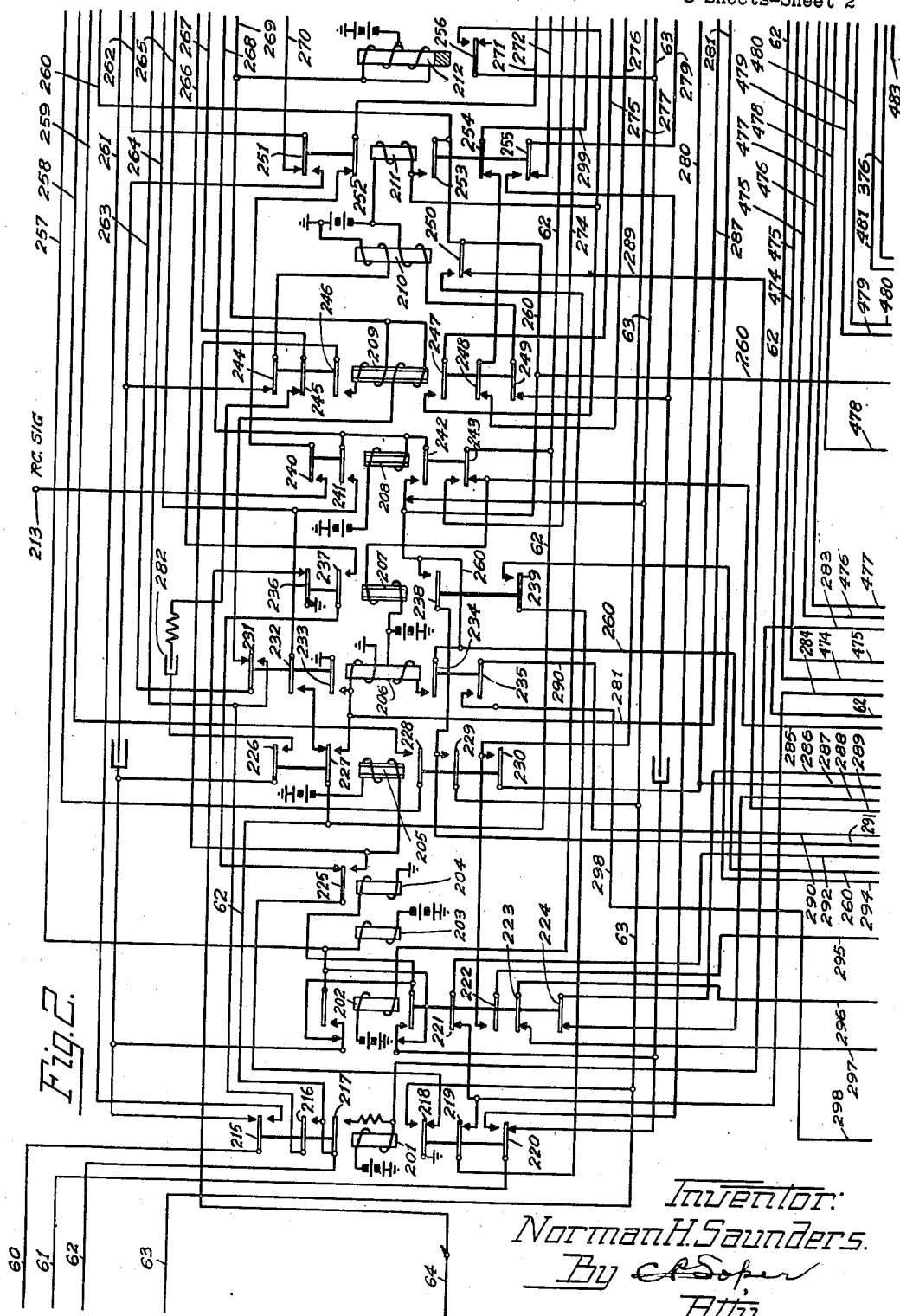
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100-LINE ALL RELAY SYSTEM

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8 Sheets-Sheet 2



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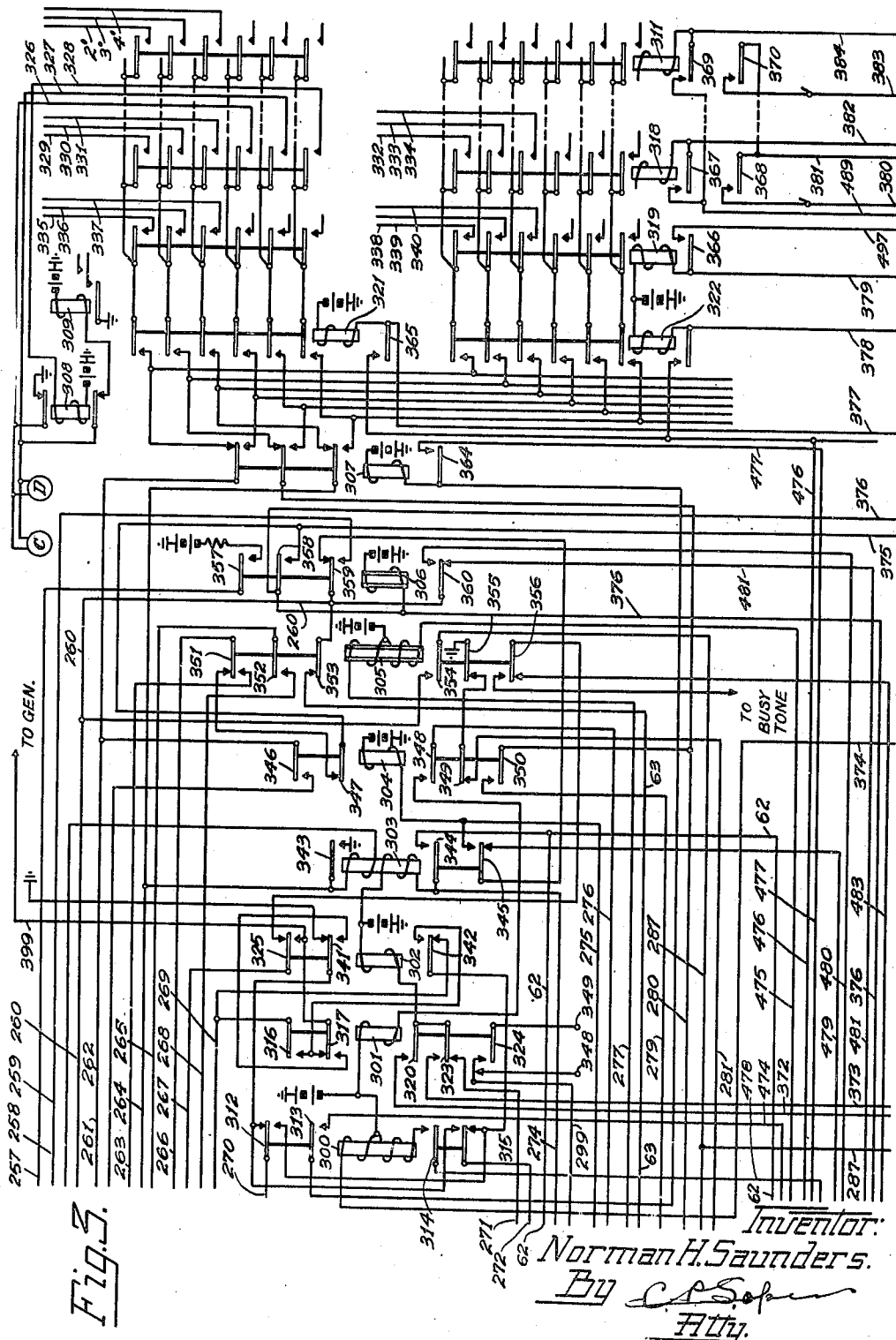
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100-LINE ALL RELAY SYSTEM

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8 Sheets-Sheet 4

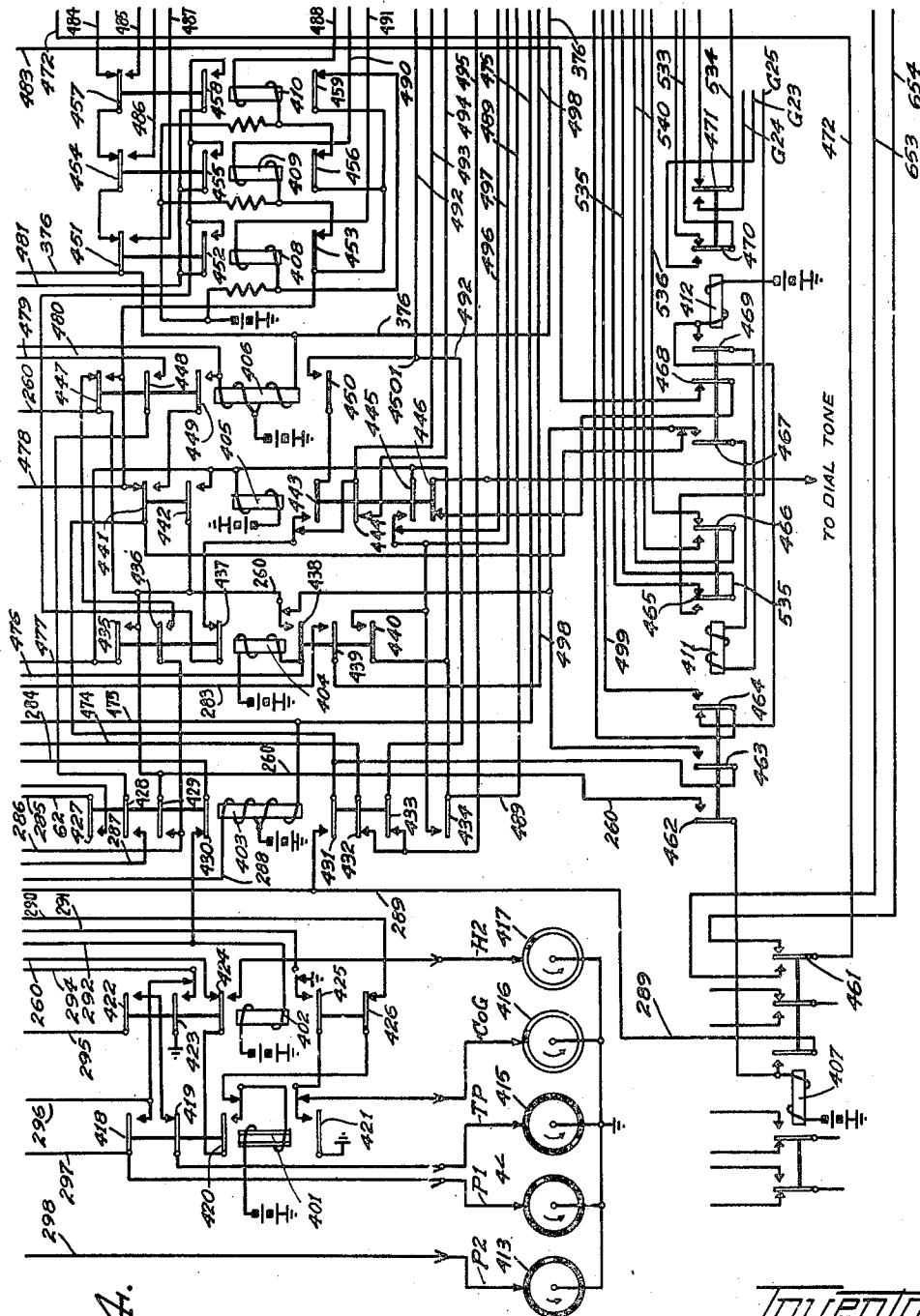


Fig. 4.

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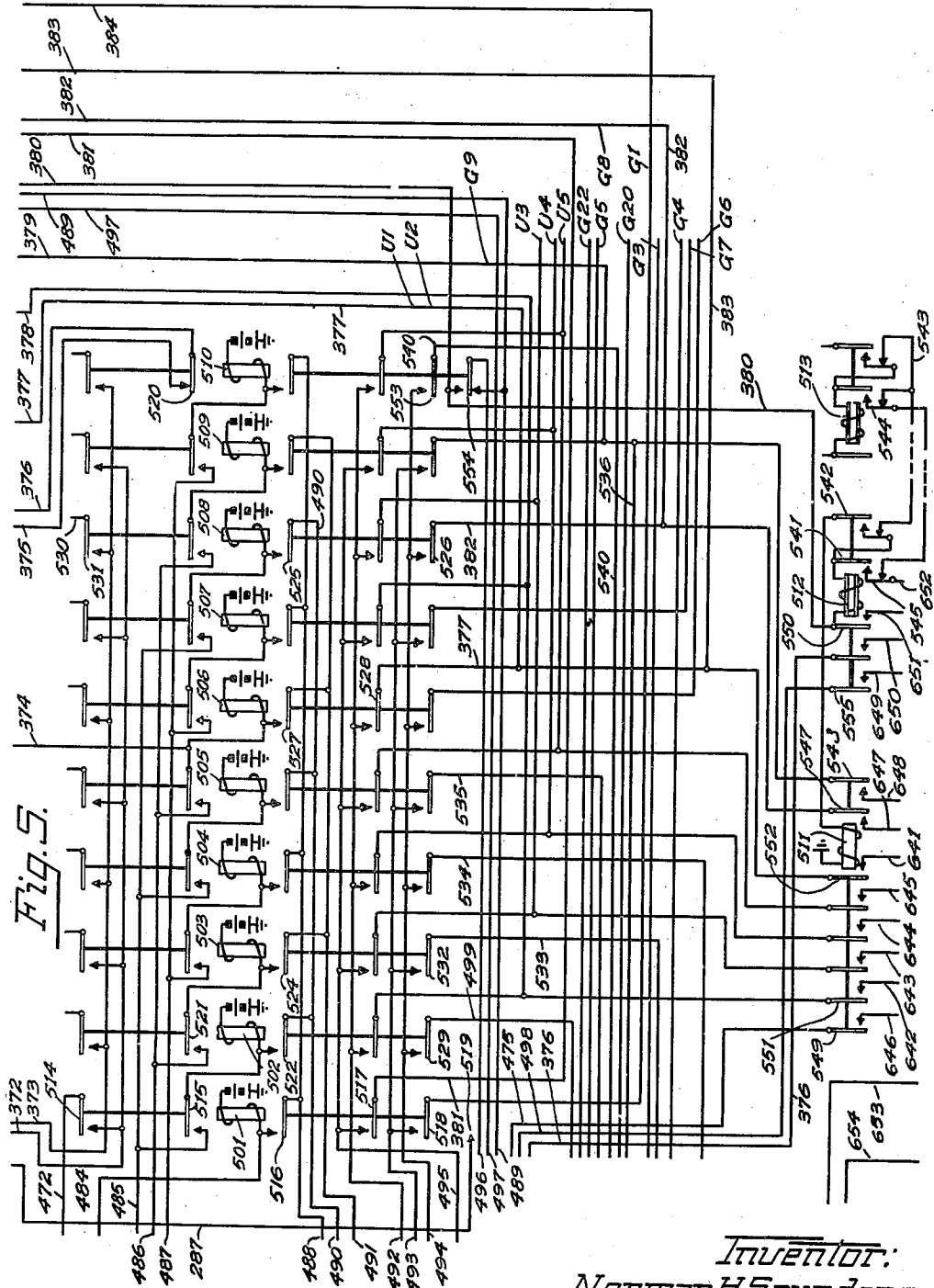
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100-LINE ALL RELAY SYSTEM

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8 Sheets-Sheet 5



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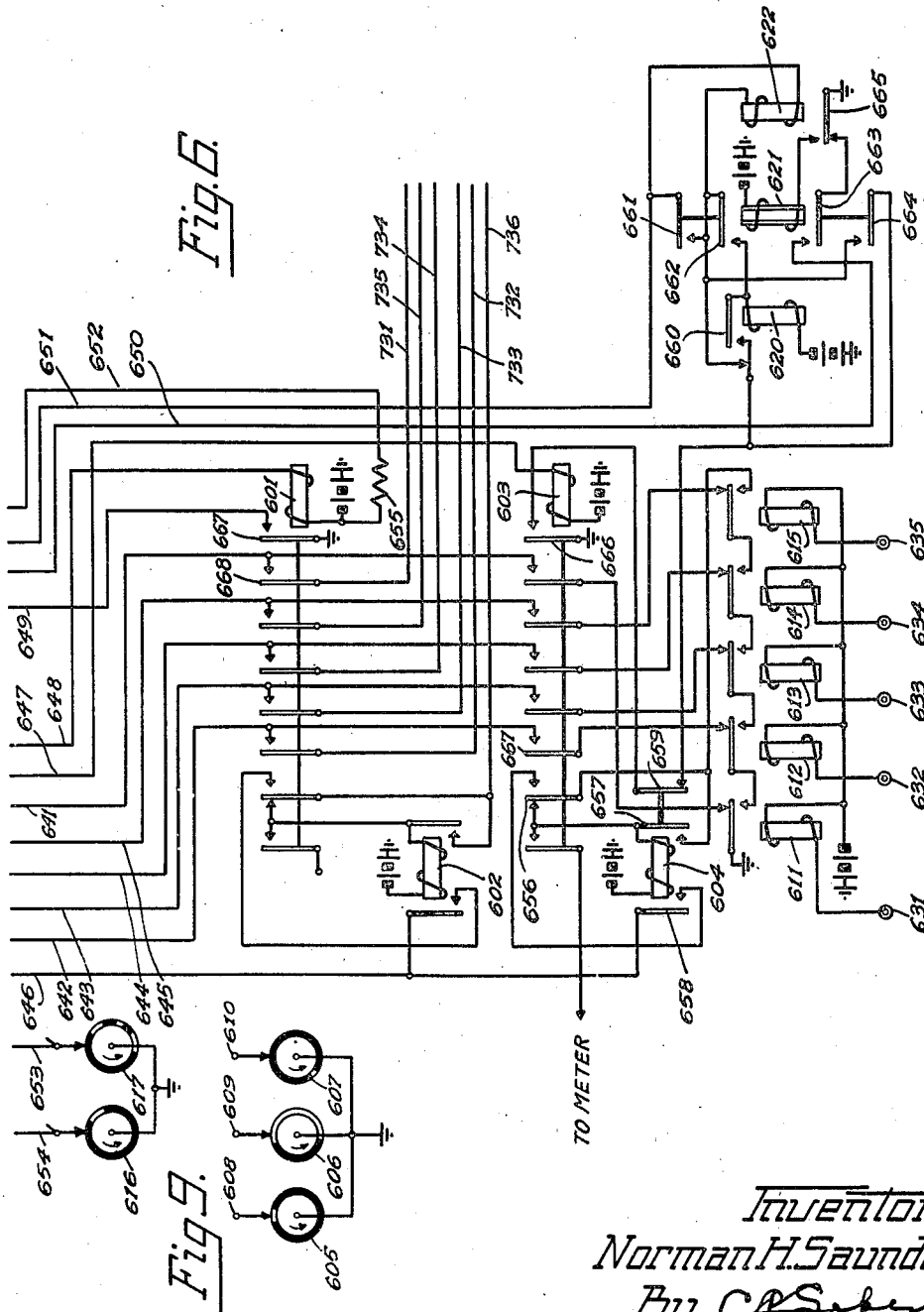
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100-LINE ALL RELAY SYSTEM

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8 Sheets-Sheet 6



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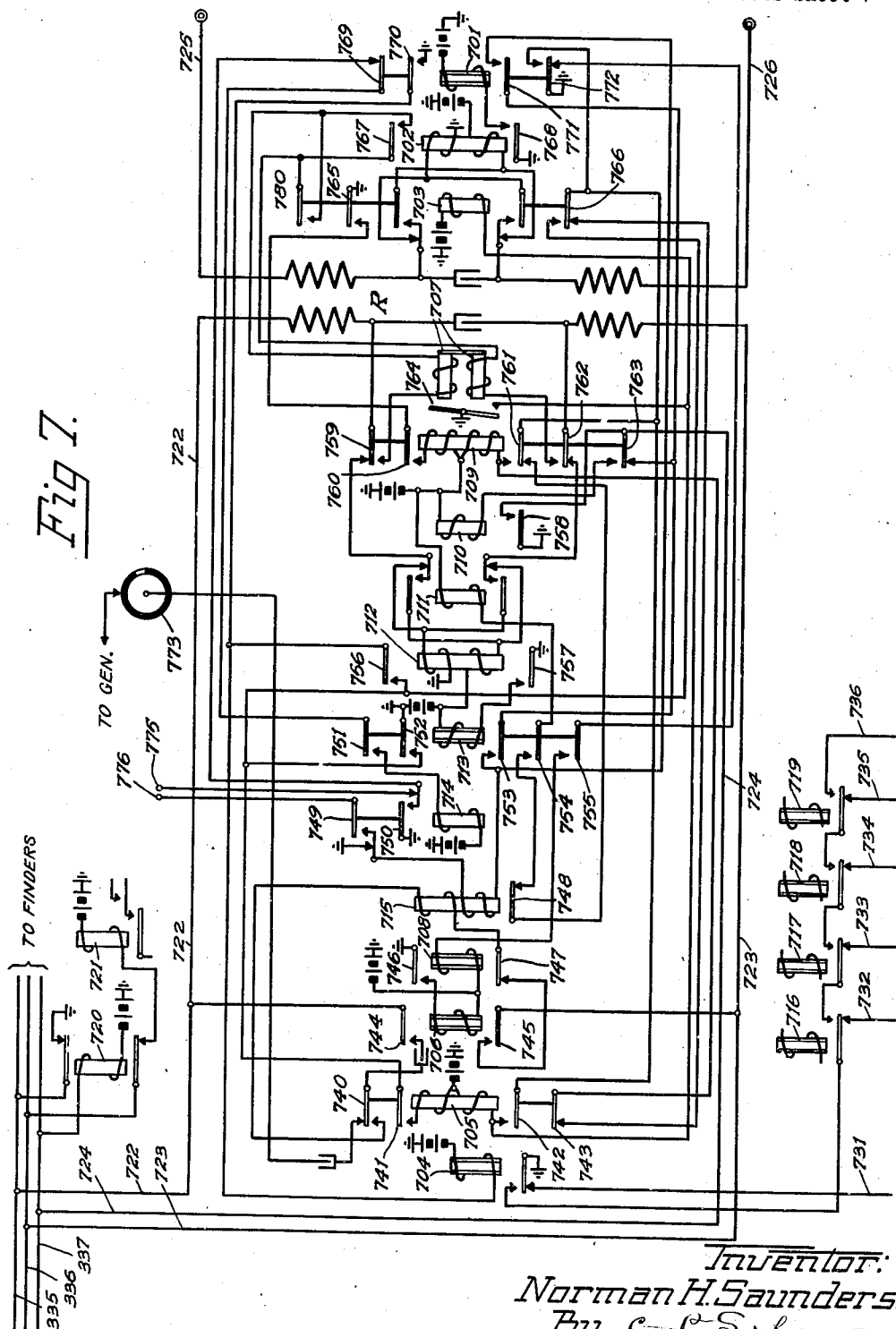
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100-LINE ALL RELAY SYSTEM

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8 Sheets-Sheet 7



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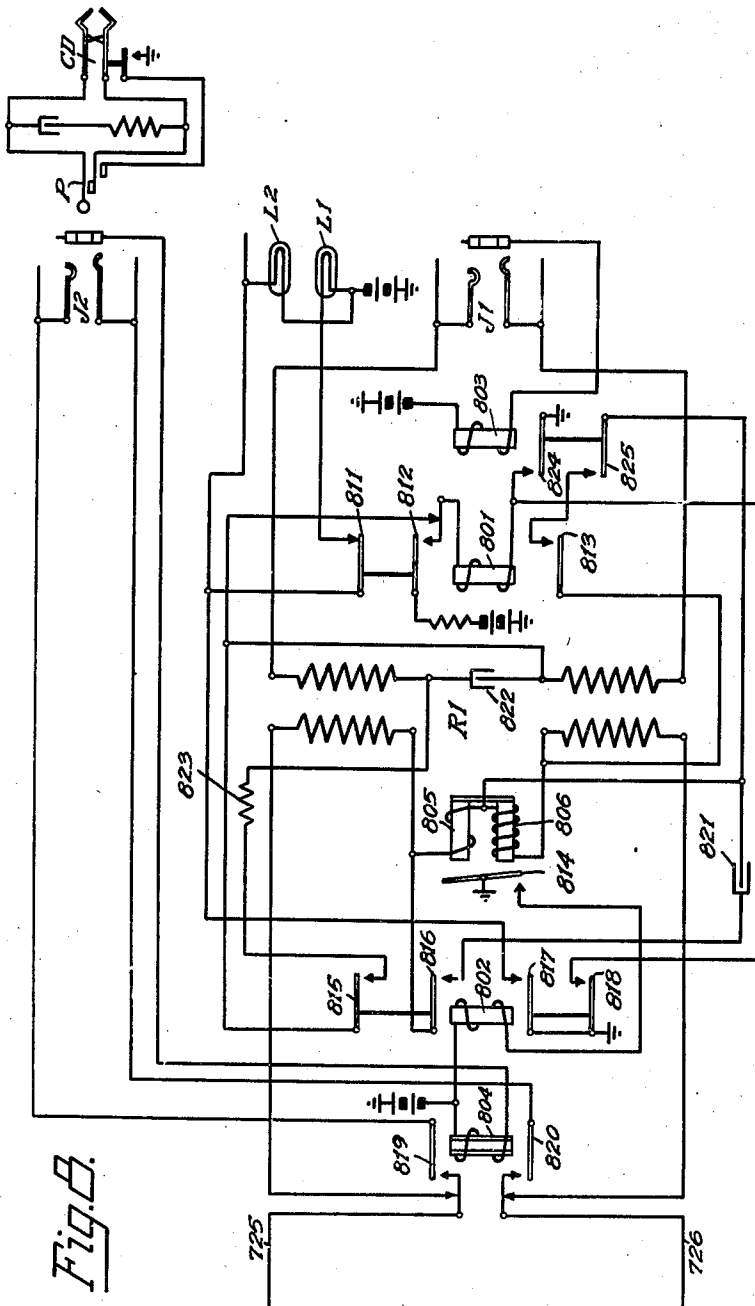
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100-LINE ALL RELAY SYSTEM

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8 Sheets-Sheet 8



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UNITED STATES PATENT OFFICE

2,325,151

100-LINE ALL RELAY SYSTEM

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The present invention relates in general to automatic telephone systems, and more in particular to automatic telephone systems of the relay type, in which connections between calling and called lines are established solely by means of relays. The general object of the invention is to provide a new and improved system of this character.

The system disclosed herein is of relatively small size, having a capacity of somewhat over one hundred lines, and is well adapted to the needs of a small town or community. A telephone exchange for use in a situation of this kind is required to provide for various types of service, as is well known. For example, the system may include party lines and rural lines in addition to individual lines, and the exchange must therefore provide suitable signalling arrangements such as semi-selective ringing, code ringing, and reverting call ringing whereby a party line subscriber may call another subscriber on the same line. There may also be several business establishments in the community served by private branch exchanges and the automatic exchange must therefore be equipped with groups of trunk lines for handling calls to and from such private branch exchanges. Except in the rare case of an isolated community, the exchange must also be provided with a group of trunk lines extending to a toll center, through which connections may be obtained with other exchanges. While not necessarily complete, the foregoing will suffice to give a general idea of the nature of the exchange and the facilities provided therein.

All connections through the exchange are established by means of link circuits, each link comprising a relay type finder and a relay type connector. The finders have common access to all subscribers' lines and trunk lines entering the exchange. An allotter is provided for the purpose of assigning idle finders to calling lines. The connectors likewise have common access to all the subscribers' lines and trunk lines and employ a variety of novel circuit arrangements, whereby they are adapted to complete connections to all of the different kinds of lines and trunk lines terminating in the exchange.

The allotter normally maintains a finder, or link circuit, in assigned condition ready to handle the next call. When the call comes in, the assigned finder connects with the calling line and thus extends it to the associated connector. The calling subscriber then dials the number of the called line, which may have from one to four

digits, depending on the kind of line or station being called. In any case the connector responds in the proper manner to complete the connection to the called line, performing an automatic trunk selecting operation in case the called number is the number of a trunk group, and effects the necessary signalling operation if the called line is idle, or if a trunk line is available in the case where a trunk group is called. Otherwise the calling subscriber is given a busy signal. The foregoing applies also in the case where the calling and called subscribers are on the same party line, except that the busy signal does not have the usual significance.

It will be understood therefore that the new system disclosed herein includes a considerable number of novel features, particularly desirable in a small system of the kind disclosed herein, but not necessarily limited to use in small exchanges. These features will be pointed out more in detail hereinafter in the course of a detailed description of the exchange and its operation.

Reference may now be made to the accompanying drawings, in which—

Fig. 1 shows a subscriber's line and individual line equipment, a number of finder control relays, a finder (not complete), and an allotter;

Figs. 2, 3, 4 and 5 show a connector (complete except for some of the group relays);

Fig. 6 shows equipment common to the exchange for use in selecting idle trunks when trunk groups are called;

Fig. 7 shows a trunk repeater for use on a trunk line extending to a toll center;

Fig. 8 shows the terminal equipment of such trunk line at the toll center; and

Fig. 9 shows a number of interrupters which are common to the connectors in the exchange.

General description

Referring to Fig. 1, the reference character A indicates a subscriber's station, which may be of any suitable common battery type. The telephone at station A is connected with the exchange over a line comprising conductors 2 and 3. At the exchange the line is provided with the individual line equipment comprising the line relay 4, the cut-off relay 5, and the lockout relay 7.

The line of station A is shown herein as a party line, there being other telephones such as the telephone at station B connected to the line. The ringers at these telephones may be bridged across the line, or as indicated herein the ring-

ers at some of the telephones may be connected between one side of the line and ground while the ringers at the other telephones are connected between the other side of the line and ground.

All the lines entering the exchange are divided into groups of ten lines each. The line of stations A and B is assumed to be line #1 of group #1 and its telephone number therefore is 11, insofar as the line selecting digits are concerned. The complete telephone number of each station includes an additional code selecting digit. Each group of lines is divided into two sub-groups, lines 1 to 5 comprising the first sub-group and lines 6 to 0 comprising the second sub-group.

For the purpose of controlling the finders, each group of lines is provided with three control relays, the control relays for the first group being indicated by reference numerals 19, 20 and 21. Of these relays, relay 19 is common to the first sub-group, relay 20 is common to the second sub-group, while relay 21 is common to all the lines of the first group. The drawings also show the control relays 22, 23 and 24 which are associated with the second group of lines.

The control relays exercise their control over the finders through the medium of an allotter, which determines the link circuit and finder to be used on each call. The allotter comprises relays 100 to 106, inclusive, and relays 111 to 120, inclusive, and as shown herein is wired for ten link circuits. This number can be increased by adding more relays to the group 111 to 120, these relays being individual to the respective link circuits.

Relay 71 is a connecting relay which is individual to the first link circuit. There is a similar relay for each of the other link circuits.

As previously stated, each link circuit comprises a finder and a connector. Each finder comprises a number of group relays equal to the number of groups of lines, five units relays, and a switching relay. The drawings shows only one group relay, being relay 41, which is assumed to be the first group relay. As shown, relay 41 only has four sets of contacts, but it will be understood that ten sets are provided, one set for each of the ten lines of the group. Relays 51 and 52 are the first and second units relays, the third, fourth and fifth units relays not being shown. Relay 55 is the switching relay.

Each group relay is adapted to connect the ten lines of the associated group to a group of ten intermediate trunks, one of which is the intermediate trunk comprising conductors 45, 46 and 47. Each units relay is adapted to select two of these intermediate trunks and the lines connected therewith and extend them to contacts of the switching relay 55. Thus units relay 51 is adapted to extend the first two intermediate trunks, to which lines 11 and 16 are connected when group relay 41 is energized, to the contacts of the switching relay. Similarly, the units relay 52 is adapted to extend the third and fourth intermediate trunks, to which lines 12 and 17 are connected when group relay 41 is energized. If the calling line is a line in the first sub-group, line 11 or 12, for example, the switching relay is not energized and the calling line is connected to the trunk line extending to the connector (conductors 60, 61 and 62) by way of back contacts of the switching relay. If the calling line is a line in the second sub-group, line 16 or 17, for example, the sub-group control relay such as 20 or 23 causes the switching relay 55 to energize, along with the proper group relay and units relay,

and the calling line is extended to the connector trunk by way of the front contacts of the switching relay.

The trunk conductors 60, 61 and 62 extend to Fig. 2, where they terminate in the connector of the first link circuit. These conductors are the two line conductors and the sleeve or test conductor. There is also a holding conductor 63 extending between the finder and connector. The conductor 64 comes from the allotter and is common to the connectors of all the link circuits.

The connector of the first link circuit is shown in Figs. 2 to 5, inclusive, and comprises the miscellaneous control relays 201 to 212, inclusive, Fig. 2, 300 to 306, inclusive, Fig. 3, and 403 to 406, inclusive, Fig. 4. The functions of these relays will be explained in the course of the general description. The connector also includes the two timer relays 401 and 402, Fig. 4. Relay 401 is a code switching relay. Relays 411 and 412 respond when the first digit dialled is the digit 2 and provide for two digit group selection as well as for controlling the code switching relay. Relays 408, 409, and 410 are counting relay control relays, and relays 501 to 510, inclusive, are counting relays. Relays 511 and 512 are connecting relays for connecting up the common trunk selecting equipment shown in Fig. 6 when a trunk number is called. Relay 513 is a relay in another connector corresponding to relay 512.

The connector is also provided with as many group relays as there are groups of lines, similar to the finder. Of these group relays the first, eighth, and ninth are shown in Fig. 3 where they are indicated by reference characters 311, 318 and 319, respectively. In addition to the group relays, there are five units relays and a switching relay. The first two units relays are shown and are indicated by reference characters 321 and 322, respectively. Relay 307 is the switching relay. It will be understood that each group relay in the connector has ten sets of line connecting contacts, like the group relays in the finder, although the drawings only show four sets of contacts on each group relay.

Fig. 3 also shows a number of lines which are accessible to the connector of the first link circuit and likewise to the connectors of the other link circuits. These lines will be described briefly.

The line comprising conductors 2', 3', and 4' is the line of station A and these conductors connect to the same numbered conductors in Fig. 1. The telephone number of this line is 11, as previously stated, and it is reached by way of contacts of the first group relay 311, contacts of the first units relay 321, and the back contacts of the switching relay 307.

The line comprising conductors 326, 327 and 328 is a party line, or rural line, and there may be twenty stations such as C and D on the line. The telephones at these stations are of the common battery type and the ringers are bridged across the line. Code ringing is employed for signalling. Stations C and D are indicated merely by circles for lack of room but it will be understood that the telephones may be of any suitable and well known type. At the exchange the line has the usual line equipment, including the line relay 309 and the cut-off relay 308. The line is accessible by way of contacts of the eighth group relay 318, contacts of the first units 321, and the front contacts of switching relay 307 and the line telephone number therefore is 86. Each station on the line has one or two additional

digits in its complete telephone number to control the ringing.

The line comprising conductors 329, 330, and 331 is a trunk line and is the first trunk line of a group of five trunk lines extending to a private branch exchange. The second trunk line of the group is the trunk line comprising conductors 332, 333, and 334. The other three trunk lines of the group are not shown. Each trunk line is provided with individual line equipment the same as a subscriber's line. At the branch exchange end the trunk lines may terminate in telephones or in a P. B. X switchboard of any suitable and well known type. The telephone number of this trunk line group is 81. When this number is dialled the first idle trunk of the group is connected with and is signalled automatically. Trunk lines 82 to 85, inclusive, may each have an individual listing also, which includes a ringing digit, and may be called individually the same as subscribers' lines. These individual trunk numbers may be used for night service.

The line comprising conductors 335, 336, and 337 is the first trunk line of a group of five trunk lines extending to a toll center. The second trunk line of the group is also shown and comprises conductors 338, 339, and 340. Access to the group is had by dialling the single digit 0. The first trunk line is shown complete in Figs. 7 and 8.

The equipment at the exchange end is shown in Fig. 7. Relays 721 and 720 are the usual line and cut-off relays. The conductors 335, 336, and 337 connect to conductors 722, 723 and 724, respectively, which terminate in the repeater comprising relays 701 to 715, inclusive, and the repeating coil R. Relays 716 to 719, inclusive, are relays of other repeaters and correspond to relay 704 of the repeater shown.

The inter-exchange section of the trunk line comprises the two conductors 725 and 726, which extend to Fig. 8, where the trunk line is provided with suitable terminal equipment. This equipment is located at the toll center and comprises relays 801 to 806, inclusive, a repeating coil R1, a trunk jack J1, a dialling jack J2, a line lamp L1, a busy lamp L2. The operator is provided with cord circuits, which are of well known type and are not shown herein. The operator also has a calling device CD, which may be connected to the dialling jack of a trunk line by means of the plug P. It will be understood that the trunk line may be multiplied to other operators' positions in known manner.

Referring now to Fig. 6, the equipment there shown is common to all the connectors and may be momentarily connected to any connector to enable the selection of an idle trunk when a trunk group is called. The equipment comprises a number of relays and circuit connections which will be explained briefly.

Relays 601 and 602 are associated with the group of trunks which extend to the toll center, the former relay being a connecting relay and the latter an all trunk busy relay. Relay 601 is energized momentarily when the trunk group is called and connects the marking conductors 641 to 645, inclusive, to conductors 731 to 735, inclusive, which extend to Fig. 7 where they terminate in contacts of the busy relays 704 and 716 to 719, inclusive. Conductor 736 also extends between Figs. 6 and 7 and serves to energize the all trunk busy relay 602 whenever all of the trunks to the toll center become busy.

Relay 603 is the connecting relay and relay 604 is the all trunk busy relay associated with the group of private branch exchange trunks; telephone number 81. When energized, relay 603 connects the marking conductors 641 to 645, inclusive, to contacts of the busy relays 611 to 615, inclusive. These busy relays are individual to the five private branch exchange trunks, respectively, and are connected to the test conductors of such trunks. Thus terminal 631 associated with relay 611 is connected to test conductor 331, Fig. 3, of the first trunk line of the group, and terminal 632 is connected to test conductor 334 of the second trunk line of the group, and so on.

Relays 620, 621, and 622 are also associated with the group of private branch exchange trunks. These relays function when a trunk of this group is connected with to transmit an impulse to the connector in use to start the ringing operation.

Fig. 9 shows three special interrupters 605, 606 and 607 which will be referred to as the pick-up, lock, and reverting call signal interrupters, respectively. They are common to all the connectors. As regards the connector shown herein, terminal 213, Fig. 2, and terminals 348 and 349, Fig. 3, are wired to terminals 610, 608, and 609, respectively, Fig. 9. The other connectors are wired to Fig. 9 in the same manner.

The reference characters 616 and 617 indicate two code interrupters. These interrupters are the first and eleventh code interrupters, respectively. There are eighteen more code interrupters, omitted for lack of space in the drawings, each generating a different code. All the code interrupters, also interrupters 605, 606, and 607 are assumed to be continuously rotating at slow speed and in synchronism with each other. It will be understood, however, that in actual practice suitable arrangements may be made for starting up this equipment only when required for ringing purposes.

Detailed explanation—station A calling station C

The operation of the system will now be described. For this purpose it will first be assumed that the subscriber at station A desires to call the subscriber at station C. The line number of the party line to which station C is connected is 86 and assuming that station C has been assigned the first of the twenty different ringing codes the complete telephone number of station C is 861.

When the receiver is removed at station A, a bridge is closed across the line conductors 2 and 3 and a circuit is completed for the line relay 6. Upon energizing, relay 6 grounds the individual marking conductor 16 and also grounds conductor 17, which is common to lines 1 to 5 of the first group, or to the first sub-group of the first group. The grounding of conductor 17 completes a circuit for the first group control relay 21 which may be traced from ground by way of contact 10 of the line relay 6, contact 13, conductor 17, winding of sub-group control relay 19, contact 37, winding of first group relay 21, contact 27, conductor 30, contacts of group relays not shown, contacts of the second group relay controlled at 29, contacts of the first group relay controlled at 23, conductor 31, contacts of relay 101 at the allotter, and resistance 38 to battery. Group control relay 21 is energized over the above circuit and locks itself at contact 28. At the same time, relay 21 disconnects battery from conductor 30, which pre-

vents all the other group control relays such as 24 from energizing responsive to calls that may be initiated in other groups. At contact 26 relay 21 places ground on the group marking conductor 36, thus preparing for energizing the first group relay such as 41 in the finder of the link circuit which is to be used for the call.

The sub-group control relay 19 is energized in series with the group control relay 21, and contact 40 opens the circuit of the sub-group control relay 20, thus preventing relay 20 from energizing in response to the grounding of conductor 18 which is common to lines of the second sub-group. Conductor 18, it will be understood, is grounded in response to the initiation of a call on any one of lines 6 to 0 of the first group. Relay 19 also connects the five individual marking conductors such as conductor 16 to five common units marking conductors such as 33. Since conductor 16 is grounded at contacts of the energized line relay 6, this operation prepares for energizing the first units relay such as 51 in the finder which will be used for the call.

The group control relay 21 also grounds the common conductor 39 extending to relay 109 in the allotter and this relay accordingly energizes. At its lower contacts relay 100 closes a circuit for the meter M, relay 77 being normally energized, and the meter is operated to register the call. The meter M may be referred to as an answered call meter and registers the total number of calls to which idle link circuits are assigned by the allotter. In explanation of the normally energized condition of relay 77 it may be pointed out that this relay is connected to the common conductor 64 which is grounded at all the idle connectors. Relay 77 will be energized therefore as long as any link circuit is available for use.

At its upper contacts relay 100 closes a circuit for relay 105, said circuit extending from ground by way of the upper contacts of relay 100, contact 80, contact 90, contact 88, and winding of relay 105 to battery. Upon energizing, relay 105 closes a circuit for relay 103 over a path extending from ground by way of contact 87, contact 78 and lower winding of relay 103 to battery. Upon energizing relay 103 closes a locking circuit for itself extending from ground by way of contact 83, upper winding of relay 102 and lower winding of relay 103 to battery. Relay 102 does not energize over this locking circuit for the time being since the junction of the windings of relays 102 and 103 is directly grounded at the contacts of relay 105. Relay 103 also breaks the circuit of relay 105 at contact 90, and at contact 81 closes a circuit for relay 111. The latter circuit extends from ground by way of chain contacts of relays 120, 119, 118, etc., contact 81 of relay 103 and winding of relay 111 to battery. Upon energizing, relay 111 locks itself to the chain circuit at contact 92, prepares a circuit for relay 112 at contact 91, and prepares a circuit for the connecting relay 71 at contact 94. Relay 111, it may be mentioned, is associated with the first link circuit.

When relay 105 falls back, it breaks the initial energizing circuit for relay 103, thereby removing the short circuit from the upper winding of relay 102, and the latter relay accordingly energizes. A circuit is now completed for the connecting relay 71, extending from ground by way of the upper contacts of relay 100, contact 80, contact 90, winding of relay 106, contact 86, contact 94,

busy key BK, and winding of relay 71 to battery. Relay 106 is included in the above circuit and being a fast operating relay it pulls up and breaks the branch circuit to relay 105 before the latter relay has time to operate. Relay 106 also places ground on the common conductor 64. Relay 71 is the connecting relay which is associated with the first link circuit and when energized over the above traced circuit it connects the group and units marking conductors to their respective relays in the finder of the first link circuit. Relay 71 also connects battery to conductor 67 at contact 74, and at contact 76 prepares a circuit for relay 104 of the allotter.

The connection of battery to conductor 67 completes a circuit for the line relay 204 of the connector of the first link circuit by way of said conductor 67, trunk conductor 60, contact 215, contacts of reversing relay 202, and winding of line relay 204 to ground. Upon energizing, relay 204 closes a circuit for the slow acting release relay 205, said circuit including contacts 225 and 218. Upon energizing, relay 205 places ground on the sleeve or test conductor 62 over a path extending from ground by way of contact 355, contact 349, conductor 281, and contact 227 to the said test conductor 62. Relay 205 also grounds the holding conductor 63 over a path extending from ground by way of contacts controlled at contact 425 of relay 402, conductor 291, and contact 229 to said holding conductor 63.

When the marking conductors are connected up by the energization of relay 71, a circuit is completed at contact 72 for the group relay 41 over the grounded group marking conductor 36, and also a circuit is completed over the grounded units marking conductor 33 for the units relay 51. Relays 41 and 51 accordingly energize and lock themselves to the holding conductor 63 at contacts 70 and 54. At contact 53 relay 51 disconnects battery from the other units relays such as 52. At its contacts 42, 43 and 44, relay 41 extends the line and test conductors of the calling line to the intermediate trunk conductors 45, 46, and 47, and at its contacts 48, 49 and 50, relay 51 extends these intermediate trunk conductors through back contacts of the switching relay 55 to the trunk conductors 60, 61 and 62 extending to the connector. The line relay 204 of the connector is now held energized over the calling line loop in series with the impedance coil 203, independent of its initial energizing circuit from the allotter.

The test conductor 62 being grounded, a circuit is now established for the cut-off relay 5 over conductors 62, 47 and 4, and said cut-off relay is energized. The line relay 6 is thus disconnected from the calling line and is deenergized. The lockout relay 7 energizes in series with relay 5, but without particular effect at the moment.

When the holding conductor 63 is grounded, the circuit for relay 104 which was prepared at contact 76 of relay 71 is completed by way of conductor 75, contact 76, and conductor 65. Upon energizing, relay 104 closes a circuit for relay 101, which energizes in turn and disconnects battery from conductor 31, thereby deenergizing relays 21 and 19. When relay 21 falls back it opens the circuit of relay 100, which deenergizes and opens the circuit of meter M, also the circuit of relays 106 and 71. When relay 71 falls back, it disconnects the marking conductors, disconnects battery from conductor 67, and opens the circuit of relay 104. Relays 104 and 101 now deenergize in succession but are slow acting and

accordingly battery is maintained disconnected from conductor 31 for a brief interval sufficient for the operation of the allotter in assigning a link circuit for the next call.

The operation of the allotter is initiated by the deenergization of relay 71, which closes a circuit for relay 103 over a path extending from the grounded holding conductor 63 by way of conductor 75, contact 76, conductor 142, contact 93 of relay 111, contact 79, contact 78, contact 84, and upper winding of relay 103 to battery. Relay 103 is differentially wound and now deenergizes due to the opposing effects of its upper and lower windings. When relay 103 falls back the circuits of both windings are opened, at contacts 93 and 84. The circuit of the upper winding of relay 102 is also opened at contact 33 but this relay remains energized over a branch of the previously traced circuit, said branch extending from contact 78 through the lower winding of relay 102 to battery.

When relay 103 deenergizes it closes a circuit for relay 112 extending from the grounded conductor 64 by way of contact 82, contact 91, and winding of relay 112 to battery. On energizing, relay 112 prepares a circuit for relay 113, and locks itself at contact 96. Also at contact 96 relay 112 opens the locking circuit of relay 111, which deenergizes and breaks the circuit through the lower winding of relay 102. The latter relay accordingly deenergizes also.

It will be convenient at this point to consider the operation of the allotter responsive to succeeding calls before continuing with the explanation of the establishment of the connection from station A. When the next call comes in relay 109 is energized as before and closes a circuit extending from ground by way of its upper contacts, contact 80, contact 90, winding of relay 106, contact 86, contact 94, contact 95, and conductor 121 to the connecting relay in the second link circuit, said connecting relay corresponding to relay 71 of the first link circuit. Upon the energization of the second connecting relay, the finder of the second link circuit is operated to connect with the calling line. When the holding conductor of the second link circuit is grounded, ground is applied to common conductor 65 and relay 104 is energized, also relay 101, with results previously described. Upon the deenergization of relay 100, the circuit of the second connecting relay is broken and it deenergizes, breaking the circuit of relay 104. The deenergization of the second connecting relay also closes a circuit for relay 103, extending from the grounded holding conductor of the second link circuit by way of a conductor corresponding to conductor 75, contact of the second connecting relay corresponding to contact 76, conductor 110, contact 97, contact 73, contact 78, and lower winding of relay 103 to battery. Upon energizing, relay 103 closes a locking circuit for itself at contact 83 and closes a circuit for relay 113 at contact 82. The latter circuit extends from grounded conductor 64 by way of contact 82, contact 95, and winding of relay 113 to battery. Upon energizing, relay 113 prepares a circuit for relay 114 at contact 122, locks itself at contact 123, and at the same contact breaks the locking circuit of relay 112. Relay 112 accordingly deenergizes and breaks the initial energizing circuit of relay 103, said relay remaining energized over its locking circuit, which now energizes relay 102. Relays 102, 103, and 113 remain energized awaiting the next call.

When the third call comes in, relay 100 ener-

gizes and closes a circuit extending through its upper contacts, contact 80, contact 90, relay 106, contact 86, contact 94, contact 98, contact 125, and conductor 127 to the connecting relay of the third link circuit. The third connecting relay accordingly energizes and brings about the operation of the finder in the third link circuit to connect with the calling line. Conductor 65 is grounded as before, causing the energization of relays 104 and 101 and the deenergization of relay 100. The latter relay breaks the circuit of the third connecting relay, which deenergizes and breaks the circuit of relay 104, also placing ground on conductor 126. The latter operation completes a circuit for the upper winding of relay 103 extending by way of grounded conductor 126, contact 124, contact 79, contact 78, contact 84, and upper winding of relay 103 to battery. Current flow over this circuit deenergizes relay 103 by differential action, while a branch circuit through the lower winding of relay 102 holds this relay energized, as previously explained. The deenergization of relay 103 closes a circuit for relay 114, extending from grounded conductor 64 by way of contact 82, contact 122, and winding of relay 114 to battery. Upon energizing, relay 114 prepares a circuit for relay 115 at contact 128, locks itself at contact 129, and at the same contact opens the locking circuit of relay 113. Upon deenergizing, relay 113 breaks the holding circuit of relay 102 and this relay accordingly deenergizes also.

From the explanation so far it will be appreciated that relay 103 is an impulsing relay for controlling the relays 111 to 129, inclusive, of the allotter, being assisted in this function by relay 102. These relays are energized and deenergized responsive to the first call, are energized responsive to the second call, deenergized responsive to the third call, etc. Relay 111 is controlled over a special circuit including contact 81 of relay 103. Of the remaining relays 112 to 129, inclusive, the even numbered relays are controlled at the back contact 82, while the odd numbered relays are controlled at the front contact 82.

When the fourth call comes in relay 100 energizes and closes a circuit over conductor 132 for the connecting relay of the fourth link circuit. This relay accordingly energizes and the finder of the fourth link circuit connects with the calling line. Conductor 65 is grounded as on previous calls and relays 104 and 101 are energized. Relay 100 then deenergizes and breaks the circuit of the fourth connecting relay. When this relay deenergizes, ground is applied to conductor 131 and a circuit is completed through the lower winding of relay 103. On energizing, relay 103 locks itself at contact 83 and at contact 82 closes a circuit for relay 115. On energizing relay 115 locks itself and breaks the locking circuit of relay 114, which deenergizes and breaks the initial energizing of relay 103, permitting relay 102 to energize over the locking circuit of relay 103. Relays 102, 103, and 115 are now in energized condition.

It will be assumed now that the fifth to ninth link circuits, inclusive, are busy. Accordingly there will be a ground on conductor 133, through a back contact of the fifth connecting relay (corresponding to back contact 76 of the first connecting relay), and conductors 134 to 137, inclusive, will be similarly grounded.

When relay 102 energizes under the foregoing circumstances, a circuit is completed over the grounded conductor 133 for the upper winding of

relay 103 and also for the lower winding of relay 102, deenergizing the former relay and holding the latter. On falling back, relay 103 operates relay 116, which locks itself and breaks the locking circuit of relay 115. On deenergizing, relay 115 breaks the holding circuit of relay 102 and this relay deenergizes.

On deenergizing, relay 102 completes a circuit over the grounded conductor 134 for the lower winding of relay 103, which locks itself and operates relay 117. Relay 117 locks itself and breaks the locking circuit of relay 116, which deenergizes and breaks the initial energizing circuit of relay 103. Relay 102 now energizes over the locking circuit of relay 103.

On energizing, relay 102 completes a circuit for its lower winding and for the upper winding of relay 103, said circuit including the grounded conductor 135. Relay 103 accordingly deenergizes by differential action and operates relay 118, which locks itself and breaks the locking circuit of relay 117. On deenergizing, the latter relay opens the holding circuit of relay 102 and this relay deenergizes.

On deenergizing, relay 102 again completes a circuit for the lower winding of relay 103, this time over grounded conductor 136. On energizing, relay 103 locks itself and operates relay 119, which locks itself and breaks the locking circuit of relay 118. On deenergizing, relay 118 breaks the initial energizing circuit of relay 103, whereupon relay 102 energizes in the locking circuit of relay 103.

On energizing, relay 102 closes a circuit for the upper winding of relay 103 over grounded conductor 137, thereby deenergizing said relay, relay 102 holding up over its lower winding. The deenergization of relay 103 operates relay 120, which locks itself at contact 138 and breaks the locking circuit of relay 119. On deenergizing, relay 119 breaks the holding circuit of relay 102, which deenergizes. In energized position relay 120 prepares a circuit at contact 139 for the connecting relay of the tenth link circuit.

The foregoing operations in which the allotter searches for an idle link circuit take place very rapidly, well within the deenergizing time of relays 104 and 101. When the next call comes in, relay 100 energizes and closes a circuit over conductor 141 for the connecting relay of the tenth link circuit. This relay accordingly energizes and the finder of the tenth link circuit connects with the calling line. Ground is applied to conductor 65 as previously described and relays 104 and 101 are energized. When relay 100 deenergizes, the circuit of the tenth connecting relay is broken and this relay falls back, grounding conductor 140 and closing a circuit for the lower winding of relay 103. Relay 103 energizes, locks itself, unlocks relay 120, and prepares a circuit for relay 111. Relay 111 energizes and locks itself over the chain circuit as soon as this circuit is closed by the deenergization of relay 102. The deenergization of relay 120 also breaks the initial energizing circuit of relay 103, whereupon relay 102 energizes over the locking circuit of relay 103. Assuming now that the first link circuit has become idle, there will be no ground on conductor 142 and relays 103 and 102 will remain energized, maintaining the first link circuit assigned for use on the next call. Subsequent calls are handled by the allotter in the manner described.

In case a link fuse is blown, the link is passed up by the allotter as in the case when the link is busy. It may be assumed, for example, that

the fuse for the first link is blown, which means that battery is disconnected from the various relays of the link, including relay 71. When the next call comes in, therefore, and relay 100 is energized, the said relay cannot close the usual circuit through relays 106 and 71. Relay 106 not being energized, the branch circuit through relay 105 is effective and this relay grounds contact 79 of relay 102, thereby completing a circuit for holding relay 102 and deenergizing relay 103. On deenergizing, relay 103 breaks the circuit of relay 105 and closes a circuit for relay 112, the latter relay locking and opening the circuit of relay 111. When relay 105 deenergizes it opens the holding circuit of relay 102, which deenergizes and completes the usual circuit for connecting relay of the second link circuit over conductor 121. That is, this circuit is completed provided the fuse for the second link circuit is all right. If the fuse is blown the circuit will not be completed, relay 106 will not energize, and relay 105 will operate to control relays 103 and 102 in the manner explained.

When all the link circuits are busy there is no ground on conductor 64 and the allotter is thus prevented from performing futile searching operations. When the last link is taken for use by energization of its associated connecting relay such as 71, the last connector ground is removed from conductor 64. Relay 106, however, energized in series with the connecting relay, maintains another ground on conductor 64 until it falls back upon the deenergization of relay 100. Thus relay 77 is maintained energized until the call is disposed of by the allotter and false operation of the overflow meter M1 is prevented. If another call comes in before a link circuit becomes idle, the energization of relay 100 will operate meter M1.

Returning now to the connection being set up from the calling station A to the called station C, the calling line has been extended to the connector of the first link circuit by operation of the associated finder and the line relay 204 is energized over the calling line loop in series with the impedance coil 203. Relay 205 is energized as previously explained. Relay 207 is also energized, being connected to the ground test conductor 62 through contact 243 of relay 208. In energized position, relay 207 removes the first link circuit ground from conductor 64 at contact 236. Relay 207 also grounds the holding conductor 269 at contact 238.

Dial tone is connected to the calling line over a path which may be traced from conductor 60 of the calling line by way of contact 215, contact 226, condenser 282, contact 245, conductor 267, contact 325, contact 356, conductor 483, contact 469, and contact 446 to the conductor labeled "Dial tone" in Fig. 4, which extends to the dial tone generator. The calling subscriber is informed by the characteristic tone in his receiver that he can start dialling the digits of the called numbers.

The first digit in the number of the called station C is the digit 8. When the calling device at station A is operated in accordance with this digit, a series of eight interruptions is produced in the calling line loop, causing the line relay 204 to deenergize momentarily eight times and transmit a series of eight impulses to the counting relays in Fig. 5. The impulsing circuit may be traced from ground by way of contact 218 of relay 201, contact 225 of line relay 204, contact 237, conductor 266, contact 351, contact

347, conductor 375, contact 520, conductor 376, contact 451, contact 454, contact 457, conductor 434, and winding of first counting relay 501 to battery. This is the circuit over which the first impulse is transmitted. The other impulses are transmitted over the same circuit except that it includes a different counting relay for each successive impulse, as will be explained. The slow acting change over relay 306, Fig. 3, is connected to conductor 376 of the impulsing circuit and energizes on the first impulse, remaining energized thereafter until the series of impulses is completed. At its contact 357, relay 306 short circuits the impedance coil 203 to improve the dialling circuit. At contact 358, relay 306 shunts contact 520. Relay 406 is also connected to conductor 376 and energizes responsive to the first impulse. This relay is not slow acting but is held energized throughout the series of impulses over conductor 480, which is connected to grounded conductor 260 at contact 360 of relay 306. Conductor 260, it will be recalled, has been grounded at contact 238 of relay 207. The operation of relay 406 in response to the first series of impulses has no particular effect.

Counting relay 501 energizes in response to the first impulse, prepares the circuit for the second counting relay 502 at contact 515, and closes a locking circuit for itself at contact 516. This locking circuit may be traced from grounded conductor 260 by way of contacts controlled at 443 (relay 404), contacts controlled at 467, contact 441, contact 456, winding of relay 410, conductor 488, contact 516, and winding of relay 501 to battery. The locking circuit becomes effective as soon as the first impulse is terminated, whereupon relay 110 is energized and transfers the impulsing circuit to relay 502 by way of contact 457, conductor 485, and contact 515.

Counting relay 502 is energized by the second impulse, prepares the circuit for the third counting relay 503 at contact 521, and closes a locking circuit for itself at contact 522. This locking circuit is the same as the locking circuit of relay 501, previously traced, except that it includes conductor 490, relay 409, and contact 453. At the termination of the second impulse relay 409 energizes in series with relay 502 and transfers the impulsing circuit to counting relay 503 by way of contact 454, conductor 486, and contact 521. Relay 409 also breaks the locking circuit of relay 501 at contact 456, whereupon relays 501 and 410 are deenergized. The circuit to battery through relays 410 and 501 is of high impedance and accordingly is shunted by a resistance as indicated in the drawing in order to suppress sparking at contact 456. The other two locking circuits are similarly provided with spark suppressor circuits.

Counting relay 503 is energized by the third impulse, prepares the circuit of relay 504 at contact 523, and closes a locking circuit for itself over contact 524, conductor 491, relay 408, and contact 459. At the termination of the impulse relay 408 energizes in series with relay 503 and transfers the impulsing circuit to relay 504 by way of contact 451, conductor 487, and contact 523. Relay 408 also breaks the locking circuit of relay 502 at contact 453, thereby deenergizing relays 502 and 409.

The operation of the counting relays continues in this manner until finally counting relay 508 is energized by the eighth impulse. Relay 508 locks itself at contact 525, over conductor 490

and relay 409, and the latter relay energizes in the locking circuit at the termination of the impulse. The preceding counting relay 507 and relay 410 are deenergized by the opening of contact 456 of relay 409. Thus at the completion of the series of impulses relays 508 and 409 remain energized.

Relays 306 and 406 restore at the end of the series of impulses and the former relay closes a circuit for the eighth group relay 318 over a path which extends from grounded conductor 260 by way of contact 360, conductor 481, contact 455 of relay 409, contact 437, contacts controlled at 443, contact 444, conductor 494, contact 523 of relay 509, conductor 382, and winding of relay 318 to battery. On energizing, relay 318 connects conductor 382 to conductor 499 at contact 337, thereby closing a circuit for relay 405 which extends from the grounded conductor 382 by way of contact 337, conductor 420, and winding of relay 405 to battery. Upon energizing, relay 405 locks itself at contact 442 to grounded conductor 260 and thereby extends ground back over its initial energizing circuit to the group relay 318. Thus relays 405 and 318 are locked in parallel to grounded conductor 260.

Other results of the energization of relay 405 that may be noted at this time are the opening of the dial tone circuit at contact 446 and the opening of the locking circuit of relays 508 and 409 at contact 441. Relays 508 and 409 accordingly deenergize and the counting relays are thus prepared for receiving the next series of impulses. Also at contact 443 relay 405 disconnects the marking circuit from the group marking conductors and connects it instead to contact 459, whence it is later extended to the units marking conductors.

As a result of the energization of the group relay 318, the ten lines 31 to 33, inclusive, are connected into the link circuit. One of these lines is line 33, the line of the called station C.

The second digit of the called number is the digit 6. When the calling subscriber dials this digit, a series of six interruptions is produced in the calling line loop and the line relay 204 is momentarily deenergized six times to transmit a series of six impulses to the counting relays. These impulses are transmitted over the same circuit as the preceding series. Relays 306 and 406 energize as before and remain energized throughout the series of impulses. Relay 406, in fact, locks itself to conductor 260 at contact 442, relay 405 being energized.

The counting relays respond to the second series of impulses the same as before, except that the locking ground is supplied to contacts of relays 408, 409, and 410 from conductor 260 by way of contact 447 of relay 406. The last impulse of the series energizes relay 506, which locks itself at contact 527 in series with relay 408. The second series of impulses therefore results in the energization of relays 506 and 408.

At the end of the second series of impulses relay 306 falls back, but relay 405 remains energized, the latter relay being locked through contact 441 of relay 405 as previously mentioned. Upon deenergizing, relay 306 closes a circuit for the units relay 321 which extends from grounded conductor 260 by way of contact 360, conductor 481, contact 452 of relay 409, contact 437, contact 443, contact 450, conductor 492, contact 523 of relay 506, conductor 377, and winding of relay 321 to battery. Upon energizing, relay 321 connects the now grounded conductor

377 to conductor 476, and thereby closes a circuit for relay 404 extending over conductor 476 and through the winding of relay 404 to battery. Upon energizing, relay 404 locks itself and relay 321 to grounded conductor 260 at contact 438.

It is necessary now to explain the operation of relay 300. This relay is energized during the dialling of the first digit in parallel with counting relay 506, said relays being connected over conductor 374. When relay 300 is thus energized, it locks itself at contact 314 over conductor 478, which connects with the counting relay locking circuit Fig. 4. Accordingly relay 300 is unlocked and deenergized along with counting relay 508 following the energization of relay 405. The operation of relay 300 responsive to the dialling of the first digit is without effect. Relay 300 also energizes in parallel with relay 506 when the second digit is dialled and locks itself over conductor 478 as before. Now when the marking circuit is closed at contact 360 of relay 306 for energizing the units relay 321, a branch of said marking circuit is also closed which may be traced from junction 4501 to the left over conductor 492 and thence by way of contact 433, contact 432, conductor 474, contact 313 of relay 300, and winding of the switching relay 307 to battery. Relay 307 is thus energized in parallel with relay 321. On energizing, relay 307 closes a locking circuit for itself which extends to grounded conductor 260 by way of contact 354, conductor 477, and contact 442 of relay 405 to conductor 260.

Returning now to relay 404, the energization of this relay opens the marking circuit at contact 437, and opens the locking circuit of relay 406 at contacts controlled by contact 438. Relay 406 accordingly deenergizes, breaking the locking circuits of relays 506, 408, and 300, which deenergize also. In addition to the foregoing, relay 406 closes a circuit for relay 493, extending from grounded conductor 260 by way of contact 447, contact 436, conductor 286, contact 224, conductor 288, and upper winding of relay 403 to battery. Upon energizing, relay 403 locks itself at contact 429 and prepares a holding circuit for relay 406 at contact 431.

The energization of units relay 321 selects lines 81 and 86 of the ten lines 81 to 90 selected by the group relay 313. The energization of the switching relay 307 selects line 86 of the two lines selected by the units relay. The line selection has accordingly been completed and the equipment is ready for the dialling of the third or code selecting digit.

The code selecting digit is the digit 1. When the dial at the calling station is operated in accordance with this digit, a single interruption is produced in the line circuit and the line relay 204 is momentarily deenergized once, thereby transmitting a single impulse over the impulsing circuit and energizing counting relay 501, which locks itself in series with relay 410 at the termination of the impulse. The counting relay holding circuit, over which relay 501 locks itself, is grounded by relay 406 at contact 447, relay 406 being energized over the impulsing circuit as before. On energizing, relay 406 locks itself over the holding circuit prepared by relay 493, said circuit extending from grounded conductor 260 by way of contact 250 of relay 210, conductor 289, contact 431, contact 441, contact 449, and upper winding of relay 406 to battery.

Relay 306 energizes over the impulsing circuit in response to the dialling of the third digit,

the same as on the previous digits, and closes a circuit for testing the called line, said circuit extending from grounded conductor 260 by way of contact 359, conductor 258, contact 228, conductor 259, upper winding of test relay 303, and contacts of relays 307, 321 and 318 to the test conductor 328 of the called line. If the line is busy there will be a ground potential on the test conductor and test relay 303 will fail to energize. This is the case also if the test conductor is open, or if the line group fuse is blown.

Assuming that test relay 303 does not energize, when relay 306 falls back at the end of the third digit a circuit is completed for the busy relay 305 over a path which may be traced from grounded conductor 260 by way of contact 359, contact 345, conductor 479, contact 448, contact 428, contact 287, contact 230, conductor 277, and upper winding of busy relay 305 to battery. Upon energizing, relay 305 locks itself to conductor 260 at contact 354, opens the impulsing circuit at contact 351, and connects busy tone to trunk conductor 60 at contact 356. The circuit may be traced from conductor 60 by way of contact 215, contact 226, condenser 282, contact 245, conductor 267, contact 325, and contact 356 to the busy tone generator. The calling subscriber is thus given the busy signal.

If the called line is idle there will be a battery potential on the test conductor 328, due to its connection through the winding of cut-off relay 308 to battery. Assuming that the line is idle when called, when the relay 306 closes the test circuit during the dialling of the third digit, the test relay 303 energizes and locks itself to grounded conductor 62 at contact 344. The test relay 303 also prepares a circuit for relay 304 at contact 345 and at contact 343 places direct ground on the test conductor 328 of the called line. The cut-off relay 308 now energizes and disconnects the line relay 309.

When relay 306 restores at the end of the third digit it opens the test circuit and closes the prepared circuit of relay 304 at contact 359. On energizing, relay 304 opens the impulsing circuit at contact 347, prepares a circuit for the pick-up relay 301 at contact 348, and closes contacts 346 and 350 in the talking circuit. This circuit is still open at contacts of relay 211, but the operation of relay 304 effects the necessary preparation for signalling the called station.

As previously explained, terminals 348 and 349, Fig. 3, are connected to terminals 608 and 609, respectively, in Fig. 9. When the pick-up interrupter 605 grounds terminal 608, a circuit is completed which extends by way of terminals 608 and 348, contacts controlled at contact 324, conductor 299, contact 254, contact 248, conductor 276, contact 348, and winding of pick-up relay 301 to battery. Upon energizing, relay 301 locks itself at contact 324, since terminals 349 and 609 are now grounded at the lock interrupter 606, Fig. 9. When the interrupters have made somewhat more than one half of a complete rotation, ground is removed from terminal 609 and relay 301 is deenergized. It energizes again when the pick-up interrupter 605 grounds terminal 608, from which it will be seen that the relay is intermittently energized and deenergized while the circuits remain in their present condition. The energization periods of relay 301 are the ringing periods.

During each ringing period the code interrupter 616 operates the ringing relay 302 over a circuit which may be traced from ground by

way of interrupter 616, conductor 654, contact 461 of relay 407, conductor 472, contact 514 of counting relay 501, conductor 372, contact 320, and winding of ringing relay 302 to battery. Interrupter 616 is arranged to close this circuit once during each ringing period, the first code being one long ring. The ringing relay 392 energizes each time its circuit is closed and completes a ringing circuit over the called line which may be traced from the ringing generator by way of conductor 399, contact 317 of relay 301, contact 341 of relay 302, contact 312, conductor 270, contact 251, conductor 262, contact 346, contacts of relays 307, 321, and 318, conductor 326 of the called line, the ringer at station C, line conductor 327, contacts of relays 318, 321, and 307, contact 350, conductor 279, contact 255, conductor 272, contact 315, contact 342, contact 316, conductor 269, and windings of relay 212 to battery. The exchange battery and the ringing generator are connected in series in this circuit, the generator being grounded. The ringer at station C signals the called subscriber each time the ringing circuit is closed. At the same time that the called subscriber is signalled a ringing signal is given the calling subscriber by connecting the generator lead to trunk conductor 60 at contact 325.

Relay 212 is the ring trip relay and will not operate effectively on ringing current but will operate if the receiver at the called station is removed during the ringing period. Relay 212 will also operate if the receiver is removed during a silent period, when the ringing relay is deenergized. Assuming that the receiver is removed at a time when the ringing relay is deenergized, the circuit for relay 212 may be traced from ground by way of contact 341, contact 312, conductor 270, contact 251, conductor 262, contact 346, contacts of relays 307, 321, and 318, line conductor 326, station C, line conductor 327, contacts of relays 318, 321, and 307, contact 350, conductor 279, contact 255, conductor 272, contact 315, contact 342, conductor 269, and winding of relay 212 to battery.

When the ring trip relay 212 energizes it connects the grounded conductor 63 to relay 211 at contact 256. Upon energizing, relay 211 locks itself to conductor 260 at contact 253, opens the circuit of the pick-up relay 301 at contact 254, and completes the talking circuit at contacts 251 and 255. The latter operation bridges the battery feed relay 210 across the called line in an obvious manner and this relay accordingly energizes over the called line, the receiver at station C having been removed.

When relay 210 energizes it connects the grounded conductor 260 to the reversing relay 202, which energizes and reverses the incoming trunk conductors 60 and 61 as regards their connections to 204 and 203, thus reversing the direction of current flow over the calling line. This operation is of no importance in the call being described. Relay 210 also opens the locking circuit of relay 406 at contact 250, this relay deenergizing and removing ground from the counting relay holding circuit. Relays 501 and 410 accordingly deenergize. The reversing relay 202 opens the locking circuit of relay 403 at contact 224 and relay 403 deenergizes.

The connection from station A to station C has now been completed, the called party has answered the call, and conversation may take place in the usual manner. The talking circuit is conventional and will not be traced in detail.

The release of the connection is under the control of the calling subscriber. When the receiver is replaced at station A, the D. C. bridge across the calling line is opened and the line relay 204 is deenergized. The line relay breaks the circuit of the release relay 205, which deenergizes an instant later, removing ground from the test conductor 62 and the holding conductor 63, the removal of ground from conductor 62 opening the circuit of relay 207. This relay now deenergizes and removes ground from conductor 250. These operations open the holding or locking circuits of all energized relays in the finder and connector and the equipment is restored to normal. These restoring operations will not be gone over in detail as they will readily be understood from the explanation of the various locking and holding circuits established during the setting up of the connection.

"Permanent" timing

When a line becomes bridged due to some abnormal cause such as the receiver being accidentally knocked off or the line being short-circuited, a call is initiated the same as when the receiver is removed by the subscriber preparatory to making a call. Such a false call is known as a "permanent," for it will cause a link circuit to be tied up indefinitely unless arrangements are provided to prevent such result. The release of a link circuit when held by a "permanent" will now be explained.

For this purpose it may be assumed that the line conductors 2 and 3 of the line of station A become short-circuited due to a case of trouble on the line. The establishment of the short-circuit causes the line relay 6 to energize with the result that the finder of an idle link circuit is operated to connect with the line, exactly as described in the case of the subscriber at station A making a regular call to station C. Assuming that the first link circuit is used, the line will be extended to the connector shown in Figs. 2 to 5, inclusive, and relays 204, 205, and 207 will be energized.

The interrupters 413 to 417, inclusive, are used for controlling certain timing operations, including the timing of all calls arriving at link circuits in order to determine if such calls are "permanents" or not. The interrupters may be continuously rotated in the direction of the arrows at a speed of about one complete rotation every two minutes. The interrupters are common to all the connectors.

When the interrupter 414 grounds the P1 conductor a circuit is completed for relay 402, extending from ground by way of 414, conductor P1, conductor 297, contact 223, conductor 296, contacts controlled at 423, conductor 294, contact 239, contact 219, contact 221, conductor 292, and winding of relay 402 to battery. From contact 219 the circuit may also be traced to relay 402 by way of conductor 284 and contact 430 of relay 403. Upon energizing, relay 402 locks itself at contact 423. In addition, relay 402 disconnects direct ground from conductor 291 and substitutes conductor CoG, which is now grounded at interrupter 416.

After about two minutes the interrupter 416 removes ground from conductor CoG. This operation removes ground from conductor 291 and from the holding conductor 63, releasing relays 41 and 51 in the finder. The energized connector relays 204, 205 and 207 now release, the latter relay breaking the circuit of relay 402. The cut-

off relay 5 is also deenergized and connects the line relay 6 across the line. Relay 7 is slow acting, however, and holds up long enough to enable the line relay 6 to energize over the short-circuited line and close a locking circuit for relay 7 at contact 10. Relays 6 and 7 accordingly remain energized until the trouble is cleared, relay 7 preventing the operation of another finder by holding open its contacts 12 and 13. It will be understood that an alarm circuit may be provided if desired, arranged to be grounded when relays 6 and 7 are both energized.

Conversation timing

The connector circuits are so arranged that after a conversation has continued for about 5½ to 7½ minutes a warning signal is given the subscribers engaged in the call, notifying them that the connection is about to be released. If the calling subscriber does not hang up, the connection is released automatically after an interval of about one-half minute more. The manner in which these operations are performed will now be described.

For this purpose the previously described connection between stations A and C will again be considered. It will be recalled that the removal of the receiver at station A brought about the operation of the finder in the first link circuit to extend the calling line to the connector, where relays 204, 205, and 207 were energized. It has also been explained, in connection with the permanent timing feature, how the grounding of the P1 conductor causes the energization and locking of relay 402. On a regular call this operation may not take place, since conductor P1 is grounded at two minute intervals and less than that time is usually required to complete the establishment of a connection. Whether conductor P1 is grounded or not before the connection can be completed obviously depends on the position of the interrupter 414 at the time the connector is taken for use, as well as on the time required to complete the connection.

Assuming that relay 402 becomes energized, the locking path over conductor 284 which was previously mentioned is broken at contact 430 when relay 403 energizes following the dialling of the second digit in the called number. When the called line is tested and found idle, relay 304 is energized as previously explained and at contact 349 removes direct ground from the test conductor 62. This conductor remains grounded, however, through the upper winding of relay 206, which energizes due to current flow through the cut-off relay of the calling line. Relay 206 locks itself at contact 234 to grounded conductor 260, places direct ground on the test conductor 62 at contact 233, and prepares a circuit for relay 401 at contact 235.

When the called subscriber answers relays 210 and 202 are energized, and at contact 221 the latter relay breaks the branch of the locking circuit of relay 402 which extends over conductor 292. Relay 402 accordingly deenergizes. At contact 224 relay 202 breaks the locking circuit of relay 403 which deenergizes and at contact 430 prepares the conductor 284 locking circuit for relay 402 in order to lock that relay when it is again energized.

When interrupter 413 grounds the P2 conductor a circuit is completed for relay 401, said circuit extending from ground by way of 413, conductor P2, conductor 298, contact 235, conductor 299, contact 426, contacts controlled at 420, and

winding of relay 401 to battery. Upon energizing, relay 401 locks itself to grounded conductor 260 at contact 420.

When interrupter 414 grounds conductor P1, after approximately one rotation of the interrupters, a circuit is closed for relay 402, extending from ground by way of 414, conductor P1, contact 418, contacts controlled at 423, conductor 294, contact 239, contact 219, conductor 284, contact 430, and winding of relay 402 to battery. Upon energizing, relay 402 locks itself at contact 423. In addition, relay 402 breaks the initial energizing circuit of relay 401 at contact 426 and at contact 424 substitutes grounded conductor H2 for conductor 260 in the locking circuit of relay 401. It will be observed that conductor 291 is still connected to direct ground, by way of contacts 425 and 421.

Upon one more rotation of the interrupters, ground is removed from conductor H2 and relay 401 is deenergized. At contact 421 and contacts controlled thereby relay 401 substitutes the grounded conductor CoG for direct ground on conductor 291, and at contact 419 the relay prepares a circuit for the busy relay 305 in Fig. 3.

When the interrupters have made about one-half of a rotation more the circuit for the busy relay 305 is completed by interrupter 415, said circuit extending from ground by way of 415, conductor TP, contact 419, contact 422, conductor 295, contact 222, conductor 271, and upper winding of busy relay 305 to battery. The busy relay energizes for a brief instant while conductor TP remains grounded and connects busy tone to the trunk conductor 60. This operation gives the conversing subscribers a signal warning them that the connection is about to be released.

When the interrupters complete the third rotation, ground is removed from conductor CoG, over which ground is being supplied to conductors 291 and 63, and the connection is released as described in connection with the "permanent" timing feature. The line relay 6 and lockout relay 7 are held energized, however, only until the calling subscriber hangs up his receiver, which he will do as soon as he finds that he has been disconnected. The replacement of the receiver permits relays 6 and 7 to deenergize and restore the line to normal condition, whereupon another call can be made or the same connection can be re-established.

It will be noticed that the initiation of conversation timing is dependent upon the energization of relay 206. On a call from the toll center direct ground is supplied to the test conductor from the repeater, as will be explained subsequently, and accordingly relay 206 cannot energize. Thus no timing takes place on such calls.

Station A calling station D

There may be twenty stations on line 85, each signalled by a different code. Since any one of ten different codes may be selected by dialling a single digit, it is necessary to add only a single digit to the line digits in order to select any one of the first ten stations. Thus station C is selected and signalled by dialling the number 861. In order to select any one of the last ten stations, however, it is necessary to employ an additional digit. As the circuits are arranged this is the digit 2, which is inserted ahead of the line selecting digits. The function of this digit is to accomplish a switching operation whereby the last ten codes are substituted for the first ten, the eleventh code being substituted for the first code,

the twelfth code for the second code, etc. In view of this explanation it will be understood that the telephone number of station D, to which the eleventh code is assigned, is 2861.

When the receiver is removed at station A the calling line is extended to the connector of an idle link circuit in the manner already explained. Assuming that the first link circuit is the one used, relays 204, 205, and 207 are energized. Relay 204, it will be recalled, is the line relay and is held up over the calling line loop.

When the first digit 2 of the called number is dialled a series of two interruptions is produced in the calling line, causing the line relay 204 to momentarily deenergize twice and transmit two impulses over the impulsing circuit extending to the counting relays. These relays operate as previously described, counting relay 501 being operated by the first impulse and counting relay 502 by the second impulse. At the end of the series of impulses relay 502 remains locked up in series with relay 499.

Relays 306 and 496 are energized on the first impulse and remain energized until the series is completed, when both relays fall back. The deenergization of relay 306 completes a circuit for relay 412 which may be traced from grounded conductor 260 by way of contact 360, conductor 481, contact 455 of relay 409, contact 437, contacts controlled at 443, contact 444, conductor 494, contact 529 of relay 502, conductor 499, contact 464, and winding of relay 412 to battery. Upon energizing, relay 412 locks itself to grounded conductor 260, the locking circuit extending from conductor 260 by way of contacts controlled at 438, contact 467, winding of relay 411, contact 469, and winding of relay 412 to battery. Relay 411 does not energize at the moment because it is shunted by direct ground on conductor 499. Until relay 412 is energized, relays 409 and 502 are locked over a circuit including grounded conductor 260 and contacts controlled at 467. This circuit is broken when relay 412 locks itself at contact 467, and accordingly relays 409 and 502 are deenergized, removing ground from conductor 499 and permitting relay 411 to energize in series with relay 412.

Upon energizing, relay 411 connects relay 407 to grounded conductor 260 at contact 452 and relay 407 energizes. Relays 411 and 412 are deenergized by the operation of relay 494 following the operation of the units relay, but relay 407 remains energized over a circuit which extends from the grounded conductor 260 by way of contact 250 of relay 210, conductor 269, locking contact of relay 407, and winding of relay 407 to battery. Relay 407 remains energized therefore until relay 210 energizes upon the answering of the call.

It will be understood that on the present call the first digit 2 is absorbed in so far as line selection is concerned, the only function which is performed by the dialling of this digit being the operation of relay 407. This relay is the code switching relay, operating to substitute the last ten codes for the first ten, and in practice is provided with ten sets of contacts. Only four sets are shown in the drawings, due to lack of space. For the same reason only one set of contacts is shown completely wired up, this being the set used to switch from the first code to the eleventh code.

To continue with the establishment of the connection, the connector responds to the dialling of the digits 8, 6, and 1 in the same manner as

previously described, and the called station D is signalled in the same manner as described in the case of signalling the station C, except that now, since relay 407 is energized, the code interrupter 617, Fig. 9, is used to operate ringing relay 302 instead of the code interrupter 616. The eleventh code is one long, one short, and one long. Operation of the ringing relay in accordance with this code signals the subscriber at station D. The remaining operations such as ring cut-off and release are carried out in the manner already described.

Reverting call

A call from a partly line subscriber to another subscriber on the same line is known as a reverting call. The manner in which such calls take place will be described next, it being assumed for this purpose that the subscriber at station A desires to call the subscriber at station B. The line number of the line of stations A and B is 11 and it will be assumed that the eighth ringing code is assigned to station B. Accordingly the complete telephone number of station B is 118.

When the receiver is removed at station A the call is extended to an available link circuit in the manner previously described. It will be again assumed that the first link circuit is used. The operation of the finder of the first link circuit will therefore extend the calling line to the connector shown, and the line relay 204 will be energized and held over the calling line. Relays 205 and 207 of the connector are also energized.

When the calling subscriber dials the first digit 1 of the called number the counting relay 501 is energized, with the result that the group relay 311 is operated over conductor 384 when relay 306 falls back at the end of the digit.

When the second digit 1 is dialled, the counting relay 501 is again energized, causing the operation of the units relay 321. The circuit of the units relay in this case is somewhat different than in the previous case when it was operated in response to the dialling of the digit 6, and accordingly will be traced. The circuit is closed when relay 306 falls back at the end of the second digit and extends from grounded conductor 260 by way of contact 360, conductor 481, contact 458 of relay 410, contact 437, contact 443, contact 459, conductor 492 left, contact 433, conductor 495, contact 517 of relay 501, conductor 381, contact 370, conductor 383, conductor 377, and winding of relay 321 to battery. When relay 321 energizes over the above circuit it connects conductors 377 and 476 with results previously described.

As the result of the dialling of the first two digits, therefore, the group relay 311 and the units relay 321 are energized and line 11 is selected and connected with. The control relays 405, 404, and 403 are also energized. The detailed explanation of how these results are brought about has been omitted, but will be understood readily from the previous explanation of the call from station A to station C.

When the third digit 8 is dialled the counting relays respond successively until relay 508 is energized, said relay locking in series with relay 499. Relay 300 energizes in parallel with counting relay 506 and locks itself as previously described. Relay 306 energizes during the operation of the counting relays and closes the test circuit including test relay 303 as previously

described. Since the called line in this case is also the calling line, there will be a ground potential on the test conductor 4' and test relay 303 will not energize. It follows, therefore, that when relay 308 falls back at the end of the third digit the circuit of the busy relay 305 will be completed, said relay energizing and locking itself at contact 354.

On energizing, the busy relay connects the busy tone source to the trunk conductor 60 at contact 356, thus transmitting a busy signal to the calling subscriber. Relay 305 also removes direct ground from the test conductor 62 at contact 355, causing relay 206 to energize. Upon energizing, relay 206 locks itself at contact 234 and grounds conductor 62 at contact 233, also preparing certain other circuits which will be described.

The calling subscriber expects to hear the busy signal, since he is calling back on his own line, which is busy by reason of the call initiated at his own station. His instructions also advise him that on hearing the busy signal when making a reverting call he should replace the receiver and await the ringing operation, which will signal the called station and also notify him when the called subscriber answers the call.

When the receiver is replaced at the calling station A, the line relay 204 is deenergized and grounds the test conductor 4' over a circuit which extends from ground by way of contact 218, contact 225, contact 237, conductor 266, contact 351 of busy relay 305, conductor 263, contact 231 of relay 206, conductor 264, and contacts of relays 307, 321, and 311 to test conductor 4'. The line relay also opens the circuit of release relay 205, which deenergizes after a brief interval and at contact 227 disconnects the incoming test conductor 62 from ground at contact 233 of relay 206. As just explained, however, test conductor 4' has been grounded by the line relay, and since conductor 4' connects to conductor 4, see Fig. 1, the incoming test conductor 62 remains grounded and the cut-off relay 5 remains energized. At contact 230, relay 205 opens the locking circuit of the busy relay 305, but this relay is slow acting and does not restore immediately.

When the release relay 205 deenergizes it also closes a circuit for relay 208, extending from grounded conductor 62 by way of contact 227, contact 232, conductor 265, contact 352, conductor 263, and winding of reverting call relay 208 to battery. Upon energizing, relay 208 locks itself to grounded conductor 260 at contact 242, and at said contact 242 and contact 241 connects grounded conductor 260 to the incoming test conductor 62 by way of contacts 232 and 227. At contact 243, relay 208 breaks the direct connection between conductor 62 and relay 207 but conductor 62 remains connected to relay 207 by way of contact 427 of relay 403 and relay 207 remains energized. At contacts controlled by contact 242, relay 208 disconnects grounded conductor 260 from the holding conductor 63, and since ground has also been removed from conductor 63 at contact 229 of relay 205, conductor 63 is ungrounded and relays 41 and 51 of the finder are released. The slow acting busy relay 305, the circuit of which was opened at contact 230 of relay 205, now falls back and reconnects ground to the holding conductor 63 at contact 353, thereby making the link busy to the allotter. When relay 208 energizes, it also closes a circuit for the test re-

lay 303, extending from grounded test conductor 62 by way of contact 243, conductor 274, and lower winding of relay 303 to battery. Relay 303 energizes before the busy relay 305 falls back to remove ground from the test conductor 4' at contact 351, locks itself to conductor 62 at contact 344, grounds test conductor 4' at contact 343, and closes a circuit for relay 304 at contact 345. Upon energizing, relay 304 completes the connection to the called line at contacts 346 and 350, and prepares a circuit for the pick-up relay 301 at contact 348.

When the pick-up interrupter 605, Fig. 9, grounds terminals 608 and 348, the circuit of pick-up relay 301 is completed and this relay locks itself at contact 324 to terminal 349, now grounded at lock interrupter 609, all as previously described.

The eighth code interrupter now grounds the conductor 530 in accordance with the eighth code, selected by the counting relay 508, and the ringing relay 302 is energized in accordance with said code over a circuit including conductor 530, contact 531 of relay 508, conductor 373, contact 323, and winding of ringing relay 302. Each time it energizes, the ringing relay 302 rings the bell at station B over a circuit which includes the generator lead 399, contact 317, contact 341, contact 315 of relay 300 (now energized), conductor 272, contact 255, conductor 279, contact 350, contacts of relays 307, 321, and 311, conductor 3', conductor 3, Fig. 1, and ringer at station B to ground. The ringing generator is grounded and accordingly the circuit is completed over the path above traced. The ringer at station B responds to signal the called subscriber.

Each time the ringing relay energizes, it also connects the ring trip relay 212 to line conductor 2 over a path which may be traced from line conductor 2 by way of conductor 2', contacts of relays 311, 321, and 307, contact 346, conductor 262, contact 251, conductor 270, contact 312, contact 342, contact 316, and conductor 269, the latter conductor connecting to the ring trip relay. Accordingly if the receiver is removed at any station on the line while the ringing relay is energized the ringing generator and the exchange battery will be connected in series through the winding of ring trip relay 212 and this relay will energize.

The ringing relay deenergizes one or more times while the ringing code is being transmitted. At such times the line conductor 3 is connected to ground at back contact 341 of ringing relay 302, while the line conductor 2 is connected to the ring trip relay 212 at back contact 342 of the ringing relay. These circuits can be readily traced, it being remembered that relays 301 and 300 are energized. It follows that if a receiver is removed at some station in a silent interval during code transmission, or during the interval between codes, the ring trip relay will be energized.

When the transmission of the ringing code is completed, the lock interrupter removes ground from terminals 609 and 349 and the pick-up relay 301 is deenergized. An instant later the reverting call signal interrupter 607 grounds terminals 610 and 213 for a short interval, closing another circuit for the ringing relay 302, which extends from ground by way of 607, terminals 610 and 213, contact 240, contact 252, conductor 271, contact 323, and winding of relay 302 to battery. Upon energizing over this circuit, relay 302 closes a circuit for ringing the bell at station A, said circuit extending from the ringing generator by way of

conductor 399, contact 317, (relay 301 deenergized), contact 342, contact 312, conductor 270, contact 251, conductor 262, contact 346, contacts of relays 307, 321, and 311, conductor 2', conductor 2, and ringer at station A to ground. The ringer responds with one short ring. Relay 302 also disconnects line conductor 3 from ground at contact 341 so that if there are any bridged ringers on the line they will not respond.

The foregoing operations are repeated at intervals, or each time the pick-up interrupter grounds the terminal 608 and energizes the pick-up relay 301. Thus the subscriber at station B is signalled at intervals by means of the code assigned to his station. After each code transmission, a ring back or reverting call signal consisting of one short ring is transmitted to the calling subscriber at station A to notify him that the ringing operations are proceeding.

When the receiver is removed at the called station B the ring trip relay 212 is energized and closes a circuit for relay 211. Upon energizing, relay 211 locks itself at contact 253, opens conductors 271 and 299 at contacts 252 and 254, respectively, and bridges the battery feed relay 210 across the called line at contacts 251 and 255. The receiver having been removed at station B, relay 210 energizes and at contact 250 opens the locking circuit of relay 406. Upon deenergizing, relay 406 opens the holding circuit for relay 409 and 508, which deenergize. At contact 250 relay 210 also closes the circuit of the reversing relay 202. Upon energizing, relay 202 breaks the locking circuit of relay 403 at contact 224 and relay 403 deenergizes, breaking the circuit of relay 207 at contact 427. Upon deenergizing, relay 207 removes ground from conductor 260 at contact 238, and also removes ground from conductors 62 and 63, since these conductors have been supplied with ground potential over conductor 260. All the relays of the connector which are locked up at this stage now deenergize and the connector is thus restored to normal.

The removal of ground from conductor 63 makes the link circuit test idle to the allotter, while the removal of ground from test conductor 4' opens the circuit of cut-off relay 5 and lockout relay 7. Upon deenergizing, the cut-off relay 5 connects the line relay 6 across the line and this relay energizes, since the receiver has been removed at station B. The line relay pulls up before the lockout relay 7 can deenergize and the latter relay remains locked up through contacts 12 and 10. Relay 7 opens the finder control circuits at contacts 12 and 13.

The cessation of the reverting call ringing signals notifies the calling subscriber at station A that the called subscriber has answered the call and the calling subscriber will therefore remove his receiver also. Transmitter current is supplied to both stations through the windings of the line relay 6. The line is guarded against intrusion, or made busy to incoming calls, by ground at the junction of relays 5 and 7. When the subscribers replace their receivers, relays 6 and 7 release and the line is restored to normal.

Two digit groups

From the explanation so far it will be understood that groups 1 and 8 are each selected by dialling a single digit. This is also true of groups 3 to 7, inclusive, and group 9. The digit 0 is used for calling the toll operator and accordingly there is no 0 group, nor is there any group designated by the digit 2, which is used for code switching as

previously explained. Thus there are eight single digit groups, designated by the digits 1, 3 to 8, inclusive, and 9, giving a capacity of eighty lines and trunks.

There are also a plurality of two digit groups, each designated by the digit 2 and another digit. The first digit in a two digit group designation conditions the equipment for group selection by the second digit, and of course cannot be used to designate a single digit group. By sacrificing one single digit group, however, a plurality of two digit groups may be added. The second single digit group is omitted due to the use of the digit 2 for code switching. It has been found to be possible to use this digit also to perform the necessary functions of the first digit in the two digit group designations, which avoids the necessity of sacrificing a second single digit group.

As illustrated in the drawings, there are five two digit groups designated as groups 22, 23, 24, 25, and 20. No two digit group relays are shown but these relays are similar to the single digit group relay 311. The marking conductors for all the group relays are shown. Thus the conductors G1, and G3 to G9, inclusive, are the marking conductors for the single digit groups, of which conductors G1, G8, and G9, also designated as 384, 382, and 379, are shown complete with their associated group relays. The conductors G22 to G25, inclusive, and G20 are the marking conductors for the two digit groups. All marking conductors corresponding to omitted group relays are terminated at the right in Fig. 5, except the two digit marking conductors G23, G24, and G25, which are terminated in Fig. 4, just to the right of relay 412.

The five two digit groups have a capacity of fifty lines, which increases the capacity of the complete system shown to one hundred and thirty lines. The lines in the two digit groups may be individual or party lines and in the case of party lines bridged or grounded ringing may be used, as in the case of the party lines already discussed. The stations are called by means of four digit telephone numbers, of which the first two digits are used for group selection, the third for units selection, and the last for code selection. In this connection it will be understood that only the last ten codes can be used, for the digit 2 not only designates a two digit group but also controls the switching over from the first ten codes to the last ten. It will also be understood that only the first ten codes can be used in the single digit groups 3, 4, and 5, due to the use of the code switching digit 2 as the prefix to the two digit group designations. It follows from all this that the twenty party lines must be assigned telephone numbers in the single digit groups 6 to 9, inclusive. If there are only a few of such lines, only ten or fifteen lines, for example, then the single digit groups 6 and 7 need not be reserved for this purpose, may be restricted to ten party service using the first ten codes, and groups 26 and 27 may be added, also restricted to ten party service but using the last ten codes.

The setting up of a connection to a line in a two digit group will now be explained briefly, it being assumed that the first link circuit is used as on previous calls. When the first digit 2 is dialled, relay 412, Fig. 4, is energized and becomes locked in series with relay 411, as explained in detail under the heading "Station A calling station D." At that time we were concerned only with the code switching feature, carried out by the energization of the relay 407, and consequent-

ly this is the only feature that was described. Now, however, we are interested in seeing how the energization of relays 412 and 411 prepares the connector for the selection of two digit groups.

As previously seen, the marking conductor 499, coming from the lower contact 529 of counting relay 562, extends to the movable contact 464 of relay 411, and when this relay is deenergized, said conductor 499 extends by way of the back contact 464 to the winding of relay 412. This is the connection over which relay 412 is energized when the digit 2 is dialled as the first digit of a number. After relays 412 and 411 have been energized in this manner, the conductor 499 is disconnected from relay 412 and is connected to the two digit group marking conductor G22, and if the digit 2 is dialled as the second digit of the number a circuit is closed for the group relay of group 22.

The marking conductor 533, coming from lower contact 532 of counting relay 503, is associated with two groups of lines. Normally conductor 533 extends by way of contact 470 of relay 412 to group marking conductor G3, and when the digit 3 is dialled as the first digit of a number a circuit is closed over 533 and G3 for the group relay of the single digit group 3. The energization of relay 412, however, switches conductor 533 over to the group marking conductor G23, and hence if the digit 3 is dialled as the second digit of a number which includes the digit 2 as the first digit, a circuit is closed over 533 and G23 for the group relay of group 23.

Conductors 534 and 535 are connected similar to conductor 533. They normally extend by way of contacts 471 and 465 to group marking conductors G4 and G5, respectively, and are switched by the energization of relays 412 and 411 to group marking conductors G24 and G25, respectively. The marking conductor 540, coming from a contact of counting relay 510, is connected similar to conductor 499. The digit 0 is used for calling toll and hence conductor 540 is normally connected through contact 466 to a conductor 436, which is properly connected to initiate a toll connection, as will be described. When relays 412 and 411 are energized, however, conductor 540 is switched over to the two digit group marking conductor G20.

Except for the manner in which the group relays are selected and energized, calls to lines in the two digit groups are carried out in the same way as previously described and hence it will not be necessary to explain such calls in detail.

Unequipped groups

When the exchange is first installed, the full capacity may not be required, and in such case the full complement of group relays may not be furnished, as some saving in cost can be effected by providing group relays only for the groups that are to be used. Of course some provision for growth will be made, but even so the estimate of this factor may indicate that the maximum number of groups will not be required for such a long period that it will be economical to omit some of the group relays at the start.

Under the circumstances described in the foregoing, it is desirable to arrange the exchange in such a manner that if a calling subscriber accidentally dials a line number in an unequipped group he will be given the busy signal. To this end the special terminal 519, Fig. 5, is provided and is connected as shown to conductor 287.

When the automatic switch board is wired up, all the group marking conductors which correspond to unequipped groups are connected to terminal 519. Suppose, for example, that group relay 311 is omitted. Then the group marking conductor G1 (384) is connected to terminal 519. With this arrangement, if a subscriber should take the link circuit into use and dial the digit 1 as the first digit of a number, terminal 519 would be grounded following the dialling of the first digit and a circuit would be closed over conductor 287 and through contact 230 of relay 205 to the busy relay 305. The operation of the busy relay gives the calling subscriber a busy signal in the manner already explained.

It will be understood that each link circuit is equipped with a special terminal such as terminal 519. If desired this unequipped group wiring may be used after the exchange is installed in connection with group relays in which no working lines are connected. Such a case will arise where one or more group relays in addition to those required at the moment are provided for future growth. The marking conductors associated with such group relays may therefore be temporarily disconnected from the relays and connected to terminal 519.

Private branch exchange

As explained in the general description, the drawings show two trunk lines of a group of five trunk lines extending to a private branch exchange the telephone number of which is 81. The first of these trunk lines comprises conductors 329, 330, and 331, while the second comprises conductors 332, 333, and 334. It has also been explained that certain relays shown in Fig. 6 are associated with this group of trunk lines and that terminals 631, 632, 633, 634, and 635 are connected to the test conductors of the five trunk lines of the group, respectively. The foregoing being recalled, the setting up of a connection to the private branch exchange may be described.

For this purpose it will be assumed that the subscriber at station A removes his receiver and dials the telephone number 81.

When the receiver is removed at station A the calling line is extended to an idle link circuit in the manner explained. It may be assumed that the first link circuit is used, as on previous calls. Relays 204, 205, and 207 are accordingly energized and dial tone is transmitted to the calling subscriber.

When the first digit 8 of the called number is dialled, certain relay operations take place at the connector, including operation of the counting relays, with the result that the group relay 318 is energized and locked. Following the energization of relay 318, relay 405 is energized and locked, all as previously described.

When the second digit 1 is dialled the counting relay 501 is energized and locked in series with relay 410. Now when the change over relay 306 falls back at the end of the second digit a circuit is completed for the sequence relay 512 over a path which extends from grounded conductor 260 by way of contact 360 of relay 306, conductor 481, contact 458 of relay 410, contact 437, contact 443, contact 450, conductor 492 left, contact 433, conductor 495, contact 517 of relay 501, conductor 381, contact 366 of relay 318, conductor 380, winding of relay 512, contacts controlled at contact 542, conductor 543, serially related chain contacts such as 544 and 545 of all sequence relays such as 513 and 512, conductor 652, and resistance

655 to battery. Assuming that no other link circuit is using the equipment shown in Fig. 6, all relays such as 513 in the other link circuits will be in deenergized condition, conductor 543 will have battery potential on it through the chain contacts, and the circuit of relay 512 will be completed as traced.

Upon energizing, relay 512 locks itself to conductor 652 at contact 541, also disconnecting conductor 652 from conductor 543 so that no other sequence relay such as 513 in another link circuit can energize. Relay 512 also closes an obvious circuit for relay 511 and this relay accordingly energizes. Relays 512 and 511 together connect up the equipment in Fig. 6 and temporarily appropriate it for use exclusively with the first link circuit.

The locking circuit of the group relay 318, which was energized responsive to dialling the first digit, includes the grounded conductor 489 (connected to grounded conductor 260 at contact 442 of relay 405) and since conductor 489 is connected to the group marking conductor 382 at contact 367, the latter conductor is still grounded. Accordingly when relay 511 energizes a circuit is completed for relay 603 extending from the grounded marking conductor 382 by way of contact 547, conductor 647, and winding of relay 603 to battery. Upon energizing, relay 603 connects the units marking conductors 641-645 to contacts of relays 611-615.

As previously explained, the terminals 631-635 are connected to the test conductors of the private branch exchange trunk lines, and accordingly the condition of relays 611-615 will depend on whether the trunk lines are busy or idle. If the first trunk line comprising conductors 329, 330, and 331 is busy, for example, relay 611 will be in energized condition.

It will be assumed now that all five of the trunk lines are busy, in which case all five relays 611-615 will be in energized condition. Relay 604 will also be in energized condition, having operated over a circuit which includes the chain contacts on relays 611-615 and contact 656 of relay 603. When relay 603 energizes it breaks the circuit over which relay 604 was initially energized but relay 604 remains locked to the chain circuit at contact 657.

When relay 603 energizes under the foregoing conditions, it also closes a circuit for the busy relay 305 over a path which may be traced from ground by way of chain contacts of relays 611-615, contact 656, contact 658, conductor 646, contact 549, conductor 475, and lower winding of busy relay 305 to battery. Upon energizing, relay 305 locks itself at contact 354 and at contact 356 connects the busy tone source to trunk conductor 60, thus giving the calling subscriber a busy signal. Relay 403 is energized in parallel with relay 305, being connected to conductor 475, locks itself at contact 429, and at contact 433 disconnects ground from conductor 495 and hence from conductors 331 and 380. This operation of course breaks the circuit of relay 512 and this relay and relay 511 deenergize, which releases relay 603, Fig. 6, and restores this equipment to normal.

When the calling subscriber hears the busy signal he will restore his receiver and the link circuit is released in the usual manner.

It will be assumed now that the call to the private branch exchange 81 is made at a time when the trunk lines are not all busy. It may be assumed, for example, that the first trunk line is

busy and that the second trunk line is idle. Relay 611 accordingly is in energized condition while relay 612 is in deenergized condition. Relay 604 is also in deenergized condition, since the chain circuit is open at contacts of relay 612.

When relay 603 energizes under the above conditions, it closes a circuit for relay 622 over a path which can be traced from ground by way of contact 656, contact 659, contacts controlled at 650, winding of relay 622, conductor 651, contact 550, winding of relay 512, contact 541, conductor 652, and resistance 655 to battery. At the time the above circuit is closed relay 512 is being held energized by ground on conductor 380 and hence relay 622 is short circuited and cannot operate for the time being. Relay 603 also closes a circuit for the units relay 322 over a path which extends from ground by way of front contact of energized relay 611, back contact of deenergized relay 612, contact 667, conductor 642, contact 551, units marking conductor U2 (378), and winding of relay 322 to battery. Upon energizing, relay 322 connects conductor 378 to conductor 476, thereby closing a circuit for relay 404. Upon energizing, the latter relay locks itself to grounded conductor 260 at contact 438 and also connects conductor 476 to conductor 260, thereby maintaining conductor 476 grounded to hold up the units relay 322. Relay 404 also performs the same functions as described in detail before, that is, it closes a circuit for relay 403 and breaks the locking circuit of relay 406. Relay 403 energizes and locks as previously described, and relay 406 deenergizes, breaking the locking circuit of relay 410 and counting relay 501 at contact 447. Relays 410 and 501 accordingly deenergize.

The selecting and connecting operations of the connector in response to the dialling of the first two digits have now been completed. The eighth group of lines has been selected by operation of relay 318, in response to the dialling of the first digit 8. This is the group of lines which includes the group of five trunk lines extending to private branch exchange 81. The equipment Fig. 6 has been connected up temporarily in response to the dialling of the second digit 1, and this equipment has functioned automatically to operate the units relay corresponding to the first idle trunk line of the group. As the second trunk line has been assumed to be the first idle trunk line, the second units relay 322 has been operated. Thus the second trunk line comprising conductors 332, 333, and 334 has been selected and connected with.

When the called line is a subscriber's line, the next operation to be performed by the calling subscriber is the dialling of the final digit in the called number, in order to bring about code selection and the testing of the called line, as described in detail in the explanation of the establishment of a connection to station C, the telephone number of which is 861. As regards the call to private branch exchange 81 which is now being described, however, all the digits in the called number have already been dialled. This situation arises from the fact that no code selection is required in the case of a call to the private branch exchange, which makes it possible to omit the ringing digit and thus simplify the numbering. The result is that the dialling operations are reduced by one third over those required for a call to the usual subscriber's station having a three-digit number. This result is accomplished by providing means in the common equipment, Fig. 6, for automatically

transmitting the digit 1 to a connector engaged in a private branch exchange call to simulate the dialling of the third or ringing digit by the calling subscriber. The operation of this arrangement will now be described.

It will be recalled that when relay 603 energized it closed a circuit for relay 622 in series with relay 512. In describing this circuit the fact was mentioned that relay 622 is short-circuited by ground on conductor 380 at the time relay 603 first closes the circuit, which prevents relay 622 from energizing. When relay 404 energizes it breaks the marking circuit at contact 437. This is the circuit over which relay 512 is energized and includes conductors 380 and 381 and contact 517 of relay 501. When the circuit is broken by relay 404, ground is removed from conductor 380 in the connector and relay 622 is energized in series with relay 512, the latter relay remaining operated.

Upon energizing, relay 622 closes a circuit for relay 621 at contact 666. Upon energizing, relay 621 places a shunt around the break contacts of relay 620 at contact 664, short-circuits relay 622 at contact 661, and closes a circuit for relay 623 at contact 662. Relay 620 energizes and locks itself at contact 660. Relay 622 now deenergizes and breaks the circuit of relay 621. Relay 621 is slow to release, however, and accordingly ground is momentarily applied to conductor 650 through contacts 665 and 663. The effect of this ground impulse will be explained presently. When relay 621 deenergizes it opens contact 661, removing the short-circuit from relay 622, but this relay cannot again energize because its initial energizing circuit has been broken by relay 620 and the shunt around the contacts of this relay which was temporarily established at contact 664 has been opened. The opening of contact 664 thus removes ground from conductor 651 and breaks the circuit of relay 512. Relays 512 and 511 accordingly deenergize, the latter relay breaking the circuit of relay 603. Relays 603 and 620 now deenergize.

The ground impulse above mentioned is transmitted over conductor 650 while relay 512 is in energized condition, the termination of the impulse being co-incident with the opening of the circuit of this relay, and is effective to ground conductor 376, which is the conductor over which the line relay 204 transmits impulses to the counting relays. The counting relay 501 is accordingly energized and locked in series with relay 410. Relay 406 and relay 306 are also deenergized over conductor 376, relay 406 locking itself through contact 431 of relay 403. Relay 306 closes a circuit for testing the connected trunk line, connecting ground through the upper winding of test relay 303 to the test conductor 334. It may be assumed that the trunk line will test idle, with the result that the test relay 303 energizes, followed by the energization of relay 304 when relay 306 falls back.

From this point on the operations of the connector are the same as described in the case where station C was called and hence they will not be gone over again in detail. It will be understood that the first code, consisting of one long ring, has been selected by relay 501 and is used for signalling over the connected trunk line. When the operator answers at the private branch exchange the ring trip relay 212 energizes and operates relay 211 to stop the ring-

ing operation. Relay 211 also completes the talking circuit in the connector. The connection to the local subscriber in the private branch exchange is completed by the operator through the medium of known equipment which forms no part of the invention. The release of the link circuit is controlled by the calling subscriber the same as on call to a subscriber's line.

The private branch exchange trunk lines being provided with the usual subscribers line equipment, they may be used also for outgoing calls from the private branch exchange. Such calls are handled the same as calls from ordinary subscribers' lines.

If there is a second private branch exchange it may be assigned the number 71, and the trunk lines will terminate at contacts of the seventh group relay. As many as five trunk lines may be provided, as in the case of private branch exchange 31. It is necessary, however, to add another pair of contacts to relay 512 and another pair of relays such as 603 and 604 in the common equipment, Fig. 6, as will be readily understood.

In this connection, it will be advisable to explain more in detail the wiring of the first units marking conductor, coming from contact 517 of counting relay 501. Whereas the units marking conductors such as 42 and 43 extend directly from contacts of the counting relays to the corresponding units relays, the first units marking conductor 381 extends to contacts such as 368 and 370 on all the group relays except group relay 319. The reason for this circuit arrangement is to enable the energized group relay to route the first marking conductor to the first units relay (if a subscriber's line is being called) or to relay 512 (if a branch exchange is being called). Thus all group relays such as relay 311, which are associated with groups containing only subscribers' lines, connect conductor 381 to conductor 383, which connects directly to conductor U1 and to units relay 321. All group relays such as 318, however, which are associated with groups containing branch exchange trunk lines, connect conductor 381 to conductor 380 which extends to relay 512. It will be clear that this arrangement provides for initiation of trunk selection (by means of the common equipment, Fig. 6) whenever the digit 1 is dialled as the second digit of a private branch exchange number such as 31 or 71.

In case the second digit dialled in calling a private branch exchange is any digit other than the digit 1 (2, 3, 4 or 5), then the trunk selecting operation does not take place and the corresponding trunk line is selected and tested the same as a subscriber's line. Numbers such as 32, 33, etc., may be assigned for night service, previously referred to, it being understood that the corresponding trunk lines are connected through to designated local stations by the branch exchange operator when she goes off duty.

Outgoing toll call

It will be assumed now that the subscriber at station A desires to call a subscriber in a distant exchange. Such calls are handled through the toll center, access to which may be had over a group of five trunk lines including the trunk line comprising conductors 335, 336, and 337 and the trunk line comprising conductors 338, 339, and 340. These two trunk lines are the first and second trunk lines of the group. The telephone

number assigned to the toll center comprises the single digit 0.

When the calling subscriber at station A removes his receiver the line is automatically extended to an idle link circuit in the usual manner. Assuming that the first link circuit takes the call, the line relay 204 will be energized and is held over the calling line. Relays 205 and 207 are also energized, with results previously described.

Upon hearing dial tone in his receiver, the calling subscriber will dial the digit 0, which is the telephone number of the toll center. The line relay 204 accordingly deenergizes momentarily ten times and transmits a series of ten impulses to the counting relays in Fig. 5. The counting relays respond in the manner already explained, with the result that relay 510 is energized and locked in series with relay 410. Relays 306 and 406 energize on the first impulse and remain in energized position until the series of impulses is completed.

When relay 306 falls back at the end of the series of impulses it completes a circuit for the group relay 319 over a path which may be traced from ground on conductor 260 by way of contact 360, conductor 481, contact 458, contact 437, contacts controlled at 443, contact 444, conductor 494, contact 553 of relay 510, conductor 540, contact 466, conductor 536, marking conductor G9 (379), and winding of group relay 319 to battery. Upon energizing, relay 319 connects conductors 379 and 497, thereby grounding the latter conductor and completing a circuit for the sequence relay 512 over a path which extends from ground by way of conductor 497, contacts of relay 405 controlled at 445, conductor 496, contact 554 of relay 510, conductor 380, winding of relay 512, contacts controlled at 542, conductor 543, serially related chain contacts of all sequence relays, conductor 652, and resistance 655 to battery. Assuming that no other sequence relay is energized (if some relay such as 513 is in energized condition the call will have to wait), the circuit is completed as traced and relays 512 and 511 are energized, as described in the case of calling the private branch exchange 81. The equipment of Fig. 6 is thus connected to the link circuit.

Since the marking conductor G9 is now grounded, the energization of relay 511 closes a circuit for relay 601, extending from the grounded marking conductor by way of contact 548, conductor 648, and winding of relay 601 to battery. Upon energizing, relay 601 connects the units marking conductors 641-645 to conductors 731-735, respectively.

Reference may now be made to Fig. 7, which shows the repeater associated with the first toll trunk line. This repeater includes a relay 704 which is energized at all times when the trunk line is in use. Relays 716-719 are the corresponding relays of the repeaters associated with the other four toll trunk lines. It will be seen that the arrangement of relays 704 and 716-719 is the same as that of relays 611-615, Fig. 6, which are associated with the group of trunks leading to the private branch exchange 81.

Assuming now that all the toll trunk lines are busy, relay 704 and relays 716-719 will be in energized condition and conductor 736 will be grounded. It follows that relay 602 will be in energized condition, so that when relay 601 pulls up a ground will be placed on conductor 646 and conductor 475 to operate the busy relay 305.

This operation is the same as previously discussed during the description of a call to the private branch exchange 81 and hence will not require further explanation.

It will now be assumed that the first toll trunk line is idle when the call to the toll center is made. Relay 704 will therefore be in deenergized condition and conductor 731 will be grounded. Under these conditions, when relay 601 energizes it closes a circuit for the units relay 321 over a path which extends from ground on conductor 731 by way of contact 668, conductor 641, contact 552, units marking conductor U1 (377), and winding of relay 321 to battery. Upon energizing, relay 321 completes the selection of the first toll trunk line 335-377, relay 319 already having been energized.

When relay 321 energizes it also connects grounded conductor 377 (the marking conductor U1) to conductor 476, thereby closing a circuit for relay 404. Upon energizing, relay 404 connects conductor 476 to grounded conductor 260, thus locking itself and units relay 321 to conductor 260, independent of ground coming over the marking conductor. At contact 436 relay 404 closes a circuit for relay 403, which energizes and locks itself at contact 429. At contact 435 relay 404 connects grounded conductor 260 to relay 405, and by means of contacts 435 and 440 in series relay 404 connects the grounded conductor 260 to conductor 497. The latter conductor extends to the group relay 319 through its contact 366 and thus relay 319 is locked against deenergizing. When relay 405 energizes it connects conductor 260 to conductor 497 by way of contacts 442 and 445 and by means of the latter contact disconnects ground from conductor 496. This operation breaks the circuit of relay 512, but relay 512 is slow to deenergize and does not fall back for an instant.

Relay 404 also breaks the marking circuit at 437, this being the circuit over which relay 319 is initially energized. As just mentioned, however, a locking circuit is closed for relay 319 at contacts 435 and 440, which holds the relay energized. At contacts controlled at contact 438, relay 404 breaks the holding circuit for the counting relays; the circuit being also opened at contact 441 of relay 405 an instant later, and relays 410 and 510 are deenergized.

We now have relays 404, 405 and 403 energized and locked to grounded conductor 260, also relays 319 and 321. The counting relay 510 has been deenergized, and the circuit of relay 512 is open, having been broken by relay 405. When relay 404 closes the circuit of relay 405, it also closes a circuit for the switching through relay 201 which extends from ground by way of contact 667 of relay 601, Fig. 6, conductor 649, contact 555, conductor 498, contact 439, conductor 283, and winding of relay 201 to battery. Relay 201 energizes over this circuit and locks itself to the grounded test conductor 62 at contact 217. Shortly after relay 201 has energized relay 512 deenergizes, also relay 511 and relay 601. This restores the equipment, Fig. 6, so that it can be used by other link circuits.

Upon energizing, relay 201 opens the connection between the P1 conductor and relay 402, thus cutting out the "permanent" timing feature, grounds the holding conductor 63 at contact 218, and connects the incoming test conductor 264, which now extends through contacts of relays 321 and 319 to the test conductor 337 of the first toll trunk line. In addition to the fore-

going, at contacts 215 and 220 relay 201 disconnects the trunk conductors 60 and 61 from the line relay 204 and the impedance coil 203, respectively, and extends these trunk conductors to conductors 261 and 280, respectively, which have been connected through contacts of relays 321 and 319 to the trunk conductors 335 and 336. The line relay 204 now deenergizes and breaks the circuit of the release relay 205. The latter relay is slow to deenergize, however, and does not fall back for an instant.

When the grounded test conductor 62 is extended through to test conductor 337, the cut-off relay 720, Fig. 7, is energized and the line relay 712 is disconnected. When the trunk conductors 60 and 61 are extended through to trunk conductors 335 and 336, the line relay 712 of the repeater is energized over the calling line, the circuit including the left hand windings of the repeating coil R and contacts of the reversing relay 711. The line relay 712 closes a circuit for the release relay 713 at contact 757, and the latter relay, upon energizing, connects ground to test conductor 337 over a path which extends from ground by way of contacts controlled at 749, lower winding of relay 715, contact 753, contact 763, and conductor 724 to test conductor 337. The windings of relay 715 are of low resistance, preferably about 30 ohms.

Since test conductor 337 is connected to test conductor 62 at the connector, the latter conductor is maintained grounded after the release relay 205 has deenergized. Relay 201 remains locked to conductor 62, and relay 207 also remains energized, maintaining ground on conductor 260 at contact 238. The current flow over the holding circuit (conductors 337 and 62) and through the windings of relays 201, 207, and the cut-off relay of the calling line energizes relay 715 at the repeater, which holds open the circuit of relay 711. In addition to grounding the holding circuit, relay 713 of the repeater closes a number of other circuits. At contact 751, relay 713 connects the timing relay 714 to terminal 775. Terminals 775 and 776 are connected to the P1 and CoG leads, respectively, Fig. 4, and relay 714 corresponds in function to relay 402. At contact 752 relay 713 closes a circuit for the reversing relay 703, which energizes with results which will be described shortly. A branch of this circuit extends through contact 756 of line relay 712 to relay 704, which energizes and removes ground from conductor 731. This operation renders the trunk line unselectable by another calling subscriber. At contact 755 relay 713 closes a circuit for relay 708, said circuit including contact 772 of relay 701. Upon energizing, relay 708 closes a circuit for relay 706, which energizes and at contact 744 connects the interrupter 773 to the trunk conductor 335 through a pair of condensers as shown. This operation gives the calling subscriber a ringing tone signal similar to the usual ringing signal obtained when calling a subscriber's line.

The operator at the toll center is not signaled by ringing current but by reversing the direction of current flow over the trunk, as will now be explained. At the repeater, Fig. 7, the line relay 702 is bridged across the trunk conductors 725 and 726 through contacts of the reversing relay 703 and the right hand windings of the repeating coil R. At the toll center, Fig. 8, the polarized relay comprising windings 805 and 806 is bridged across the trunk conductors through contacts of the relay 804 and the left-

hand windings of the repeating coil R1. The winding 806 is of very high resistance, 30,000 ohms, for example, which prevents the line relay 702 from energizing as long as this winding is included in the circuit. The normal direction of current flow over the trunk is such that the polarized relay holds its contact 814 open. Thus neither the line relay 702 nor the polarized relay 805-806 is operatively energized under normal conditions.

When the release relay 713 of the repeater is energized, it closes a circuit for the reversing relay 703 as previously mentioned. Upon energizing, relay 703 reverses the direction of current flow over the trunk to the toll center, whereupon the polarized relay 805-806 operates to close its contact 814, thereby completing a circuit for relay 802. Upon energizing, relay 802 connects the resistance 823 in shunt of condenser 822 at contact 815, connects the condenser 821 in parallel with winding 805 at contact 816, and closes circuits for the line and busy lamps L1 and L2 at contact 817. The lighting of the line lamp L1 signals the operator.

If the call is not answered promptly the timing equipment including relay 714 at the repeater will release the connection after about two minutes, or somewhat more, by removing ground from the holding circuit, as will be readily understood. Such a long delay in the answering of a call is not to be expected, however, and the chief purpose of the timing equipment is to insure the clearing out of the toll trunk at the end of conversation, as will be explained subsequently.

It will be assumed now that the call is answered without any unusual delay. When the answering plug of the cord circuit taken for use is inserted in jack J1, a circuit is closed over the sleeve of the jack in the usual manner for relay 803. Upon energizing, relay 803 closes a circuit for relay 801, extending from ground by way of contact 824, winding of relay 801, contacts controlled at 812, lower right hand winding of the repeating coil, ring contact of jack J1, and ring contact of the plug to battery in the cord circuit. Upon energizing, relay 801 locks itself at contact 812, and opens the circuit to the line lamp L1 at contact 811. At the latter contact another circuit is closed for the busy lamp L2 and similar lamps at other positions.

Since the condenser 822 is shunted by the resistance 823, the supervisory relay in the cord circuit will operate and prevent the supervisory lamp from lighting.

When relay 801 energizes it also short-circuits the winding 806 of the polarized relay at contact 813, relay 803 having closed contact 825. The line relay 702 at the repeater accordingly energizes and closes a circuit for the release relay 701. Upon energizing, relay 701 opens the circuit of timer relay 714 at contact 769, and at contact 770 closes a new circuit for relay 704. Relay 701 also closes a circuit for relay 705, extending from ground by way of contact 772, contact 766, and lower winding of relay 705 to battery. Upon energizing, relay 705 closes a locking circuit for its lower winding at contact 742 which is independent of contact 766 of relay 703, and also closes a locking circuit for its upper winding at contact 741. At contact 740 relay 705 opens the circuit to the interrupter 773 and thus stops the transmission of ringing signals to the calling subscriber.

Another result of the energization of relay

701 is the opening of the circuit of relay 708 at contact 712. When relay 708 falls back it bridges the upper winding of relay 715 across the talking conductors of the trunk lines, the circuit extending from trunk conductor 335 by way of contact 744, a condenser, contact 740, upper winding of relay 715, contact 747, and contact 745 to trunk conductor 335. This circuit is broken after an instant by the deenergization of relay 706. The purpose of the operation just described is to give the operator a special tone signal if the calling line is a pay station. In the case of a pay station line the terminals 14 and 15, Fig. 1, are strapped together, which connects the pay station tone source to the test conductor such as conductor 4. When the toll center is called, therefore, the tone will be placed on the holding circuit and since this circuit includes the lower winding of relay 715 the tone will be extended to the trunk where it can be heard by the operator, the two windings of relay 715 acting as a transformer. In the present case, where the calling line is the line of station A, the terminals 14 and 15 are not strapped. The operator hears no tone when she plugs in to answer the call, therefore, and is thus advised that she does not have to demand payment in advance.

The connection to the toll center has now been established and the calling subscriber can talk to the operator and give her the necessary information as to the name and location of the called party. The operator will complete the connection in the usual manner, whereupon the calling and called parties may converse as desired.

When the calling subscriber replaces his receiver at the end of the conversation, the line relay 712 deenergizes, followed by the deenergization of the release relay 713. Relay 713 opens a point in the holding circuit at contact 753, but the holding circuit remains grounded by way of contact 771 of relay 701 and the connection to the toll trunk is not released. Relay 713 also breaks the circuit of relay 703 at contact 752, and this relay deenergizes, restoring current flow over the trunk line to its normal direction. At the toll center the polarized relay 805-806 now operates to open its contact 814, thereby breaking the circuit of relay 802, which deenergizes and opens the shunt around condenser 822 at contact 815. The latter operation stops current flow from the cord circuit and thus gives the operator disconnect supervision in the usual manner.

It will be observed that the calling subscriber can recall the operator by operation of the switch hook at his telephone. When the hook is "flashed" the relays 712, 713, and 703 at the repeater are intermittently energized and deenergized and the latter relay intermittently reverses the current flow over the trunk line to control relay 805-806, which in turn controls relay 802.

Assuming that the calling subscriber has replaced his receiver, the disconnect signal notifies the operator that the parties are through talking and she will pull down the connection. When the plug is withdrawn from jack J1, the relay 803 deenergizes and breaks the circuit of relay 801, which deenergizes also. These relays open the shunt around winding 806 of the polarized relay. The line relay 702 of the repeater is accordingly deenergized and opens the circuit of relay 701. The latter relay, upon deen-

energizing, opens the holding circuit at contact 771, and opens the circuit of relay 704 at contact 770. The opening of the holding circuit restores the link circuit to normal and also restores the cut-off relay of the calling line. The release of relay 704 replaces ground on conductor 731 and renders the trunk line available to other calls.

If the calling subscriber should fail to replace his receiver when the conversation is over with, the operation is somewhat different. When the operator withdraws the plug from jack J1, relay 803 deenergizes but relay 801 is held up over a circuit including contact 818 of relay 802, and the busy lamp L2 is maintained in lighted condition at contact 811. Relay 803 opens the shunt around winding 806 of the polarized relay at contact 825, causing the line relay 702 at the repeater to deenergize and break the circuit of relay 701. Upon deenergizing, relay 701 unlocks relay 705 at contact 772 and at the same contact closes the circuit of relay 708. Relays 708 and 706 energize and the ringing signal is transmitted over the calling line as before. Relay 701 also opens the shunt around contact 753 in the holding circuit at contact 771, opens one circuit of relay 704 at contact 770, and at contact 769 reconnects relay 714 to the P1 lead.

When interrupter 414, Fig. 4, grounds the P1 lead relay 714 energizes and locks itself at contact 750, also replacing direct holding ground by ground on the CoG lead at contact 749. About two minutes later interrupter 416 removes ground from the CoG lead, which opens the holding circuit. The link circuit is thus restored to normal, and the calling line is locked out as previously described. The energized repeater relays including relay 703 also restore and the direction of current flow over the trunk line is restored to normal. Relay 805-806 accordingly opens the circuit of relay 802 and this relay and relay 801 restore, the latter extinguishing the busy lamp, which notifies the operator that the connection to the trunk has been released.

Incoming toll call

The trunk lines extending to the toll center are two-way trunks and are used also for incoming calls. It may be assumed, therefore, that the operator at the toll center receives a call from some distant point for a station served by the automatic exchange disclosed herein, and the operations involved in completing the connection to the called party may be described. The required connection is completed by inserting the C. B. end of the cord circuit in use in the jack such as J1 of an idle trunk line, by inserting the calling device plug P in the corresponding dialling jack such as J2, and by dialling the number of the called station.

Assuming that the trunk line shown is used for the call, when the operator plugs into jack J1, relays 803 and 801 are energized as previously described, lighting the busy lamp L2 and closing a shunt around winding 806 of the polarized relay. The line relay 702 in the repeater is accordingly energized and closes a circuit for relay 701. Upon energizing, relay 701 disconnects the timer relay 714 at contact 769, closes a circuit for relay 704 at contact 770, said relay operating to make the trunk busy, and closes a circuit for relay 709 which may be traced from ground by way of contact 772, contact 766, contact 743, and lower winding of relay 709 to battery. Upon energizing, relay 709 locks itself at contact 761 and at

contacts 759 and 762 disconnects the trunk conductors 335 and 336 from the windings of the line relay 712 and connects them to the windings of the polarized relay 707. The windings of the polarized relay have been connected together at contact 767 of line relay 702 and accordingly the operation of relay 709 bridges the polarized relay 707 across the trunk conductors 335 and 336.

The line relay 721 and the polarized relay 707 are now energized in series, the direction of current flow being such that relay 707 holds its contact 764 open. The energization of the line relay 721 brings about the operation of the finder in an idle line circuit to extend the trunk line comprising conductors 335, 336, and 337 to the connector of such link circuit in the same manner as a calling subscriber's line is extended when the line relay operates responsive to the removal of the receiver. It may be assumed that the first link circuit is used again. Relays 204, 205, and 207 will energize, therefore, relay 205 placing ground on holding conductor 62. Since the test conductor 337 is connected to the holding conductor 62 by the operation of the finder, the test conductor 337 is also grounded and a circuit is completed for the cut-off relay 720. This relay accordingly operates and disconnects the line relay 721. In the repeater the ground on conductor 337 operates relay 710, over a circuit including contact 763 of relay 709. Upon energizing, relay 710 grounds conductor 337 at contact 758.

Being given the usual dial tone, the operator now inserts the dial plug P into the jack J2 and dials the first digit of the called number. The calling device CD is so arranged that during the setting and return movement of the dial a ground is placed on the sleeve of the plug P. When the first digit is dialled, therefore, relay 804 is energized, substituting the calling device for the polarized relay bridge, and the calling device interrupts the circuit of the line relay 702 of the repeater a number of times depending on the digit dialled. The line relay 702 responds to these interruptions of its circuit and at contact 767 produces a like series of interruptions in the circuit of the line relay 204 of the connector. The remaining digits are dialled in the same manner, relay 804 energizing each time when the dial is moved off normal and deenergizing when it returns to normal.

The operation of the connector is the same as when used by a calling subscriber, except that relay 206 does not energize in response to the energization of relay 304. Relay 710 of the repeater grounds the test conductor 337 as previously explained and hence ground is fed forward over the holding circuit (conductor 62) to the connector where it maintains the upper winding of relay 206 short-circuited after relay 304 has operated. Since relay 206 is not energized, the P2 conductor is not connected up at contact 235 and the starting of the conversation timing operation is prevented.

When the called party answers, relays 210 and 202 of the connector energize and the latter relay reverses the direction of current flow in the line circuit incoming to the connector, which now includes the trunk conductors 335 and 336 and the polarized relay 707 at the repeater. Relay 707 now operates to close its contact 764, closing a circuit for the reversing relay 703. Upon energizing, relay 703 reverses the direction of current flow over the trunk line comprising conductors 725 and 726, whereupon the polarized relay 805-806 operates to close its contact

814 and operate relay 802. The latter relay locks relay 801 at contact 818 and at contact 815 connects resistance 823 in parallel with condenser 822 to pull the supervisory relay in the operator's cord circuit and give her answering supervision.

At the repeater it will be observed that relay 703 closes a circuit for relay 705, the circuit including contacts 772 and 766. Relay 705 locks itself at contact 742 and at contact 743 opens the initial energizing circuit of relay 709. The latter relay, however, remains locked through contacts 772 and 761. Relay 709 is also locked up through its upper winding at contact 765 of relay 703. The last mentioned locking circuit, together with the shunt around contact 767 which relay 703 closes at contact 780, makes it possible for the operator to change cords without releasing the connection.

When the called subscriber hangs up at the end of the conversation, the direction of current flow over trunk conductors 335 and 336 is restored to normal and relay 707 operates to open its contact 764, thereby releasing relay 703. This relay, upon deenergizing, restores the normal direction of current flow over trunk conductors 725 and 726, operating relay 805-806 to open its contact 814 and release relay 802. The deenergization of relay 802 opens the shunt around condenser 822 at contact 815 and gives the operator disconnect supervision. When the operator withdraws the plug from jack J1 relays 803 and 801 deenergize, opening the shunt around the winding 806 of the polarized relay. Relays 702, 701, 709, and 710 in the repeater now deenergize. The deenergization of the line relay 702 opens the bridge across the trunk conductors 335 and 336 and brings about the release of the link circuit in the usual manner.

In describing the foregoing connection it was explained how relay 710 energizes and feeds ground forward over the holding circuit to prevent the energization of relay 206 at the connector and thereby prevent the initiation of conversation timing. Relay 710 has an additional function in case the connector is operated to select a trunk to another manual exchange which is equipped with a repeater similar to the repeater shown. At the second repeater a holding circuit will be established for the connector the same as described in the case of an outgoing toll call, the holding circuit including the lower winding of a relay 715. Since the calling line is not a subscriber's line, however, but a toll trunk including a repeater, relay 710 of this repeater will feed ground forward through the connector to the second repeater where it will shunt the lower winding of relay 715 and prevent its energization. It follows therefore that relay 711 of the second repeater will not have its circuit opened at contact 748 of the associated relay 715 and will remain under the control of relay 701. When the operator at the second manual exchange answers, therefore, relay 701 will operate relay 711 to reverse the direction of current flow in the trunk line coming from the first repeater, operating relay 707 in the first repeater to give the calling operator in the first exchange answering supervision in the manner previously explained.

The invention having been described, that which is believed to be new and for which the protection of Letters Patent is desired will be pointed out in the appended claims.

I claim:

1. In a relay automatic exchange, a plurality of link circuits, a relay allotter for assigning idle

link circuits to calling lines, a pair of relays in said allotter, means controlled from said link circuits for alternately energizing and deenergizing said relays in response to successive calls, a plurality of assignment relays in said allotter individual to the link circuits, respectively, and circuits for the odd and even numbered relays of said plurality controlled, respectively, at the front and back contacts of one of said first mentioned relays.

2. In a relay automatic exchange, a plurality of relay finder switches, a set of common marking conductors, relays individual to said finders, respectively, for connecting said marking conductors to said finders, a relay allotter adapted to complete energizing circuits for successive connecting relays in response to successive calls, a control relay included in all said energizing circuits, a branch circuit common to said energizing circuits and extending through contacts of said control relay, and means operated over said branch circuit for advancing said allotter in case said control relay fails to operate when any energizing circuit is closed at the allotter.

3. In a relay automatic exchange, a relay connector including group and units relays, means for energizing a group relay and a units relay to select a called line responsive to the dialling of a plurality of digits in the called number, party selecting means in said connector responsive to the dialling of the final digit in the called number, means comprising a test relay in said connector for testing the selected line while the final digit is being dialled, a slow acting change-over relay for connecting said test relay in series with the test conductor of the selected line throughout the dialling of said final digit, said test relay energizing if the selected line is found idle during the dialling of said final digit, a connecting relay having contacts for extending connection to the selected line, and means including said test relay in energized condition for operating said connecting relay after the dialling of the final digit has been completed provided the selected line is idle.

4. In a relay automatic exchange, a connector comprising group relays each adapted to select a group of lines, units relays each adapted to select a pair of lines in a group selected by a group relay, a switching relay for selecting one line of a pair selected by a units relay, counting relays for controlling said group and units relays in response to successive digits in a called number, and means including a relay energized in parallel with one of said counting relays in responding to the units digit for operating said switching relay in case the units digit is greater than the digit 5.

5. In a relay automatic exchange, a connector, relays in said connector for selecting and connecting with a desired line, counting relays responsive to successive digits in the called number for controlling said relays, a plurality of code devices any one of which is selectable by said counting relays in response to the final digit in the called number, means controlled by the selected code device for connecting ringing current to one conductor of the selected line, and a relay energized in parallel with one of said counting relays while the same are responding to the final digit in case said digit is greater than the digit 5 for reversing the connections between said ringing means and the selected line to cause ringing current to be connected to the other side of the line.

6. In a relay automatic exchange, four lines

designated, respectively, by one, two, three, and four digit telephone numbers, a relay type connector having access to all said lines, means in said connector for selecting and signalling any line, and a single set of counting relays in said connector adapted to respond to all the digits in the number of any called line to control said selecting and signalling operations.

7. In a relay automatic exchange, a group of trunk lines having a single digit telephone number, a group of trunk lines having a two digit telephone number, a connector including two group relays for selecting said groups of trunk lines, respectively, lines having three digit telephone numbers also adapted to be selected by said group relays, means including a plurality of units relays for selecting individual lines from the group of lines selected by any group relay, and a set of counting relays in said connector adapted to respond to all the digits in any called number for controlling the selecting operations performed by said group and units relays.

8. In a relay automatic exchange, a connector including group and units relays, subscribers' lines and a group of trunk lines accessible to said connector through contacts of said units relays and one of said group relays, and means in said connector for energizing said one group relay in response to the dialling of two different digits, the digit used depending on whether a subscriber's line or the group of trunk lines is being called.

9. In a relay automatic exchange, a connector including group and units relays, lines accessible to said connector through contacts of said relays, means in said connector for energizing a first one of said group relays in response to the dialling of a single digit, and means in said connector for energizing another of said group relays in response to the dialling of the same digit preceded by the dialling of a different digit.

10. In a relay type connector, a plurality of group relays, one and two digit groups of lines adapted to be selected by said relays, the two digit groups having the same prefix, counting relays, marking conductors normally extending from certain of said counting relays to the single digit group relays, a relay for switching said marking conductors from the single digit group relays to the two digit group relays, and a marking conductor extending from the counting relay which corresponds to the prefix digit to said switching relay.

11. In a relay automatic exchange, a connector including group and units connecting relays, groups of lines accessible to said connector through contacts of said relays, one or more of said groups of lines including trunk lines while the other groups include only subscribers' lines, trunk selection control equipment common to said connector and other connectors, means in said connector responsive to the dialling of a digit in a called number for energizing one of said group relays to select a group of lines, and means responsive to the dialling of the next digit in the number for energizing the corresponding units relay or for seizing and operating said control equipment, depending on whether the selected group of lines includes only subscribers' lines or includes trunk lines.

12. In a relay automatic exchange, a plurality of connectors, each including group and units relays, groups of lines accessible to said connectors through contacts of said relays, certain of said groups each including a group of trunk lines,

means in each connector responsive to the dialling of a digit in a called number for energizing a group relay, equipment common to said connectors for controlling the operation of the units relays in said connectors, means comprising sequence relays individual to said connectors, respectively, for temporarily connecting said equipment to any connector, and means in each connector responsive to the dialling of a digit following the group selecting digit for closing a circuit to the associated relay.

13. In a relay automatic exchange, a connector including group and units relays, groups of trunk lines accessible to said connector through contacts of said relays, means in said connector responsive to the dialling of a digit in a called number for operating a group relay, a set of marking conductors in said connector for operating said units relays, a set of marking conductors for each group of trunk lines, means including a connecting relay individual to each of said last mentioned sets for connecting the marking conductors of each set to the set of marking conductors in the connector, and means responsive to the dialling of the next digit in the called number for energizing the connecting relay which corresponds to the energized group relay.

14. In a relay automatic exchange, a connector including group and units relays, subscribers' lines having three digit numbers and a group of trunk lines having a two digit number accessible to said connector through contacts of said relays, means in said connector responsive to the dialling of the first two digits in a number for selecting a subscriber's line or an idle trunk line of said group, depending on the number dialled, ringing means in said connector responsive to the dialling of the third digit in case a three digit number is being called, and means automatically effective in case the two digit number is called for simulating the dialling of another digit in order to bring about the operation of said ringing means.

15. In a relay automatic exchange, a group of trunk lines, a relay connector including means for selecting said group in response to the dialling of a digit in the telephone number of the group, control equipment for selecting an idle trunk temporarily assigned to said connector in response to the dialling of another digit in the number, means in said connector for releasing said equipment after trunk selection has been completed, means in said equipment for maintaining it in association with said connector for a predetermined interval after it is released at the connector, an means in said equipment automatically effective during said interval to transmit an impulse to said connector to start ringing over the selected trunk.

16. In a relay automatic exchange, a relay connector, a twenty party line accessible to said connector, a group of ten code interrupters, means for calling certain of the parties on said line by dialling a plurality of line selecting digits and a code selecting digit, and means for calling the remaining parties on said line by dialling the same digits after first dialling a code switching digit, said last means including a second group of ten code interrupters, and a code switching relay responsive to said switching digit.

17. In a relay automatic exchange, a relay connector, two groups of group relays in said connector, two groups of code ringing conductors in said connector, and means in said con-

nectors responsive to the dialling of a digit in a called number for simultaneously selecting a group of group relays and a group of code ringing conductors.

18. In a relay automatic exchange, a party line, stations on said line having grounded ringers connected to the opposite sides of said line, means including a relay type finder and connector whereby a station on said line may call another station on the same line, means responsive to the replacement of his receiver by the calling subscriber when he hears the busy signal for releasing the finder while maintaining the connector on the line, means in said connector for projecting ringing current over one of said lines to signal the called subscriber, means in said connector for projecting ringing current over the other side of the line to signal the calling subscriber, means for releasing said connector responsive to the removal of the receiver at the called station, and means individual to said line for supplying the calling and called stations with transmitter current.

19. In a relay automatic exchange, a relay connector, subscribers' lines and trunk lines having access to said connector, means for controlling said connector over a calling subscriber's line or over a trunk line to complete a connection to a called line, timing apparatus for releasing the connection after a predetermined time interval, means for starting said timing apparatus if the calling line is a subscriber's line, and means for preventing the starting of said timing apparatus if the calling line is a trunk line.

20. In a relay automatic exchange, a plurality of connectors, each including group and units relays, groups of lines accessible to said connectors through contacts of said relays, one of said groups including a group of trunk lines, means in each connector responsive to the dialling of the first digit in the number of the said trunk group for energizing the corresponding group relay in the connector in use, control apparatus common to said connectors, means responsive to the dialling of the second digit in the number of said trunk group for connecting said control apparatus to the connector in use, and means in said control apparatus for energizing a units relay in such connector which corresponds to an idle trunk line in said group of trunk lines.

21. In a relay automatic exchange, a plurality of connectors, each including group and units relays, groups of lines accessible to said connectors through contacts of said relays, one of said groups including a group of trunk lines, means in each connector responsive to the dialling of a digit designating said trunk group for energizing the corresponding group relay in the connector in use, control apparatus common to said connectors, means responsive to the energization of said group relay for connecting said control apparatus to the associated connector, and means in said control apparatus for energizing a units relay in such connector which corresponds to an idle trunk line in said trunk group.

22. In a relay automatic exchange, a connector including group and units relays, two groups of trunk lines accessible to said connector through contacts of said units relays and two of said group relays, means effective in case either group of trunk lines is called for energizing the corresponding group relay responsive

to the dialling of a single digit, units relay control apparatus common to said connector and other connectors, means effective automatically in response to the energization of the group relay corresponding to one of said groups of trunk lines for connecting said control apparatus to said connector, and means effective in case the group relay corresponding to the other group of trunk lines is energized for operating the control apparatus connecting means in response to the dialling of another digit.

23. In a relay automatic exchange, a relay connector having group and units relays, individual lines and a group of trunk lines accessible to said connector through contacts of said relays, marking conductors individual to said units relays, counting relays in said connector for energizing said units relays over said marking conductors when individual lines are called, control conductors individual to the trunk lines of said group and common to said connector and other similar connectors, means associated with said group of trunk lines and controlled by the busy or idle condition thereof for maintaining a potential on one and only one of said control conductors to place the same in condition for energizing a units relay, and means for energizing said units relays when trunk lines are called by connecting said control conductors to said marking conductors.

24. In an automatic telephone system, a plurality of link circuits, a relay allotter, assignment relays in said allotter individual to said link circuits, respectively, two operating circuits over which said relays are successively energized, a control relay in said allotter having contacts for closing one circuit in energized condition and the other circuit in deenergized condition, and means responsive to each call for changing the condition of said control relay from energized to deenergized condition or vice versa, depending on the condition of the relay at the time of the call.

25. In an automatic telephone system, a plurality of link circuits, a relay allotter including a plurality of assignment relays individual to said link circuits, respectively, an impulsing relay in said allotter for successively energizing said assignment relays in search of an idle link circuit, test conductors individual to said link circuits, respectively, means whereby said assignment relays connect up said test conductors successively to control said impulsing relay, and means for maintaining an effective test potential only on the test conductors of busy link circuits, whereby when the test conductor of an idle link circuit is connected the operation of said impulsing relay will cease.

26. In an automatic telephone system, a plurality of link circuits, a relay allotter for preselecting idle link circuits, said allotter including assignment relays individual to said link circuits, a common operating relay in said allotter, circuits over which said operating relay energizes said assignment relays successively in search of an idle link circuit, test conductors individual to said link circuits, contacts on each assignment relay for extending its associated test conductor to said operating relay, and means for placing a test potential on the test conductor of any busy link circuit to control said operating relay to effect the energization of the assignment relay associated with the next link circuit.

27. In an automatic telephone system, a plurality of link circuits each including a relay type

line finder, a relay allotter, assignment relays in said allotter individual to said link circuits, respectively, means for maintaining an assignment relay corresponding to an idle link circuit energized, marking conductors, a connecting relay individual to each link circuit for extending said marking conductors to its associated finder, means responsive to a call for energizing the connecting relay of said idle link circuit over a circuit prepared by said energized assignment relay, a relay in said allotter energized from said link circuit over a circuit extending through contacts of the energized connecting relay to cause the opening of the circuit of such connecting relay and the deenergization thereof, and means in the allotter responsive to the deenergization of said connecting relay for energizing the next assignment relay.

28. In a relay automatic exchange, a connector including group and units relays, subscribers' lines and a group of trunk lines accessible to said connector through contacts of said units relays and one of said group relays, counting relays in said connector adapted to respond to the group digits in the numbers of called lines, marking conductors extending from contacts of certain counting relays to corresponding group relays in said connector, marking conductors extending from contacts of two counting relays to the said one of said group relays, and means responsive to a call for energizing said last mentioned group relay over one or the other of said last mentioned marking conductors, depending on whether the call is intended for a subscriber's line or said group of trunk lines.

29. In a relay automatic exchange, a connector having group and units relays for extending connections to called lines, a train of counting relays for controlling said group and units relays, a marking conductor extending from contacts of one counting relay to one of said group relays, a marking conductor extending from contacts of another counting relay to the same group relay, and a relay for switching said last mentioned marking conductor to another group relay.

30. In a relay automatic exchange, a connector having group and units relays for extending connections to called lines, a train of counting relays for controlling said group relays, a marking conductor selectable by one of said counting relays and extending to one of said group relays, a relay for switching said marking conductor to another group relay, means for energizing either group relay over said marking conductor, and means including a marking conductor selectable by another of said counting relays for energizing said switching relay.

31. In a relay type connector, group relays having access to called lines, counting relays for selectively energizing said group relays, marking conductors over which such energization is effected, additional group relays in said connector, relay switching means, means for energizing said switching means, and contacts operated by said switching means for switching said marking conductors from said first mentioned group relays to said additional group relays, whereby the latter relays may be selectively energized under control of said counting relays.

32. In a relay type connector, group and units relays for extending connections to called lines, a train of counting relays for selectively energizing said group and units relays, marking conductors over which such energization is effected, said marking conductors including a certain number

which extend directly from contacts of certain of said counting relays to certain units relays and at least one marking conductor which extends from contacts of a counting relay to a units relay through contacts of one of said group relays provided such group relay is energized.

33. In a relay type connector, group and units relays for extending connections to called lines, group marking conductors over which the group relays are energized, units marking conductors over which the units relays are energized, one of said units marking conductors being normally open, and multiple connected contacts on a plurality of said group relays whereby said normally open units marking conductor is closed by the energization of any group relay of said plurality of group relays.

34. In a relay type connector, group and units relays for extending connections to called lines, group and units marking conductors over which said relays may be energized, including a normally open units marking conductor, contacts on one or more group relays for extending said normally open marking conductor to the associated units relay, a sequence relay, and contacts on another group relay for extending said normally open marking conductor to said sequence relay.

35. In a relay type connector, group and units relays for extending connections to called lines, group and units marking conductors over which said relays may be energized, including a special units marking conductor normally disconnected from its associated units relay, means controlled by a group relay for connecting said special marking conductor to its associated units relay, additional units marking conductors, means including a relay for connecting said additional units marking conductors to said first mentioned units marking conductors, and means controlled by another group relay for connecting said special marking conductor to said last mentioned relay.

36. In a relay automatic exchange, a relay type connector having access to subscribers' lines and trunk lines, means in said connector for selecting and signalling any line responsive to the receipt of three digits, said trunk lines having a telephone number consisting of only two digits, apparatus common to said connector and other similar connectors, means for assigning said apparatus to said connector when the trunk line number is called, and means in said apparatus for automatically transmitting the omitted third digit to said connector.

37. In an automatic exchange, a connector having access to two kinds of lines, the lines of one kind being designated by numbers having a certain number of digits and the lines of the other kind being designated by numbers having one less digit, selecting and signalling means in said connector requiring the full complement of digits for its complete operation, and means effective responsive to the calling of a line of the second kind for automatically transmitting an additional digit to said connector to enable it to complete its operation.

38. In a relay automatic exchange, a relay type connector including group and units relays for selecting lines accessible to the connector, a train

of counting relays for selectively controlling said relays, ringing equipment selectively controlled and rendered operative by said counting relays, apparatus common to said connector and other similar connectors, means for temporarily assigning said apparatus to the exclusive use of said connector, and means in said common apparatus for energizing one of said counting relays to cause the same to control said ringing equipment.

39. In a relay automatic exchange, a plurality of connectors, each having group and units relays for connecting to called lines, means including counting relays in each connector for controlling the associated group relays and also for controlling the associated units relays when certain lines are called, a set of marking conductors common to said connectors for controlling the units relays in any connector when the same is in use to call certain other lines, means including a sequence relay in each connector for extending said common marking conductors to the units relays in such connector, and means for insuring the energization of no more than one of said sequence relays at a time.

40. In a relay automatic exchange, a plurality of connectors, each having group and units relays for connecting to called lines, means including counting relays in each connector for controlling the associated group relays and also for controlling the associated units relays when certain lines are called, a set of marking conductors common to said connectors for controlling the units relays in any connector when the same is in use to call certain other lines, means including a sequence relay in each connector for extending said common marking conductors to the units relays in such connector, means in each connector for energizing its associated sequence relay, and means comprising a chain circuit extending through serially related contacts of all said sequence relays for preventing the energization of more than one sequence relay at a time.

41. In a relay automatic exchange, a relay connector having group and units relays for connecting with subscribers' lines, counting relays responsive to group designating digits for energizing said group relays, marking conductors over which such energization is effected, a group of toll trunks designated by the digit "0" accessible to a group relay having a different group digit designation, and a connection between the group marking conductor corresponding to the digit "0" and the group marking conductor over which the group relay having access to said toll trunk is energized.

42. In a relay automatic exchange, a relay connector having group relays for connecting with groups of lines, counting relays responsive to group selecting digits, marking conductors corresponding to the respective group digits selected by said counting relays for energizing said group relays, a connection from one marking conductor to another marking conductor to energize the group relay corresponding to said other marking conductor, and means for switching said one marking conductor from said other marking conductor to another group relay.

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