Feb. 1, 1944. S. E. PETERSON 2,340,555

TELEPHONE SYSTEM

Original Filed Nov. 8, 1940 10 Sheets-Sheet 1

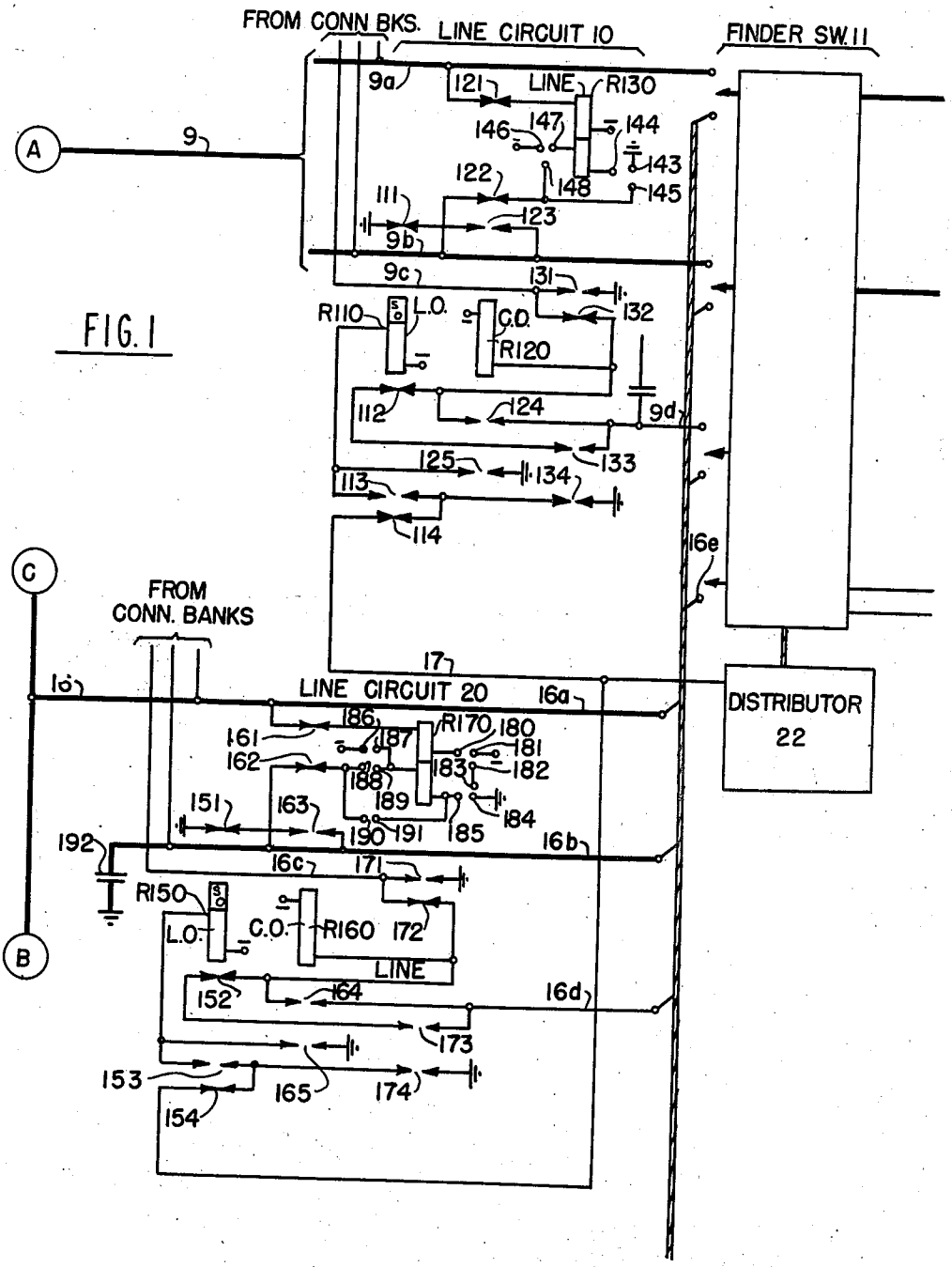


FIG. 1

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TELEPHONE SYSTEM

Original Filed Nov. 8, 1940 10 Sheets-Sheet 2

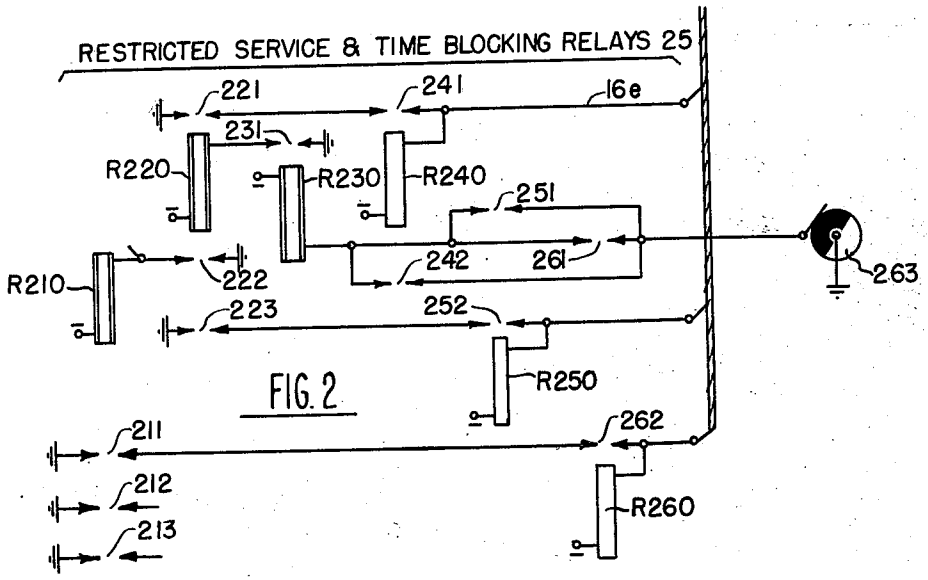


FIG. 2

FIG. 11

FIG. 1	FIG. 3	FIG. 4	FIG. 5	FIG. 6	FIG. 7	FIG. 8
FIG. 2			FIG. 9	FIG. 10		

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TELEPHONE SYSTEM

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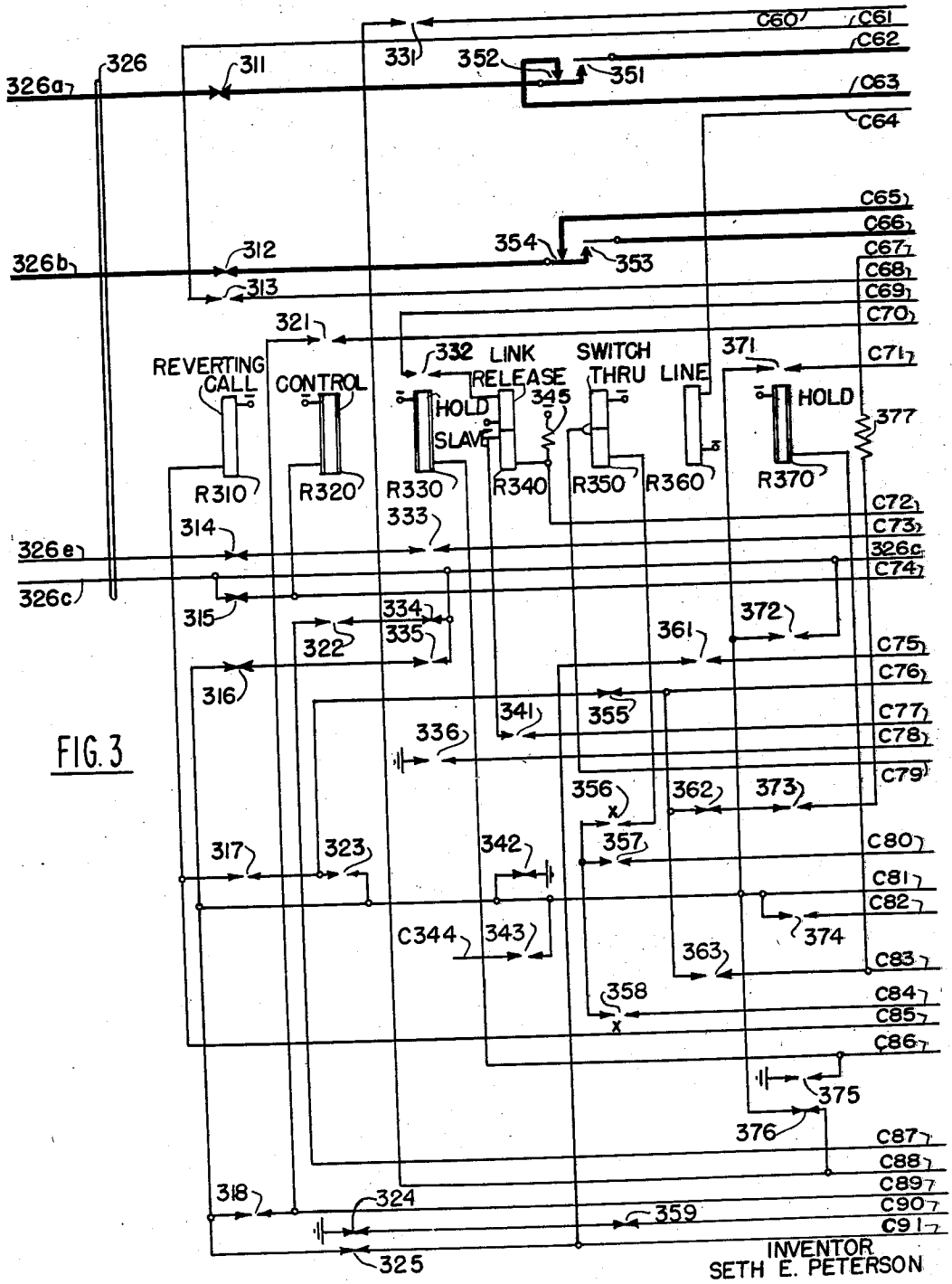


FIG. 3

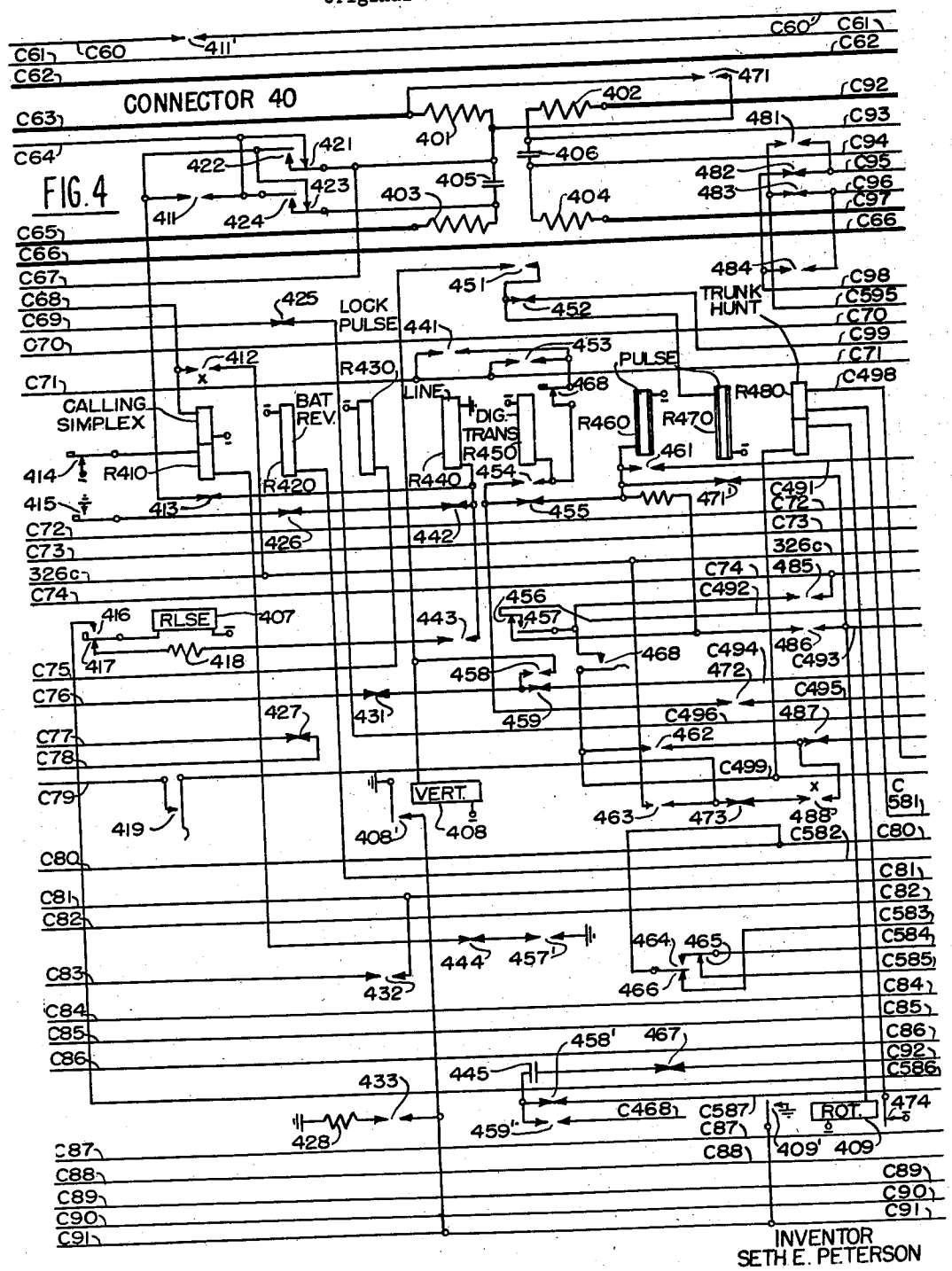
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TELEPHONE SYSTEM

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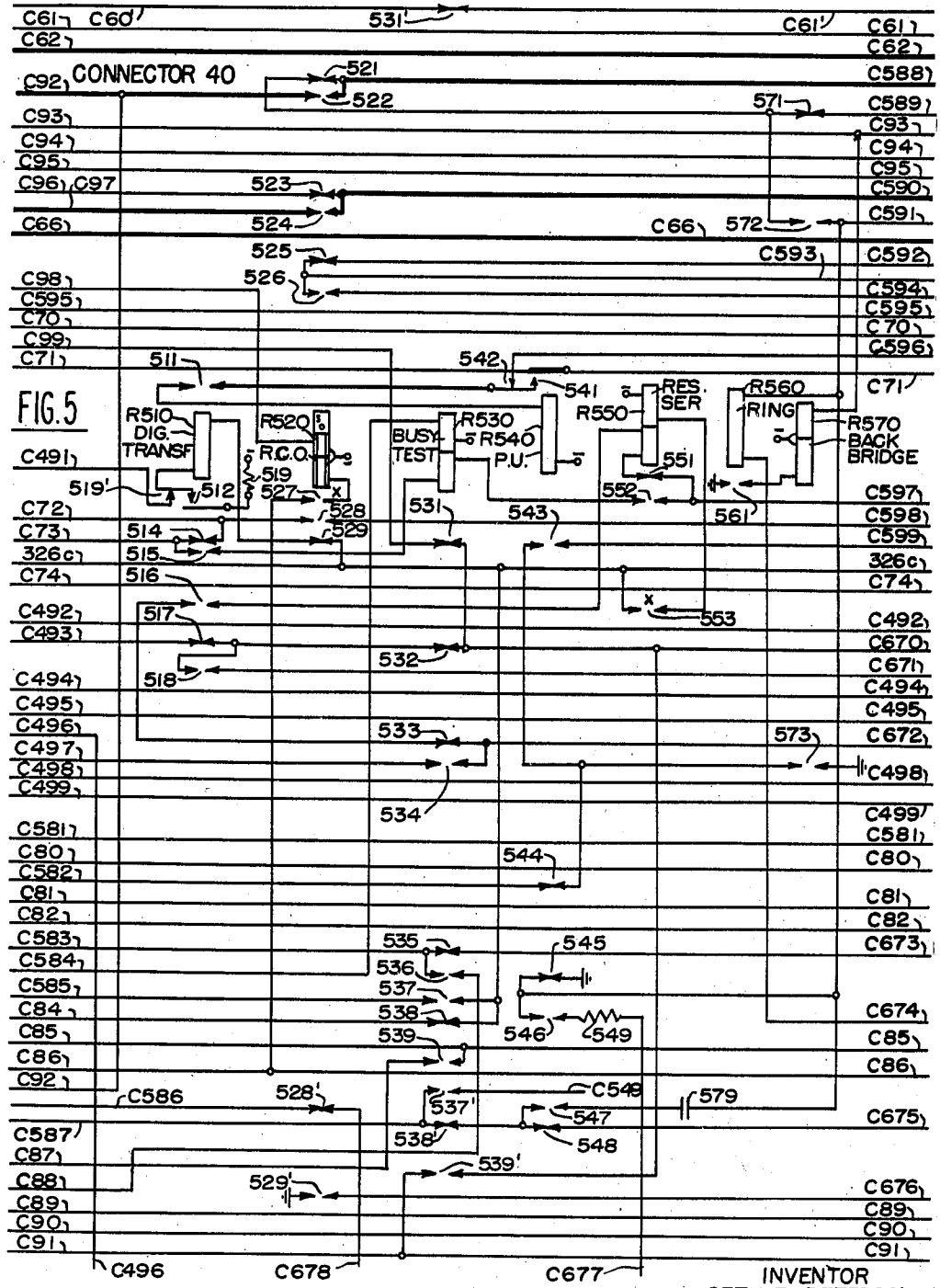


FIG. 5

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TELEPHONE SYSTEM

Original Filed Nov. 8, 1940 10 Sheets-Sheet 6

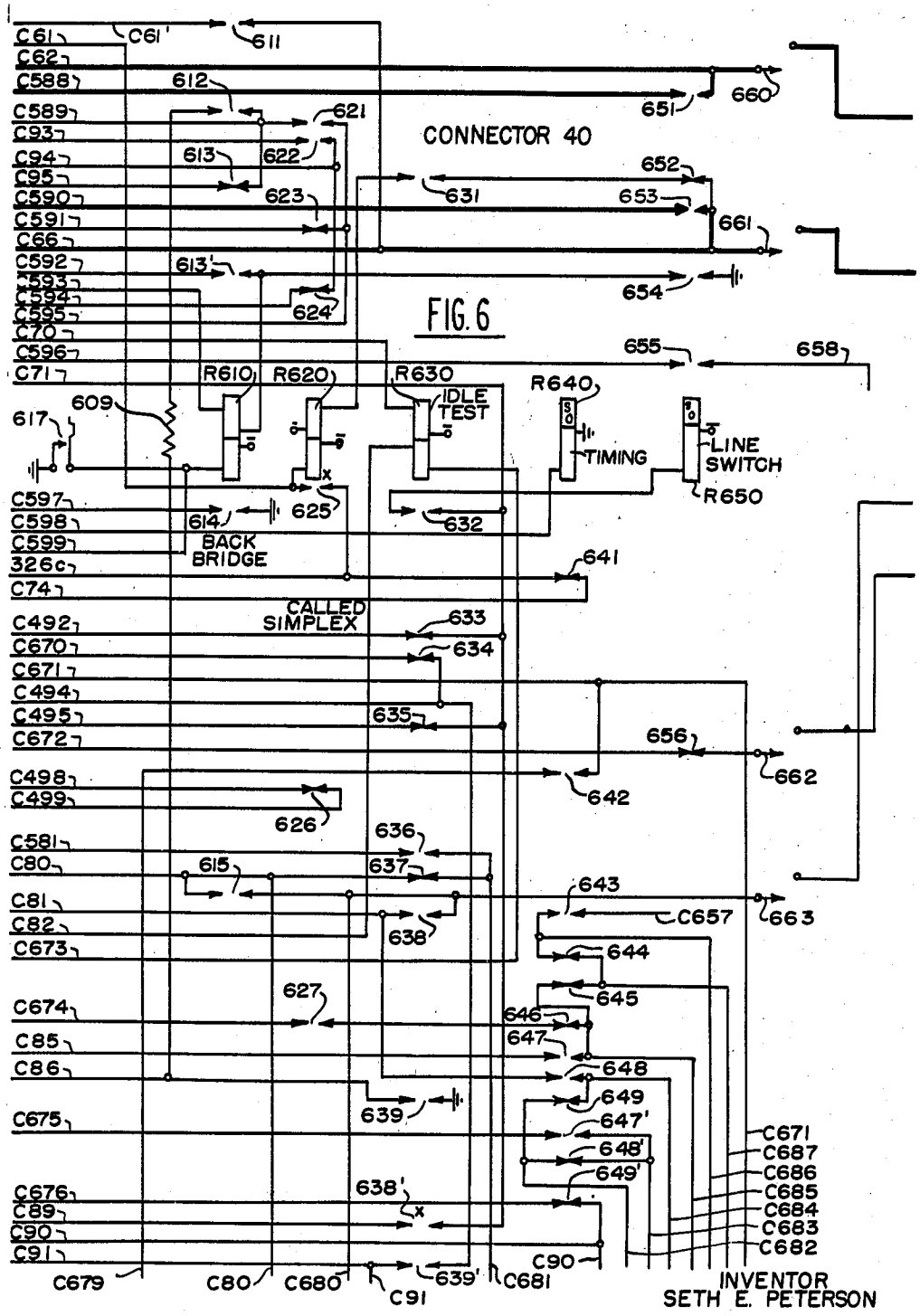


FIG. 6

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TELEPHONE SYSTEM

Original Filed Nov. 8, 1940 10 Sheets-Sheet 7

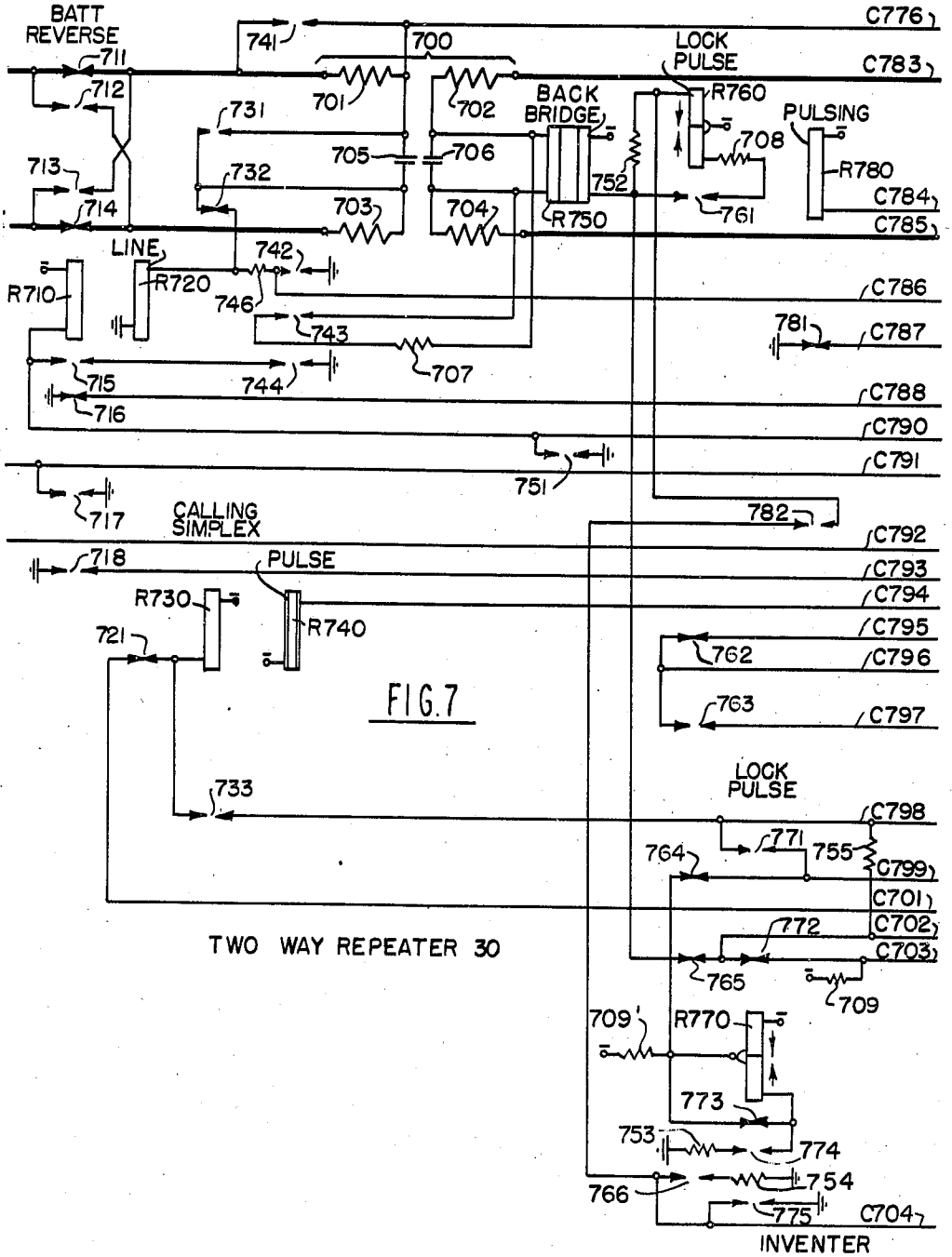


FIG. 7

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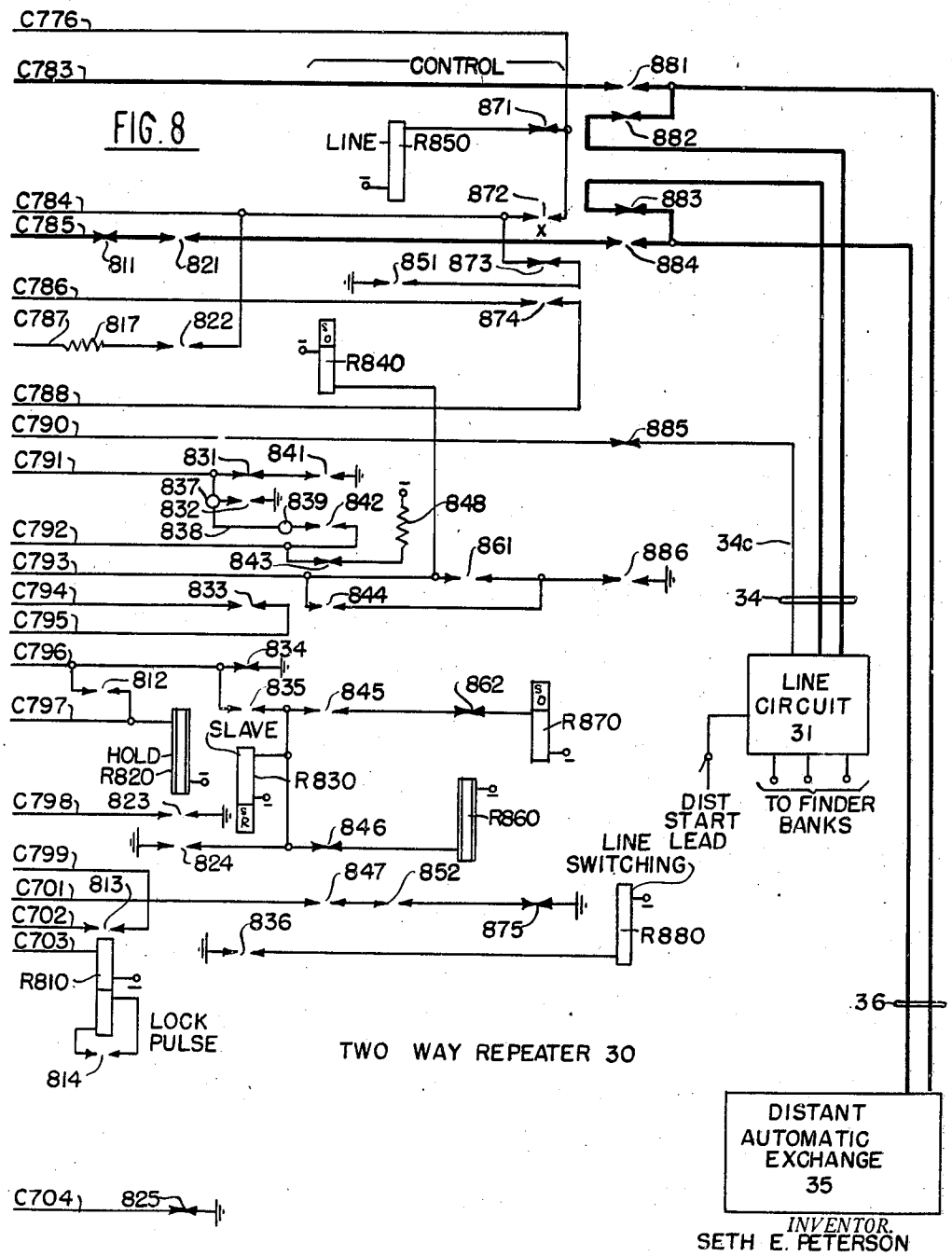
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TELEPHONE SYSTEM

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FIG. 8



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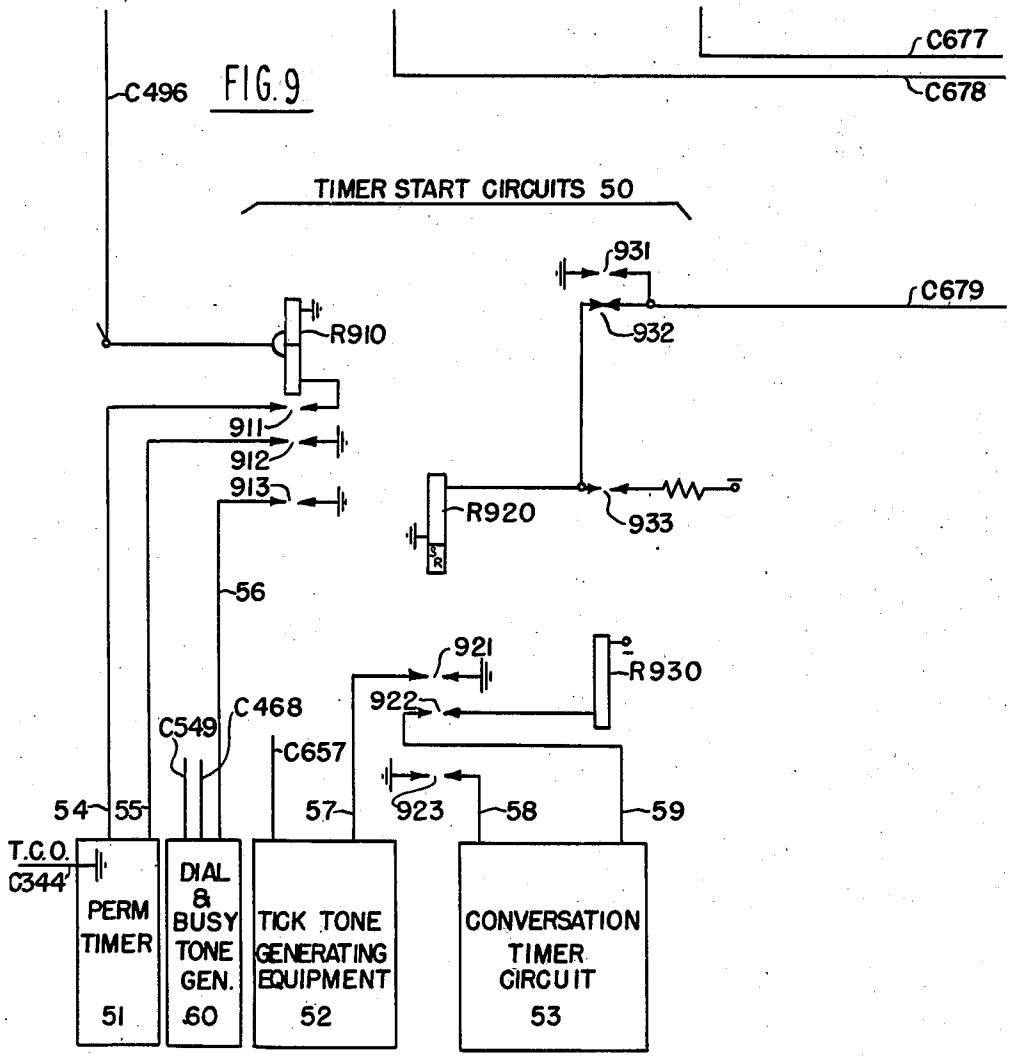
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FIG. 9



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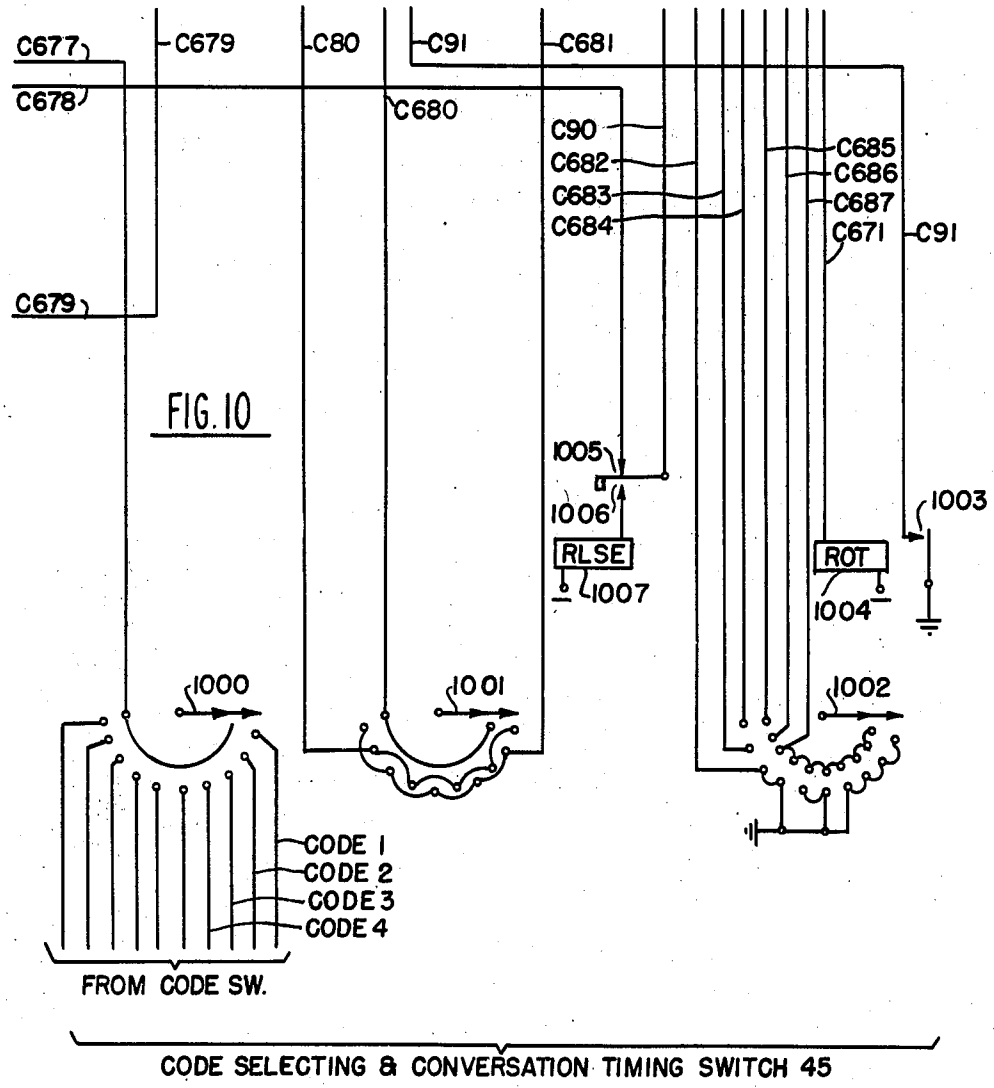


FIG. 10

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2,340,555

UNITED STATES PATENT OFFICE

2,340,555

TELEPHONE SYSTEM

Seth E. Peterson, Bogota, Colombia, assignor to Automatic Electric Laboratories, Inc., a corporation of Delaware

Original application November 8, 1940, Serial No. 364,824. Divided and this application June 29, 1942, Serial No. 448,961

49 Claims. (Cl. 179—17)

The present invention relates to telephone systems, and more particularly to improved automatic line-switching equipment which is controllable in a simple and reliable manner over lines of different types, such, for example, as full metallic lines of both the loop and simplex types, and ground return lines, to provide different classes of service to subscribers paying different rates. The present application is a division of copending application Serial No. 364,824, filed November 8, 1940.

It is an object of the invention to provide in a system of the character described, an improved and exceedingly simple arrangement whereby the regular line-terminating equipment, individual to the lines of the system, is utilized to signal the automatic switching apparatus as to the type or class of the calling lines over which the apparatus is seized.

According to another object of the invention, the line-class signaling circuits are so arranged that extra control paths extending through the outlet contacts of the automatic switches are not required for the transmission of the signals.

It is another object of the invention to provide in a telephone system of the character described, an arrangement whereby the station selective operation of the ringing control equipment provided in the connector switches of the system is in part controlled from the line circuits terminating the calling lines over which the connector switches are seized.

It is another object of the invention to provide in a telephone system of the character described, an arrangement wherein the station selective operation of the ringing control equipment provided in the connector switches of the system is in part controlled from the line circuits terminating called lines seized by the connector switches.

In accordance with a further object of the invention, an improved arrangement is provided whereby the line circuits terminating multiparty subscriber lines of the ground return type are arranged to control the ringing control equipment of the connector switches in a manner such that ringing current transmission over the ground return side of a selected line of this type is positively prevented.

It is another object of the invention to provide in a telephone system of the character described, automatic switching equipment which is so arranged that one type of ring cut-off is provided for terminating the transmission of ringing current over certain called lines of the system, and a different type of ring cut-off is utilized in terminating the transmission of ringing current over other called lines of the system.

According to a further object of the invention, the type of ring cut-off utilized in terminating the transmission of ringing current over a seized line is automatically determined during seizure of the line.

It is a further object of the invention to provide in a line-selecting switch, an improved circuit arrangement whereby the back-bridge relay of the switch functions both as a supervisory signal control relay and as a ringing control relay.

In the illustrated embodiment of the invention there is provided a system which comprises a plurality of subscriber lines, certain of which are of the multiparty type individually having a plurality of substations associated therewith, and automatic switching apparatus in the form of finder-connector links for setting up connections between the lines of the system. The connector switches of the links also have access to one or more groups of trunks which are provided to serve only the substations arranged for unrestricted service and may extend, for example, to one or more distant suburban or central exchanges. Timing equipment common to the links is provided for conversation timing and for forcibly releasing links held over lines having permanent calling conditions thereon.

The subscriber lines of the system are of several different types and include lines arranged for loop circuit control of the automatic switching equipment, simplex circuit control of the automatic switching equipment, and also lines of the ground return type. These lines are individually terminated in line circuits which conventionally comprise line, cut-off and lockout relays. In accordance with one feature of the present invention, the cut-off and lockout relays provided in the line circuits terminating lines of the simplex and ground return types, are arranged to transmit a control pulse over the positive talking conductors of the respective associated lines when calls are initiated on these lines. A control pulse of this character, when transmitted to a link assigned to the use of a calling simplex or ground return line, is utilized to condition the relay equipment of the link to be controlled over the metallic side of a ground return line or the two sides of a simplex line in parallel. These line circuit relays, when operated in response to seizure of the associated line through one of the connector switches of the system, function to transmit a control pulse back to the connector

switch which serves to control the setting of the ringing control equipment provided in the switch in a manner such that the transmission of ringing current over the ground return side or positive talking lead of the associated line is positively prevented. Further in accordance with this feature of the invention, the circuit arrangement of the finder-connector links is such that the ringing control equipment of an assigned link is, in setting up a reverting call connection involving a line of the ground return type, so controlled from the line circuit terminating the calling line that the possibility of ringing current transmission over the positive or ground return side of the line is precluded.

In accordance with another feature of the present invention, the cut-off and lockout relays embodied in the line circuits terminating the subscriber lines are also arranged to control the ringing control equipment of the links in a manner such that one mode of ring cut-off, i. e., instantaneous ring cut-off, is provided for terminating the transmission of ringing current over a called line of the full metallic loop type; and another mode of ring cut-off, i. e., silent period cut-off, is utilized to terminate the transmission of ringing current over a called line of the simplex or ground return type. More specifically, the circuit arrangement of the finder-connector links is such that when the cut-off and lockout relays of the line circuit terminating a called line operate to transmit a control pulse over the positive talking conductor of the associated line in response to seizure of this line, the back-bridge relay of the link occupied with the call is conditioned to function as a ringing control relay before the call is answered, and to function as a supervisory control relay after the call is answered at the called substation.

The novel features believed to be characteristic of the invention are set forth with particularity in the appended claims. The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the specification taken in connection with the accompanying drawings, in which Figures 1 to 10, inclusive, when combined in the manner illustrated in Fig. 11, illustrate an automatic telephone system having embodied therein the features of the invention briefly outlined above. More specifically, Fig. 1 illustrates the line equipment serving two of the subscriber lines of the system, the link distributor, and, in diagrammatic form, one of the finder switches at which the illustrated lines terminate; Fig. 2 illusrtates a relay network which is utilized for controlling the restricted service and timing relays of the links; Figs. 3 to 6, inclusive, and 10 illustrate the connector end of the link comprising the finder shown in Fig. 1; Figs. 7 and 8 illustrate the repeater terminating one of the inter-office trunks of the system; and Fig. 9 illustrates, in partially schematic form, the timing and tone equipment common to the link circuits.

Referring now more particularly to the drawings, the telephone lines and automatic switching equipment there illustrated may comprise, for example, a small exchange, commonly known as a community automatic exchange or C. A. X, which is designed to serve a suburban area of limited population and is geographically adjacent a larger city or town served by a central exchange. More specifically, the exchange is illustrated as being connected with a distant central automatic exchange **35** by means of a group of trunks including the trunk **36**. This trunk is terminated in the C. A. X exchange in a repeater **30**. The subscriber substations served by the automatic switching apparatus illustrated may be arranged for three different classes of service. For example, the line **9**, which extends only to the substation A and terminates in the exchange in a line circuit **10**, may be arranged for unlimited central exchange trunk service, and also for local calls of unlimited duration. The other illustrated subscriber line **16**, which terminates in the exchange in the line circuit **20**, is of the multiparty type, this line being arranged to serve the two substations B and C. These two substations may be arranged for either semi-restricted or fully restricted service. For example, the substations B and C may be arranged so that central office trunk calls over the restricted trunks are prohibited, but local connections established through the automatic switching equipment of the C. A. X may be held for unlimited periods. Alternatively, the subscribers at the substations B and C may be prohibited both from routing calls over the restricted central office trunks, and also from holding local call connections for unlimited periods. The particular type of service provided for the various substations is determined by the wiring arrangement of the line circuits individual to the lines with which the substations are associated. More specifically, if all of the substations associated with a particular line are to be denied central office trunk service, the line circuit terminating this line is provided with an E. C. marking path extending to the finder E. C. contact bank and having resistance battery potential applied thereto through the winding of one of the relays provided in the restricted service and time blocking relay network **25**. If the subscribers served by the line **16** are not to be restricted as to the duration of local call connections, the E. C. marking path just mentioned is arranged to have ground pulses intermittently applied thereto through operation of the relays in the relay network **25**.

The subscriber lines terminating at the exchange may be of several different types. For example, the line **9** and the substation equipment connected to this line may be arranged for either simplex or loop circuit control of the automatic switching equipment, and may be either an extremely long line or a relatively short line. Further, the substation apparatus provided at the substation A may be of the conventional common battery type or of the conventional local battery type. Similarly, the line **16** may be of the full metallic type employing two line conductors, or may be of the ground return type utilizing a conductor as one side of the line and ground as the return side of the line. In the illustrated arrangement, the line **9** is shown as being of the full metallic type, and the line **16** as being of the ground return type. In order to adapt the automatic switching equipment for control over the lines of different types, different wiring arrangements are utilized in the line circuits, the particular type of wiring of each circuit being determined by the particular character of the associated line. These line circuits are substantially conventional insofar as the relay equipment embodied therein is concerned. Thus, the line circuit **10** comprises the usual line, cut-off and lockout relays indicated at R**130**, R**120** and R**110**, respectively. Similarly, the line circuit **20** terminating the line **16** is provided with a line relay

R170, a cut-off relay R160, and a slow-to-operate lockout relay R150.

The automatic switching apparatus provided in the exchange for setting up connections between the various lines and trunks terminating thereat, comprises a plurality of finder-connector links each having a contact bank capacity of one hundred lines. The illustrated link is shown as comprising a finder switch 11 and a connector switch 40. For the purpose of assigning these links to the use of calling lines in a definite order, there is provided a distributor 22, preferably of the preselective type, which is arranged to initiate the operation of the finder portion of a preselected link to search for a calling line in response to the application of ground potential to the distributor start lead 17. Since the finder switch 11 and the distributor 22 may be of conventional construction and wiring arrangement, these switching units have been only schematically illustrated in the drawings. The connector switch 40 is illustrated in Figs. 3, 4, 5, 6 and 9 of the drawings as being of the well-known Strowger type, employing a Strowger switching mechanism having its contact field divided into four banks each including ten levels or rows of bank contacts. Preferably, the lowermost levels are reserved for the termination of subscriber lines, branch exchange trunks and one or more central exchange trunk lines extending to a toll operator switchboard in the distant central exchange. The uppermost levels of the connector switch are used to terminate the regular or restricted central exchange trunks over which the subscribers having unrestricted service may route connections to the central office subscribers without the intervention of a toll operator. For example, the tenth level of bank contacts in the connector switch 40 may be reserved for the termination of trunks of the last-mentioned group.

Referring now in greater detail to the connector switch 40, the Strowger switching mechanism of this switch comprises the above-mentioned contact field at which the conductors of the lines extending to the C. A. X are terminated; a set of wipers 660 to 663, inclusive, and the usual vertical and rotary magnets 408 and 409, respectively, which are operative in conjunction with their associated ratchet and pawl mechanisms, not shown, to impart vertical and rotary movement to the wiper carriage structure. This mechanism is also equipped with vertical off-normal springs 414, 415, 416 and 468, which perform various circuit control operations described with particularity hereinafter. The switching mechanism further comprises a release magnet 407 which, when energized, permits the wipers of the switch to be returned to vertical and rotary normal in the usual manner; and normal post springs 419 and 468', which are arranged to be moved off normal from the normal positions shown in the drawings in response to elevation of the wipers 660 to 663, inclusive, to one or more predetermined vertical off-normal positions and perform additional circuit control operations described with particularity hereinafter. The equipment for controlling the vertical, rotary and release magnets of the switching mechanism, and for performing the auxiliary control operations required incident to the setting up of the various types of connections referred to above, includes a pair of line relays R360 and R440 which are normally connected to be energized in series over the two talking conductors of the trunk 326 incoming to the connector switch 40. This equipment further comprises a slow-acting hold relay R370, a slow-acting hold slave relay R330, a reverting call relay R310, a slow-acting control relay R320, a link release relay R340, a switch-through relay R350 of the two-step type, a calling simplex relay R410, a battery reversing relay R420, a lock-pulse relay R430, a digit transfer relay R450, a pair of slow-acting pulse controlled relays R460 and R470, and a combined ringing and trunk-hunting control relay R480. Additional control relays embodied in the connector switch and shown in Figs. 5 and 6 of the drawings include a second digit transfer relay R510, a slow-to-operate, slow-to-release ring cut-off relay R520, a busy test relay R530, a ring pickup relay R540, a restricted service control relay R550, an alternating current ringing control relay R560, a pair of back-bridge relays R570 and R610, a called simplex relay R620, an idle test relay R630, a slow-to-operate conversation timing relay R640, and a slow-to-operate line-switching relay R650. Selection of the ringing code which is to be utilized in signaling over a called multiparty line is accomplished through the provision of a minor switch 45, which also functions as a conversation timing switch after the ringing period is ended and a talking circuit is established through the connector. This switch also functions to determine the side of a selected line over which ringing current is to be projected in signaling over a called multiparty line arranged for divided ringing. More specifically, this switch is of the eleven-point type and includes three wipers 1000, 1001, 1002, the usual operating and release magnets 1004 and 1007, respectively, and off-normal springs 1005 and 1006.

The inter-office trunks connecting the exchange illustrated with the distant automatic exchange 35 are of the two-way type arranged to handle calls routed in either direction thereover, and each thereof is terminated in the C. A. X in a two-way repeater. Thus, the trunk 36, which terminates in the repeater 30, has access to the links of the C. A. X over a link line 34 which terminates in a line circuit 31. Briefly described, the repeater 30 comprises a pair of line relays R720 and R850, a slow-acting hold-relay R820, a slow-to-release hold slave relay R830, and a group of control relays R840, R870 and R960, the first two of which are of the slow-to-operate type, and the last of which is of the slow-acting type. The relay equipment of the repeater further includes a battery reversing relay R710, a calling simplex relay R730, a slow-acting pulse controlled relay R740, an electro-polarized back-bridge relay R750, a line-switching relay R880, and three lock-pulse relays R760, R770 and R810 which are provided for impulse correcting purposes. The various enumerated relays are interconnected by control circuits which are described with particularity hereinafter.

The equipment common to the finder-connector links provided in the exchange includes the usual ringing current generator and a ringing interrupter for interrupting the alternating ringing current in accordance with the various ringing codes. The common equipment also includes tick-tone generating equipment 52, dial and busy-tone generators 60, a conversation timer 53 and a permanent timer 51. These four units may be of conventional arrangement and, accordingly, have been only schematically illustrated in the drawings. The control circuits for these units are, however, novel in character and, accordingly, the details thereof have been shown. More specifi-

cally, the control circuit for the permanent timer 51 and the tone generator 60 comprises a relay R910 which is so connected and arranged that a single control lead C496 is utilized for the purpose of initiating the operation of the timer 51 and for the purpose of transmitting timing pulses to the various links. Similarly, the control circuit for the tone generating equipment 52 and the conversation timer 53 comprises a slow-to-release start relay R920 and a pulsing relay R930, these relays being so connected and arranged that a single lead C679 is used for initiating the operation of these two units and for the purpose of transmitting timing pulses to the link circuits.

The equipment common to the links and line circuits further includes the restricted service and time blocking relay network 25. Briefly described, this network includes a pulrality of line relays R240, R250 and R260, which are individual to the lines with respect to which restricted service or time blocking is required, and a plurality of slow-acting relays R210, R220 and R230, which are common to the lines with respect to which such service restrictions are imposed.

Local Calls

Referring now more particularly to the operation of the apparatus to set up a local call connection between two of the substations terminating at the C. A. X, it may be assumed, for example, that a call intended for the substation C is initiated at the substation A. In order to initiate the call, the calling subscriber removes the receiver provided at the substation A from its supporting hook or cradle, thereby to complete a circuit for energizing the line relay R130 in the usual manner. The circuit over which this line relay is energized is different, depending upon the wiring arrangement utilized in the line circuit 10. Thus, if the substation equipment provided at the substation A is wired for simplex control of the automatic switching equipment provided in the exchange, the terminals 146 and 147 are connected together, and the terminals 144 and 145 are connected together. If the line 9 is of the loop or ground return type, or is of the simplex type and the loop resistance thereof is less than 3500 ohms, the relay R130 is equipped with windings each having a resistance of 200 ohms. If the line is of the simplex type and the loop resistance thereof exceeds 3500 ohms, the relay R130 is equipped with windings each having a resistance of 1200 ohms. When the above-described wiring arrangement is used, one branch of the operating circuit for the relay R130 extends from ground through the springs of the hook switch provided at the substation A by way of the positive line conductor 9b, the contacts 122, the strapped terminals 145 and 144, the lower winding of R130 and the strapped terminals 147 and 146 to battery. The other branch of this circuit extends from ground through the springs of the hook switch provided at the substation A by way of the negative line conductor 9a, the contacts 121 and the upper winding of R130 to battery. On the other hand, if the equipment provided at the substation A is arranged for loop control of the automatic switching apparatus provided in the community exchange, the terminals 143 and 144 are strapped and the terminals 147 and 148 are strapped. With this wiring arrangement, the operating circuit for the line relay R130 may be traced as extending from ground by way of the strapped terminals 143 and 144, the lower winding of R130, the strapped terminals 147 and 148, the contacts 122, the conductor 9b, the bridge across the conductors 9b and 9a at the substation A, the conductor 9a, the contacts 121 and the upper winding of R130 to battery. In order more completely to describe the different wiring arrangements of the line circuits, it is pointed out that if the line 16 is of the simplex type or is a relatively short ground return line, the line circuit 20 is wired in the manner described above with reference to the line circuit 10 in considering simplex control of the line relay R130. More specifically, in this case the terminals 180 and 181 are strapped, the terminals 190 and 191 are strapped, and the terminals 186 and 187 are strapped. On the other hand, if the substations served by the line 16 are arranged for loop circuit control of the automatic switching equipment, the terminals 180 and 181 are strapped, the terminals 184 and 185 are strapped, and the terminals 188 and 189 are strapped. As a further alternative, if the line 16 is of the ground return type, a wiring arrangement is utilized which comprises the strapping of the terminals 189 and 182, 183 and 185, 186 and 187, and 190 and 191, respectively. With this wiring arrangement, the relay R170 is energized over a circuit including the grounded conductor 16a, the contacts 161 and the two windings of R170 in series when a call is initiated at one of the substations B and C.

Continuing now with the operation of the line circuit 10, when the line relay R130 is energized over any one of the circuits traced above, it operates to complete, at its contacts 131, an obvious circuit for impressing ground potential upon the private conductor 9c, thereby to mark the line 9 as busy in the bank contacts of the connector switches. At its contacts 132, the relay R130 opens the circuit for energizing the cut-off relay R120 when the line 9 is seized through the connector end of one of the links. At its contacts 133, the relay R130 completes a path including the winding of the relay R120 and the contacts 112 for impressing negative battery potential upon the marking conductor 9d, thereby to identify the line 9 as a calling line in the bank contacts of the finder switches having access thereto. At its contacts 134, the relay R130 completes a path including the contacts 114 for impressing ground potential upon the distributor start lead 17. When this lead is grounded, the control equipment of the distributor 22 operates in a well-known manner to cause the finder portion of a previously assigned link to seize the calling line 9. Assuming that the link illustrated, namely, that comprising the finder switch 11 and the connector switch 40, has previously been selected for use by the distributor 22, the wipers of the finder switch 11 are first elevated to a position opposite the level of contacts terminating the line 9 and are then rotated to engage the contacts terminating the conductors 9a, 9b and 9d. When the line 9 is found in this manner by the finder switch 11, the control equipment of the finder switch operates to extend the calling circuit through to the connector portion of the link and to connect the marking lead 9d to the control conductor 326c of the trunk 326 incoming to the connector switch 40. In response to this cut-through operation of the finder switch 11, both of the line relays R360 and R440 are energized. Assuming that the line 9 is arranged for loop circuit control of the automatic switching equipment, the relays R440 and R360 are energized in series over a circuit which extends from ground

by way of the winding of R440, the contacts 413 and 423, the repeating coil winding 403, C65, the contacts 354 and 312, the trunk conductor 326b, the positive line wiper of the finder switch 11, the conductor 9b, the bridge across the conductors of the line 9 at the substation A, the conductor 9a, the negative wiper of the finder switch 11, the conductor 326a, the contacts 311 and 352, C63, the repeating coil winding 401, the contacts 421, C64 and the winding of R360 to battery. When energized over this circuit, both of the line relays operate. In the event the line 9 is arranged for simplex control of the automatic switching equipment, the line relay R360 is initially energized over a circuit extending from ground at the substation A by way of the conductor 9a, the negative line wiper of the finder switch 11, the conductor 326a, the contacts 311 and 352, C63, the repeating coil winding 401, the contacts 421, C64 and the winding of R360 to battery. The other line relay R440 is energized in parallel with the positive side of the line 9 and in series with the lower winding of the line relay R130 over a circuit which extends from ground by way of the winding of R440, the contacts 413 and 423, the winding 403, C65, the contacts 354 and 312, the conductor 326b, the positive line wiper of the finder switch 11, the contacts 122, the strapped terminals 144 and 145, the lower winding of R130 and the strapped terminals 147 and 146 to battery. It will further be noted that in the event the calling line is of the ground return type, the relay R440 is energized in series with the lower winding of the line relay R130 over the circuit just traced.

The relay R440, in operating, closes its contacts 441 to prepare the operating circuit for the digit transfer relay R450. At its contacts 443, the relay R440 completes a locking circuit for itself which extends to battery through the resistor 418, the off-normal springs 417 and the winding of the release magnet 407. The resistance value of the resistor 418 is such that the release magnet 407 is insufficiently energized to operate when this circuit is completed. At its contacts 442, the relay R440 opens a point in one of the paths for short-circuiting its own winding. At its contacts 444, the relay R440 opens a point in the operating circuit for the calling simplex relay R410. The line relay R360, upon operating, closes its contacts 361 to complete a circuit for energizing the lock-pulse relay R430, this circuit extending from ground by way of the contacts 342, 325 and 361, C75 and the winding of R430 to battery. At its contacts 363, the relay R360 prepares a holding circuit for the hold relay R370. At its contacts 362, the relay R360 opens a point in a priming circuit for itself.

The lock-pulse relay R430, upon operating, locks to ground over a path including C75, the contacts 361, C91, the contacts 433 and the resistor 428. At its contacts 431, the relay R430 opens a point in the common portion of the circuits over which the vertical magnet 408, the rotary magnet 409, the operating magnet 1004 of the minor switch 45 and the relays R460 and R470 are energized during the transmission of impulses to the connector switch. At its contacts 432, the relay R430 completes a circuit for energizing the slow-acting hold relay R370, this circuit extending from ground by way of the contacts 342, C81, the contacts 432, C83 and the winding of R370 to battery.

The relay R370, upon operating, closes its contacts 371, to complete the operating circuit for the digit transfer relay R450, this circuit extending from ground by way of the contacts 342 and 371, C71, the contacts 441, the off-normal springs 468 and the winding of R450 to battery. At its contacts 371, the relay R370 also prepares the operating circuit for the line switching relay R650 and additional operating and locking circuits described more fully hereinafter. At its contacts 372, the relay R370 completes a path including the contacts 342 for impressing ground potential upon the release conductor 326c, thereby to prepare certain locking and operating circuits subsequently referred to in detail. When ground potential is applied to this conductor, a holding circuit is provided for the cut-through relay of the finder switch 11, the slow-acting control relay R320 is energized over an obvious circuit, and the cut-off relay R120 is energized over a circuit including this conductor, the test wiper of the finder switch and the contacts 133 and 112. At its contacts 373, the relay R370 further prepares the above-mentioned priming circuit for the line relay R360. At its contacts 374, the relay R370 prepares an operating circuit for the idle test relay R630. At its contacts 375, the relay R370 completes an obvious circuit for energizing the slow-acting hold slave relay R330. At its contacts 376, the relay R370 opens a point in a path traced hereinafter, over which ground potential may be impressed upon the positive line wiper 661 of the connector switching mechanism.

The digit transfer relay R450, upon operating, locks to ground over a path including the off-normal springs 468, the contacts 453, C71 and the contacts 371 and 342. At its contacts 454, the relay R450 prepares an alternative locking circuit for itself. At its contacts 451 and 458, the relay R450 prepares the above-mentioned circuit for energizing the vertical magnet 408 and the pulse controlled relay R470 in parallel. At its contacts 452, the relay R450 opens one of the alternative circuits for energizing the pulse controlled relay R470. At its contacts 455, the relay R450 opens a point in one of the operating circuits for the pulse controlled relay R460. At its contacts 457, the relay R450 prepares one of the operating circuits for the trunk-hunting relay R480. At its contacts 459, the relay R450 opens a point in the common portion of the operating circuits for the rotary magnet 409 and the operating magnet 1004 of the minor switch 45. At its contacts 457', the relay R450 prepares a circuit for energizing the calling simplex relay R410. At its contacts 456', the relay R450 opens a point in the circuit for transmitting busy and tick-tone currents over the calling end of the connection. At its contacts 459', the relay R450 completes a circuit for transmitting dial tone current over the calling end of the connection. The circuit traversed by the dial tone current may partially be traced as extending from the ungrounded terminal of the dial tone generator by way of C468, the contacts 459', the condenser 445, the contacts 467, C92 and the repeating coil winding 402. This current is, by induction, repeated through the windings of the repeating coil to the calling circuit and is reproduced by the receiver provided at the calling substation to indicate that the dialing operation may be started.

The hold slave relay R330, upon operating, completes a multiple path for impressing ground potential upon the release conductor 326c, this path including the contacts 342, 316 and 335. At its contacts 334, the relay R330 opens a point

in the operating circuit for the reverting call relay R310. At its contacts 331, the relay R330 prepares the above-mentioned path for impressing ground potential upon the positive line wiper 661 of the connector switching mechanism. At its contacts 333, the relay R330 prepares a path for short-circuiting the conversation timing relay R640 and the lower winding of the link release relay R340, and prepares another operating circuit for the busy test relay R530. At its contacts 336, the relay R330 prepares a locking circuit for the link release relay R340. At its contacts 332, the relay R330 completes a circuit for energizing the upper winding of the link release relay R340 in series with the upper winding of the permanent timer start relay R910, this circuit extending from ground through the upper winding of R910 by way of the combined time pulse and start lead C496, the contacts 425, C69, the contacts 332 and the upper winding of R340 to battery. Due to the high resistance of the upper winding of the relay R910, the relay R340 does not operate when this circuit is completed. The relay R910, however, operates to complete an obvious path for grounding the permanent timer start lead 55, thereby to initiate the operation of the permanent timer 51 in the usual manner. At its contacts 913, the relay R910 completes an obvious path for grounding the start lead 56, whereby operation of the dial and busy tone generating equipment 60 is initiated.

The slow-acting control relay R320, upon operating, closes its contacts 322 to prepare the above-mentioned operating circuit for the reverting call relay R310. At its contacts 321, the relay R320 prepares one of the circuits for energizing the idle test relay R630. At its contacts 323, the relay R320 further prepares the previously mentioned priming circuit for the line relay R360, and completes a locking circuit for the hold relay R370. The last-mentioned circuit extends by way of the grounded hold conductor C81, the contacts 323, 355 and 363, and the winding of R370 to battery. At its contacts 324, the relay R320 opens a point in the common portion of the operating circuits for the release magnets 407 and 1007. At its contacts 325, the relay R320 interrupts the previously traced operating circuit for the lock-pulse relay R430. Following the operation of the relays R360, R440, R430, R450, R370, R330 and R320 in the manner just explained, no further operation of the link circuit equipment occurs until the dialing operation is started at the calling substation or the link is forcibly released under the control of the permanent timer 51.

When the cut-off relay R120 is energized, it locks to the grounded release conductor 326c over a path including the contacts 124 and the test wiper of the finder switch 11. At its contacts 125, the relay R120 completes an obvious circuit for energizing the slow-to-operate lockout relay R110. At its contacts 121 and 122, the relay R120 disconnects the windings of the line relay R130 from the conductors of the line 9, thereby to clear the line of the impedance represented by these windings. At its contacts 122, the relay R120 also interrupts the previously traced operating circuit for the line relay R440, assuming the line 9 to be of the simplex or ground return type. When the line relay R130 is thus deenergized, it restores to interrupt, at its contacts 131, the initially completed path for grounding the private conductor 9c of the line 9. At its contacts 132, the relay R130 completes an alternative path for impressing ground potential upon this private conductor, which path extends through the contacts 124 to the grounded test wiper of the finder switch 11. At its contacts 133, the relay R130 interrupts the operating circuit for the cut-off relay R120. At its contacts 134, the relay R130 disconnects the distributor start lead 17 from ground and opens a point in the locking circuit for the lockout relay R110.

In the event the line 9 is of the ground return or simplex type, a path including the make contacts 123 of the cut-off relay R120, and the break contacts 111 of the lockout relay R110, is provided for transmitting a control pulse over the positive talking conductor 9b and the positive side of the trunk 326. This control pulse is utilized to short-circuit the line relay R440. On the other hand, if the line 9 is arranged for loop control of the automatic switching equipment, this pulsing path, controlled by the cut-off and lockout relays individual to the line 9, is omitted from the line circuit 10. When the illustrated circuit wiring is provided, the short-circuiting path just mentioned is completed at the contacts 123 when the cut-off relay R120 operates. This path may be traced as extending from ground by way of the contacts 111 and 123, the positive wiper of the finder switch 11, the trunk conductor 326b, the contacts 312 and 354, C65, the winding 403, the contacts 423 and 413, and the winding of R440 back to ground. When thus short-circuited, the relay R440 is deenergized and restores. In releasing, the relay R440 opens its contacts 443 to interrupt its locking circuit as traced above, and opens its contacts 441 to interrupt the previously traced operating circuit for the digit transfer relay R450. At its contacts 444, the relay R440 completes the prepared operating circuit for the calling simplex relay R410, this circuit extending from ground by way of the contacts 457' and 444, the lower winding of R410 and the off-normal springs 414 to battery. When thus energized, the calling simplex relay R410 operates and locks to the grounded release conductor 326c over a path including its preliminary make contacts 412. At its contacts 413, the relay R410 interrupts a point in the common portion of the above-traced operating circuit and short-circuiting path for the relay R440. At its contacts 411, the relay R410 completes the second branch of the circuit for energizing the line relay R360 over the two sides of the line 911 in parallel, in the event this line is of the simplex type. More specifically, this second branch may be traced as extending from ground at the substation A by way of the line conductor 9b, the positive line wiper of the finder switch 11, the trunk conductor 326b, the contacts 312 and 354, C65, the winding 403, the contacts 423 and 411, C64 and the winding of R360 to battery. Thus, the resistance of the calling circuit over which the line relay R360 is energized is materially reduced in response to operation of the calling simplex relay R410.

Shortly following the operation of the calling simplex relay R410 in the manner pointed out above, the slow-to-operate lockout relay R110 operates and opens its contacts 111 to interrupt the above-traced path short-circuiting the line relay R440. At its contacts 112, the relay R110 opens a further point in the operating circuit for the cut-off relay R120. At its contacts 113, the relay R110 prepares a locking circuit for itself. At its contacts 114, the relay R110 opens another point in the path for connecting the distributor start lead 17 to ground.

Upon receiving the dial tone signal in the manner pointed out above, the calling subscriber may proceed to dial the three digits of the directory number designating the desired substation C. The first two of these digits are utilized to direct the wipers of the connector switch 40 into engagement with the contacts terminating the conductors of the called line 16, and the third digit is utilized to direct the wipers of the code selecting and conversation timing switch 45 to the position corresponding to the code designating the desired substation C. The line relay R360 and the lock-pulse relay R430 follow the impulses of the three digits and function to repeat the impulses of the first digit to the vertical magnet 408 and the relay R470 in parallel over the above-mentioned pulsing circuit. More specifically, the relay R360, upon restoring at the beginning of each impulse, opens its contacts 361 to interrupt the previously traced locking circuit for the lock-pulse relay R430, causing the latter relay to restore. At its contacts 362, the relay R360 completes the previously mentioned priming circuit for itself, this circuit extending by way of the grounded hold lead C81, the contacts 323, 355, 362 and 373, the resistor 377, C67, the contacts 421, C64 and the winding of R360 to battery. This priming circuit is utilized to render the relay R360 exceedingly fast to operate when the calling loop, simplex or single wire circuit is recompleted at the calling substation at the end of the open-circuit period of the impulse. At its contacts 363, the relay R360 opens the locking circuit for the hold relay R370.

The lock-pulse relay R430, upon restoring at the beginning of each impulse, opens its contacts 432 to interrupt the operating circuit for the hold relay R370. Due to its slow-to-release characteristic, the last-mentioned relay remains operated during impulsing. At its contacts 433, the relay R430 opens another point in its locking circuit. At its contacts 431, the relay R430 completes the circuit for energizing the vertical magnet 408 and the pulse controlled relay R470, in parallel. This circuit extends by way of the grounded hold conductor C81, the contacts 323 and 355, C76 and the contacts 431 to the contacts 458 where it divides, one branch extending through the winding of the magnet 408 to battery, and the other branch of the circuit extending through the contacts 451 and the winding of R470 to battery. When first energized over this circuit, the relay R470 operates to complete, at its contacts 472, an alternative locking circuit for the relay R450, this alternative circuit extending by way of the grounded hold lead C81, the contacts 371, C71, the contacts 635, C495, the contacts 472 and 454, and the winding of R450 to battery. At its contacts 471', the relay R470 opens a point in one of the operating circuits for the relay R460. At its contacts 473, the relay R470 opens a point in the common portion of the operating circuits for the busy test relay R530 and the idle test relay R630. At its contacts 471, the relay R470 completes an obvious path for short-circuiting the winding 401 of the repeating coil, thereby to reduce the resistance of the pulsing circuit over which the line relay R360 is energized under the control of the calling device provided at the calling substation A. Due to its slow-to-release characteristic, the relay R470 remains operated during each digit and restores shortly after the digit is ended.

The vertical magnet 408, upon operating, elevates the wipers 660 to 663, inclusive, to the first vertical off-normal position and closes its contacts 408', to prepare an alternative operating circuit for the lock-pulse relay R430. In response to this movement of the switch wipers, the off-normal springs 414 are opened further to interrupt the operating circuit for the calling simplex relay R410, the off-normal springs 415 are closed to prepare or complete a path including the contacts 426 and 442 for short-circuiting the winding of the line relay R440, and the off-normal springs 468 are opened to interrupt the operating circuit and the initially completed holding circuit for the digit transfer relay R450. At the off-normal springs 417, the previously traced locking circuit for the line relay R440 is interrupted, causing this relay to restore, if operated. At the off-normal springs 416, the operating circuit for the release magnet 407 is prepared. In restoring, the relay R440 opens its contacts 443, further to interrupt its locking circuit, and closes its contacts 442 to complete the short-circuiting path described above. When this short-circuiting path is completed, the winding of the relay R440 is excluded from the calling loop circuit over which the other line relay R360 is energized, thereby to decrease the resistance of the circuit for energizing the latter relay. At its contacts 441, the relay R440 opens another point in the operating circuit for the digit transfer relay R450. At its contacts 444, the relay R440 reprepares the operating circuit for the calling simplex relay R410. From the above explanation it will be apparent that if the line 9 is arranged for loop circuit control of the automatic switching equipment, the line relay R440 is caused to restore and the winding of this relay is excluded from the calling loop circuit in response to the dialing of the first impulse of the first digit of the directory number designating the desired substation.

At the end of the open-circuit period of each impulse of the first digit, the line relay R360 reoperates to complete the above-mentioned alternative operating circuit for the lock-pulse relay R430, this circuit extending from ground by way of the contacts 403', C91, the contacts 361, C75 and the winding of R430 to battery. At its contacts 362, the relay R360 opens the above-described priming circuit for itself. At its contacts 363, the relay R360 recompletes the holding circuit for the hold relay R370. The lock-pulse relay R430, upon reoperating, opens its contacts 431 to deenergize the vertical magnet 408 and the pulse controlled relay R470, closes its contacts 432 to recomplete the operating circuit for the hold relay R370, and closes its contacts 433 to recomplete its own locking circuit. From the above explanation it will be understood that the line relay R360, the lock-pulse relay R430 and the vertical magnet 408 interact in the exact manner just described during each impulse of the first digit. It will further be understood that each time the vertical magnet 408 is energized, the wipers 660 to 663 are elevated one step. Accordingly, at the end of the first digit, these wipers are left standing opposite the level of bank contacts in which the conductors of the called line 16 are terminated.

During the inter-digit pause between the first and second digits, the line relay R360 and the lock-pulse relay R430 are held operated for a time interval in excess of the release period of the slow-acting pulse controlled relay R470. Accordingly, the relay R470 is caused to restore. In releasing, this relay opens its contacts 471 to interrupt the path short-circuiting the winding 401 of the repeating coil, and closes its contacts 471' to reprepare one of the operating circuits for the pulse controlled relay R460. At its con-

tacts 473, the relay R470 reprepares the operating circuits for the busy test relay R530 and the idle test relay R630. At its contacts 472, the relay R470 opens the above-traced alternative holding circuit for the digit transfer relay R450, causing the latter relay to restore.

In releasing, the relay R450 closes its contacts 452 to prepare an alternative operating circuit for the pulse controlled relay R470. At its contacts 451, the relay R450 opens another point in the initially completed operating circuit for the relay R470. At its contacts 453, the relay R450 opens another point in its initially completed holding circuit. At its contacts 454, the relay R450 opens another point in its alternative holding circuit as traced above. At its contacts 455, the relay R450 prepared one of the operating circuits for the pulse controlled relay R460. At its contacts 458, the relay R450 opens another point in the above-traced circuit for energizing the vertical magnet 408 and the relay R470 in parallel. At its contacts 459, the relay R450 prepares a circuit for energizing the relays R460 and R470 in parallel with the rotary magnet 409. At its contacts 457', the relay R450 opens another point in the incomplete operating circuit for the calling simplex relay R410. At its contacts 458', the relay R450 prepares the previously mentioned circuit for transmitting busy and tick-tone currents over the calling end of the connection. At its contacts 459', the relay R450 interrupts the previously traced circuit traversed by the dial tone signal current, thereby to terminate the dial tone signal being reproduced by the receiver provided at the calling substation A. Following the release of the relay R450, the link circuit equipment is conditioned to respond to the impulses of the second digit.

During the dialing of the second digit, the line relay R360 and the lock-pulse relay R430 cooperate to repeat the dial pulses to the relays R460 and R470, and the rotary magnet 409 in parallel. More specifically, the circuit over which current pulses are transmitted to these control elements extends by way of the grounded hold lead C81, the contacts 323 and 355, C76, the contacts 431 and 459, C494, the contacts 634, C670 and the contacts 532 and 517 to C493 where it divides, one branch extending through the winding of the magnet 409 to battery, and a second branch extending through the contacts 471' and the winding of R460 to battery. A third branch of this circuit extends from the conductor C670 by way of the contacts 531, C99, the contacts 452 and the winding of R470 to battery. When this circuit is initially completed at the beginning of the open-circuit period of the first impulse of the second digit, the relays R460 and R470 both operate. Upon operating, the relay R470 closes its contacts 471 to recomplete the path for short-circuiting the repeating coil winding 401, opens its contacts 471' to interrupt the initially completed operating circuit for the relay R460, and closes its contacts 472 to complete an alternative circuit for energizing the last-mentioned relay. This alternative circuit extends by way of the grounded hold conductor C81, the contacts 371, C71, the contacts 635, C495, the contacts 472 and 455, and the winding of R460 to battery. At its contacts 473, the relay R470 again opens a point in the operating circuits for the busy and idle test relays.

The relay R460, upon operating, closes its contacts 461 to complete a path for short-circuiting the winding of the digit transfer relay R510, this path extending by way of the grounded hold conductor C81, the contacts 371, C71, the contacts 635, C495, the contacts 472, 455 and 461, C491, the contacts 519', the winding of R510 and the contacts 529 to the grounded release conductor 326c. At its contacts 463, the relay R460 prepares a circuit for energizing the upper winding of the two-step switching-through relay R350. At its contacts 464, the relay R460 prepares the operating circuit for the busy test relay R530. At its contacts 465, the relay R460 opens a point in the holding circuit for the busy test relay R530. At its contacts 466, the relay R460 opens a point in the operating circuit for the idle test relay R630. At its contacts 467, the relay R460 opens a point in the path for transmitting signal currents over the calling end of the connection. Due to the slow-to-release characteristics thereof, the relays R470 and R460 remain operated throughout the second series of impulses transmitted to the link.

Each time the rotary magnet 409 is energized, it operates to rotate the wipers 660 to 663, inclusive, one step, and closes its contacts 409' to prepare an alternative operating circuit for the lock-pulse relay R430. This alternative circuit is completed in response to the reoperation of the line relay R360 at the end of the open-circuit period of each impulse. Specifically, this circuit extends from ground by way of the contacts 409', C91, the contacts 361, C75 and the winding of R430 to battery. Each time the lock-pulse relay R430 reoperates, it recompletes its holding circuit in the manner previously explained.

From the above explanation, it will be understood that in response to the impulses of the second digit, the wipers 660 to 663, inclusive, are rotated step by step until at the end of the digit they stand in engagement with the contacts terminating the conductors of the called line 16. During the inter-digit pause between the second and third digits, the line relay R360 and the lock-pulse relay R430 remain operated for an interval in excess of the combined release periods of the relays R470 and R460. Upon restoring, the relay R470 opens its contacts 472 to interrupt the locking circuit for the relay R460, and closes its contacts 471' to reprepare the operating circuit for the relay R460. At its contacts 473, the relay R470 reprepares the operating circuit for the busy test relay R530. At its contacts 472, the relay R470 also interrupts the above-traced path short-circuiting the winding of the digit transfer relay R510, permitting the last-mentioned relay to be energized in series with the relay R460 over a circuit which extends by way of the grounded release conductor 326c, the contacts 529, the winding of R510, the contacts 519', C491, the contacts 461 and the winding of R460 to battery. When thus energized, the relay R510 operates and locks up in a circuit including the grounded release conductor 326c, the contacts 512 and the resistor 519. After this locking circuit is completed, the relay R510 opens its contacts 519' to interrupt its operating circuit and thus deenergize the relay R460, causing the latter relay to restore. At its contacts 511, the relay R510 prepares the operating circuit for the ring pickup relay R540. At its contacts 514, the relay R510 opens a point in the common portion of the paths for short-circuiting the timing relay R640 and the lower winding of the link release relay R340. At its contacts 515, the relay R510 prepares an alternative circuit for energizing the

busy test relay R530, this circuit only being utilized in providing the restricted service facilities described more fully hereinafter. At its contacts 516, the relay R510 prepares the operating circuit for the restricted service relay R550. At its contacts 517, the relay R510 opens a point in the common portion of the above-traced branch circuits for energizing the relay R460 in parallel with the rotary magnet 409. At its contacts 518, the relay R510 prepares a circuit for transmitting impulses to the operating magnet 1004 of the code selecting and conversation timing switch 45. The release of the pulse controlled relay R460 in response to operation of the digit transfer relay R510 is without effect at this time.

The impulses of the third digit dialed at the calling substation are repeated by the line relay R360 and the lock-pulse relay R430 to the pulse controlled relay R470 and the operating magnet 1004 of the switch 45 in parallel. In this case, the pulsing circuit extends from the grounded hold conductor C81 by way of the contacts 323 and 355, C76, the contacts 431 and 459, C494 and the contacts 634 to C670 where it divides, one branch extending by way of the contacts 531, C99, the contacts 452 and the winding of R470 to battery, and the other branch extending by way of the contacts 532 and 518, C671 and the winding of the magnet 1004 to battery. When thus energized at the beginning of the first impulse of the third digit, the relay R470 again completes the previously traced circuit for energizing the relay R460. The two relays R460 and R470 remain operated until shortly following the end of the digit. Each time the operating magnet 1004 is energized over the pulsing circuit just traced, it operates to step the wipers 1000, 1001 and 1002 one step, and closes its contacts 1003 to prepare another operating circuit for the lock-pulse relay R430. When the enumerated wipers of the switch 45 are moved off normal, the off-normal springs 1005 are disengaged to open a point in the operating circuit for the release magnet 407, and the off-normal springs 1006 are moved into engagement further to prepare the circuit for energizing the release magnet 1007. In the present case, the lock-pulse relay R430 is energized in response to each reoperation of the line relay R360 over a circuit which extends from ground by way of the contacts 1003, C91, the contacts 361, C75 and the winding of R430 to battery. This relay in reoperating, locks to ground through the contacts 433 and the resistor 428, and opens its contacts 431 to interrupt the pulsing circuit extending to the magnet 1004 and the relay R1070. Thus, the magnet 1004 is energized once in response to each impulse transmitted to the link over the calling line. Accordingly, the wipers of the switch 45 are, at the end of the digit, left in the off-normal position corresponding to the code designation of the desired substation.

Busy test

At the end of the third digit, the pulse controlled relays R470 and R460 restore in the order named. The operations which occur in response to the sequential release of these relays depend upon the idle or busy condition of the called line 16. In this regard it will be noted that if this line is idle, the line, cut-off and lockout relays of the line circuit 20 are at normal so that the private conductor 16c of the line 16 is marked with negative battery potential through the winding of the cut-off relay R160. On the other hand, if the line 16 is occupied with a call, the private conductor 16c is marked with ground potential over a path including the grounded test conductor 16d and the engaged make contacts 164 of the operated cut-off relay R160.

Assuming that the called line 16 is busy at the time it is selected in the manner explained above, the relay R470, upon restoring at the end of the third digit, completes the prepared operating circuit for the busy test relay R530. This circuit extends by way of the grounded private conductor 16c, the private wiper 663, C580, the wiper 1001, C80 or C681 and the contacts 637, depending upon the off-normal position occupied by the wipers of the switch 45, C80, the contacts 473 and 464, C584 and the upper winding of R530 to battery. When thus energized, the relay R530 operates and closes its contacts 537 to prepare a locking circuit for itself. At its contacts 531, the relay R530 opens another point in the operating circuit for the relay R470. At its contacts 532, the relay R530 opens a point in the common portion of the operating circuits for the rotary magnet 409 and the operating magnet 1004. Thus, following operation of the busy test relay R530, the magnets 408, 409 and 1004, and the relays R460 and R470 are prevented from responding to further operation of the calling device provided at the calling substation. At its contacts 533, the relay R530 opens the prepared operating circuit for the restricted service relay R550. At its contacts 534, the relay R530 further prepares the operating circuit for the trunk-hunting relay R480. At its contacts 535, the relay R530 opens a point in the operating circuit for the idle test relay R630. At its contacts 536, the relay R530 prepares a locking circuit for the switching-through relay R350 and a path for connecting the release conductor 326c to the test wiper 663. At its contacts 538, the relay R530 opens a point in another of the locking circuits for the switching-through relay R350. At its contacts 537', the relay R530 prepares the circuit for transmiting busy tone current over the calling end of the connection. At its contacts 538', the relay R530 opens a point in the circuits for transmitting ringing current and tick-tone current over the calling end of the connection. At its contacts 539', the relay R530 prepares an alternative locking circuit for the lock-pulse relay R430, which circuit is utilized only in the event further impulses are inadvertently dialed at the calling substation. Thus, if an additional digit is dialed at the calling substation after the three digits of the directory number designating the desired substation are dialed, the line relay R360, upon restoring at the beginning of the open-circuit period of each impulse, opens the locking circuit for the lock-pulse relay R430, causing the latter relay to restore. Thereafter, and when the line relay R360 reoperates, the lock-pulse relay R430 is energized over a circuit extending by way of the grounded conductor C81, the contacts 323 and 355, C76, the contacts 431 and 459, C494, the contacts 634, C670 the contacts 539', C91, the contacts 361 and C75 and the winding of R430 to battery. When thus energized, the relay R430 locks to ground through its make contacts 433 and the resistor 428, and then opens its contacts 431 to interrupt the alternative operating circuit just traced.

Shortly following the operation of the busy test relay R530 in the manner pointed out above, the slow-acting pulse controlled relay R460 re-

stores. At its contacts 465, the relay R460 completes the prepared locking circuit for the busy test relay R530, this circuit extending by way of the grounded release conductor 326c, the contacts 537, C585, the contacts 465, C584 and the upper winding of R530 to battery. At its contacts 467, the relay R460 completes the prepared circuit for transmitting busy tone current over the calling end of the connection. This circuit parallels that traversed by the dial tone current as traced above, but is derived from the busy tone current source over a path including the conductor C549, the contacts 537', C587 and the contacts 458'. The reproduction of this signal current by the receiver provided at the calling substation A serves to inform the calling subscriber that the desired line is busy. The manner in which the operated switching equipment is released when the call is abandoned at the called substation is described with particularity hereinafter.

Idle test

In the event the called line 16 is idle at the time it is selected, no circuit is provided for energizing the busy test relay R530 when the pulse-controlled relay R470 restores, the upper winding of the busy test relay being short-circuited in series with the winding of the cut-off relay R160 when the relay R470 restores. Shortly thereafter, and when the pulse-controlled relay R460 restores, a circuit is completed for energizing the lower winding of the idle test relay R630 in series with the cut-off relay R160, this circuit extending by way of the grounded hold conductor C81, the contacts 374, C82, the lower winding of R630, C673, the contacts 535, C583, the contacts 466 and 473, C80 alone or C80 and the contacts 637 and C681, the wiper 1001, C680, the test wiper 663, the private conductor 16c, the contacts 172 and the winding of R160 to battery. When thus energized, the relay R630 closes its preliminary make contacts 638' to complete a locking circuit for itself. This locking circuit extends by way of the grounded hold conductor, C81, the contacts 371, C71, the contacts 638', C89, the contacts 321, C70 and the upper winding of R630 to battery. At its contacts 635, the relay R630 opens another point in the previously traced operating circuit for the pulse-controlled relay R460. At its contacts 634, the relay R630 opens a point in the common portion of the previously traced operating circuits for the relays R460 and R470, the rotary magnet 409 and the operating magnet 1004 of the switch 45. At its contacts 633, the relay R630 opens a point in the operating circuit for the trunk-hunting relay R480. At its contacts 637, the relay R630 opens one of the above-traced branches of the series operating circuit for itself and the cut-off relay R160. At its contacts 631, the relay R630 prepares the operating circuit for the called simplex relay R620. At its contacts 632, the relay R630 completes the operating circuit for the slow-to-operate line-switching relay R650, this circuit extending by way of the grounded hold conductor C81, the contacts 371, C71, the contacts 632 and the winding of R650 to battery. At its contacts 638, the relay R630 completes a path for impressing ground potential directly upon the private conductor 16c of the called line 16, this path extending from ground as applied to the hold conductor C81 by way of the contacts 638 and the test wiper 663 to the conductor 16c. When this path is completed, the cut-off relay R160 provided in the line circuit 20 is fully energized and operates, and the called line 16 is marked against seizure by another of the connector switches. At its contacts 639, the relay R630 prepares a multiple locking circuit for the ring cut-off relay R520, and completes a multiple holding circuit for the hold slave relay R330. The latter circuit extends from ground by way of the contacts 639, C86 and the winding of R330 to battery. At its contacts 639', the relay R630 shunts the contacts 539' of the busy test relay R530, so that in the event any further impulses are dialed at the calling substation they are absorbed in the manner explained above.

At its contacts 636, the relay R630 prepares or completes one of the operating circuits for the trunk-hunting relay R480, depending upon the setting of the code-selecting and conversation timing switch 45. The last-mentioned relay, during the ringing period, serves to determine the side of a selected called line of the loop type over which ringing current is to be transmitted, and is selectively controlled in accordance with the odd or even character of the third digit dialed at the calling substation. Thus, if the ringer provided at a called substation is connected between the negative side of the associated line and ground, a third digit comprising an even number of impulses is dialed at the calling substation. In this case, the operating circuit for the relay R480 is completed in response to operation of the idle test relay R630, this circuit extending by way of the grounded hold conductor C81, the contacts 638, C680, the wiper 1001 bridging even-numbered contacts of its associated contact bank, C681, the contacts 636, C581, the upper winding of R480, C498, the contacts 626, C499, the lower winding of R480 and the contacts 474 to battery. It will be observed from the wiring arrangement of the contact bank associated with the wiper 1001, that if a ringing digit is dialed at the calling substation which comprises an odd number of impulses, the circuit just traced is not completed through the contact bank of the switch 45 and, accordingly, the trunk-hunting relay R480 remains in its restored position. With the relay R480 in its restored position, the ringing current transmission circuits are prepared at the contacts 482 and 483 for the transmission of ringing current over the positive side of the selected called line. With the relay R480 operated on the other hand, these circuits are opened at the contacts 482 and 483, and circuits are prepared at the contacts 431 and 434 for the transmission of ringing current over the negative side of the called line, all in the manner more fully explained hereinafter.

The line-switching relay R650, upon operating, closes its contacts 651 and 653 to prepare the ringing current transmission circuits, and opens its contacts 652 to interrupt the prepared or completed operating circuit for the called simplex relay R620. At its contacts 654, the relay R650 prepares a circuit for energizing the back-bridge relay R510 over the called end of an established connection. At its contacts 655, the relay R650 prepares a circuit for energizing the ring pickup relay R540 in accordance with the ground pulses conventionally applied to the pickup lead 658 by the ringing interrupter at the beginning of each code cycle. At its contacts 656, the relay R650 opens a point in the common portion of the operating and test circuits controlled over the E. C. wiper 662.

Classifying the called line

As indicated in the introductory portion of the specification, provisions are made in the line and link circuits for distinguishing between lines of the simplex and ground return type on the one hand, and lines of the loop type on the other hand, thereby to control the setting of the ringing control equipment and to select the type of ring cut-off to be utilized in terminating the transmission of ringing current over the associated line. In signaling over a loop line, either side of the line may be used for ringing current transmission, and the ringing control equipment is automatically conditioned to provide instantaneous ring cut-off. Moreover, the arrangement is such that the code-selecting and conversation timing switch 45 determines the code of the ringing current to be utilized in signaling over a called line and also determines, in accordance with the odd or even number of impulses transmitted thereto, the side of the line over which the ringing current is to be transmitted. In signaling over a simplex or ground return line, on the other hand, the ringing control equipment is controlled from the line circuit associated with the called line to restrict the transmission of ringing current to the negative side of the line, regardless of the setting of the code-selecting and conversation timing switch 45, and is also conditioned to provide silent period cut-off of the ringing current transmission. To this end the marking paths described above and controlled by the cut-off and lockout relays of the line circuits are utilized to control the setting of the called simplex relay R620 of the link illustrated, and the corresponding relays of the other links. Thus, in the case under consideration, wherein the called line 16 is of the ground return type, the cut-off relay R160 operates substantially concurrently with the idle test relay R630 and prior to the operation of the line-switching relay R650. Upon operating, the relay R160 completes the operating circuit for the called simplex relay R620, this circuit extending from ground by way of the contacts 151 and 163, the positive talking conductor 16b, the positive line wiper C61, the contacts 652 and 631, and the upper winding of R620 to battery. It will be understood that in the event the line 16 is of the loop type, the marking path including the contacts 151 and 163 is omitted from the line circuit 20, so that the relay R620 is not energized in response to the operation of the idle test relay R630 and the cut-off relay R160.

In operating, the called simplex relay R620 first locks to the grounded release conductor 326c over a path including its preliminary make contacts 625. At its contacts 626, the relay R620 opens a point in the above-traced operating circuit for the trunk-hunting relay R480. At its contacts 627, the relay R620 prepares the operating circuit for the alternating current ringing control relay R560. At its contacts 622, the relay R620 prepares a circuit for energizing the upper winding of the back-bridge relay R570 over one side of a called line of the loop type. At its contacts 624, the relay R620 opens a point in one of the operating circuits for the back-bridge relay R610. At its contacts 621, the relay R620 prepares a circuit for energizing the relay R570. At its contacts 623, the relay R620 opens a point in the common portion of the ringing current transmission circuits utilized in signaling over lines of the loop type.

Shortly following the operation of the relay R620, the line-switching relay R650 operates to open its contacts 652 and thus interrupt the operating circuit for the relay R620. This circuit is further opened at the contacts 151 of the slow-to-operate lock-out relay R150 when this relay operates in response to operation of the cut-off relay R160. More specifically, the relay R160, upon operating, closes its contacts 165 to complete an obvious circuit for energizing the lockout relay R150, closes its contacts 164 to connect the test lead 16d to the grounded private conductor 16c, and opens its contacts 161 and 162 to disconnect the windings of the line relay R170 from the talking conductors 16a and 16b of the line 16, thereby to clear the line of the shunt impedance represented by these windings.

Ringing the called substation—Grounded or simplex lines

Ringing current transmission over the selected called line 16 is initiated in response to operation of the ring pickup relay R540, which occurs following the operation of the line-switching relay R650. More specifically, when the ringing interrupter operates to impress a ground pulse upon the pickup lead 658 at the beginning of the code cycle next following operation of the line switching relay R650, the pickup relay R540 is energized over a circuit including this lead, the contacts 655, C596, the contacts 542 and 511, and the winding of R540 to battery. When thus energized, the relay R540 locks to ground over a path including the contacts 511 and 541, C71, the contacts 371 and the grounded hold conductor C81. After this locking circuit is completed, the relay R540 operates its contacts 542 to interrupt its operating circuit and disconnect the pickup lead 658 from ground. At its contacts 544, the relay R540 opens a point in the operating circuit for the battery reversing relay R420. At its contacts 543, the relay R540 prepares one of the operating circuits for the back-bridge relay R610. At its contacts 545, the relay R540 opens the path short-circuiting the winding of the alternating current relay R560. At its contacts 548, the relay R540 opens a point in the circuit over which tick-tone signal current may be impressed upon the calling end of the connection. At its contacts 547, the relay R540 prepares a path for transmitting ringing current over the calling end of the connection for the purpose of signaling the calling subscriber that the called substation is being rung. At its contacts 546, the relay R540 completes a circuit for energizing the alternating current ringing control relay R560 in accordance with the particular code of the ringing voltage impressed upon the selected code lead. Thus, if the wipers of the code-selecting and conversation timing switch 45 occupy their respective fourth off-normal positions, ringing current is transmitted through the winding of the relay R560 over a circuit which extends from the ungrounded terminal of the ringing current generator by way of the code 4 ringing current lead, the wiper 1000, C677, the resistor 549, the contacts 546, the winding of R560, C674, the contacts 627, 646 and 645, C687 and the wiper 1002 to the grounded terminal of the ringing current source. It will be noted that if the wipers of the switch 45 occupy their ninth or tenth off-normal positions, the portion of this circuit extending from the contacts 627 to the grounded terminal of the ringing current generator is slightly different. Thus, if these wipers engage their respective as-

sociated ninth contacts, the circuit extends from the contacts 627 by way of the contacts 646, 645 and 644, C686, the wiper 1002, C683, the contacts 648' and C682 to the grounded terminal of the ringing current generator. If the wipers of the switch 45 engage their respective associated tenth contacts, the indicated portion of the operating circuit for the relay R560 extends from the contacts 627 by way of the contacts 646, C685, the wiper 1002, C684, the contacts 649 and C682 to the grounded terminal of the ringing current generator. It will also be noted that a portion of the ringing current transmitted over the selected code lead is caused to traverse a circuit including the wiper 1000, C677, the resistor 549, the contacts 546, the condenser 579, the contacts 547 and 538', C587, the contacts 458', the condenser 445, the contacts 467, C92, and the repeating coil winding 402. The current traversing the last-mentioned circuit is, by induction, repeated to the calling end of the connection and is reproduced by the receiver provided at the calling substation to indicate that the called substation is being rung.

The ringing relay R560, upon operating, closes its contacts 561 to complete an obvious circuit for energizing the back-bridge relay R570. The relay R570 now operates and closes its contacts 573 to complete the prepared circuit for energizing the lower winding of the back-bridge relay R610, this circuit extending from ground by way of the contacts 573 and 543, C599 and the lower winding of R610 to battery. At its contacts 571, the relay R570 opens a point in the prepared operating circuit for the ring cut-off relay R520. At its contacts 572, the relay R570 completes the prepared circuit for transmitting ringing current over the negative side of the selected line 16 to energize the ringers bridged between this side of the line and ground. More specifically, the circuit traversed by the ringing current extends from the ungrounded terminal of the ringing current generator by way of the selected code lead, the wiper 1000, C677, the resistor 549, the contacts 546, 572 and 521, C588, the contacts 651, the wiper 660, the negative talking conductor 16a, and through the parallel connected ringers bridged between this conductor and ground to the grounded terminal of the ringing current generator. All of the ringers bridged between the negative side of the line 16 and ground operate when energized by the current traversing this circuit.

The relay R610, upon operating, closes its contacts 612 to prepare a drain circuit for discharging, at the end of the ringing period, the energy stored in the distributed capacitance of the line and in the ringing condensers connected in series with the station ringers. At its contacts 613 the relay R610 opens another point in the operating circuit for the ring cut-off relay R520. At its contacts 614, the relay R610 prepares the operating circuit for the restricted service relay R550. At its contacts 613', the relay R610 completes a path including the conductors C592 and C593 and the contacts 525 for short-circuiting its upper winding, thereby to render itself slow to release. At its contacts 615 the relay R610 connects the test conductor C80 to the test wiper 663, this operation being without effect at the present time. At its contacts 611, the relay R610 prepares a path for impressing ground potential upon the positive line wiper 661.

The three relays R560, R570 and R610 remain operated during the ringing interval. At the end of this interval the selected code lead is disconnected from the ungrounded terminal of the ringing generator by the ringing interrupter, so that the relays R560, R570 and R610 restore in the order named and in an obvious manner. Due to the short-circuited condition of the upper winding of the relay R610, a short interval occurs between the release of the relay R570 and the restoration of the relay R610. During this interval the above-mentioned resistance drain path is completed, this path extending from the negative talking conductor 16a by way of the wiper 660, the contacts 651, C588, the contacts 521 and 571, C589, the contacts 612, the resistor 609 and the contacts 639 to ground. The completion of this path permits the accumulated energy on the line 16 to be dissipated, before the relay R610 restores to reprepare the operating circuit for the ring cut-off relay R520. Thus the energy accumulated on the line 16 during the ringing interval is not discharged through the operating winding of the ring cut-off relay R520, and premature operation of this relay is positively precluded. It will be noted that the resistance drain path just described is interrupted at the contacts 612 in response to the release of the relay R610.

The relays R560, R570 and R610 operate and restore at the beginning and expiration of each additional ringing period in the exact manner just described.

The desired conversational circuit between the calling and called substations is completed at the beginning of the first silent or spacing interval following the answering of the call at the called substation. In this regard it will be noted that with the relays R570 and R610 operated, the operating circuit for the ring cut-off relay B520 is held open at the contacts 571 and 613. Accordingly, this relay cannot operate until the ringing period in progress is terminated. When, however, the two relays R570 and R610 restore after the call is answered at the called substation, the operating circuit for the relay R520 is completed, this circuit extending, in the case of a line of the grounded return type, from ground by way of the negative or metallic talking conductor of the line, the wiper 660, the contacts 651, C588, the contacts 521 and 571, C589, the contacts 613, C95, the contacts 482, C98, and the upper winding of R520 to battery. In the event the called line 16 is of the simplex type, a parallel branch of the circuit just traced extends from ground by way of the positive talking conductor of the line, the wiper 661, the contacts 653, C590, the contacts 523, C69, the contacts 483, C595, the contacts 621 and 613, C95, the contacts 482, C98 and the upper winding of R520 to battery. When its upper winding is energized over either or both of these circuits, the relay R520 closes its preliminary make contacts 527 to complete a locking circuit for itself, this circuit extending from ground by way of the contacts 375, C96, the contacts 527 and the lower winding of R520 to battery. After this locking circuit is completed, the relay R520 opens its contacts 521 and 523 to interrupt both branches of its operating circuit as traced above, and to open the above-traced ringing current transmission circuit, thus terminating the transmission of ringing current over the called line. At its contacts 525, the relay R520 opens a point in the above-traced path for short-circuiting the upper winding of the back-bridge relay R510. At its contacts 526, the relay R520 prepares a circuit for energizing the upper

winding of the relay R510 in series with the upper winding of the relay R570 and the two sides of a selected called line of the loop type. At its contacts 522 and 524, the relay R520 connects the wipers 660 and 661 to the line terminals of the repeating coil windings 402 and 404 and in so doing completes a circuit for energizing the upper winding of the back-bridge relay R570. In the event the called line is of the ground return type the last-mentioned circuit has only one branch, this branch extending from ground through the substation equipment provided at the called substation by way of the negative or metallic side of the called line, the wiper 660, the contacts 651, C586, the contacts 522, C92, the repeating coil winding 402, C93 and the upper winding of R570 to battery. In the event the called line is of the simplex type a parallel branch of the circuit just traced is also completed when the ring cut-off relay R520 operates, this branch extending from ground through the substation equipment at the called substation by way of the positive side of the called line, the wiper 661, the contacts 653, C590, the contacts 524, C97, the repeating coil winding 404, C94, the contacts 622, C93 and the upper winding of R570 to battery.

At its contacts 528, the relay R520 completes the operating circuit for the timing relay R640, this circuit being subsequently described with reference to the conversation timing facilities provided in the link. At its contacts 529, the relay R520 interrupts the established locking circuit for the digit transfer relay R510, causing the latter relay to restore. At its contacts 528', the relay R520 opens a point in the operating circuit for the release magnet 407. At its contacts 529', the relay R520 completes the prepared operating circuit for the release magnet 1007 of the code selecting and timing switch 45. This circuit extends from ground by way of the contacts 529', C676, the contacts 649', C90, the off-normal springs 1006 and the winding of the magnet 1007 to battery. When thus energized the magnet 1007 attracts its holding pawl in the usual manner, permitting the wipers 1000, 1001 and 1002 to be returned to normal. When these wipers are restored to normal, the off-normal springs 1006 are opened to deenergize the release magnet 1007, and the off-normal springs 1005 are closed, further to prepare the operating circuit for the release magnet 407.

The digit transfer relay R510, upon restoring, opens its contacts 516 further to interrupt the operating circuit for the restricted service relay R550, opens its contacts 515 further to interrupt an incomplete alternative operating circuit for the busy test relay R530, opens its contacts 512 further to interrupt its own locking circuit, closes its contacts 519' to reprepare its own operating circuit, closes its contacts 514 to complete the operating circuit for the timing relay R640, and opens its contacts 511 to interrupt the established holding circuit for the pickup relay R540. At its contacts 517, the relay R510 reprepares the operating circuit for the relay R460 and the rotary magnet 409. At its contacts 518, the relay R510 opens another point in the previously traced operating circuit for the operating magnet 1004 of the switch 45.

The back-bridge relay R570, upon operating, closes its contacts 573 to prepare the operating circuit for the battery reversing relay R420. At its contacts 571 and 572, the relay R570 rearranges the ringing current transmission and ring cut-off circuits, but without effect at this time. The relay R540, upon restoring, opens its contacts 543 further to interrupt the above-traced operating circuit for the back-bridge relay R610, and closes its contacts 542 to reprepare its own operating circuit. At its contacts 541, the relay R540 opens another point in its locking circuit as traced above. At its contacts 544, the relay R540 completes the prepared operating circuit for the battery reversing relay R420, this circuit extending from ground by way of the contacts 573 and 544, C582 and the winding of R420 to battery. At its contacts 545, the relay R540 reprepares the path for short-circuiting the winding of the alternating current relay R560. At its contacts 546, the relay R540 opens another point in the ringing current transmission circuits traced above. At its contacts 546 and 547, the relay R540 opens two points in the above-traced path for transmitting ringing current over the calling end of the connection, thus terminating the ringback tone signal. At its contacts 548, the relay R540 prepares the above-mentioned path for transmitting tick-tone signal current over the calling end of the connection.

The battery reversing relay R420, upon operating, opens its contacts 425 to interrupt the previously traced circuit for energizing the link release relay R340 and the timer start relay R910 in series. At its contacts 427, the relay R420 opens a point in the locking circuit for the link release relay R340, causing the latter relay to restore if operated. At its contacts 426, the relay R420 opens a point in the previously traced path for short-circuiting the winding of the line relay R440. When this path is opened the relay R440 is energized in series with the relay R360 and reoperates in the event the calling line is of the loop type. At its contacts 421 to 424, inclusive, the relay R420 reverses the direction of current flow over the calling circuit in the event the calling line is of the loop type. This current reversal is utilized for supervisory purposes in handling trunk calls of the character described hereinafter. If the calling line is of the simplex or ground return type, the operation of the contacts 421 to 424, inclusive, is without effect.

As indicated above, the link release relay R340 is deenergized and restores in response to the operation of the battery reversing relay R420. This relay, upon restoring, opens its contacts 343 to interrupt the connection between the time cut-off lead C344 and the hold conductor C81, and closes its contacts 342 to impress ground potential directly upon the hold conductor C81. At its contacts 341, the relay R340 opens a further point in its locking circuit as traced above.

Following the relay operations just described the desired conversational circuit between the calling and called substations is fully established. The calling end of this circuit comprises the two talking conductors 9a and 9b, the two trunk conductors 326a and 326b, the repeating coil windings 401 and 403, and the condenser 405. Assuming that the line 9 is of the loop type, talking battery is supplied to the transmitter provided at the calling substation A through the windings of the line relays R360 and R440. In the event the line 9 is of the simplex type, talking battery may be supplied to the transmitter provided at the substation A over the two sides of the line in parallel or may be furnished locally at the substation. The called end of the voice current transmission circuit includes the line

conductors 16a and 16b, the condenser 192, the ground return side of the line, the trunk conductors C588 and C590, C92 and C97, the repeating coil windings 402 and 404, and the condenser 406. Current for energizing the transmitter provided at the called substation C may be supplied through the upper winding of the back-bridge relay R570 or locally at the substation C as required.

Ringing the called substations—Loop lines

As pointed out above, if a selected called line is of the loop type, the transmission of ringing current over the called line to signal the desired substation is accomplished in a manner slightly different from that just described. In this regard it will be recalled that when a line of the loop type is selected, the called simplex relay is not energized. Accordingly, the operating circuit for the alternating current relay R560 is held open at the contacts 627 during the ringing period. With the relay R620 in its restored position, the pickup relay R540, upon operating, transmits ringing current directly to the selected side of the called line. In this regard it will be recalled that if the ringer provided at the desired substation is connected between the negative side of the called line and ground, a ringing digit is dialed at the calling substation which comprises an even number of impulses, so that the trunk hunting relay R480 is operated during the ringing period. With this relay operated, the ringing current transmission circuit may be traced as extending from one of the even-numbered code leads by way of the wiper 1000, C677, the resistor 549, the contacts 546, C591, the contacts 623, C595, the contacts 481, C95, the contacts 613, C589, the contacts 571 and 521 C588, the contacts 651 and the wiper 660 to the negative side of the called line. After traversing the negative talking conductor of the called line, the ringing current traverses the windings of the ringer provided at the called substation and follows the ground return path to the grounded terminal of the ringing current generator. From the preceding explanation it will be recalled that if the ringer provided at the called substation is connected between the positive side of the associated line and ground, the ringing digit dialed at the calling substation will necessarily comprise an odd number of impulses, such that the operating circuit for the trunk hunting relay R480 is not completed through the contact bank associated with the wiper 1001. Accordingly, the relay R480 remains in its restored position. With this relay deenergized the ringing current transmission circuit may be traced as extending from an odd-numbered code lead by way of the wiper 1000, C677, the resistor 549, the contacts 546, C591, the contacts 623, C595, the contacts 583, C96, the contacts 523 C590, the contacts 653 and the wiper 661 to the positive side of the called line. After traversing the positive talking conductor of the called line, the ringing current is transmitted through the windings of the ringer provided at the called substation and follows the ground return path to the grounded terminal of the ringing current generator.

In the event the ringer provided at the desired substation is bridged across the two conductors of the associated line, the ringing current may traverse the loop circuit including the two metallic sides of the line in either of two directions, depending upon the setting of the trunk hunting relay R480. If this relay is operated during the ringing period the ringing current is transmitted to the negative talking conductor of the called line over the circuit traced above, and is returned to the grounded terminal of the generator over a path including the positive talking conductor of the called line, the wiper 661, the contacts 653, C590, the contacts 523, C96, the contacts 484, C98, the upper winding of R520 and the exchange battery. On the other hand if the trunk hunting relay R480 occupies its restored position during the ringing period, such that ringing current is projected over the positive side of the called line, the return path extending to the grounded terminal of the ringing current generator extends by way of the negative talking conductor of the called line, the wiper 660, the contacts 651, C588, the contacts 521 and 571, C589, the contacts 613, C95, the contacts 482, C98, the upper winding of R520 and the exchange battery.

It will be understood that the ringing current projected over either side of a selected called line not only traverses the windings of the ringer provided at the called substation, but also the windings of the ringers provided at other substations and connected in parallel therewith. The coded character of the signals produced through operation of these ringers serves to indicate the particular substation which is being called.

When the call is answered at the called substation the upper winding of the ring cut-off relay R520 is instantly energized over one of two paths, depending upon the setting of the trunk hunting relay R480. If this relay is operated the circuit for energizing the ring cut-off relay R520 may be traced as extending from ground through the ringing current generator by way of the selected even-numbered code lead, the wiper 1000, C677, the resistor 549, the contacts 546, C591, the contacts 623, C595, the contacts 481, C95, the contacts 613, C589, the contacts 571 and 521, C588, the contacts 651, the wiper 660, the negative talking conductor of the called line, the bridge established across the talking conductors of the called line when the call is answered, the positive side of the called line, the wiper 661, the contacts 653, C590, the contacts 523, C96, the contacts 484, C98 and the upper winding of R520 to battery. In the event the trunk hunting relay R480 occupies its restored position at the time the call is answered, the operating circuit for the ring cut-off relay R520 may be traced as extending from ground through the ringing current generator by way of the selected odd-numbered code lead, the wiper 1000, C677, the resistor 549, the contacts 546, C591 the contacts 623, C595, the contacts 483, C96, the contacts 523, C590, the contacts 653, the wiper 661, the positive talking conductor of the called line, the bridge established across the talking conductors of the called line at the called substation, the negative talking conductor of the called line, the wiper 660, the contacts 651, C588, the contacts 521 and 571, C589, the contacts 613, C95, the contacts 482, C98 and the upper winding of R520 to battery.

When energized over either of these circuits the ring cut-off relay R520 operates to perform the functions described above, among which is the completion of the operating circuit for the back-bridge relay R570. In the present case wherein the called line is of the loop type, this operating circuit includes the upper winding of the back-bridge relay R610. More specifically,

this circuit extends from ground by way of the contacts 654, the upper winding of R610, C593, the contacts 526, C594, the contacts 624, C94, the repeating coil winding 404, C97, the contacts 524, C590, the contacts 653, the wiper 661, the positive talking conductor of the called line, the bridge established between the talking conductors of the called line at the called substation, the negative talking conductor of the called line, the wiper 660, the contacts 651, C588, the contacts 522, C92, the repeating coil winding 402, C93 and the upper winding of R570 to battery. Current for energizing the transmitter provided at the called substation is supplied over this circuit. When thus energized the two relays R570 and R610 both operate. The relay R570, upon operating, causes the operation of the battery reversing relay R420, followed by the release of the link release relay R340 in the exact manner described above. The operation of the back-bridge relay R610 is without effect. Following the operation of the relays R520, R570, R610, and R420, and the release of the relays R510, R540 and R340 in the manner previously explained, no further operation of the link circuit apparatus occurs until the connection is released at one or both of the calling and called substations.

Release

The normal release of the link circuit equipment is under the control of the calling subscriber at the substation A. Thus, if the connection is abandoned at the called substation C before it is released at the calling substation, the back-bridge relay R570 is deenergized and restores. If the called line is of the loop type the back-bridge relay R610 is also deenergized when the called party restores the receiver provided at the called substation to its supporting hook or cradle. The release of the relay R610 is without effect. The relay R570, upon restoring, opens its contacts 573 to interrupt the operating circuit for the battery reversing relay R420. The relay R420, upon restoring, reverses the direction of current flow over the calling end of the connection, assuming the calling line to be of the loop type, and recompletes the circuit for energizing the upper winding of the link release relay R340 in series with the upper winding of the timer start relay R910. Thus, the link release relay R340 is again conditioned to be controlled by the permanent timer 51.

When the connection is released at the calling end thereof the line relay R360 is deenergized and restores. If operated, the relay R440 is also deenergized when the receiver provided at the calling substation is restored to its supporting hook or cradle. The release of the relay R440 is without effect. The relay R360, upon restoring, opens its contacts 361 to interrupt the holding circuit for the lockpulse relay R430, and opens its contacts 363 to interrupt the holding circuit for the hold relay R370. The relay R430, upon restoring, opens its contacts 432 to interrupt the operating circuit for the hold relay R370 and thus cause the release of the latter relay. The relay R370, upon restoring, opens its contacts 372 to interrupt one of the paths over which ground potential is impressed upon the release conductor 326c. At its contacts 371 the relay R370 opens the locking circuit for the idle test relay R630, and the operating circuit for the line switching relay R650, causing both of these relays to restore. At its contacts 375, the relay R370 interrupts the operating circuit for the hold slave relay R330 and one of the holding circuits for the ring cut-off relay R520.

The relay R630, upon restoring, opens its contacts 639 to interrupt the holding circuits for the hold slave relay R330 and the ring cut-off relay R520. At its contacts 638, the relay R630 disconnects the test wiper 663 from ground, thereby to initiate the release of the line circuit 20 in the manner described hereinafter. The relay R330, in releasing, opens its contacts 332 and 336 to interrupt the operating and locking circuits for the link release relay R340. At its contacts 335, the relay R320 disconnects the release conductor 325c from ground. When this conductor is disconnected from ground the operated ones of the four relays R320, R410, R460 and R620 are deenergized and restore. The relays R330, upon restoring, also completes the prepared operating circuit for the release magnet 1007, this circuit extending from ground by way of the contacts 324 and 359, C90, the off-normal springs 1006 and the winding of the magnet 1007 to battery. When thus energized the magnet 1007 attracts its holding pawl, permitting the wipers 1000, 1001 and 1002 to be returned to normal. During the release of the switch 45, the off-normal springs 1006 are disengaged to deenergize the release magnet 1007, and the off-normal springs 1005 are moved into engagement to complete the prepared operating circuit for the release magnet 407. The last-mentioned circuit extends from the grounded conductor C90 by way of the off-normal springs 1005, C678, the contacts 528', C586, the off-normal springs 416 and the winding of the release magnet 407 to battery. When thus energized the magnet 407 attracts its holding pawl, permitting the wipers 660 to 663, inclusive, to be returned to rotary and vertical normal in the usual manner. When these wipers are restored to normal the off-normal springs 416 are disengaged to deenergize the release magnet 407 and the off-normal springs 417 are moved into engagement to reprepare the holding circuit for the line relay R440. In addition, the off-normal springs 414 and 468 are respectively moved into engagement and the off-normal springs 415 are disengaged, whereby the control circuits for the calling simplex relay R410, the line relay R440 and the digit transfer relay R450, are all restored to normal. Following the operations just described the connector portion of the link is fully released.

When ground potential is removed from the test wiper 663 the cut-off and lockout relays R160 and R150 of the line circuit 20 are deenergized and sequentially restore in an obvious manner. The substitution of negative battery potential, as derived through the winding of the cut-off relay R160 for ground potential on the private conductor 16c, serves to identify the line 16 as idle in the bank contacts of the connector switches.

When the release conductor 326c is disconnected from ground in the manner just described, the finder switch 11 is released in a manner well understood in the art, and the link illustrated is marked as idle in the link selecting circuits of the distributor 22. The removal of ground potential from the release conductor 326c also results in the deenergization and sequential release of the cut-off and lockout relays R120 and R110, respectively. When these relays restore the line circuit 10 is fully released and negative battery potential is impressed upon the private conductor 9c of the line 9, thereby to mark this line as idle

in the bank contacts of the connector switches.

In the event the connection is released at the calling substation A prior to its release at the called substation C, the line circuit 10, the finder switch 11 and the connector switch 40 are restored to normal in the exact manner described above. It is noted, however, that in such case the back-bridge relays R570 and R610 are deenergized and restore to cause the release of the battery reversing relay R420, in response to the release of the line switching relay R650. It is further noted that when the cut-off relay R160 restores in response to the removal of ground potential from the private conductor 16c, the windings of the line relay R170 are again connected to the conductors of the line 16. Since a calling condition still persists on this line, the line relay R170 operates to complete the prepared locking circuit for the lockout relay R150, this circuit extending from ground by way of the contacts 174 and 153, and the winding of R150 to battery. Thus the line relay R170 and the lockout relay R150 are held operated until the called subscriber restores the receiver provided at the called substation to its supporting hook or cradle, to terminate the calling condition present on the line 16. With these two relays operated, ground potential is impressed upon the private conductor 16c to guard the line 16 against seizure, and the path for impressing ground potential upon the distributor start lead 17 is held open at the contacts 154. Obviously, the line relay R170 and the lockout relay R150 are deenergized in sequence when the call is abandoned at the called substation C.

The manner in which the link comprising the finder switch 11 and the connector switch 40 is released, following selection of a busy called line, is substantially similar to the release of the link as described above. In this regard it will be recalled from the preceding explanation that following the selection of a busy called line the relays R360, R330, R320, R370, R430, R510, R530, and possibly the relays R340, R410 and R440, are operated in the connector switch 40 following the selection of a busy called line. When the connection is cleared out at the calling substation the relays R360, R440 if operated, R430, R370, R330, R340 and R320 are released in sequence and in the exact manner described above. The relays R330 and R370, upon restoring, disconnect the release conductor 326c from ground, thereby to cause the release of the finder switch 11 and the line circuit 10 in the manner explained above. The relay R320, upon restoring, also completes the operating circuit for the release magnet 1007, whereby the code selecting and conversation timing switch 45 and the Strowger switching mechanism of the switch 40 are sequentially restored to normal. The digit transfer relay R510 and the busy test relay R530 are deenergized and restore when the release conductor 326c is disconnected from ground. Thus the link circuit equipment is fully restored to normal.

Conversation timing

As indicated above, the slow-to-operate timing relay R640 functions to time local call connections resulting from calls originating at fully restricted substations. In the event the link illustrated is seized over a calling line serving substations of this character, and the desired called line is idle, the ring cut-off relay R520 operates in the manner explained above to terminate the transmission of ringing current over the called line when the call is answered. This relay, in operating, opens its contacts 529 to interrupt the locking circuit for the digit transfer relay R510, causing the latter relay to restore. At its contacts 528 the relay R520 completes the operating circuit for the timing relay R640. This circuit extends from ground by way of the winding of R640, C598, the contacts 528, C72 and the resistor 345 to battery. In operating, the relay R640 opens its contacts 641 to interrupt one of the parallel branches of the circuit for energizing the control relay R320. At its contacts 642, the relay R640 prepares a circuit for transmitting timed impulses to the operating magnet 1004 of the switch 45. At its contacts 643 and 647', the relay R640 further prepares the previously mentioned circuit for transmitting tick-tone current over the connection. At its contacts 644, 645, 649 and 648', the relay R640 opens points in the previously traced ground return paths utilized for ringing current transmission during the ringing period. At its contacts 646, the relay R640 also opens a point in the previously traced operating circuit for the ringing control relay R560. At its contacts 647 and 648, the relay R640 prepares one of the operating circuits for the reverting-call relay R310. At its contacts 649', the relay R640 opens a point in the operating circuit for the release magnet 1007, as traced above.

Following the operation of the relay R640 at the start of the conversation period, the pulsing relay R930 responds to operation of the conversation timer 53, to transmit timed ground pulses over a path including the contacts 931, C679, the contacts 642 and C671, to the operating magnet 1004 of the switch 45, causing this switch to operate as a time measuring device. At the expiration of a predetermined time interval the wipers of this switch are advanced to the ninth off-normal position, wherein the previously mentioned circuit is completed for impressing tick-tone signal voltage upon the established connection. This circuit may partially be traced as extending from the high potential terminal of the tick-tone signal current source by way of the conductor C657, the contacts 643, C686, the wiper 1002 bridging its associated ninth contacts, C683, the contacts 647', C675, the contacts 548 and 538', C587, the contacts 458', the condenser 445, the contacts 467 and C92 to the negative side of the circuit extending to the called substation. From this point the tick-tone signal current is transmitted directly through the receiver provided at the called substation and is by induction repeated through the repeating coil of the connector to the calling end of the connection, to be reproduced by the receiver provided at the calling substation. The reproduction of this signal current by the receivers at the calling and called substations serves to inform the parties conversing over the established connection that the connection will shortly be released.

In the event the connection is immediately cleared out at the calling substation, the link circuit equipment is released in the exact manner described above, it being noted that the timing relay R640 is deenergized and restores in response to the release of the ring cut-off relay R520. On the other hand, if the connection is held from the calling substation for a substantial time interval after the tick-tone signal is received, the wipers of the switch 45 are advanced to the tenth off-normal position, wherein the prepared operating circuit for the reverting-call relay R310 is completed. This circuit extends by way of the

grounded hold conductor C81, the contacts 648, C684, the wiper 1002 bridging its associated tenth contacts, C685, the contacts 647, C85 and the winding of R310 to battery. Upon operating, the relay R310 opens its contacts 311 and 312 to interrupt the operating circuit for the line relays R360 and R440. At its contacts 315, the relay R310 opens the operating circuit for the control relay R320. At its contacts 316, the relay R310 opens one of the paths over which ground potential is impressed upon the release conductor 326c. At its contacts 317, the relay R310 locks to the grounded hold conductor C81 and completes a multiple locking circuit for the hold relay R370, this circuit including the grounded conductor C85 and the contacts 317, 355 and 363. At its contacts 313, the relay R310 completes an operating circuit for the called simplex relay R620 in the event the calling simplex relay R410 is operated. The resulting operation of the called simplex relay R620 is without effect at this time. At its contacts 318, the relay R310 completes one of the operating circuits for the idle test relay R630, but the resulting operation of the latter relay is also of no effect at this time.

The line relay R360, upon restoring, causes the release of the relay R430 in the manner previously explained. When these relays restore, the link circuit equipment is released in the exact manner explained above. The control relay R320, in restoring, completes the previously traced operating circuit for the release magnet 1007 and opens the locking circuits for the reverting call relay R310, the idle test relay R630 and the line switching relay R650. Thus, the relays R630, R650 and R330 are deenergized and release. During the release of this equipment, the called simplex relay R620 is deenergized and restores in response to the removal of ground potential from the release conductor 326c; the timing relay R640 is deenergized and restores in response to the release of the ring cut-off relay R520, and the reverting-call relay R310 is deenergized and restores in response to the release of the timing relay R340. During the release of the link circuit equipment, and when ground potential is removed from the release conductor 326c and the test wiper 663, the line circuits terminating the calling and called line assume their line lockout settings, wherein the line and lockout relays thereof are operated. This is accomplished in the manner explained above with reference to the operation of the line circuit 20 terminating the line 16. So long as these line circuits occupy their line lockout settings the respectively associated lines are guarded against seizure, and the start circuits extending to the distributor 22 are held open. These two line circuits are restored to normal when the call is abandoned at the calling and called substations, respectively.

In the event the link illustrated is seized over a calling line serving substations arranged for semi-restricted or non-restricted service, the operation of the conversation timing equipment is blocked so that a connection set up to a desired called line through the link may be held for a period of unlimited duration. Assuming that the calling line is connected to serve substations arranged for semi-restricted service, the E. C. contact of the contact set in each finder switch to which the conductors of the calling line extend, is connected to one of the line relays included in the restricted service and time blocking relay network 25. As explained hereinafter, the arrangement of this network is such that when one of the line relays included therein is operated, ground pulses are periodically transmitted over the E. C. marking path associated with the operated line relay under the control of one or more of the common relays R210, R220 and R230. The spacing interval between each pair of ground pulses thus transmitted is less than the time interval required for the wipers of the switch 45 to be operated to their tenth off-normal positions. These ground pulses are utilized to block the operation of the timing equipment. Thus, if the link illustrated is seized over a calling line having a marking path of the character just described associated therewith, periodic ground pulses are transmitted from the relay network 25 over the finder E. C. wiper and the E. C. conductor 326e of the trunk 326 after a connection is fully established through the link. Each time this conductor is connected to ground, the timing relay R640 is short-circuited over a path extending by way of the grounded conductor 326e, the contacts 314 and 333, C73, the contacts 514 and 528, C598 and the winding of R640 back to ground. When thus short-circuited, the relay R640 restores to complete at its contacts 649' the initially traced operating circuit for the release magnet 1007. This magnet, in operating, permits the wipers of the switch 45 to be returned to normal, at which time the off-normal springs 1006 are disengaged to deenergize the release magnet. Thus a second timing operation of the switch 45 is initiated. The timing operation of the switch 45 continues, but in each case the wipers of this switch are restored to normal under the control of the timing relay R640, before reaching the tenth off-normal position. Thus the timing equipment is rendered ineffective to release the link.

In the event the link is seized over a calling line serving substations arranged for non-restricted service, the timing relay R640 is short-circuited for the duration of the call, thus preventing any operation on the part of the code selecting and conversation timing switch 45. More specifically, the line circuits terminating lines of this type are each provided with a marking path which extends directly from ground to the E. C. contact of the contact set in each finder switch where the conductors of the associated line are terminated. With this wiring arrangement, ground potential is maintained upon the E. C. conductor 326e of the trunk 326 for the duration of a call routed through the link illustrated from a line of the non-restricted type. Thus, the timing relay R640 is short-circuited for the duration of the call and operation of the code selecting and conversation timing switch 45 is prevented.

Reverting Call

The arrangement of the connector switch 25 is such that in setting up reverting-call connections between substations served by the same lines the selective signaling of called substations is accomplished by directory number dialing. More particularly, if a call originating at the substation B is intended for another substation, such, for example, as the substation C also connected to the line 16, the calling subscriber, after initiating the call in the manner previously described, dials the directory number of the desired substation C. The first two digits of this directory number designate or identify the line 16, while the third digit is utilized to select ringing current of the particular code designating the called substation.

If the link illustrated is utilized in handling the call, the connector switch 40 thereof responds to the three digits of the directory number in the exact manner described above with reference to the call routed to the substation C from the calling substation A. In this case, since the line selected, namely the line 16, is marked as busy, due to the operated condition of the cut-off and lockout relays in the line circuit 20, the usual busy tone signal is transmitted to the calling substation B shortly following the end of the digit. Upon receiving the busy signal, the calling subscriber must hang up in order to initiate the ringing operation necessary to signal the called substation. In response to this release operation performed at the substation B, the calling circuit is interrupted to cause the release of one or both of the line relays R360 and R440. The relay R360, upon restoring, initiates the sequential release of the relays R430, R370 and R330, in the manner pointed out above. In this case, since the calling substation and the called substation are served by the same line, the test wiper 663 of the connector switch is connected to the private conductor 16c of the line 16. From this private conductor a connection extends through the contacts 172 and 164, and the test wiper of the finder switch 11 to the release conductor 326c of the trunk 326. The hold relay R370, upon restoring, completes an alternative path for impressing ground potential upon the connected private and release conductors 16c and 326c, respectively. This path extends by way of the grounded conductor C81, the contacts 376, C88, the closed make contacts 536 of the busy test relay R530, C583, the contacts 466 and 473 to the conductor C80. From this point the path may follow one of two branches, depending upon the setting of the switch 45. If the wipers of this switch stand in engagement with odd-numbered contacts in the associated contact banks, the path branches through the wiper 1001 and the bridged contacts engaged thereby to the conductor C680 which is now connected through the test wiper 663 to the private conductor 16c of the line 16. On the other hand, if the wipers of the switch 45 stand in engagement with even-numbered contacts of their associated contact banks, the path under consideration extends from the conductor C80 by way of the contacts 637, C681, the wiper 1001, C680 and the test wiper 663 to the private conductor 16c. The completion of this path serves to prevent the deenergization and release of the relays R160, R150, R320, R510 and R530, and the relays R410 and R480, if operated.

When the hold slave relay R330 restores shortly following the release of the hold relay R370, it opens its contacts 332 and 336 to interrupt the control circuits for the link release relay R340, causing the latter relay to restore, if operated. At its contacts 335, the relay R330 opens one of the initially completed paths for grounding the release of conductor 326c. At its contacts 334, the relay R330 completes the prepared operating circuit for the reverting-call relay R310, this circuit extending by way of the grounded release conductor 326c, the contacts 334 and 322, C87, the contacts 539, C85 and the winding of R310 to battery. The relay R310, in operating, opens its contacts 315 to interrupt one of the branches of the operating circuit for the relay R320. At its contacts 314, the relay R310 opens a point in the previously traced path for short-circuiting the timing relay R640 and a point in a path traced hereinafter for short-circuiting the lower winding of the link release relay R340. At its contacts 316, the relay R310 opens another point in one of the paths for connecting the release conductor 326c to ground. At its contacts 311 and 312, the relay R310 opens two additional points in the operating circuits for the line relays R360 and R440. At its contacts 317, the relay R310 completes a locking circuit for itself, this locking circuit extending by way of the grounded hold conductor C81, the contacts 323, 317 and the winding of R310 to battery. In completing this holding circuit, the relay R310 also completes a multiple path over which ground potential is impressed upon the connected release and private conductors 326c and 16c, respectively, this path extending from the grounded hold conductor C81 by way of the contacts 323 and 317, C85, the contacts 539, C87 and the contacts 322 and 334 to the release conductor 326c. At its contacts 313, the relay R310 completes an alternative circuit for energizing the called simplex relay R620, in the event the line 16 is of the simplex or ground return type. This circuit extends from the grounded release conductor 326c by way of the contacts 412, C68, the contacts 313, C61 and the lower winding of R620 to battery. It will be noted that this circuit is only completed if the calling simplex relay R410 is operated to identify the line 16 as a line of the simplex or ground return type. When energized over the circuit just traced, the called simplex relay R620 locks to the grounded release conductor 326c through its preliminary make contacts 625 and prepares the ringing current transmission circuits for the transmission of ringing current over the negative side of the line 16 in the manner explained above with reference to the call originated at the substation A. At its contacts 318, the relay R310 completes an alternative operating circuit for the idle test relay R630, this circuit extending by way of the grounded hold conductor C81, the contacts 318 and 321, C70, and the upper winding of R630 to battery. The idle test relay R630, upon operating, initiates the ringing operation in the exact manner described above; the particular code of the ringing current and the side of the line over which this current is projected being determined by the setting of the switch 45 and the position of the relay R480, in the event the line occupied with the call is of the loop type; and the code of the ringing current transmitted over the negative side of the line being determined by the setting of the switch 45, in the event the line is of the simplex or ground return type. In this regard it will be recalled that the pickup relay R540 operates to initiate the ringing operation in signaling over lines of the loop type, whereas the three relays R560, R570 and R610 cooperate to control the transmission of ringing current over lines of the simplex or ground return type.

When the call is answered at the called substation the operating circuit for the ring cut-off relay R520 is completed, in the manner previously explained. This relay, in operating, locks to ground over a path including its preliminary make contacts 527, C86 and the contacts 639; closes its contacts 528 to complete the previously traced operating circuit for the timing relay R640; and interrupts the locking circuit for the digit transfer relay R510. The relay R640, upon operating, opens its contacts 641 to interrupt the circuit for energizing the control relay R320. The relay R320 now restores. At its contacts 321, the relay R320 interrupts the above-traced alterna-

tive operating circuit for the idle test relay R630 and the operating circuit for the relay R650. At its contacts 323, the relay R320 interrupts the holding circuit for the relay R310 and the multiple path over which ground potential is impressed upon the release conductor 326c. At its contacts 324, the relay R320 completes the previously traced circuit for energizing the release magnets 1007 and 407 in sequence, whereby the code selecting and conversation timing switch 45 and the Strowger switching mechanism are successively released. The idle test relay R630, upon restoring, opens its contacts 639 to interrupt the operating and locking circuits for the relays R330 and R520, causing both of these relays to restore. When the wiper 1001 of the switch 45 is restored to normal, the above-traced path over which ground potential is impressed upon the private conductor 16c, and the release conductor 326c, is interrupted. The removal of ground potential from these two conductors results in the deenergization and release of the relays R160 and R530, and the relays R410 and R620 if operated. In addition, the finder switch 11 is caused to restore when ground potential is removed from the two indicated conductors. When the cut-off relay R160 restores, the line circuit 20 assumes its line lockout setting in the manner previously explained.

The busy test relay R530, upon restoring, opens its contacts 539 to deenergize the reverting-call relay R310. Thus the link is fully restored to normal.

Trunk Call—Two-Digit Trunk Selection on Switching-Through Levels

The connector switch 40 is arranged to have access to groups of trunks which may be selected in response to one-digit, two-digit or three-digit calling operations at the various substations. The trunks which are selected in response to two series of impulses transmitted to the connector switch are usually grouped in groups of less than ten, and the unused contact sets of the connector switch contact levels terminating such trunks may be utilized for subscriber line termination. For the purpose of providing automatic selection of idle trunks in these groups, each trunk of each group is terminated in the contact field of the connector switching mechanism in a set of contacts comprising the usual private contact and an extra control contact. These private and extra control contacts of each contact set, except that terminating the last trunk of the group, are arranged to be connected together in the repeaters terminating the respective associated trunks when the trunks are seized.

In order to select an idle trunk of a desired group arranged for two-digit selection, a calling subscriber, such, for example, as a subscriber at the substation A, dials a first digit which designates the level of contacts at which the trunks of the desired group are terminated, and a second digit which designates the first trunk of the group. The manner in which the control apparatus of the connector switch 40 responds to these two digits is exactly the same as described previously with reference to the local call originating at the substation A.

During the vertical movement of the wipers 660 to 663, inclusive, to a position opposite a level of contacts terminating the desired group of trunks, the normal post springs 419 are operated into engagement to complete a circuit for energizing the upper winding of R350, and the normal post springs 617 are moved into engagement to complete an obvious circuit for energizing the lower winding of the back-bridge relay R610. The circuit for energizing the switch-through relay R350 extends by way of the grounded release conductor 326c, the contacts 463, the normal post springs 419, C79 and the upper winding of R350 to battery. When thus energized the relay R350, which is of the two-step type, operates to close its preliminary make contacts 356 and 358 only. At these contacts a path is completed for short-circuiting the lower winding of the relay R350, this path extending from the grounded release conductor 326c by way of the contacts 463, the normal post springs 419, C79, the lower winding of R350, the contacts 356 and 358, C84 and the contacts 538 back to the grounded release conductor 326c. The relay R610, upon operating, closes its contacts 615 to prepare a trunk test circuit which extends from the test wiper 663 through the upper winding of the busy test relay R530. At its contacts 614, the relay R610 prepares a circuit for energizing the restricted service relay R550. The remaining circuit controlling operations performed by the back-bridge relay R610 are without effect at this time.

At the end of the second digit, the wipers 660 to 663, inclusive, are positioned in engagement with the contacts terminating the first trunk of the group. Shortly following the end of this digit, the relay R470 restores and closes its contacts 471' to prepare an alternative circuit for energizing the relay R460. At its contacts 473, the relay R470 completes the above-mentioned trunk test circuit. If the first trunk of the selected group is busy, ground potential is present upon the private contact thereof. Ground potential is also present upon the extra control contact thereof, due to the established connection between the private and extra control contacts individual to this trunk. With the private wiper 663 connected to ground, the trunk test circuit may be traced as extending from this wiper by way of the contacts 615, C80, the contacts 473 and 464, C584 and the upper winding of R530 to battery. When thus energized the relay R530 operates to complete a test circuit over which the trunk hunting relay R480 is energized, this test circuit extending by way of the grounded E. C. wiper 662, the contacts 656, C572, the contacts 534, C497, the contacts 487 and 462, the lower winding of R480 and the contacts 474 to battery. At its contacts 538, the relay R530 opens the above-traced path short-circuiting the lower winding of the switch-through relay R350. In operating, the relay R480 first closes its preliminary make contacts 488 to complete a locking circuit for itself which extends by way of the grounded release conductor 326c, the contacts 463, 488 and 462, the lower winding of R480 and the contacts 474 to battery. At its contacts 486, the relay R480 completes the prepared circuit for energizing the pulse-controlled relay R460, in parallel with the rotary magnet 409, this circuit extending by way of the grounded hold conductor C81, the contacts 371, C71, the contacts 633, C492 and the contacts 456 to the contacts 486 where it divides, one branch extending through the winding of the rotary magnet 409 to battery, and the other branch extending through the contacts 471' and the winding of R460 to battery. The current flow over this circuit serves to prevent the release of the slow-to-release pulse-controlled relay R460. When energized over the circuit just traced, the magnet 409 rotates the wip-

ers 660 to 663, inclusive, into engagement with the contacts terminating the conductors of the second trunk in the selected group, and opens its contacts 474 to interrupt the above-traced circuit for energizing the lower winding of the relay R480. The relay R480, upon restoring, opens its contacts 488 further to interrupt its locking circuit, reprepares its operating circuit at its contacts 487, and opens its contacts 486 to interrupt the above-traced circuit for energizing the relay R460 and rotary magnet 409 in parallel. In the event the second trunk is also busy, and is not the last trunk of the group, ground potential is maintained upon the E. C. and private wipers 662 and 663, respectively, so that the rotary magnet 409, upon restoring, recompletes the above-traced circuit for energizing the trunk hunting relay R480. This relay, upon operating again, completes the circuit for energizing the relay R460 in parallel with the rotary magnet 409, whereby the wipers 660 to 663 are rotated another step to engage the contacts terminating the conductors of the third trunk in the selected group.

The interrelated operation of the trunk hunting relay R480 and the rotary magnet 409 continues until an idle trunk is found, or until all of the trunks of the selected group have been tested and found to be busy. In this regard it will be recalled from the preceding explanation that the private and E. C. contacts of the contact set terminating the last trunk of the group, are not connected together. More specifically, the E. C. contact of this contact set is either left unwired or is connected to the negative terminal of the exchange battery through a resistance, depending upon the restricted or non-restricted character of the trunk. With either arrangement, the circuit for energizing the trunk hunting relay R480 is held open when the last trunk of the group is selected. Accordingly, the relay R480 does not reoperate to recomplete the circuit for energizing the relay R460 in parallel with the rotary magnet 409. Thus, the stepping operation of the wipers 660 to 663, inclusive, is terminated. Shortly following the selection of the last trunk of the group, the relay R460 restores. At its contacts 463, the relay R460 interrupts the above-traced circuit for energizing the upper winding of the switch-through relay R350, causing the latter relay to restore. At its contacts 465, the relay R460 completes the previously traced locking circuit for the busy test relay R530. At its contacts 467, the relay R460 completes the previously traced circuit for transmitting busy tone current over the calling end of the connection. The reproduction of this current by the receiver provided at the calling substation serves to inform the calling party that the desired connection cannot be obtained. The manner in which the connection is released when the call is abandoned at the calling substation is exactly the same as described previously.

Idle trunks of the selected group are identified by the presence of negative battery potential upon the private conductors thereof and the absence of ground potential from the E. C. conductors thereof. When the test wiper 663 is disconnected from ground in response to the selection of an idle trunk, the busy test relay R530 is deenergized and restores. In releasing this relay opens its contacts 534 further to interrupt the above-traced circuit for energizing the trunk hunting relay R480, and closes its contacts 538 to recomplete the above-traced path for short-circuiting the lower winding of the switch-through relay R350. At its contacts 533, the relay R530 prepares or completes the operating circuit for the restricted service relay R550, depending upon the character of the trunk selected. At its contacts 537', the relay R530 opens a point in the previously traced circuit for transmitting busy tone current over the calling end of the connection. At its contacts 537, the relay R530 opens a point in its locking circuit as traced above. Shortly following the release of the busy test relay R530, the pulse-controlled relay R460 restores. At its contacts 463, the relay R460 opens the above-traced path short-circuiting the lower winding of the switch-through relay R350, permitting the two windings of this relay to be energized in series over a circuit which extends by way of the grounded release conductor 326c, the contacts 538, C84, the contacts 358 and 356 and the two windings of R350 to battery. The switch-through relay R350 now completes its operation. At its contacts 357, the relay R350 completes a path for impressing ground potential upon the test wiper 663 and, incident thereto, the test conductor of the selected trunk, thereby to mark this trunk against seizure. This path extends by way of the grounded release conductor 326c, the contacts 538, C84, the contacts 358 and 357, C80 and the contacts 615 to the wiper 663. At its contacts 359, the relay R350 opens a point in the incomplete circuits for energizing the release magnets 1007 and 407. At its contacts 351 to 354, inclusive, the relay R350 switches the calling circuit through to the repeater associated with the selected trunk. Incident to this line switching operation, the relay R350 opens its contacts 352 and 354 to interrupt the previously traced circuits for energizing the line relays R360 and R440. At its contacts 355, the relay R350 interrupts the previously traced locking circuit for the hold relay R370 and a point in the previously traced pulsing circuits over which current pulses are transmitted to the magnets 408, 409 and 1004, and the relays R460 and R470.

Shortly following the operation of the switch-through relay R350, the line relay R360 restores. In releasing, this relay opens its contacts 361 to interrupt the locking circuit for the lock-pulse relay R430, whereby the relays R430, R370 and R330 are released in sequence. The relay R370, upon restoring, closes its contacts 376 to prepare or complete the previously mentioned path for impressing ground potential upon the positive line wiper 661, depending upon the position of the calling simplex relay R410, as determined by the character of the calling line. If the calling simplex relay R410 is operated, the path just mentioned is completed, this path extending by way of the grounded holding conductor C81, the contacts 376 and 331, C60, the contacts 411', C60', the contacts 531', C61' and the contacts 611 to the positive line wiper 661. It will be noted that this path is held open at the contacts 411' in the event the calling simplex relay R410 occupies its restored position, indicating that a loop line is calling. This path, if completed, is interrupted at the contacts 331 in response to the release of the hold slave relay R330. Thus it will be understood that the two relays R370 and R330 cooperate to transmit a ground pulse over the positive talking conductor of the selected trunk for the purpose of informing the repeater associated with this trunk as to the character of the calling line. The two hold relays R370 and R330, upon restoring, also disconnect the release conductor 326c

from ground in the connector switch 40. Prior to the release of these relays, however, the control equipment of the repeater associated with the seized trunk functions to connect the test wiper 663 to ground. This wiper is now connected over a path including the contacts 615, C80, the contacts 357 and 358, C84, and the contacts 538 to the release conductor 326c. Thus, the relays R320, R350, R510 and R610, and the relays R410 and R550, if operated, are prevented from releasing. These relays are held operated until the connection is released. It will be noted that with the switch-through relay R350 operated, an uninterrupted metallic circuit is established through the connector switch 40, over which dial pulses and supervisory pulses may be transmitted to the repeater associated with the seized trunk. The manner in which the connector switch 40 and the finder switch 11 are released under the control of the calling party is described with particularity hereinafter.

TRUNK CALL—ONE-DIGIT TRUNK SELECTION OF SWITCHING-THROUGH LEVELS

In order to provide for one-digit automatic trunk selection on switching-through levels, the normal post springs 419, 617 and 468' are arranged to operate in response to the elevation of the wipers 660 to 663, inclusive, to a position opposite a level of bank contacts terminating the trunk groups arranged for this type of selection. Preferably, the trunks arranged for one-digit selection are terminated in the uppermost levels of the connector contact bank, whereby the normal post springs 468' are only moved off normal when a trunk in one of these groups is to be selected.

With this arrangement, if a call originating at the substation A, for example, is routed by way of the finder switch 11 to the connector switch 40, and the calling subscriber dials a single digit designating one of the groups of trunks arranged for one-digit selection, the enumerated normal post springs are respectively moved into engagement immediately the wipers of the connector switch are elevated to the position opposite the contact level in which the desired group of trunks are terminated. When the normal post springs 419 and 617 are moved to their closed circuit position, the relay R610 is energized and operates to perform the functions described above, and the circuit for energizing the upper winding of the switch-through relay R350 is prepared. At the normal post springs 468' an alternative operating circuit for the relay R480 is completed, this circuit extending by way of the grounded hold conductor C81, the contacts 371, C71, the contacts 633, C492, the contacts 457, the normal post springs 468', the lower winding of R480 and the contacts 474 to battery. When thus energized the relay R480 closes its preliminary make contacts 488 to prepare one of its locking circuits, and closes its contacts 485 to complete another of its locking circuits, the latter circuit extending by way of the ground release conductor 326c, the contacts 315 and 641 in parallel, C74, the contacts 485, the normal post springs 468', the lower winding of R480 and the contacts 474 to battery. At its contacts 486, the relay R480 prepares a circuit for energizing the rotary magnet 409 in parallel with the pulse-controlled relays R460 and R470.

Shortly after the end of the single digit dialed at the calling substation A, the relay R470 restores. At its contacts 472, the relay R470 opens the locking circuit for the digit transfer relay R450. The relay R450 now restores and closes its contacts 456 to complete the prepared operating circuit for the relays R460 and R470 and the rotary magnet 409. This circuit extends by way of the grounded hold conductor C81, the contacts 371, C71, the contacts 633, C492 and the contacts 456 to the contacts 486, where it divides, one branch extending through the winding of the rotary magnet 409 to battery, a second branch extending through the contacts 471' and the winding of R460 to battery, and the third branch extending by way of C493, the contacts 517, 532 and 531, C99, the contacts 452 and the winding of R470 to battery. At its contacts 457, the relay R450 opens the operating circuit for the relay R480. The relay R470, upon operating, closes its contacts 472 to complete the previously traced locking circuit for the relay R460, and opens its contacts 471' to interrupt the operating circuit for the relay R460. At its contacts 473, the relay R470 opens a point in the operating circuit for the busy test relay R530. The relay R460, in operating, closes its contacts 461 to short-circuit the digit transfer relay R510, closes its contacts 462 and 463 to complete an obvious multiple holding circuit for the relay R480, opens its contacts 465 further to interrupt the incomplete holding circuit for the busy test relay R530, and closes its contacts 464 to prepare the operating circuit for the busy test relay R530. At its contacts 467, the relay R460 opens a point in the previously traced circuit for transmitting busy tone current over the calling end of the connection. At its contacts 462, the relay R460 also prepares the previously traced trunk test circuit, including the E. C. wiper 662 and the lower winding of the trunk hunting relay R480. At its contacts 463, the relay R460 also completes the previously traced circuit for energizing the upper winding of the switch-through relay R350, whereby the latter relay partially operates to close its preliminary make contacts 356 and 358. At these contacts the previously traced path is completed for short-circuiting the lower winding of the relay R350. The rotary magnet 409, upon operating, functions to rotate the wipers 660 to 663, inclusive, into engagement with the contacts of the first contact set of the selected level, whereby the first trunk of the group is selected. At its contacts 474, the magnet 409 interrupts the locking and operating circuits for the trunk hunting relay R480, causing this relay to restore. Upon restoring, the relay R480 opens its contacts 486 to deenergize the relays R460 and R470 and the rotary magnet 409. At its contacts 485 and 488, the relay R480 further interrupts its two locking circuits. Shortly following the release of the relay R480, the pulse-controlled relay R470 restores. At its contacts 471', the relay R470 reprepares the operating circuit for the relay R460. At its contacts 472, the relay R470 interrupts the locking circuit for the relay R460 and the path short-circuiting the winding of the digit transfer relay R510. The relay R510 is now energized in series with the relay R460. In operating, the relay R510 locks up in a circuit including the grounded release conductor 326c, the contacts 529 and 512 and the resistor 519. After this locking circuit is completed, the relay R510 opens its contacts 519' to deenergize the relay R460. At its contacts 517, the relay R510 opens another point in the above-traced circuit for energizing the relay R470.

The relay R470, in restoring, also closes its contacts 473 to complete the above-traced trunk test

circuit including the upper winding of the busy test relay R530. In the event the first trunk of the selected group is busy, the busy test relay R530 operates to initiate the trunk hunting operation of the connector switch in the manner previously explained. This trunk hunting operation continues until an idle trunk in the selected group is found, or until all of the trunks in the group have been tested and found to be busy. If all of the trunks are busy, the busy signal is returned to the calling subscriber. On the other hand if an idle trunk of the selected group is found, the switch-through relay R350 operates to extend the calling circuit to the repeater associated with the idle trunk and the trunk is marked against seizure by the other connector switches. All of these operations are accomplished in the exact manner described above with reference to two-digit trunk selection.

The release of a connection routed through the link comprising the finder switch 11 and the connector switch 40 to an inter-office trunk is under the control of the calling party. Thus when the calling party disconnects, the control equipment of the repeater associated with the inter-office trunk in use functions in the manner subsequently explained to disconnect the test wiper 663, and incident thereto the release conductor 326c from ground. When ground potential is removed from this conductor, the finder switch 11 and the line circuit 10 are restored to normal in the manner previously described. The removal of ground potential from the ground conductor 326c also results in the deenergization and release of the relays R320, R350 and R510, and the relay R410 if operated. The relay R350, upon restoring, closes its contacts 359 to complete the operating circuit for the release magnet 407, whereby the Strowger switching mechanism is restored to normal. During the release of this mechanism, the normal post springs 419, 468' and 617 are respectively disengaged; the vertical off-normal springs 414, 417 and 468 are respectively moved into engagement; and the off-normal springs 415 and 416 are moved out of engagement. At the normal post springs 617, the circuit for energizing the relay R610 is interrupted. Following the release of this relay, the link circuit equipment is fully restored to normal.

TRUNK CALL—THREE-DIGIT TRUNK SELECTION

The trunks in the group or groups which are selected in response to three series of impulses transmitted to the connector switch 40 may comprise, for example, ring-down trunks extending to one or more manual exchanges. For the purpose of providing automatic selection of idle trunks of these groups, each trunk of each group is terminated in the contact field of the connector switching mechanism at a set of contacts comprising the usual private contact and an extra control or E. C. contact, and these private and extra control contacts of each contact set, except that terminating the last trunk of the group, are strapped together.

In order to select an idle trunk of a desired group arranged for three-digit selection, a calling subscriber, such, for example, as a subscriber at the substation A, dials a first digit which designates the level of contacts at which the trunks of the desired group are terminated, a second digit which designates the first trunk of the group, and a ringing digit. The manner in which the control apparatus of the connector switch responds to these three digits is exactly the same as described previously with reference to the local call originating at the substation A. At the end of the second digit the wipers 660 to 663, inclusive, are positioned in engagement with the contacts terminating the first trunk of the group. If this trunk is busy at the time it is thus selected, ground potential is present upon the private contact thereof, and, due to the strapping between this contact and the extra control contact, is also present upon the extra control wiper 662.

The third or ringing digit is utilized in the manner pointed out above to step the wipers of the minor switch 45 to one of its off-normal positions. Shortly following the end of the third digit, the relay R470 restores to open the holding circuit for the relay R460 and to complete at its contacts 473 the previously traced operating circuit for the busy test relay R530. Assuming that the first trunk of the selected group is busy, the relay R530 now operates to prepare the previously traced circuit for transmitting busy tone current over the calling end of the connection and to prepare its locking circuit. At its contacts 534, the relay R530 completes a circuit for energizing the trunk hunting relay R480, this circuit extending by way of the grounded E. C. wiper 662, the contacts 656, C672, the contacts 534, C497, the contacts 487 and 462, the lower winding of R480 and the contacts 474 to battery. Obviously this circuit and the operating circuit for the busy test relay R530 are not energized if the first trunk of the selected group is idle, such that negative battery potential is impressed upon the private and extra control wipers 663 and 662, respectively. When energized over the test circuit traced above, the relay R480 operates and locks to the grounded release conductor 326c, in the manner previously explained. At its contacts 486, the relay R480 completes a circuit for energizing the pulse-controlled relay R460 and the rotary magnet 409 in parallel, this circuit extending by way of the grounded conductor C81, the contacts 371, C71, the contacts 633, C492, and the contacts 456 to the contacts 486, where it divides, one branch extending through the winding of the magnet 409 to battery and the second branch extending by way of the contacts 471' and the winding of R460 to battery. When thus energized the rotary magnet 409 operates to step the wipers 660 to 663, inclusive, one step in the rotary direction, thereby to select the second trunk of the selected group. At its contacts 474 the magnet 409 interrupts the above-traced operating and holding circuits for the relay R480. The relay R480 now restores to open its holding circuit and the circuit for energizing the relay R460 and the magnet 409 in parallel. The magnet 409, in releasing, recompletes the test circuit which extends through the lower winding of the trunk hunting relay R480. Assuming that the second trunk of the selected group is also busy, ground potential is held on the private and extra control wipers 663 and 662, respectively, so that the energization of the relay R530 is maintained and the relay R480 is again energized. The relay R480, in reoperating, performs the functions described above. The interrelated operation of this relay and the rotary magnet 409 continues until an idle trunk of the selected group is found, or until all of the trunks of the selected group have been tested and found to be in a busy condition. During this trunk hunting operation, the

relay R460, due to its slow-to-release characteristic, remains operated.

Assuming that an idle trunk in the selected group is available, the wipers 660 to 663, inclusive, are operated step by step until the contacts terminating the idle trunk are engaged thereby. As indicated above, an idle trunk of this type is identified by the presence of negative battery potential upon the private and extra control contacts in the contact set at which it is terminated. Accordingly, when an idle trunk is selected, the lower winding of the relay R480 is short-circuited and does not reoperate. Due to the presence of battery potential upon the private wiper 663, the upper winding of the busy test relay R530 is also deenergized when the idle trunk of the selected group is found. Accordingly, the relay R530 immediately restores to reprepare the operating circuit for the idle test relay R630. Shortly following the release of the relay R530, the relay R460 also restores to complete the previously traced operating circuit for the idle test relay R630. From this point on the manner in which ringing current of the selected code is transmitted over the selected idle trunk, to signal the operator attending the switchboard at which the distant end of this trunk is terminated, is exactly the same as described previously with reference to the local call originating at the substation A. Moreover, the operation of the connector switch 40 incident to the answering of the call at the called end of the connection, and incident to the release of the connection at the calling substation, are the same as described above with reference to the setting up and releasing of a local call connection.

It will be understood from the foregoing explanation that if the first trunk of the selected group is idle, the relays R480 and R530 are not caused to operate. In such case the relay R460 is deenergized and restores to complete the operating circuit for the idle test relay R630 shortly following the end of the third digit. The relay R630, in operating, initiates the ringing operation, in the manner previously explained.

If all of the trunks of the selected group are busy, the wipers 660 to 663, inclusive, are, through the interrelated operation of the relay R480 and the rotary magnet 409, operated into engagement with the contacts of the contact set terminating the last trunk in the group. In this contact set the extra control contact is not wired. Hence, the extra control wiper 662 is open-circuited when the last trunk of the group is selected. Accordingly, the relay R480 remains in its restored position and the trunk hunting operation of the connector switch is arrested. Since ground potential is, under the conditions stated, present on the private wiper 663, the busy test relay R530 is not deenergized and remains in its operated position. Shortly following the selection of the last trunk, the relay R460 restores to complete the previously traced holding circuit for the busy test relay R530 and to complete the previously traced circuit for transmitting busy tone current over the calling end of the connection to signal the calling subscriber that the desired connection cannot be obtained. It will be noted that at this time the condition of the connector switch is exactly the same as previously described with reference to the selection of a busy subscriber line. Accordingly, the manner in which this connector switch, the preceding finder switch 11, and the line circuit terminating the calling line are released, when the call is abandoned at the calling substation, will be clearly apparent from the previous explanation.

Restrictive Service

As pointed out previously, provisions are made in the system for providing restricted service, which excludes free central office trunk calls, to certain subscribers of the system who pay a low flat fee for service, and for providing unrestricted central office trunk service to other subscribers who pay a high flat fee for the service rendered. To this end, the restricted service relay R550 is controlled over the marking paths individual to the trunks to determine whether or not a selected trunk is restricted, and the busy test relay R530 is controlled by the restricted service relay R550 and over the marking paths individual to the subscriber lines serving the substations arranged for restricted service. In this regard it will be recalled from the preceding explanation that when the digit transfer relay R510 operates, incident to the dialing of the second digit of a directory number or incident to an automatic cut-in operation on the part of the connector switch, it closes its contacts 515 to connect the lower winding of the busy test relay R530 for energization over a circuit including the E. C. wiper of the finder switch 11. It will also be recalled that the back-bridge relay R610 is energized and operates incident to the operation of the connector switch wipers to a position opposite a level of bank contacts terminating a group of trunks arranged for one digit selection. This relay, in operating, closes its contacts 614 to prepare a trunk test circuit which extends through the lower winding of the restricted service relay R550. With the circuits in this condition, i. e. with the relays R510 and R610 operated, if a trunk hunting operation on the part of the connector switch 40 is initiated, the test circuit through the lower winding of the restricted service relay R550 is held open at the contacts 533 until an idle trunk in the selected group is found. When an idle trunk is located, the busy test relay R530 restores and closes its contacts 538 to short-circuit the lower winding of the switch-through relay R350, in the manner previously explained. At its contacts 533, the relay R530 completes the trunk test circuit extending through the lower winding of the restricted service relay R550. If the selected trunk is non-restricted, the E. C. contact of the contact set terminating the conductors thereof will be open-circuited, with the result that the restricted service relay R550 remains in its restored position. In this case, therefore, regardless of the restricted or non-restricted character of the calling line, the connector switch 40 operates to set up a connection between the calling line and the repeater associated with the selected trunk. On the other hand, if the selected trunk is of the restricted type, the E. C. contact individual thereto in the contact field of the connector switch 40 is marked with negative battery potential through a resistance of approximately 500 ohms. Accordingly, the lower winding of the relay R550 is energized over the test circuit. This circuit may be traced as extending from ground by way of the contacts 614, C597, the contacts 551, the lower winding of R550, the contacts 516 and 533, C672, the contacts 656, the E. C. wiper 662 and the marking resistor individual to the selected trunk to battery. When thus energized the relay R550 first locks to ground over a path including its preliminary make contacts 553 and the release conductor 326c. After

this locking circuit is completed, the relay R550 opens its contacts 551 to interrupt the test circuit extending through its lower winding and the E. C. wiper 662. At its contacts 552, the relay R550 prepares or completes the test circuit extending through the lower winding of the busy test relay R530 and including the marking path individual to the calling line. Assuming that the line 16, for example, is occupied with the call, this test circuit may be traced as extending from ground by way of the contacts 614, C597, the contacts 552, the lower winding of R530, the contacts 515, C73, the contacts 333 and 314, the conductor 326e, the E. C. wiper of the finder switch 11, the conductor 16e, and the winding of R240 to battery. Obviously, this test circuit is not completed in the absence of negative battery potential upon the test wiper of the finder switch, indicating that the calling line is non-restricted and, hence, is entitled to free central office trunk service. When the test circuit just traced is completed, the busy test relay R530 reoperates. At its contacts 538, the relay R530 opens a point in the previously traced circuit for energizing the two windings of the switch-through relay R350 in series, thereby to prevent this relay from operating in response to the subsequent release of the relay R460. Thus the connection is prevented from being extended to the selected trunk. At its contacts 537', the relay R530 reprepares the previously traced circuit for transmitting busy tone current over the calling end of the connection, this circuit being completed in response to the subsequent release of the relay R460. The relay R460, upon restoring, shortly following the reoperation of the busy test relay R530, also functions to complete the above-traced locking circuit for the latter relay. Thus, following the release of the relay R460, the link circuit is in substantially the condition which prevails when a call is routed through the link to a busy subscriber line. The busy signal transmitted to the calling substation serves to inform the calling subscriber that the desired connection cannot be obtained. The manner in which the connection is released when the calling subscriber disconnects is exactly the same as set forth above, it being noted that the restricted service relay R550 is released in response to the removal of ground potential from the release conductor 326c.

Release On Permanents

As indicated previously, provisions are made in the connector switch 40 for forcibly releasing this switch and the preceding finder switch 11, in the event the link is seized over a line having a permanent calling condition thereon, or over a line having a call initiated thereon, and the calling subscriber fails to complete dialing; fails to receive an answer from the called substation and to abandon the call; fails to release the connection after the called subscriber has disconnected; fails to abandon the connection after receiving a busy tone signal; and in the case of a reverting call, fails to receive an answer within a specified period, or to release the connection by establishing an answering circuit over the line involved. The arrangement for this purpose includes the permanent timer 51, which is common to the selected links, and the link release relay R340. More specifically, the timer 51 is arranged to be started in operation in response to the application of ground potential to the timer start lead 55. This apparatus functions periodically to impress ground pulses upon the time-pulse lead 54, and normally maintains ground potential upon the time cut-off lead C344. A predetermined time interval after each ground pulse is applied to the time-pulse lead 55, the timer functions in a well-known manner to disconnect the time cut-off lead C344 from ground for a predetermined period, which is in excess of that required for any operated connector switch fully to release.

In considering the operation of the permanent timer 51 forcibly to release the link illustrated, it will be recalled from the preceding explanation that when the finder switch 11 and the connector switch 40 are seized over a calling line, the hold slave relay R330 operates and closes its contacts 332 to energize the upper winding of the link release relay R340 in series with the high resistance upper winding of the timer start relay R910. Due to the relatively high resistance of the latter winding, the relay R340 does not operate when its upper winding is energized in this circuit. The relay R910, however, operates and closes its contacts 912 to impress ground potential upon the start lead 55 and thus initiate the operation of the permanent timer 51. If the desired connection is fully established between the calling substation and the called substation before a ground pulse is transmitted through the contacts 911 and the low resistance lower winding of the relay R910 to the time-pulse lead C496, the battery reversing relay R420 is energized and operates to open the operating and holding circuits for the link-release relay R340. Accordingly, the link release relay is rendered ineffective forcibly to release the connection. Moreover, if the connector switch 40 is seized over a calling line, such, for example, as the line 9, which is arranged for unrestricted service, the link release relay R340 is rendered ineffective forcibly to release the operated switch train. In this case, the permanent timer 51, upon operating to impress ground potential upon the time pulse lead C496, completes a low resistance circuit including the contacts 425, C69 and the contacts 332 for energizing the upper winding of the link release relay R340. This relay, in operating, completes a path for short-circuiting its lower winding, which path extends from ground by way of the contacts 336, C78, the contacts 427, C77, the contacts 341, the lower winding of R340, C72, the contacts 514, C73, the contacts 333 and 314, the conductor 326e and the E. C. wiper of the finder switch 11 to the grounded E. C. contact engaged by this wiper. In this regard it will be recalled from the above explanation that the finder E. C. contacts which are individual to lines of the non-restricted type are connected directly to ground. At its contacts 342 and 343, the relay R340 provides a substitute holding ground on the hold conductor C81, which substitute ground is derived from the grounded time cut-off lead C344. When, however, the ground pulse impressed on the time pulse lead C496 is terminated, the link release relay R340 is deenergized and restores due to the short-circuited condition of its lower winding. Accordingly, ground as derived through the break contacts 342 is again connected to the hold conductor C81 in lieu of the ground connection to the time cut-off lead C344. Thus, when the connector switch 40 is seized over a line arranged for unrestricted service, the link release relay R340 periodically operates, but its operation is without effect.

In the event the connector switch 40 is seized over a calling line serving substations arranged

for semirestricted service, the relay network 25 operates, in the manner subsequently explained, periodically to impress ground potential upon the E. C. wiper of the finder switch 11. The periodicity of these ground pulses is such that the lower winding of the link release relay R340 is, in each case, short-circuited over the short-circuiting path traced above prior to the expiration of each timing interval when ground potential is removed from the time cut-off lead by the permanent timer 51. Accordingly, when the connector switch 40 is seized over a line arranged for semirestricted service, the link release relay R340 periodically operates, but its operation is without effect. It will be noted that in each of the two cases last considered, the link releases relay R340 is rendered ineffective forcibly to release the link, due to the completion of a path for short-circuiting its lower winding. This path extends through the break contacts 514 controlled by the digit transfer relay R510, which means, of course, that when the digit transfer relay R510 operates at the end of the second digit dialed at a calling substation, the link release relay R340 is again rendered effective forcibly to release the link, regardless of the character of the calling line.

In the event the connector switch 40 is seized over a line arranged for restricted service, or is seized over a line arranged for restricted or semirestricted service and the digit transfer relay R510 is operated, the link release relay R340 is free to operate under the control of the timer 51. When energized by a pulse transmitted over the lead C496, the relay R340 locks to ground over a path including the resistor 345, the contacts 341, C77, the contacts 427, C78 and the contacts 336. At its contacts 342 and 343, the relay R340 connects the hold conductor C81 to ground over a path including the time cut-off lead C344 and opens the direct ground path normally extending to this conductor. In the event the battery reversing relay R420, which is energized in response to the answering of a call routed through the link, operates before the time cut-off lead C344 is disconnected from ground following operation of the link release relay R340, the link release relay is caused to restore and the connection is not released. More specifically, the relay R420, in operating, opens its contacts 425 and 427 to interrupt the operating and locking circuits for the link release relay, causing the latter relay to restore and again connect the holding conductor C81 to ground through the contacts 342.

Assuming that the link release relay is held operated for the predetermined time interval which elapses between the transmission of a ground pulse over the time pulse lead C496 and the removal of ground potential from the time cut-off lead C344, the operated switch train comprising the finder switch 11 and the connector switch 40 is released. More specifically, when the time cut-off lead C344 is disconnected from ground, ground potential is removed from the release conductor 326e and the test conductor individual to the calling line, causing the finder switch 11 to release in the manner pointed out above. In response to the removal of ground potential from the test conductor individual to the calling line, the cut-off relay embodied in the line circuit terminating this line is deenergized and restores to again connect the windings of the associated line relay to the conductors of the calling line, whereby the line relay is again energized over the established calling circuit. The line relay associated with the calling line now reoperates to complete the holding circuit for its associated line lockout relay. With the line and lockout relays of the line circuit terminating the calling line operated, the line is marked against seizure and the distributor start circuit individual thereto is held open. During the release of the finder switch 11, the cut-through relay conveniently embodied therein restores to open the operating circuits for the line relays R360 and R440, causing these two relays to restore. The relay R360, upon restoring, initiates the release of the connector portion of the link, in the exact manner described above. During the release of the control equipment embodied in the connector switch the link release relay R340 is deenergized and restores in response to the release of the hold slave relay R330.

It will be apparent from the above explanation that if a connection is established by way of the finder switch 11 and the connector switch 40, the link release relay is rendered inactive so long as the connection is not released at the called end thereof, due to the fact that the battery reversing relay R420 is operated. When, however, the called subscriber hangs up to cause the deenergization and release of the battery reversing relay R420, the operating and locking circuits for the link release relay R340 are again prepared. Hence, if the calling subscriber fails to disconnect within a reasonable time interval, the link release relay, in cooperation with the associated permanent timer 51, functions to initiate the release of the operated switches 11 and 40 and to cause the calling line to be locked out of service, all in the manner explained above.

From the foregoing explanation with reference to reverting calls routed by way of the connector switch 40, it will be recalled that, when this connector switch is engaged in performing a reverting call signaling operation, the relay R330 is deenergized in response to the operation of the reverting call relay R310 and is caused to reoperate when the calling subscriber hangs up to initiate the ringing operation. The relay R330, upon restoring in response to the operation of the reverting call relay R310, opens the operating and locking circuits for the link release relay R340, causing this relay to restore if operated. Upon reoperating, however, the hold slave relay R330 reprepares the operating and locking circuits for the link release relay R340, whereby a second timing interval is initiated. Thus, the permanent timer 51, operating in conjunction with the link release relay R340, functions to time the ringing periods used in reverting call signaling and forcibly to release the link in any case where the signaling period is excessive. It will be noted that in this case the reverting call relay R310 and the digit transfer relay R510 are operated. Accordingly, the previously traced path for short-circuiting the lower winding of the link release relay R340 is held open at the contacts 314 and 514, so that the timing operation proceeds regardless of the character of the calling line.

It will be apparent from the foregoing explanation that in those cases where the conversation timing facilities are active, the conversation period is timed from the instant when the ring cut-off relay R520 operates. If the called party disconnects before the conversation timing period expires, but the calling party fails to disconnect, the operating and locking circuits for the link release relay R340 are reprepared at the break contacts 426 and 427, respectively, when the battery

reversing relay R420 restores. In this case the connection may be released either by the permanent timer 51 cooperating with the link release relay R340, or by the conversation timer 53 cooperating with the reverting call relay R310, depending upon which set of apparatus is first to complete its timing operation.

INTER-OFFICE TRUNK CALLS

In routing calls from the non-restricted subscriber lines terminating at the C. A. X to the subscriber lines terminating at the distant automatic exchange 35, any one of the restricted trunks in the group including the trunk 36 may be utilized. Thus, if a call intended for a subscriber served by the automatic exchange 35 and initiated at the substation A, for example, is routed to the connector switch 40 through the finder switch 11, the calling subscriber may dial the single digit designating the group of trunks in which the trunk 36 is included. In response to the dialing of this digit, the connector switch 40 operates in the manner previously explained, to select an idle trunk in this group. Assuming that the trunk 36 is the first available idle trunk of the group, the connector switch 40, upon testing this trunk and finding it idle, extends the calling circuit to the repeater 30 associated therewith. When the calling circuit is thus extended to the repeater 30, one or both of the line relays R720 and R850 may be energized. If the calling line is of the loop type, these relays are energized over the calling loop circuit which has now been extended to include the contacts 711, 714, 732 and 871, and the repeating coil windings 701 and 703. In the event the calling line is of the simplex type, only the relay R850 is energized, this relay being energized over a circuit including the contacts 871, C776, the winding 701, the contacts 711 and the negative side of the calling simplex circuit. In this case, the relay R720 is short-circuited over a path including the contacts 732, the repeating coil winding 703, the contacts 714 and the positive side of the calling simplex circuit. In the event the calling line is of the ground return type, the relay R720 is open-circuited and, accordingly, does not operate.

Assuming that the calling line is of the loop type, the relay R720 is energized and operates to open, at its contacts 721, a point in the operating circuit for the calling simplex relay R730. The relay R850, in operating, closes its contacts 851 to complete a circuit including the contacts 873 and C784 for energizing the pulsing relay R780. At its contacts 852, the relay R850 prepares the operating circuit for the calling simplex relay R730.

The pulsing relay R780, upon operating, closes its contacts 782 to complete a circuit including the contacts 825 and C704 for energizing the upper winding of the lock-pulse relay R760. At its contacts 781, the relay R780 opens a point in its own booster circuit. The relay R760, upon operating, closes its contacts 761 to prepare a circuit for energizing its lower winding. At its contacts 766, the relay R760 locks to ground over a path including the contacts 782 and the resistor 754. At its contacts 762, the relay R760 opens a point in the operating circuit for the pulse-controlled relay R740. At its contacts 764, the relay R760 opens a point in the operating circuit for the relay R770. At its contacts 765, the relay R760 opens a point in the operating circuit for the relay R810. At its contacts 763, the relay R760 completes a circuit including the contacts 834 and the conductors C796 and C797 for energizing the slow-acting hold relay R820.

The relay R820, upon operating, closes its contacts 824 to complete an obvious circuit for energizing the relays R830 and R860 in parallel. At its contacts 823, the relay R820 prepares the operating circuits for the relays R810 and R770, prepares a locking circuit for the relay R730, and completes a multiple holding circuit for the relay R760, the latter circuit extending from ground by way of the contacts 823, C798, the resistor 752 and the upper winding of R760 to battery. At its contacts 825, the relay R820 opens the operating circuit for the relay R760. At its contacts 823, the relay R820 also completes a circuit including the conductor C798, the resistor 755, the contacts 772 and C703 for energizing the upper winding of the lock-pulse relay R810. The current supplied to this winding over the circuit just traced is insufficient to cause the operation of the relay R810, but renders this relay exceedingly fast to operate. At its contacts 822, the relay R820 prepares the above-mentioned booster circuit for the pulsing relay R780. At its contacts 821, the relay R820 prepares a loop circuit extending by way of the conductors of the trunk 36 to the automatic switching equipment provided in the distant exchange 35. At its contacts 823, the relay R820 also completes a circuit for energizing the right winding of the electropolarized back-bridge relay R750, this circuit extending from ground by way of the contacts 823, C798 and the right winding of R750 to battery. It will be noted that a branch of this circuit extends through the resistor 708 and the lower or restoring winding of the differentially wound lock-pulse relay R760. The energization of the upper winding of the relay R760 still predominates, however, so that this relay remains in its operated position. The relay R750 does not operate when this circuit is completed.

The relay R830, in operating, closes its contacts 832 to complete an obvious path for impressing ground potential upon the test conductor C791, thereby to complete the previously mentioned locking circuits for the operated relays in the connector switch 40 and the finder switch 11, and to maintain the busy marking of the trunk 34. At its contacts 831, the relay R830 opens an incomplete alternative path for grounding the test conductor C791. At its contacts 833, the relay R830 prepares the operating circuit for the pulse-controlled relay R740. At its contacts 835, the relay R830 completes a locking circuit for the hold relay R820, this circuit extending from ground by way of the contacts 824 and 835, C796, the contacts 763, C797 and the winding of R820 to battery. At its contacts 834, the relay R830 interrupts the operating circuit for the hold relay R820. At its contacts 836, the relay R830 completes an obvious circuit for energizing the line-switching relay R839.

The relay R860, in operating, opens its contacts 882 and 883 to disconnect the conductors of the trunk 36 from the line circuit 31. At its contacts 881 and 884, the relay R880 completes a calling loop circuit which extends from the repeating coil 700 to the repeater terminating the trunk 36 in the distant automatic exchange 35. This loop circuit may partially be traced as extending by way of the contacts 881, C783, the repeating coil winding 702, the left winding of the back-bridge relay R750, the repeating coil winding 704, C785, and the contacts 811, 821 and 884.

The direction of current flow over this circuit is such that the polarized back-bridge relay R750 does not operate. When this loop circuit is completed, the automatic switching equipment provided in the exchange 35 is conditioned in a well-known manner to respond to impulses transmitted over the trunk 36 and dial tone is returned to the calling subscriber. At its contacts 885, the relay R880 opens a point in one of the operating circuits for the battery reversing relay R710. At its contacts 886, the relay R880 prepares the operating circuit for the control relay R840.

Grounded or simplex line test

The relay R860 operates shortly following the operation of the relay R880, and closes its contacts 861 to complete the prepared operating circuit for the control relay R840. At its contacts 862, the relay R860 opens a point in the operating circuit for the control relay R870. The relay R840 operates after an interval and opens its contacts 843 to interrupt the path over which negative battery potential is normally impressed upon the E. C. conductor C792. More specifically, this conductor is normally connected to the negative terminal of the exchange battery over a path including the contacts 843 and the resistor 848, this marking path serving to identify the trunk 36 as a restricted trunk and to provide a circuit for energizing the restricted service relay R550 of the connector switch 40 in the manner previously explained. At its contacts 842, the relay R840 completes a path for impressing ground potential upon the E. C. conductor C792. This ground path is utilized in the manner previously described to control the trunk-hunting operation of the other connector switches in searching for an idle trunk in the group including the trunk 36, and extends from ground by way of the contacts 832 and 842 to the conductor C792. In this regard it is pointed out that if the trunk 36 is the last trunk of the group, the strap 838 connecting the terminals 837 and 839 is omitted from the repeater circuit wiring so that the path just traced is not completed. The omission of this strap serves to prevent further searching of a connector switch occupied with a trunk call intended for one of the restricted trunks when the last trunk of the group is selected. Thus, with the E. C. conductor C792 disconnected from ground, the previously traced trunk test circuit over which the trunk-hunting relay R480 is energized is held open when the trunk 36 is selected.

At its contacts 841, the relay R840 prepares the above-mentioned alternative path for impressing ground potential upon the test and E. C. conductors C791 and C792. At its contacts 844, the relay R840 locks to ground over a path including the contacts 886. At its contacts 845, the relay R840 prepares the operating circuit for the slow-to-operate control relay R870. At its contacts 846, the relay R840 interrupts the operating circuit for the relay R860. At its contacts 847, the relay R840 prepares or completes the operating circuit for the calling simplex relay R730, depending upon the position of the line relay R720. This circuit extends from ground by way of the contacts 875, 852 and 847, C791, the contacts 721 and the winding of R730 to battery, and is completed in response to operation of the relay R840 in the event the line relay R720 occupies its restored position. On the other hand, if this line relay is operated and the calling line is of the simplex or ground return type, the relays R610 and R330 cooperate to transmit a ground pulse over the positive wiper 661 which serves to short-circuit the line relay R720. When thus deenergized, the relay R720 restores to complete the prepared operating circuit for the relay R730.

The relay R730, upon operating, locks to ground over a path including the contacts 733, C798 and the contacts 823. At its contacts 732, the relay R730 disconnects the winding of the line relay R720 from the positive line wiper 661. At its contacts 731, the relay R730 connects the positive line wiper 661 to the conductor C776 to complete a multiple circuit for energizing the line relay R850, assuming that the calling line is of the simplex type. In the event the calling line is of the ground return type, the operation of the relay R730 is without effect to increase the energization of the line relay R850.

The relay R860 restores shortly following the operation of the relay R840, and opens its contacts 861 to interrupt the operating circuit for the relay R840. At its contacts 862, the relay R860 completes the prepared operating circuit for the slow-to-operate control relay R870, this circuit extending from ground by way of the contacts 824, 845 and 862, and the winding of R870 to battery. The relay R870 now operates and opens its contacts 875 to interrupt the above-traced operating circuit for the calling simplex relay R730. At its contacts 874, the relay R870 completes a path including the resistor 746, the conductors C786 and C788, and the contacts 874 and 716 over which the line relay R720 is partially short-circuited, thereby to decrease the resistance of the calling circuit if the calling line is of the loop type. At its preliminary make contacts 872, the relay R870 includes the winding of the pulsing relay R780 in the calling circuit. At its contacts 873, the relay R870 interrupts the initially completed operating circuit for the pulsing relay R780. At its contacts 871, the relay R870 excludes the winding of the line relay R850 from the calling circuit, thereby to cause the deenergization and release of the latter relay. In restoring, the relay R850 opens its contacts 851 to interrupt the operating circuit for the pulsing relay R780, and opens its contacts 852 further to interrupt the operating circuit for the calling simplex relay R730. Following the release of the line relay R850, the control equipment of the repeater 30 is conditioned to respond to the impulses of the additional digits designating the desired substation served by the distant automatic exchange 35. From the above explanation, it will be noted that if the calling line is of the grounded or simplex type, the relays R780, R820, R830, R840, R870, R880, R760 and R730 are operated following seizure of the repeater 30 and prior to the transmission of impulses to this repeater. In this case, the negative terminal of the exchange battery is connected to both sides of the calling circuit through the winding of the pulsing relay R780. On the other hand, if a loop line is calling, the relays R780, R820, R830, R840, R870, R880, R760 and R720 are operated following seizure of the repeater 30, and the exchange battery is connected between the two sides of the calling loop circuit in series with the windings of the relays R720 and R780. Talking battery may be supplied to the transmitter provided at the calling substation over this battery feed circuit.

Repeating dial pulses to the distant exchange

When a link in the distant automatic exchange 35 is seized through the repeater terminating

the trunk 36 in this exchange, the control equipment thereof functions in the usual manner to transmit dial tone signal current back over the trunk 36 and the calling line, thereby to signal the calling subscriber that the dialing operation may be continued. During the dialing of further digits at the calling substation, the pulsing relay R780, operating in conjunction with the lock-pulse relays R760, R770 and R810 functions to repeat the pulses to the seized switching equipment in the exchange 35. More specifically, when the pulsing relay R780 restores at the beginning of the first impulse transmitted to the repeater 30, it opens its contacts 782 to interrupt the branch holding circuit for the lock-pulse relay R760 which includes the resistor 754. When this circuit is opened, the energization of the lower winding of the differentially wound relay R760 predominates, with the result that this relay is restored electrically. At its contacts 781, the relay R780 completes the above-mentioned booster circuit for itself, this circuit extending from ground by way of the contacts 781, C787, the resistor 817, the contacts 822, C784 and the winding of R780 to battery. The current flow over this circuit is insufficient to cause the reoperation of the pulsing relay R780, but renders this relay exceedingly fast-to-operate when the calling circuit is recompleted at the end of the open-circuit period of the impulse. In restoring, the relay R760 opens its contacts 761 to interrupt the previously traced circuit for energizing its lower winding. At its contacts 762, the relay R760 completes the prepared operating circuit for the pulse-controlled relay R740, this circuit extending from ground by way of the contacts 824 and 835, C796, the contacts 762, C795, the contacts 833, C794 and the winding of R740 to battery. At its contacts 763, the relay R760 opens the operating circuit for the hold relay R820. At its contacts 764, the relay R760 prepares a circuit for energizing the upper winding of the lock-pulse relay R770. At its contacts 766, the relay R760 opens another point in its own locking circuit. At its contacts 765, the relay R760 completes a circuit for fully energizing the upper winding of the lock-pulse relay R810, this circuit extending from ground by way of the contacts 823, C798, the contacts 765 and 772, C703 and the upper winding of R810 to battery.

The relay R810, upon operating, closes its contacts 814 to complete an obvious path for short-circuiting its lower winding, thereby to render itself slow-to-release. At its contacts 812, the relay R810 completes an obvious holding circuit for the hold relay R820. At its contacts 813, the relay R810 completes the above-mentioned circuit for energizing the upper winding of the slow-to-operate lock-pulse relay R770, this circuit extending from ground by way of the contacts 823, C798, the contacts 765, C702, the contacts 813, C799, the contacts 764 and the upper winding of R770 to battery.

The lock-pulse relay R770 operates after an interval and opens its contacts 773 to interrupt the path normally short-circuiting its lower winding. At its contacts 771, the relay R770 completes an obvious multiple circuit for energizing its upper winding. At its contacts 772, the relay R770 interrupts the above-traced operating circuit for the lock-pulse relay R810, causing the latter relay to restore after an interval. At its contacts 771 and 774, the relay R770 completes an alternative path for short-circuiting its lower winding, this path extending from ground by way of the resistor 753, the contacts 774, the lower winding of R770, the contacts 764 and 771, C798 and the contacts 823 back to ground. At its contacts 775, the relay R770 prepares an alternative operating circuit for the lock-pulse relay R760. Shortly following the operation of the relay R770, the relay R810 restores and opens its contacts 814 to interrupt the path short-circuiting its lower winding. At its contacts 813, the relay R810 opens the above-traced operating circuit for the relay R770. At its contact 812, the relay R810 opens the holding circuit for the relay R820. When the pulsing relay R780 reoperates at the end of the open-circuit period of the first impulse, it closes its contacts 782 to complete the above-mentioned alternative operating circuit for the relay R760, this circuit extending from ground by way of the contacts 775 and 782, and the upper winding of R760 to battery. At its contacts 781, the relay R780 opens its booster circuit as traced above. The relay R760 now reoperates to perform the functions described above. At its contacts 764, the relay R760 interrupts the above-traced path short-circuiting the lower winding of the relay R770, and opens the circuit for energizing the upper winding of the latter relay. When the short-circuiting path just mentioned is interrupted, the lower winding of the relay R770 is energized over a circuit including the resistors 709 and 753, and the contacts 774. This relay is differentially wound. Accordingly, the energization of its lower winding in the manner just explained causes this relay rapidly to restore. In releasing, the relay R770 opens its contacts 774 to interrupt the path for energizing its lower winding, opens its contacts 775 to interrupt the operating circuit for the relay R760, closes its contacts 773 to short-circuit its lower winding, and closes its contacts 772 to reprepare the operating circuit for the relay R810. Following the release of this relay, the pulse regenerating relays R780, R760, R770 and R810 are prepared to respond to another impulse. The manner in which these four relays coact in response to additional impulses transmitted to the repeater 30 is exactly the same as just explained.

As indicated above, the relay R740 is energized and operates in response to the release of the relay R760 at the beginning of the open-circuit period of the first impulse. In operating, the relay R740 closes its contacts 744 to prepare a locking circuit for the battery reversing relay R710, and closes its contacts 743 to shunt the resistor 707 across the operating winding of the back-bridge relay R750, thereby to reduce the resistance of the pulsing circuit which extends by way of the trunk 36 to the distant exchange 35. At its contacts 742, the relay R740 completes a path including the resistor 746 for short-circuiting the winding of the relay R720, thereby to reduce the resistance of the calling circuit in the event the calling line is of the loop type. At its contacts 741, the relay R740 completes an obvious path for short-circuiting the repeating coil winding 701, thereby further to reduce the resistance of the calling circuit over which the impulses are transmitted to the relay R780 from the calling station. Due to the slow-to-release characteristics thereof, the relays R740 and R820 remain operated during each series of impulses transmitted to the repeater 30. The relay R740, however, restores during the inter-digit pause between each series of impulses, and remains in its

restored position after the calling operation is terminated.

Each time the relay R810 restores in response to the release of the pulsing relay R780, it opens its contacts 811 to interrupt the established loop circuit extending to the seized automatic switching equipment in the exchange 35. This loop circuit is obviously recompleted each time the relay R810 restores in response to operation of the lock-pulse relay R770. Thus, the relay R810 functions to repeat the corrected impulses to the loop circuit extending from the repeating coil 700 to the automatic switching equipment of the distant exchange 35. This automatic switching equipment responds to the repeated dial pulses by operating to select the desired called line in the usual manner. After this line is selected it is tested to determine the idle or busy condition thereof and, if busy, the usual busy tone signal is returned over the connection to signal the calling subscriber that the desired connection cannot be obtained. On the other hand, if the called line is idle, ringing current is transmitted thereover for the purpose of signaling the called subscriber, and the usual ring-back tone signal is transmitted back over the connection to signal the calling subscriber that the called substation is being rung.

When the call is answered at the called substation, the desired conversational circuit between the calling and called substations is fully completed, and the transmission of ringing current over the called line and the trunk 36 is arrested. In addition, the control equipment of the switching apparatus in use at the exchange 35 operates to reverse the direction of current flow over the trunk 36 and through the left-hand winding of the back-bridge relay R750. As a result, the electro-polarized back-bridge relay R750 operates to complete, at its contacts 751, an obvious circuit for energizing the battery reversing relay R710. At its contacts 711 to 714, inclusive, the relay R710, in operating, reverses the direction of current flow over the calling circuit in the event the calling line is of the loop type. At its contacts 715, the relay R710 prepares a locking circuit for itself. At its contacts 716, the relay R710 opens a point in the above-traced path for short-circuiting the winding of the line relay R720. At its contacts 717, the relay R710 completes an obvious multiple path for impressing guarding ground potential upon the connected test and E. C. conductors C791 and C792, respectively. At its contacts 718, the relay R710 completes a multiple holding circuit for the relay R840, this circuit extending from ground by way of the contacts 718, C793 and the winding of R840 to battery.

In the event further impulses are dialed at the calling station after the call is answered, the four relays R780, R760, R770 and R810 cooperate in the manner explained above to repeat these impulses over the trunk 36 to the distant exchange 35. At the beginning of such dialing, the relay R740 is energized and operates to complete the prepared holding circuit for the relay R710, this circuit extending from ground by way of the contacts 744 and 715, and the winding of R710 to battery. This locking circuit is obviously interrupted at the contacts 744 at the end of each series of impulses. Each time the loop circuit including this trunk is opened at the contacts 811, the back-bridge relay R750 restores and opens its contacts 751 to interrupt the operating circuit for the battery reversing relay R710. The latter relay R710 is, however, held energized over its locking circuit as traced above.

It will be apparent from the above explanation that the back-bridge relay R750 responds to switchhook operation at the called substation by opening and closing the operating circuit for the battery reversing relay R710. Thus, each time the called subscriber hangs up, the control equipment of the automatic switching apparatus occupied with the call in the exchange 35 operates to reverse the direction of current flow through the winding of the back-bridge relay R750, and this relay restores to interrupt the operating current for the battery reversing relay R710. These two relays are obviously reoperated in the order named each time the called subscriber removes the receiver provided at the called substation from its supporting hook or cradle prior to the release of the connection. Each time the battery reversing relay R710 restores, it reverses the direction of current flow over the calling circuit, assuming the calling line to be of the loop type; closes its contacts 716 to reprepare the path for short-circuiting the winding of the line relay R720; opens its contacts 717 to interrupt the multiple path for impressing ground potential upon the connected test and E. C. conductors C791 and C792, respectively, and opens its contacts 718 to interrupt the established locking circuit for the control relay R840.

Release

In the event the call is cleared out at the calling substation prior to its release at the called substation, the relays R750 and R710 are caused sequentially to restore in the manner just explained. Thereafter, and when the calling subscriber disconnects, the pulsing relay R780 and the relay R720, if operated, are deenergized and restore. In response to the release of the relay R780, the relay R760 restores, the relay R810 operates, the relay R770 operates, and the relay R810 restores, in the sequence named and in the exact manner described above. With the relays R760 and R810 in their restored positions, the operating and locking circuits for the hold relay R820 are held open at the contacts 763 and 812, respectively. The relay R820 restores after an interval and opens its contacts 823 to interrupt the operating and locking circuits for the relays R770 and R730. At its contacts 824, the relay R820 opens the operating and locking circuits for the relays R830, R860, R870 and R740. Thus, the five relays R730, R740, R770, R830 and R870 are caused to restore. The relay R830, in releasing, opens the operating circuit for the relay R880, thereby to cause the sequential release of the latter relay and the relay R840. Following the release of the two last-mentioned relays, the repeater 30 is fully restored to normal. The relays R830 and R840, in restoring, open the two available paths over which ground potential may be impressed upon the test and E. C. conductors C791 and C792, respectively. At its contacts 843, the relay R840 recompletes the path for impressing negative battery potential upon the E. C. conductor C792 for the purpose of indicating the restricted character of the trunk 36. When ground potential is removed from the test conductor C791, the preceding switches 40 and 11, and the line circuit 10, are released in the manner previously described.

In the event the connection is cleared out at the calling substation prior to its release at the called substation served by the distant automatic

exchange 35, the back-bridge relay R750 and the battery reversing relay R710 are held operated until the hold relay R820 releases in the manner just explained. When the hold relay restores, the loop circuit extending by way of the trunk 36 to the distant automatic exchange is opened at the contacts 821, causing the back-bridge and battery reversing relays sequentially to restore. In this case, the relay R880, upon restoring, closes its contacts 882 and 883 to connect the conductors of the trunk 36 to the talking conductors of the trunk 34, thus establishing a loop circuit between the line circuit 31 and the repeater terminating the trunk 36 in the distant exchange 35. When this loop circuit is completed, the line circuit 31 operates to seize an assigned one of the idle finder-connector links provided in the C. A. X, thereby to cause the finder portion of the assigned link to seize the trunk 36 over the link line 34, and to impress ground potential upon the private conductor 34c. When the conductor 34c is connected to ground, the battery reversing relay R710 is energized over a circuit including this conductor, the contacts 885 and the conductor C790. In operating, the relay R710 closes its contacts 717 to impress ground potential upon the test conductor C791, thereby to mark the trunk 36 as busy in the bank contacts of the connector switches. At its contacts 718, the relay R710 completes a circuit extending by way of the conductor C793, for energizing the control relay R840. The relay R840 now operates and opens its contacts 843 to disconnect the E. C. conductor C792 from the negative terminal of the exchange battery. At its contacts 842, the relay R840 connects the E. C. conductor C792 to the grounded test conductor C791 for the purpose of controlling the trunk-hunting operation of the connector switches. When the connection is cleared out at the called substation, the loop circuit extending between the line circuit 31 and the repeater terminating the trunk 36 in the exchange 35 is interrupted by the control equipment of this repeater. As a result, the line circuit 31 and the seized link in the C. A. X are released. During the release of the line circuit 31, the private conductor 34c is disconnected from ground to deenergize the battery reversing relay R710. Thus, the relays R710 and R840 are caused sequentially to restore, whereby the test and E. C. conductors C791 and C792, respectively, are disconnected from ground, and the E. C. conductor is connected to the negative terminal of the exchange battery through the resistor 848.

When a call intended for a subscriber served by the C. A. X is routed through the automatic switching equipment of the exchange 35 and over the trunk 36 to the line circuit 31, the line relay of this line circuit operates to impress ground potential upon the private conductor 34c in the manner described in the preceding paragraph. When this conductor is connected to ground, the relays R710 and R840 operate to perform the functions described above. The line circuit 31, in operating, also functions to seize an idle one of the links in the C. A. X in the exact manner described previously with reference to the call originating at the substation A. The manner in which such a call is routed to the desired substation and the connection is released when no longer desired is also the same as described above and will be clearly apparent from the preceding explanation.

Operation of the Restricted Service and Time-Blocking Network 25

As pointed out previously, the relay network 25 is provided for the purpose of controlling the operation of the link release relay R340, the restricted service relay R550 and the timing relay R640 of the link illustrated, and the corresponding relays provided in the other links of the C. A. X. This network includes the relays R240, R250 and R260, individual to the lines upon which service restrictions are imposed, and having windings which are utilized as resistance marking paths over which negative battery potential is impressed upon the E. C. contacts of the finder contact sets terminating the respective associated lines. In this regard, it will be recalled that the resistance battery marking paths, including the windings of the relays R240, R250, R260, etc., are utilized to prevent the respective associated lines from obtaining access to certain of the central office trunks through the links. The additional relays R230, R220 and R210 are controlled by the pulsing element 263 to transmit ground pulses over the E. C. conductors individual to the semi-restricted lines for the purpose of rendering the link release relay R340 and the timing relay R640 of the link illustrated, and the corresponding relays of the other links, ineffective forcibly to release connections routed through the links.

In considering the operation of the network 25, it may be assumed that a call intended for one of the restricted trunks is initiated at a semi-restricted substation, such, for example, as the substation C served by the line 16. It may further be assumed that the link illustrated is utilized in handling the call. During the operation of the connector switch to select an idle one of the restricted trunks, the digit transfer relay R510 is caused to operate. Thereafter, and when an idle trunk is selected, the restricted service relay R550 is energized over the trunk test circuit previously described, and operates to complete a circuit for energizing the lower winding of the busy test relay R530 in series with the relay R240 individual to the line 16, this circuit extending from ground by way of the contacts 614, C597, the contacts 552, the lower winding of R530, the contacts 515, C73, the contacts 333 and 314, the E. C. conductor 326e, the E. C. wiper of the finder switch 11, the E. C. conductor 16e, and the winding of R240 to battery. When energized over this circuit, the relay R240 operates and closes its contacts 242 to prepare a pulsing circuit to the slow-acting relay R230. With the relay R240 operated, the continuously driven pulsing element 263 operates periodically to transmit ground pulses through the contacts 242 to the relay R230. Each time the relay R230 operates, it closes its contacts 231 to complete an obvious operating circuit for the slave relay R220. The relay R220, in operating, closes its contacts 221 to complete an obvious locking circuit for the relay R240, and impresses ground potential upon the E. C. conductor 16e. Each time the relay R230 restores, it deenergizes its slave relay R220, and the latter relay restores to disconnect the conductor 16e from ground. Thus, ground pulses are periodically transmitted over the E. C. conductor 16e, which are utilized in the manner previously described to control the timing relay R640 and the link release relay R340. If the calling line is arranged to provide fully restricted service to the subscriber or subscribers served thereby, the ground pulsing path just described, which is in-

dividual to the line and extends to the E. C. conductor 16e, is omitted from the wiring of the network 25. In the absence of this path, ground pulses are not transmitted over the E. C. conductor 16e to cause the periodic release of the relays R340 and R640, if operated. Thus, the timing operation of these relays is not interfered with. It will be noted that the pulsing circuit extending to the relay R230 from the pulsing element 263 may be completed by any one of the line relays provided in the network 25. It will also be noted that each of the line relays, in operating, functions to prepare the pulsing circuit to its associated E. C. conductor. In this regard, it is pointed out that if only a small number of the lines terminating at the exchange are restricted, the slave relays R220 and R210, and the circuits controlled thereby, may be omitted, the ground pulsing circuits being directly controlled by the relay R230. These slave relays are provided solely for the purpose of enabling the network 25 to serve a relatively large number of lines.

OPERATION OF THE TIMER START CIRCUIT 50

As pointed out in the introductory portion of the specification, the arrangement of the timer start circuit 50 is such that a single lead connecting each link with the start relay individual to each timing unit is utilized for the dual purpose of controlling the energization of the associated start relay and the transmission of the control pulses to the link. Thus, it is pointed out above that when negative battery potential is impressed upon the time pulse lead C496 through operation of the hold slave relay R330 provided in the link illustrated, the upper winding of the timer start relay R910 is energized, causing this relay to operate. In operating, the relay R910 closes its contacts 912 to impress ground potential upon the permanent timer start lead 55 and thus initiates the operation of the permanent timer 51. At its contacts 913, the relay R910 also impresses ground potential upon the start lead 56 for the purpose of initiating the operation of the dial and busy tone generators 60. The permanent timer 51, in operating, functions periodically to impress ground pulses upon the time pulse lead 54, which is now connected through the lower winding of the relay R910 to the time pulse lead C496. When the time pulse lead 54 is connected to ground, the high resistance upper winding of the relay R910 is effectively short-circuited over a path including the low resistance lower winding of this relay and the contacts 911. The current flow through this lower winding, and the upper winding of the link release relay R340, however, serves to prevent the relay R910 from releasing. Moreover, the low resistance path through the lower winding of the relay R910 does not materially restrict the energization of the upper winding of the link release relay R340. Thus, the lead C496 is utilized both for the purpose of controlling the energization of the relay R910 and for the purpose of transmitting control pulses to the link illustrated. Obviously, the relay R910 is deenergized and restores when the time pulse lead C496 is disconnected from the negative terminal of the exchange battery.

In a similar manner, the start relay R920 may be energized in series with the winding of the magnet 1004 in response to operation of the timing relay R640. This series circuit extends from ground through the winding of R920 by way of the contacts 932, C679, the contacts 642, C671 and the winding of the magnet 1004 to battery. Due to the relatively high resistance of the winding of the relay R920, the magnet 1004 is insufficiently energized to operate when this circuit is completed. The relay R920, however, operates and closes its contacts 921 to complete an obvious path for impressing ground potential upon the start conductor 57 extending to the tick-tone generating equipment 52. At its contacts 923, the relay R920 completes an obvious path for impressing ground potential upon the timer start lead 58. When the two leads 57 and 58 are thus connected to ground, operation of the tick-tone generating equipment 52 and the conversation timer 53 is initiated. At its contacts 922, the relay R920 prepares a circuit including the pulsing lead 59 over which ground pulses may be transmitted to the pulsing relay R930 under the control of the timer 53. Following the operation of the relay R920, the pulsing relay R930 as controlled over the pulsing lead 59 by the conversation timer 53 periodically operates and restores. Each time this relay operates, it opens its contacts 932 to interrupt the operating circuit for the relay R920, closes its contacts 933 to complete an obvious holding circuit for the relay R920, and closes its contacts 931 to complete an obvious path for impressing ground potential directly upon the combined start and pulse lead C679. Each time the relay R930 restores, it disconnects the lead C679 from ground to terminate the pulse, closes its contacts 932 to recomplete the operating circuit for the relay R920, and opens its contacts 933 to interrupt the holding circuit for the relay R920. Obviously, when the lead C679 is disconnected from the negative terminal of the exchange battery in response to the release of the timing relay R640, the relay R920 is deenergized and restores. In releasing, the relay R920 disconnects the two start leads 57 and 58 from ground to arrest the operation of the tick-tone generating equipment 52 and the conversation timer 53, and opens its contacts 922 to interrupt the pulsing circuit extending to the pulsing relay R930.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein, and it is contemplated to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a telephone system, a line, a line circuit terminating said line and including a cut-off relay, a link including an automatic switch having access to said line and means responsive to the application of a pulse of predetermined potential to one of the talking conductors of said line for conditioning certain of the control equipment of said link to be controlled over said line, and means controlled by said relay for transmitting a current pulse over said one talking conductor during operation of said switch to seize said line.

2. In a telephone system, a line, a link including an automatic switch having access to said line and means responsive to the application of a pulse of predetermined potential to one of the talking conductors of said line for conditioning certain of the control equipment of said link to be controlled over said line, a line circuit terminating said line and including a pair of relays sequentially operative in response to operation of said switch to select said line, means respon-

sive to the operation of one of said relays for applying said predetermined potential to said one talking conductor, and means responsive to the subsequent operation of the other of said relays for removing said predetermined potential from said one talking conductor.

3. In a telephone system, a line, a line circuit terminating said line and including a cut-off relay operative in response to seizure of said line by a connecting link, and means controlled by said relay for transmitting a control pulse over one of the talking conductors of said line.

4. In a telephone system, a line, a line circuit terminating said line and including a cut-off relay operative in response to seizure of said line by a connecting link, and means responsive to operation of said relay for transmitting a control pulse over one of the talking conductors of said line to the control equipment of said link.

5. In a telephone system, a line, a link including an automatic switch having access to said line and control equipment normally controllable over the two sides of a line in series, means responsive to a control pulse transmitted over one of the talking conductors of said line for conditioning said control equipment to be controlled over the two sides of said line in parallel, and means operative during operation of said switch to seize said line for transmitting a control pulse over said one talking conductor.

6. In a telephone system, a line having a wire side and a ground return side, a link including an automatic switch having access to said line and control equipment normally controllable over the two sides of a two-wire line in series, means responsive to a control pulse transmitted over one of the sides of said line for conditioning said control equipment to be controlled over the wire side of said line, and means operative during operation of said switch to seize said line for transmitting a control pulse over said one side of said line.

7. In a telephone system, a line, a link including an automatic switch having access to said line and control equipment normally controllable over the two sides of a line in series, means responsive to a control pulse transmitted over one of the talking conductors of said line for conditioning said control equipment to be controlled over the two sides of said line in parallel, a line circuit terminating said line and including cut-off and lockout relays sequentially operative in response to operation of said switch to seize said line, and means responsive to operation of said relays for transmitting a control pulse over said one side of said line.

8. In a telephone system, a line having a wire side and a ground return side, a link including an automatic switch having access to said line and control equipment normally controllable over the two sides of a two-wire line in series, means responsive to a control pulse transmitted over one of the sides of said line for conditioning said control equipment to be controlled over the wire side of said line, a line circuit terminating said line and including cut-off and lockout relays sequentially operative in response to operation of said switch to seize said line, and means responsive to operation of said relays for transmitting a control pulse over said one side of said line.

9. In a telephone system, a line, a connector switch having access to said line and including ringing control equipment, means responsive to a control pulse transmitted over one of the conductors of said line for controlling said ringing control equipment, and means operative during operation of said switch to seize said line for transmitting a control pulse over said one conductor.

10. In a telephone system, a line, a connector switch having access to said line and including ringing control equipment, means responsive to a control pulse transmitted over one of the talking conductors of said line for controlling said ringing control equipment, and means operative during operation of said switch to seize said line for transmitting a control pulse over said one talking conductor.

11. In a telephone system, a line, a connector switch having access to said line and including ringing control equipment having different settings individually corresponding to different modes of ringing, means responsive to a control pulse transmitted over one of the conductors of said line for causing said ringing control equipment to assume a predetermined setting, and means operative during operation of said switch to seize said line for transmitting a control pulse over said one talking conductor.

12. In a telephone system, a line, a connector switch having access to said line and including ringing control equipment having different settings individually corresponding to different modes of ringing, means responsive to a control pulse transmitted over one of the talking conductors of said line for causing said ringing control equipment to assume a predetermined setting, and means operative during operation of said switch to seize said line for transmitting a control pulse over said one talking conductor.

13. In a telephone system, a line, a connector switch having access to said line and including ringing control equipment, means responsive to a control pulse transmitted over one of the conductors of said line for controlling said ringing control equipment, a line circuit terminating said line and including cut-off and lockout relays sequentially operative in response to seizure of said line by said switch, and means responsive to operation of said relays for transmitting a control pulse over said one conductor.

14. In a telephone system, a line, a connector switch having access to said line and including ringing control equipment having different settings individually corresponding to different modes of ringing, means responsive to a control pulse transmitted over one of the talking conductors of said line for causing said ringing control equipment to assume a predetermined setting, a line circuit terminating said line and including cut-off and lockout relays sequentially operative in response to seizure of said line by said switch, and means responsive to operation of said relays for transmitting a control pulse over said one conductor.

15. In a telephone system, lines of different types requiring different modes of ringing for signaling thereover, a connector switch having access to said lines and including ringing control equipment having different settings for providing said different modes of ringing, line circuits individually terminating said lines, and means controlled from said line circuits over paths including the outlet contacts of said switch for determining the setting of said ringing control means.

16. In a telephone system, lines of different types requiring different modes of ringing for signaling thereover, a connector switch having access to said lines and including ringing control

equipment having different settings for providing said different modes of ringing, line circuits individually terminating said lines and each including cut-off and lockout relays, and means controlled by said line and lockout relays over paths including the outlet contacts of said switch for determining the setting of said ringing control equipment.

17. In a telephone system, a line, a connector switch having access to said line and including means responsive to the transmission of a control pulse over one of the talking conductors of said line for conditioning certain of the control equipment of said switch to be controlled over said line, a line circuit terminating said line and including a pair of relays sequentially operative in response to operation of said switch to seize said line, and means responsive to the operation of said relays for transmitting a control pulse over said one talking conductor.

18. In a telephone system, a line, a connector switch having access to said line and including means responsive to the transmission of a control pulse over one of the talking conductors of said line for conditioning certain of the control equipment of said switch to be controlled over said line, a line circuit terminating said line and including cut-off and lockout relays operative in response to operation of said switch to seize said line, and means controlled by said relays for transmitting a control pulse over said one talking conductor.

19. In a telephone system, multiparty lines of the metallic and ground return types, certain of said lines being arranged for divided ringing in signaling thereover, a connector switch having access to said lines and including ringing control equipment controllable from a calling station to select either side of a line for ringing current transmission, and means controlled over one side of a selected line of the ground return type for preventing the ground return side of the selected line from being used for ringing current transmission.

20. In a telephone system, multiparty lines of the metallic and ground return types, certain of said lines being arranged for divided ringing in signaling thereover, a connector switch having access to said lines and including ringing control equipment controllable from a calling station to select either side of a line for ringing current transmission, means responsive to the transmission of a control pulse over one side of a selected line of the ground return type for preventing the ground return side of the selected line from being used for ringing current transmission, and means operative during the operation of said switch to seize said selected line for transmitting a control pulse over said one side of said line.

21. In a telephone system, multiparty lines of the metallic and ground return types, certain of said lines being arranged for divided ringing in signaling thereover, a connector switch having access to said lines and including ringing control equipment controllable from a calling station to select either side of a line for ringing current transmission, line circuits individually terminating said lines, and means controlled from the line circuit terminating a selected line of the ground return type for preventing the ground return side of the selected line from being used for ringing current transmission.

22. In a telephone system, multiparty lines of the metallic and ground return types, certain of said lines being arranged for divided ringing in signaling thereover, a connector switch having access to said lines and including ringing control equipment controllable from a calling station to select either side of a line for ringing current transmission, line circuits individually terminating said lines and each including a cut-off relay operative in response to the operation of said switch to seize the associated line, and means controlled by the cut-off relay of a line circuit terminating a selected line of the ground return type for preventing the ground return side of the selected line from being used for ringing current transmission.

23. In a telephone system, multiparty lines of the metallic and ground return types, certain of said lines being arranged for divided ringing in signaling thereover, a connector switch having access to said lines and including ringing control equipment controllable from a calling station to select either side of a line for ringing current transmission, and means individual to the lines of the ground return type for preventing the ground return side of the associated line from being used for ringing current transmission regardless of the setting of said ringing control equipment.

24. In a telephone system, lines of different types requiring different modes of ringing for signaling thereover, a connector switch having access to said lines and including ringing control equipment having different settings for providing said different modes of ringing, and means individual to one of said lines for determining the setting of said ringing control equipment incident to the operation of said switch to seize said one line.

25. In a telephone system, lines of different types requiring different modes of ringing for signaling thereover, a connector switch having access to said lines and including ringing control equipment having different settings for providing said different modes of ringing, line circuits individually terminating said lines and each including a cut-off relay operative in response to seizure of the associated line by said switch, and means controlled by said cut-off relays for determining the setting of said ringing control equipment.

26. A line selecting switch including a ringing current transmission circuit, and a back-bridge relay having contacts included in said circuit.

27. A line selecting switch including a ringing current transmission circuit, and a back-bridge relay having contacts operative to complete said circuit.

28. A line selecting switch including a ringing current transmission circuit, a back-bridge relay having contacts included in said circuit, an operating circuit for said back-bridge relay, an alternating current relay energized by current traversing a portion of said circuit, and means controlled by said alternating current relay for completing said operating circuit.

29. A line selecting switch including a ringing current transmission circuit, a back-bridge relay operative to control said circuit before a call routed through said switch is answered, and a supervisory relay controlled by said back-bridge relay after said call is answered.

30. A connector switch having access to lines of two different types and including a ringing current transmission circuit having three branches, impulse controlled means for selectively conditioning two of said branches for ringing current transmission, and means responsive to operation

of said switch to select a line of one type for opening said two branches and for conditioning the third branch of said circuit for ringing current transmission.

31. A connector switch having access to lines of two different types and including a ringing current transmission circuit having three branches, impulse controlled means for selectively conditioning two of said branches for ringing current transmission, means responsive to operation of said switch to select a line of one type for opening said two branches and for conditioning the third branch of said circuit for ringing current transmission, a back-bridge relay operative to complete said third branch before a call routed through said switch is answered, and a supervisory relay controlled by said back-bridge relay after said call is answered.

32. In a telephone system, a plurality of lines, a connector switch having access to said lines and including means for transmitting pulses of ringing current over a selected one of said lines, means responsive to the answering of a call routed through said switch to one of said lines for instantaneously cutting off the transmission of ringing current over the selected line, and means responsive to the answering of a call routed through said switch to another of said lines for cutting off the transmission of ringing current over the selected line during a spacing interval which follows the transmission of a pulse of ringing current.

33. In a telephone system, lines of different types, a connector switch having access to said lines and including ringing control equipment having different settings for providing both instantaneous ring cut-off and silent period ring cut-off, and means controlled in accordance with the type of line selected by said switch for determining the setting of said ringing control equipment.

34. In a telephone system, lines of different types, a connector switch having access to said lines and including ringing control equipment having a normal setting for providing instantaneous ring cut-off and operative to another setting to provide silent period ring cut-off, and means responsive to the operation of said switch to select a line of a predetermined type for causing said ringing control equipment to assume said other setting.

35. In a telephone system, lines of different types, a connector switch having access to said lines and including ringing control equipment for providing both instantaneous ring cut-off and silent period ring cut-off, and means controlled in accordance with the type of line selected by said switch for conditioning said ringing control equipment to provide instantaneous ring cut-off when a line of one type is selected by said switch and for conditioning said ringing control equipment to provide silent period ring cut-off when a line of a different type is selected by said switch.

36. In a telephone system, full metallic lines and ground return lines, a connector switch having access to said lines and including ringing control equipment for providing both instantaneous ring cut-off and silent period ring cut-off, and means controlled in accordance with the type of line selected by said switch for conditioning said ringing control equipment to provide instantaneous ring cut-off when a metallic line is selected by said switch and for conditioning said ringing control equipment to provide silent period ring cut-off when a ground return is selected by said switch.

37. In a telephone system, simplex lines and loop lines, a connector switch having access to said lines and including ringing control equipment for providing both instantaneous ring cut-off and silent period ring cut-off, and means controlled in accordance with the type of line selected by said switch for conditioning said ringing control equipment to provide instantaneous ring cut-off when a loop line is selected and for conditioning said ringing control equipment to provide silent period ring cut-off when a simplex line is selected.

38. In a telephone system, a connector switch having access to lines of two different types and comprising a ring cut-off relay normally connected to be energized in series with the two sides of a selected line when a call routed through the switch to the selected line is answered, and means responsive to the operation of said switch to select a line of a particular type for connecting said ring cut-off relay to be energized over both sides of the selected line in parallel.

39. In a telephone system, a connector switch having access to lines of two different classes and comprising a ring cut-off relay adapted to be energized over a called one of said lines, ringing control equipment operative to transmit ringing current over a called one of said lines during ringing intervals which are separated by spacing intervals, means for connecting said ring cut-off relay to be energized over a called line of one class during both the ringing and spacing intervals, and means for connecting said ring cut-off relay to be energized over a called line of the other class only during the spacing intervals separating the ringing intervals.

40. In a telephone system, a connector switch having access to lines of two different classes and comprising a ring cut-off relay adapted to be energized over a called one of said lines, ringing control equipment operative to transmit ringing current over a called one of said lines during ringing intervals which are separated by spacing intervals, means for connecting said ring cut-off relay to be energized over a called line of one class during both the ringing and spacing intervals, and means responsive to the operation of said switch to select a called line of the other class for connecting said ring cut-off relay to be energized over the called line only during the spacing intervals separating the ringing intervals.

41. In a telephone system, a connector switch having access to lines of two different types and comprising a ring cut-off relay adapted to be energized over a called one of said lines, ringing control equipment operative to transmit ringing current over a called one of said lines during ringing intervals which are separated by spacing intervals, means for connecting said ring cut-off relay to be energized over the two sides of a called line of one type in series during both the ringing and spacing intervals, and means responsive to the operation of said switch to select a line of the other type for connecting said ring cut-off relay to be energized over the two sides of the called line in parallel only during the spacing intervals separating the ringing intervals.

42. In a connector switch, a ring cut-off relay, a back-bridge relay, operating circuits for said relays, contacts controlled by said back-bridge relay and included in the operating circuit for said ring cut-off relay, and contacts controlled

by said ring cut-off relay and included in the operating circuit for said back-bridge relay.

43. In a connector switch, a ring cut-off relay, a back-bridge relay operative to control the energization of said cut-off relay before a call routed through said switch is answered, and an operating circuit for said back-bridge relay controlled by said cut-off relay after a call routed through said switch is answered.

44. In a telephone system, multiparty lines of different types requiring different modes of ringing for signaling thereover, a connector switch operative to seize one of said lines in setting up a reverting call connection and including ringing control equipment having different settings for providing said different modes of ringing, means operative to extend a connection from said one line to said switch, and means responsive to the extension of said connection to said switch for determining the setting of said ringing control equipment.

45. In a telephone system, multiparty lines of different types requiring different modes of ringing for signaling thereover, a connector switch operative to seize one of said lines in setting up a reverting call connection and including ringing control equipment having different settings for providing said different modes of ringing, a test relay controlled in accordance with the character of said one line, a reverting call relay operative during seizure of said one line by said switch, and means jointly controlled by said relays for determining the setting of said ringing control equipment.

46. In a telephone system, multiparty lines of the metallic and ground return types, a connector switch operative to seize one of said lines of the ground return type in setting up a reverting call connection and including ringing control equipment for transmitting ringing current over either side of a line selected by said switch, means operative to extend a connection from said one line to said switch, and means responsive to the extension of said connection to said switch for preventing ringing current from being transmitted over the ground return side of said one line.

47. In a telephone system, multiparty lines of the metallic and ground return types, a connector switch operative to seize one of said lines of the ground return type in setting up a reverting call connection and including ringing control equipment for transmitting ringing current over either side of a line selected by said switch, means operative to extend a connection from said one line to said switch, a test relay operative in response to the extension of said connection to said switch, a reverting call relay operative during seizure of said one line by said switch, and means jointly controlled by said relays for determing the setting of said ringing control equipment.

48. In a telephone system, lines of different types requiring different modes of ringing for signaling thereover, line circuits individually terminating said lines, a connector switch having access to said lines and including ringing control equipment having different settings for providing said different modes of ringing, and means controlled from the line circuit terminating a calling one of said lines for determining the setting of said ringing control equipment.

49. In a telephone system, lines of different types requiring different modes of ringing for signaling thereover, line circuits individually terminating said lines and each including a cut-off relay, a connector switch having access to said lines and including ringing control equipment having different settings for providing said different modes of ringing, and means controlled by the cut-off relay of a line circuit terminating a calling one of said lines for determining the setting of said ringing control equipment.

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