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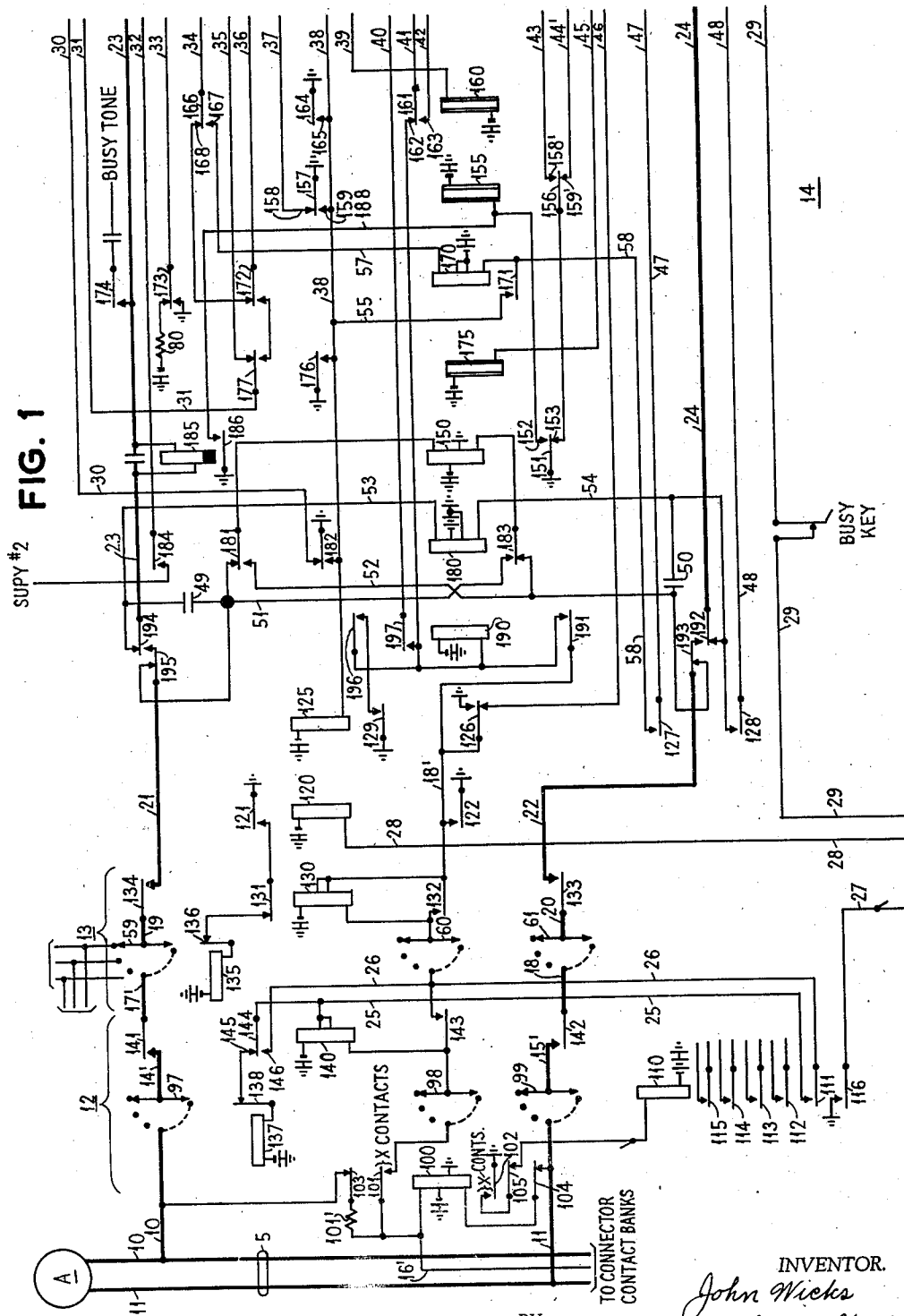
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2,137,518

TELEPHONE SYSTEM

Filed May 15, 1937

4 Sheets-Sheet 1



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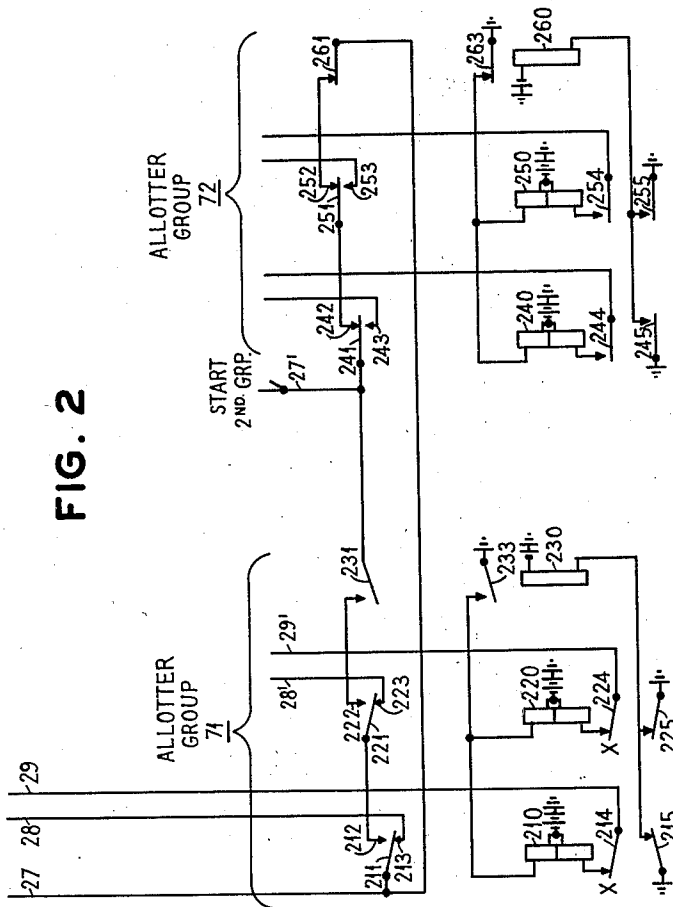
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4 Sheets-Sheet 2



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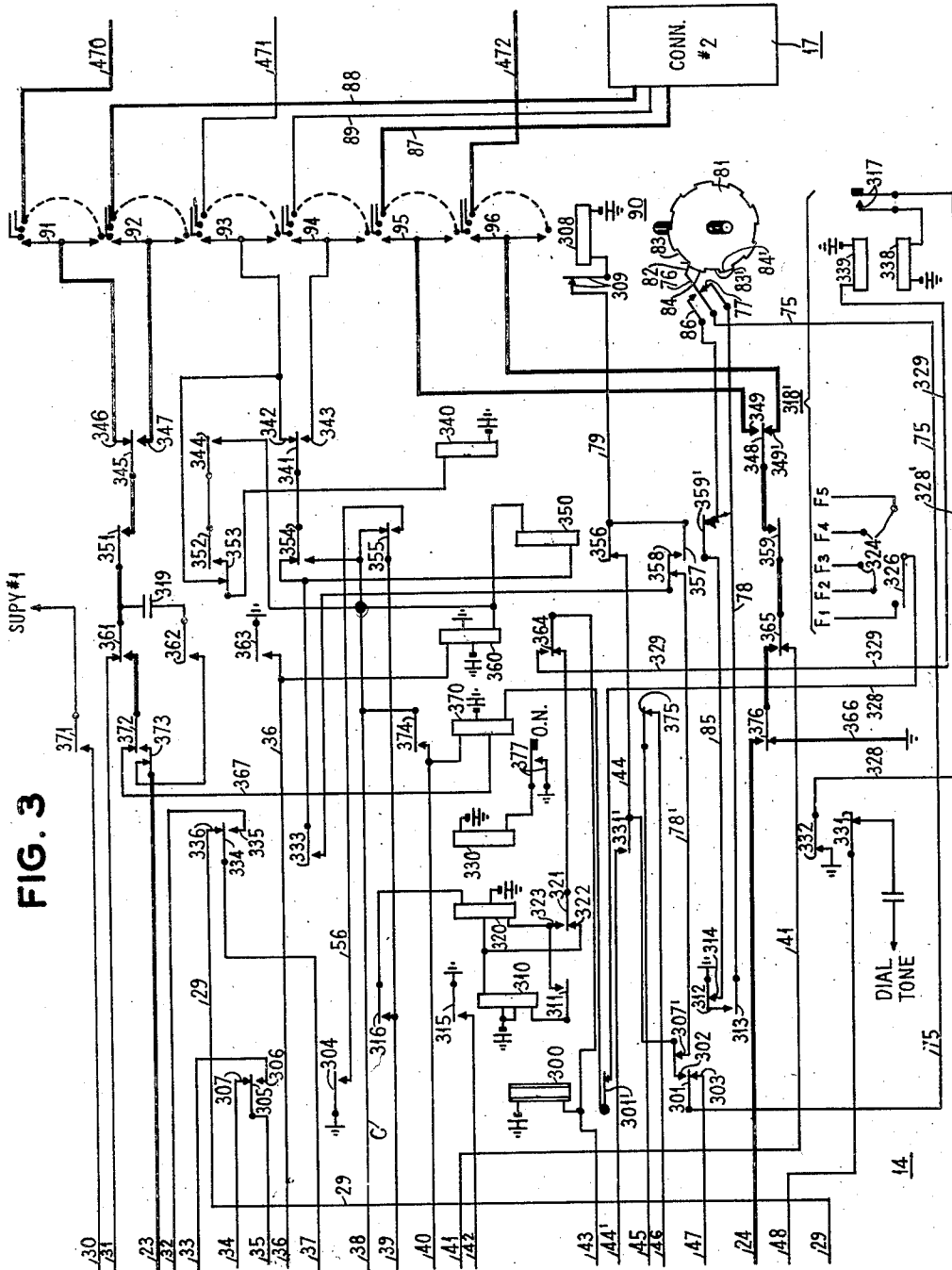
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4 Sheets-Sheet 3



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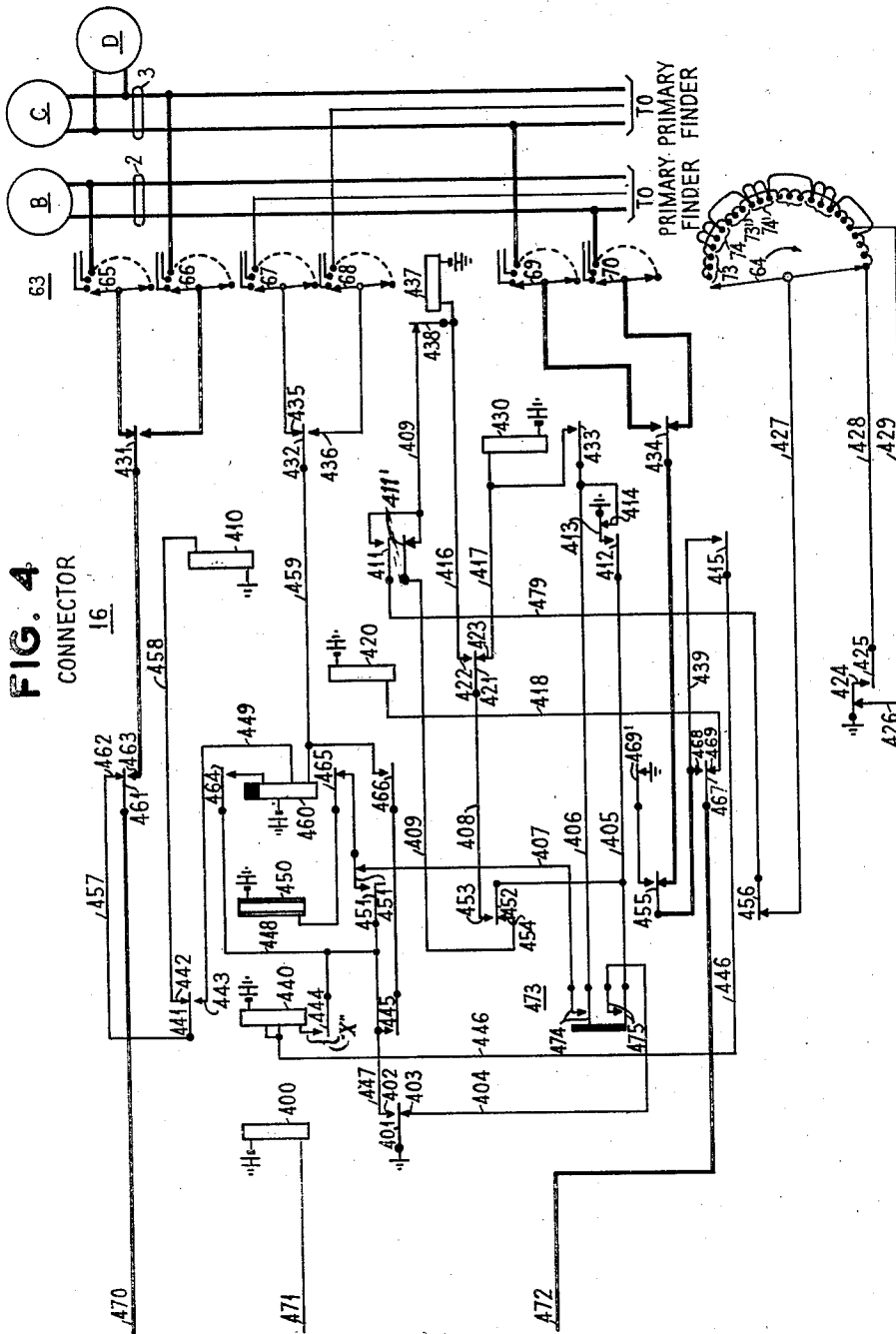
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TELEPHONE SYSTEM

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4 Sheets-Sheet 4



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2,137,518

TELEPHONE SYSTEM

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Application May 15, 1937, Serial No. 142,779

30 Claims. (Cl. 179—17)

The present invention relates to signalling systems and more particularly to automatic switching equipment of the type adapted for use in automatic telephone systems serving a comparatively small number of subscribers' lines.

One of the most widely used types of telephone systems yet devised is that employing single movement step-by-step line or finder switches and dual movement step-by-step selector and connector switches of the Strowger type, for setting up connections between the various lines of the system. In such a system the bank contacts of the final and intermediate selector switches are conventionally multiplied in groups, each unit multiple being connected to the trunk line of a connector switch, and the bank contacts of the connector switches are multiplied in groups, each unit multiple being connected to a subscriber's line or an inter-exchange trunk line. With this arrangement a connection may be established between any pair of lines included in the system by way of the selector switch or switches of a particular group or groups and a connector switch in the group of connector switches to which extends the called subscriber's line. While this type of system is perfectly satisfactory in operation, it is uneconomical in first cost when used in a small exchange, in that a large group of comparatively expensive connector switches is necessary if reasonably good service is to be obtained. Moreover, the equipment is costly to install in that large and expensive multiples must necessarily be carried between the bank contacts of the various switches. In addition, and due to the structural features of the Strowger type of switch, a considerable amount of space is necessary to accommodate the switching apparatus.

The disadvantages of a system of the above character are at least in part overcome by the arrangement disclosed in the prior Patent No. 1,903,207, Wicks et al., granted March 28, 1933. In the system of this patent, single movement rotary stepping switches are used both as concentration switches and as numerical switches with a consequent decrease in the cost per unit thereof and a lessened installation cost because of the smaller multiples therebetween. The rotary switches employed are of the fifty point line variety having embodied therein six levels of bank contacts and, while a greater number thereof is required than in the system employing Strowger switches, the smaller size thereof more than offsets the increase in number as regards cost and the space requirements for a given installation.

In the system of this patent, only one set of intermediate selector switches is employed, the incoming lines to the bank contacts of the selector and connector switches being, in each instance, multiplied in groups, with each unit multiple of the final intermediate selector switches extending to the trunk line of a connector switch and each unit multiple of the connector switches extending to a subscriber's line. As thus arranged, each particular group of connector switches has access to a group of fifty subscribers' lines. The control equipment associated with each of the selector switches is arranged to be responsive to impulses dialed at a substation on a line which has seized the corresponding switch and operates in a manner such that the wipers of each selector switch are, during the impulses of one series of impulses, driven over their respective associated bank contacts at the rate of one group of contact sets for each impulse and, at the conclusion of the impulse series, stand on the first contact set of the group of contacts to which extend the trunk lines of the connector switches in the bank contacts of which the particular called line terminates. In each position of the wipers the operated selector switch has access to the trunk line and test conductors of two connector switches in the selected group and, when the first series of impulses is ended, the trunk lines extending to the respective connector switches of this group are automatically and successively tested until an idle switch in the selected group is found. Immediately upon the seizure of an idle connector switch, it is conditioned to be responsive to further series of impulses transmitted from the impulsing device at the calling subscriber's substation.

The connector switches as disclosed in the above referred to prior patent are similar to the selector switches in that the subscribers' lines are multiplied in groups in the bank contacts thereof and the wipers for engaging these contacts when moved to any one of a plurality of positions to which they are operable have access to two different subscribers' lines. Here again the control equipment is so arranged that in response to the dialing of a second series of impulses the wipers are automatically stepped over the bank contacts at the rate of one contact group for each impulse. At the conclusion of the second series of impulses the control equipment is conditioned so that in response to a third series of impulses the wipers are stepped from one contact set to the succeeding contact set during each alternate impulse until the wipers engage the contacts of

the called line corresponding to the number of impulses of the digit dialed. More or less conventional means are provided for applying ringing current to the called line, for applying ring-back tone current to the calling line and for applying busy tone current to the calling line in the event the called line is found busy. Similarly, the release of a connection is effected in a more or less conventional manner by the removal of ground potential from the control conductor of the operated line, selector and connector switches when the established loop is interrupted at both the calling and called substations.

While the above-described prior arrangement of the patent noted is entirely satisfactory in operation, the economy resulting from the use of smaller switches and smaller multiples is offset to a certain extent by the fact that the required operating speed for the various rotary switches used is considerably in excess of the speed attainable by any of the low cost switches of this type now commercially available. Thus, with the arrangement shown, the wipers of each of the switches must, with a standard impinging rate ranging from 8 interruptions per second to 12 interruptions per second, necessarily travel at a rate of fifty contacts per second or more, in order to traverse one group of contacts during each impulse. Hence, the system necessarily requires expensive, specially constructed switches in order to operate in a satisfactory manner. Moreover, in the system of the prior patent, the selector and connector switches are practically independent in so far as the operation of the control apparatus included therein is concerned. In addition, the usual auxiliary functions such, for example, as the application of ringing current to a called subscriber's line, the application of ring-back tone current to a calling subscriber's line, the application of a busy tone current to a calling subscriber's line in the event a particular called line is found busy, and other similar functions of this nature are under the control of apparatus individually provided in each of the connector switches. Since, with the arrangement disclosed, the small rotary switches necessarily have a limited line capacity, a considerable number of connector units is required, thereby entailing a large amount of duplication in the matter of the control equipment provided for performing the specified auxiliary functions.

It is an object of the present invention, therefore, to provide an exceedingly simple and inexpensive arrangement of the general form briefly described in the immediately preceding paragraphs which does not require single movement rotary switches of special construction for satisfactory operation.

More specifically, it is an object of the invention to provide such a system which is susceptible of being incorporated in a larger system embodying a number of exchanges and wherein the auxiliary functions incident to the establishing of a connection between a pair of lines included in the system are concentrated in the selector switches and at least a portion of the control equipment provided in each of the connector switches is susceptible of being controlled from a portion of the control equipment necessarily included in each of the selector switches.

In general, the objects as set forth above are in part attained in accordance with the present invention by providing control means in each of the intermediate selector switches, which means are operated when the corresponding

switch is seized and during and following the establishment of a connection between a pair of lines in the system, and perform the group of auxiliary functions normally performed in a final selector or connector switch. These functions, as noted above, comprise the application of ringing current to the called line, the application of ring-back tone current to the calling line, and the application of busy tone current to the calling line in the event a called line is busy at the time a call is initiated thereto. As in the system of the prior patent referred to above, the impulse responsive means in each of the selector switches comprise a pair of relays, one of which operates on each alternate impulse of a series of received impulses. These relays comprise a portion of means for causing the associated selector switch to seize an idle connector switch of a particular desired group and in addition comprise means to which are responsive means in the seized connector switch for causing the last-mentioned switch to seize a desired called line.

The system is arranged to provide selective harmonic ringing of particular substations on a party line; that is, the ringing apparatus associated with each of the selector switches includes means responsive to a final digit dialed at a calling subscriber's substation for transmitting ringing current to a called line of a particular frequency to which is responsive only the signal device associated with the desired one of the telephones on the called line. The ringing operation is interrupted and the talking connection completed in response to the operation of a ring cut-off relay included in each selector switch.

The grouping of the lines extending to each of the automatic switches comprising the selector and connector switches is such that the number of contact sets in each group is so proportioned relative to the rate of impinging that the speed at which the switch wipers traverse the contact sets does not exceed forty contact sets per second. By this grouping arrangement, and by concentrating the auxiliary functions noted in the selector switches, the cost of the system, as installed, is considerably lessened.

The novel features believed to be characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, 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 Figs. 1, 2, 3 and 4, considered together, illustrate a system of the character briefly described above having the features of the present invention embodied therein.

Referring now to the drawings, there is illustrated an automatic telephone system having embodied therein the features of the present invention and employing exclusively automatic switches of the single movement step-by-step type for setting up connections between any pair of telephone lines of the system. In general, the system comprises a plurality of telephones or subscribers' substations, four of which are shown at A, B, C and D adapted to be interconnected by means including their respective associated lines 5, 2 and 3 and switch trains including the aforementioned step-by-step switches. These switch trains, when established, may individually comprise an operated primary finder switch, an operated secondary finder switch, an operated selector switch and a connector switch

accessible to the operated selector switch and having bank contacts in which the called subscriber's line terminates. Thus, in the system shown, the line 5 terminates at the bank contacts of a primary finder switch 12, which switch is accessible to at least one group of secondary finder switches, one of which is shown at 13. The latter switch is, in turn, associated with a selector switch indicated generally at 14 and in combination therewith forms a finder-selector unit. The selector switch 14 has access to each of the connector switches included in the system, one of these switches being indicated generally at 16 as including bank contacts in which the lines 2 and 3 terminate. In order that an idle secondary finder-selector unit will always be started, without delay, in search of a calling line, there are provided, as shown in Fig. 2, two groups of allotter relays indicated, respectively, at 71 and 72. As will be pointed out in detail hereinafter, the operation of these allotter groups is such that when a particular finder-selector unit is seized, the next succeeding idle finder-selector unit is conditioned to be seized by the next succeeding calling line.

It will be understood that the primary finder switches are arranged in groups having their bank contacts multiplied in groups to serve particular groups of subscribers' lines. With the system shown, each of the secondary finder switches has access to each of the primary finder switches. The connector switches, like the primary finder switches, are arranged in groups with each connector switch of each group having its bank contacts multiplied to the bank contacts of the other switches included in the same group, so that each group of connector switches serves a particular group of subscribers' lines. The selector switches, individual ones of which are associated with individual ones of the secondary finder switches, individually have access through their respective banks of contacts to each of the connector switches.

With a system employing apparatus of the type mentioned and designed to provide good service for 400 subscribers' lines, approximately forty-eight twenty-five point primary finder switches, twenty-one twenty-five point secondary finder switches, twenty-one twenty-five point selector switches and forty-eight twenty-five point connector switches are required. The forty-eight finder switches may be divided into eight groups with six switches in each group so that each subscriber's line has access to six different primary finder switches. Each of the twenty-one secondary finder switches, through the bank contacts embodied therein, has access to each of the forty-eight primary finder switches. Similarly, each of the selector switches has access through its bank contacts to each of the forty-eight connector switches. The last-mentioned switches, like the primary finder switches, are arranged in eight groups of six each with multiples extending between the corresponding contacts of the switches of each group so that six connector switches are available for completing a connection to each subscriber's line.

Each of the rotary primary and secondary finder switches is of more or less conventional form and is of the non-homing type; that is, of the type which is not restored to normal following the release of a switch train in which it is involved. Each switch comprises a twenty-five point, six contact set, bank contact arrangement with double-ended wipers for engaging the con-

tacts, the opposite ends of each wiper being offset so that each end engages or traverses the contacts of a different set of contacts. Thus, the switch 12 comprises six sets of bank contacts, three of which are shown in the drawings, and double-ended wipers 97, 98 and 99 for engaging the respective sets of contacts. This switch also includes a motor magnet 137 which in cooperation with a ratchet and pawl mechanism, not shown, is arranged to drive the wipers to engage the respective contacts, and a fast acting relay 140 for interrupting the circuit of the motor magnet when the wipers are stepped into engagement with the contacts of the calling line. The relay 140 is of the electro-polarized type such that energization of its upper winding does not cause the operation thereof, but only conditions the relay to be exceedingly fast acting when its lower winding is energized. Similarly, the switch 13 comprises six sets of bank contacts, three of which are shown, and double-ended wipers 59, 60 and 61 having their respective opposite ends offset so that, when driven by the motor magnet 135, they engage the contacts of different sets. This switch, like the primary finder switch 12, includes a fast acting relay 139 identical with the relay 140 which operates when the wipers of the switch come into engagement with the bank contacts corresponding to a primary finder switch seized by a calling line. The operation of the primary and secondary finder switches is initiated by line relays individually associated with the subscriber's lines, such, for example, as the relay 100 associated with the line 5.

Each of the two allotter groups 71 and 72 comprises a plurality of two-step relays individually associated with each of the secondary finder-selector links and a common relay which is normally operated but which restores when all of the links associated with the other relays of the corresponding allotter are busy. Thus, the group 71 comprises a number of relays 210, 220, etc. and a common relay 230 which is normally operated but which restores when all of the relays 210, 220, etc. are restored incident to an all busy condition of the respective associated finder-selector links. Similarly, the allotter group 72 comprises relays 240, 250, etc. individual to other finder-selector links of the system and a common relay 260. It will be noted that the relay 210 is individually associated with the finder-selector link 13, 14 by means of the conductor 29, this relay determining by the position of its armature 211 whether the indicated link 13, 14 or the next succeeding idle link will be seized. Seizure of the idle links of each group is in order and is accomplished through the contacts of the respective relays 210, 220, etc., start conductors 27, 28, 28', etc., and group relays such, for example, as the relay 110 associated with the group of lines including the line 5.

Neglecting for the present the arrangement of the selector switch 14 and the connector switch 16, the system as described above is more or less conventional in form, and its operation is well understood in the art. Thus, assuming that a connection is desired between the subscribers' substations A and B on a call from the line 5 to the line 2 and assuming that the switches illustrated are the switches involved in establishing this connection, the operation of the apparatus is initiated by the calling party at the substation A lifting his receiver from its hook to cause the line relay 100 to operate and mark the calling line in the bank contacts of the group

of primary finder switches including the switch 12. Simultaneously the start relay 110 is energized to mark in the bank contacts of the secondary finder switch 13 the primary finder switches of the group at which the calling line terminates.

The secondary finder switch 13 thereupon operates to seize the first idle primary finder switch in the group including the switch 12; and assuming this particular primary finder switch is seized, it operates to seize the calling line 5. When this occurs, the line conductors 10, 11 of the line 5 are connected directly to the conductors 21, 22 leading to the selector switch 14. The control equipment of the seized selector switch 14 is thereupon conditioned to be responsive to the first series of impulses transmitted from the impinging device at the substation A.

In response to the dialing of the first digit comprising the first series of impulses, the control equipment of the seized selector switch 14 causes the wipers of this switch to be stepped into engagement with the first contact set of the group of contact sets to which extend the lines of the respective connector switches in the group of connector switches at which the called line terminates. Thereafter, and at the conclusion of the first series of impulses, the selector switch 14 automatically and in succession tests the line conductors leading to the respective connector switches of the selected group until an idle switch in this group is found, whereupon the idle switch is seized and the control equipment included therein is conditioned to be responsive to further impulses transmitted from the impinging device at the calling substation A.

In response to the dialing of the second or tens digit and assuming the switch 16 to be the switch seized, the wipers of this switch are stepped into engagement with the last contact set of the group of contact sets preceding the group of contact sets in which is included the contact set corresponding to the called line. When the third or units digit is dialed, the wipers of this switch are stepped into engagement with the contacts at which the called line terminates.

If the called line is idle at the time the wipers of the connector switch are stepped into engagement with these contacts, ringing current is automatically applied thereto and ring-back tone current is transmitted back over the calling loop to indicate to the calling party that the called line is idle. In the event the called line is busy, busy tone current is returned over the loop to the calling subscriber to indicate the busy condition of the line.

As will be pointed out in greater detail hereinafter, the release of a connection established in the above described manner is under the control of the last party to hang up his receiver. Thus, if the party at the calling substation A replaces his receiver on its hook, the switch train is held operated until the called party at the substation B hangs up. Similarly, if the party at the substation B hangs up first, the switch train is held operated until the connection is cleared out at the calling subscriber's substation A.

Referring now more particularly to the details of the selector and connector switches having embodied therein the features of the present invention, each of these switches comprises a bank of contacts arranged in six sets, six double-ended wipers, individual ones of which are associated with each level of contacts, a motor magnet and

associated ratchet and pawl mechanism for driving the wipers, and control means comprising a plurality of interrelated relays for controlling the operation of the motor magnet and for completing a talking loop between a pair of subscribers' lines once a connection has been set up therebetween. As will be pointed out in detail hereinafter, each of the selector switches is, by virtue of the wiper rotating mechanism included therein, operable to a plurality of positions and, through the action of a wiper switching relay, has access to two of the connector switches in each position thereof. Similarly, each of the connector switches is operable to a plurality of positions and has access to two subscribers' lines in each position thereof. Each of the selector switches differs from each of the connector switches in that there are provided impulse responsive means comprising a pair of relays, one of which operates during each alternate impulse of a series of received impulses and restores during each of the remaining impulses. The control means in each of the selector switches includes means responsive to the operation of the impulse responsive relays for causing the motor magnet and its associated ratchet and pawl mechanism to step the associated wipers over their associated contact sets at the rate of one group of contact sets for each impulse during a particular series of impulses. The motor magnet of each selector switch is also adapted to be controlled automatically to step the wipers at the rate of one contact set each time the magnet is energized after these wipers have been stepped into engagement with the first contact set of the group of contact sets corresponding to the desired group of connector switches.

The control apparatus included in each of the connector switches is simple in the extreme. Certain of the relays individually included therein are arranged to be responsive to the one relay of the aforementioned impulse responsive means which operates on each alternate impulse of a series of received impulses. The control of the switch mechanism is fundamentally the same as that of each of the selector switches in that the wipers are first stepped over groups of contact sets at the rate of one group of contacts for each impulse, following which, and during a succeeding series of impulses, the wipers are stepped at the rate of one contact set per impulse until they engage the contacts at which the conductors of the called line terminate.

Considering specifically the selector switch illustrated in Figs. 1 and 3, this switch comprises a switch mechanism 90 which includes six sets of bank contacts at which the outgoing trunks leading to the connector switches are terminated, wipers 91 to 96, inclusive, for engaging the respective sets of contacts, a camming element 81 on the same shaft as the wipers 91 to 96, inclusive, a ratchet and pawl mechanism, not shown, for driving the wipers and the camming element, and a motor magnet 308 for causing the actuation of the ratchet and pawl mechanism. The control means included in this selector switch comprises a plurality of interrelated relays 125, 150, 155, 160, 170, 175, 180, 185, 190, 300, 310, 320, 330, 340, 350, 360 and 370, their control and controlled circuits, all arranged to cause the switch 14 to operate in the manner briefly set forth above. Of the enumerated relays, the relays 316 and 320 comprise the impulse responsive means to which the actuating means of this selector switch is responsive and also to which certain of the control relays in

any connector switch seized by this selector switch are responsive. As will be pointed out in greater detail hereinafter, the sequence of operation of the two relays is such that the relay 310 operates at the beginning of each odd impulse, the relay 320 operates at the end of each odd impulse, the relay 310 restores at the beginning of each even impulse, and the relay 320 restores at the end of each even impulse. These relays in cooperation with the camming element 81, the cam springs 76, 77 and 86 and the relays 300, 340 and 350 comprise the necessary control means for causing the motor magnet 308 to step the wipers 91 to 96, inclusive, into engagement with the first contact set of a desired group of contact sets at the rate of one group for each impulse, and also the means for automatically stepping the wipers over the contact sets of the desired group until a trunk leading to an idle connector switch in the selected group of connector switches is found. Selective harmonic ringing of a desired substation on a party line is achieved by the provision of a frequency selecting minor switch 318' including one set of bank contacts indicated at 324, a wiper 326 for engaging the contacts, a ratchet and pawl mechanism, not shown, for actuating the wiper, a motor magnet 339 for driving the ratchet and pawl mechanism, and a release magnet 338 for permitting the minor switch to restore to its normal position during the release of an established connection involving the selector switch 14. The control of this minor switch is such that it is automatically connected by means comprising the relay 360 to be responsive to a final digit dialed at a calling substation, when the wipers thereof are rotated in accordance with the impulses of this digit to select ringing current of the frequency to which only the particular desired substation on the called party line is responsive.

The connector switch 16 is, from the standpoint of construction, substantially similar to the selector switch 14 but differs therefrom in that an added set of contacts is included therein and the camming mechanism is omitted. In brief, the mechanism of the switch indicated at 63 comprises seven sets of bank contacts, double-ended wipers 64 to 72, inclusive, for engaging the respective sets of contacts, a ratchet and pawl mechanism, not shown, for actuating the wipers, a motor magnet 437 for driving the ratchet and pawl mechanism, and control means comprising relays 400, 410, 420, 430, 440, 450 and 460, their control and controlled circuits for causing the motor magnet 437 and its associated ratchet and pawl mechanism to drive the wipers of the switch in the manner briefly described above. The control circuits for these relays are so connected and arranged that following seizure of this switch by a selector switch such, for example, as the switch 14, and at the beginning of the second series of impulses, the circuit for the relay 410 is completed immediately upon the operation of the slow-to-release relay 300 of the operated selector switch and conditions the circuits associated with the relay 420 to operate in accordance with the operation of the impulse responsive relay 310. These two relays, namely the relays 410 and 420, in cooperation with the wiper 64 and its associated set of bank contacts specifically comprise the means responsive to the operation of the relay 310 for causing the motor magnet 437 to operate, thereby causing the wipers of the switch 63 to be stepped at the rate of one group of contact sets per impulse during the series of impulses com-

prising the second dialed digit. In order to rearrange the control circuit for the motor magnet 437 so that the wipers will be stepped at the rate of one contact set for each odd impulse during the third series of impulses, the relay 450 is adapted to operate, when the relay 410 restores at the end of the second series of impulses, to prepare an alternative circuit for the winding of the motor magnet 437 such that this magnet is energized and deenergized in accordance with the operation and restoration of the relays 310 and 420 during the third series of impulses.

Referring now more specifically to the operation of the system during a call from the substation A, for example, to the substation C, for example, the operation of the apparatus is initiated, as was pointed out above, in response to the subscriber at the first-mentioned substation lifting his receiver from its hook. This operation closes a bridge across the line conductors 10 and 11 of the calling line 5 to complete a circuit for energizing line relay 100 in series with the resistor 101', this circuit extending from ground at the lower winding of the relay 100, through this winding and by way of the armature 104, the line conductor 11, the bridge at the calling substation, the line conductor 10, the armature 103, the resistor 101' and through the upper winding of the relay 100 to battery. Due to the presence of the resistor 101' in the above traced circuit, relay 100 only partially operates to make only the "X" contacts associated with the armatures 101 and 102. At the second of these armatures a circuit is completed for energizing the relay 110, and at the first thereof a path is completed for marking the calling line 5 in the control contact banks of the primary finder switches in which the line 5 terminates. The relay 110, upon operating, closes its armatures 111 to 116, inclusive, to their respective associated contacts. When the contacts associated with the respective armatures 111 to 116, inclusive, make, each of the group of primary finder switches at which the calling line conductors 10, 11 terminate is marked in the control contact banks of the secondary finder switches. Thus, when the contacts associated with the armature 111 engage, a path is completed extending from battery at the upper winding of the relay 140 by way of the conductor 25, the armature 111, and the conductor 26 to the fourth control contact of the switch 13. When the armature 116 is operated to engage its associated contact, it applies ground to the start conductor 27, thereby to cause the relays in the allotter group 71 to select an idle secondary finder-selector link.

Before proceeding with the operation of the finder switches, a brief description of the allotter relays or common control apparatus is deemed to be in order. As noted previously, each of these relays 210, 220, 240 and 250, etc. corresponds to one of the secondary finder-selector links, these relays preferably being divided into two or more groups for a system embodying four hundred or more subscribers' lines, for the purpose of expediting the selection of an idle selector link.

As will be pointed out more specifically hereinafter, when any given link is idle, ground is present on the conductor corresponding to the conductor 29 for the selector switch 14. Thus, when the selector switch 14 is idle, ground extends from the armature 157 of the relay 155 by way of its associated contact 158, the conductor 37, the armature 334 and its associated contact 336 to the conductor 29. As a result, the lower or active winding of the relay 210 is energized

and all of the armatures of the relay are in their fully operated positions. The armature 211, therefore, is closed to its associated contact 213 to prepare a circuit for energizing the relay 120.

At the armature 215, a circuit is completed for energizing the relay 230 which relay, in its operated position, holds interrupted the circuits for energizing the respective primary windings of all the relays common to the group 71 in which the relay 210 is included. When a connection by way of the finder switches 12 and 13 is completed to the selector link 14, ground is removed from the conductor 29 at the armature 157 of the relay 155 and hence this relay is permitted to restore. In its restored position the relay 210 connects the start conductor 27 by way of its armature 211 to the conductor, corresponding to the conductor 28, for the next succeeding idle selector link controlled by the allotter group 71. Thus, if the link corresponding to the relay 220 is idle this relay will be in its fully operated position so that the start conductor 27 is connected over an obvious path to the conductor 28'. In this manner the selector links are successively seized and an idle selector link is always immediately available for a calling line in the group corresponding to the allotter group 71, so long as all of the selector links thereof are not busy. When the last relay, corresponding to the relays 210 and 220, of the first group, is restored, following the seizure of its associated selector link, the operating circuit for the relay 230 is opened at the armatures 215, 225, etc., and this relay momentarily restores to complete at its armature 233 the primary circuits for re-energizing the upper windings of the relays 210, 220, etc. These latter relays in turn partially operate to close their respective "X" contacts. Those of the associated selector links which are idle will, as was pointed out above, have ground on the associated conductor such, for example, as the conductors 29 and 29' and hence, when the "X" contacts of the associated allotter relays are closed, these relays will assume their fully operated positions to render available for use all of the selector links not busy and to cause the re-operation of the relay 230. If all of the selector links corresponding to the allotter relays of the group 71 become busy at the same time, the operating circuit for the relay 230 is interrupted because all of the armatures corresponding to the armatures 215 and 225 of the relays 210 and 220, respectively, are restored. As a consequence, the relay 230 restores to connect, over an obvious path including the armature 231, the start conductor 27 of the first group to the conductor corresponding to the conductor 28 for the first idle selector link available in the group governed by second allotter group 72. The operational sequence of the relays 240, 250, etc., and 260, included in the allotter group 72 is identical with that described above for the relays of the allotter group 71 and hence a description thereof is omitted in the interests of simplifying the description.

Continuing now with the operation of the primary and secondary finder switches to search for and seize the calling subscriber's line 5, and assuming that the selector link 14 is the first idle link available, when ground is extended by way of the armature 116, the conductor 27 and the armature 211 to the conductor 28, a circuit is completed for energizing the relay 120. This relay thereupon operates to complete, at its armature 122, an obvious circuit for energizing the upper winding of the relay 130, thereby to render

this relay fast to operate, and to complete, at the same armature, a circuit for energizing the relay 175. The last-mentioned circuit extends from ground at the armature 122 over the conductor 18' through the restored armature 126, over the conductor 46 through the armature 375, over the conductor 45, and through the winding of the relay 175 to battery. In response to its energization over the above traced circuit, the last mentioned relay operates partially to condition the selector switch 14 to be responsive to impulses transmitted from the calling substation A. Thus, upon operating this relay applies at its armature 176, ground to the control conductor 38 thereby to complete circuits for energizing the relays 125 and 160. The first of these circuits extends from ground at the armature 176 by way of the conductor 38 through the winding of the relay 125 to battery and the second thereof extends from ground at the same armature over the conductor 39, through the armature 355, over the conductor 38 and through the winding of the relay 160 to battery. When the relay 125 operates it opens, at its armature 126, the previously traced energizing circuit for the relay 175. Before the last-mentioned relay falls back, however, the relay 160 is operated to close at its armature 164 and associated contact 165 multiple ground to the conductor 38 thereby to hold itself and the relay 125 operated.

Returning now to the operations which occur when the relay 120 operates, it will be seen that this relay in its operated position completes, at its armature 121, an obvious circuit for energizing the motor magnet 135. This magnet includes self-interrupting contacts associated with the armature 136 such that it operates buzzer fashion to cause the associated ratchet and pawl mechanism to advance the wipers 59-61, inclusive, of the switch 13 into engagement with the contacts corresponding to the first idle primary finder switch of the group at which the calling line terminates, or in the case assumed, to the fourth position corresponding to the primary finder switch 12. When this occurs a circuit is completed for energizing the lower winding of the relay 130, this circuit extending from ground at the armature 122 through the lower winding of the relay 130, the control wiper 60 and its associated fourth contact, over the conductor 26, the armature 111 and the conductor 25 and through the upper winding of the relay 140 to battery. The relay 130 immediately opens, at its armature 131, the operating circuit for the motor magnet 135, connects the conductors 21 and 22, respectively, to the conductors 19 and 20, respectively, at the respective armatures 134 and 133, and short circuits, at its armature 132, its lower winding. The relay 130 remains operated, however, by virtue of the energized condition of its upper winding. When the armature 132 is operated into engagement with its associated contact a direct path from ground is completed for energizing the motor magnet 137 and the upper winding of the relay 140, this path extending from ground at the armature 122 through the armature 132, the control wiper 60 and its associated fourth contact, and over the conductors 26 and 25, where the path divides, one branch extending through the armatures 144 and 138, and the winding of the motor magnet 137 to battery, and the other branch extending through the upper winding of the relay 140 to battery. Energization of the last-mentioned winding conditions, in a well-known manner, the relay 140 to be exceedingly

fast in operating when its lower winding is energized. By virtue of the self-interrupting contacts associated with the armature 138, the motor magnet 137 in cooperation with its associated ratchet and pawl mechanism drives the wipers of the primary finder switch 12 to a position corresponding to the calling line 5, or, in this case, into engagement with the fourth set of contacts in the contact bank. When this occurs a circuit is completed for energizing the lower winding of the relay 140 and the upper winding of the relay 100 in series, this circuit extending from ground at the armature 122, over the conductor 18' through the armature 132, the control wiper 60 and its associated fourth contact, over the conductors 26 and 25, and through the lower winding of the relay 140, the control wiper 98 and its associated fourth contact, the "X" contacts associated with the armature 101 and the upper winding of the relay 100 to battery. The relay 140 immediately operates in response to such energization to interrupt, at its armature 144 and associated contact 145, the operating circuit for the motor magnet 137, and to place a shunt around the armature 111 at this same armature and its associated contact 146. The relay 140, upon operating, also connects, at its armatures 141 and 142, respectively, the conductors 21 and 22 to the conductors 10 and 11, respectively, of the calling line 5. At its armature 143, this relay short circuits its lower winding, but remains operated by virtue of the energized condition of its upper winding.

When the relay 140 operates to short circuit its lower winding, a direct path is completed for causing the energization of the upper winding of the relay 100, this path starting at ground on the operated armature 122 and extending through the armature 132, the wiper 60, the armature 143, the wiper 98, the closed "X" contacts associated with the armature 101 and the upper winding of the relay 100 to battery. Thereupon, this line relay fully operates to interrupt, at its armature 105, the operating circuit for the relay 110, permitting this relay to restore and open the contacts associated with the armatures 111 to 116, inclusive, thereby to release the start conductor 27 and the allotter group 71 for further use. The relay 100, upon operating, also interrupts, at its armatures 103 and 104, and their respective associated contacts, its original energizing circuit. When the relay 110 falls back it opens, at its armature 116 and associated contact, the previously traced operating circuit for the relay 120, which latter relay restores to open, at its armature 121, a further point in the operating circuit for the motor magnet 135. At its armature 122, the relay 120 also removes multiple ground from the conductor 18' but ground is retained on this conductor at the armature 126 and the associated front contact of the relay 125, so that the relays 100, 140 and 130 are held operated.

With the system in this condition the bridge at the calling substation A across the line conductors 10 and 11 is extended to the line conductors 21 and 22 to complete a circuit for energizing the line relay 150, this circuit extending from ground at the lower winding of the relay 150 by way of the armatures 183 and 193, the conductors 22, 20, 18, 15', and 11, through the bridge across the conductors 11 and 10 at the calling substation, over the conductors 10, 14', 17', 19 and 21, and through the armatures 195, 181, and the upper winding of the relay 150 to

battery. When the line relay 150 operates, it completes, at its armature 151 and associated contact 152, an obvious circuit for energizing the slow-to-release hold relay 155. The latter relay, in turn, operates to interrupt, at its armature 157 and associated contact 158, the circuit extending by way of the conductors 37 and 29 for energizing the lower winding of the allotter relay 210. Thus, this allotter relay is permitted to restore and prepare, at its armature 211 and associated contact 212, a circuit for energizing the relay corresponding to the relay 120, in the next succeeding idle secondary finder-selector link. The relay 155, at the same armature 157 and its associated contact 159, closes multiple ground to the control conductor 38. It is noted that the application of ground to the conductor 38 completes an obvious circuit for energizing the lower winding of the relay 360. This relay is of the polarized type such that it does not operate when its lower winding is energized but is rendered exceedingly fast to operate when its upper winding is subsequently energized. At its armature 156 and associated contact 158', the relay 155 prepares a circuit extending by way of the conductor 43 for energizing the slow-to-release relay 300, and a circuit extending by way of the conductor 43, the armature 364, and the armature 321 for energizing the impulse responsive means comprising the relays 310 and 320.

With the system in this condition the calling line is extended through the primary finder switch 12 and the secondary finder switch 13 to the idle selector switch 14, which switch is now in condition to be responsive to impulses transmitted from the impulsing device at the calling substation A. By way of summarizing, it is pointed out that the allotter group No. 1 is now released and that the relays 100, 140, 130, 125, 150, 155 and 160 are in their respective operated positions, the remaining relays shown in Figs. 1, 3 and 4 of the drawings being in their respective restored positions. It is further pointed out that immediately upon the wipers of the primary finder switch 12 coming into contact with the bank contacts corresponding to the line 10, 11, dial tone is returned over the loop to the calling subscriber. Thus, when the relay 125 operates in the sequence of operations thus far described, it completes, at its armature 128, a circuit including the loop extending to the calling substation, the condenser 50 and the upper winding of the relay 150, for energizing the receiver at the calling substation with dial tone current.

As pointed out previously the control circuits for the relays 310 and 320 are so connected and arranged that the relay 310 operates at the beginning of each odd numbered impulse, the relay 320 operates at the end of each odd numbered impulse, the relay 310 restores at the beginning of each even numbered impulse, and the relay 320 restores at the end of each even numbered impulse, all in response to the alternate operation and restoration of the line relay 150. Thus, at the beginning of the first impulse transmitted from the impulsing device at the calling subscriber's substation, the bridge across the line conductors 10 and 11 is interrupted at the calling substation A to open the operating circuit for the line relay 150 and permit this relay to restore. At its armature 151 and associated contact 153, this relay completes the previously prepared circuit extending by way of the operated armature 156 and the conductor 43, for energizing the relay 300 and the upper winding of the relay 310, 75

causing both relays to operate. When the relay 310 operates it closes, at its armature 316, a shunt around the upper winding of the relay 320, this shunt extending from ground on the conductor 38 through the armature 316, the upper winding of the relay 320 and the armatures 321 and 364, over the conductor 43 and through the armatures 156 and 151 back to ground. At its armature 311, the relay 310 prepares a circuit for energizing its lower winding. At the end of the first impulse when the line relay 150 reoperates to interrupt at its armature 151 the original circuit for energizing the relay 310, the above traced shunt is removed from around the upper winding of the relay 320, permitting this relay to energize in series with the upper winding of the relay 310. The relay 320 thereupon operates to prepare, at its armature 321 and associated contact 323, a circuit for energizing the lower windings of each of the relays 310 and 320.

At the beginning of the second impulse when ground is returned to the conductor 43 at the armature 151 of the line relay 150, the respective lower windings of the two relays 310 and 320 are energized. The lower winding of the relay 310 is differentially wound with respect to the upper winding thereof and, consequently, causes this relay immediately to restore to interrupt, at its armature 316, the original circuit over which the upper winding of the relay 320 was energized. In order to render the relay 310 quick to restore the lower winding thereof is so proportioned relative to the upper winding that the magnetic field produced thereby greatly predominates over that of the upper winding. At its armature 311, the relay 310, upon restoring, obviously interrupts the circuit including its lower winding and, at its armature 316, interrupts the circuit including the upper winding of the relay 320 and the relay 310 in series. The relay 320 remains operated, however, by virtue of a direct circuit from ground on the conductor 43, through the armature 321 and its associated contact 323 and the lower winding thereof to battery. At the end of the second impulse when ground is again removed from the conductor 43 at the armature 151, the operating circuit including the lower winding of the relay 320 is interrupted, permitting this relay to restore. Thus, the control circuits for the relays 310 and 320 are in the condition which prevailed before the beginning of the first impulse. The same sequence of operations as that described above for the first and second impulses occurs during each succeeding pair of impulses. From the foregoing description, it will be seen that the condition of the relays 310 and 320 at the end of a particular digit depends upon the number of impulses in the digit. Thus, if the number of impulses is odd, both of the relays 310 and 320 are operated, whereas if an even number of impulses comprises a particular digit, both of the relays are restored.

Returning now to the operations which occur in response to the impulses comprising the first digit, at the beginning of the first impulse of this digit and simultaneously with the first operation of the relay 310, the relay 300 operates. Due to its slow-to-release characteristic this relay remains operated during the remaining impulses of the digit. At its armature 301 and associated contact 302, this relay prepares a circuit for energizing the motor magnet 308, this circuit extending from battery at the magnet 308, through the winding of this magnet, the self-interrupting contacts associated with the armature 309, over the conductor 79, through the restored armature 356,

over the conductor 44, through the contact 302 and its associated armature 301, over the conductor 75, through the cam spring 76 and the associated lower spring 77, and over the conductor 78 to the armature 313. At its armature 301 and associated contact 302, the relay 300 opens a point in the circuit, traced hereinafter, for energizing the relay 350 from battery at the motor magnet 308. This prevents the relay 350 from operating as the test wipers 93 and 94 pass over contacts corresponding to idle trunks outgoing from the selector switch during the trunk group selection. At its armature 304, the relay 300 prepares an alternative circuit for holding the relay 160 operated, this circuit being held open at the armature 355 of the restored relay 350.

Since the relay 310 operates simultaneously with the slow-to-release relay 300, it completes at its armature 313 the previously traced circuit for energizing the motor magnet 308. This magnet thereupon, in cooperation with its associated ratchet and pawl mechanism, starts to drive the wipers 91-96, inclusive, and the camming element 81. Almost immediately, however, the cam follower portion 82 of the spring 76 is lifted from the depression 83 onto the first cam projection 84, thereby to interrupt at the spring 77 the previously traced circuit for energizing the motor magnet 308.

With the camming element 81 in this position the cam follower portion 82 of the spring 76 rests just on the leading edge of the projection 84, and the wipers 91-96, inclusive, are in engagement with the first contact set in the contact bank. Simultaneously with the interruption of the previously traced circuit for energizing the motor magnet 308 an alternative circuit is prepared for this magnet, this circuit extending from ground at the armature 312 by way of the contact 314, the conductor 85, and the upper spring 86 associated with the cam spring 76 to the conductor 75 which leads, over the branch of the circuit described above, through the winding of the motor magnet 308 to battery. This circuit is maintained open until the beginning of the second impulse when the relay 310 restores. At the beginning of the second impulse when the relay 310 is de-energized, the armature 312 falls back and completes this alternative circuit, whereby the motor magnet 308 is again energized to operate buzzer fashion and, in cooperation with its associated ratchet and pawl mechanism, drives the wipers 91-96, inclusive, and the camming element 81 over an arc including the first group of three contacts and corresponding to one group of six connector switches. This driving operation is interrupted when the follower portion 82 of the cam spring 76 falls from the trailing edge of the cam projection 84 into the leading edge of the second depression 83'. When this occurs the alternative operating circuit for the motor magnet 308 is interrupted at the spring 76 and the associated spring 86 and the first traced circuit for this magnet is again prepared at the springs 76 and 77.

At the beginning of the third impulse when the relay 310 is again energized, the first-mentioned circuit for energizing the magnet 308 is recompleted at the armatures 312 and 313. The motor magnet 308 thereupon causes the wipers 91-96, inclusive, and the camming element 81 to be rotated over a second group of contacts and into engagement with the first contact set of the third group of contact sets when the follower portion 82 of the spring 76 rides over the leading edge

of the second projection 84' of the camming element and the operating circuit for the magnet 308 is again opened at the springs 76 and 77.

This mode of operation continues for succeeding impulses, the wipers of the rotary switch 90 being driven over a complete group of contacts for each impulse and engaging at the end of each impulse the first contact set of the succeeding group of contact sets. During the first impulse the wipers 91-96, inclusive, are driven into engagement with the first contact set of the first group of contacts. In order to secure the above-described operation it will be apparent that the width of the projections 84, 84', etc., and the depressions 83, 83', etc., must be so related to the number of contact sets of each group that at the end of each impulse the wipers are standing on the first contact set of the group of contact sets corresponding to the number of the impulse. Thus, the relation is such that at the end of the first impulse the wipers rest on the first contact set of the first group of contact sets, at the end of the second impulse the wipers rest on the first contact set of the second group, and so on.

The speed at which the wipers 91-96, inclusive, must travel in order to cover an entire group of contacts during each impulse is determined by the relation between the number of contact sets constituting a group of contact sets and the rate of impulsing. As pointed out previously, this speed is great and considerably in excess of the normal speeds of which standard rotary switches are capable when the arrangement requires a standard impulsing rate ranging from eight to twelve impulses per second and any considerable number of contact sets per group.

In accordance with one feature of the present invention the number of contact sets for each group and more particularly the number of lines terminating at the respective contact sets of each group are so related to the impulsing rate that the required speed of the switch wipers is well within the maximum speed attainable by standard commercial rotary switches. Thus, with the forty-eight connector switches of a four hundred line system divided into eight groups and each group requiring only three contact sets in the contact banks of the respective selector switches, it will be seen that each wiper need travel over only three contacts to pass from one group of connector switches to the next succeeding group. With a standard impulsing rate of eight to twelve impulses per second this corresponds to a wiper speed of something less than forty contacts per second which is well within the maximum operating speed attainable by standard switches. In this connection it is pointed out that if the wipers, during any one impulse, travel from one group of contact sets to the first contact of the succeeding group before the impulse terminates, no harm is done since the cam spring 76 automatically opens the operating circuit for the motor magnet 308 immediately upon the wipers reaching the first contact of the second group and independently of the duration of the impulse. If, however, the speed of the rotary switch is insufficient to insure the wipers traveling over an entire group of contact sets false routing of calls results. As pointed out previously, with the above-described arrangement of the connector switches a twenty-five point rotary switch having six sets may conveniently be used as the switch 90. Thus, with three contacts of each set in use for each group of six connector switches only twenty-four con-

tacts will be required, the twenty-fifth being left for the normal or home position of the wipers.

Returning again to the operations which occur in response to the dialing of the first digit, at the beginning of the first impulse of this digit and when the wipers are stepped into engagement with the first contact set of the first group, the off-normal springs 377 are closed. The springs 377, upon closing, complete an obvious circuit for energizing the relay 330, which relay operates and, at its armature 334 and associated contact 336, opens a further point in the circuit including the lower winding of the allotter relay 210. At this same armature and its associated contact 335, the relay 330 prepares a circuit including the conductors 37 and 32 for energizing the supervisory lamp No. 2, this circuit being held open at the armature 184 of the battery reversing relay 180. The relay 330, at its armature 332 and the associated contact, also opens a point in the circuit through the off-normal springs 317 for energizing the release magnet 338 of the minor switch 318'. At its armature 333, the relay 330 prepares a circuit, traced hereinafter, for energizing the relay 350 from battery at the winding of the motor magnet 308. The relay 330 also interrupts, at its armature 331, the application of dial tone to the loop extending to the calling substation A.

Assuming that the called subscriber's line such, for example, as the line 3 leading to the substation C, terminates in the bank contacts of the group of connector switches corresponding to the first group of contact sets of the rotary switch mechanism 90, the first digit will comprise only a single impulse such that the wipers 91 to 96, inclusive, are each moved into engagement with the first contact of their respective associated sets of bank contacts and both of the relays 310 and 320 are operated. Shortly after the first digit is concluded, the slow-to-release relay 300 restores to prepare, at its armature 301 and associated contact 303, a circuit, traced hereinafter, for energizing the lower winding of the busy relay 170.

With the system in this condition, the selector switch automatically operates to select an idle connector switch in the selected group. Thus, let it be assumed that the first four connectors of the selected first group are busy. When this condition prevails, ground is present on the first two contacts of each of the contact sets associated with the test wipers 93 and 94, so that, when the wiper 93 engages the first contact of its associated set, circuits are completed for energizing the wiper switching relay 340 and the motor magnet 308. The first of these circuits extends from ground on the wiper 93 through the restored armature 353 and the winding of the relay 340 to battery, and the second of these circuits extends from ground on the same wiper, through the contact 342, the restored armature 341, the armatures 354, 333 and 358 and by way of the conductor 78', the contact 307', the armature 302, the conductor 44, the armature 356, the conductor 79, the self-interrupting contacts associated with the armature 309, and the winding of the motor magnet 308 to battery. The relay 340 is constructed and adjusted to be extremely quick acting so that it interrupts, at its armature 341 and associated contact 342, the above traced circuit for energizing the motor magnet 308 before sufficient time has elapsed to permit the latter magnet, in cooperation with its associated ratchet and pawl mechanism, to step the wipers 91 to 96, inclusive, off of the first contact set. Since, how-

ever, under the conditions assumed, the second connector of this group is also busy, ground is present on the wiper 94 so that the previously traced circuit for energizing the motor magnet 308 is completed from ground on this wiper instead of from ground on the wiper 93 when the wiper switching relay 340 operates. Thus, the motor magnet operates, in response to its energization, to step the wipers 91 to 96, inclusive, into engagement with the second contact set of the first group. During this stepping operation, the previously traced circuit for energizing the relay 340 is interrupted so that its armature 341 is restored to again engage the contact 342 leading to the wiper 93. Since, however, under the assumed conditions, the second and fourth connector switches of the group are also busy, the circuit for the last-mentioned relay is immediately recompleted upon engagement of the wiper 93 with its associated second contact. As a consequence, this relay operates to complete, at its armature 341 and associated contact 343, a circuit extending from ground at the wiper 94 for again energizing the motor magnet 308, thereby causing the wipers of the switch 90 to be stepped into engagement with the third or last contact set of the first group of contact sets.

It will be noted that each time ground is placed on the testing armature 341 of the relay 340 by one or the other of the test wipers 93 or 94, a path for short circuiting the winding of the switching through relay 350 is completed, this path extending from ground on the armature noted by way of the restored armature 354, the winding of the relay 350 and back to ground on the conductor 38. This short circuiting of the winding of the relay 350 prevents the relay from being energized over its operating circuit, traced hereinafter and extending from battery at the magnet 308, until such time as a trunk leading to an idle connector switch in the selected group of connector switches is found. In this connection it is pointed out that the battery potential applied to the test contacts of the sets associated respectively with the test wipers 93 and 94 from the line relays, corresponding to the relay 400, for the connector switch shown in Fig. 4, is so low as not to cause the operation of the relay 350 during the trunk group selecting function and when the wipers 93 and 94 pass over test contacts corresponding to idle connector switches. This potential causes current momentarily to flow by way of the armatures 341 and 354 through the winding of the relay 350 to ground, but the magnitude of the current is insufficient to cause operation of the relay. Thus, the relay 350 is prevented from operating to interfere with the trunk group selecting operations while these operations are occurring. It will also be noted that the winding of the wiper switching relay 340 is normally connected by way of the armature 353 to the test wiper 93. Accordingly, this relay is energized during the primary movement or group selecting operation of the switch each time the wiper 93 encounters the test contact terminating a control conductor leading to a busy connector switch. Such operation of the relay 340 is without effect in the operation of the system.

Under the conditions assumed, the connector switch 16 is idle so that battery from the line relay 400 is present on the directing wiper 93 instead of ground and, consequently, no circuits are completed for energizing the relay 340 and the motor magnet 308. The relay 340, therefore, remains in its restored position such that its

armatures 345 and 348 are in engagement with their respective associated contacts 346 and 349' leading respectively, by way of the wipers 91 and 96, to the trunk conductors 470 and 472 of the connector switch 16. The engagement of the control or directing wiper 93 with the third contact of its associated contact set removes the short circuit from across the winding of the relay 350 permitting this winding to be energized over a circuit extending from ground on the control conductor 38 through the winding of the relay 350 and by way of the armatures 333 and 352, the conductor 78', the contact 307' and its associated armature 302, the conductor 44, the armature 356, the conductor 79, the self-interrupting contacts associated with the armature 309, and through the winding of the magnet 308 to battery. The relay 350 operates in response to its energization over the above traced circuit, and at its armature 357 and associated contact 358, completes a holding circuit for itself independently of the relay 300 and extending from battery at the winding of the motor magnet 308 by way of the self-interrupting contacts associated with the armature 309, the conductor 79, the armature 357 and associated contact 358, the armature 333 and the winding of the relay 350 to ground on the control conductor 38. Due to the resistance of the winding of the relay 350 the current through the winding of the motor magnet 308 is insufficient to cause this magnet to operate its self-interrupting contacts 309.

At its armature 354 and associated lower contact, the relay 350, upon operating, completes a circuit for energizing the line relay 400 of the connector switch, this circuit extending from ground on the control conductor 38 by way of the armature 354, the armature 341 and its associated contact 342, the wiper 93 and its associated third bank contact, the conductor 471 and the winding of the relay 400 to battery. It is noted that the application of ground to the control conductor 471 marks the seized connector switch as busy in the bank contacts of the other selector switches having bank contacts to which the trunk line of the seized connector switch extends. At its armature 355 and associated upper contact, the relay 350 removes ground from the conductor 39 thereby to interrupt the previously traced operating circuit for the relay 160 and the circuit holding the impulse responsive relays 310 and 320 operated. All three of these relays restore, but without effect at this time. At its armature 355 and associated lower contact, the relay 350 prepares an alternative circuit for energizing the relay 160 and for holding the relays 310 and 320 operated during impulsing, the first of these circuits being held open at and extending from ground on the armature 304 by way of the conductor 56, the armature 355, the conductor 39, and through the winding of the relay 160 to battery. The second circuit, namely that for the relays 310 and 320, is the same except that it branches at the conductor 39 to extend through the upper winding of the relay 320 by way of the armature 316.

The relay 350, upon operating, opens, at its armature 352, a point in the circuit for energizing the relay 340 and, at this same armature and the associated armature 353 prepares a locking circuit for the relay 340, the latter circuit being held open at the armature 344. At its armature 356, the relay 350 opens a point in the previously traced circuit leading from the cam spring 76 for energizing the motor magnet 308. At its ar-

matures 351 and 359, respectively, the relay 350 extends the trunk conductors 470 and 472 of the connector switch 16 to the armatures 361 and 365 of the restored relay 360 further to prepare the connection to the called line. The relay 350, upon operating, also opens, at its armature 359', a point in the circuit for energizing the busy relay 170, this circuit being traced in detail hereinafter.

Before proceeding with the description of the operations which occur upon the dialing of the second and third digits at the calling substation and in order to complete the description, it will be assumed that the fifth connector switch of the first group, namely the connector switch 16, is busy and that only the sixth or last connector switch 17 of this group is idle. When this condition prevails, the relay 340 is energized in the manner noted above immediately upon the wiper 93 coming into engagement with its associated third contact. This relay, upon operating, prepares, at its armature 344, a locking circuit for itself and, at its armatures 341, 345 and 348 switches the trunk conductors of the selector switch 14 from the trunk conductors 470, 471 and 472 leading to the connector switch 16 to the trunk conductors 88, 89 and 87, respectively, leading to the connector switch 17. Since the last-mentioned connector switch is idle, battery is present on the control conductor 89 so that the short circuit is removed from around the winding of the relay 350 and this relay is energized from battery at the magnet 308 over the exact circuit traced above. The relay 350, upon operating, performs the same functions as are described above in connection with the seizing of the connector switch 16, and, in addition, completes the previously prepared locking circuit for the relay 340. This circuit extends from ground on the control conductor 38 by way of the armatures 344, 352 and 353, and through the winding of the relay 340 to battery. As a result, the relay 340 is maintained in its operated position so that the desired connection is extended by way of the connector switch 17 rather than by way of the connector switch 16.

Provision is made whereby, in the event all of the connector switches of a selected group are busy and following the testing of the lines corresponding to the connector switches included in the selected group, busy tone is returned to the calling subscriber. Thus, in the event all six of the lines corresponding to the connector switches of the first group are tested and found busy, the relay 350 fails to operate. Hence, the rotary portion of the mechanism 90 is actuated by the motor magnet 308 and its associated ratchet and pawl mechanism, until the follower portion 82 of the spring 76 leaves the trailing edge of the projection 84 and drops into the depression 83' to make contact between the springs 76 and 77. It will be remembered that the relays 310 and 320 are in their respective operated positions so that when the relay 300 assumes its restored position shortly following the end of the first digit, a circuit is completed for energizing the lower winding of the busy relay 170, this circuit extending from ground at the armature 312, through the armature 313, over the conductor 78, through the springs 76 and 77, over the conductor 75, through the armature 301 and its associated contact 303, over the conductor 47, through the armature 127, over the conductor 58, and through the lower winding of the relay 170 to battery. In response to the energization of its lower winding,

the relay 170 operates and, at its armature 171, completes an obvious locking circuit for itself extending from ground on the control conductor 38. This circuit maintains the busy relay operated until the connection as thus partially established is cleared out at the calling substation A. At its armature 174, the busy relay 170 applies busy tone current to the calling loop which is transmitted through the condensers 49 and 50 and the receiver at the calling subscriber's substation to inform the party thereat that a connection can not be completed to the called subscriber's line.

In connection with the above described circuits for the busy relay 170, it is pointed out that the restoration of the impulse responsive relays 310 and 320 in response to the operation of the relay 350, when an idle trunk is found in a group corresponding to an odd number of impulses causes the preparation of an alternative circuit for energizing the relay 170, this circuit extending from ground at the armature 312 by way of the contact 314, and the conductor 85 to the conductor 75. Since, however, the armature 359' of the relay 350 is pulled up before the armature 302 of the relay 300 falls back, this circuit is not completed and the busy relay is not energized.

By way of completing the description it is pointed out that the busy relay is energized to perform the functions noted above in all cases where all of the trunks associated with any selected one of the groups of bank contacts of the selector switch 14 are busy. If all of the group of trunks associated with a group of contacts corresponding to any odd number of impulses are found busy the sequence of operations resulting in the operation of the busy relay 170 are exactly the same as that described above for the trunks associated with the first group of contacts. If, however, the all busy condition exists in a selected group of trunks associated with a group of contacts corresponding to a digit comprising an even number of impulses the method by which the busy relay is energized is slightly different. In this regard it will be remembered that the impulse responsive relays 310 and 320 are both restored at the end of any even impulse and that the follower portion 82 of the spring 76 rides in one of the depressions 83, 83', etc., during the testing of the trunks of a selected group of trunks corresponding to any even impulse. During the testing of a group of trunks corresponding to any even impulse the springs 76 and 77 are in engagement and the above traced circuit for energizing the lower winding of the busy relay 170 is held open at the restored armature 313 of the impulse responsive relay 310. If an idle trunk in the selected group of trunks is found the follower portion 82 of the spring 76 does not leave the depression in which it rides and, consequently, the lower winding of the busy relay 170 remains de-energized. When, however, all of the trunks of the selected group are busy the rotary portion of the mechanism 90 is driven until the follower portion 82 of the spring 76 leaves the depression corresponding to the selected group of trunks and rides over the leading edge of the next succeeding cam projection. When this occurs the springs 76 and 86 engage and a different circuit is completed for energizing the lower winding of the relay 170, this circuit extending from ground on the restored armature 312, by way of the contact 314, the conductor 85, the restored armature 359', the springs 86 and 76, the conductor 75, the restored arma-

ture 301 and associated lower contact 303, the conductor 47, the armature 127, the conductor 58 and the lower winding of the relay 170, to battery. The busy relay thereupon operates, locks up, and causes busy tone to be transmitted to the calling party just as in the case described for an all busy condition of the trunks associated with the first group of contacts.

Continuing now with the sequence of operations which occur following the seizure of the connector switch 16, when the relay 400 operates as described above it prepares a locking circuit extending from ground at the armature 401 for the restored relays 440, 450 and 460. It will be recalled that the circuit for energizing the motor magnet 308 is interrupted at the armature 356 upon the operation of the relay 350 so that the impulses comprising further digits dialed at the calling telephone A have no effect upon this magnet. With the system in this condition, the control relays associated with the connector switch 16 are prepared to be responsive to further operation of the slow-to-release relay 300 and the impulse responsive relays 310 and 320. The operation of these relays during further impulsing is exactly the same as that described above; i. e., the relay 310 operates at the beginning of each odd impulse of each digit, the relay 320 operates at the end of each odd impulse, the relay 310 restores at the beginning of each even impulse and the relay 320 restores at the end of each even impulse. At the beginning of the first impulse of the second digit when the relays 300 and 310 operate, circuits are completed for causing the operation of the relay 160 in the selector switch 14 and the relays 410 and 420 in the seized connector switch 16. The first of these circuits extends from ground on the operated armature 304 by way of the conductor 56, the operated armature 355, the conductor 39 and the winding of the relay 160 to battery. The second of these circuits, namely that for the relay 410, extends from ground through the winding of the relay 410 by way of the conductor 458, the contact 442 and associated armature 441, the conductor 457, the contact 462 and associated armature 461, the trunk conductor 470, the wiper 91 and its associated third bank contact, the contact 345 and its associated armature 345, the armatures 351 and 361, the conductor 31, the restored armature 177, the conductor 35, the armature 305 and associated lower contact 306, the conductor 33, and through the armature 173 and the resistor 80 to battery. The circuit for energizing the relay 420 extends from ground at the operated armature 315 by way of the conductor 42, the contact 163 and its associated operated armature 161, the conductor 41, the armatures 365 and 359, the armature 348 and associated contact 349', the wiper 96 and its associated third bank contact, the trunk conductor 472, the armature 467 and associated contact 469, the conductor 418 and the winding of the relay 420, to battery. Since the above-traced circuit for the relay 410 is maintained completed by the slow-to-release relay 300, it stays in its operated position throughout the impulses comprising the second digit. The relay 410, at its armature 411, prepares a circuit for the motor magnet 437, which circuit is completed when the relay 420 operates, and interrupts at its armature 411' a point in the release circuit for the motor magnet 437. The first mentioned circuit for the motor magnet 437, which is completed upon the operation of the relay 420, extends from ground at the

armature 424 by way of the armature 425, the conductor 428, the wiper 64 and the last or twenty-fifth contact of the associated set of contacts, the conductor 427, the restored armature 456, the conductor 479, the armature 411, the conductor 409, the self-interrupting contacts 438 and through the winding of the motor magnet 437 to battery. In response to its energization, the motor magnet 437 starts to operate buzzer fashion but, upon taking a single step, the lower end of the wiper 64 leaves its associated twenty-fifth contact and interrupts the above-traced operating circuit for the motor magnet. When the wipers of the switch mechanism 63 take their first step, the off-normal springs 473 are closed to prepare a circuit for energizing the slow-to-release relay 450 and an alternative circuit for energizing the motor magnet 437 during the release of the switch 16. In this position of the switch, the upper end of the wiper 64 is in engagement with the first contact of the group of three contacts indicated at 73 and the lower ends of other wipers are in engagement with the respective twenty-fifth contact of the other contact sets included in the switch. Hence, the wipers are just ready to be stepped onto the first contact set of the group of contact sets corresponding to the first group of lines included in the plurality of lines to which the switch 16 has access.

At the beginning of the second impulse of the second digit when the relay 310 restores in the manner described previously, the above-traced circuit for the relay 420 is interrupted at the armature 315, causing this relay to restore. Upon falling back, the relay 420 completes, at its armature 424 and associated contact 426, an alternative circuit for energizing the motor magnet 437, this circuit being exactly the same as that just described with the exception that the wiper 64 is connected to ground at the armature 424 and associated contact 426 by way of the first contact of the contact group 73 and the conductor 429, rather than by way of the twenty-fifth contact and the conductor 428. The motor magnet thereupon operates buzzer fashion and in cooperation with its associated ratchet and pawl mechanism drives the wipers 64 to 70, inclusive, until the wiper 64 leaves the third or last contact of the first contact group 73 and stands in engagement with the first contact of the second contact group indicated at 74. When this occurs the alternative circuit for the motor magnet 437 is interrupted. It is pointed out that the wiper 64 is so arranged relative to the other wipers 65-70 that when it stands on the first contact of its associated set of contacts, each of the remaining wipers stands on the twenty-fifth contact of its associated set of contacts. As a consequence, if the second digit comprises one impulse the wipers 65-70, inclusive, are in a position such that an additional step will cause them to engage the first contact set of the first group of contact sets. In the event the called line terminates at a contact set in a group of contact sets other than the first and corresponding to a digit having more than two impulses, the motor magnet 437 is energized each time the relay 420 operates and restores and drives the wipers 64 to 70, inclusive, over a complete group of contacts. The number of the group of contacts which the wipers traverse during any given impulse is in any instance one less than the number of the impulse in the digit, i. e., during the second impulse the wipers 64 to 70, inclusive, 75

traverse the first group of contact sets, during the third impulse the wipers traverse the second group of contact sets and so on. In this manner the wipers always stand in engagement with the last contact set of the group of contact sets having a number one less than the number of the impulse. In the present assumed case, wherein the called line C terminates at the third or last contact set of the first group of contact sets, a single impulse will constitute the second digit so that at the conclusion of the digit the wiper 64 stands on the first contact of its associated level and the wipers 64 to 70, inclusive, are ready to be stepped onto the respective first contacts of their respective associated levels.

From the foregoing description it will be apparent that in the connector switch 16 as well as in the selector switch 14 the number of contact sets in each group of contact sets are so related to the impulsing rate that the required speed of the switch wipers is well below the maximum speed attainable by standard commercial rotary switches. Thus with each of the groups of contact sets including only three contact sets at which six lines terminate and with a standard impulsing rate ranging from eight to twelve impulses per second the required speed at which the wipers must travel is something less than forty points or contact sets per second.

At the conclusion of the second digit and in response to the restoration of the relay 300, the relays 160, 310, 320, 410 and 420 restore. When the relay 410 falls back, it completes the previously prepared circuit for energizing the relay 450, this circuit extending from ground at the armature 413 by way of the contact 414, the conductor 406, the off-normal springs 474, the conductor 407, the armatures 451' and 455, and through the winding of the relay 450 to battery. The last-mentioned relay upon operating completes, at its armature 451, a locking circuit for itself, which circuit extends from ground at the operated armature 401 by way of the contact 402, the conductor 447, the armatures 451, 451' and 455 and through the winding of the relay 450 to battery. At its armature 456, the relay 450 interrupts the previously traced operating circuit extending by way of the self-interrupting contacts 438, for the motor magnet 437. At its armature 452 and associated contact 453, the relay 450 prepares an alternative circuit for energizing the motor magnet 437 independently of the self-interrupting contact 438 and in accordance with the operation of the relay 420 during the impulses of the third digit, which circuit is completed only when both of the relays 410 and 420 are operated. This circuit extends from battery through the winding of the magnet 437 and by way of the conductor 416, the contact 422 and associated armature 421, the conductor 408, the contact 453 and associated operated armature 452, the conductor 405, and the armature 412 to ground at the armature 413. The relay 450, upon operating, also prepares, at its armature 455, a circuit for energizing the upper winding of the relay 440, this circuit being completed at the armature 415 of the relay 410 when the latter relay again operates.

At the beginning of the first impulse of the third or units digit, when the relays 160, 300 and 310 again operate, the previously traced circuits for energizing the relays 410 and 420 are again completed to cause the operation thereof. At its armature 415, the relay 410 completes the previously prepared circuit for energizing the upper

winding of the relay 440, this circuit extending from ground at the armature 469' by way of the armature 455, the conductor 439, the armature 415, the conductor 446 and the upper winding of the relay 440 to battery. The last-mentioned relay is so constructed that only its armature 444 operates in response to the energization of its upper winding and this armature, upon operating, closes the "X" contacts associated therewith to short-circuit the lower winding of the relay, the path comprising this short circuit starting from ground at the armature 469' and extending over the above traced circuit for energizing the upper winding of the relay, through the lower winding thereof, the armature 444 and the associated "X" contacts and ending at ground on the grounded conductor 447. As a consequence, the armatures 441 and 445 are not operated at this time. The relays 410 and 420, upon operating, also complete the previously traced circuit for energizing the motor magnet 437, independently of the self-interrupting contacts 438. At the beginning of the second impulse, when the relay 310 restores to cause the restoration of the relay 420, this circuit for the motor magnet 437 is interrupted, at the armature 421 and associated contact 422, whereby the wipers 65 to 70, inclusive, are stepped one step or into engagement with the first contact set of the first group of contact sets. Simultaneously, a circuit is completed for energizing the wiper switching relay 430, this circuit extending from ground at the armature 413 by way of the operated armature 412, the conductor 405, the operated armature 452 and associated contact 453, the conductor 408, the restored armature 421 and associated contact 423, the conductor 417 and through the winding of the relay 430 to battery. The relay 430, upon operating, obviously operates its armatures 431, 432, and 434 into engagement with the contacts to which are connected the conductors of the line terminated at the respective first contacts of the contact sets associated with the wipers 66, 68 and 69. At its armature 433, the relay 430 prepares an obvious locking circuit for itself, which circuit is held open at the operated armature 413 of the relay 410.

At the beginning of the third impulse, when the relay 310 again operates to complete the circuit for causing the operation of the relay 420, the previously traced circuit for the motor magnet 437 is again completed and the circuit holding the wiper switching relay 430 operated is interrupted, permitting it to restore. At the beginning of the fourth impulse, when the relays 310 and 420 again restore, in the order named, the ratchet and pawl mechanism associated with the motor magnet 437 steps the wipers 65 to 70, inclusive, into engagement with the second contact set of the first group of contact sets. During the fifth and sixth impulses the motor magnet is again energized and de-energized to cause the wipers 65-70, inclusive, to be stepped into engagement with the third set of contacts in the first group of contact sets. With the wipers in this position, the connector switch 16 has access to either the subscriber's line 2 or the subscriber's line 3, depending upon the condition of the wiper switching relay 430. It will be seen that if this relay is de-energized the armatures 431 and 434 of the relay are connected to the respective line conductors of the line 2 leading to the substation B, whereas, if this relay is energized, the armatures noted are connected to the respective line conductors of the subscriber's line 3 leading to the called substation C.

The condition of the wiper switching relay 430 at

the end of the third digit depends upon the number of impulses constituting this digit. More specifically, if the number of impulses in the digit is odd, the relay 430 remains de-energized at the conclusion of the digit but if the number of impulses of the digit is even, the relay is energized and locked in its operated position. Thus, assume it is desired to establish a connection to the substation B instead of the substation C. In this case the third digit dialed must necessarily be 5, or odd. At the conclusion of this digit, the relays 410 and 420 are in their respective operated positions. With the relay 420 operated, the previously traced operating circuit for the wiper switching relay 430 is open at the armature 421. Shortly following the end of the fifth or final impulse of the units digit the relay 300 restores and interrupts, at its armature 305 and associated contact 306, the previously traced operating circuit for the relay 410. Simultaneously, the relay 300, at its armature 304, interrupts the circuit holding the relays 160, 310 and 320 operated. The relay 410 restores immediately following the restoration of the relay 300, and interrupts, at its armatures 412 and 413, the previously traced circuit for energizing the relay 430. Simultaneously with the restoration of the relay 410, the relay 310 restores to interrupt the previously traced operating circuit for the relay 420, which latter relay falls back shortly after the restoration of the relay 410 to prepare, at its armature 421, the circuit for energizing the relay 430. By the time the armature 421 engages its associated contact 423, however, the armature 412 of the relay 410 has restored to normal and, hence, the energization of the relay 430 is prevented. Thus, this latter relay does not operate and the armatures 431 and 434 are connected by way of the wipers 65 and 70 to the line conductors leading to the substation B.

In the present case wherein a connection is desired with the substation C rather than the substation B, the third digit dialed at the calling substation will necessarily comprise six impulses instead of five so that, at the end of the digit, the impulse responsive relay 310 is restored and the relay 420 is in the same condition. As a consequence, the previously traced circuit for energizing the relay 430 is completed at the armature 421 and its associated contact 423, the relay 430 is in its operated position and the locking circuit for this relay is prepared at the armature 433. Hence, at the end of the digit when the relay 300 falls back to cause the restoration of the relay 410, this locking circuit is completed at the armature 413 and its associated contact 414 simultaneously with the interruption of its original operation circuit at the armatures 412 and 413. Accordingly, the relay 430 is locked in its operated position and the armatures 431, 432 and 434 are connected by way of the wipers 66, 68 and 69 to the line conductors of the line 3 leading to the desired or called substation C. It is pointed out that the relay 430 remains locked up until the connector switch 16 is seized during the establishing of a subsequent connection.

Returning again to the operations which occur at the conclusion of the third or units digit, the relay 410 upon restoring, opens, at its armature 415, the shunt around the lower winding of the relay 440, permitting the last mentioned relay fully to operate. Operation of the relay 440 causes a path to be prepared, at the armature 445, for applying ground to the control conductor 459 from the grounded conductor 447. The operation

of the apparatus from this point on depends upon the condition of the called line 3.

If the called line 3 is idle, battery from the line relay associated therewith is present on the wiper 68, whereby the relay 440, upon operating, completes a circuit for energizing the relay 460 and the upper winding of the relay 360 in series, this circuit extending from battery at the line relay associated with the line 3, by way of the wiper 68, the control conductor 459, the lower winding of the relay 460, the conductor 449, the contact 443 and its associated operated armature 441, the conductor 457, the contact 452 and its associated armature 461, the conductor 470, the wiper 91 and its associated third bank contact, the armatures 345, 351 and 361, the conductor 31, the restored armature 177 and its associated upper contact, the conductor 35, the restored armature 305 and its associated contact 307, the conductor 34, the restored armature 166 and its associated contact 168, the restored armature 172, the conductor 36, and through the upper winding of the relay 360 to ground.

The relay 460 operates in response to its energization over the above traced circuit and completes, at its armature 464, a holding circuit extending from battery through the upper winding of the relay to the grounded conductor 448. At its armature 459', the relay 460 opens a further point in the previously traced path for short circuiting the lower winding of the relay 440 and prevents the application of ground to the lower trunk conductor 472. At its armatures 461 and 467 and their respective associated contacts 463 and 468, the relay 460 prepares points in the loop extending to the called substation and, at these same armatures and their respective associated contacts 462 and 469, interrupts points in the respective previously traced circuits for energizing the relays 410, 420 and 460. At its armature 466, the relay 460 completes an obvious path for applying ground to the control conductor 459, thereby to mark the called line as busy in the bank contacts of the connector and finder switches to which the called line 3 extends. At its armature 465, the relay 460 interrupts the circuit holding the relay 450 operated, permitting this relay to restore and complete, at its armature 455, a further point in the loop extending to the called substation. The relay 450, upon falling back, at its armature 452 and associated contact 454, prepares a further point in the circuit for causing the motor magnet 437 to return the wipers 64 to 70, inclusive, to their normal positions when the connection is cleared out and the switch 16 is released. At its armature 451, the relay 450 opens a further point in its locking circuit and, at its armature 456, it prepares the previously traced circuit extending by way of the wiper 64 for energizing the motor magnet 437 in accordance with the impulses of the first digit to which the switch 16 is responsive. With the connector switch 16 in this condition it will be seen that the line conductors of the called line are extended back to the trunk conductors of the selector switch and that the loop between the calling and called lines is complete except for the open points existing at the restored armatures 361 and 365 of the relay 360 and the restored armatures 372 and 376 of the relay 370.

When the relay 360 operates simultaneously with the operation of the relay 460, it stays operated by virtue of the energized condition of its lower winding. Upon operating, it short-circuits its upper winding at the armature 363, thereby to render itself slightly slow to release. At its arma-

tures 361 and 365, this relay prepares a further point in the loop extending between the calling and called lines and, at its armature 362, it completes a path for the transmission of ring back tone current by way of the condenser 319 to the loop extending to the calling subscriber's substation. The relay 360, upon operating, also interrupts, at its armatures 361 and 365, further points in the respective circuits for energizing the relays 410 and 420. At its armature 364 and associated lower contact, the relay 360 opens the circuit leading to the impulse responsive relays 310 and 320 and, at this same armature and its associated upper contact, this relay prepares a circuit for energizing the motor magnet 339 to cause the step-by-step operation of the minor switch 318.

The last-mentioned switch is for the purpose of selectively applying in a well-known manner ringing current of any one of five different frequencies to the loop extending to the called line, whereby the signal device at any one of five different substations connected across the line may be caused to operate to the exclusion of all of the other similar devices. When the relay 360 operates as above described, it conditions the minor switch 318 to be responsive to the dialing of the fourth or final digit. At the beginning of the first impulse of this digit, a circuit is completed for energizing the relay 300 and the motor magnet 339 in parallel, whereupon the relay 300 operates to open at its armature 301' a point in the paths for applying ringing current and ring-back tone current to the loops extending, respectively, to the called and calling substations. This is necessary to prevent current of the various frequencies F₁, F₂, etc., from being transmitted out over the called line during the stepping operation of the minor switch 318. The above-noted circuit for the motor magnet 339 extends from ground at the armature 151, by way of the contact 153, the operated armature 156, the contact 158', the conductor 43, the armature 364 and its associated upper contact, the conductor 329 and through the winding of the magnet 339 to battery. The motor magnet 339 is alternately energized and de-energized in accordance with the impulses of the final digit and, in cooperation with its associated ratchet and pawl mechanism, steps the wiper 326 of the switch 318' to a position corresponding to the number of impulses of the digit dialed. At the conclusion of this digit, the wiper of the switch stands in engagement with a contact leading to an alternating current generator having an output frequency the same as that to which the signal device of the called subscriber's substation on the party line is responsive. Assuming the signal device of the called substation D is responsive to current of the frequency the same as that of the generator connected to the second contact of the group of contacts, the final digit dialed will be 2 so that at the conclusion of the digit the wiper 326 stands on its associated second contact of the contact set 324. It is noted here that when the wiper 326 takes its first step, the off-normal springs 317 are closed to prepare a circuit for operating the release magnet 339, this circuit being held open at the operated armature 332 of the relay 330.

With the system in this condition and when the relay 300 restores shortly following the end of the fourth or final digit, ringing current is transmitted over the conductors 366 and 328, the lower winding of the ring cut-off relay 370 and the conductor 367 to the loop extending to the called substation D causing the signal device

thereat to operate and inform the called party that he is being called. Ring-back tone current is transmitted back over the calling loop to the calling subscriber's substation to inform the calling party that the called line is idle.

When the called party answers by lifting his receiver from its hook, a circuit is completed for energizing the lower winding of the ring cut-off relay 370, this circuit extending from battery on the wiper 326 of the minor switch 318', over the conductor 328, through the lower winding of the relay 370, over the upper side of the loop extending to the called subscriber's substation D including the conductor 470, through the bridge at the called substation, back over the lower line conductor of the loop, and the conductor 366 to ground. The relay 370 operates in response to the energization of its lower winding and completes, at its armature 374, a locking circuit for itself extending from ground on the control conductor 38, through the armature 374 and the upper winding of the relay to battery. At its armatures 372 and 376, this relay interrupts the application of ringing current to the loop extending to the called substation, the application of ring back tone current to the loop extending to the calling substation and completes a talking loop between the calling and called parties. At its armature 375, this relay interrupts a point in the operating circuit for the relay 175 and, at its armature 371, it prepares a point in the circuit for energizing the supervisory lamp No. 1. In response to the completion of the talking loop in the above-described manner, a circuit is completed including this loop for causing the operation of the battery reversing relay 180 which relay operates and, at its armatures 181 and 183, reverses battery back over the loop extending to the calling subscriber's substation. At its armature 184, the relay 180 prepares a point in the circuit for energizing the supervisory lamp No. 2, this circuit being held open at the armature 157 and associated contact 158 of the hold relay 155. At its armature 182, the battery reversing relay 180 opens a point in the circuit for energizing the supervisory lamp No. 1 and closes multiple ground to the control conductor 38. With the system in this condition, a talking connection is established between the calling and called parties, which connection is maintained until both of the parties hang up.

Before describing the release of the connection as thus established, and in order to complete the description of the operation of the system, it will be assumed that, at the time the connector switch 16 steps its wipers into engagement with the contacts at which the line conductors of the called line 3 terminate, this line is busy instead of idle. When this condition prevails, ground is present on the control wiper 68 and the control conductor 459 and, consequently, a circuit is completed for causing the operation of the busy relay 170. This circuit extends from ground on the conductor 459 through the lower winding of the relay 460, by way of the conductor 449, the contact 443 and associated operated armature 441, the conductor 457, the armature 461 and associated contact 462, the conductor 470, the wiper 91, the armatures 345, 351 and 361, the conductor 31, the restored armature 177, the conductor 35, the armature 205 and associated contact 307, the conductor 34, the operated armature 166 and associated contact 167, the conductor 57, and through the upper winding of the relay 170 to battery.

It will be understood that this circuit is completed immediately upon the falling back of the armatures associated with the relay 410 and the consequent operation of the relay 440, which operations occur before the restoration of the slow-to-release relay 160. It is pointed out that the current which flows over the above-traced circuit is of the wrong polarity to cause the operation of the relay 460, this latter relay remaining in its restored condition. Immediately upon the completion of the above-traced circuit, the relay 170 operates to complete, at its armature 171, a locking circuit for itself, this circuit extending from ground on the control conductor 38, over the conductor 55, and through the lower winding of the relay 170 to battery.

The busy relay 170, upon operating, applies at its armature 174, busy tone to the loop extending to the calling subscriber's substation, thereby to indicate to this party the busy condition of the called line. At its armature 172, the relay 170 opens a point in the circuit for energizing the upper winding of the relay 360 and, at its armature 173, it applies ground to the conductor 33. The system remains in this condition until the connection is cleared out at the calling subscriber's substation.

In the event the called line is found busy and busy tone is returned to the calling subscriber, this subscriber may release the operated switch train, by hanging up his receiver to open a point in the loop comprising a portion of the circuit holding the line relay 150 operated. This relay, upon restoring, interrupts, at its armature 151 and associated contact 152, the operating circuit for the hold relay 155 and simultaneously completes, at this same armature and its associated contact 153, the operating circuit for the relay 300. The latter relay operates and, at its armature 304, completes the operating circuit for the relay 160, which latter relay also pulls up. The operation of the remaining armatures of the relay 300 is without effect. Shortly following the restoration of the line relay 150, the hold relay 155 restores to interrupt the circuit for the relay 300 and causes the sequential restoration of this relay and the relay 160. With the relays 155 and 160 in their restored positions, ground is removed from the control conductor 38 so that holding circuits for the relays 125, 340, 350 and 400 are interrupted. As a consequence, all of these relays restore.

The relay 350, upon falling back, completes, at its armature 356, a circuit for energizing the motor magnet 308, this circuit extending from ground at the armature 151 by way of the contact 153, the armature 156 and associated contact 159', the conductor 44', the armature 331', the conductor 44, the armature 356, the conductor 79, the self-interrupting contacts 309, and through the winding of the magnet 308 to battery. This magnet thereupon, in cooperation with its associated ratchet and pawl mechanism steps the wipers 91 to 96, inclusive, to their respective normal positions when the off-normal contacts 377 are opened to interrupt the operating circuit of the release relay 330. This relay 330, upon restoring, interrupts, at its armature 331', the previously traced circuit for energizing the motor magnet 308 with the result that the rotary portion of the switch mechanism 90 comes to rest in its normal position such that the follower portion 82 of the spring 76 just engages the leading edge of the cam projection 84. When the rotary portion of the switch mechanism 90

is returned to its normal position, the elements of the selector switch 14 are all in the condition which prevailed at the outset and before the selector switch was seized.

When the relay 125 restores in response to the removal of ground potential from the control conductor 38, it interrupts, at its armature 126, the previously traced circuit holding the relays 130, 140 and the line relay 100 operated, permitting these relays to restore. Thus, the control equipment associated with the primary and secondary finder switches 12 and 13, respectively, is returned to normal.

The release of the connector switch 16, under the conditions stated, is initiated when the relay 400 restores to interrupt, at its armature 401 and associated contact 402, the holding circuit for the relay 440. When the armature 401 falls back to engage the contact 403 it completes a circuit for energizing the motor magnet 437 by way of the self-interrupting contacts 438, this circuit extending from ground at the armature 401 by way of the contact 403, the conductor 404, the off-normal springs 475, the armature 452 and associated contact 454, the conductor 409, through the self-interrupting contacts 438 and the winding of the magnet 437 to battery. This magnet thereupon operates buzzer fashion and in conjunction with its associated ratchet and pawl mechanism and drives the wipers 64 to 70, inclusive, to their respective normal or home positions at which time the off-normal springs 474 and 475 are opened. When the springs 475 are opened the above-traced circuit for energizing the magnet 437 is interrupted. The normal position of the wipers 64-70, inclusive, it will be understood, are attained when the lower half of the wiper 64 rests on the twenty-fifth contact of its associated contact level. When this switch is returned to normal, the elements of the connector switch 16 are in the condition which prevailed before this switch was seized and the switch is in condition for further use.

In the event a talking connection is established between the calling subscriber's substation and the desired called substation and both of the parties involved hang up, the operations which occur to release the connection are substantially similar to those described above. Under the condition stated, however, the switch train is held operated so long as either party remains on the connection. In this connection it will be seen that if only the calling party hangs up, the battery reversing relay 180, by maintaining ground on the control conductor 38 at its armature 182, holds the primary and secondary finder switches 12 and 13, the selector switch 14 and the connector switch 16 operated until the connection is cleared out at the called substation. Thus, the only operations which occur following the interruption of the loop at the calling substation are the restoration of the line relay 150, followed by the operation of the relays 160 and 300, the restoration of the hold relay 155, and the subsequent restoration of the relays 160 and 300. When the connection is cleared out at the called substation to interrupt the circuit holding the battery reversing relay 180 operated, ground potential is removed from the control conductor 38 and the elements of the primary and secondary finder switches, the selector switch 14, and the connector switch 16 restore in the exact manner described above in connection with the clearing out of a connection established to a busy line. It is pointed out, however, that, when the release

relay 330 restores during this sequence of operations, an obvious circuit is completed at the armature 332 of the relay 330 for energizing the release magnet 338. This magnet operates to permit the wipers of the switch 318' to restore to normal, at which time the off-normal contacts 317 are opened to interrupt the circuit including the release magnet winding. Thus, the entire system is in a normal condition and ready for further use. In the event the called party hangs up first, the battery reversing relay 180 is the only relay which restores, the remaining operated relays being held up until the connection is cleared out at the calling substation, when the relays 150 and 155 restore to remove ground from the control conductor 38 and initiate the sequence of operations just described.

It will be observed that at no time during the establishing of the connection just described did the relay 190 operate. Consequently, the established talking loop includes therein the coupling condensers 49 and 50. In the rendition of certain types of service such, for example, as in those cases where the system shown constitutes only a part of a larger system, and impulsing from one exchange of the larger system to another is desired, it is necessary that these capacitive coupling elements be eliminated and a through metallic circuit be established. These services usually involve special trunk lines terminating at the bank contacts of the connector switches and extending to a distant exchange. If ground is present on a predetermined side of such lines the relays such, for example, as the relay 190 of the selector switch 14, may be caused automatically to operate to replace the coupling condensers such, for example, as the condensers 49 and 50, with metallic paths. Thus assume that the selector switch 14 and the connector switch 16 set up a connection to one such trunk line and that the side thereof which is connected back through the connector switch to the armature 348 of the wiper switching relay 340, is grounded. When this occurs a circuit is completed for energizing the relay 190, this circuit extending from ground on the armature 348, by way of the armatures 359 and 365, the conductor 41, the restored armature 161, and associated contact 162 and the winding of the relay 190 to battery. The relay 190 thereupon operates and at its armatures 194, 195 and 192, respectively, connects the conductors 21 and 22 directly to the conductors 23 and 24, respectively. At its armatures 191 and 196 the relay 190 completes obvious locking circuits for itself. At its armature 197, the relay 190 completes a circuit extending from ground on the conductor 18', by way of the conductor 40 for energizing the relay 370, which relay operates to complete a metallic loop from the calling substation to the line seized by the connector switch. Presumably the latter line terminates at the windings of a line relay so that current flows over the metallic loop to cause the operation of the slow-to-release series connected relay 185. This relay has a low impedance winding which is by-passed in the line circuit by a coupling condenser, whereby the transmission of voice frequency currents are not interfered with. The relay 185, upon operating, completes, at its armature 186, a multiple holding circuit, extending by way of the conductor 188, for the hold relay 155. The relay 190, upon operating, also opens, at its armatures 194, 195 and 192, 193, points in the circuit for energizing the battery reversing relay 180 and interrupts the previously

traced circuit holding the line relay 150 operated. As a consequence the relay 150 restores to open the original holding circuit for the hold relay 155. This relay remains operated, however, to retain ground on the control conductor 38, by virtue of the energized condition of the series relay 185. It is pointed out that the relay 185 operates to complete the multiple holding circuit for the hold relay 155 simultaneously with the restoration of the line relay 150 and before sufficient time elapses to permit the slow-to-release hold relay 155 to restore. It is also noted that the relay 185, due to its slow-to-release characteristic, remains operated during the transmission of impulses to the control apparatus of the distant exchange. The relay 150 being restored following operation of the relay 190, any impulses following the third digit transmitted from the calling substation have no effect on the impulse responsive relays 310 and 320 but are transmitted directly to the control apparatus and, more particularly, the line relay at the distant end of the line seized by the connector switch 16. It will be seen from the immediately preceding description that the provision of the relays 185 and 190, operative in the manner noted, renders the system shown susceptible of being incorporated in a larger system including several automatic exchanges at least a portion of which are so arranged that the automatic switching equipment included therein is controllable from an impulsing device on a line terminating at the exchange including the switches illustrated.

The release of a connection established in the manner described immediately above is under the control of the series relay 185. Thus, shortly after the loop is interrupted at the calling substation this relay restores to interrupt the only remaining holding circuit for the hold relay 155. The last-mentioned relay, in turn, restores after an interval to remove ground from the control conductor 38. This operation initiates the release of the switches 12, 13, 14 and 16 in the exact manner described previously in connection with a connection established between the line 5 and the line 3 of the exchange illustrated. It is noted that during the release of the switch train the relay 190 falls back following the restoration of the relay 125.

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 without departing therefrom and it is aimed in the appended claims to cover all such modifications as fall within the true spirit and scope of the invention.

I claim:

1. In a telephone system, a first line, a second line, a first automatic switch, a second automatic switch, means including said switches, operative in the order named, for establishing a connection between said lines on a call from said first line to said second line, and control means included in said first switch and operative during and following the establishing of said connection for performing the group of auxiliary functions normally performed in an operated connector switch and comprising the application of ringing current to said second line, the application of ring-back tone current to said first line and the application of busy tone current to said first line in the event said second line is busy at the time said call is initiated.

2. In a telephone system, a first line, a second

line, a first automatic switch, a second automatic switch, means included in said first switch for causing said first switch to seize said second switch on a call from said first line to said second line, said means including a pair of impulse responsive relays one of which operates on each alternate impulse of a series of received impulses, and means comprising apparatus included in said second switch and responsive to operation of said one relay for establishing a connection between said lines in the event said second line is idle at the time said call is initiated.

3. In a telephone system, a first line, a second line, a first automatic switch, a second automatic switch, means included in said first switch for causing said first switch to seize said second switch on a call from said first line to said second line, said means including a pair of impulse responsive relays one of which operates on each alternate impulse of a series of received impulses, means comprising apparatus included in said second switch and responsive to operation of said one relay for establishing a connection between said lines in the event said second line is idle at the time said call is initiated, and control means included in said first switch and operative during and following the establishing of said connection for performing the group of auxiliary functions normally performed in an operated connector switch and comprising the application of ringing current to said second line, the application of ring-back tone current to said first line, and the application of busy tone current to said first line in the event said second line is busy at the time said call is initiated.

4. In a telephone system, a first line, a plurality of additional lines, a plurality of connector switches, each of said connector switches being operable to a plurality of positions and having access to two of said lines in each position thereof, a plurality of selector switches, each of said selector switches being operable to a plurality of positions and having access to two of said connector switches in each position thereof, means comprising one of said selector switches operated to one of its positions and one of said connector switches operated to one of its positions for establishing a connection between said first line and one of said plurality of lines on a call from said first line to said one of said plurality of lines, and control means included in said operated selector switch and operative during and following the establishing of said connection for performing the group of auxiliary functions normally performed in an operated connector switch and comprising the application of ringing current to said one line, the application of ring-back tone current to said first line and the application of busy tone current to said first line in the event said second line is busy at the time said call is initiated.

5. In a telephone system, a first line, a plurality of additional lines, a plurality of connector switches, each of said connector switches being operable to a plurality of positions and having access to two of said lines in each position thereof, a plurality of selector switches, each of said selector switches being operable to a plurality of positions and having access to two of said connector switches in each position thereof, means for seizing one of said selector switches on a call from said first line to one of said plurality of lines, impulse responsive means included in said seized selector switch for causing said seized selector switch to be operated to a predetermined

one of its positions to seize an idle one of a particular group of said connector switches, said impulse responsive means including a pair of relays one of which operates during each alternate impulse of a received series of impulses, and means comprising apparatus included in said seized connector switch and responsive to the operation of said one relay during a series of received impulses for causing said seized connector switch to be operated to the one of its positions corresponding to said one line and for establishing a connection between said one line and said first line in the event said one line is idle.

6. In a telephone system, a first line, a plurality of additional lines, a plurality of connector switches, each of said connector switches being operable to a plurality of positions and having access to two of said lines in each position thereof, a plurality of selector switches, each of said selector switches being operable to a plurality of positions and having access to two of said connector switches in each position thereof, means for seizing one of said selector switches on a call from said first line to one of said plurality of lines, impulse responsive means included in said seized selector switch or causing said seized selector switch to be operated to a predetermined one of its positions to seize an idle one of a particular group of said connector switches, said impulse responsive means including a pair of relays one of which operates during each alternate impulse of a received series of impulses, means comprising apparatus included in said seized connector switch and responsive to the operation of said one relay during a series of received impulses for causing said seized connector switch to be operated to the one of its positions corresponding to said one line and for establishing a connection between said one line and said first line in the event said one line is idle, and means included in said operated selector switch and operative during the establishing of said connection for performing the group of auxiliary functions normally performed in an operated connector switch and comprising the application of ringing current to said one line, the application of ring-back tone current to said first line and the application of busy tone current to said first line in the event said second line is busy at the time said call is initiated.

7. In a telephone system, a group of lines, a group of automatic switches having access to said lines, a selector switch having access to a plurality of switches including said group of switches, said selector switch including an incoming line, impulse responsive means included in said selector switch and comprising a pair of relays one of which operates during each alternate impulse of a received series of impulses, said means being responsive to a predetermined series of impulses to cause said selector switch to select said group of switches from said plurality of switches, means included in said selector switch for thereafter automatically selecting an idle switch from said group of switches, and means included in said selected idle switch and responsive to the operation and restoration of said one relay for causing said selected switch to seize a desired line in said group of lines.

8. In a telephone system, a group of lines, a group of automatic switches having access to said lines, a selector switch having access to a plurality of switches including said group of switches, said selector switch including an incoming line, impulse responsive means included

in said selector switch and comprising a pair of relays one of which operates during each alternate impulse of a received series of impulses, said means being responsive to a predetermined series of impulses to cause said selector switch to select said group of switches from said plurality of switches, means included in said selector switch for thereafter automatically selecting an idle switch from said group of switches, means included in said selected idle switch and responsive to the operation and restoration of said one relay for causing said selected switch to seize a desired line in said group of lines, and means included in said selector switch and operable in the event said desired line is busy for applying busy tone current to said incoming line.

9. In a telephone system, a group of lines, a group of automatic switches having access to said lines, a selector switch having access to a plurality of switches including said group of switches, said selector switch including an incoming line, impulse responsive means included in said selector switch and comprising a pair of relays one of which operates during each alternate impulse of a received series of impulses, said means being responsive to a predetermined series of impulses to cause said selector switch to select said group of switches from said plurality of switches, means included in said selector switch for thereafter automatically selecting an idle switch from said group of switches, means included in said selected idle switch and responsive to the operation and restoration of said one relay for causing said selected switch to seize a desired line in said group of lines, ringing apparatus associated with said selector switch, and means operable only in the event said desired line is idle for causing said apparatus to transmit ringing current to said desired line.

10. In a telephone system, a group of lines, a group of automatic switches having access to said lines, a selector switch having access to a plurality of switches including said group of switches, said selector switch including an incoming line, impulse responsive means included in said selector switch and comprising a pair of relays one of which operates during each alternate impulse of a received series of impulses, said means being responsive to a predetermined series of impulses to cause said selector switch to select said group of switches from said plurality of switches, means included in said selector switch for thereafter automatically selecting an idle switch from said group of switches, means included in said selected idle switch and responsive to the operation and restoration of said one relay for causing said selected switch to seize a desired line in said group of lines, means included in said selector switch and operable in the event said desired line is busy for applying busy tone current to said incoming line, ringing apparatus associated with said line, and means operable only in the event said desired line is idle for causing said apparatus to transmit ringing current to said desired line.

11. In a telephone system, a group of lines, a group of automatic switches having access to said lines, a selector switch having access to a plurality of switches including said group of switches, said selector switch including an incoming line, impulse responsive means included in said selector switch and comprising a pair of relays one of which operates during each alternate impulse of a received series of impulses, said means being responsive to a predetermined

series of impulses to cause said selector switch to select said group of switches from said plurality of switches, means included in said selector switch for thereafter automatically selecting an idle switch from said group of switches, means included in said selected idle switch and responsive to the operation and restoration of said one relay for causing said selected switch to seize a desired line in said group of lines, ringing apparatus associated with said selector switch, means operable only in the event said called line is idle for causing said apparatus to transmit ringing current to said desired line, a ring cut-off relay included in said selector switch, and means including said ring cut-off relay for interrupting the application of ringing current to said desired line and for establishing a connection between said incoming line and said desired line.

12. In a telephone system, a group of lines, a group of automatic switches having access to said lines, a selector switch having access to a plurality of switches including said group of switches, said selector switch including an incoming line, impulse responsive means included in said selector switch and comprising a pair of relays one of which operates during each alternate impulse of a received series of impulses, said means being responsive to a predetermined series of impulses to cause said selector switch to select said group of switches from said plurality of switches, means included in said selector switch for thereafter automatically selecting an idle switch from said group of switches, means included in said selected idle switch and responsive to the operation and restoration of said one relay for causing said selected switch to seize a desired line in said group of lines, means included in said selector switch and operable in the event said desired line is busy for applying busy tone current to said line, ringing apparatus associated with said selector switch, means operable only in the event said called line is idle for causing said apparatus to transmit ringing current to said desired line, a ring cut-off relay, and means including said ring cut-off relay for interrupting the transmission of ringing current to said desired line and for establishing a connection between said incoming line and said desired line.

13. In a telephone system, a group of lines, a group of automatic switches having access to said lines, a selector switch having access to a plurality of switches including said group of switches, said selector switch including an incoming line, impulse responsive means included in said selector switch and comprising a pair of relays one of which operates during each alternate impulse of a received series of impulses, said means being responsive to a predetermined series of impulses to cause said selector switch to select said group of switches from said plurality of switches, means included in said selector switch for thereafter automatically selecting an idle switch from said group of switches, means included in said selected idle switch and responsive to the operation and restoration of said one relay for causing said selected switch to seize a desired line in said group of lines, a plurality of telephones on said desired line, each of said telephones having associated therewith a signal device responsive to current of a frequency different from that to which each of the other similar devices is responsive, ringing apparatus associated with said selector switch, and means operable only when said desired line is idle and responsive to a final predetermined series of im-

pulses for causing said ringing apparatus to transmit ringing current to said desired line of the frequency to which only the signal device associated with a desired one of said telephones is responsive.

14. In a telephone system, a group of lines, a group of automatic switches having access to said lines, a selector switch having access to a plurality of switches including said group of switches, said selector switch including an incoming line, impulse responsive means included in said selector switch and comprising a pair of relays one of which operates during each alternate impulse of a received series of impulses, said means being responsive to a predetermined series of impulses to cause said selector switch to select said group of switches from said plurality of switches, means included in said selector switch for thereafter automatically selecting an idle switch from said group of switches, means included in said selected idle switch and responsive to the operation and restoration of said one relay for causing said selected switch to seize a desired line in said group of lines, a plurality of telephones on said desired line, each of said telephones having associated therewith a signal device responsive to current of a frequency different from that to which each of the other similar devices is responsive, ringing apparatus associated with said selector switch, means operable only when said desired line is idle and responsive to a final predetermined series of impulses for causing said ringing apparatus to transmit ringing current to said desired line of the frequency to which only the signal device associated with a desired one of said telephones is responsive, a ring cut-off relay included in said selector switch, and means including said ring cut-off relay for interrupting the transmission of ringing current to said desired line and for establishing a connection between said incoming line and said desired line.

15. In a telephone system, a plurality of lines including a group of lines, a group of automatic switches having access to said lines, a selector switch having access to a plurality of switches including said group of switches, said selector switch including an incoming line, impulse responsive means included in said selector switch and comprising a pair of relays one of which operates during each alternate impulse of a received series of impulses, said means being responsive to one predetermined series of impulses to cause said selector switch to select said group of switches from said plurality of switches, means included in said selector switch for thereafter automatically selecting an idle switch from said selected group of switches, means included in said selected idle switch and responsive to the operation and restoration of said one relay during a succeeding predetermined series of impulses for causing said selected idle switch to select said group of lines from said plurality of lines, and means included in said selected idle switch and responsive to the operation and restoration of said one relay during an additional predetermined series of impulses for causing said selected idle switch to seize a desired line in said group of lines.

16. In a telephone system, a plurality of lines including a group of lines, a group of automatic switches having access to said lines, a selector switch having access to a plurality of switches including said group of switches, said selector switch including an incoming line, impulse responsive means included in said selector switch

and comprising a pair of relays one of which operates during each alternate impulse of a received series of impulses, said means being responsive to one predetermined series of impulses to cause said selector switch to select said group of switches from said plurality of switches, means included in said selector switch for thereafter automatically selecting an idle switch from said group of switches, means included in said selected idle switch and responsive to the operation and restoration of said one relay during a succeeding predetermined series of impulses for causing said selected idle switch to select said group of lines from said plurality of lines, means included in said selected idle switch and responsive to the operation and restoration of said one relay during an additional predetermined series of impulses for causing said selected idle switch to seize a desired line in said group of lines, a plurality of telephones on said desired line, each of said telephones having associated therewith a signal device responsive to current of a frequency different from that to which each of the other similar devices is responsive, ringing apparatus associated with said selector switch, and means operable only when said desired line is idle and responsive to a final predetermined series of impulses for causing said ringing apparatus to transmit ringing current to said desired line of the frequency to which only the signal device associated with a desired one of said telephones is responsive.

17. In a telephone system, a plurality of lines including a group of lines, a group of automatic switches having access to said lines, a selector switch having access to a plurality of switches including said group of switches, said selector switch including an incoming line, impulse responsive means included in said selector switch and comprising a pair of relays one of which operates during each alternate impulse of a received series of impulses, said means being responsive to one predetermined series of impulses to cause said selector switch to select said group of switches from said plurality of switches, means included in said selector switch for thereafter automatically selecting an idle switch from said group of switches, means included in said selected idle switch and responsive to the operation and restoration of said one relay during a succeeding predetermined series of impulses for causing said selected idle switch to select said group of lines from said plurality of lines, means included in said selected idle switch and responsive to the operation and restoration of said one relay during an additional predetermined series of impulses for causing said selected idle switch to seize a desired line in said group of lines, and means included in said selector switch and operable in the event said desired line is busy for applying busy tone current to said incoming line.

18. In a telephone system, a plurality of lines including a group of lines, a group of automatic switches having access to said lines, a selector switch having access to a plurality of switches including said group of switches, said selector switch including an incoming line, impulse responsive means included in said selector switch and comprising a pair of relays one of which operates during each alternate impulse of a received series of impulses, said means being responsive to one predetermined series of impulses to cause said selector switch to select said group of switches from said plurality of switches, means included in said selected idle switch and

responsive to the operation and restoration of said one relay during a succeeding predetermined series of impulses for causing said selected idle switch to select said group of lines from said

and means included in said second switch and responsive to the continued restoration and operation of said second relay during a particular series of impulses for moving said wipers over a complete group of contact sets for each position of said second relay, said wipers being in engagement with the last contact set of a predetermined group of contact sets at the conclusion of said particular series of impulses.

7 plurality of lines, means included in said selected idle switch and responsive to the operation and restoration of said one relay during an additional predetermined series of impulses for causing said selected idle switch to seize a desired line in said group of lines, a plurality of telephones on said desired line, each of said telephones having associated therewith a signal device responsive to current of a frequency different from that to which each of the other similar devices is responsive, ringing apparatus associated with said selector switch, means operable only when said desired line is idle and responsive to a final predetermined series of impulses for causing said ringing apparatus to transmit ringing current to said desired line of the frequency to which only the signal device associated with a desired one of said telephones is responsive, a ring cut-off relay included in said selector switch, and means including said ring cut-off relay for interrupting the transmission of ringing current to said desired line and for establishing a connection between said incoming line and said desired line.

19. In combination, a first automatic switch, a second automatic switch, said switches being adapted to be connected in tandem in the order named, said second switch including bank contacts, groups of lines terminating at said contacts, impulse responsive means included in said first switch and comprising a pair of relays one of which operates during each alternate impulse of a series of received impulses, means included in said second switch and responsive to the operation and restoration of said one relay during one series of impulses for causing said second switch to select a predetermined one of said groups of lines, and means included in said second switch and responsive to the operation and restoration of said one relay during a succeeding series of impulses for causing said second switch to seize a particular line in said selected group of lines.

20. In combination, a first automatic switch, a second automatic switch, said second switch including groups of bank contact sets and wipers for engaging the contacts of said contact sets, groups of lines terminating at said contacts, impulse responsive means included in said first switch and comprising a pair of relays one of which operates during each alternate impulse of a series of received impulses, means including said impulse responsive means for connecting said switches in tandem, in the order named, in response to a predetermined series of received impulses, a slow-to-release relay included in said first switch and operative at the beginning of each series of impulses, said slow-to-release relay being constructed to remain operated throughout each series of impulses, a first relay included in said second switch and operative in response to the operation of said slow-to-release relay, a second relay in said second switch, said second relay being arranged to operate and restore in accordance with the operation and restoration of said one relay during particular series of received impulses, means responsive to the operation of said first and second relays for causing said wipers to move to a position just preceding the first set of contacts in the group of contact sets corresponding to the first of said groups of lines, means included in said second switch and responsive to the continued restoration and operation of said second relay during a succeeding particular series of impulses for moving said wipers over a complete group of contact sets for each position of said second relay, said wipers being in engagement with the last contact set of a predetermined group of contact sets at the conclusion of said particular series of impulses, and means responsive to the operation of said second relay during a succeeding series of impulses for moving said wipers into engagement with a particular set of contacts at which the conductors of a desired line terminate.

21. In combination, a first automatic switch, a second automatic switch, said second switch including groups of bank contact sets and wipers for engaging the contacts of said contact sets, groups of lines terminating at said contacts, impulse responsive means included in said first switch and comprising a pair of relays one of which operates during each alternate impulse of a series of received impulses, means including said impulse responsive means for connecting said switches in tandem, in the order named, in response to a predetermined series of received impulses, a slow-to-release relay included in said first switch and operative at the beginning of each series of impulses, said slow-to-release relay being constructed to remain operated throughout each series of impulses, a first relay included in said second switch and operative in response to the operation of said slow-to-release relay, a second relay in said second switch, said second relay being arranged to operate and restore in accordance with the operation and restoration of said one relay during particular series of received impulses, means responsive to the operation of said first and second relays for causing wipers to move to a position just preceding the first set of contacts in the group of contact sets corresponding to the first of said groups of lines, means included in said second switch and responsive to the continued restoration and operation of said second relay during a succeeding particular series of impulses for moving said wipers over a complete group of contact sets for each position of said second relay, said wipers being in engagement with the last contact set of a predetermined group of contact sets at the conclusion of said particular series of impulses, and means responsive to the operation of said second relay during a succeeding series of impulses for moving said wipers into engagement with a particular set of contacts at which the conductors of a desired line terminate.

22. In combination, a first automatic switch, a second automatic switch, said second switch including groups of bank contact sets and wipers for engaging the contacts of said sets, groups of lines terminating at said contacts, impulse responsive means included in said first switch and comprising a pair of relays one of which operates during each alternate impulse of a series of received impulses, means including said impulse responsive means for connecting said switches in tandem, in the order named, in response to a predetermined first series of received impulses, a slow-to-release relay in said first switch and operative at the beginning of each series of impulses, said slow-to-release relay being constructed to remain operated throughout each series of impulses, a first relay included in said second switch and operative in response to the operation of said slow-to-release relay, a second relay in said second switch, said second relay being arranged to operate and restore in accordance with the operation and restoration of said one relay during particular series of received impulses, driving means including a motor magnet for moving said wipers over said contact sets, means responsive

to the operation of said first and second relays at the beginning of a second series of impulses for causing said driving means to move said wipers to a position just preceding the first set of contacts in the group of contact sets corresponding to the first of said groups of lines, means included in said second switch and responsive to the continued restoration and operation of said second relay during said second series of impulses for causing said driving means to move said wipers over a complete group of contact sets for each position of said second relay, said wipers being in engagement with the last contact set of a predetermined group of contact sets at the conclusion of said second series of impulses, a third relay in said second switch, means whereby said third relay operates in response to the restoration of said second relay at the conclusion of said second series of impulses, a circuit for said motor magnet, said circuit being prepared when said third relay operates, and being so related to said second relay that it is completed each time said second relay operates, whereby said driving means moves said wipers from one set of contacts into engagement with the succeeding set of contacts during each alternate impulse of a third series of received impulses.

23. In an automatic switch, groups of bank contact sets, wipers for engaging said contact sets, and means including impulse responsive means for causing said wipers to traverse and engage said groups of contact sets at the rate of one group of contact sets for each impulse of a series of received impulses, the number of contact sets in each group being so proportioned relative to the rate of impinging that the speed at which said wipers traverse and engage said contact sets does not exceed forty contact sets per second.

24. In an automatic switch, groups of bank contacts, a wiper for engaging said contacts, and means including impulse responsive means for causing said wiper to traverse and engage said groups of contacts at the rate of one group of contacts for each impulse of a series of received impulses, the number of contacts in each group of contacts being so proportioned relative to the rate of impinging that the speed at which said wipers traverse and engage said contacts does not exceed forty contacts per second.

25. In a telephone system, a first line, a second line, a first automatic switch, a second automatic switch, means included in said first switch for causing said first switch to seize said second switch on a call from said first line to said second line, said means including an impulse responsive relay which operates on each alternate impulse of a series of received impulses, means included in said second switch and responsive to the operation of said relay for causing said second switch to select said second line, and means for establishing a connection between said lines in the event said second line is idle.

26. In a telephone system, an incoming line, a plurality of outgoing lines, a first selector switch, a group of second selector switches, means included in said first selector switch for causing said first selector switch to seize an idle one of said second selector switches, said means including an impulse responsive relay which operates on each alternate impulse of a series of received impulses, and means included in said last-mentioned second selector switch and responsive to operation of said relay for causing said last-mentioned second selector switch to select one of said

outgoing lines, and means for establishing a connection between said incoming line and said one of said outgoing lines in the event said one outgoing line is idle.

27. In a telephone system, groups of lines, a selector switch having access to said lines, a pair of talking conductors incoming to said switch, impulse responsive means adapted to receive a series of dialed impulses and to transmit a control pulse over one of said talking conductors during each alternate impulse of a series of received dialed impulses, a first relay and a second relay included in said switch, a circuit including the other of said talking conductors for causing the operation of said first relay during each series of dialed impulses received by said impulse responsive means, a circuit including said one talking conductor for causing the operation of said second relay during each control pulse transmitted over said one talking conductor, means responsive to the first operation of said first relay and the first operation of said second relay for causing said switch to select the first of said groups of lines, and means responsive to the continued operation of said first relay and the restoration of said second relay for causing said switch to select the second of said groups of lines.

28. In a telephone system, groups of lines, a selector switch having access to said lines, a pair of talking conductors incoming to said switch, impulse responsive means adapted to receive a series of dialed impulses and to transmit a control pulse over one of said talking conductors during each alternate impulse of a series of received dialed impulses, a first relay and a second relay included in said switch, a circuit including the other of said talking conductors for causing the operation of said first relay during each series of dialed impulses received by said impulse responsive means, a circuit including said one talking conductor for causing the operation of said second relay during each control pulse transmitted over said one talking conductor, means responsive to the first operation of said first relay and the first operation of said second relay for causing said switch to select the first of said groups of lines, means responsive to the continued operation of said first relay and the restoration of said second relay for causing said switch to select the second of said groups of lines, and means responsive to the continued operation of said first relay and the second operation of said second relay for causing said switch to select the third of said groups of lines.

29. In a telephone system, two groups of lines, a selector switch having access to said lines, a pair of talking conductors incoming to said switch, impulse responsive means adapted to receive a series of dialed impulses and to transmit a control pulse over one of said talking conductors during each alternate impulse of a series of received dialed impulses, a first relay and a second relay included in said switch, a circuit including the other of said talking conductors for causing the operation of said first relay during each series of dialed impulses received by said impulse responsive means, a circuit including said one talking conductor for causing the operation of said second relay during each control pulse transmitted over said one talking conductor, means responsive to the operation of said first relay and the first operation of said second relay during one series of impulses received by said impulse responsive means for causing said switch to select the first line in one of said groups of

lines, and means responsive to the continued operation of said first relay and the restoration of said second relay for causing said switch to select the first line in the other of said groups of lines.

5 30. In a telephone system, two groups of lines, a selector switch having access to said lines, a plurality of talking conductors incoming to said switch, impulse responsive means adapted to receive a series of dialed impulses and to transmit
10 a control pulse over one of said talking conductors during each alternate impulse of a series of received dialed impulses, a first relay and a second relay included in said switch, a circuit including the other of said talking conductors for
15 causing the operation of said first relay during each series of dialed impulses received by said impulse responsive means, a circuit including said one talking conductor for causing the operation of said second relay during each control

pulse transmitted over said one talking conductor, means responsive to the operation of said first relay and the first operation of said second relay during one series of impulses received by said impulse responsive means for causing said
5 switch to select the first line in one of said groups of lines, means responsive to the continued operation of said first relay and the first restoration of said second relay for causing said switch to select the first line in the other of said groups of
10 lines, means responsive to the continued operation of said first relay and the second operation of said second relay for causing said switch to select the second line in said one group of lines, and means responsive to the continued operation of said
15 first relay and the second restoration of said second relay for causing said switch to select the second line in said other group of lines.

JOHN WICKS.