Jan. 28, 1947. J. WICKS 2,415,057

TELEPHONE SYSTEM

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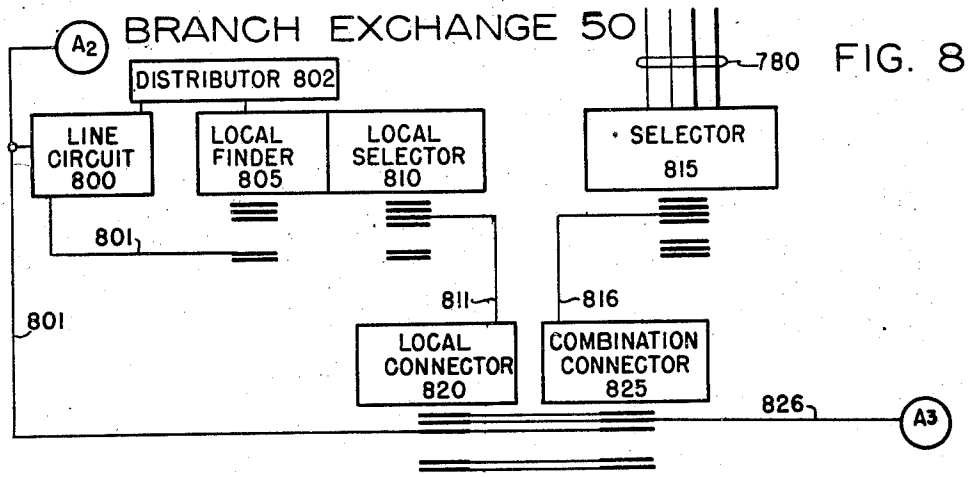
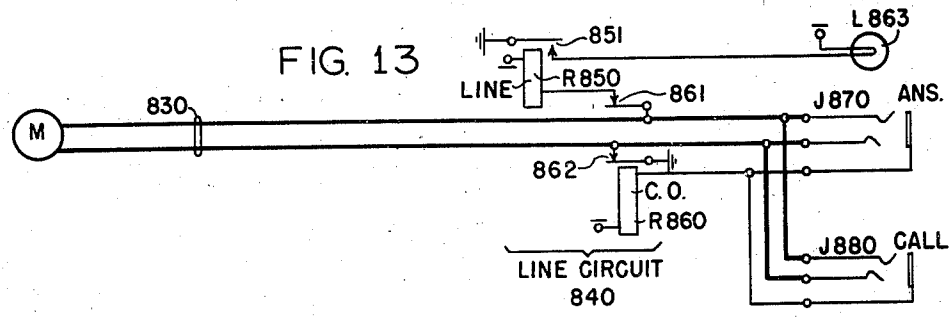
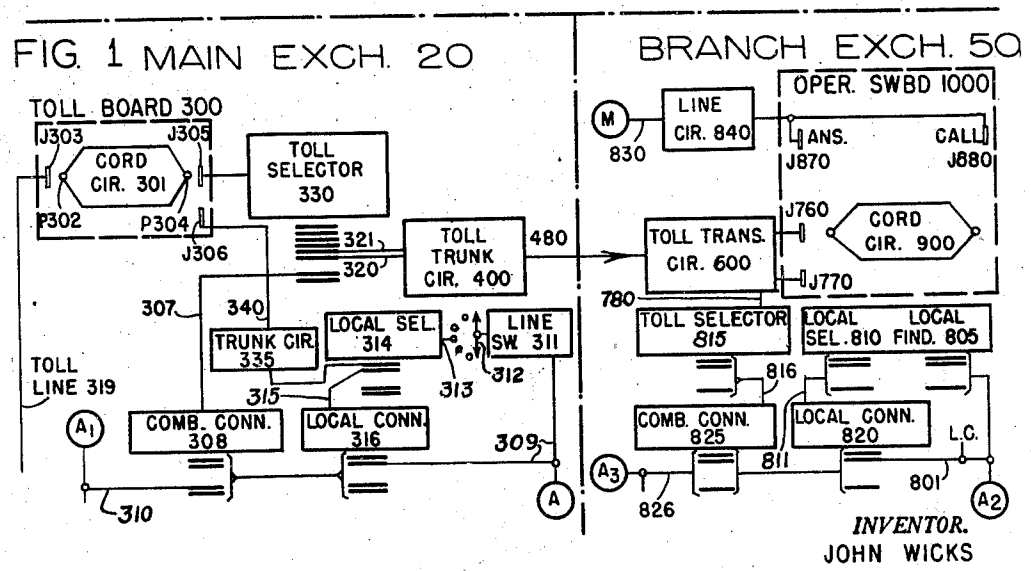


FIG. 8





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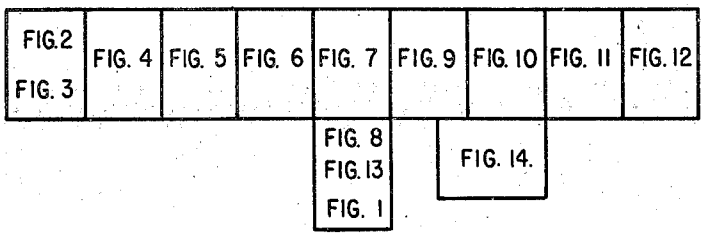
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FIG. 2



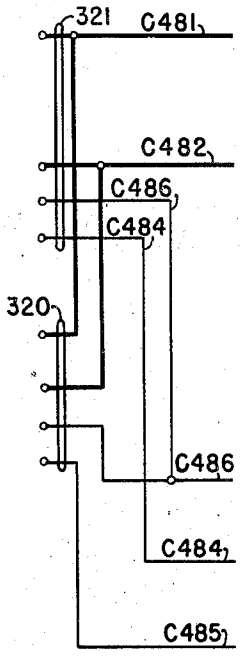
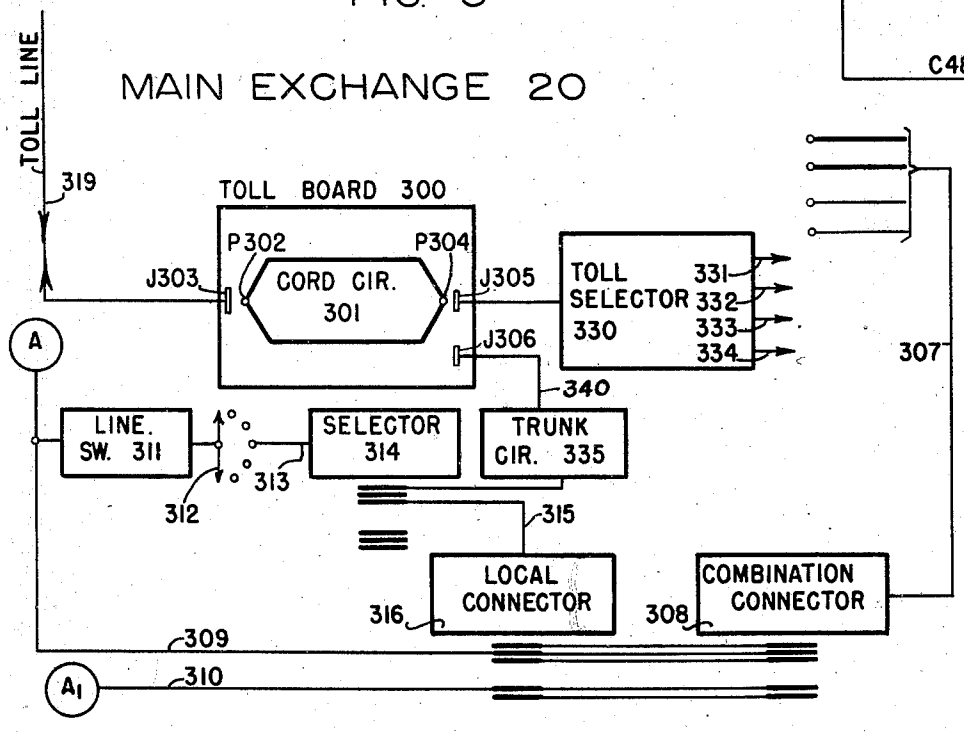


FIG. 3

MAIN EXCHANGE 20



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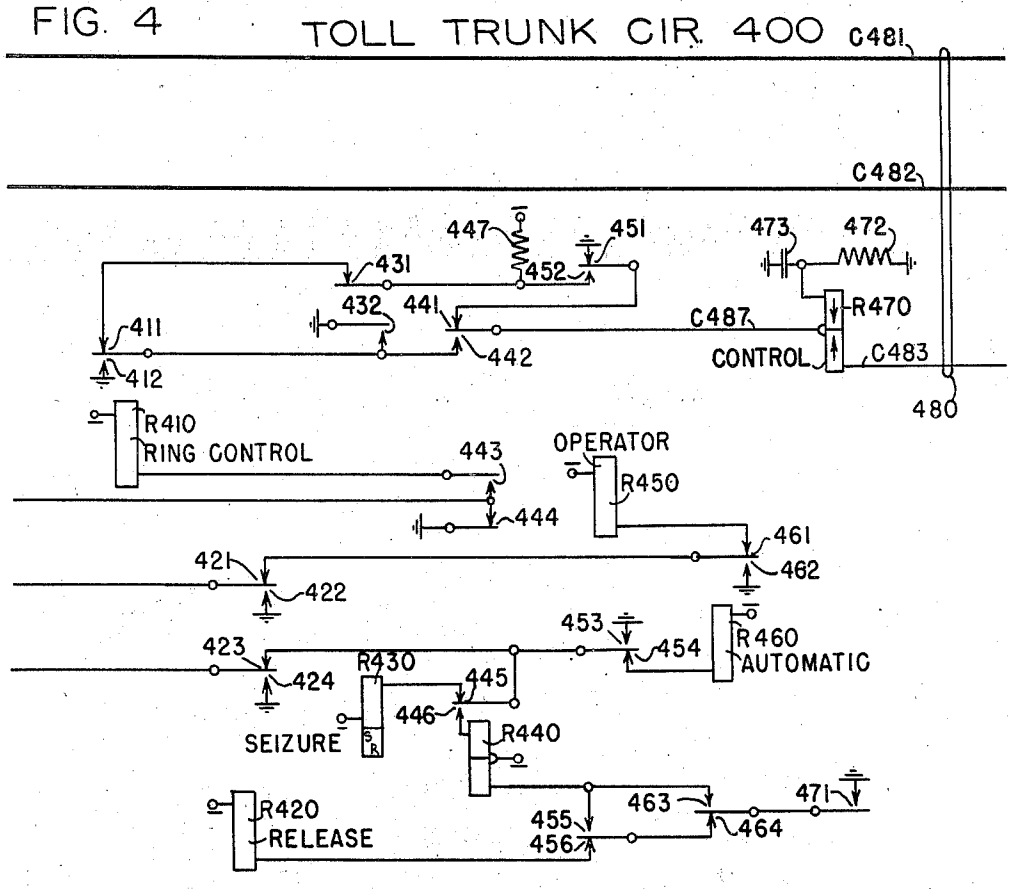
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FIG. 4



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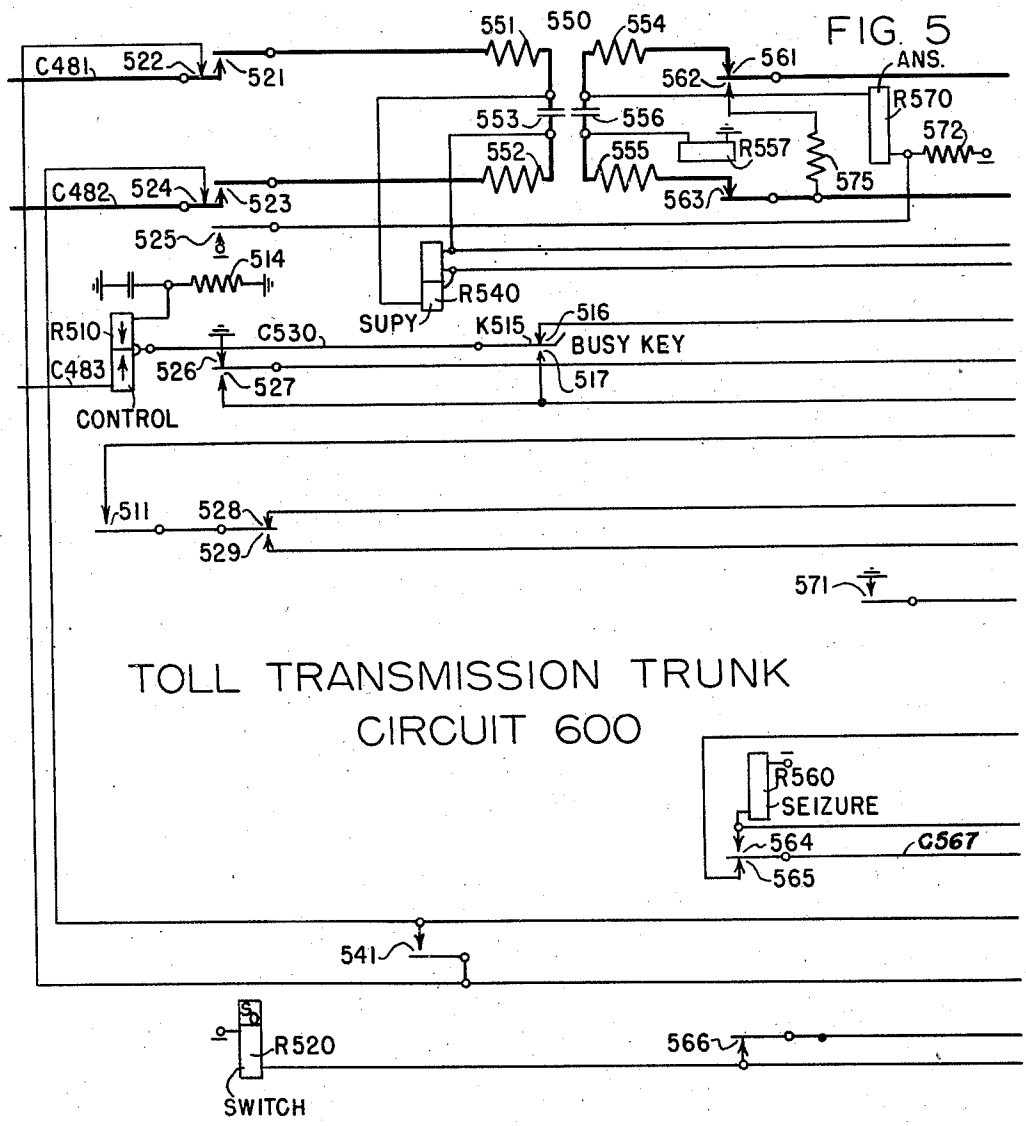
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FIG. 5



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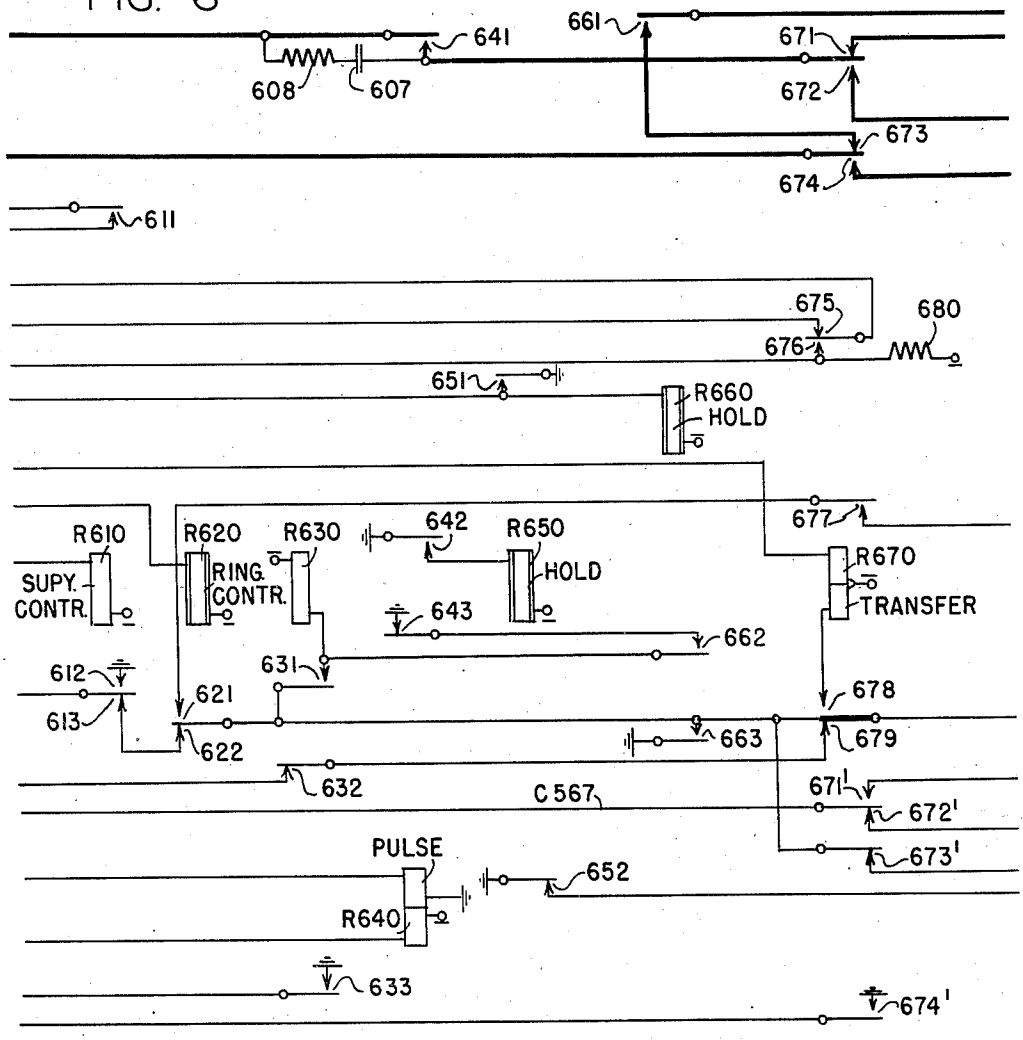
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FIG. 6



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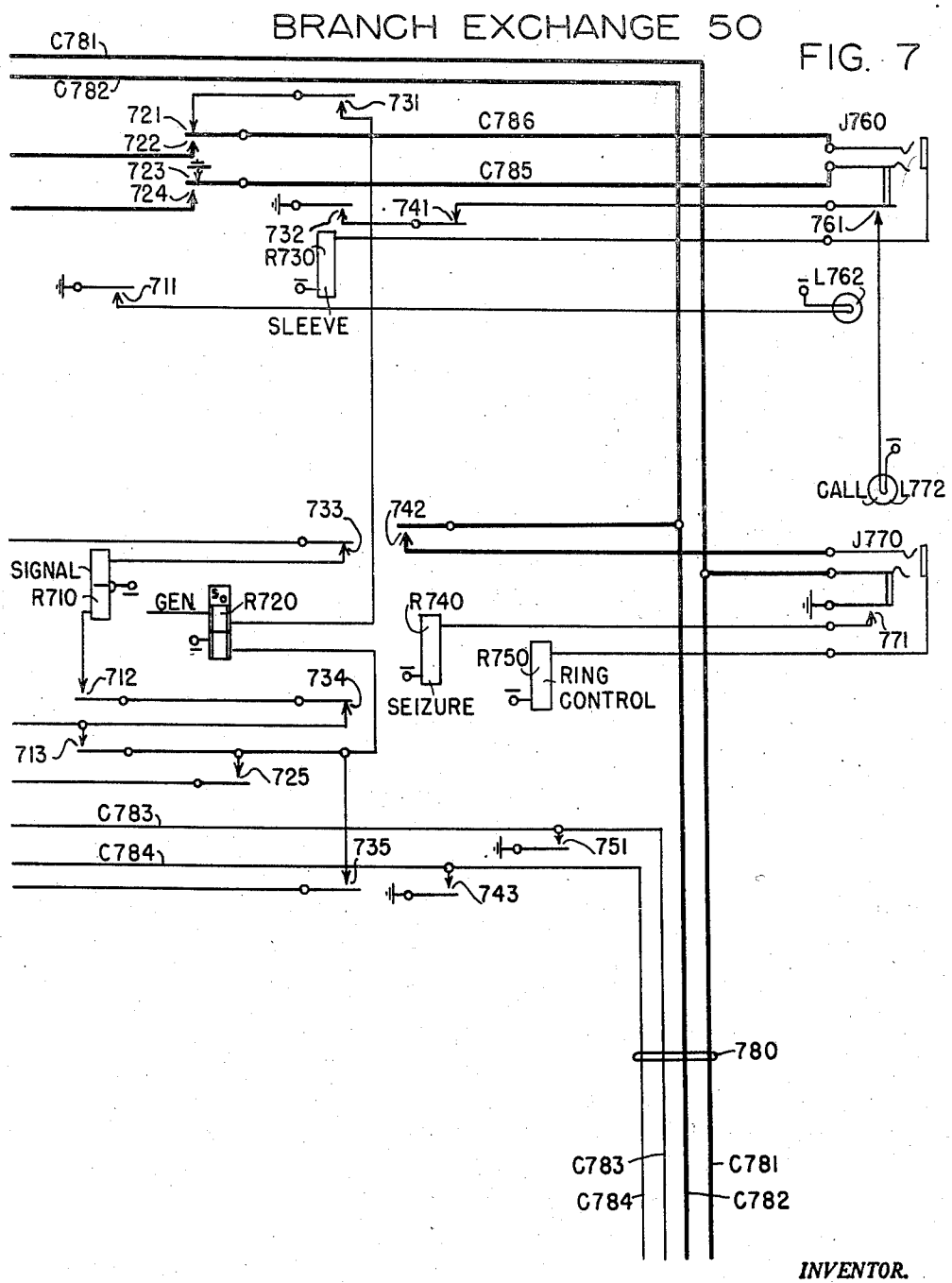


FIG. 7

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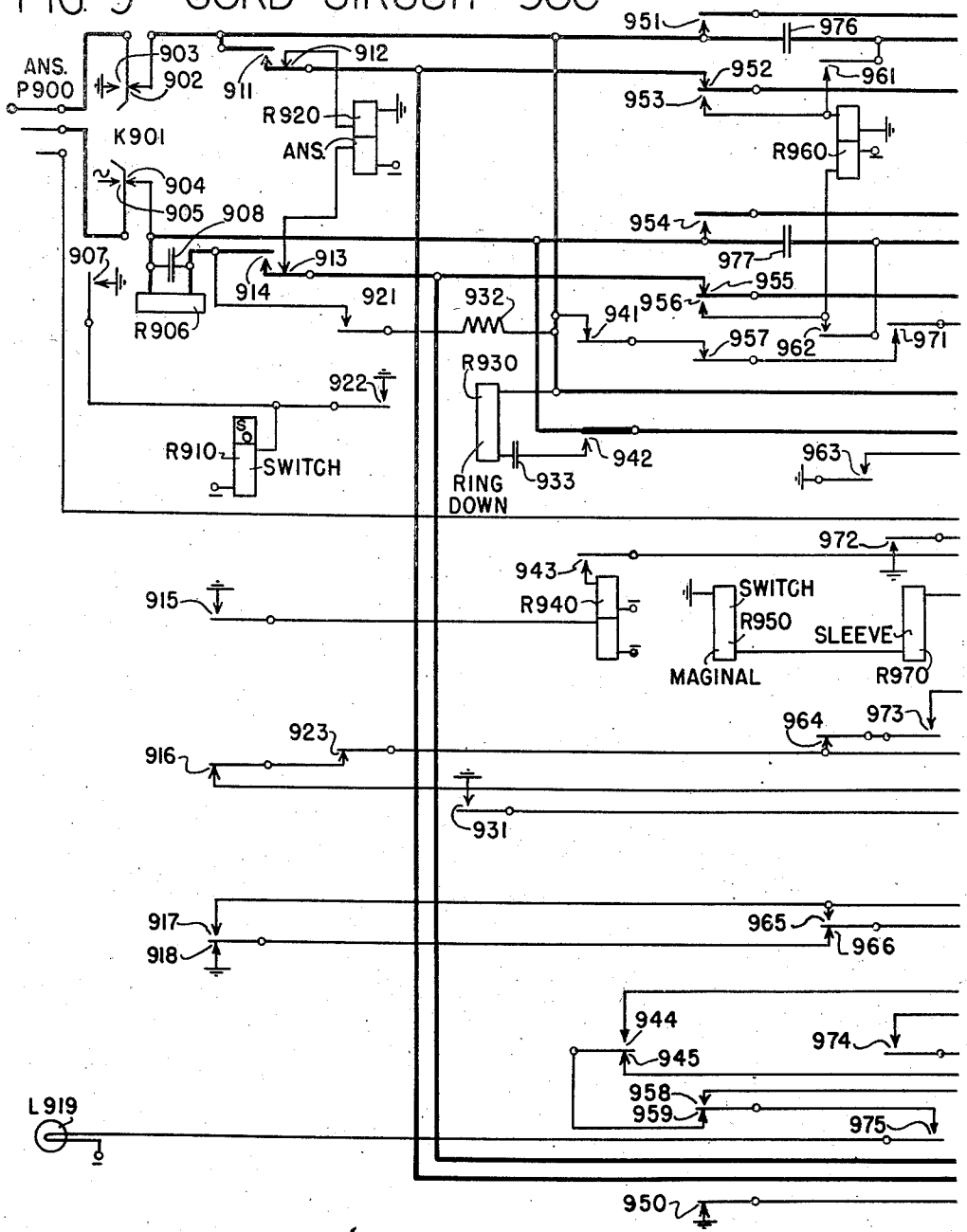
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FIG. 9 CORD CIRCUIT 900



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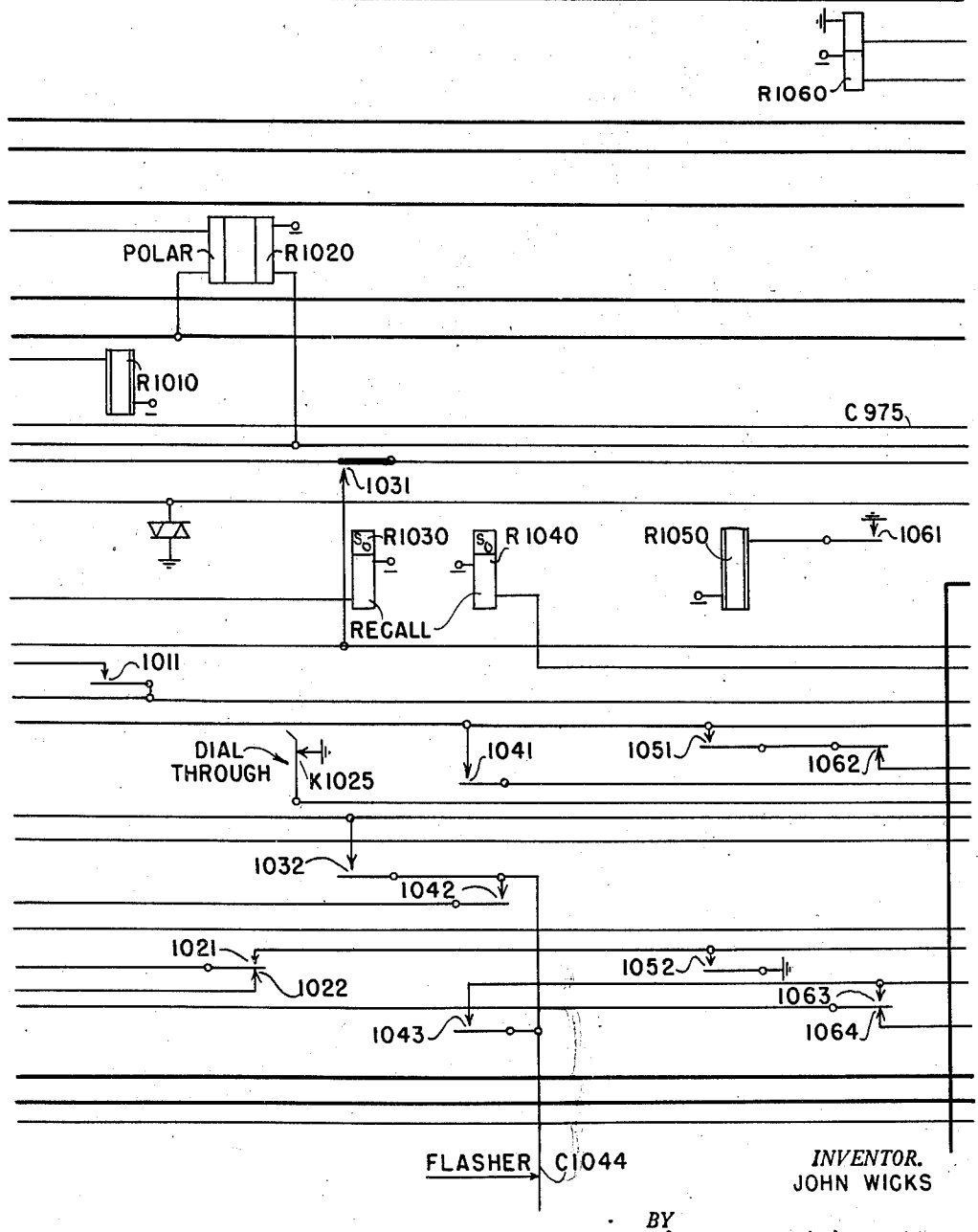
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TELEPHONE SYSTEM

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FIG. 10



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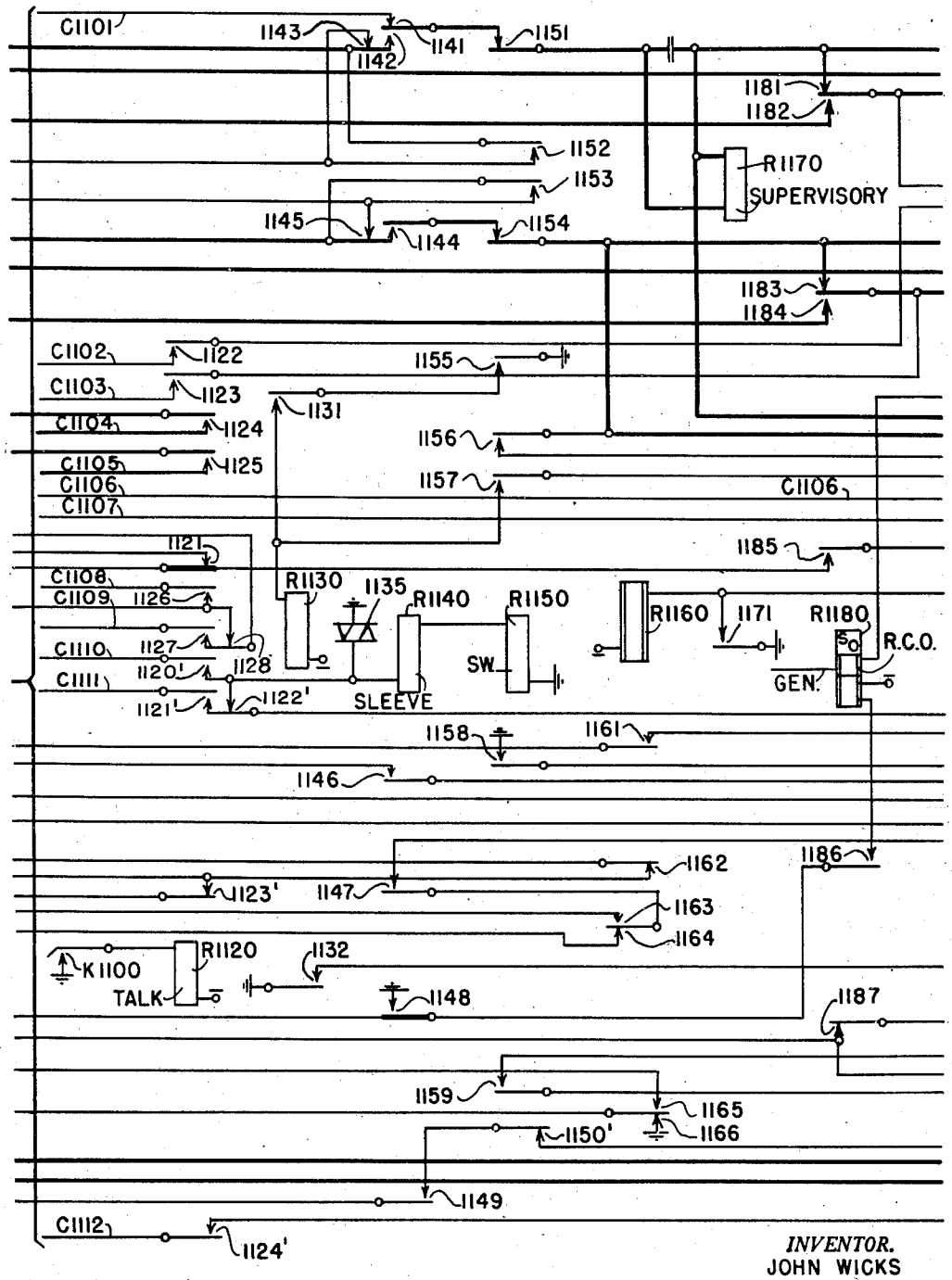


FIG. 11

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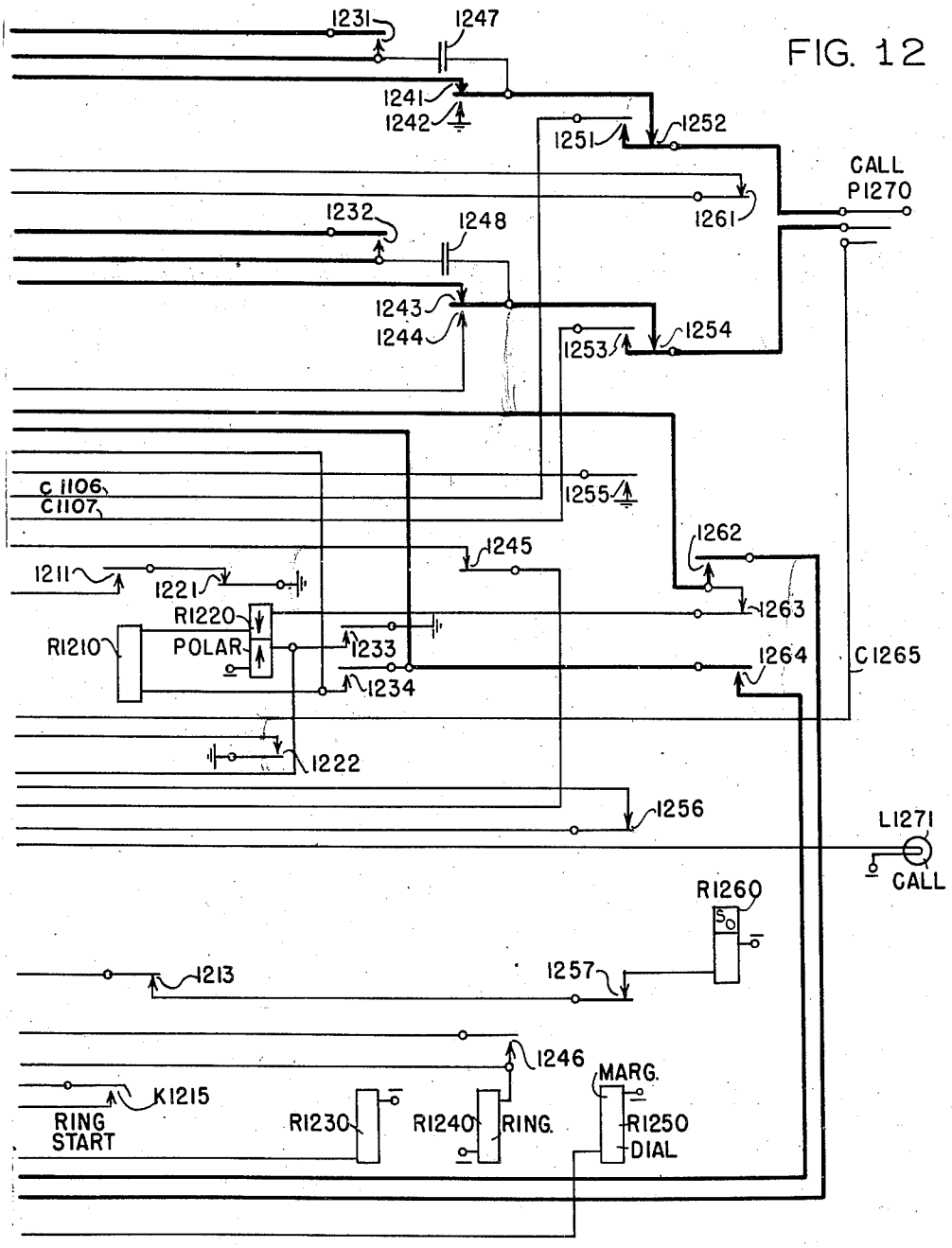
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TELEPHONE SYSTEM

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FIG. 12



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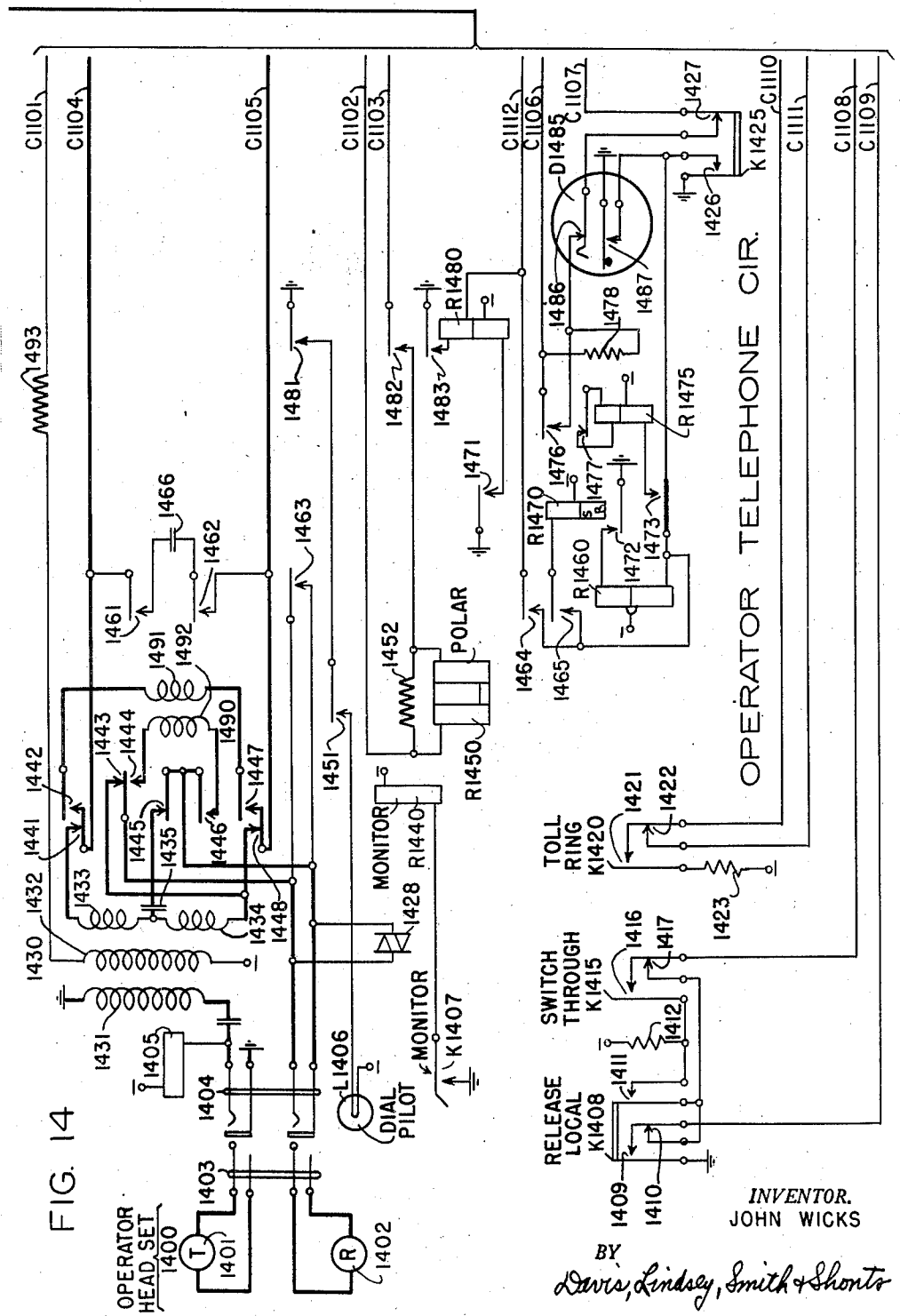


FIG. 14

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Patented Jan. 28, 1947

2,415,057

UNITED STATES PATENT OFFICE

2,415,057

TELEPHONE SYSTEM

John Wicks, Biloxi, Miss., assignor to Automatic Electric Laboratories, Inc., Chicago, Ill., a corporation of Delaware

Application February 9, 1945, Serial No. 576,912

27 Claims. (Cl. 179—27)

1

The present invention relates to telephone systems in general and, more particularly, to improvements in the apparatus provided for setting up toll connections in an interexchange network including both automatic and combined automatic and manual exchanges.

It is an object of the present invention to provide, in a telephone system of the character indicated, a novel arrangement whereby a toll operator in a main automatic exchange or toll office may interconnect toll lines terminating at her position with subscriber lines which terminate in a combined manual and automatic private branch exchange, either with or without the assistance of the branch exchange operator.

According to another object of the invention, facilities are provided for selecting the interexchange trunk lines over either one of two paths and for determining in accordance with the path over which the trunk line is selected whether the toll connection is to be completed to the desired called subscriber line under the exclusive control of the toll operator or whether the toll connection is to be completed under the joint control of the toll operator and the branch exchange operator.

It is another object of the invention to provide, in a telephone system of the character indicated, a new and improved arrangement for transmitting various supervisory and control signals in two directions over the interexchange trunk lines.

The invention, both as to its organization and method of operation, together with other objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings, in which Figure 1 illustrates the general arrangement of a telephone system embodying the invention; Fig. 2 illustrates the mode of combining Figs. 3 to 14, inclusive, of the drawings to form a unified system; and Figs. 3 to 14, taken together, illustrate a telephone system having incorporated therein the features of the invention, as briefly outlined above. More specifically, Fig. 3 shows a schematic layout of the switching apparatus and the toll board 300 located in the main exchange 20; Fig. 4 shows the detailed circuits of the toll trunk circuit 400 in the main exchange 20; Figs. 5, 6 and 7 show the detailed circuits of the toll transmission trunk circuit 600 in the branch exchange 50; Fig. 8 shows a schematic layout of the switching apparatus located in the branch exchange 50; Figs. 9 to 12, inclusive, show the detailed circuits of the cord circuit 900 at the manual switchboard 1000 in the branch exchange

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50; Fig. 13 shows the detailed circuits of the equipment for the manual line 830; and Fig. 14 shows the detailed circuits of the operator telephone circuit associated with the cord circuit 900.

Referring now more particularly to Fig. 1 of the drawings, the telephone system there illustrated comprises a main exchange 20 and a private branch exchange 50. The main exchange 20 terminates a number of automatic subscriber lines which may be interconnected with the automatic and manual subscriber lines terminating in the branch exchange 50, in the manner described in detail in the copending Burgener application, Serial No. 576,913, filed Feb. 9, 1945. The main exchange 20 also includes a toll switchboard 300 which terminates a plurality of toll lines 319 from distant exchanges and which has access to a toll switch train, in order that toll calls received from the distant exchanges may be extended either to main exchange subscribers or to the branch exchange subscribers. Facilities are also provided at the main exchange 20 whereby the subscribers thereat may call the toll board 300 in order that the toll operator thereat may complete toll connections to the subscribers served by the distant exchanges reached by way of the toll lines 319.

The branch exchange 50 is provided with a toll switch train of the Strowger type, whereby the toll operator in the main exchange 20 may extend connections to the automatic subscriber lines in the branch exchange 50. The branch exchange 50 is also provided with a manual switchboard 1000 whereby the operator thereat may extend toll calls received from the toll operator at the main exchange to the branch exchange manual or automatic subscriber lines.

When a toll call is received over the toll line 319 at the toll board 300, the operator thereat may extend the connection to the line of substation A or A1 in the main exchange 20 by means of the plug P304 of the cord circuit 301, the jack J305, the toll selector 330, and the combination connector 308. The toll operator may also extend a toll connection received over the toll line 319 to the line of the automatic substation A2 or A3 in the branch exchange 50 by means of the plug P304 of the cord circuit 301, the jack J305, the toll selector 330, the trunk line 320, the toll trunk circuit 400, the interexchange trunk line 430, the toll transmission trunk circuit 600, the toll selector 815, and the combination connector 825. It should be noted that the toll operator may also extend a toll connection to the line of the manual substation M in the branch exchange 50 by means of the plug

P304 of the cord circuit 301, the jack J305, the toll selector 330, the trunk line 321, the toll trunk circuit 400, the interexchange trunk line 480, the toll transmission trunk circuit 600, and the jack J760 to the manual operator at the switchboard 1000, who in turn completes the connection by means of the cord circuit 900, the jack J880, the line circuit 840, and the line 830 of the substation M. If the toll call received by the manual operator at the branch exchange 50 is intended for the line of the automatic substation A2 or A3, the operator thereat may also complete such a connection by means of the cord circuit 900, the jack J770, the toll transmission trunk circuit 600, the toll selector 815, and the combination connector 825.

When the local subscriber at the substation A in the main exchange 20 desires to extend a toll call to a distant exchange reached by way of the toll line 319, the connection is extended by means of the line switch 311, the local selector 314, the trunk circuit 335, and the trunk line 340 to the jack J306 at the toll board 300, and the operator thereat completes the connection by means of the cord circuit 301 to the desired distant exchange reached by way of the toll line 319, all in the same manner as has been explained in the previously mentioned Burgener application.

In the event that a subscriber in the branch exchange 50 desires to call a subscriber reached by way of the toll line 319, a connection is first extended to the branch exchange switchboard 1000. After obtaining the necessary information for completing the toll call the manual operator at the switchboard 1000 informs the calling subscriber that he will be recalled as soon as the toll connection is completed to the desired called subscriber. The manual operator now extends a connection over a special switch train to the toll board 300 and releases the connection, after giving the toll operator the necessary information for completing the toll connection. The circuits and apparatus for extending a connection from the calling branch exchange subscriber to the manual operator and from the manual operator to the toll operator are disclosed and described in detail in the previously mentioned Burgener application. After the operator at the toll board 300 obtains the desired called subscriber in the distant exchange, she completes the connection by recalling the original calling subscriber in the branch exchange 50, as will be more fully described hereinafter.

Toll Call from a Distant Exchange to the Automatic Substation A3 in the Branch Exchange 50

Having described in general terms the manner in which various toll connections are established, a more detailed description will now be given of the operation of the circuits and apparatus utilized in establishing the various connections. For this purpose it will be assumed that the operator at the toll board 300 has answered a toll call received over the toll line 319, by inserting the answer plug P302 of the cord circuit 301 into the jack J303, and that the calling subscriber or operator, as the case may be, in the distant exchange desires to communicate with the subscriber at substation A3 in the branch exchange 50. It will also be assumed that the toll operator has inserted the call plug P304 into the jack J305 and has seized the toll selector 330. The operator may now actuate her calling device (not shown) in order to operate the selector 330, in a well known manner, to raise its wipers 331 to 334, inclusive, in a vertical direction to a level corresponding to the digit dialed, after which the wipers are rotated automatically to select an idle toll trunk circuit.

It should be noted that the toll selector 330 may be controlled to select the toll trunk circuit 400 over either the trunk line 320 or the trunk line 321. Referring now to Figs. 3 to 14, inclusive, it will be noted that the trunk line 320 terminates in the fifth level of the bank contacts accessible to the wipers 331 to 334, inclusive, of the toll selector 330 and that the trunk line 321 terminates in the sixth level. Accordingly, when the toll operator dials the digit "5" and thereby selects a toll trunk circuit, such as 400, over a trunk line, such as 320, the toll transmission trunk circuit 600 in the branch exchange is automatically controlled to direct the connection to the toll switch train in the branch exchange 50. The toll operator may then directly control the toll switch train in order to extend the call to the desired automatic subscriber line.

If the toll operator should find it necessary to call the branch exchange operator in order to complete a desired toll call, she may dial the digit "6" whereupon a toll trunk circuit, such as 400, is seized over a trunk line, such as 321. The toll transmission trunk circuit 600 in the branch exchange 50 now functions, in a manner to be fully explained hereinafter, to extend the connection to the manual switchboard 1000. When the manual operator at the switchboard 1000 receives such a call, she may complete it by way of the cord circuit 900, either to a manual subscriber line, or by way of the toll transmission trunk circuit 600, the toll selector 815, and the combination connector 825, to an automatic subscriber line.

It will be assumed that the digit "5" was dialed by the toll operator and that the trunk line 320 is the one selected by the wipers 331 to 334, inclusive, of the toll selector 330, whereupon ground potential is applied from the toll selector 330, by way of the wiper 334, the conductor C485, and the contacts 423, one branch of the circuit extending by way of the contacts 454 and the winding of the automatic relay R460, to battery, and the other branch of the circuit extending by way of the contacts 445 and the winding of the seizure relay R430, to battery. As a further result of the engagement of the wipers 331 to 334, inclusive, with the trunk line 320, a loop circuit is completed including the cord circuit 301, the plug P304, the jack J305, the toll selector 330, the wipers 331 and 332, the conductors C481 and C482 of the interexchange trunk line 480, the contacts 522 and 524, and the lower and upper windings of the pulse relay R540, to battery and ground respectively. The relay R540 operates over the above traced loop circuit to control the toll transmission trunk circuit 600, in a manner to be explained hereinafter.

When the above mentioned circuit for the automatic relay R460 is completed, the relay operates and, at its contacts 463, prepares a circuit for subsequently operating the relay R440; and, at its contacts 461 and 462, it transfers the conductors C484 from battery, through the winding of the operator relay R450, to direct ground, in order to mark the toll trunk circuit 400 busy in the banks of the selectors having access thereto. When the relay R430 operates over the above mentioned circuit, at its contacts 431, it opens a

point in an incomplete circuit for applying resistance battery by way of conductor C487 to the control relay R470; and, at its contacts 432, it prepares a point in an incomplete circuit for applying ground potential by way of conductor C487 to the control relay R470.

Attention is directed to the fact that the conductor C483 of the interexchange trunk line 480 is the control conductor over which the duplex relays R470 and R510 are controlled in order to perform various operations in the main and branch exchanges. At the present time the windings of the above mentioned relays are shunted over a circuit which may be traced from ground, by way of the contacts 451 and 441, the conductor C487, the lower winding of the relay R470 (the upper winding of this relay being connected to ground by way of the resistance 472), the conductor C483, the lower winding of the relay R510 (the upper winding of this relay being connected to ground by way of the resistance 514), the conductor C530, and the contacts 516, 675 and 526, to ground. Since the above traced circuit, including the windings of the relays R470 and R516, is traced from ground to ground, the relays remain in their normal positions, and it will be understood from a further description of the operation of the system that signals may be transmitted over this circuit in both directions between the main and the branch exchanges to perform various supervisory and control operations.

When the previously traced loop circuit is completed for the pulse relay R640, the relay operates and, at its contacts 641, it applies battery potential by way of the high resistance 572, the winding of the relay R570, the winding 554 of the repeating coil 550, the contacts 551, 641 and 671, to the conductor C782 to prepare a point in the circuit for controlling the selector 815; at its contacts 642, it completes an operating circuit for the hold relay R650; and, at its contacts 643, it opens a point in an incomplete circuit for subsequently operating the relay R630. The relay R550, upon operating, at its contacts 551, completes an operating circuit for the hold relay R560. At its contacts 562, the relay R560 upon operating, closes a point in the incomplete for the relay R530; and, at its contacts 563, it completes an operating circuit for the relay R560 which may be traced from ground, by way of the contacts 663, 679 and 632, and the winding of the relay R560, to battery, and, at the same time, ground potential is extended by way of contacts 663, 622, 613 and 565, conductor C567, and contacts 672', to the conductor C783 and by way of contacts 663 and 673', to the conductor C784. The ground potential applied to conductors C783 and C784 prepares the selector 815 for subsequent operation. The relay R560, at its contacts 661, also applies ground potential by way of the winding of the relay R557, the winding 555 of the repeating coil 550, the contacts 563, 673 and 631, to the conductor C781, to prepare a point in the circuit for controlling the selector 815.

The relay R560 operates over the above traced circuit and, at its contacts 564, applies the operating ground potential for the relay R560 to the conductor C567. At its contacts 566, the relay R560 opens a point in the incomplete circuit for the switching relay R520; at its contacts 562, it places a resistance 575 in series with the conductors C781 and C782; and, at its contacts 561 and 563, it disconnects the windings 554 and 555, of the repeating coil 550, and the battery and ground potentials, applied thereto by way of the windings of the relays R557 and R570, from the conductors C781 and C782. When ground potential is applied to the conductors C783 and C784 and when the resistance 575 is connected in series with the conductors C781 and C782, the selector 815 is seized, in a well known manner, and may respond to impulses transmitted thereto under the control of the pulse relay R640.

The operator at the toll board 300 may now actuate the dial thereat in accordance with the next digit of the called subscriber number and, as a result thereof, the pulse relay R640, in the toll transmission trunk circuit 600, at its contacts 641 repeats the impulses constituting the dialed digit, by opening and closing the loop circuit extending to the selector 815. The first time the relay R640 restores to normal during impulsing, at its contacts 643, it completes a circuit from ground, by way of the contacts 643 and 662 for operating the relay R630; at its contacts 642, it opens the circuit of relay R650; and, at its contacts 641, it interrupts the loop circuit in order to transmit the first pulse to the selector 815. Since the relay R650 is of the slow-to-release type, it remains in its operated position during impulsing. The relay R630, upon operating over the above traced circuit, at its contacts 631, completes a holding circuit for itself from ground at contacts 663, thereby maintaining itself in an operated position over a circuit which is independent of its initial energizing circuit. At its contacts 632, the relay R630 opens the initial operating circuit for the seizure relay R560, but this relay now remains locked up from ground applied to conductor C783 upon the seizure of the selector 815. At its contacts 633, the relay R630 prepares a point in the circuit for operating the switching relay R520.

Each time the pulse relay R640 reoperates after the termination of each impulse, at its contacts 643, it opens the initial operating circuit for the relay R630; at its contacts 642, it recloses the energizing circuit for the hold relay R650; and, at its contacts 641, it recloses the loop circuit including the conductors C781 and C782 to terminate each impulse transmitted to the selector 815. In the above described manner the relay R640 follows the series of impulses transmitted by the operator at the toll board 300, and repeats these impulses, at the contacts 641, to the selector 815 and the subsequent switches in the train in order to complete the connection to the desired called subscriber line.

Referring to Fig. 8, it will be assumed that the digit dialed to control the selector 815 is the digit "8" and that the selector 815 has elevated its wipers in a vertical direction to the eighth level, and has automatically rotated the wipers over the contacts of the associated level to select the trunk line 816 extending to the combination connector 825. The final two digits of the desired called subscriber number are now dialed by the operator and, in the manner described above, are repeated by the pulse relay R640 in order to control the operation of the connector 825. The connector 825 responds, in a well known manner, to raise its wipers to the level of its associated bank contacts terminating the line 826 of the called subscriber substation A3 and, in response to the final digit dialed by the toll operator, rotates its wipers over the selected level into engagement with the set of bank contacts terminating the line 826.

If the desired called line is busy when the wipers of the connector 825 are positioned into engagement therewith, the usual busy tone signal is transmitted to the operator at the switchboard 300 to indicate that the called line cannot be signaled at the present time. It will be assumed, however, that the called line is idle when the wipers of the connector 825 are placed into engagement therewith, and the connector, in a well known manner, switches the connection through to the selected line. The ringing control of the combination connector 825, when utilized in a toll connection, is such that the connector does not automatically ring the desired called line but must be controlled by the operator at the toll board to signal the called subscriber.

When the connector 825 switches the connection through to the line 826, ground potential is removed from the conductor C783, thereby opening the circuit of the relay R560. The relay R560 now restores to normal and, at its contacts 565, connects ground potential by way of the contacts 663, 622, 613 and 565, to the conductor C783 in order to prepare the connector to ring the desired called subscriber line when ground potential is subsequently removed from the conductor C783 by the operation of the ring control relay R620, as will be described hereinafter. At its contacts 561, 562 and 563, the relay R560 removes the resistance 575 from the conductors C781 and C782 and reconnects battery and ground potentials by way of the relays R570 and R557 and the windings 554 and 555, to the conductors C782 and C781, respectively; and, at its contacts 566, it completes an operating circuit for the switching relay R520.

Upon operating, the relay R520, at its contacts 521 to 524, inclusive, transfers the loop circuit including the conductors C481 and C482, from the windings of the pulse relay R640, to the windings 551 and 552 of the repeating coil 550 and the upper and lower windings of the supervisory relay R540 in series. The relay R540 operates at this time over a circuit including the cord circuit 301 and, at its contacts 541, completes a circuit for maintaining the pulse relay R640 in its operated position to prevent the relays in the toll transmission trunk circuit 600 from restoring. It should be noted at this time that since the contacts 521 to 524, inclusive, are of the make-before-break variety, the relay R540 operates to close its contacts 541 before the relay R640 is restored to normal. As a further result of the operation of the relay R520, at its contacts 529, it prepares a circuit for operating the ring control relay R620; at its contacts 525 it connects battery potential through the winding of the answer relay R570 in order to shunt out the battery potential applied thereto by way of the high resistance 572. At its contacts 526, the relay R520 removes ground potential from the control conductor C483 extending to the main exchange, and, at its contacts 527, it applies battery potential to the conductor C483. As a result of the latter operation a circuit is now completed which may be traced from ground, by way of the contacts 451 and 441, the conductor C487, the lower winding of the control relay R470, the conductor C483, the lower winding of the control relay R510, the conductor C530, the contacts 516 of the busy key K515, the contacts 675 and 527, and the resistance 680, to battery.

As a result of the above traced circuit the relay R470 in the toll trunk circuit 400 is operated, but the relay R510 in the toll transmission trunk 600 is not operated. More specifically, the circuit including the upper winding of the control relay R470 is rendered ineffective since the circuit therefor may be traced from ground, conductor C487, the upper winding of the relay R470, and the resistance 472, to ground. No current flows through the upper winding of the relay and the current flow through its lower winding is sufficient to cause it to operate at this time. Referring to the control relay R510, it is to be noted that when battery potential is connected to the conductor C530, a circuit is completed for its upper winding from ground, by way of the resistance 514, and the upper winding of the relay R510, to battery potential connected to the conductor C530. A circuit is also completed for the lower winding of the relay in series with the lower winding of the control relay R470 in the toll trunk circuit 400. Since the windings of the relay R510 are in opposition to each other, and since the energizing circuit is completed for both windings, the relay does not operate at the present time.

The control relay R470 in the toll trunk circuit 400 operates over the above traced circuit and, at its contacts 471, it completes a circuit from ground, by way of the contacts 463 and the lower winding of the relay R440, to battery. The relay R440 operates over the above traced circuit and completes a holding circuit including its upper winding, the contacts 446, and ground potential applied to the conductor C485; and, at its contacts 445, it opens the circuit of the seizure relay R430. As a further result of the operation of the relay R440, at its contacts 444 it removes ground potential from the conductor C486; and, at its contacts 443, it applies battery potential through the winding of the ring control relay R410 to the conductor C486. At its contacts 441 and 442, the relay R440 transfers the connection of ground potential to the conductor C487 from contacts 451 to contacts 432.

When the ground potential is removed from the conductor C486 upon the operation of the relay R440, the toll selector 330 operates to prepare the circuit including the talking conductors C481 and C482 for transmission, and to return ground potential by way of the wiper 333 and the conductor C486 in order to complete an operating circuit for the ring control relay R410. Consequently, when ground potential is applied to the conductor C486 by the toll selector 330, the ring control relay R410 operates and, at its contacts 412, applies a multiple ground potential to the conductor C487. The relay R430 which is of the slow-to-release type, subsequently restores to normal and, at its contacts 432, removes the ground potential from the conductor C487; however, ground potential is maintained thereon through the contacts 412. At its contacts 431, the relay R430 prepares a point in the circuit for applying battery by way of the resistance 447 to the conductor C487. The latter circuit, however, is not completed until the ring control relay R410 is restored to normal.

At the present time the relays R410, R440, R430 and R470 of the toll trunk circuit 400 are in their operated positions and the circuit is ready to respond to the control exercised by the toll operator to signal the called subscriber. It should be noted at this time that when the toll trunk circuit 400 functions to remove ground potential from the conductor C486 the toll selector 330, in addition to returning ground potential to the control conductor C486, also signaled the operator at the toll board 300 to in-

dicate that the connection had been extended to the line of the desired called subscriber and that it may now be signaled.

When the operator at the toll board 300 is ready to signal the called subscriber, she causes ground potential to be removed from the conductor C486, whereupon the ring control relay R410 restores to normal. Upon restoring to normal, at its contacts 411, the relay R410 applies resistance battery potential to the conductor C487 and the conductor C483 over the following circuit: battery, resistance 447, contacts 431, 411 and 442, the conductor C487; one branch extending by way of the upper winding of the control relay R470 and the resistance 472, to ground, and the other branch extending by way of the lower winding of the relay R470, the conductor C483, and the lower winding of the control relay R510, one branch extending by way of the upper winding of the relay R510 and the resistance 514, to ground, and the other branch extending by way of the conductor C530, the contacts 516, 675 and 527, and the resistance 680, to battery. In the above traced circuits it is to be noted that the lower winding of the control relay R470 is now shunted because the conductor C487 is connected to resistance battery and the conductor C483 is also connected to resistance battery, but a circuit is now completed for the upper winding of the relay R470 by way of the resistance 472, to ground. In view of the foregoing, the relay R470 remains in its operated position. However, when resistance battery potential is applied to the conductor C483 the lower winding of the relay R510 is shunted because resistance battery is also connected to the conductor C530 and a circuit is completed for the upper winding of the relay, which includes the resistance battery applied to conductor C530, and ground through the resistance 514. The relay R510 now operates over the circuit including its upper winding and, at its contacts 511, completes a circuit which may be traced from ground by way of the contacts 651, 511 and 529, and the winding of the ring control relay R620, to battery. The ring control relay R620 operates over the above traced circuit and, at its contacts 622, removes ground potential from the conductor C783, thereby causing the combination connector 825 to signal the substation A3 over the line 826.

When the called subscriber answers by removing his receiver from his associated telephone instrument, the combination connector 825 functions, in a well known manner, to cause the operation of the answer relay R570 in the toll transmission trunk circuit 600. When the relay R570 is operated in response to the called subscriber answering the connection, at its contacts 571, it completes an operating circuit for the supervisory control relay R610. The relay R610, upon operating, at its contacts 612, reapplies ground potential to the conductor C783 to terminate the ringing control operation of the combination connector 825. As a further result of the operation, the relay R610, at its contacts 611, places a short circuit around the upper high resistance winding of the supervisory relay R540. The shunting of the high resistance upper winding of the relay R540, in addition to improving the transmission qualities of the trunk line 490, also causes an answer signal to be given to the operator at the toll board 300 to indicate that the subscriber has answered the call.

When the toll operator receives the answer supervision she again causes ground potential to be connected to the conductor C486 and thus reoperates the relay R410. Upon operating, the relay R410, at its contacts 411, removes the resistance battery potential from the conductor C487 and, at its contacts 412, it substitutes a direct ground potential. A circuit is now completed for the lower winding of the control relay R470 in order to maintain the relay in its operated posititon, but the circuit including its upper winding is of no effect since the winding is shunted at this time. When ground potential is applied to the conductor C483 through the lower winding of the relay R470, an energizing circuit is completed for the lower winding of relay R510 which includes the resistance battery potential connected to the conductor C530 and an energizing circuit is also completed for the upper winding of the relay R510 by way of the resistance 514 and ground. However, since the windings of the relay R510 are in opposition to each other, the above traced circuit for both windings causes the relay to restore to its normal position at this time. When the relay R510 restores to normal, at its contacts 511, it opens the operating circuit of the ring control relay R620. The relay R620 now restores to normal, and, at its contacts 622, again prepares the circuit for applying ground potential to the conductor C783 when ground is removed therefrom by restoration of the supervisory control relay R610.

The desired connection between the operator at the toll board 300 and the called subscriber at the substation A3 is now completed and the toll operator may withdraw from the connection to permit the distant calling subscriber to converse with the called subscriber at the substation A3. It is to be noted that transmission current for the called station is supplied through the windings of the relays R570 and R557, and the transmission current for the calling end of the connection may be supplied from either the cord circuit 301 or from the toll selector 330.

Recall supervision to the toll operator

In the event that the toll operator at the distant toll board desires to communicate with the operator at the toll board 300, she may do so in any well known manner, such as, for example, transmitting ringing current over the toll line 319. When ringing current is transmitted over the toll line 319 a signal, at the toll board 300, is operated to indicate to the operator thereat that the distant toll operator desires to converse with her. The toll operator may now actuate a talk key (not shown) at her position in order to reconnect her telephone circuit to the toll line 319. After the toll operator at the toll board 300 receives the information from the distant toll operator she may remove her telephone circuit from the connection by restoring the talk key to its normal position.

In the event that the called subscriber at the substation A3 desires to communicate with the operator at the toll board 300, he may do so by momentarily actuating the switchhook at his telephone instrument a number of times. Attention is directed to the fact that the relay R570 in the toll transmission trunk circuit 600 is maintained in its operated position during the time that conversation takes place between the calling and called subscribers. Consequently, each time the called subscriber actuates the switchhook at the substation A3 the switching apparatus functions, in a well known manner, to interrupt the circuit of the answer relay R570. Each time the relay R570 restores to normal, at its contacts 571, it

opens the circuit of the supervisory control relay R610. Each time the relay R610 restores to normal, at its contacts 613, it maintains a ground potential upon the conductor C783 extending to the selector 815; and, at its contacts 611, it removes the shunt from the high resistance upper winding of the supervisory relay R540.

It will be recalled that when the supervisory control relay R610 was energized in response to the called subscriber answering the connection, the high resistance upper winding of the relay R540 was removed from the loop circuit including the talking conductors C481 and C482, thereby to control a signal at the toll board 300 to indicate that the called subscriber answered the connection. When the high resistance upper winding of the relay R540 is intermittently reinserted in the above described circuit under control of the relay R610, it causes an intermittent signal to be given to the operator at the toll board 300 as an indication that the called subscriber at the substation A3 desires to communicate with her. The toll operator may reconnect her telephone circuit to the connection extending between the toll board 300 and the called subscriber at the substation A3 by actuating the talk key (not shown) at her position, and may then communicate with the called subscriber in a well known manner. After the toll operator has communicated with the called subscriber at the substation A3 she may again restore the talk key at her position in order to reestablish the connection between the calling subscriber in the distant exchange and the called subscriber at the substation A3.

Disconnect supervision

After the conversation between the calling and the called subscriber has been terminated and the called subscriber at the substation A3 has restored his receiver upon the switchhook of his telephone instrument, the switching apparatus including the combination connector 825 and the selector 815 operates, in a well known manner, to open the circuit of the relays R570 and R557. The relay R570 restores to normal and, in the previously described manner, causes the relay R610 to restore to normal and again insert the high resistance upper winding of the relay R540 into the loop circuit including the conductors C481 and C482. The insertion of the high resistance upper winding of the relay R540 into the above mentioned loop circuit causes a signal to be given to the operator at the toll board 300 as an indication that the called subscriber has disconnected. It is to be noted, however, that the switching apparatus, including the selector 815 and the combination connector 825, is not restored to normal at the present time due to the fact that ground potential is still maintained upon the conductor C784 by way of the contacts 663 and 673'.

Recalling the called subscriber

In order to describe the manner in which the operator at the toll board 300 may resignal the called subscriber at the substation A3, it will be assumed that the subscriber at the substation A3 has prematurely restored his receiver upon the switchhook of his telephone instrument and that the toll operator at the distant toll board has resignaled the operator at the toll board 300 and has informed her that the calling subscriber desires to be reconnected to the subscriber at the substation A3.

In order to re-ring the called subscriber at the substation A3, the operator at the toll board 300 controls the cord circuit 301 and the toll selector 330, in a well known manner, whereupon ground potential is removed from the conductor C486. Removal of ground potential from the conductor C486 opens the circuit of the ring control relay R410, whereupon this relay restores to normal and, at its contacts 411, reapplies resistance battery potential, over the previously described circuit, to the conductor C487. When battery potential is connected to the conductor C487, a circuit is completed by way of the upper winding of the relay R470 and resistance 472, to ground, in order to maintain the relay in its operated position, and battery potential is extended by way of the lower winding of the relay and conductor C483 through the lower winding of the relay R510 to resistance battery connected to the conductor C530. This circuit shunts the lower windings of the relays R470 and R510. Simultaneously with the completion of the above mentioned shunting circuit, a circuit may now be traced from the resistance battery applied to the conductor C530, by way of the upper winding of relay R510 and the resistance 514, to ground, whereupon the relay R510 operates and closes its contacts 511.

When the above mentioned contacts 511 are closed a circuit is completed from ground, by way of the contacts 651, 511 and 529, and the winding of the ring control relay R620, to battery. The relay R620 operates over the above mentioned circuit and, at its contacts 622, it removes the ground potential applied to the conductor C783. Removal of ground potential from the conductor C783 controls the combination connector 825, in the previously described manner, to transmit ringing current over the called subscriber line 826.

When the called subscriber at the substation A3 responds by removing his receiver from the telephone instrument, the relays R570 and R557 are again operated and control the switching apparatus involved in the connection in order to transmit answer supervision to the operator at the toll board 300. When the operator at the toll board 300 receives the answer supervision, she again causes the cord circuit 301 and the toll selector 330 to apply ground potential to the conductor C486 and again operate the ring control relay R410. As has been mentioned above, operation of the relay R410 removes the resistance battery potential from the conductor C487 and substitutes a ground potential, whereupon the relay R510 in the toll transmission trunk circuit 500 restores to normal and the relay R470 in the toll trunk circuit 400 remains in its operated position. Upon restoration, the relay R510, at its contacts 511, again opens the circuit of the ring control relay R620. The relay R620 now restores to normal and, at its contacts 622, reapplies ground potential to the conductor C783. The calling subscriber in the distant toll office may now communicate with the called subscriber at the substation A3 and complete the conversation that was prematurely interrupted by the disconnection of the subscriber at the substation A3.

Release

In order to describe the release of the connection established between the calling subscriber in the distant toll office and the called subscriber at the substation A3, it will be assumed

that when the called subscriber at the substation A3 replaced his receiver upon the switchhook of his telephone instrument, the calling subscriber in the distant toll office also replaced his receiver upon his telephone instrument. As a result of the latter operation the distant toll operator receives the usual disconnect supervision and thereupon breaks down the toll connection between the distant toll office and the toll board 300. When the latter connection is taken down, the toll operator at the toll board 300 receives the usual disconnect supervision at the answer end of the cord circuit 301, and since she has also received a disconnect supervision upon the called end of the cord circuit 301 she may now withdraw the cord circuit 301 from the jacks J303 and J305. When the plug P304 of the cord circuit 301 is withdrawn from the jack J305, the toll selector 330 restores to normal in a well known manner, thereby removing ground potential from the conductors C485 and C486. As a further result of the restoration of the toll selector 330, the operating circuit, including the conductors C481 and C482, for the supervisory relay R540 in the toll transmission trunk circuit 600, is opened, whereupon the relay R540 restores to normal.

Referring now to the toll trunk circuit 400, it will be noted that when ground potential is removed from the conductor C486 the ring control relay R410 restores to normal and, at its contacts 411, reapplies the resistance battery potential to the conductor C487. The reconnection of resistance battery potential to the conductor C487 completes a holding circuit including the upper winding of the relay R470 and the resistance 472, to ground, in order to maintain the relay R470 in its operated position. The resistance battery potential connected by way of the lower winding of the relay R470 to the conductor C483 causes the relay R510 in the toll transmission trunk circuit 600 to reoperate in the previously described manner.

When ground potential is removed from the conductor C485, the relay R460 restores to normal and, at its contacts 464, completes a circuit from ground, by way of the contacts 471, 464 and 456, and the winding of the release relay R429, to battery. The relay R420 operates over the above traced circuit and, at its contacts 422 and 424, applies ground potential to the conductors C484 and C485, respectively, in order to maintain the toll trunk circuit 400 busy in the banks of the selectors having access thereto. As a further result of the restoration of the relay R460, at its contacts 461, it prepares a circuit for the relay R450; and at its contacts 463, it opens the initial operating circuit for the lower winding of the relay R440. As a further result of the removal of ground potential from the conductor C485, the relay R440 also restores to normal. Upon restoring to normal, the relay R440, at its contacts 443, disconnects the relay R410 from the conductor C486; and, at its contacts 444, it reapplies ground potential to the conductor C486 in order to prepare the toll trunk circuit 400 for subsequent seizure. At its contacts 442, the relay R440 disconnects the resistance battery potential applied to the conductor C487; and, at its contacts 441, substitutes therefor a ground potential applied by way of the contacts 451. The substitution of ground potential to the conductor C487 completes a shunt circuit around the upper winding of the relay R470 and it completes a holding circuit for the lower winding of the relay in order to maintain the relay in its operated position. The substitution of ground potential for the resistance battery potential to the conductor C483 causes the relay R510 in the toll transmission trunk circuit 600 to restore to normal.

Referring now to the toll transmission trunk circuit 600, it will be noted that when the relay R540 restored to normal as a result of the restoration of the toll selector 330, at its contacts 541, it opened a loop circuit including the upper and lower windings of the pulse relay R640. When the pulse relay R640 restores to normal, at its contacts 642, it opens the circuit of the hold relay R550. At its contacts 641, the relay R540 also disconnects the battery potential, applied by way of the winding of the relay R570, from the conductor C782. Since the relay R650 is of the slow-to-release type, it subsequently restores to normal and, at its contacts 651, it opens the circuit for the relay R660. The relay R660 is also of the slow-to-release type and, upon restoring to normal at its contacts 661, it disconnects ground potential, applied by way of the winding of the relay R557, from the conductor C781; at its contacts 662, it opens a point in the initial operating circuit for the relay R630; and, at its contacts 663, it removes ground potential from the conductors C783 and C784.

Removal of ground potential from the conductor C784 causes the selector 815 and the connector 825 to restore their associated wipers to their normal positions, whereupon the line 825 of the subscriber at the substation A3 is rendered available for further calls. As a further result of the restoration of the relay R660, at its contacts 663, it also opens the holding circuit of the relay R630. The relay R630 now restores to normal and, at the contacts 633 opens the circuit of the relay R520. At its contacts 631, the relay R630 opens a point in the holding circuit for itself; and, at its contacts 632, it prepares a point in the initial operating circuit for the relay R560.

Responsive to the opening of the holding circuit of the switching relay R520, the relay restores to normal and, at its contacts 521 to 524, inclusive, it disconnects the left-hand windings of the repeating coil 550 from the trunk conductors C481 and C482, and it connects these conductors to the windings of the pulse relay R540. At its contacts 525, the relay R520 disconnects the battery potential from the winding of the answer relay R570, thereby removing the shunt circuit from around the high resistance 572; and, at its contacts 526 and 527, it disconnects the resistance battery potential applied to the conductor C530 and substitutes in place thereof a direct ground potential. Attention is directed to the fact that when the toll trunk circuit 400 restored to normal, direct ground potential was applied by way of the lower winding of the relay R470 to the conductor C483, and extending therefrom, by way of the lower winding of the relay R510, to the resistance battery potential applied to the conductor C530. When the circuit including the lower windings of the relays R470 and R510 is energized in the above described manner, the relay R470 remains in its operated position and the relay R510 restores to normal. Accordingly, when ground potential is substituted for the resistance battery potential applied to the conductor C530, the energizing circuit for maintaining the lower winding of the relay R470 in its operated position is opened, there-

by causing the latter relay to restore to normal.

It will be recalled that during the release operations of the toll trunk circuit 400 the relay R510 in the toll transmission trunk circuit 600 was momentarily operated and restored to normal. Due to the fact that the ring control relay R620 is of the slow-to-operate type, the momentary completion and interruption of its circuit at the contacts 511 does not permit sufficient time for the relay to operate. Accordingly, ground potential is maintained upon the conductor C783 during the releasing operations of the toll trunk circuit 400. Ground potential is removed from the conductors C783 and C784 upon the restoration of the hold relay R660 in the manner previously described.

When the relay R470 restores to normal, in the above described manner, at its contacts 471, it opens the operating circuit for the release relay R420 which also restores to normal. At its contacts 422 and 424, the relay R420, upon restoring to normal, removes the busy marking ground potentials from the conductors C484 and C485; and, at its contacts 421 and 423, it reconnects the windings of the operator relay R450, and the windings of the automatic relay R460 and seizure relay R430 to the conductors C484 and C485, respectively. The switching apparatus including the toll transmission trunk circuit 600 and the toll trunk circuit 400 have now been restored to normal and may be selected by the operator at the toll board 300 to extend additional connections to the branch exchange 50.

Toll Call from a Distant Exchange Extended by the Toll Operator to the Branch Exchange Operator for Completion

The manner in which toll calls are established by the toll operator in the main exchange 20 by directly controlling the automatic switching apparatus in the branch exchange 50 having been described above, a description will now be given of the operation of the switching apparatus when the toll operator in the main exchange 20 extends a toll connection to the manual operator in the branch exchange 50 for completion. When the operator at the toll board 300 desires to extend a toll call to the operator at the switchboard 1000, she selects a toll selector, such as 330, and dials the digit "6," whereupon the toll selector raises its wipers to the sixth level and automatically rotates its wipers over the selected level to select an idle trunk line, such as 321.

Accordingly, it will be assumed that the operator at the toll board 300 has received a toll call over the toll line 319 and has answered the call by inserting the plug P302 into the jack J303. It will also be assumed that the calling subscriber in the distant exchange desires to communicate with the subscriber at the substation A3 in the branch exchange 50. It will be understood that all of the automatic subscribers in the branch exchange may be called directly by the operator at the toll board 300; however, it is sometimes desirable to route such connections to the branch exchange operator for completion. For example, if the local subscriber at the substation A3 is going to be absent from his premises for a certain period of time, he may inform the branch exchange operator that he may be reached by extending a connection to some other subscriber substation.

It will now be assumed that the toll operator has inserted the call plug P304 into the jack J305, and has operated the toll selector 330, in the previously described manner, and that the selector 330 has selected the trunk line 321 extending to the toll trunk circuit 400. When the wipers 331 to 334, inclusive, of the toll selector 330 engage the contacts of the bank terminating the conductors of the trunk line 321, ground potential is applied by way of the wiper 334, the conductor C484, the contacts 421 and 461, and the winding of the operator relay R450, to battery. The relay R450 operates over the above traced circuit and, at its contacts 453, applies ground potential to the conductor C435 in order to busy the toll trunk circuit 400 in the banks of the toll selectors having access thereto. At the contacts 453, the relay R450 also completes a circuit by way of the contacts 445 for operating the slow-to-release seizure relay R439. At its contacts 454, the relay R450 disconnects the automatic relay R460 from the conductor C485; at its contacts 456, it opens a point in the circuit for the release relay R420; and, at its contacts 455, it prepares a point in the circuit for operating the relay R449. As a further result of the operation of the relay R450, at its contacts 451, it disconnects direct ground potential from the conductor C487; and, at its contacts 452, it applies battery potential by way of the resistance 447 and the contacts 452 and 441, to the conductor C437.

When the relay R439 operates over the above described circuit, at its contacts 431, it opens a point in the incomplete circuit for applying resistance battery by way of the contacts 411 to the conductor C487 and, at its contacts 432, it prepares a point in the circuit for subsequently applying ground potential to the conductor C487.

As a further result of the engagement of the wipers 331 to 334, inclusive, with the trunk line 321, a loop circuit is completed including the cord circuit 301, the toll selector 330, the conductors C481 and C482, the contacts 522 and 524, and the lower and upper windings of the pulse relay R540, to battery and ground, respectively. The pulse relay R540 operates over the above traced loop circuit to control the toll transmission trunk circuit 600, in a manner to be explained hereinafter.

Attention is now directed to the fact that the control conductor C483 of the interexchange trunk line 400, prior to the seizure of the toll trunk circuit 400, has ground potential applied thereto through the lower winding of the control relay R470 and through the lower winding of the control relay R510. This circuit may be traced from ground, by way of the contacts 451 and 441, the conductor C487, the lower winding of the relay R470, the conductor C483, the lower winding of the control relay R510, the conductor C530, the contacts 516 of the key K515, and the contacts 675 and 526, to ground. In view of the above circuit the lower windings of the relays R470 and R510 are not energized. It should also be noted that ground potential is connected to the upper winding of the relay R470 by way of the resistance 472, and that ground potential is connected to the upper winding of the relay R510 by way of the resistance 514.

When the toll trunk circuit 400 is seized and the relay R450 operates, a resistance battery potential is applied to the conductor C487 from battery, by way of the resistance 447, and the contacts 452 and 441. When resistance battery potential is substituted for the ground potential applied to the conductor C487, a circuit is completed for energizing the upper and the lower windings of the relay R470. The circuit for the upper winding may be traced from ground, by

way of the resistance 472 and the upper winding of the relay R470; and the circuit for the lower winding of the relay may be traced from the ground potential applied to the conductor C483 at the toll transmission circuit 600 and the lower winding of the relay R470. Since the windings of the relay R470 are in opposition to one another, the above traced energizing circuits for these windings prevent the relay from operating at this time. However, in the toll transmission trunk circuit 600, the application of resistance battery to the conductor C483 by the toll trunk circuit 400 completes a circuit for energizing the lower winding of the relay R510. This circuit may be traced from ground, by way of the contacts 526, 675 and 516, the conductor C530 and the lower winding of the relay R510, to battery potential applied to the conductor C483. A branch of this circuit is also extended by way of the upper winding of the relay R510, and the resistance 514, to ground. The latter circuit, however, since it is traced from ground to ground, does not have any effect upon the upper winding of the relay. The relay R510 now operates as a result of the energizing circuit completed through its lower winding and, at its contacts 511, prepares a circuit for the upper winding of the transfer relay R670.

When the pulse relay R640 operates over the previously traced loop circuit, including the conductors C481 and C482, at its contacts 641, it applies battery potential by way of the high resistance 572, the winding of the relay R570, the winding 554 of the repeating coil 550, and the contacts 561, 641 and 671, to the conductor C782. The latter circuit, as has been pointed out hereinbefore, prepares a point in the circuit for controlling the selector 815. However, as will be pointed out, the relay R670 will subsequently be operated to disconnect the above traced circuit from the conductor C782. As a further result of the operation of the relay R640, at its contacts 642, it completes an operating circuit for the slow-to-release hold relay R650; and, at its contacts 643, it opens a point in the incomplete circuit for subsequently operating the relay R630. The relay R650, upon operating, at its contacts 651, completes an obvious circuit for operating the relay R660 and also completes a circuit from ground by way of the contacts 651, 511 and 523 for energizing the upper winding of the transfer relay R670.

The relay R670 operates when the above traced energizing circuit is completed for its upper winding and, at its contacts 676, it prepares a locking circuit for its lower winding. As a further result of the operation of the relay R670, at its contacts 671 and 673 it disconnects the talking conductors extending from the right-hand windings of the repeating coil 550 from the conductors C781 and C782, and connects the right-hand windings of the repeating coil 550 by way of its contacts 672 and 674, thereby to prepare a circuit for extending the connection to the jack J760 at the switchboard 1000. At its contacts 675, the relay R670 disconnects the direct ground potential from the conductor C530 and, at its contacts 676, it connects battery by way of the resistance 680, and the contacts 676 and 516 to conductor C530. At its contacts 677, the relay R670 prepares a circuit for the upper winding of the relay R710; at its contacts 679, it opens a point in the operating circuit for the relay R560; at its contacts 672' and 673' it disconnects the conductors C783 and C784 from the toll transmission trunk circuit 600; and, at its contacts 671' it prepares a point in the holding circuit for the relay R720. At its contacts 674', the relay R670 completes a circuit from ground by way of the contacts 674' and the winding of the switching relay R520, to battery.

It will be recalled that the relays R660 and R670 operated when the hold relay R650 closed its contacts 651. As a result of the operation of the relay R660, at its contacts 661, it closed a point in the circuit of the conductor C781 which, however, has no effect at this time since the relay R670 has operated. At its contacts 662, it prepares a point in the incomplete circuit for operating the relay R630; and, at its contacts 663, it completes a holding circuit for the relay R670 which may be traced from ground, by way of the contacts 663 and 678, and the lower winding of the relay R670, to battery.

The latter relay will now remain in its operated position, even though the circuit for its upper winding is subsequently disconnected.

Before discussing the operation of the relay R520, a description will now be given of the effect of the substitution of resistance battery for ground potential to the conductor C530 as a result of the closure of the contacts 676 by the relay R670. When resistance battery potential is applied to the conductor C530, one branch of the circuit extends by way of the upper winding of the relay R510 and resistance 514, to ground, whereupon the upper winding is energized; and another branch of the circuit extends by way of the lower winding of the relay R510, the conductor C483, and the lower winding of the relay R470 to resistance battery connected to the conductor C487. In this circuit the lower windings of the relays R470 and R510 are shunted and therefore the lower windings of these relays are not energized. A circuit is now, however, completed for the upper winding of the relay R470 which may be traced from the resistance battery applied to the conductor C487 through the upper winding of the relay R470 and the resistance 472, to ground. The relay R470 operates as a result of the above traced energizing circuit for its upper winding and the relay R510 remains in its operated position as a result of the above traced energizing circuit for its upper winding.

As a result of the operation of the relay R470, at its contacts 471 it completes a circuit which may be traced from ground by way of the contacts 471, 464 and 455, and the lower winding of the relay R440, to battery. Relay R440 operates over the above traced circuit and, at its contacts 445, disconnects the seizure relay R430 from ground at contacts 453; and, at its contacts 446, it connects its upper winding to ground at contacts 453. The latter circuit maintains the relay R440 in its operated position even though the circuit for its lower winding is subsequently opened by the restoration of the relay R470. As a further result of the operation of the relay R440, at its contacts 444, it removes ground potential from the conductor C486; and, at its contacts 443, it applies battery potential through the winding of the ring control relay R410 to the conductor C486. At its contacts 441 and 442, the relay R440 transfers the connection to the conductor C487 from resistance battery potential to ground potential at the contacts 432.

When ground potential is applied to the conductor C487, the upper winding of the relay R470 is short-circuited and an energizing circuit is completed for the lower winding of the relay in

order to maintain it in its operated position. The ground potential is further extended by way of the conductor C483 to the lower winding of the control relay R510, whereupon an energizing circuit is now completed for its lower winding, in addition to the energizing circuit for its upper winding. Since the energizing circuit for the relay R510 includes the opposing windings of the relay, it now restores to normal.

When ground potential is removed from the conductor C486, in response to the operation of the relay R440, the toll selector 330 functions, in a well known manner, to prepare the circuit including the talking conductors C481 and C482 for transmission and to return ground potential by way of the wiper 333 and the conductor C486 in order to operate the ring control relay R410. Upon operating, the relay R410, at its contacts 412, applies ground potential to the conductor C487. The relay R430, which is of the slow-to-release type, subsequently restores to normal and, at its contacts 431, prepares a point in the circuit for subsequently applying resistance battery potential to the conductor C487.

When the relay R510 restores to normal as a result of the energizing circuits completed for its opposing windings, at its contacts 511, it opens the initial energizing circuit for the upper winding of the transfer relay R670 but the latter relay remains in its operated position over a circuit completed for its lower winding.

It will be recalled that when the transfer relay R670 operated, it completed a circuit at its contacts 674' for operating the slow-to-operate switching relay R520. Since the relay R520 is of the slow-to-release type, the above described operations of the relays in the toll trunk circuit 400 are completed before the relay R520 has had sufficient time to operate its associated contacts. It will therefore be understood that the relay R510 has restored to normal prior to the operation of the relay R520. As a result thereof, the contacts 529 are not closed prior to the opening of the contacts 511, and the relay R620 cannot be operated at the present time. As a further result of the operation of the relay R520, at its contacts 521 to 524, inclusive, it disconnects the talking conductors C481 and C482 from the circuit including the upper and lower windings of the pulse relay R640 and, simultaneously therewith, it connects the talking conductors C481 and C482 by way of the contacts 521 and 523, the windings 551 and 552 of the repeating coil 550, to the upper and lower windings of the relay R540 in series. At its contacts 525, the relay R520 connects battery potential to the winding of the answer relay R570, thereby shorting out the high resistance 572.

Referring now to the toll trunk circuit 400, it will be recalled that ground potential was removed from the conductor C486 upon the operation of the relay R440 and, as a result thereof, the toll selector 330 operates to prepare the circuit including the talking conductors C481 and C482 for transmission and to return ground potential by way of the wiper 333 to the conductor C486 in order to operate the ring control relay R410. When the above described operation was performed, the operator at the toll board 300 was signaled to indicate that the toll transmission trunk circuit 600 is in condition to respond to a signal control transmitted thereto in order to signal the branch exchange operator at the switchboard 1000. As a further result of the above described operations of the toll selector 330, a loop circuit is completed by way of the talking conductors C481 and C482, thereby operating the relay R540. Upon operating, the relay R540, at its contacts 541, completes a holding circuit including the upper and lower windings of the pulse relay R640. Attention is directed to the fact that the latter circuit for holding the relay R640 operated is completed incident to the disconnection of the windings of the relay from the talking conductors C481 and C482. Consequently, the relay R640 is maintained in its operated position during the transitory period between the operation of the relays R520 and R540.

The operator at the toll board 300 may now operate her cord circuit 301 in order to control the signaling of the branch exchange operator. In response to the signal control operation at the cord circuit 301 the toll selector 330 functions to remove ground potential from the conductor C486, whereupon the ring control relay R410 restores to normal and, at its contacts 411, completes a circuit from battery by way of the resistance 447, the contacts 431, 411 and 442 to the conductor C487; and, at its contacts 412 it removes ground potential from the conductor C487. When resistance battery potential is substituted for ground potential on the conductor C487, the circuits for the windings of the relay R470 and the windings of the relay R510 are such that the relay R470 remains in its operated position and the relay R510 reoperates, in the same manner as has been previously described. In response to the reoperation of the relay R510, at its contacts 511, it completes a circuit which may be traced from ground, by way of the contacts 651, 511 and 529, and the winding of the ring control relay R620, to battery. The relay R520 now operates and, at its contacts 621, completes a circuit which may be traced from ground by way of the contacts 663, 621, 677 and 733, and the upper winding of the signal relay R710 to battery. The relay R710 operates over the above described circuit, whereupon a locking circuit is completed for its lower winding, which may be traced from ground, by way of the contacts 663, 734 and 712, and the lower winding of the relay R710, to battery; at its contacts 711, it completes a circuit for illuminating the answer lamp L762 at the branch exchange switchboard 1000; and, at its contacts 713, it completes a circuit for operating the relay R720 which may be traced from ground by way of the contacts 663 and 713, and the lower winding of the relay R720, to battery. The relay R720 operates over the above described circuit and, at its contacts 725, it prepares a locking circuit for its lower winding; and, at its contacts 722 and 724, it extends the circuit, including the windings of the relays R557 and R570 and the right-hand windings 554 and 555 of the repeating coil 550, to the tip and ring elements of the jack J760 at the switchboard 1000.

It may be well to mention at this time that when the operator has taken her position at her section of the switchboard 1000 and is ready to handle calls, she must first insert the plug of the operator headset 1400 into the jack terminating the operator telephone circuit of Fig. 14. Thus to answer and extend calls received at the switchboard 1000 the headset plug 1403 is inserted into the jack 1404. In response to this operation the transmitter 1401 is inclued in a series circuit with the battery feed impedance coil 1405 and in multiple with the left-hand winding 1431 of the induction coil 1430. Furthermore, the receiver 1402 is bridged across the lower right-hand winding 1434 of the induction coil

1430 in series with the contacts 1443 and 1445, and the condenser 1435. It should also be noted that a pair of oppositely poled copper oxide half-wave rectifiers 1428 is included in a circuit shunting the receiver 1402. These rectifiers are connected in parallel in order to pass current in both directions and therefore do not actually rectify. However, at the speech level of ordinary conversation the rectifiers as a unit have a high resistance and do not introduce any appreciable loss to the speech currents traversing the circuit, but on the other hand they have a relatively low resistance to a large voltage change, such as would produce a loud click in the receiver 1402, and thereby practically short-circuit the receiver 1402 to weaken the clicks to a point where they are no longer objectionable to the operator.

Branch exchange operator answers

Accordingly, when the operator is signaled by the illumination of the lamp L762, indicating that a call is to be answered, she inserts the answer plug of one of her cord circuits into the jack associated with the lamp L762. It will be assumed that the operator has selected the cord circuit 900 of Figs. 9 to 12, inclusive, and that she has inserted the plug P900 into the jack J760.

When the plug P900 is inserted into the jack J760 the series connected relays R950 and R970 in the cord circuit 900 and the sleeve relay R730 of the toll transmission trunk circuit 600 are connected over a series circuit which may be traced from ground, by way of the windings of the marginal switching relay R950 and the sleeve relay R970, the contacts 1128, the conductor C975, the sleeve elements of the plug P900 and the jack J760, and the winding of the relay R730, to battery. The sleeve relays R970 and R730 operate over the above mentioned circuit, but due to the resistance included in this circuit the switching relay R950 does not operate at this time.

When the sleeve relay R970 operates over the above traced circuit, at its contacts 971, it completes a circuit for bridging the left-hand operating winding of the shunt field relay R1020 across the tip and ring conductors C785 and C786 by way of the tip and ring elements of the plug P900 and the jack J760, whereupon a circuit may be traced from ground, by way of the winding of the relay R557, the winding 555 of the repeating coil 550, the contacts 563, 674 and 724, the conductor C785, the tip elements of the jack J760 and the plug P900, the contacts 902 of the key K901, the contacts 941, 975 and 971, the left-hand operating winding of the relay R1020, the contacts 904 of the key K901, the ring elements of the plug P900 and jack J760, the conductor C786, the contacts 722, 672, 641 and 561, the winding 554 of the repeating coil 550, the winding of the relay R570, and the contacts 525, to battery. The relay R570 in the toll transmission trunk circuit 600 operates over this circuit and, as will be subsequently noted, relay R1020 will also be operated. As a further result of the operation of the relay R970, at its contacts 972, it completes an obvious circuit for the right-hand polarizing winding of the shunt field relay R1020, and, at its contacts 973, it prepares a point in the operating circuit for the recall relay R1030. The relay R970 also, at its contacts 974 and 975, prepares points in the incomplete circuit for the answer lamp L919.

When the left and right-hand windings of the shunt field relay R1020 are energized in the above described manner, the relay operates and, at its contacts 1021, prepares a point in the incomplete circuit of the ring relay R1240; and, at its contacts 1022, it interrupts a point in the incomplete circuit of the answer lamp L919.

Having answered the call by inserting the plug P900 into the jack J760, the operator at the switchboard 1000 may now actuate the talk key K1100 in order to associate her operator telephone circuit (Fig. 14) with the selected cord circuit 900. When the talk key K1100 is actuated, a circuit is completed for operating the relay R1120. Upon operating the talk relay R1120, at its various contacts, associates the operator telephone circuit of Fig. 14 with the selected cord circuit 900. It will be noted, however, that the various conductors C1101 to C1112, inclusive, which are individual to the operator telephone circuit, are also common to all of the cord circuits available to the operator in order that she may associate the operator telephone circuit with any one of the selected cords by merely operating the talk key individual thereto.

Accordingly, when the relay R1120 operates, at its contacts 1124 and 1125, it extends the tip and ring conductors of the cord circuit 900 by way of the conductors C1104 and C1105 to the right-hand windings of the induction coil 1430, whereupon a conversational circuit is completed between the operator headset 1400 and the tip and ring conductors of the cord circuit 900. It may be well to mention at this time that when the voice currents from the operator at the toll board 300 are received at the operator telephone circuit, they are extended by way of the upper right-hand winding 1433 and the lower right-hand winding 1434 of the induction coil 1430. The receiver 1402, which is bridged across the lower right-hand winding 1434, carries a greater part of the voice currents because of the low impedance path it offers in comparison with the lower right-hand winding 1434. When the operator speaks into the transmitter 1401 the resistance of the transmitter varies, causing the current supplied from the battery through the winding of the impedance coil 1405 to vary at different voice frequencies. This fluctuation in current also passes through the left-hand winding 1431 of the induction coil 1430 but is kept out of the battery circuit by the impedance 1405 in order to prevent cross-talk. The current fluctuates passing through the left-hand winding 1431 and causes a similar voltage to be induced into the windings 1433 and 1434, and since the winding 1434 has the same number of turns as the winding 1433, the induced voltage across the winding 1434 will be equal to that induced across the winding 1433. Since the resistance of the winding 1434 is approximately equal to the resistance of the winding 1433 plus the loop resistance of the connected line, the voltage induced in the windings 1433 and 1434 produces current flow through the receiver of the toll operator. It should also be noted that there are two paths through the receiver 1402 that the voice currents may follow. One path extends from the midpoint of the windings 1433 and 1434 through the winding 1434, the contacts 1443, the receiver 1402, the contacts 1445, the condenser 1435, and back to the midpoint between the windings 1433 and 1434. The second path may be traced from the midpoint of the windings 1433 and 1434, by way of the condenser 1435, the contacts 1445, the receiver 1402, the contacts 1443 and 1446, the conductor C1105 extending to the toll operator

loop circuit, and returning by way of the conductor C1104, the contacts 1441, the winding 1433, and back to the midpoint between the windings 1433 and 1434. Since these two circuits have equal voltages induced therein and have approximately equal resistances, the resulting currents will be approximately equal. Since the direction of the current flow in these circuits opposes each other through the receiver 1402, and since they are also approximately equal in magnitude, the resulting current flow through the receiver will be quite small, thereby minimizing the voice currents through the receiver 1402 when the voice currents originate from the transmitter 1401 associated therewith.

Referring again to the operation of the talk relay R1120, at its contacts 1122 and 1123, it prepares a circuit for connecting the tip and ring conductors of the call plug P1270 to the operator circuit by way of the conductors C1102 and C1103. At its contacts 1128, the relay R1120 disconnects the sleeve conductor C975 from the circuit including the series connected switching relay R950 and the sleeve relay R970, and substitutes in place thereof, at its contacts 1127 and 1126, a circuit including the conductors C1108 and C1109, the contacts 1410 of the release local key K1408, and the contacts 1417 of the switch-through key K1415. Accordingly, the series circuit for the switching relay R350 and the sleeve relay R970 now includes the previously traced circuit including the sleeve conductor C975, the contacts 1126 and 1127, the conductors C1108 and C1109, and the above mentioned contacts of the keys K1408 and K1415. At its contacts 1120', 1121' and 1122', the relay R1120 prepares a point in the circuit for controlling the relays R1140 and R1150 over the sleeve conductor C1205 of the call plug P1270, as will be described hereinafter. Furthermore, at its contacts 1123', the relay R1120 opens a point in the circuit of the dial-through key K1025, and, at its contacts 1124', it prepares a point in the circuit for the dial relay R1250.

It will be recalled that the answer relay R570 and the sleeve relay R730 in the toll transmission trunk circuit 500 were operated when the plug P900 was inserted into the jack J760. When the sleeve relay R730 operates over the above traced circuit, at its contacts 732, it completes a circuit from ground, by way of the contacts 732, 741 and 751 (closed by the insertion of the plug P900 into the jack J760) and the call lamp L772, to battery, thereby indicating, to the operator at the switchboard 1000, the particular jack to be utilized in the event the particular connection is to be extended to an automatic subscriber located in the branch exchange 50; at its contacts 734, it opens the holding circuit for the lower winding of the signal relay R710; and, at its contacts 733, it opens the original operating circuit for the upper winding of the signal relay R710. At its contacts 731, the relay R730 also prepares a circuit for recalling the operator at the switchboard 1000.

When the above mentioned circuits for the upper and lower windings of the signal relay R710 are opened by the operation of the relay R730, the relay restores to normal and, at its contacts 711, extinguishes the answer lamp L762; and, at its contacts 713, it opens a point in the previously traced holding circuit for the lower winding of the relay R720. However, before the relay R720 has had sufficient time to restore to normal, a new holding circuit for the relay will be completed as a result of the operation of the relay R570, as will now be described.

When the answer relay R570 operates in response to the insertion of the plug P900 into the jack J760, at its contacts 571, it completes an operating circuit for the relay R610. The relay R610, upon operating, at its contacts 612, completes a circuit which may be traced from ground, by way of the contacts 612 and 565, the conductor C567, the contacts 671' and 725, and the lower winding of the relay R720, to battery. From the foregoing explanation it will be understood that the relays R570 and R730 are operated simultaneously, the relay R570 completing a circuit for the relay R610 which, in turn, closes a locking circuit for the lower winding of the relay R720. It will also be understood that the relay R730, upon operating, opens the circuit for relay R710 which, upon restoring to normal, removes the initial holding circuit for the lower winding of the relay R720, and consequently the holding circuit for the lower winding of the relay R720 is replaced by way of its contacts 725 before the holding circuit including the contacts 713 is opened.

As a further result of the operation of the relay R610, at its contacts 611, it shunts the high resistance upper winding of the relay R540 from the connection extending to the toll board 300 in order to improve the transmission qualities of the trunk line 400 and to return answer supervision to the operator at the toll board 300. When the high resistance of the upper winding of the relay R540 is removed from the circuit, including the conductors C481 and C482, the operator at the toll board 300 is signaled to indicate that the operator at the branch exchange switchboard 1000 has answered the call. The toll operator now reapplies ground potential to the conductor C486 in order to reoperate the ring control relay R410. Upon operating, the relay R410, at its contacts 411 and 412, substitutes ground potential for the resistance battery potential applied to the conductor C487. With ground potential connected to the conductor C487 and resistance battery potential applied to the conductor C530, a shunt circuit is completed for the upper winding of the relay R470 and an energizing circuit is completed for its lower winding. The relay R470 remains operated as a result of the above mentioned energizing circuit for its lower winding, but the relay R510 now restores to normal because energizing circuits are completed for its oppositely connected upper and lower windings. The relay R510, upon restoring to normal, at its contacts 511, opens the previously traced operating circuit for the ring control relay R620, whereupon the latter relay also restores to normal.

The operator at the toll board 300 may now converse with the operator at the switchboard 1000 and inform her that a toll call is to be extended to the subscriber at the substation A3. It should be noted at this time that transmission current is extended to the operator at the branch exchange switchboard 1000 by way of the windings of the relays R570 and R557 of the toll transmission trunk circuit 500, and that transmission current may be supplied to the operator at the toll board 300 either by way of the cord circuit 301 or the toll selector 330.

In order to extend the connection to the subscriber at the local substation A3, the operator at the switchboard 1000 inserts the call plug P1270 into the jack J775, which has been indicated by the illumination of the call lamp L772 to be the proper jack to be utilized in completing the toll

connection to the substation A3. When the plug P1270 is inserted into the jack J770 a circuit is completed for operating the relays R1140 and R1150 in the cord circuit 900 and the relay R750 in the toll transmission trunk circuit 600, from ground, by way of the windings of the relays R1150 and R1140, the contacts 1129', the conductor C1110, the contacts 1422 of the toll ring key K1420, the conductor C1111, the contacts 1121', the conductor C1265, the sleeve elements of the call plug P1270 and the jack J770, and the winding of the relay R750, to battery. As a result of the above described circuit, relays R1140, R1150 and R750 operate.

When the relay R1150 operates, at its contacts 1157, it prepares a point in the incomplete operating circuit for the control relay R1130, and, at its contacts 1155, it prepares a point in the incomplete locking circuit for the relay R1130. At its contacts 1150', the relay R1150 opens a point in the incomplete circuit for the relay R1230; at its contacts 1158, it completes an energizing circuit for the lower polarizing winding of the relay R1220; and, at its contacts 1156, it completes a circuit for bridging the upper winding of the relay R1220 and the winding of the relay R1210 across the tip and ring conductors of the call plug P1270. The operations performed by the remaining contacts of the relay R1150 are incidental and are not necessary for an understanding of the connection being described. The circuit for connecting the upper winding of the relay R1220 and the winding of the relay R1210 to the tip and ring conductors of the plug P1270 may be traced from the tip element of the plug P1270 by way of the contacts 1252, 1241, 1181 and 1263, the upper winding of the relay R1220, the winding of the relay R1210, the contacts 1156, 1163, 1243 and 1254, and the ring element of the call plug P1270. Before describing the operations which take place as a result of the bridging of the above mentioned relays across the tip and ring elements of the call plug P1270, the circuit operations performed by the operation of the relays R1140 and R750 will be described.

When the relay R1140 operates over the previously traced circuit, at its contacts 1146, it prepares a point in the incomplete circuit for the relay R1240; at its contacts 1148, it prepares a point in the incomplete operating circuit for the relay R1240; and, at its contacts 1147, it completes a circuit for illuminating the call lamp L1271, which may be traced from ground, by way of the contacts 918, 966, 1164 and 1147, and the call lamp L1271, to battery.

When the relay R750 in the toll transmission trunk circuit operates, as a result of the insertion of the plug P1270 into the jack J770, at its contacts 751, it applies ground potential to the conductor C783 extending to the selector 815. As a further result of the insertion of the plug P1270 into the jack J770, the jack contacts 771 are closed, whereupon an operating circuit is completed for the seizure relay R740. The relay R740 now operates and, at its contacts 741, extinguishes the call lamp L772 associated with the jack J770; at its contacts 742, it connects the ring conductor of the plug P1270 to the conductor C782 extending to the selector 815; and, at its contacts 743, it applies ground potential to the conductor C784 extending to the selector 815.

As a result of the application of ground potential to the conductor C784 and the connection of the above traced loop circuit, including the serially connected windings of the relays R1210 and R1220, by way of the tip and ring elements of the plug P1270 and the jack J770, to the conductors C781 and C782, the selector 815 is seized in a well known manner and transmits dial tone to the operator at the switchboard 1000 to indicate that the number of the desired called subscriber may be dialed.

When the selector 815 is seized in the above described manner, battery and ground potentials are applied to the conductors C781 and C782, thereby operating the relays R1220 and R1210 in the cord circuit 900. The current flow through the upper and lower windings of the relay R1220 is in such a direction that the relay R1220 operates at this time. When the relay R1220 operates, at its contacts 1221, it opens a point in the incomplete circuit of relay R1160; and, at its contacts 1222, it prepares a point in the incomplete circuit for the relay R1030. When the relay R1210 operates, at its contacts 1211, it prepares a point in the incomplete circuit for the relay R1160 and, at its contacts 1213, it opens a point in the incomplete circuit for the relay R1260.

When the operator at the switchboard 1000 hears the dial tone signal she may actuate the dial D1485 in accordance with the first digit of the telephone number of the subscriber at the substation A3. When the dial D1485 is rotated off normal in the dialing of the first digit, a circuit is completed from ground, by way of the off-normal contacts 1487 and the lower winding of the relay R1460, to battery. The relay R1460 operates over the above traced circuit and, at its contacts 1461 and 1462, it bridges the capacitance 1466 across the talking conductors C1104 and C1105 of the operator telephone circuit; at its contacts 1463, it completes a circuit for shunting the operator receiver 1402. The above traced circuits including the contacts 1461, 1462 and 1463 provide a click reducing arrangement for both the distant toll operator and the operator at the switchboard 1000 during the dialing period. At its contacts 1464, the relay R1460 also completes a circuit for operating the dial relay R1250 in the cord circuit 900, which may be traced from ground, by way of the off-normal contacts 1487 of the dial D1485, the contacts 1464, the conductor C1112, the contacts 1124', and the winding of the relay R1250, to battery. At its contacts 1465, the relay R1460 also completes an operating circuit for the relay R1470, which includes the ground potential applied to the contacts 1465 by way of the off-normal contacts 1487 of the dial D1485.

When the relay R1470 operates over the above traced circuit, at its contacts 1471, it completes an operating circuit for the lower winding of the relay R1460; at its contacts 1472, it completes an energizing circuit for the upper winding of the relay R1460 in order to hold the latter relay in its operated position for a short period of time after the dial D1485 has restored to normal; and, at its contacts 1473, it completes an operating circuit for the lower winding of the relay R1475 which includes ground at the off-normal contacts 1487. The relay R1480 now operates and, at its contacts 1482, it prepares a circuit for bridging the polar relay R1450 across the tip and ring elements of the plug P1270, after the dial relay R1250 restores to normal at the end of each series of impulses transmitted by the dial D1485. However, as will be subsequently described, this circuit will not be completed dur-

ing the establishment of the present connection because the relay R1250 opens this circuit at its contacts 1251.

It will be recalled that the dial relay R1250 operated when the dial D1485 was actuated off normal and, upon operating, at its contacts 1252 and 1254, it disconnects the previously traced circuit including the upper winding of the relay R1220 and the winding of the relay R1210 from the tip and ring elements of the plug P1270; and, at its contacts 1251 and 1253, it substitutes in place thereof a dialing circuit including the conductors C1106 and C1107, the contacts 1427 of the dial release key K1425, the impulsing contacts 1486 of the dial D1485, and the resistance 1478. Since the latter circuit is now bridged across the tip and ring elements of the plug P1270, the circuit extending to the selector 815 will include the impulsing contacts 1486 of the dial D1485. At its contacts 1481, the relay R1480 also prepares a circuit for illuminating the dial pilot lamp L1406; and, at its contacts 1483, it prepares a circuit for maintaining the relay operated over its upper winding in series with the dial relay R1250 after the dial D1485 has restored to normal, as will be subsequently explained.

As a further result of the operation of the dial relay R1250 a circuit is completed from ground, by way of its contacts 1255, the contacts 1157, and the winding of the control relay R1130, to battery. The relay R1130 now operates and, at its contacts 1131, completes a locking circuit for itself which is independent of the initial energizing circuit; and, at its contacts 1132, it prepares a circuit for subsequently operating the relay R1260.

When the relay R1475 operates over the previously traced circuit, the short-circuit around its upper winding, which makes the relay slightly slow-to-operate, is removed at its contacts 1477; and, at its contacts 1476, it places a shunt circuit around the resistance 1478 in order to improve the above traced impulsing circuit extending to the selector 815.

Since the operator at the switchboard 1000 has actuated the dial D1485 in accordance with the first digit of the telephone number of the subscriber at the substation A3, the dial will now automatically return to its normal position and, in doing so, will transmit impulses to the above mentioned selector by interrupting the loop circuit, including the conductors C1106 and C1107 at the impulsing contacts 1486, a number of times corresponding to the value of the digit dialed. The selector 815 responds to the series of impulses transmitted and raises its wipers to a level of its associated bank contacts corresponding to the number of impulses constituting the first digit of the called subscriber number. The selector then operates automatically to rotate its wipers over the contacts of the selected level to select a trunk line 816 extending to an idle connector, such as the combination connector 825.

When the dial D1485 returns to its normal position the impulsing contacts 1486 remain in their closed position and the off-normal contacts 1487 are opened, thereby to interrupt the circuit for holding the relays R1460, R1470 and R1475. It is also to be noted that the ground potential connected by way of the off-normal contacts 1487 to the conductor C1112 is now disconnected therefrom and causes the relay R1250 in the cord circuit 900 to restore to normal. It should also be noted that the circuit including the upper winding of the relay R1480 will now become effective to maintain the relay R1480 energized over a circuit including its upper winding, after the circuit for its lower winding is opened at the contacts 1471. This circuit may be traced from ground, by way of the contacts 1483, the upper winding of the relay R1480, the conductor C1112, the contacts 1124', and the winding of the relay R1250, to battery. The relay R1480 remains operated over this circuit but due to the resistance of its upper winding the relay R1250 remains in its normal position.

When the relay R1475 restores to normal, at its contacts 1476, it removes the shunt from around the resistance 1478; and, at its contacts 1477, it again completes a circuit for its upper winding to render the relay slow-to-operate. When the relay R1470 restores to normal, at its contacts 1471, it opens the energizing circuit for the lower winding of the relay R1480, but the latter relay remains in its operated position, as has been mentioned above; at its contacts 1472, it opens the holding circuit for the relay R1460; and, at its contacts 1473, it opens a point in the circuit for the lower winding of the relay R1475. The relay R1460 now restores to normal and, at its contacts 1461 and 1462, it removes the capacitance 1466 from across the conductors C1104 and C1105; at its contacts 1463, it removes the short-circuit from the receiver 1402; and, at its contacts 1464 and 1465, it opens points in previously traced circuits for controlling the relays R1250 and R1470, respectively.

Referring again to the cord circuit 900, it will be recalled that when the dial relay R1250 was operated, a circuit was completed, at its contacts 1255, for operating the control relay R1130, and that, at its contacts 1252 and 1254, it opened the previously traced circuit including the upper winding of the relay R1220 and the winding of the relay R1210. When the above mentioned circuit for the relays R1210 and R1220 was opened the relays restored to their normal positions. At its contacts 1213, the relay R1210, upon restoring to normal, prepares a point in the incomplete circuit for relay R1260; and, at its contacts 1211, it opens a point in the incomplete circuit for the relay R1160. When the relay R1220 restores to normal, at its contacts 1221, it prepares a point in the incomplete circuit for the relay R1160. The above mentioned relays of the cord circuit 900 remain in the positions described during the period of time the impulses constituting the first digit of the called subscriber number are being transmitted by the dial D1485.

As a result of the restoration of the dial D1485 to its normal position, the relay R1250 was restored to normal and, at its contacts 1251 and 1253, it disconnects the dialing circuit including the conductors C1106 and C1107 from the tip and ring elements of the call plug P1270; and, at its contacts 1252 and 1254, it reconnects the upper winding of the relay R1220 and the winding of the relay R1210 to the tip and ring elements of the plug P1270. Since the connection being described has now been extended by the selector 815, to the combination connector 825, the ground and battery potential applied to the tip and ring elements of the call plug P1270 by the selector 815 has been disconnected from these conductors, and the conductors have been extended, by way of the trunk line 816, to the combination connector 825. The connector 825, however, does not return battery and ground potential over the

conductors extending to the tip and ring elements of the plug P1270 and, consequently, no circuit is completed for operating the relays R1210 and R1220 in the cord circuit 900. In other words, the connection which is now completed between the operator at the switchboard 1000 and the combination connector 825 has been dried to prevent operation of the relays R1210 and R1220 at this time.

As a further result of the restoration of the dial relay R1250, at its contacts 1257, it completes a circuit from ground, by way of the contacts 1132, 1213 and 1257 for operating the slow-to-operate relay R1260. At its contacts 1261, the relay R1260 prevents the supervisory circuit, including the conductors C1102 and C1103 of the operator telephone circuit, from being bridged across the tip and ring elements of the call plug P1270 at this time; and at its contacts 1263, it opens a point in the previously traced circuit for bridging the upper winding of the relay R1220 and the winding of the relay R1210 across the tip and ring elements of the call plug P1270. As a further result of the operation of the relay R1260, at its contacts 1262 and 1264, it connects the windings of the relay R920 to the tip and ring elements of the call plug P1270, which may be traced from ground, by way of the upper winding of the relay R920, the contacts 912, 1262, 1181, 1241 and 1252, to the tip element of the plug P1270, and from battery by way of the lower winding of the relay R920, the contacts 913, 1264, 1183, 1243 and 1254 to the ring element of the plug P1270.

When the dial D1485 is actuated off-normal in order to transmit the next digit of the called subscriber number, the relays R1460, R1470 and R1475 operate in the manner previously described and the dial relay R1250 is again operated to reconnect the dialing circuit including the conductors C1106 and C1107 to the tip and ring elements of the call plug P1270. At its contacts 1257, the relay R1250 opens the circuit of the relay R1260 which now restores to normal and, at its contacts 1262 and 1264, it opens points in the circuits including the windings of the relay R920. It will be understood that after the relay R1250 restores to normal at the termination of the digit dialed, the impulsing circuit including the conductors C1106 and C1107 is disconnected from the call plug P1270; the relay R1260 is again operated, and the windings of the relay R920 are again connected to the tip and ring elements of the call plug P1270. The previously described cycle of operation of the relays R1460, R1470, R1475, R1250 and R1260 is repeated each time the operator at the switchboard 1000 actuates the dial D1485.

Accordingly, it will be understood that when the operator at the switchboard 1000 actuates the dial D1485 in accordance with the final two digits of the called subscriber number, the combination connector 825 positions its wipers into engagement with its associated bank contacts terminating the line 826 of the called subscriber at the substation A3. The combination connector 825 is one that is used in establishing toll connections and, accordingly, does not automatically transmit ringing current to signal the called subscriber when its wipers are positioned into engagement with the called subscriber line.

In order to control the connector 825 to initiate the automatic ringing of the called subscriber line, the operator at the switchboard 1000 momentarily operates the toll ring key K1420. In response to the momentary operation of the toll ring key K1420, a circuit is completed from battery, by way of the resistance 1423, the contacts 1421 of the key K1420, the conductor C1110, the contacts 1120', the winding of the relay R1140, and the winding of the relay R1150, to ground. The relays R1140 and R1150 remain operated over the above described circuit but the circuit including the conductor C1111, the contacts 1121', the conductor C1265, the sleeve elements of the call plug P1270 and the jack J770, and the winding of the relay R750, to battery, is opened. The relay R750 restores to normal and, at its contacts 751, it removes ground potential from the conductor C783, thereby to control the combination connector 825 to initiate the automatic ringing of the called subscriber at the substation A3. Since the toll ring key K1420 is only momentarily operated the above traced holding circuit for the relays R1140 and R1150, including the contacts 1421 of the key K1420, is transferred to the contacts 1422 and the winding of the relay R750, to battery, whereupon the relay R750 again operates and applies ground potential to the conductor C783. During the period of time the ringing current is transmitted by the connector 825 to the called line of the substation A3 a ringback tone signal is transmitted to the operator at the switchboard 1000 and to the toll operator in the main exchange 20.

Attention is directed to the fact that the operator at the switchboard 1000 remains associated with the connection until the called subscriber answers the call. Consequently, if the called subscriber fails to answer, the operator at the toll board 300 may at any time converse with the operator at the switchboard 1000 to inform her to release the connection. It will be assumed, however, that the subscriber at the substation A3 responds by removing his receiver from the switchhook of the associated telephone instrument, whereupon the combination connector 825 is controlled to terminate the ringing signal and to connect battery and ground potentials to the conductors C781 and C782, respectively. Battery potential applied to the conductor C781 is extended by way of the tip elements of the jack J770 and the plug P1270, the contacts 1252, 1241, 1181, 1262 and 912, and the winding of the relay R920, to ground; and ground potential applied to the conductor C782 is extended by way of the contacts 742, the ring elements of the jack J770 and the plug P1270, the contacts 1254, 1243, 1183, 1264 and 913, and the lower winding of the relay R920, to battery. The relay R920 operates in response to the above traced circuit and, at its contacts 921, it completes a circuit for bridging the winding of the relay R906 and the resistance 932 across the tip and ring elements of the plug P900.

In response to the above mentioned circuit for bridging the relay R906 and the resistance 932 across the tip and ring elements of the plug P900, a circuit, including the windings of the relays R557 and R570, is completed from ground, by way of the relay R557, the winding 555 of the repeating coil 550, the contacts 563, 674 and 724, the conductor C785, the tip elements of the jack J760 and the plug P900, the contacts 902 of the key K901, the resistance 932, the contacts 921, the winding of the relay R906, the contacts 904 of the key K901, the ring elements of the plug P900 and the jack J760, the conductor C785, the contacts 722, 672, 641 and 561, the winding 554 of the repeating coil 550, the winding of the relay R570, and the contacts 525, to battery. The relay R906

in the cord circuit 900 operates and the relays R557 and R570 in the toll transmission trunk circuit 600 remain operated over the above traced circuit. The relay R906, at its contacts 907, provides a holding circuit for the relay R910.

Referring again to the operation of the relay R920, it will be noted that, at its contacts 922, it completes an operating circuit for the switching relay R910 and, at its contacts 923, it opens a point in the incomplete operating circuit for the relay R1030. The relay R910, upon operating, at its contacts 915, completes an operating circuit including the lower winding of the relay R940; and, at its contacts 911 to 914, inclusive, it disconnects the windings of the relay R920 from the tip and ring elements of the call plug P1270 and substitutes in place thereof a circuit including the tip and ring elements of the plug P900. As a further result of the operttion of the relay R910, at its contacts 918, it extinguishes the call lamp L1271. The relay R940, upon operating over the circuit including its lower winding, at its contacts 943, closes a point in the locking circuit for the relay, which is completed when the operator at the switchboard 1000 restores the talk key K1100 to normal. As a further result of the operation of the relay R940, at its contacts 941, it disconnects the left-hand winding of the relay R1040 from the tip and ring elements of the plug P900; and, at its contacts 942, it bridges the ring-down relay R930, including the condenser 933, across the tip and ring elements of the plug P900 in order to provide recall facilitates whereby the operator at the toll board 300 may recall the operator at the switchboard 1000 in the event the latter operator has disassociated her telephone circuit from the cord circuit 900. At its contacts 944, the relay R940 prepares a point in the circuit for flashing the answer lamp L919 in the event the toll operator recalls the operator at the switchboard 1000.

As has been mentioned above, the relay R920 restores to normal upon the operation of the switching relay R910 and, at its contacts 921, it removes the resistance 932 from the bridging circuit including the tip and ring elements of the plug P900; at its contacts 922, it opens the initial energizing circuit of the switching relay R910, which relay is now held in its operated position from ground at the contacts 907; and, at its contacts 923, it prepares a point in the incomplete circuit for operating the recall relay R1030.

As a result of disconnecting the left-hand winding of the relay R1020 from the tip and ring elements of the plug P900, the circuit through its right-hand winding, although maintained, is insufficient to retain the relay in its operated position. The relay R1020 now restores to normal and, at its contacts 1022, prepares a further point in the incomplete circuit of the answer lamp L919.

The operator at the switchboard 1000 may now retire from the connection by restoring the key K1103 to normal, whereupon the relay R1120 restores to normal to disassociate the conductors of the operator telephone circuit of Fig. 14 from the cord circuit 900. It is to be noted that upon restoring, the relay R1120, at its contacts 1121, completes a circuit which may be traced from ground, by way of the contacts 972, 1121 and 943, and the winding of the relay R940, to battery, in order to maintain the relay in its operated position after the initial energizing circuit for its lower winding has been opened. At its contacts 1126 to 1128, inclusive, the relay R1120 transfers the sleeve conductor C975 from the operator telephone circuit to the windings of the relays R950 and R970 in series, in order to maintain the circuit for these relays; and, at its contacts 1120' to 1122', inclusive, it transfers the sleeve conductor C1265 from the operator telephone circuit to the relays R1140 and R1150 in order to maintain these relays in their operated positions.

When the called subscriber at the substation A3 has answered the call, the operator at the toll board 300 may withdraw from the connection, thereby establishing a talking connection from the calling subscriber in the distant office to the called subscriber at the substation A3. Transmission current for the called station is supplied through the windings of the relays R557 and R570 in the toll transmission trunk circuit 600, and transmission current for the calling end of the connection is supplied either from the toll selector 330 or the cord circuit 301 at the toll board 300. It should be noted that the talking circuit extending through the cord circuit 900 extends from the tip and ring elements of the plug P900, the contacts 902 and 904, the winding of the relay R906, the contacts 911 and 914, 1262 and 1264, 1181 and 1183, 1241 and 1243, 1252 and 1254, and the tip and ring elements of the call plug P1270. The relay R906 is maintained operated over a circuit including the one of the talking conductors from battery supplied through the winding of the relay R570 and ground applied to conductor C782 by the connector 525.

Disconnect supervision

When the conversation between the calling and called subscribers has been terminated and the called subscriber at the substation A3 has replaced his receiver upon his telephone instrument, the connector 525 responds, in a well known manner, to reverse the battery and ground potentials applied to the conductors C781 and C782. Referring to the cord circuit 900, the reversal in the potentials applied to the above mentioned conductors short-circuits the relay R906 which now restores to normal and, at its contacts 907, opens the holding circuit for relay R910. The relay R910 restores to normal and, at its contacts 912 and 913, reconnects the relay R920 across the tip and ring elements of the call plug P1270, but since the potentials applied to the conductors C781 and C782 have been reversed by the connector 525, the relay R920 does not operate at this time. As a further result of the restoration of the relay R910, at its contacts 915 it opens the initial operating circuit including the lower winding of the relay R940, but the latter relay remains in its operated position over a holding circuit including its upper winding. At its contacts 916, the relay R910 prepares a point in the incomplete circuit of the recall relay R1030 and, at its contacts 918, it completes the previously traced circuit for illuminating the call lamp L1271. As a further result of the restoration of the relay R910, at its contacts 911 and 914, it disconnects the call plug P1270 from the answer plug P900.

In response to the reversal in the potentials applied to conductors C781 and C782 the relay R570 also restores to normal and, at its contacts 571, opens the circuit for the supervisory control relay R610, which also restores to normal. At its contacts 613, the relay R610 reapplies

ground potential upon the conductor C567 from the contacts 663 of the relay R660; and, at its contacts 611, it removes the short-circuit from around the high resistance upper winding of the relay R540 in order to transmit disconnect supervision to the operator at the toll board 300.

Recalling the branch exchange operator

In order to describe the recall facilities for enabling the toll operator to recall the operator at the switchboard 1000, it will be assumed that the called subscriber at the substation A3 has prematurely disconnected from the connection and that it is necessary for the toll operator to recall the operator at the switchboard 1000. In order to recall the operator at the switchboard 1000 the operator at the toll board 300 causes ground potential to be removed from the conductor C486, whereupon the relay R410 restores to normal. At its contacts 411, the relay R410 reapplies resistance battery potential to the conductor C487 whereupon the relay R470 is energized over a circuit including its upper winding and remains in its operated position. Application of the resistance battery potential to the conductor C483 shunts out the energizing circuit for the lower winding of the relay R510, whereupon an energizing circuit, including the upper winding of the relay R510, causes the relay to operate and close its contacts 511. In response to the closing of the contacts 511, the relay R620 operates and, at its contacts 622, opens the circuit for the lower winding of the relay R720. The relay R720 now restores to normal whereupon, at its contacts 725, it opens a point in the incomplete circuit for its lower winding; at its contacts 722 and 724, it disconnects the right-hand windings of the repeating coil 550 from the tip and ring conductors C785 and C786; and, at its contacts 721 and 723, it completes a circuit for transmitting ringing generator over the tip and ring conductors C785 and C786 to signal the operator at the switchboard 1000.

The operator at the toll board 300 may now reapply ground potential to the conductor C486 and again operate the ring control relay R410 in the toll trunk circuit 400. Upon operating, the relay R410, at its contacts 411 and 412, disconnects the resistance battery potential and connects direct ground potential to the conductor C487. When ground potential is applied to the conductor C487, the circuit including the upper winding of the relay R470, is shunted and an energizing circuit is now completed for its lower winding in order to maintain the relay R470 in its operated position. Application of ground potential to the conductor C483 completes an energizing circuit for the lower winding of the relay R510 and, since the relay is also energized over a circuit including its upper winding, the relay R510 now restores to normal in the manner previously described. Upon restoring, the relay R510, at its contacts 511, again opens the circuit of relay R620, which relay now restores to normal and again prepares the holding circuit for the lower winding of the relay R720.

Referring again to the restoration of the relay R720, it will be noted that the circuit for signaling the operator at the switchboard 1000 may be traced from the generator conductor GEN., by way of the upper winding of the relay R720, the contacts 731 and 721, the conductor C786, the ring elements of the jack J760 and the plug P900, the contacts 904 of the key K901, the contacts 942, the condenser 933, the winding of the ring-down relay R930, the contacts 902 of the key K901, the tip elements of the plug P900 and the jack J760, the conductor C785, and the contacts 723, to ground. Transmission of the ringing generator current over the above traced circuit causes the relay R930 to operate and, at its contacts 931, it completes a circuit from ground, by way of the contacts 931, 1256, and 1146, and the winding of the answer recall relay R1040, to battery. The relay R1040 operates over the above traced circuit and, at its contacts 1041, completes a locking circuit for itself, which is independent of the ground at the contacts 931, over a circuit which may be traced from ground, by way of the contacts of the dial-through key K1025, the contacts 1123', 1041, 1256 and 1146, and the winding of the relay R1040, to battery. As a further result of the operation of the relay R1040, at its contacts 1042, it completes a circuit from the intermittently grounded conductor C1044, by way of the contacts 1042, 944, 959 and 975, and the answer lamp L919, to battery. The answer lamp L919 is intermittently illuminated as a result of the above traced flashing circuit to indicate to the operator at the switchboard 1000 that the operator at the toll board 300 desires to recommunicate with her.

In order to reconnect her telephone circuit to the cord circuit 900, the operator at the switchboard 1000 actuates the talk key K1100 to reoperate the relay R1120. The relay R1120, upon operating, performs the same functions as have been described hereinbefore and, in addition thereto, at its contacts 1123', it opens the previously traced holding circuit for the relay R1040; and, at its contacts 1121, it opens a point in the previously traced holding circuit for the upper winding of the relay R940. The relay R940, upon restoring to normal, at its contacts 941 bridges the left-hand winding of the relay R1020 across the tip and ring elements of the plug P900 in order to terminate the transmission of ringing current by the relay R720; and at its contacts 944, it interrupts the flashing circuit in order to extinguish the flashing condition of the lamp L919. However, at its contacts 945, the relay R940 completes a circuit from ground by way of the contacts 1148, 974, 1022, 945, 959 and 975 for steadily illuminating the answer lamp L919. As a further result of the restoration of the relay R940, at its contacts 942, it disconnects the ring-down relay R930 from the tip and ring elements of the plug P900.

When the left-hand winding of the relay R1020 is bridged across the tip and ring elements of the plug P900, a direct current circuit is completed for energizing the upper winding of the relay R720 in series with the left-hand winding of the relay R1020. The relay R1020, upon operating, at its contacts 1022, opens a point in the previously traced circuit of the answer lamp L919 in order to extinguish the same. When the above mentioned direct current circuit is completed for the upper winding of the relay R720, the relay operates and, at its contacts 725, completes a holding circuit for its lower winding, which may be traced from ground, by way of the contacts 663, 622, 613 and 565, the conductor C567, the contacts 671' and 725, and the lower winding of the relay R720, to battery. As a further result of the operation of the relay R720, at its contacts 723 and 721, it disconnects ground and the ringing generator current from the conductors C785 and C786, respectively; and, at its contacts 724 and 722, it reconnects the tip and ring conductors

C785 and C786 to the right-hand windings of the repeating coil 550 and the windings of the relays R557 and R570 to ground and battery, respectively.

When the above traced circuit is established in series with the left-hand winding of the relay R1020 in the cord circuit 900, the relay R570 operates and, at its contacts 571, it completes an operating circuit for the relay R610. The relay R610 again operates, substituting ground potential at the contacts 612, for the ground potential at the contacts 663, in order to maintain the relay R720 in its operated condition and, at its contacts 611, it shunts the high resistance upper winding of the relay R540 in order to give answer supervision to the operator at the toll board 300. When the operator at the toll board 300 receives the answer supervision, she may communicate with the operator at the switchboard 1000 and inform her to resignal the subscriber at the substation A3 in the same manner as that which has been previously described when the branch exchange operator initially signaled the subscriber at the substation A3.

Recalling the toll operator

In the foregoing description of operation it was assumed that the called subscriber at the substation A3 released the connection by hanging up his receiver and that the operator at the toll board 300 desired to recall the operator at the switchboard 1000 in order to be reconnected to the subscriber at the substation A3. In the following description it will be assumed that the subscriber at the substation A3 has replaced his receiver and has again removed it in order to signal the operator at the toll board 300. When the subscriber disconnected by replacing his receiver upon the switchhook of his associated telephone instrument, the connector 825 functioned, in the manner previously described, and reversed the connection of battery and ground potentials to the conductors C781 and C782. As a result thereof, the relay R906 in the cord circuit 900 and the relays R570 and R557 in the toll transmission trunk circuit 600 restored to normal. Restoration of the relay R906 caused the relay R910 to restore to normal and illuminate the call lamp L1271. As a further result of the restoration of the relay R910, the relay R920 was again bridged across the tip and ring elements of the call plug P1270 but was not energized over this circuit because the reversal of the battery and ground potentials to the conductors C781 and C782 prevented the relay from operating. When the relay R570 in the toll transmission trunk circuit 600 restored to normal, the relay R610 also restored to normal and removed the shunt circuit from around the high resistance upper winding of the relay R540 and transmitted disconnect supervision to the operator at the toll board 300.

When the called subscriber at the substation A3 again removes his receiver from the switchhook of his associated telephone instrument, the connector 825 functions to again reverse the potentials on the conductors C781 and C782. A circuit is now completed for the upper and lower windings of the relay R920 which operates and, at its contacts 922, completes a circuit for the relay R910. At its contacts 921, the relay R920 completes a circuit for bridging the winding of the relay R906 and the resistance 932 across the tip and ring elements of the plug P900 in order to reoperate the relays R557 and R570 in the toll transmission trunk circuit 600. As a result of this operation, the relay R610 is again operated to place a shunt circuit around the high resistance upper winding of the relay R540 in order to signal the operator at the toll board 300 that the called subscriber at the substation A3 desires to communicate with her. The relay R306 also operates in series with the relays R557 and R570 and, at its contacts 907, completes a holding circuit for the relay R910. The relay R910, upon operating, at its contacts 915, completes an energizing circuit for the lower winding of the relay R940, but this relay has not restored at this time due to the locking circuit including its upper winding. At its contacts 918, the relay R910 opens the circuit for illuminating the call lamp L1271 and, at its contacts 911 to 914, inclusive, it disconnects the relay R920 from the tip and ring elements of the call plug P1270 and connects the tip and ring elements of the answer plug P900 in series with the winding of the relay R906, to the tip and ring elements of the call plug P1270. The relay R820, upon restoring to normal, at its contacts 921, removes the resistance 932 from the above mentioned bridging circuit and, at its contacts 922, it opens a point in the multiple circuit for the relay R910. When the operator at the toll board 300 receives a disconnect signal which is immediately followed by an answer signal, she is informed of the fact that the subscriber at the substation A3 desires to communicate with her. The toll operator now associates her telephone circuit with the above connection extended to the called subscriber at the substation A3 and communicates with the subscriber thereat.

Releasing the connection

It will now be assumed that the called subscriber at the substation A3 has replaced his receiver on the switchhook of his associated telephone instrument in order to terminate the previously described toll connection. As a result of the replacement of the receiver upon the telephone instrument by the subscriber at the substation A3, the circuits involved in the connection operate in the manner previously described to give the operator at the toll board 300 disconnect supervision. Accordingly, it will also be assumed that the originating subscriber in the distant office has also replaced his receiver and that disconnect supervision has been transmitted to the operator at the toll board 300. When the toll operator receives disconnect supervision from both ends of the connection she may release the connection by withdrawing the plugs P302 and P304 of the cord circuit 301 from the jacks J303 and J305, respectively. As a result of the withdrawal of the plug P304 from the jack J305, the toll selector 330 removes ground potential from the conductor C486, thereby restoring the ring control relay R410 to normal. As a further result of the withdrawal of the plug P304 from the jack J305, ground potential is also removed from the conductor C484. The toll selector 330 now restores its wipers 331 to 334, inclusive, to normal in a well known manner. When ground potential is removed from the conductors C486 and C484, the relays R410 and R450 restore to normal.

The relay R450, upon restoring to normal, at its contacts 451, prepares a circuit for applying ground potential to the conductor C487; at its contacts 453, it removes ground potential from the conductor C485, thereby opening the circuit for the upper winding of the relay R440; and, at its contacts 456, it completes a circuit for

operating the release relay R420, which may be traced from ground, by way of the contacts 471, 464 and 456, and the winding of the release relay R420, to battery The relay R440 now restores to normal and, at its contacts 442, completes a circuit for applying ground potential by way of the contacts 451 to the conductor C487. The relay R470 remains in its operated position over a circuit including its lower winding, the conductor C483, the lower winding of the control relay R510 to resistance battery potential connected to the conductor C530. The relay R510 remains in its restored position since an energizing circuit is completed for its upper and lower windings. As a further result of the restoration of the relay R440, at its contacts 443, it disconnects the winding of the relay R410 from the conductor C486 and, at its contacts 444, it applies ground potential to the conductor C486. In response to the operation of the release relay R420, at its contacts 422 and 424, it applies ground potential to the conductors C484 and C485, respectively, in order to mark the toll trunk circuit 400 busy in the banks of the selectors having access thereto.

It will be recalled that when the subscriber at the substation A3 replaced his receiver, the cord circuit 900 functions to illuminate the call lamp L1271 to indicate to the operator at the switchboard 1000 that the called subscriber has disconnected. The operator at the switchboard 1000 may now remove the answer plug P900 and the call plug P1270 from the jacks J760 and J770, respectively. As a result of the removal of the plug P900 from the jack J760 the previously traced circuit including the windings of the relays R950 and R970 and the relay R730 is opened, whereupon the relay R970 restores to normal. Although the relay R950 has been energized over the above mentioned circuit, due to the resistance included in the circuit the relay has not been operated.

When the relay R970 restores to normal, at its contacts 972, it opens the energizing circuit for the right-hand winding of the relay R920 and it opens the locking circuit for the upper winding of the relay R940. The relays R940 and R1020 also restore to normal. When the plug P1270 is withdrawn from the jack J770, the relays R1140 and R1150 are restored to normal. The relay R1150, upon restoring to normal, at its contacts 1155, opens the circuit for the control relay R1130. The relay R1130, upon restoring to normal, at its contacts 1132, opens the circuit for the relay R1260, which also restores to normal. When the relay R1140 restores to normal, at its contacts 1147, it extinguishes the call lamp L1271. The cord circuit 900 has now been restored to normal and it may be utilized by the operator at the switchboard 1000 in extending other connections.

As a result of the removal of the plug P900 from the jack J760, the previously traced circuit for the relay R730 is opened and the relay restores to normal. Upon restoring to normal, the relay R730, at its contacts 731, opens a point in the incomplete circuit for the upper winding of the relay R720; at its contacts 732, it opens a point in the incomplete circuit of the call lamp L772; and, at its contacts 733 and 734, it again prepares points in the incomplete circuits for the windings of the relay R710.

As a result of the removal of the plug P1270 from the jack J770, the circuit for the ring control relay R750 is opened and the relay restores to normal. Upon restoring to normal, the relay R750, at its contacts 751, removes ground potential from the conductor C783 extending to the selector 815. As a further result of the removal of the plug P1270 from the jack J770, the jack springs 771 are opened and the relay R740 restores to normal. Upon restoring to normal, the relay R740, at its contacts 743, removes ground potential from the conductor C784 extending to the selector 815; at its contacts 742, it opens a point in the circuit of the conductor C782; and, at its contacts 741, it prepares a point in the incomplete circuit for the call lamp L772. As a result of the removal of ground potential from the conductors C783 and C784, the selector 815 and the combination connector 825 restore to normal in a well known manner.

Attention is now directed to the fact that when the operator at the toll board 300 disconnected, the toll selector 330 restored to normal, thereby opening the circuit of the relay R540. Upon restoring to normal the relay R540, at its contacts 541, opens the circuit for the relay R640. The relay R640 now restores to normal and, at its contacts 642, it opens the circuit of the hold relay R650; and, at its contacts 643, it completes a circuit for the relay R630. The relay R630 now operates and, at its contacts 631, completes a locking circuit for itself including ground at the contacts 663; and, at its contacts 633, it completes a multiple circuit for the relay R520.

The slow-to-release hold relay R650 now restores to normal and, at its contacts 651, opens the circuit for the hold relay R660. The relay R660 is of the slow-to-release type and subsequently restores to normal. Upon restoring to normal, the relay R660, at its contacts 663, removes the holding ground potential for maintaining the relays R670, R630 and R720 in their operated positions. Consequently, the above mentioned relays also restore to normal.

When the relay R630 restores to normal, at its contacts 633, it opens a point in the multiple circuit for the relay R520; at its contacts 631, it opens a point in the incomplete holding circuit for itself; and, at its contacts 632, it prepares a point in the incomplete operating circuit for the relay R560.

When the relay R670 restores to normal, at its contacts 674', it opens the circuit for the relay R520; at its contacts 676, it removes resistance battery potential from the conductor C530; and, at its contacts 675, it prepares a point in the circuit for applying ground potential to the conductor C530. As a further result of the restoration of the relay R670, at its contacts 671 to 674, inclusive, it prepares points in the talking circuit extending through the toll transmission trunk circuit 600 for subsequent operation.

As a result of the restoration of the relay R720, at its contacts 721 to 724, inclusive, it disconnects the tip and ring conductors C785 and C786 from the talking conductors of the trunk circuit 600 including the right-hand windings of the repeating coil 550; and it prepares points in the circuits for transmitting ringing current over the above mentioned tip and ring conductors. As a result of the above described restoration of the relays R630 and R670, the relay R520 now restores to normal and, at its contacts 521 to 524, inclusive, disconnects the left-hand windings of the repeating coil 550 from the conductors C481 and C482 and connects the windings of the relay R640 to the above mentioned conductors. At its contacts 525, the relay R520 disconnects battery potential from the

answer relay R570; and, at its contacts 526, it applies ground potential to the conductor C530.

When battery potential is removed from the conductor C530 and ground potential is substituted in place thereof, the relay R470 restores to normal. As a result of the restoration of the relay R470, at its contacts 471, it opens the previously traced circuit for the relay R420. The relay R420 now restores to normal and, at its contacts 422 and 424, it removes busy marking ground potential from the conductors C484 and C485; and, at its contacts 421 and 423, it prepares points in the circuits for the relays R450 and R460. The toll trunk circuit 400 and the toll transmission trunk circuit 600 have now been restored to normal and may again be utilized by the operator at the toll board 300 in extending further toll calls to the branch exchange 50.

TOLL CALL FROM A DISTANT EXCHANGE TO THE MANUAL SUBSTATION M IN THE BRANCH EXCHANGE 50

In order to describe the operation of the switching apparatus in extending a toll call to the manual substation M in the branch exchange 50, it will be assumed that the operator at the toll board 300 has answered a toll call received over the toll line 319 and that she has extended the call to the manual operator at the switchboard 1000 by dialing the digit "6" in the previously described manner. It will also be assumed that the manual operator at the switchboard 1000 has answered the connection by inserting the plug P900 into the jack J760 and has ascertained that the call is to be extended to the manual subscriber at the substation M. The operation of the toll trunk circuit 400, the toll transmission trunk circuit 600, and the answer end of the cord circuit 900 is the same as has been described in connection with the extension of a toll call via the branch exchange operator to the automatic subscriber at the substation A3.

Before extending the connection to the called subscriber at the substation M, the operator at the switchboard 1000 may restore the talk key K1100 in order to disconnect her operator telephone circuit from the cord circuit 900. The operator may now test the line of the substation M by placing the tip of the plug P1270 against the sleeve element of the jack J880 (Fig. 13) terminating the line 830 of the substation M. If the called line is busy, a ground potential is applied to the sleeve element of the jack J880 from another cord circuit involved in the connection established between the substation M and some other line. Consequently, when the tip of the plug P1270 is placed into engagement with the sleeve element of the jack J880, the ground potential thereon will be extended by way of the tip element of the plug P1270, the contacts 1252, 1241, 1181, 1151 and 1141, the conductor C1101, the resistance 1493, and the winding 1432 of the induction coil 1430, to battery. As a result of the above traced circuit, a click is produced in the receiver 1402 of the operator headset 1400 to indicate that the line of the substation M is busy.

It will be assumed, however, that when the above described busy test is made by the operator, the line 830 of the substation M is idle, and therefore no click is produced in the receiver of the telephone circuit. The operator now inserts the plug P1270 into the jack J880 and, as a result thereof, a circuit is completed for operating the relays R1150 and R1140 of the cord circuit 900, in series with the relay R860 of the line circuit 840, individual to the line 830 of the substation M. The circuit for operating the above mentioned relays may be traced from ground, by way of the windings of the relays R1150 and R1140, the contacts 1122', the conductor C1265, the sleeve elements of the call plug P1270 and the jack J880, and the winding of the relay R860, to battery.

The relay R1150, upon operating over the above traced circuit, opens points in the circuits including the tip and ring conductors of the cord circuit; at its contacts 1159', it opens a point in the incomplete circuit for the relay R1230; at its contacts 1155 and 1157, it prepares separate operating and holding circuits for the control relay R1130; and, at its contacts 1158, it completes a circuit for energizing the lower polarizing winding of the relay R1220. The last mentioned circuit merely prepares the relay R1220 for quick operation when a circuit including its upper winding is subsequently completed. At its contacts 1156, the relay R1150 completes a circuit for the upper winding of the relay R1220 and the winding of the relay R1210, which may be traced from the tip element of the call plug P1270, by way of the contacts 1252, 1241, 1181 and 1263, the upper winding of the relay R1220, the winding of the relay R1210, the contacts 1156, 1123, 1243 and 1254, and the ring element of the call plug P1270. At its contacts 1159, the relay R1150 prepares a point in the circuit for controlling the ring relay R1240.

The relay R1140, upon operating over the previously traced circuit, interrupts, at its contacts 1143 and 1145, a point in the incomplete circuit of the relay R1060. Attention is directed to the fact that the relay R1060, although bridged across the talking conductors of the cord circuit through the contacts 1152 and 1153, cannot operate at the present time because it is disconnected from the answering end of the cord circuit at the contacts 951 and 954. At its contacts 1141, the relay R1140 disconnects the busy test circuit including the conductor C1101; at its contacts 1146, it prepares a point in the incomplete circuit for the answer recall relay R1040; and, at its contacts 1147, it completes a circuit for illuminating the call lamp L1271, which may be traced from ground, by way of the contacts 918, 966, 1164 and 1147, and the call lamp L1271, to battery. As a further result of the operation of the relay R1140, at its contacts 1148, it prepares another point in the incomplete circuit for the relay R1240; and, at its contacts 1149, a point is closed in the incomplete operating circuit for the relay R1230.

As a result of the above described operations of the relays R1140 and R1150, the cord circuit 900 is now in condition to be controlled by the operator to signal the wanted subscriber at the substation M. However, before this operation is described, it will be recalled that as a result of the seizure of the called line of the substation M, the cutoff relay R860 operated. When the relay R860 operates, at its contacts 861 and 862, battery and ground potentials are removed from the conductors of the line 830.

Since the connection has now been extended to the called subscriber at the substation M, the operator at the switchboard 1000 may now momentarily actuate the ring start key K1215 individual to the selected cord circuit 900, in order to signal the called subscriber. As a result of the momentary operation of the ring start key K1215, a circuit is completed from ground, by way of the contacts 1148, 974 and 1021, the contacts of the key K1215, the contacts 1159, and

the winding of the relay R1240, to battery. The relay R1240 operates over this circuit and, at its contacts 1246, completes a holding circuit for itself, which may be traced from ground by way of the contacts 1148, 974, 1021, 1187 and 1246, and the winding of the relay R1240, to battery. It will be noted that the holding circuit is independent of the contacts of the ring start key K1215 and, therefore, the relay remains in its operated position after the key has been restored to normal. As a further result of the operation of the relay R1240, at its contacts 1242 and 1244, it completes a circuit for signaling the wanted subscriber at the substation M. This circuit may be traced from the ungrounded terminal of the ringing generator GEN., the upper winding of the ring cutoff relay R1180, the contacts 1244 and 1254, the ring elements of the plug P1270 and the jack J880, the upper ring conductor of the line 830, through the ringer bridged across the line 830 at the substation M, the lower tip conductor of the line 830, the tip elements of the jack J880 and the plug P1270, the contacts 1252 and 1242, to the grounded terminal of the interrupter generator. A ring-back tone signal is transmitted to the toll operator by way of the condensers 1247 and 1248, 976 and 977, the contacts 902 and 904, and the tip and ring elements of the plug P900 and the jack J760, to the right-hand windings of the repeating coil 550, whereat the tone is repeated to the operator at the toll board 300. The ring-back tone signal indicates to the toll operator that the called subscriber is now being signaled.

Called subscriber answers

When the called subscriber at the substation M responds to the signal by removing his receiver, a direct current bridge is connected across the line 830 in order to operate the ring cutoff relay R1180. When the direct current bridge is connected across the line 830, the relay R1180 operates and, at its contacts 1186, completes a holding circuit, including its lower winding, from ground at the contacts 1148. As a further result of the operation of the relay R1180, at its contacts 1187, it opens the holding circuit for the ringing relay R1240 which now restores to normal and, at its contacts 1242 and 1244, it disconnects the ringing generator GEN. from the called subscriber line 830. At its contacts 1182 and 1184, the relay R1180 also prepares circuits for connecting the answer relay R920 to the called line 830; and, at its contacts 1181 and 1183, it disconnects the previously traced circuit including the upper winding of the relay R1220 and the winding of the relay R1210 from the tip and ring elements of the call plug P1270. As a result of the restoration of the ringing relay R1240, at its contacts 1241 and 1243, it connects the windings of the answer relay R920 to the tip and ring conductors of the called line 830; and, at its contacts 1245, it completes a circuit for operating the recall relay R1030.

Since the answer relay R920 is now connected to the called subscriber line, the relay is operated over a circuit which may be traced from ground, by way of the upper winding of the relay R920, the contacts 912, 952, 1182, 1241 and 1252, the tip elements of the call plug P1270 and the jack J880, the tip conductor of the line 830, the direct current bridge circuit at the called substation M, the ring conductor of the line 830, the ring elements of the jack J880 and the call plug P1270, the contacts 1254, 1243, 1184, 955 and 913, and the lower winding of the relay R920, to battery.

At its contacts 921, the relay R920 places a bridge circuit across the tip and ring elements of the plug P900 which includes the relay R906, the contacts 921, and the resistance 932, in order to maintain the answer relay R570 and the relay R557 in the toll transmission trunk circuit 600 in their operated positions. At its contacts 923, the relay R920 opens a point in the completed circuit for the slow-to-operate recall relay R1030. The circuit for the latter relay was completed upon the restoration of the ring relay R1240 over a circuit which may be traced from ground by way of the contacts 972, 1121, 1185, 1245, 916, 923, 964 and 973, and the winding of the relay R1030, to battery. Since the relay is of the slow-to-operate type, the above traced circuit is opened, at the contacts 923, before the relay has had sufficient time to operate its associated contacts 1031 and 1032. At its contacts 922, the relay R920 also completes an operating circuit for the switching relay R910.

When the series relay R906 is bridged across the tip and ring elements of the plug P900, a circuit is completed therefor which may be traced from ground and battery applied to the tip and ring elements of the plug P900, by way of the windings of the relays R557 and R570 in the toll transmission trunk circuit 600. The relay R906 operates over this circuit and, at its contacts 907, completes a multiple circuit for the relay R910.

When the relay R910 operates over the previously described circuit, at its contacts 911 and 914, it extends ground and battery potential, applied to the tip and ring elements of the answer plug P900, by way of the contacts 902 and 904 of the key K901, the winding of R906, the contacts 911 and 914, 952 and 955, 1182 and 1184, 1241 and 1243, and 1252 and 1254, the tip and ring elements of the plug P1270 and the jack J880, and the conductors of the line 830, including the loop circuit at the substation M.

As a result of the above described circuit, the relays R570, R557 and R906 are maintained energized over a loop circuit including the called manual substation M. As a further result of the operation of the relay R910, at its contacts 912 and 913, it disconnects the windings of the relay R920 from the above mentioned loop circuit. The relay R920 now restores to normal and, at its contacts 921, it opens the bridging circuit including the resistance 932 and, at its contacts 922, it opens a point in the initial operating circuit for the relay R910. The relay R910 now remains in its energized position due to the circuit completed at the contacts 907 upon the operation of the relay R906. As a further result of the operation of the relay R910, at its contacts 916, it open a further point in the incomplete circuit for the relay R1030, and, at its contacts 918, it opens the circuit for illuminating the call lamp L1271. At its contacts 915, the relay R910 also completes a circuit for the lower winding of the relay R940, which relay now operates. At its contacts 943, the relay R940 completes a holding circuit for its upper winding which may be traced from ground, by way of the contacts 972, 1121 and 943, and the upper winding of the relay R940, to battery.

As a further result of the operation of the relay R940, at its contacts 942, it bridges the ring-down relay R930, in series with the condenser 933, across the tip and ring elements of

the answer plug P900, to prepare the cord circuit 900 for recall signals transmitted by the operator at the toll board 300. At its contacts 941, the relay R940 also disconnects the left-hand winding of the shunt field relay R1020 from across the tip and ring elements of the plug P900 and, at its contacts 946, it prepares a flashing circuit for the answer lamp L919. Since the relay R1020 is now only energized over its right-hand polarizing winding, the relay restores to normal; and, at its contacts 1022, it prepares a further point in the circuit for the answer lamp L919.

The connection between the operator at the toll board 300 and the called manual subscriber at the substation M is now completed and conversation may now take place. When the operator at the toll board 300 has ascertained that the connection is satisfactory, she withdraws from the connection and interconnects the calling subscriber at the distant office with the called subscriber at the manual substation M. It should be noted that transmission current for the called substation M is supplied through the windings of the relays R557 and R570 in the toll transmission trunk circuit 600.

Called subscriber releases

When the conversation between the distant subscriber and the subscriber at the substation M has been completed, the subscriber at the substation M replaces his receiver upon the switchhook of his telephone instrument. Replacement of the receiver, by the subscriber at the substation M, opens the loop circuit including the relay R906 of the cord circuit 900 and the relays R557 and R570 in the toll transmission trunk circuit 600, whereupon these relays restore to normal. When the relay R906 in the cord circuit 900 restores to normal, at its contacts 907, it opens the circuit for the relay R910. The relay R910 now restores to normal and, at its contacts 911 and 914, it disconnects the tip and ring elements of the plug P900 from the tip and ring elements of the plug P1270; and, at its contacts 912 and 913, it reconnects the answer relay R920 to the tip and ring conductors extending to the plug P1270 in order to provide recall facilities for the subscriber at the substation M. As a further result of the restoration of the relay R910, at its contacts 915, it opens the circuit for the lower winding of the relay R940; and, at its contacts 916, it completes an operating circuit for the recall relay R1030, which may be traced from ground, by way of the contacts 972, 1121, 1135, 1245, 916, 923, 964 and 973, and the winding of the slow-to-operate recall relay R1030, to battery. As a further result of the restoration of the relay R910, at its contacts 918, it completes a circuit for illuminating the call lamp L1271, which may be traced from ground, by way of the contacts 918, 966, 1164 and 1147, and the call lamp L1271, to battery, in order to indicate to the operator at the switchboard 1000 that the called subscriber at the substation M has disconnected. When the relay R1030 operates over the previously traced circuit, at its contacts 1031, it completes a locking circuit for itself from ground, by way of the contacts 972, 1121, 1031 and 973, and the winding of the relay R1030, to battery; and, at its contacts 1032, it prepares a circuit for flashing the call lamp L1271 in the event the subscriber at the substation M should recall the operator at the switchboard 1000 by again removing his receiver from the switchhook of his associated telephone instrument.

It will be recalled that when the subscriber at the substation M replaced his receiver upon the switchhook of his associated telephone instrument, the loop circuit including the relays R557, R570 and R906 was interrupted, thereby releasing the above mentioned relays. When the relay R570 restored to normal, at its contacts 571, it opened the circuit for the relay R610 which also restored to normal. At its contacts 611, the relay R610 removes the shunt circuit from around the high resistance upper winding of the relay R540, whereupon disconnect supervision is given to the operator at the toll board 300. Other operations performed as a result of the restoration of the relay R610 are the same as have been previously described. The operator at the toll board 300 and the operator at the switchboard 1000 may withdraw the plugs of the cord circuits at their respective positions from the associated jacks in order to release the connection between the calling subscriber in the distant exchange and the called subscriber at the substation M.

Called subscriber recalls the toll operator

Before describing the operations which take place when the operator at the switchboard 1000 removes the plugs P900 and P1270 from their respective jacks J760 and J880, the operations which take place when the subscriber at the substation M desires to recall the toll operator at the switchboard 300 will now be described. When the receiver is again removed by the subscriber at the substation M, after it has been momentarily replaced upon the telephone instrument, a circuit described hereinbefore is again completed for reoperating the answer relay R920 in the cord circuit 900. The relay R920, upon operating, at its contacts 922, causes the relay R910 to reoperate and again bridge the called subscriber line 830 across the tip and ring conductors terminating in the plug P900. As a result of the above operation, the relays R557 and R570 in the toll transmission trunk circuit 600, and the relay R906 in the cord circuit 900, are reoperated. The relay R910, upon reoperating, at its contacts 917 completes a circuit for flashing the call lamp L1271 and, at its contacts 915, reenergizes the lower winding of the relay R940. The relay R906, upon reoperating, at its contacts 907, completes a holding circuit for the relay R910. The relay R920 restores when the relay R910 operates and, at its contacts 922, it opens the original operating circuit for the relay R910. In the toll transmission trunk circuit 600, the reoperation of the relay R570 causes the relay R610 to reoperate and again shunt the high resistance upper winding of the relay R540. When the high resistance upper winding of the relay R540 is again excluded from the circuit extending by way of the conductors C481 and C482 to the toll board 300, the operator thereat receives a signal to indicate that the called subscriber at the substation M desires to communicate with her. Upon noting the above described recall signal the toll operator reconnects her telephone circuit to the connection and converses with the subscriber at the substation M. When the operator at the switchboard 1000 receives a flashing signal on the lamp L1271 she reoperates the talk key K1100 in order to associate her telephone circuit with the cord circuit 900. The operator may now listen in to the conversation between the toll operator and the subscriber at substation M in order to determine whether it will be necessary for her to perform

any operation in connection with the toll call. When the relay R1120 operates under control of the key K1100 in addition to performing the operations previously described, at its contacts 1121, it opens the holding circuit for relay R1030 which now restores to normal and extinguishes the lamp L1271.

Recalling the branch exchange operator

If the operator at the toll board 300 desires to be reconnected to the operator at the branch exchange switchboard 1000, after the called subscriber has answered or has disconnected, she may do so by controlling the toll transmission circuit 600, in a previously described manner, to transmit ringing current over the tip and ring elements of the jack J760 and the associated plug P900, under the control of the relay R720. When ringing current is transmitted to the cord circuit 900, from the toll transmission trunk circuit 600, the ring-down relay R930 responds and, at its contacts 931, operates the relay R1040 over a circuit which may be traced from ground, by way of contacts 931, 1256, and 1146, and the winding of relay R1040, to battery. Relay R1040 operates over this circuit and, at its contacts 1042, completes a circuit for intermittently illuminating the answer lamp L919 to indicate to the operator at the switchboard 1000 that the toll operator desires to communicate with her.

The operator at the switchboard 1000 may now communicate with the toll operator by actuating the talk key K1100, thereby to associate her telephone circuit (Fig. 14) with the cord circuit 900, in the same manner as has been previously described. The relays R940, R1030 and R1040 restore to normal, the former relay controlling the toll transmission trunk circuit 600 to terminate the automatic ringing signal transmitted to the cord circuit 900, and the latter relay terminating the flashing condition of the answer lamp L919.

Recalling the subscriber at substation M

In order to describe the manner in which the operator at the switchboard 1000 resignals a called subscriber, it will be assumed that the subscriber at the substation M has disconnected and that the toll operator has recalled the operator at the switchboard 1000, in the manner described above. It will also be assumed that the toll operator has instructed the branch exchange operator to recall the subscriber at the substation M. In order to resignal the called subscriber, the operator at the switchboard 1000 restores her talking key K1100 and momentarily withdraws the call plug P1270 from the jack J880. Momentary withdrawal of the plug P1270 from the jack J880 momentarily deenergizes the relays R1140, R1150 and R860. Restoration of the relay R1140, at its contacts 1148, opens the locking circuit for the relay R1180, which also restores to normal. The relays R1140, R1150 and R860 are reoperated upon the re-insertion of the call plug P1270 in the jack J880. The relays R1140 and R1150, upon reoperating, perform the same functions that have been previously described and, in particular, at the contacts 1148, the relay R1140 again prepares a point in the locking circuit for the lower winding of the relay R1180. To resignal the subscriber at the substation M, the operator momentarily actuates the ring start key K1215, whereupon the ring relay R1240 is operated and locked in its operated position by way of the contacts 1246. As a further result of the operation of the relay R1240, at its contacts 1242 and 1244 it connects ringing generator GEN., by way of the upper winding of the relay R1180 to the called line, in the same manner as has been previously described. When the called subscriber at the substation M responds to the ringing signal transmitted over the line 830, the relay R1180 operates, thereby to disconnect the ringing signal from the called line and to prepare the cord circuit to switch the connection from the toll board 300 through to the called subscriber at the substation M.

Releasing the connection

It will be recalled that when the toll operator and the operator at the switchboard 1000 received disconnect supervision, from the calling and called subscriber lines, the respective operators removed their cord circuits from the associated jacks involved in the connection. When the call plug P1270 is removed from the jack J880, the relay R860 of the called subscriber line circuit 840 is restored to normal to prepare the line 830 for additional calls. In the cord circuit 900 the withdrawal of the call plug P1270 from the jack J880 causes the various relays controlled over the called end of the connection to restore to normal, in the manner previously described. As a result of the withdrawal of the answer plug P900 from the jack J760, the various relays controlled over the answer end of the cord circuit 900 are also restored to normal in the same manner as has been previously described. In the toll transmission trunk circuit 600 the withdrawal of the plug P900 from the jack J760 causes the various relays therein to restore to normal and prepares the relay R470 in the toll trunk circuit 400, so that the toll trunk circuit may be restored to normal when the toll operator withdraws the cord circuit 301 from the jack J305. Restoration of the toll selector 330 and the toll trunk circuit 400 has been previously described and need not be repeated.

Guarding a defective toll transmission trunk circuit

In the event that the toll transmission trunk circuit 600 is found to be defective, the attendant in the branch exchange 50 may control the main exchange toll trunk circuit 400 and thereby place a busy marking thereon in order to prevent its seizure by the selectors, such as 330, having access thereto. In order to prevent seizure of the toll trunk circuit 400 the busy key K515 is actuated to open its contacts 516 and to close its contacts 517, whereupon resistance battery potential is substituted for the ground potential normally applied to the conductor C530. When resistance battery potential is applied to the conductor C530 an energizing circuit is completed for the lower winding of relay R470 and the upper and lower windings of relay R510 which may be traced from ground, by way of contacts 451 and 441, conductor C487, the lower winding of relay R470, the conductor C483, and the lower winding of relay R510, to resistance battery applied to the conductor C530. A circuit for the upper winding of the relay R510 may be traced from ground, by way of the resistance 514, and the upper winding of relay R510, to resistance battery applied to the conductor C530. Since the upper and lower windings of the relay R510 oppose each other the relay R510 remains in its restored position.

Referring to the relay R470, it is to be noted that when the above traced energizing circuit is completed for its lower winding, the upper wind-

ing of the relay is shunted from ground applied to the conductor C487 and the resistance 472. Relay R470 now operates and, at its contacts 471, completes a circuit which may be traced from ground, by way of contacts 471, 464 and 456, and the winding of relay R420, to battery. Relay R420 operates over the above traced circuit and, at its contacts 422 and 424, applies a busy marking ground potential to the inductors C484 and C485 in order to prevent the selectors, such as 330, from selecting the toll trunk circuit 400 and the associated toll transmission trunk circuit 600.

When the fault in the defective toll transmission trunk circuit 600 has been cleared, the busy key K515 is restored to normal. At its contacts 516 and 517, the key K515 substitutes ground potential for the resistance battery potential applied to conductor C530 and thereby causes the relay R470 to restore to normal. Upon restoring, the relay R470, at its contacts 471, opens the circuit for relay R420 which relay also restores to normal. At its contacts 422 and 424, the relay R420 removes the busy marking ground potential from the conductors C484 and C485 and, at its contacts 421 and 423, it reconnects battery potential through the relays R450 and R460, to the conductors C484 and C485, respectively, in order to prepare the toll trunk circuit 400 for subsequent seizure by a toll selector.

While one embodiment of the invention has been disclosed, it will be understood that various modifications may be made therein which are within the true spirit and scope of the invention.

What is claimed is:

1. In a telephone system, main and branch exchanges, a trunk line interconnecting said exchanges for extending connections from said main exchange to subscriber lines in said branch exchange, an automatic switch, an operator position, a toll selector in said main exchange responsive to a first or a second digit for selecting said trunk line, switching means in said branch exchange operated when said trunk line is selected in response to said first digit for extending said connection to said switch, means in said main exchange for thereafter controlling said switch to extend said connection to a branch exchange subscriber line, said switching means operated when said trunk line is selected in response to said second digit for extending said connection to said operator position and for marking said switch as the one to be used by the operator at said position, and means including said operator position for thereafter controlling said switch to extend said connection to a branch exchange subscriber line.

2. In a telephone system, a trunk line including a pair of talking conductors and a control conductor, a trunk circuit terminating said trunk line, an operator position, a switch having access to called lines, means for extending a connection to said trunk line over a first or a second path, a relay in said trunk circuit, means for controlling said relay over said control conductor in one manner in the event a connection is extended over said first path to said trunk line thereby to extend said connection to said operator position, means operated in the event a connection is extended over said second path to said trunk line for extending the said connection to said switch and for operating said switch to complete the said connection to a called line, and means for controlling said relay over said control conductor in another manner to signal said called line.

3. In a telephone system, a trunk line including a pair of talking conductors and a control conductor, a trunk circuit terminating said line, an operator position, a called line, a switch having access to said line, means for extending a connection to said trunk line over a first or a second path, means operated responsive to the extension of a connection to said trunk line over said first path for controlling said trunk circuit to extend said connection to said switch, means for controlling said switch to extend said connection to said called line, a relay controlled over said control conductor for signaling said line, and means operated responsive to the extension of a connection to said trunk line over said second path for controlling said relay over said control conductor thereby to extend the said connection to said operator position.

4. In a telephone system, a first and a second operator position, a trunk line comprising talking conductors and a control conductor, a first trunk circuit accessible to said first operator position over two paths, means including said first operator position for extending a connection to said trunk circuit over either one of said paths, a second trunk circuit, subscriber lines, means in said second trunk circuit controlled over said trunk line in response to said connection for extending the said connection to said second operator position or to one of said subscriber lines depending upon the path over which said connection is extended to said first trunk circuit, and means in said second trunk circuit operated over said control conductor for signaling said second operator position or said one of said subscriber lines.

5. In a telephone system, a first and a second operator position, a trunk line comprising talking conductors and a control conductor, a first trunk circuit accessible to said first operator position over two paths, means including said first operator position for extending a connection to said trunk circuit over either one of said paths, a second trunk circuit, subscriber lines, means in said second trunk circuit controlled over said trunk line in response to said connection for extending the said connection to said second operator position or to one of said subscriber lines depending upon the path over which said connection is extended to said first trunk circuit, signaling means for said second operator position and said subscriber lines, and means in said second trunk circuit operated over said control conductor for operating said position signaling means or said subscriber line signaling means.

6. In a telephone system, an operator position, a switch, an incoming trunk circuit, an outgoing trunk circuit, a trunk line terminating at one end in said incoming trunk circuit and at the other end in said outgoing trunk circuit, a control conductor, means for extending a connection to said outgoing trunk circuit and for seizing said incoming trunk circuit, means in said outgoing trunk circuit for controlling said incoming trunk circuit over said control conductor substantially simultaneously with the seizure thereof or subsequent to the seizure thereof, and means in said incoming trunk circuit operated in the event the control over said control conductor is exercised upon the seizure of said incoming trunk circuit for extending said connection to said operator position or for extending said connection to said switch in the event the control over said control conductor is exercised subsequent to the seizure of said incoming trunk circuit.

7. In a telephone system, a first operator position, a second operator position, a called line, switching means for extending a connection from said first position to said called line or to said second position, said means including a trunk line having a pair of talking conductors and a control conductor, and means controlled over said control conductor from said first operator position for controlling said switching means to selectively determine whether the destination of said connection is to be said second position or said called line.

8. In a telephone system, a first operator position, a second operator position, a called line, switching means for extending a connection from said first position to said called line or to said second position, said means including a trunk line having a pair of talking conductors and a control conductor, means controlled over said control conductor from said first operator position for controlling said switching means to selectively determine whether the destination of said connection is to be said second position or said called line, and means operated over said talking conductors for controlling said switching means to complete the said connection to the selected destination.

9. In a telephone system, an operator position, a trunk circuit, a trunk line including talking conductors and a control conductor terminating in said trunk circuit, a first path extending from said trunk circuit to said position, automatic switching apparatus, a second path extending from said trunk circuit to said switching apparatus, means in said trunk circuit operated responsive to a connection received over said trunk line for normally extending said connection over said second path, and control means included in said trunk circuit operated over said control conductor when a connection is received over said trunk line for controlling said trunk circuit to extend said connection over said first path.

10. In a telephone system, a trunk circuit, a trunk line including talking conductors and a control conductor terminating in said trunk circuit, a first path extending from said trunk circuit, a second path extending from said trunk circuit, means in said trunk circuit automatically operated over said talking conductors responsive to a connection received over said trunk line for normally extending said connection over said second path, and control means included in said trunk circuit automatically operated over said control conductor in conjunction with the operation of said first means over said talking conductors for controlling said trunk circuit to extend said connection over said first path.

11. In a telephone system, a main exchange, a branch exchange, a trunk line including a control conductor and a pair of talking conductors interconnecting said exchanges, an operator position, an automatic switch train, a trunk circuit in said branch exchange terminating said trunk line having access to said operator position and to said automatic switch train, and means in said trunk circuit controlled from said main exchange over said control conductor and said talking conductors for directing a call from said main exchange to said operator position or to said switch train.

12. In a telephone system, an operator position, automatic switching apparatus, a trunk circuit, a three conductor trunk line terminating in said trunk circuit, means for seizing said trunk circuit over said trunk line, control means included in said trunk circuit, and means operated responsive to said seizure of said trunk circuit over said trunk line for automatically operating said control means to extend said connection to said operator position or to said spitching apparatus, depending upon whether said trunk circuit is seized over the three conductors of said trunk line or over only two of the conductors of said trunk line.

13. In a telephone system, a first operator position, a trunk circuit, a second operator position, a first branch line interconnecting said trunk circuit and said second operator position, an automatic switch, a second branch line interconnecting said trunk circuit and said automatic switch, means including said first operator position for extending a connection to said trunk circuit, means in said trunk circuit selectively controlled over said connection for routing said connection to said first branch line or to said second branch line, means at said second operator position for answering a connection extended over said first branch line and for further extending said connection over said second branch line to said switch, a called line, means in said trunk circuit controllable from said first operator position in the event a connection is extended to said second branch line for operating said switch to extend the said connection to said called line, and means controllable from said second operator position in the event the said connection is extended from said first operator position to said second operator position over said first branch line for operating said switch over said second branch line to extend the said connection to said called line.

14. In a telephone system, a first operator position, a trunk circuit, a second operator position, a first branch line interconnecting said trunk circuit and said second operator position, an automatic switch, a second branch line interconnecting said trunk circuit and said automatic switch, means including said first operator position for extending a connection to said trunk circuit, means in said trunk circuit selectively controlled over said connection for routing said connection to said first branch line or to said second branch line, means at said second operator position for answering a connection extended over said first branch line and for further extending said connection over said second branch line to said switch, a called line, and means in said trunk circuit controllable from said first operator position in the event a connection is extended to said second branch line for operating said switch to extend the said connection to said called line.

15. In a telephone system, a first operator position, a trunk circuit, a second operator position, a first branch line interconnecting said trunk circuit and said second operator position, an automatic switch, a second branch line interconnecting said trunk circuit and said automatic switch, means including said first operator position for extending a connection to said trunk circuit, means in said trunk circuit selectively controlled over said connection for routing said connection to said first branch line or to said second branch line, and means at said second operator position for answering a connection extended over said first branch line and for further extending said connection over said second branch line to said switch.

16. In a telephone system, a trunk circuit, a first operator position, a second operator position, a called line, a switch train, means for extending a connection from said first operator position to

said trunk circuit, means in said trunk circuit selectively controllable from said first operator position for extending the said connection to said second operator position or to said switch train, means in said trunk circuit operable from said first operator position in the event the said connection is extended to said switch train for controlling said switch train to complete the said connection between said first operator position and said called line excluding said second operator position, and means in said trunk circuit operable from said second operator position in the event the said connection is extended thereto for controlling said switch train to complete the said connection between said first operator position and said called line including said second operator position.

17. In a telephone system, a trunk circuit, a first operator position, a second operator position, a called line, a switch train, means for extending a connection from said first operator position to said trunk circuit, means in said trunk circuit selectively controllable from said first operator position for extending the said connection to said second operator position or to said switch train, and means in said trunk circuit operable from said second operator position in the event said connection is extended thereto for controlling said switch train to complete the said connection between said first operator position and said called line including said second operator position.

18. In a telephone system, a trunk circuit, a first operator position, a second operator position, a called line, a switch train, means for extending a connection from said first operator position to said trunk circuit, means in said trunk circuit selectively controllable from said first operator position for extending the said connection to said second operator position or to said switch train, and means in said trunk circuit operable from said first operator position in the event the said connection is extended to said switch train for controlling said switch train to complete the said connection between said first operator position and said called line excluding said second operator position.

19. In a telephone system, a first operator position, a second operator position, a called line, switching means for extending a connection from said first position to said called line or to said second position, said means including a trunk line having a pair of talking conductors and a control conductor, means controlled over said control conductor from said first operator position for controlling said switching means to selectively determine whether the destination of said connection is to be said second position or said called line, means controlled over said talking conductors for controlling said switching means to complete the said connection to the selected destination, and means thereafter controlled over said control conductor for signaling said second operator position or said called line depending upon the destination of said connection.

20. In a telephone system, a first operator position, a second operator position, a called line, switching means for extending a connection from said first position to said called line or to said second position, said means including a trunk line having a pair of talking conductors and a control conductor, means controlled over said control conductor from said first operator position for controlling said switching means to selectively determine whether the destination of said connection is to be said second position or said called line, means controlled over said talking conductor for controlling said switching means to complete the said connection to the selected destination, means thereafter controlled over said control conductor for signaling said second operator position or said called line, depending upon the destination of said connection, and means controlled over said control conductor when said completed connection is answered for signaling said first operator position.

21. In a telephone system, an operator position, a trunk circuit, a trunk line including talking conductors and a control conductor terminating in said trunk circuit, a first path extending from said trunk circuit to said position, automatic switching apparatus, a second path extending from said trunk circuit to said switching apparatus, means in said trunk circuit operated responsive to a connection received over said trunk line for normally extending said connection over said second path, control means included in said trunk circuit operated over said control conductor when a connection is received over said trunk line for controlling said trunk circuit to extend said connection over said first path, signal means associated with said position and said switch train, and means controllable by said control means after a connection has been extended for operating the said signal means corresponding to the destination of said connection.

22. In a telephone system, a main exchange and a branch exchange, a three conductor trunk line interconnecting said exchanges, a trunk circuit in said branch exchange terminating said trunk line, an operator position, an automatic switch, a subscriber line accessible to said switch, means controlled over two conductors of said trunk line for extending a connection from said main exchange to said operator position or to said switch, means for signaling said operator position or for controlling said switch to signal said subscriber line depending upon whether said connection is extended to said position or to said switch, and means controlled over the remaining conductor of said trunk line for determining whether the said connection is to be extended to said operator position or to said switch and for controlling the operation of said last named means.

23. In a telephone system, an operator position, a trunk line including a pair of talking conductors and a control conductor, means for extending a connection to said trunk line, a trunk circuit, a called subscriber, means in said trunk circuit operated over said control conductor in response to the extension of a connection to said trunk line for extending the said connection to said operator position, means at said position for answering the said connection and for completing the said connection to said called subscriber, means in said trunk circuit operated in response to the disconnection of said called subscriber from the said connection for transmitting disconnect supervision over said talking conductors, and means in said trunk circuit controlled over said control conductor for transmitting ringing current to recall the operator at said position.

24. In a telephone system, an operator position, a trunk line including a pair of talking conductors and a control conductor, means for extending a connection to said trunk line, a trunk circuit, a called subscriber, means in said trunk cir-

cuit operated over said control conductor in response to the extension of a connection to said trunk line for extending the said connection to said operator position, means at said position for answering the said connection and for completing the said connection to said called subscriber, means in said trunk circuit operated in response to the disconnection of said called subscriber from the said connection for transmitting disconnect supervision over said talking conductors, means in said trunk circuit controlled over said control conductor for transmitting ringing current to recall the operator at said position, and a relay operated in response to the operator at the said position answering said recall for terminating the transmission of said ringing current.

25. In a telephone system, an operator position, a trunk line including a pair of talking conductors and a control conductor, means for extending a connection to said trunk line, a trunk circuit, a called subscriber, a signal at said position, means in said trunk circuit operated over said control conductor in response to the extension of a connection to said trunk line for extending the said connection to said position and for actuating said signal, means at said position for answering said connection and for restoring said signal to normal, means at said position for completing the said connection to said called subscriber via said trunk circuit, means in said trunk circuit operated in response to said called subscriber disconnecting from the said connection for transmitting disconnect supervision over said talking conductors, means operated over said control conductor for transmitting a recall signal to said position, and means operated in response to the operator at said position answering said recall for terminating the transmission of said recall signal and for transmitting answer supervision over said talking conductors.

26. In a signaling circuit, a first relay and a second relay, each of said relays having first and second windings opposing each other, a first conductor connected to the midpoint of the windings of said first relay, a second conductor connected to the midpoint of the windings of said second relay, a control conductor interconnecting said second winding of each of said relays, said first winding of each of said relays connected to ground, means for selectively applying battery potential to said first conductor while ground potential is applied to said second conductor thereby to energize said second winding of said first relay in series with said control conductor and said second winding of said second relay and for simultaneously energizing said first winding of said first relay and shunting said first winding of said second relay, said first relay remaining in its normal position in response to said energizing circuits for its first and second windings and said second relay operating in response to said energizing circuit for its second winding.

27. In a signaling system, a relay having a first and a second winding, an external circuit connected to a terminal of said first winding, a local circuit including ground potential connected to a terminal of said second winding, means for connecting ground potential to said external circuit, means for applying battery potential to the remaining terminals of said windings thereby completing opposing energizing circuits for said relay and preventing the operation of said relay, and means for substituting battery potential for the said ground potential connected to said external circuit thereby to shunt said first winding and to permit operation of said relay over the energizing circuit for its second winding.

JOHN WICKS.