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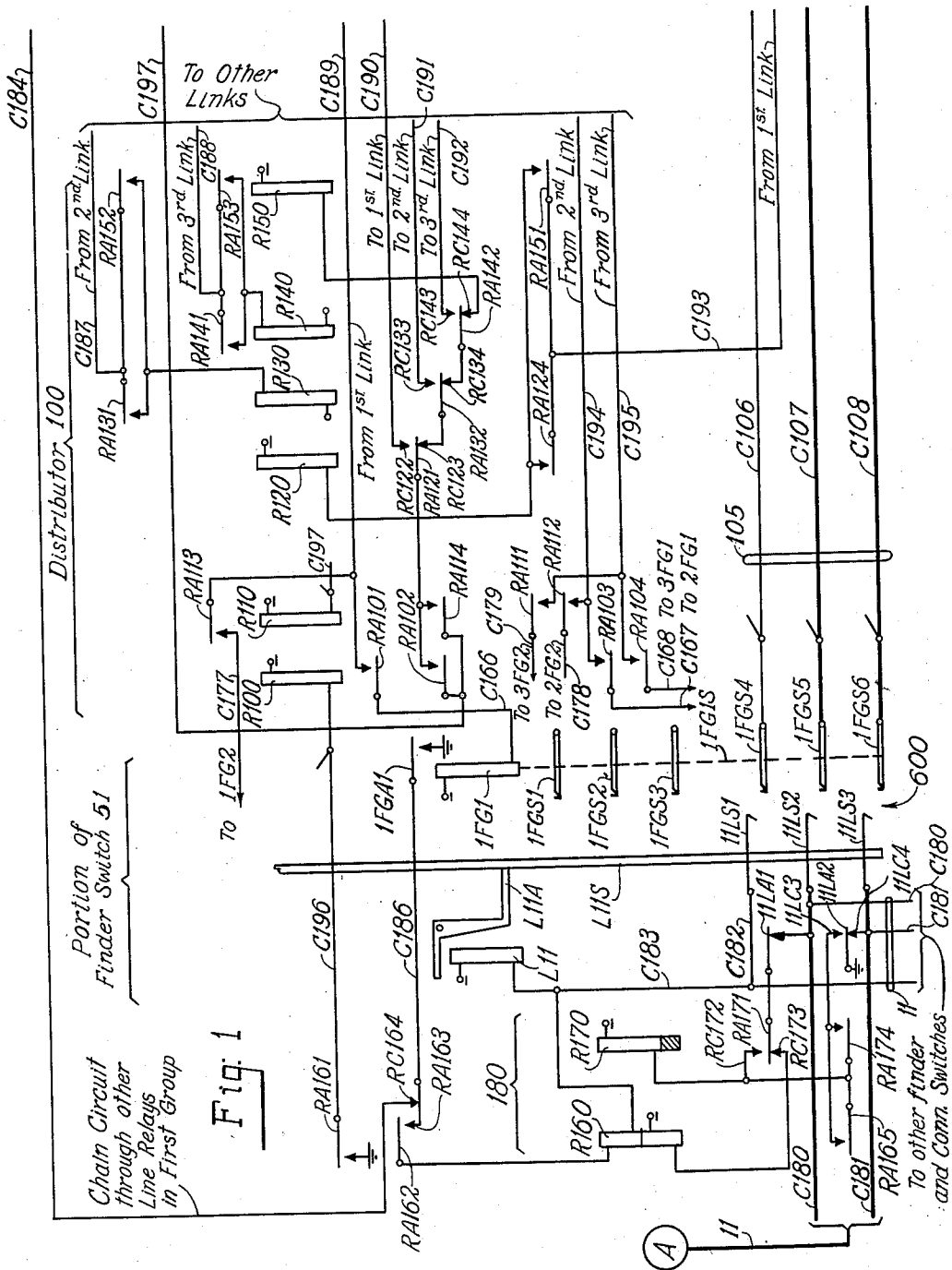
J. WICKS

2,253,743

SIGNALING SYSTEM

Filed Oct. 31, 1938

5 Sheets-Sheet 1



INVENTOR.
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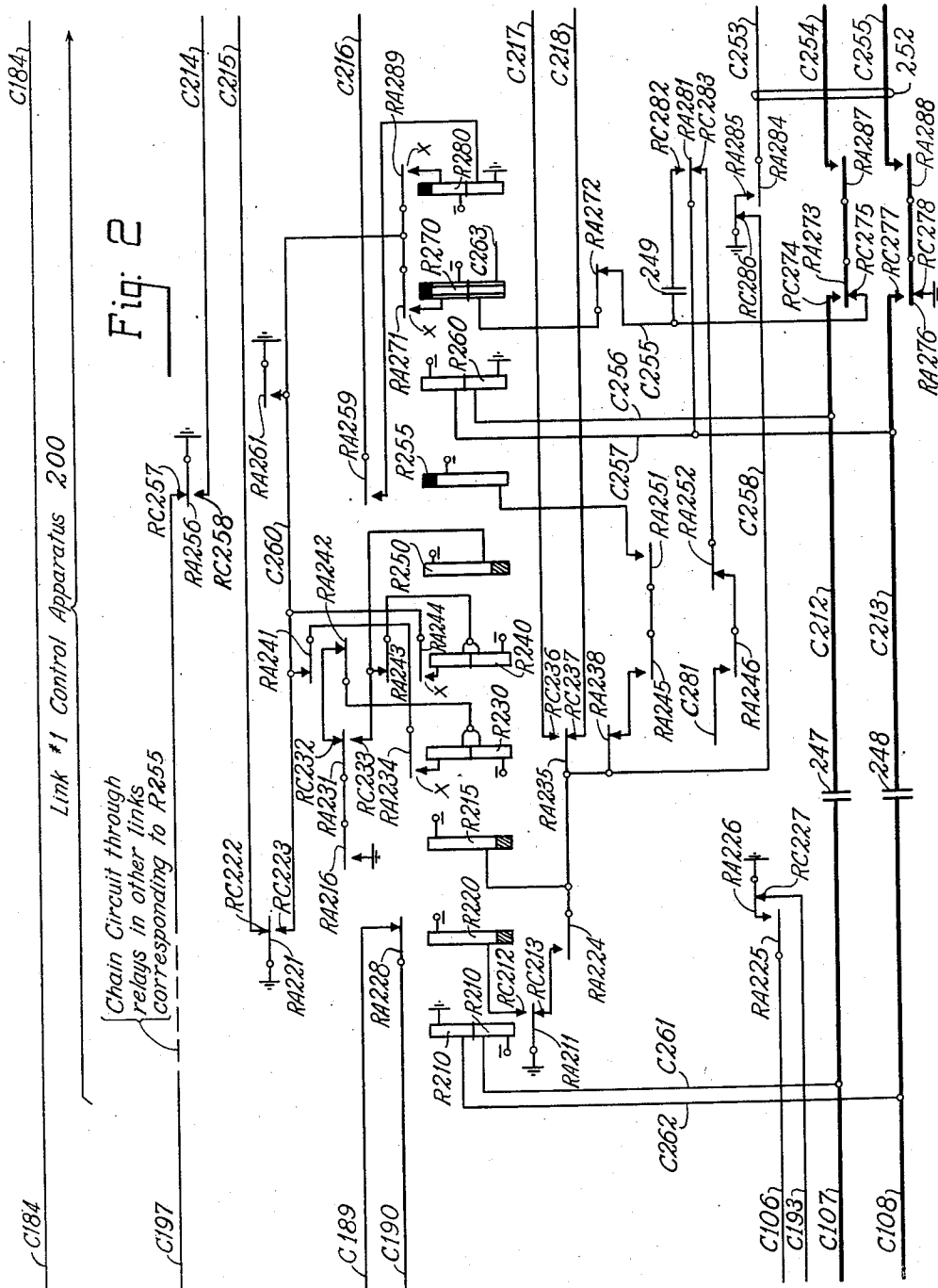
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SIGNALING SYSTEM

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5 Sheets-Sheet 2



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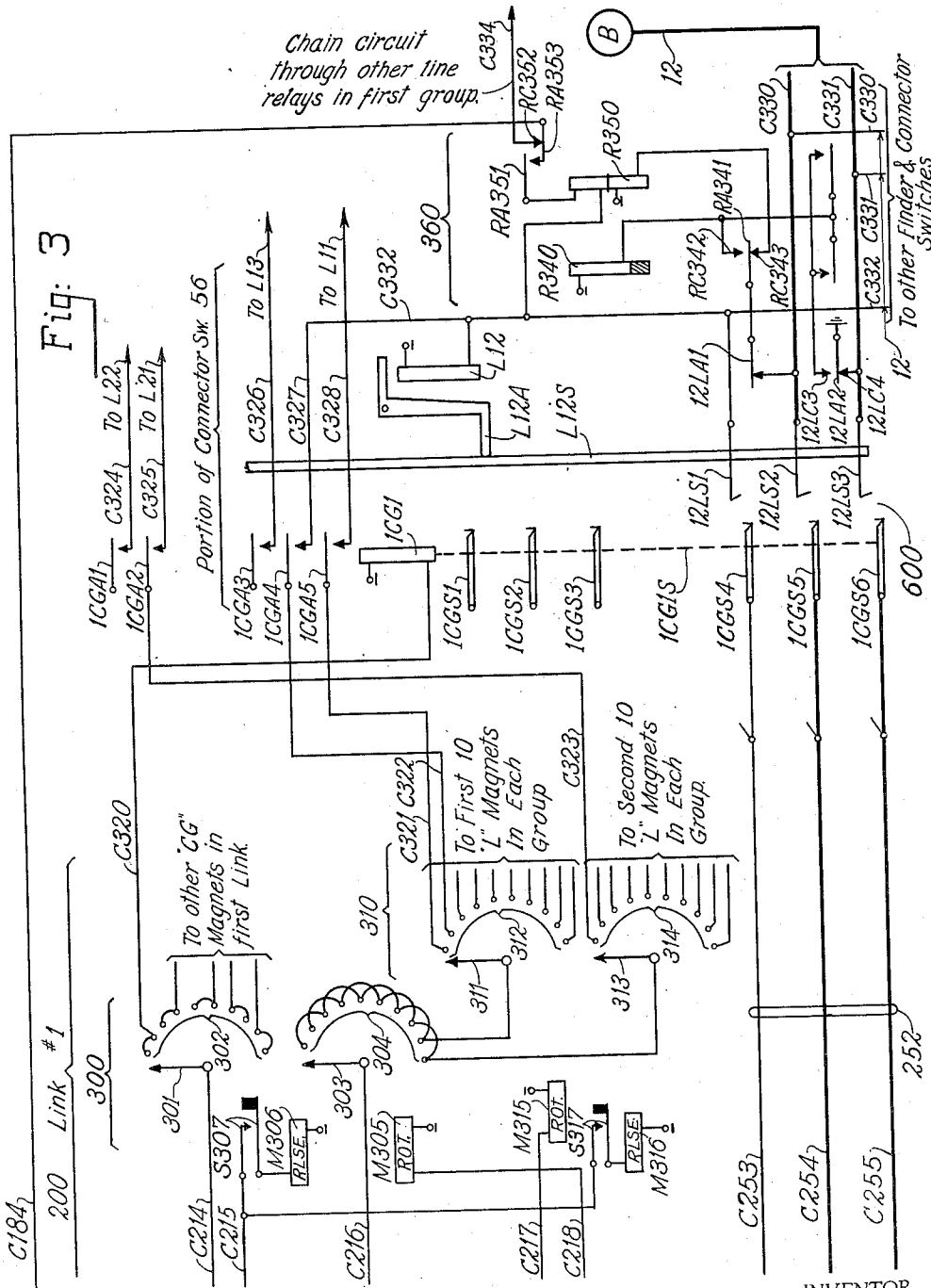
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SIGNALING SYSTEM

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5 Sheets-Sheet 3



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SIGNALING SYSTEM

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5 Sheets-Sheet 4

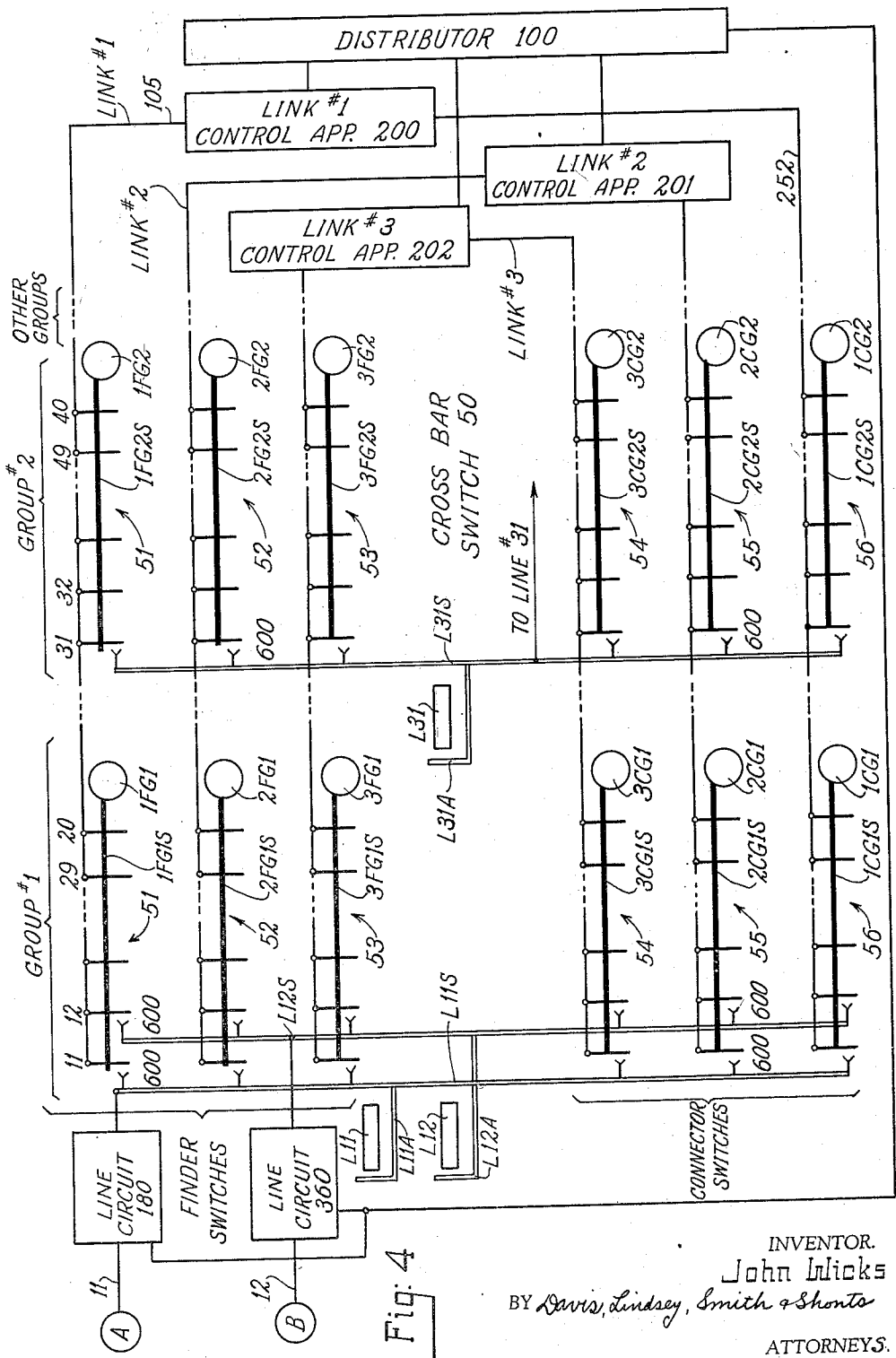


Fig. 4

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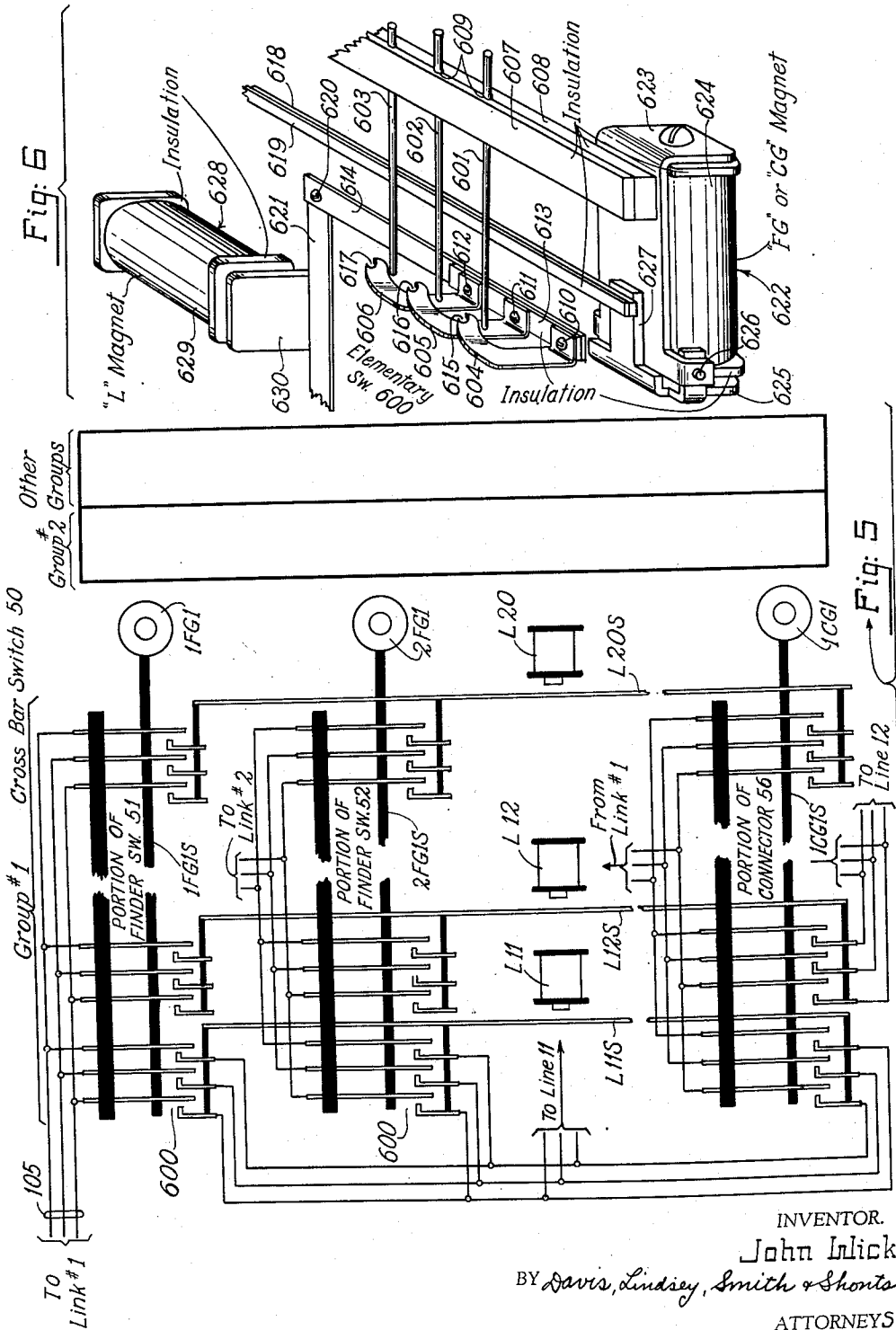
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2,253,743

SIGNALING SYSTEM

Filed Oct. 31, 1938

5 Sheets-Sheet 5



UNITED STATES PATENT OFFICE

2,253,743

SIGNALING SYSTEM

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Application October 31, 1938, Serial No. 237,891

8 Claims. (Cl. 179—22)

The present invention relates to signaling systems and more particularly to automatic switches of the so-called cross-bar type for use in setting up connections between the various lines of an automatic telephone system.

In a telephone system, apparatus is provided for the purpose of setting up a connection between one line and any other line in the system which conventionally comprises finder and connector switches having access to each line in the system and a number of intermediate traffic concentrating switches interposed between the finder and connector switches. In a small telephone system, intermediate traffic concentrating switches are unnecessary and each finder and connector switch has access to each line in the system. In such a small telephone system, a finder switch and a connector switch are arranged in a link, the finder switch being operative to find a calling line in the system, and the connector switch being operative to select a desired called line in the system; and the call is routed between the calling and called lines by way of a link circuit extending between the finder and connector switches of the link. Various types of finder and connector switches for performing the functions noted are known in the art, one such type of switch being the so-called cross-bar switch. One of the best known and most successful forms of the cross-bar switch comprises first and second sets of movable bars arranged in intersecting relation, the first set of bars individually corresponding to the groups of lines in the system and the second set of bars individually corresponding to particular lines in each of the groups of lines in the system. A number of contact sets individually terminating the lines in the system are associated with the bars, each contact set being partially operative under the control of a particular bar in each of the first and second sets of bars associated therewith and being fully operative under the joint control of the two associated bars. The construction and arrangement of the cross-bar switch is such that, when a particular bar in the first set of bars is operated, the group of contact sets terminating the associated group of lines in the system is partially operated; and, when a particular bar in the second set of bars is operated, the group of contact sets terminating the associated and corresponding lines in the groups of lines is partially operated, only the contact set associated with both of these bars

being fully operated. Thus, these operations of the two bars noted are effective to cause the switch to seize in the group of lines corresponding to the first-mentioned bar the line corresponding to the second-mentioned bar.

While the above-described type of cross-bar switch has met with some approval, it has not been generally accepted due to certain disadvantages in regard to the constructional and operational features thereof. More particularly, from the foregoing description of the construction and arrangement of this type of cross-bar switch, it will be apparent that only one call at any given time may be routed therethrough; and the cross-bar switch may be employed as the switching mechanism in only one finder or connector switch, two cross-bar switches being required in each finder-connector link in the system. Hence, a relatively large number of such links are required in even a small telephone system if an adequate number of links are provided to render satisfactory services to the subscribers.

Accordingly, it is an object of the present invention to provide, in a signaling system, improved unitary switching apparatus which is so constructed and arranged that it comprises both a finder switch and a selector switch.

Another object of the invention is to provide, in a signaling system, improved unitary switching apparatus which is so constructed and arranged that it comprises a plurality of finder and connector switches arranged in a number of finder-connector links in order to provide for the routing of co-existing calls through the switching apparatus.

A further object of the invention is to provide improved switching apparatus of the cross-bar type which is of simple construction and arrangement and which is economical to manufacture and thoroughly reliable in operation.

The features of the present invention are illustrated as being incorporated in an automatic signaling or telephone system including a plurality of signal or subscriber lines, each line having a line circuit individually associated therewith, and means including improved unitary switching apparatus of the cross-bar type for setting up connections between the various lines. The improved switching apparatus is so constructed and arranged that it comprises a number of finder and connector switches, each switch having access to each line in the system.

The finder and connector switches are arranged in links, each link including a link circuit provided with control and impulse responsive apparatus for governing the operations of the associated finder and connector switches, respectively. Subscriber substations are associated with the lines; and a distributor is provided for the purpose of assigning idle ones of the links to calling ones of the lines in a predetermined order.

In accordance with one feature of the invention, the unitary switching apparatus comprises a plurality of operating elements, each of the operating elements being associated with only one of the groups of lines in the system, a plurality of operating members, each of the operating members being associated with only one of the lines in the system, and means controlled by the joint operations of one of the operating elements and one of the operating members for selecting from the group of lines corresponding to the one operating element the line corresponding to the one operating member. More particularly, this switching apparatus comprises a plurality of divisions of operating elements, each of the divisions of operating elements being associated with only one of the groups of lines, whereby a particular line in a particular group of lines may be selected by the joint operation of any one of the operating elements in the division of operating elements corresponding to the group of lines including the particular line and the operating member corresponding to the particular line. More specifically, the switching apparatus comprises a plurality of first and second operating elements arranged in divisions as previously noted, the first operating elements being operative in conjunction with the operating members to select calling lines, and the second operating elements being operative in conjunction with the operating members to select called lines. Corresponding ones of the first operating elements in the divisions of first operating elements are respectively associated with trunk lines extending to the link circuits from the switching apparatus; and corresponding ones of the second operating elements in the divisions of second operating elements are respectively associated with trunk lines extending from the link circuits to the switching apparatus, whereby a selected calling line may be connected to a trunk line extending to one of the link circuits and a selected called line may be connected to a trunk line extending from one of the link circuits.

In accordance with another feature of the invention, the distributor associated with the switching apparatus is so connected and arranged that it is operative in response to the creation of a calling condition on one of the signal lines to cause the operations of one of the first operating elements associated with a trunk line extending to an idle one of the link circuits and included in the one of the divisions of first operating elements associated with the group of signal lines including the calling signal line and the one of the operating members associated with the calling signal line, thereby to seize the calling signal line and to connect the calling signal line to the trunk line extending to the one link circuit. Also, each one of the link circuits includes impulse responsive means for selecting any one of the called signal lines and for testing the idle or busy condition of the selected called signal line, and means controlled by the last-mentioned means in the event

the selected called signal line is tested idle for causing the one of the second operating elements associated with the trunk line extending from the one link circuit and included in the one of the divisions of second operating elements associated with the group of signal lines including the selected called signal line and the one of the operating members associated with the selected called signal line to be operated, thereby to seize the selected called signal line and to connect the seized called signal line to the trunk line extending from the one link circuit. Subsequently, the trunk lines extending to and from the one link circuit are connected together, thereby to interconnect the seized calling signal line and the seized called line for communication therebetween.

In accordance with a further feature of the invention, the switching apparatus comprises a plurality of groups of elementary switches, each group of elementary switches being associated with only one of the first or second operating elements, and each elementary switch being associated with only one of the operating members. Each of the elementary switches is so constructed and arranged that it is partially operative under the control of the operating element and under the control of the operating member associated therewith and is fully operative under the joint control of the associated operating element and operating member. More specifically, each of the elementary switches constitutes a circuit controlling device and comprises a flexible first contact member mounted at one portion thereof and provided with an outwardly extending portion having a normal position and a second contact member having a normal position. The second contact member has a recess therein adapted to receive and engage the outwardly extending portions of the first contact member. The operating element associated with the elementary switch is operative to flex the outwardly extending portion of the first contact member away from its normal position along a first path into the intersection of the first path and a second path; and the operating member associated with the elementary switch is operative to move the second contact member away from its normal position along the second path across the intersection of the first and second paths. The elementary switch is so constructed and arranged that the recess in the second contact member receives and engages the outwardly extending portion of the first contact member only in the event that the outwardly extending portion of the first contact member is disposed in the intersection of the first and second paths when the second contact member is moved thereacross and that the outwardly extending portion of the first contact member is flexed along the second path when it is engaged by the second contact member. Also, the recess provided in the second contact member comprises means for restraining the outwardly extending portion of the first contact member in engagement with the second contact member under the control of the operating member associated with the elementary switch and until the second contact member is returned toward its normal position.

Further features of the invention pertain to the particular arrangement of the circuit elements of the system and to the particular construction and arrangement of the elements of the

switching apparatus, whereby the above-outlined and additional features are attained.

The novel features believed to be characteristic of the invention are set forth with particularity in the appended claims. The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings in which Figures 1, 2 and 3, taken together, illustrate diagrammatically a telephone system incorporating a cross-bar switch and embodying the present invention; Fig. 4 illustrates diagrammatically the general trunking arrangement of the telephone system shown in Figs. 1, 2 and 3, and the general construction and arrangement of the cross-bar switch incorporated in the telephone system and embodying the present invention; Fig. 5 is a schematic illustration of a portion of the cross-bar switch further illustrating the construction and arrangement thereof; and Fig. 6 is a perspective view of one of the elementary switches included in the cross-bar switch shown in Fig. 5.

Referring now more particularly to Figs. 1 to 4, inclusive, of the drawings, the telephone system there illustrated comprises an exchange having a plurality of subscriber lines including the subscriber lines 11 and 12, terminating thereat, a cross-bar switch 50 therein and provided with a plurality of links, the first, second and third links being indicated, for setting up connections between the various subscriber lines. Also, a distributor 100 is provided for assigning idle ones of the links to the use of calling ones of the lines. More specifically, the exchange has an ultimate capacity of one hundred lines and the number of links is determined by the amount of traffic which the exchange is required to handle, usually ten links being adequate to render satisfactory service.

The subscriber lines terminating at the exchange are arranged in five groups of twenty lines each, the subscriber lines 10 to 29, inclusive, comprising group one; the lines 30 to 49, inclusive, comprising group two; etc.; and the lines 90 to 99, inclusive, and 00 to 09, inclusive, comprising group five. The cross-bar switch 50 is so constructed and arranged that it comprises a finder switch and a connector switch individually associated with each link and each switch having access to each line in the system; the first, second and third links have the finder switches 51, 52 and 53 and the connector switches 56, 55 and 54 respectively associated therewith. Each finder switch comprises five portions respectively associated with the five groups of lines terminating at the exchange, each portion being provided with a group or "FG" magnet operative to condition any one of the twenty lines in the associated group of lines to be seized. Similarly, each connector switch comprises five portions respectively associated with the five groups of lines terminating at the exchange, each portion being provided with a group or "CG" magnet operative to condition any one of the twenty lines in the associated group of lines to be seized. Furthermore, the cross-bar switch comprises a plurality of line or "L" magnets individually associated with the lines terminating at the exchange, each of the "L" magnets being operative to cause the associated line to be seized by the finder or connector switch of one of the links in the event the group of lines including the as-

sociated line has been previously conditioned to be seized by the operation of the associated "FG" or "CG" magnet, respectively, therein, in a manner more fully explained subsequently. Also, each link is provided with control apparatus individually associated therewith, the control apparatus individually associated with the first, second and third links being respectively indicated at 200, 201 and 202.

Each of the links may be identical to the first link illustrated, and the control apparatus individually associated with each link may be identical to the control apparatus 200 individually associated with the first link. Referring now more particularly to Figs. 1, 2 and 3, it will be observed that the first link comprises a finder switch 51 and a connector switch 56, each having access to each line in the system; and the control apparatus 200 individually associated with the first link comprises a line relay R210, a hold relay R220, a back bridge relay R260, a ring cut-off relay R270, a busy relay R280, two transfer relays R230 and R240, two control relays R215 and R250, a test relay R255, the control and controlled circuits associated therewith, and two minor switches 300 and 310. The minor switch 300 comprises two contact banks 302 and 304, respectively provided with contact wipers 301 and 303, a rotary magnet M305 for simultaneously rotating the two wipers 301 and 303 across the contacts in the associated contact banks, and a release magnet M306 for releasing these two wipers and for causing these two wipers to be returned to their normal positions. The minor switch 310 comprises two contact banks 312 and 314, respectively provided with the contact wipers 311 and 313, a rotary magnet M315 for simultaneously rotating the two wipers 311 and 313 across the contacts in the associated contact banks, and a release magnet M316 for releasing these two wipers and for causing these two wipers to be returned to their normal positions. Furthermore, two sets of switch springs S307 and S317 are respectively associated with the wipers of the minor switches 300 and 310, and are actuated into engagement when the wipers of the associated minor switch are rotated away from their normal positions.

A subscriber substation is associated with each of the subscriber lines, the subscriber substations A and B being respectively associated with the subscriber lines 11 and 12. Each of the subscriber substations is provided with a telephone instrument, a dial mechanism, and a ringer. A line circuit is individually associated with each subscriber line in the system, the line circuit 180 being individually associated with the subscriber line 11 and the line circuit 360 being individually associated with the subscriber line 12. The line circuit 180 comprises a line relay R160 and a cut-off relay R170; and the line circuit 360 comprises a line relay R350 and a cut-off relay R340. Furthermore, each of these line circuits is provided with control and controlled circuits associated with the relays therein. Preferably, the line circuits are of identical connection and arrangement.

The distributor 100 comprises five group relays individually associated with the five groups of lines terminating at the exchange, the group relays R100 and R110, illustrated, being individually associated with the first and second groups of lines terminating at the exchange, a relay individually associated with each link included in the system, the relays R120, R130 and

R140 being respectively associated with the first, second and third links, illustrated, included in the system, and a reset relay R150. Furthermore, the distributor 100 comprises control and controlled circuits associated with the relays therein.

Referring now more particularly to Figs. 4 and 5 of the drawings, the cross-bar switch there illustrated and incorporated in the telephone system, shown in Figs. 1, 2 and 3, comprises a number of finder switches 51, 52, 53, etc., and a number of connector switches 56, 55, 54, etc., respectively included in the first, second, third, etc., links. Each of the finder and connector switches includes five portions, each portion having access to one of the groups of twenty lines terminating at the exchange. Each portion of each of the finder switches is provided with an operating element or bar which is operated by an "FG" magnet individually associated therewith. For example, the first portions of the finder switches 51, 52 and 53 are provided with the operating elements 1FG1S, 2FG1S and 3FG1S, respectively, these operating elements being operated by the "FG" magnets 1FG1, 2FG1 and 3FG1, respectively, and constituting a division of first operating elements, and the first and second portions of the finder switch 51 are provided with the operating elements 1FG1S and 1FG2S, respectively, these operating elements being operated by the "FG" magnets 1FG1 and 1FG2, respectively. Similarly, each portion of each of the connector switches is provided with an operating element which is operated by a "CG" magnet individually associated therewith. For example, the first portions of the connector switches 56, 55 and 54 are provided with the operating elements 1CG1S, 2CG1S and 3CG1S, respectively, these operating elements being operated by the "CG" magnets 1CG1, 2CG1 and 3CG1, respectively, and constituting a division of second operating elements; and the first and second portions of the first connector switch 56 are provided with the operating elements 1CG1S and 1CG2S, respectively, these operating elements being operated by the "CG" magnets, 1CG1 and 1CG2, respectively. Also, each operating element causes twenty elementary switches 600 associated therewith and included in the associated portion of the finder or connector switch to be partially operated. For example, the operating element 1FG1S causes the twenty elementary switches 600 associated therewith and included in the associated first portion of the finder switch 51 to be partially operated; and the operating element 1CG1S causes the twenty elementary switches 600 associated therewith and included in the associated first portion of the connector switch 56 to be partially operated.

Furthermore, the cross-bar switch comprises a number of operating members or bars individually associated with the lines in the system, each operating member being operated by an "L" magnet individually associated therewith. For example, the operating members L11S and L12S are respectively associated with the lines 11 and 12 and are operated by the "L" magnets L11 and L12 respectively associated therewith. Also, each operating member causes a number of elementary switches 600, associated therewith and individually included in corresponding portions of each of the finder and connector switches, to be partially operated. For example,

the operating member L11S causes the elementary switches 600 included in the first portions of the finder switches 51, 52, 53, etc., and included in the first portions of the connector switches 56, 55, 54, etc., to be partially operated.

Furthermore, it is noted that the twenty elementary switches 600 associated with each of the five operating elements in each finder switch are multiplied together and connected to a trunk line extending to the control apparatus associated with the link which includes the finder switch; and the twenty elementary switches 600 associated with each of the five operating elements in each connector switch are multiplied together and connected to a trunk line extending from the control apparatus associated with the link which includes the connector switch. For example, the twenty elementary switches 600 associated with each of the five operating elements in the finder switch 51 are multiplied together and connected to the trunk line 105 extending to the control apparatus 200 associated with the first link; and the twenty elementary switches 600 associated with each of the five operating elements in the connector switch 54 are multiplied together and connected to the trunk line extending from the control apparatus 202 associated with the third link. Also, the elementary switches associated with each of the operating members are multiplied together and connected to the subscriber line associated therewith. For example, the elementary switches associated with the operating member L11S are multiplied together and connected to the subscriber line 11 associated therewith. Furthermore, it is noted that an elementary switch in either a finder or a connector switch is fully operated when it has been partially operated by both the operating element and the operating member with which it is associated, and when the elementary switch is fully operated it is effective to connect a subscriber line to a trunk line extending to or from the control apparatus associated with one of the links. For example, the subscriber line 11 is connected to the trunk line 105 extending to the control apparatus 200 associated with the first link when the operating element 1FG1S and the operating member L11S are operated; and the subscriber line 12 is connected to the trunk line extending from the control apparatus 202 associated with the third link when the operating element 3CG1S and the operating member L12S are operated. Finally, it is noted that, in fully operating one of the elementary switches 600, the "FG" or "CG" magnet with which it is associated is operated first, and then the "L" magnet with which it is associated is operated; and that the elementary switch 600 is retained in its operated position under the control of only the "L" magnet with which it is associated, the "FG" or "CG" magnet being restored after the "L" magnet is operated, as will be more fully explained subsequently.

Referring now more particularly to Fig. 6 of the drawings, one of the elementary switches 600 is shown in detail, and comprises three flexible contact rods 601, 602, and 603 arranged in a horizontal plane disposed below three cooperating contact strips 604, 605 and 606, respectively associated therewith. The contact rods 601, 602 and 603 are securely retained in place by two insulating members 607 and 608 between which the inner ends of the contact rods are firmly clamped.

Also, it is noted that the contact rods 601, 602 and 603 are arranged in spaced parallel relationship, these contact rods being retained in this position by cooperating slots 609 formed in the engaging faces of the insulating members 607 and 608. The contact strips 604, 605 and 606 are securely retained by a number of screws 610, 611 and 612, respectively, to an insulating member 613 which is carried by a movable strap 614. Each of the contact strips is of substantially inverted L-shaped configuration, the forward end of the leg of the L being provided with a recess therein which is adapted to receive the outer end of the contact rod associated therewith. The recesses provided in the forward ends of the legs of the contact strips 604, 605 and 606 are respectively shown at 615, 616 and 617.

The contact rods 601, 602 and 603 are associated with a movable operating element or bar 618 which is disposed below the rods. Also, the operating element 618 is provided with an insulating plate 619 on its upper surface which is adapted to be moved into engagement with the contact rods 601, 602 and 603. Also, the movable strap 614 is secured by a screw 620 to a movable operating member or bar 621. It is noted that the operating element 618 is movable in a vertical direction, whereas, the operating member 621 is movable in a direction transversely of the contact rods. The operating element 618 is operated by one of the "FG" or "CG" magnets 622, which comprises a field structure 623 to which the insulating members 607 and 608 are secured, a winding 624 and a movable armature 625 pivotally mounted upon the field structure 623 by a pair of spaced apart pivot pins 626. Also the armature 625 is provided with a rearwardly extending flange 627 which directly engages the lower surface of the operating element 618. The operating member 621 is operated by one of the L magnets 628 which comprises a magnetic field structure provided with a winding 629 and a movable armature 630 associated therewith and secured to the operating member 621.

In operating the elementary switch 600, the winding 624 of the magnet 622 is first energized, thereby to cause the armature 625 thereof to be pivoted in a counter-clockwise direction, as viewed in Fig. 6, about the pivot pins 626. This movement of the armature 625 causes the flange 627 carried thereby to engage the operating element 618 and move this element upwardly. This movement of the operating element 618 flexes the contact rods 601, 602 and 603 upwardly and out of the horizontal plane which they normally occupy, whereby the outer ends of these rods are positioned in alignment with the recesses 615, 616 and 617, respectively, provided in the contact strips 604, 605 and 606, respectively. The winding 629 of the magnet 628 is then energized, thereby to cause the armature 630 to be attracted toward the field structure thereof and the operating member 621 to be moved rearwardly, as viewed in Fig. 6. This movement of the operating member 621 causes the strip 614 carrying the contact strips 604, 605 and 606 to be moved transversely with respect to the contact rods 601, 602 and 603. When the contact strips 604, 605 and 606 are thus moved, the recesses 615, 616 and 617, respectively provided therein, receive the ends of the contact rods 601, 602 and 603, respectively, thereby to flex these contact rods rearwardly and establish a connection between the respectively engaged contact rods and contact strips. Thus, the elementary switch 600 is partially op-

erated by each of the magnets 622 and 628, thereby to cause this elementary switch to be fully operated. After the elementary switch 600 is fully operated, the magnet 622 may be deenergized, thereby to cause the operating element 618 to be returned to its normal position without affecting the operated position of the elementary switch 600, the contact rods 601, 602 and 603 being retained in their upwardly and rearwardly flexed positions under the control of the operated magnet 628.

In order to release the elementary switch 600 the winding 629 of the magnet 628 is deenergized, whereupon the contact rods 601, 602 and 603 are moved forwardly, due to their resiliency; and the ends thereof are moved out of the recesses 615, 616 and 617 provided in the contact strips 604, 605 and 606, respectively, whereupon the contact rods are moved downwardly, due to their resiliency, to their normal positions.

Also it is noted that, in the event the winding 629 of the magnet 628 is energized prior to the energization of the winding 624 of the magnet 622, the contact strips 604, 605 and 606 are moved transversely with respect to the contact rods 601, 602 and 603 and over the outer ends of the contact rods without engagement therewith. Subsequently, if the winding 624 of the magnet 622 is energized, the contact rods 601, 602 and 603 are moved upwardly without engaging the contact strips 604, 605 and 606, respectively, due to the fact that the ends of the legs of the contact strips 604, 605 and 606 provided with the recesses therein are slightly offset with respect to the stems of these contact strips. Thus, it will be apparent that, although the elementary switch is partially operated by both of the magnets 628 and 622, when the winding 629 of the magnet 628 is energized prior to the energization of the winding 624 of the magnet 622, no contact is established between the contact rods 601, 602 and 603 and the respective contact strips 604, 605 and 606. At this time, the contact rods 601, 602 and 603 are returned downwardly to their normal positions in response to the deenergization of the winding 624 of the magnet 622; similarly, the contact strips 604, 605 and 606 are returned forwardly to their normal positions in response to the deenergization of the winding 629 of the magnet 628. When the contact strips 604, 605 and 606 are returned forwardly to their normal positions under these conditions and prior to the time the contact rods 601, 602 and 603 are returned to their normal positions, the rear surfaces of the outer ends of the legs of these contact strips may contact the outer ends of the respective contact rods. However, there is no positive engagement therebetween and the contact strips are forced thereby forwardly to their normal positions.

From the foregoing it is apparent that the elementary switch 600 is partially operated when the winding 624 of the magnet 622 is energized and when the winding 629 of the magnet 628 is energized. Furthermore, it is noted that the elementary switch 600 is fully operated to establish a connection between the contact rods 601, 602 and 603 and the contact strips 604, 605 and 606, respectively, only in the event that the winding 624 of the magnet 622 is energized prior to the energization of the winding 629 of the magnet 628. Also, from the foregoing description of the cross-bar switch it will be understood that the contact rods of twenty of the elementary switches 600 are associated with the operating element 618, and that the contact strips

of two of the elementary switches 600 for each link provided in the system are associated with the operating member 621.

The construction and arrangement of the elementary switch 600 is disclosed and claimed in the copending application of John Wicks, Serial No. 296,167, filed September 22, 1939, which is a division of the present application.

Referring again to Fig. 4 of the drawings, the operation of the cross-bar switch will best be understood by a more detailed consideration of the sequence of operations of the elements thereof to establish a connection between two of the lines in the system. For example, assuming that the subscriber line 11 is a calling line, the distributor 100 associated with the system causes a "FG" magnet associated with the group of twenty lines including the calling line 11, and included in the finder switch of an idle one of the links, to be operated. Thus, one of the "FG" magnets (FG1, 2FG1, etc., associated with the first group of lines including the calling line 11 and included in the finder switches 51, 52, etc., respectively, of the first, second, etc., links, respectively, is energized. Assuming that the first link is assigned by the distributor to the use of the called line, the magnet (FG1 associated with the first group of lines and included in the first portion of the finder switch 51 of the first link is energized, thereby to cause the operating element (FG1S associated therewith to operate partially the twenty elementary switches 600 associated therewith. More particularly, the operating element (FG1S associated with the magnet (FG1 flexes the contact rods included in the twenty elementary switches 600 associated therewith upwardly out of their normal positions. Subsequently, the distributor causes the magnet L11 associated with the calling subscriber line 11 to be energized, whereupon the operating member L11S associated therewith is operated. This operation of the operating member L11S causes the contact strips of the elementary switches associated therewith and included in the first portion of the finder and connector switches to be moved transversely of the contact rods included in these elementary switches. From the foregoing description of the elementary switch 600, it will be apparent that this movement of the contact strips of the elementary switches associated with the operating member L11S will be effective to cause only the elementary switch 600 associated with both the operating element (FG1S and the operating member L11S to be fully operated, thereby to connect the subscriber line 11 to the trunk line 105 extending to the control apparatus 200 associated with the first link. Subsequently, the distributor causes the magnet (FG1 to be deenergized, whereby the contact rods of each of the elementary switches 600 associated with the operating element (FG1S, with the exception of the contact rods in the fully operated elementary switch 600 associated with both the operating element (FG1S and the operating member L11S, are returned to their normal positions, the contact rods in the fully operated elementary switch 600 being retained in their operated positions due to the fact that the operating member L11S occupies its operated position under the control of the operated magnet L11.

Assuming that the subscriber line 11 is to be connected to the subscriber line 12, the control apparatus 200 associated with the first link is then operated under the control of the subscriber

substation associated with the subscriber line 11, thereby to cause one of the "CG" magnets associated with the group of twenty lines, including the called line 12, and included in the connector switch 56 of the first link, to be operated. In the present instance, the called line 12 is in the first group of lines and the magnet (CG1 associated with this group of lines is energized. When the magnet (CG1 is energized, the operating element (CG1S associated therewith is operated, thereby to cause the contact rods of the twenty elementary switches associated therewith to be moved upwardly from their normal positions. Subsequently, the control apparatus 200 associated with the first link tests the called subscriber line 12 and, in the event this subscriber line is idle, causes the magnet L12 associated therewith to be energized. When the magnet L12 is thus energized, the operating member L12S associated therewith is operated, thereby to cause the contact strips of the elementary switches 600 associated therewith to be moved transversely of the contact rods included in these elementary switches. From the foregoing description of the operation of the elementary switch 600 it will be apparent that only the elementary switch 600 associated with both the operating element (CG1S and the operating member L12S will be fully operated, thereby to establish a connection between the trunk line 252 extending from the control apparatus 200 associated with the first link and the called subscriber line 12. Subsequently, the control apparatus 200 associated with the first link causes the magnet (CG1 to be deenergized, thereby to cause the contact rods of each of the elementary switches 600 associated with the operating element (CG1S associated with this magnet, with the exception of the contact rods in the fully operated elementary switch 600 associated with both the operating element (CG1S and the operating member L12S, to be returned to their normal positions, the contact rods in the fully operated elementary switch 600 being retained in their operated positions due to the fact that the operating member L12S occupies its operated position under the control of the operated magnet L12. Finally, the control apparatus 200 associated with the first link operates to connect the trunk line 105 extending thereto from the cross-bar switch 50 to the trunk line 252 extending therefrom to the cross-bar switch 50, thereby to complete an established connection between the calling subscriber line 11 and the called subscriber line 12.

The release of this established connection is under the control of the control apparatus 200 associated with the first link, and this control apparatus is controlled to cause this established connection to be released by causing the windings of the magnets L11 and L12 to be deenergized. When the windings of the magnets L11 and L12 are deenergized, the operating members L11S and L12S, respectively associated therewith, are returned to their normal positions, thereby to cause the contact strips of the elementary switches associated with each of these operating members to be returned to their normal positions, as previously explained.

Also it is noted that, while this established connection between the calling subscriber line 11 and the called subscriber line 12 is completed, these two subscriber lines are marked as busy to the connector switches of the links having access thereto. However, there is no interference with

the completion of other calls from and to other subscriber lines in the system. For example, should a call be initiated on another line in the first group of lines at this time, the distributor 100 associated with the cross-bar switch 50 is operative to cause the second idle link to be assigned to the use of the calling subscriber line, whereupon the magnet 2FG1 associated with the first group of twenty lines and included in the first portion of the finder switch 52 of the second link is energized, in a manner similar to that previously explained. When the winding of the magnet 2FG1 is thus energized the operating element 2FG1S is operated, thereby to cause the contact rods of the twenty elementary switches associated therewith to be operated away from their normal positions, in the manner previously explained. At this time, although the contact strips of the elementary switches respectively associated with the operating members L11S and L12S and associated with the operating element 2FG1S are operated, these elementary switches are not fully operated to cause the subscriber lines 11 and 12 to be connected to the trunk line extending from the cross-bar switch 50 to the control apparatus 201 associated with the second link, due to the fact that the contact strips of these elementary switches were operated prior to the operation of the contact rods thereof. Thus, the established connection between the subscriber lines 11 and 12 is not interfered with in any way due to the subsequent operation of the operating element 2FG1S. Moreover, this established connection between the subscriber lines 11 and 12 does not interfere, in any way, with the operation of the operating element 2FG1S in the first portion of the finder switch 52 to seize the calling subscriber line in the first group of twenty lines or the operation of the connector switch 55 of the second portion to seize a called subscriber line in the first or any other group of twenty lines in the system.

The connection and arrangement of the system will best be understood from a consideration of the following description, with reference to Figs. 1, 2 and 3 of the drawings, of the detail operation of the apparatus incorporated therein to set up the different connections between the various subscriber lines.

For example, a call which is to be extended from the subscriber substation A to the subscriber substation B is first initiated at the substation A by removing the receiver of the telephone instrument thereat from its hook, thereby to complete a bridge path at the telephone instrument at the substation A between the line conductors C180 and C181 of the subscriber line 11 extending to the substation A. When this bridge path is completed between the line conductors of the subscriber line 11, a bridge circuit is completed for energizing the lower winding of the line relay R160 in the line circuit 180 individually associated with the subscriber line 11, which extends from ground, at 11LA2, by way of 11LC4, C181, the bridge path at the substation A between C181 and C180, 11LA1, RA171, RC173, and the lower winding of R160 to battery. When energized over the above-traced circuit the line relay R160 operates to complete, at RA161, an obvious path for applying ground potential, at RA161, to the start conductor C196 extending into the distributor 100. It is noted that the start conductor C196 is multiplied to the line circuits individually associated with the other subscriber lines in the

first group of twenty lines including the subscriber line 11. Thus, it will be apparent, when a call is initiated on any one of the subscriber lines included in the first group of twenty lines, the line circuit individually associated with the calling line is operative to complete a path for applying ground potential to the start conductor C196. In a similar manner, it will be understood that, when a call is initiated on a subscriber line in the second group of subscriber lines, the line circuit individually associated with the calling subscriber line is operative to complete a path for applying ground potential to the start conductor C197 extending into the distributor 100. Similarly, three other start conductors, not shown, are extended into the distributor 100 which are respectively associated with the third, fourth and fifth groups of subscriber lines.

Continuing now with the operation of the line circuit 180 individually associated with the calling subscriber line 11, the line relay R160 also prepares, at RA165, a point in a circuit traced hereinafter for energizing the cut-off relay R170, prepares, at RA162 and RA163, a point in a circuit traced hereinafter for energizing the upper winding of the line relay R160 in series with the winding of the magnet L11 individually associated with the subscriber line 11. Finally, the line relay R160 interrupts, at RA163 and RC164, a point in a chain ground circuit including the conductors C186, C184 and C334 extending through the line circuits associated with the subscriber lines in the first group of twenty lines, thereby to prevent circuits for energizing the "L" magnets individually associated with the other subscriber lines in the first group of twenty lines and corresponding to the magnet L11 from being completed prior to the completion of the previously mentioned circuit for energizing in series the upper winding of the line relay R160, and the winding of the magnet L11. This interruption of the above-mentioned chain ground circuit prevents more than one of the "L" magnets individually associated with the subscriber lines in the first group of lines from being simultaneously energized, thereby to prevent the cross-bar switch 50 from operating and seizing two calling lines simultaneously.

Continuing now with the operation of the distributor 100, when ground potential is applied to the start conductor C196 an obvious circuit is completed for energizing the relay R100 therein. When thus energized, the relay R100 operates to condition, at RA102, a chain circuit for energizing the reset relay R150 in the event the distributor 100 has previously operated to assign the last link therein to the use of a calling line. This chain circuit is completed from ground, at RA256, in the event the test relay R255 in the first link and the corresponding test relays in the other links are not operated at this time, and extends from ground, at RA256, by way of RC257, the chain circuit extending through the contacts controlled by the test relays in the other links corresponding to the test relay R255 in the first link, C197, RA102, RA121, RC123, RA132, RC134, RA142, RC144, and the winding of R150 to battery. When energized over the above-traced circuit the reset relay R150 operates to complete, at RA151, a circuit for energizing the relay R120 in the distributor 100 in the event the first link is idle, this circuit extending from ground, at RA226 by way of RC227, C193, RA151, and the winding of R120 to battery. When energized over the above-traced circuit the relay

R120 operates to complete, at RA124, an obvious holding circuit for energizing the winding thereof extending from ground, at RA226, to battery at the winding of R120. Also it is noted that the reset relay R150 completes, at RA152, RA153, etc., respectively, circuits for energizing the relays R130 and R140, etc., respectively, in the distributor 100 in the event that the second, third, etc. links, respectively, are idle at this time, these circuits extending from ground, at an armature in the second, third, etc. links, respectively, corresponding to the armature RA226 of the hold relay R220 in the first link to the conductors C187, C188, etc., respectively. More particularly, the circuit for energizing the relay R130 extends from the grounded conductor C187, by way of RA152, and the winding of R130 to battery; and the circuit for energizing the relay R140 extends from the grounded conductor C188, by way of RA153, and the winding of R140 to battery. When thus energized the relays R130 and R140 operate to complete, at RA131 and RA141, respectively, obvious holding circuits for energizing the respective windings thereof.

Upon operating, the relay R120 prepares, at RA121 and RC122, a circuit traced hereinafter for energizing one of the "FG" magnets in the finder switch 51 of the first link, and interrupts, at RA121 and RC123, a point in the above-traced circuit for energizing the reset relay R150 in the distributor 100. Similarly, the relay R130 prepares, at RA132 and RC133, a point in a circuit extending into the second link by way of the control conductor C191 and extending from the second link by way of the control conductor C184 for energizing one of the "FG" magnets in the finder switch 52 of the second link. Similarly, the relay R140 prepares, at RA142 and RC143, a point in a circuit extending into the third link by way of the control conductor C192 and extending from the third link by way of the control conductor C195 for energizing one of the "FG" magnets in the finder switch 53 of the third link.

Also, upon operating, the relay R100 prepares, at RA101, at RA103, at RA104, etc., circuits for energizing the magnets IFG1, 2FG1, 3FG1, etc. respectively, included in the first portion of the finder switches 51, 52, 53, etc. respectively, of the first, second, third, etc. links, respectively. One of the previously mentioned circuits for energizing one of the magnets IFG1, 2FG1, 3FG1 or etc. is completed at this time, depending upon which of the first, second, third or etc. links is assigned to the use of the calling subscriber line, in the event that each of the test relays corresponding to the relay R255 in the first link occupies a restored position at this time. The link which is assigned to the use of the calling subscriber line 11 is dependent upon the idle or busy condition of the links, as the distributor 100 is operative to assign the first, second, third, etc. links to the use of calling ones of the lines sequentially. In the present instance, it is assumed that the first link is idle and that the relay R120 occupies its operated position, as previously noted. Furthermore, it is noted that the completion of the circuit for energizing one of the "FG" magnets noted is dependent upon the restored position of the test relays corresponding to the test relay R255 in the first link. More particularly, it is noted that this circuit is completed only in the event that each of these test relays occupies a restored position. This arrangement is provided for the purpose of preventing the operation of

one of the "FG" magnets in one of the finder switches simultaneously with the operation of one of the "CG" magnets in one of the connector switches or one of the "L" magnets by the control apparatus associated with one of the links, due to the fact that such simultaneous operation of the magnets noted would cause improper operation of the cross-bar switch 50 to select a called line at this time, as will appear hereinafter.

Assuming that each of the test relays in each of the links occupies a restored position at this time, a circuit is completed for energizing the magnet IFG1 by the joint operation of the relays R100 and R120. This circuit extends from ground, at RA256, by way of RC257, the chain circuit through the contacts controlled by the test relays in the other links, C197, RA102, RA121, RC122, C190, RA228, C189, RA101, and the winding of IFG1 to battery. When energized over the above-traced circuit the magnet IFG1 operates to operate the operating element IFG1S associated therewith, thereby to cause the contact rods of the twenty elementary switches 600 associated with the operating element IFG1S to be operated from their normal positions, as previously explained. Also, the magnet IFG1 completes, at IFGA1, a circuit for energizing in series the upper winding of the line relay R160, and the winding of the magnet L11, this circuit extending from ground, at IFGA1, by way of C186, RA163, RA162, the upper winding of R160, C183, and the winding of L11 to battery. When energized over the above-traced circuit the line relay R160 is retained in its operated position and the magnet L11 is operated. Upon operating, the magnet L11 actuates its armature L11A, thereby to operate the associated operating member L11S. This operation of the operating member L11S is effective to cause the contact strips of the elementary switches 600 associated therewith to be operated away from their normal positions in order to cause the elementary switch 600 illustrated, which is associated with both the operating member L11S and the operating element IFG1S, to be fully operated. When this elementary switch 600 is fully operated the trunk line 105 extending to the control apparatus 200 is connected to the calling subscriber line 11. More particularly, the contact strips 11LS1, 11LS2, and 11LS3 in the fully operated elementary switch 600 illustrated and associated with both the operating element IFG1S and the operating member L11S engage the contact rods IFGS4, IFGS5, IFGS6, respectively, in this elementary switch. Also, upon operating, the magnet L11 interrupts, at 11LA2 and 11LC4, and at 11LA1, points in the original bridge circuit for energizing the lower winding of the line relay R160, and completes, at 11LA2 and 11LC3, the circuit for energizing the winding of the cut-off relay R170. The latter circuit extends from ground, at 11LA2 by way of 11LC3, RA165, and the winding of R170 to battery. When energized over the above-traced circuit the cut-off relay R170 operates to interrupt, at RA171 and RC173, a further point in the original bridge circuit for energizing the lower winding of the line relay R160, and completes, at RA174, a holding circuit for energizing the winding thereof, extending from ground, at 11LA2, by way of 11LC3, RA174, and the winding of R170 to battery.

When the calling line 11 is connected to the trunk line 105 extending to the control apparatus

200 associated with the first link, a circuit is completed for energizing the line relay R210 included in the control apparatus 200. This circuit extends from ground, at the upper winding of R210, by way of the upper winding of R210, C262, C108, IFGS6, 11LS3, C181, the bridge path at the substation A between C181 and C180, C180, 11LS2, IFGS5, C107, C261, and the lower winding of R210 to battery. When energized over the above-traced circuit the relay R210 operates to complete, at RA211 and RC212, an obvious circuit for energizing the hold relay R220. When thus energized the hold relay R220 operates to interrupt, at RA221 and RC222, a point in a circuit traced hereinafter for energizing the release magnets M306 and M316 of the minor switches 300 and 310, respectively, to prepare, at RA221 and RC223, a point in a circuit traced hereinafter for energizing the transfer relays R230 and R240, the ring cut-off relay R270 and the busy relay R280, and to prepare, at RA224, a point in a pulsing circuit traced hereinafter for energizing the rotary magnets M305 and M315 of the minor switches 300 and 310, respectively. Further the hold relay R220 interrupts, at RA228, a point in the previously traced circuit for energizing the magnet IFG1, completes, at RA225 and RA226, a path for applying ground potential to the control conductor C106 of the trunk line 105, and interrupts, at RA226 and RC227, a point in the previously traced circuit for energizing the relay R120 in the distributor 100.

When the path is completed for applying ground potential to the control conductor C106, a holding circuit is completed for energizing the magnet L11 and for applying ground potential to the control conductor C183 of the subscriber line 11, this path extending from ground, at RA226, by way of RA225, C106, IFGS4, 11LS1 and C182 to C183, and from C183 by way of the winding of L11 to battery. Thus, the magnet L11 is retained in its operated position, thereby to retain the elementary switch 600 illustrated in its fully operated position. Also this application of ground potential to the control conductor C183 of the subscriber line 11 marks the subscriber line 11 as busy to the connector switches 54, 55, 56, etc., of the first, second, third, etc., links having access thereto. When the circuit for energizing the magnet IFG1 is interrupted, this magnet restores, thereby to cause the contact rods of each of the elementary switches 600 associated therewith, with the exception of the fully operated elementary switches illustrated, to be returned to their normal positions. Also, upon restoring, the magnet IFG1 interrupts, at IFGA1, the previously traced circuit for energizing the upper winding of the line relay R160 in series with the winding of the magnet L11, thereby to cause the line relay R160 to restore. Also, when the circuit for energizing the relay R120 in the distributor 100 is interrupted, the relay R120 restores, thereby to interrupt, at RA124, a further point in the holding circuit for the winding thereof, to interrupt, at RA121 and RC122, a further point in the circuit for energizing the magnet IFG1, and to prepare, at RA121 and RC123, a point in the circuit for energizing the "FG" magnets included in the finder switch 52 of the second link. Upon restoring, the line relay R160 interrupts, at RA165, a point in the original circuit for energizing the cut-off relay R170, interrupts, at RA162 and RA163, a further point in the circuit

for energizing the upper winding of the line relay R160 in series with the winding of the magnet L11, prepares, at RA163 and RC164, a point in the previously mentioned ground circuit including the control conductors C186, C184 and C334, and interrupts, at RA161, the circuit for energizing the relay R100 in the distributor 100. When the previously mentioned chain circuit including the control conductors C186, C184 and C334 is prepared, at RA163 and RC164, the circuits for energizing the upper windings of the line relays included in the line circuits, individually associated with the other subscriber lines in the first group of lines, are conditioned to be operated. When the circuit for energizing the winding of the relay R100 in the distributor 100 is interrupted, the latter relay restores, thereby to interrupt, at RA102, a point in the previously prepared circuits for energizing the "FG" magnets included in the finder switches of the links, and to interrupt, at RA101, RA103, RA104, etc., points in the previously prepared circuits for energizing the magnets IFG1, 2FG1, 3FG1, etc., respectively, included in the first portions of the finder switches 51, 52, 53, etc., respectively, of the first, second, third, etc., links. At this time the distributor 100 is completely released for further use and the second link in the system is assigned to the use of a calling one of the lines due to the fact that the relays R120 and R130 therein occupy their restored and operated positions, respectively.

From the foregoing description of the operation of the distributor 100 to cause the finder switch 51 to seize the calling subscriber line 11, it will be understood that, in the event the calling subscriber line had been a line in the second group, such, for example, as the line 31 rather than the line 11, the line circuit individually associated therewith would have been operated to cause ground potential to be applied to the start conductor C197 extending into the distributor 100, whereupon the relay R110 would have been operated. Upon operating, the relay R110 prepares, at RA114, a point in the previously traced circuits extending into the first, second, third, etc., links, and prepares, at RA113, RA112, RA111, etc., respectively, circuits for energizing the magnets IFG2, 2FG2, 3FG2, etc., respectively, included in the second portions of the finder switches 51, 52, 53, etc., respectively, of the first, second, third, etc., links, respectively. The subsequent operation of the distributor to cause one of these "FG" magnets to be energized is the same as that previously described, depending upon the one of the links assigned to the use of the calling subscriber line and upon the restored positions of each of the test relays in the first, second, third, etc., links corresponding to the test relay R255 in the first link.

Continuing now with the operation of the control apparatus 200 included in the first link to cause the cross-bar switch 50 to operate and seize the called subscriber line 12, the control apparatus 200 associated with the first link is conditioned to be responsive to digits dialed at the substation A associated with the calling subscriber line 11 when the finder switch 51 is operated to connect the trunk line 105 extending to the control apparatus 200 to the calling subscriber line 11.

The subscriber at the substation A then dials the first digit of the directory number of the called subscriber line at the dial mechanism thereat, thereby to transmit a first series of im-

pulses over the loop circuit extending by way of the calling subscriber line 11 between the substation A and the line relay R210 included in the control apparatus 200. The line relay R210 follows the impulses transmitted thereto, operating each time this loop circuit is completed and restoring each time this loop circuit is interrupted. Each time the line relay R210 operates, it completes, at RA211 and RC212, the previously mentioned circuit for energizing the hold relay R220; and each time the line relay R210 restores it completes, at RA211 and RC213, a circuit for energizing in multiple the winding of the control relay R215 and the rotary magnet M305 of the minor switch 300.

This circuit extends from ground, at RA211, by way of RC213 to RA224, one branch extending from RA224 by way of the winding of R215 to battery, and the other branch of this circuit extending from RA224 by way of RA235, RC237, C218, and the winding of M305 to battery. Each time the above-traced circuit is completed the control relay R215 is energized and the rotary magnet M305 is energized, the successive energization of the rotary magnet M305 being effected to rotate the wipers 301 and 303 of the minor switch 300 step by step in a clockwise direction and into engagement with the successive contacts in the associated contact banks 302 and 304, respectively. Upon operating, the control relay R215 completes, at RA216, a circuit for energizing the lower winding of the transfer relay R230, this circuit extending from ground, at RA216, by way of RA231, RC232, RA242, and the lower winding of R230 to battery. When energized over the above-traced circuit the transfer relay R230 partially operates to close the "X" contacts associated with RA234, thereby to complete a path for short-circuiting the upper winding thereof, this path extending from ground, at RA216, by way of RA231, RC232, RA242, the upper winding of R230, RA234, RA241, C260, RC223 and RA221 to ground. Due to the facts that the hold relay R220 and the control relay R215 are of the slow-to-release type and that the above-mentioned circuits for energizing these relays are alternately completed these relays remain in their operated positions during the series of impulses comprising the first digit. When the wipers 301 and 303 of the minor switch 300 are rotated away from their normal positions, the switch springs S307 are actuated into engagement, thereby to prepare a circuit traced hereinafter for energizing the release magnet M306 of the minor switch 300.

At the conclusion of the first digit, the wipers 301 and 303 of the minor switch 300 engage odd or even contacts in the associated contact banks 302 and 304, respectively, depending upon the number of impulses comprising the first digit. In the event the first digit dialed comprises one or two impulses, the wiper 301 engages the first or second contacts, respectively, in the associated contact bank 302, which contacts are multiplied together and terminate the control conductor C320 extending to the "CG" magnet included in the first portion of the connector switch 56 of the first link. Similarly, should the first digit comprise three or four impulses, the wiper 301 engages the third or fourth contacts, respectively, in the associated contact bank 302, which contacts are multiplied together and connected to a control conductor extending to the "CG" magnet included in the second portion of the connector

switch 56 of the first link. Likewise, it will be understood that, if the first digit comprises 5, 6 or 7, 8 or 9, 0, the wiper 301 will engage a corresponding contact in the associated contact bank 303, thereby respectively to prepare a circuit for energizing the "CG" magnet in the third, fourth or fifth portions, respectively, of the connector switch 56 of the first link. Also, it will be noted that, in the event the first digit comprises an odd number of impulses, the wiper 303 engages a corresponding odd contact in the associated contact bank 304 multiplied to the wiper 311 of the minor switch 310; and, in the event the first digit comprises an even number of impulses, the wiper 303 engages a corresponding even contact in the associated contact bank 304 multiplied to the wiper 313 of the minor switch 310. In the present instance, in view of the fact that the called subscriber line 12 is included in the first ten line portion of the first twenty line group, the first digit dialed necessarily comprises a single impulse. Accordingly, the wiper 301 of the minor switch 300 engages the first contact in the associated contact bank 302, thereby to prepare a circuit traced hereinafter for energizing the magnet 1CG1 in the first portion of the connector switch 56 of the first link; and the wiper 303 engages the first contact in the associated contact bank 304, thereby to prepare a circuit traced hereinafter for energizing one of the "L" magnets included in the first ten line portion of the first twenty line group by way of the wiper 311 of the minor switch 310. On the other hand, if the wiper 303 had engaged an even contact in the associated contact bank 304 instead of an odd contact therein, a circuit would have been prepared for energizing one of the "L" magnets associated with a line in the second ten line portion of the first twenty line group by way of the wiper 313 of the minor switch 310.

At the conclusion of the first digit dialed the line relay R210 reoperates, thereby to complete the previously mentioned circuit for energizing the hold relay R220 and to interrupt the previously traced circuit for energizing in multiple the winding of the control relay R215, and the winding of the rotary magnet M305 of the minor switch 300, in order to retain the hold relay R220 in its operated position, to arrest further operation of the minor switch 300, and to cause the control relay R215 to restore shortly thereafter. Upon restoring, the control relay R215 interrupts, at RA216, a point in the previously traced path for short-circuiting the upper winding of the transfer relay R230, whereby a circuit is completed for energizing the upper and lower windings of the transfer relay R230 in series, this circuit extending from ground, at RA221, by way of RC223, C260, RA241, RA234, and the upper and lower windings of R230 to battery. When the upper and lower windings of the transfer relay R230 are thus energized in series, this transfer relay fully operates, thereby to interrupt, at RA231 and RC232, a further point in the path for short-circuiting the upper winding thereof, to prepare, at RA231 and RC233, a point in a circuit traced hereinafter for energizing in multiple the lower winding of the transfer relay R240, and the winding of the control relay R250, to interrupt, at RA235 and RA237, a further point in the circuit for energizing the rotary magnet M305 of the minor switch 300, to prepare, at RA235 and RC236, a point in a circuit traced hereinafter for energizing the rotary mag-

net M315 of the minor switch 310, and to interrupt, at RA238, a point in a circuit traced hereinafter for energizing the test relay R255.

The subscriber at the substation A then dials the second digit of the directory number of the called subscriber line at the dial mechanism thereat, thereby to transmit a second series of impulses over the loop circuit extending by way of the subscriber line 11 to the line relay R210 included in the control apparatus 200 associated with the first link. The line relay R210 follows this series of impulses, as previously explained. Each time the line relay R210 operates it completes, at RA211 and RC212, the previously mentioned circuit for energizing the hold relay R220; and each time the line relay R210 restores it completes, at RA211 and RC213, a circuit for energizing in multiple the winding of the control relay R215, and the winding of the rotary magnet M315 of the minor switch 310. This circuit extends from ground, at RA211, by way of RC213 to RA224, one branch of this circuit extending from RA224 by way of the winding of R215 to battery, and the other branch of this circuit extending from RA224 by way of RA235, RC236, C217, and the winding of M315 to battery. Each time the above-traced circuit is completed, the winding of the control relay R215 and the winding of the rotary magnet M315 are energized, thereby to cause the control relay R215 to operate and remain operated during the second series of impulses, and to cause the rotary magnet M315 to operate a number of times corresponding to the number of impulses comprising the second digit.

Upon reoperating, the control relay R215 completes, at RA216, the previously mentioned circuit for energizing in multiple the lower winding of the transfer relay R240 and the winding of the control relay R250, this circuit extending from ground, at RA216, by way of RA231 to RC233, one branch of this circuit extending from RC233 by way of RA243, and the lower winding of R240 to battery, and the other branch of this circuit extending from RC233 by way of the winding of R250 to battery. When energized over the above-traced circuit the transfer relay R240 operates to close the "X" contacts associated with the armature RA244, thereby to complete a path for short-circuiting the upper winding of R240, this path extending from ground, at RA216, by way of RA231, RC233, RA243, the upper winding of R240, RA244, C260, RC223, and RA221 to ground. When the control relay R250 is energized over the above-traced circuit it operates, thereby to prepare, at RA251, a point in the previously mentioned circuit for energizing the test relay R255, and to interrupt, at RA252, a point in a circuit traced hereinafter for returning busy tone current over the loop circuit including the calling subscriber line 11 extending to the substation A.

At the conclusion of the second digit, the wipers 311 and 313 engage contacts in the associated contact banks 312 and 314, respectively, corresponding to the number of impulses comprising the second digit. The engagement of the wiper 311 and one of the contacts in the associated contact bank 312 prepares a point in a circuit for energizing one of the "L" magnets in the connector switch 56 and associated with a subscriber line in the first ten line portion of the previously selected twenty line group in the system; and the engagement of the wiper 313 and one of the contacts in the associated contact bank 314 prepares a point

in a circuit for energizing one of the "L" magnets in the connector switch 56 and associated with a subscriber line in the second ten line portion of the previously selected twenty line group in the system. In the present instance, the called subscriber line 12 is the second line in the first ten line portion of the first twenty line group in the system. Accordingly, the second digit dialed comprises two impulses, and a circuit is prepared for energizing the winding of the magnet L11 individually associated therewith at the wiper 311 and the second contact in the associated contact bank 312 of the minor switch 310, the path prepared at the wiper 313 and second contact in the associated contact bank 314 of the minor switch 310 being open-circuited at the contact bank 304 of the minor switch 300 due to the fact that the first digit dialed, the No. 1, comprised an odd number of impulses.

At the conclusion of the second digit dialed, the line relay R210 in the control apparatus 200 reoperates, thereby to complete the previously mentioned circuit for energizing the hold relay R220, and to interrupt the previously traced circuit for energizing in multiple the winding of the control relay R215, and the winding of the rotary magnet M315 of the minor switch 310 in order to retain the hold relay R220 in its operated position to arrest further operation of the minor switch 310, and to cause the control relay R215 to restore shortly thereafter. Upon restoring, the control relay R215 interrupts, at RA210, the previously traced circuit for energizing the winding of the control relay R250 and the path for short-circuiting the upper winding of the transfer relay R240, whereupon a circuit is completed for energizing in series the upper and lower windings of the transfer relay R240. The latter circuit extends from ground, at RA221, by way of RC223, C260, RA244, and the upper and lower windings of R240 to battery. The transfer relay R240 immediately operates fully when it is energized over the above-traced circuit, and the control relay R250, being of the slow-to-release type, does not restore until a predetermined time interval elapses after the circuit for energizing the winding thereof is interrupted. Upon fully operating, the transfer relay R240 interrupts, at RA241, the circuit for energizing in series the upper and lower windings of the transfer relay R230, thereby to cause the latter transfer relay to restore. Also the transfer relay R240 prepares, at RA245, a point in the previously mentioned circuit for energizing the test relay R255, and prepares, at RA246, a point in the previously mentioned circuit for returning busy tone current over the loop circuit extending by way of the calling subscriber line 11 to the substation A. Upon restoring, the transfer relay R230 completes, at RA238, the previously mentioned circuit for energizing the test relay R255, this circuit extending from ground, at RA235, by way of RC236, C258, RA238, RA245, RA251, and the winding of R255 to battery.

When energized over the above-traced circuit the test relay R255 operates to interrupt, at RA256 and RC257, the previously traced path for applying ground potential to the control conductor C197, thereby to prevent the operation of other of the "FG" magnets in the finder switches 52, 53, etc., of the second, third, etc., links prior to the restoration of the test relay R255. Further, the test relay R255 completes, at RA258 and RC258, the previously mentioned circuit for energizing the magnet 1CG1 in the first portion of the connector switch 56 of the first link, this cir-

cuit extending from ground, at RA256, by way of RC258, C214, the wiper 301 and first contact in the associated contact bank 302 of the minor switch 300, C320, and the winding of ICG1 to battery. When energized over the above-traced circuit the magnet ICG1 operates, thereby to operate the operating element ICG1S associated therewith. This operation of the operating element ICG1S operates away from their normal positions the contact rods of the twenty elementary switches 600 associated therewith and included in the first portion of the connector switch 56 of the first link. Also, upon operating, the magnet ICG1 prepares, at ICGA1, ICGA2, ICGA3, ICGA4, ICGA5, etc., circuits for testing the idle or busy conditions of the subscriber lines 22, 21, 13, 12, 11, etc., included in the first group of twenty lines. More specifically, the magnet ICG1 prepares, at ICGA4, a circuit traced hereinafter for testing the idle or busy condition of the called subscriber line 12. Also, upon operating, the test relay R255 completes, at RA259, the circuit for testing the idle or busy condition of the called subscriber line. More specifically, the test relay R255 completes, at RA259, the circuit for testing the idle or busy condition of the called subscriber line 12, this circuit extending from ground at the lower winding of the busy relay R280, by way of the lower winding of R280, RA259, C216, the wiper 303 and first contact in the associated contact bank 304 of the minor switch 300, the wiper 311 and second contact in the associated contact bank 312 of the minor switch 310, C322, ICGA4 and C327, to the control conductor C332 of the called subscriber line 12.

The subsequent operation of the control apparatus 200 associated with the first link depends upon the idle or busy condition of the called subscriber line 12. In the event the called subscriber line 12 is busy, ground potential appears upon the control conductor C332 thereof; and on the other hand, in the event the called subscriber line 12 is idle, battery potential appears upon the control conductor C332 thereof. Assuming that the called subscriber line 12 is busy, ground potential appears upon the control conductor thereof and the lower winding of the busy relay R280 is short-circuited in an obvious manner over the above-traced test circuit. Thus, the busy relay R280 does not operate, and shortly after the test relay R255 operates the control relay R250 restores. Upon restoring, the control relay R250 interrupts, at RA251, the circuit for energizing the test relay R255, thereby to cause the latter relay to restore. Upon restoring, the test relay R255 re-completes, at RA256 and RC257, the previously traced path for applying ground potential to the control conductor C197 included in the chain circuit extending through the contacts controlled by the test relays in the other links corresponding to the test relay R255, and interrupts, at RA256 and RC258, the previously traced circuit for energizing the magnet ICG1, thereby to cause the latter magnet to restore. Also, upon restoring, the test relay R255 interrupts, at RA259, a point in the previously traced circuit for testing the idle or busy condition of the called subscriber line 12. Also, upon restoring, the control relay R250 completes, at RA252, a circuit for returning busy tone current over the loop circuit including the calling subscriber line 11 extending to the substation A, this circuit extending from the ungrounded terminal of the grounded winding of a source of busy tone current by way of the busy tone con-

ductor C281, RA246, RA252, RC283, RA281, C287, C213, and the condenser 248 to the line conductor C108 of the trunk line 105, and from ground, at the lower winding of the back bridge relay R260, by way of the lower winding of R260, C256, C212, and the condenser 247 to the line conductor C107 of the trunk line 105, the line conductors C108 and C107 of the trunk line 105 being connected, respectively, by way of IFGS6, 11LS3, and IFGS5, 11LS2, to the line conductors C181 and C182, respectively, of the calling subscriber line 11, and the receiver of the telephone instrument at the substation A being included in a bridge circuit across the line conductors C181 and C180 of the calling subscriber line 11. The resulting busy tone produced in the receiver of the telephone instrument at the substation A indicates to the subscriber thereat that the desired connection cannot immediately be had due to the busy condition of the called subscriber line 12. The subscriber at the substation A then replaces the receiver of the telephone instrument thereat upon its hook, thereby to cause the portions of the crossbar switch 50 included in the finder and connector switches 51 and 56, respectively, of the first link and the control apparatus 200 associated with the first link to be released. The exact manner in which these operated pieces of apparatus are released is described in detail hereinafter.

Assuming that the called subscriber line 12 is idle when the test relay R255 is operated, battery potential appears upon the control conductor C332 thereof, as previously noted, this battery potential being derived at one terminal of the winding of the magnet L12 and extending therefrom by way of the winding of L12 to the control conductor C332. Under these conditions, when the previously traced test circuit is completed, at RA259, upon the operation of the test relay R255, a circuit is completed for energizing in series the lower winding of the busy relay R280 and the winding of the magnet L12. This circuit extends from ground at the lower winding of R280, by way of the lower winding of R280, RA259, C216, the wiper 303 and first contact in the associated contact bank 304 of the minor switch 300, the wiper 311 and second contact in the associated contact bank 312 of the minor switch 310, C322, ICGA4, C327, C332, and the winding of L12 to battery. When energized over the above-traced circuit, the busy relay R280 partially operates, thereby to close, at RA289, the "X" contact associated therewith, and the magnet L12 fully operates. When the busy relay R280 partially operates to close the "X" contact associated with RA289, a holding circuit is completed for energizing the upper winding of R280, this circuit extending from ground, at RA221, by way of RC223, C260, RA289, and the upper winding of R280 to battery. When the above-traced holding circuit is completed for energizing the upper winding of the busy relay R280, this relay fully operates, thereby to interrupt, at RA281 and RC283, a point in the previously traced circuit for returning busy tone current over the loop circuit including the calling subscriber line 11 extending to the substation A, and to complete, at RA281 and RC282, a circuit traced hereinafter for returning ring-back-tone current over the loop circuit including the calling subscriber line 11 extending to the substation A.

Upon operating, the magnet L12 actuates its associated armature L12A, thereby to operate the operating member L12S associated therewith.

This operation of the operating member L12S operates the contact strips of the elementary switches 600 associated therewith. However, only the illustrated elementary switch 600 associated with both the operating element ICG1S and the operating member L12S is fully operated, thereby to cause the trunk line 252, extending from the control apparatus 200 associated with the first link, to seize the called subscriber line 12. More particularly, the contact rods ICGS4, ICGS5 and ICGS6 engage the contact strips 12LS1, 12LS2 and 12LS3, respectively, in the illustrated elementary switch 600.

Also, upon operating, the busy relay R280 completes, at RA284 and RA285, a holding circuit for energizing the magnet L12, this circuit extending from ground, at RA285, by way of RA284, C253, ICGS4, 12LS1, C332, and the winding of L12 to battery. Also, this circuit is effective to apply ground potential to the control conductor C332, thereby to mark the subscriber line 12 as busy to the connector switches 55, 54 of the second, third, etc., links, respectively, having access thereto. Furthermore, the busy relay R280 interrupts, at RA285 and RC286, a point in the previously traced circuit for energizing the test relay R255, thereby to cause the latter relay to restore prior to the restoration of the control relay R250, which latter relay restores shortly after the operation of the busy relay R280. Upon restoring, the test relay R255 interrupts, at RA256 and RC258, the previously traced circuit for energizing the magnet ICG1, and completes, at RA256 and RC257, the previously traced path for applying ground potential to the control conductor C197. Finally, the control relay R255 interrupts, at RA259, a point in the original circuit for energizing the lower winding of the busy relay R280 in series with the winding of the magnet L12.

When the circuit for energizing the magnet ICG1 is interrupted the latter magnet restores, thereby to cause the contact rods of the twenty elementary switches 600 associated therewith, with the exception of the fully operated elementary switch 600 illustrated, to be returned to their normal positions. The fully operated elementary switch 600 illustrated is retained in its operated position due to the fact that the magnet L12 occupies its operated position, the magnet L12 being energized at this time by way of the previously traced holding circuit for energizing the winding thereof, and the original circuit for energizing the winding thereof being interrupted, as previously noted. Also, when the magnet L12 operates it interrupts, at 12LA1 and at 12LA2 and 12LC4, points in the bridge circuit for energizing the lower winding of the line relay R350 included in the line circuit 360 individually associated with the subscriber line 12, thereby to prevent the line relay R350 from being operated when the call is answered at the substation B by the removal of the receiver of the telephone instrument thereat from its hook.

Finally, when the busy relay R280 operates it completes, at RA287 and RA288, points in a circuit for projecting ringing current over the called subscriber line 12 extending to the substation B. The circuit for projecting ringing current over the called subscriber line 12 extending to the substation B extends from ground, at RC278, by way of RA276 and RA288, to the line conductor C255 of the trunk line 252, and from the ungrounded terminal of a grounded winding of a source of ringing current by way

of the ringing conductor C263, the lower winding of the ring cut-off relay R270, RA272, RC278, RA273 and RA287, to the line conductor C254 of the trunk line 252, the line conductors C255 and C254 of the trunk line 252 being respectively connected by way of ICGS6, 12LS3 and ICGS5, 12LS2, to the line conductors C331 and C330, respectively, of the called subscriber line 12, and the ringer at the substation B being included in a circuit extending between the line conductors C330 and C331. When the above-traced circuit is completed the ringer at the substation B is operated, thereby to indicate to the subscriber thereat that the substation B is a called substation. Also a circuit is completed at this time for returning ring-back-tone current over the loop circuit including the calling subscriber line 11 extending to the substation A, as previously noted. This circuit extends from ground at one terminal of the lower winding of the back bridge relay R260 by way of the lower winding of R260, C256, C212, and the condenser 247, to the line conductor C107 of the trunk line 105, and from the source of potential appearing upon the ringing conductor C263, as previously noted, by way of the lower winding of the ring cut-off relay R270, RA272, the condenser 249, RC282, RA281, C257, C213, and the condenser 248 to the line conductor C108 of the trunk line 105, the line conductors C107 and C108 of the trunk line 105 being connected to the line conductors C180 and C181, respectively, of the calling subscriber line 11, and the receiver of the telephone instrument at the substation A being included in a bridge circuit extending between the line conductors C180 and C181 of the calling subscriber line 11, as previously noted. This ring-back-tone current returned over the loop circuit including the calling subscriber line 11 and extending to the substation A causes the receiver thereat to be actuated, thereby to produce ring-back-tone therein in order to indicate to the subscriber at the substation A that the ringer at the substation B associated with the called subscriber line 12 is being actuated.

The call is answered at the substation B associated with the called subscriber line 12 when the receiver of the telephone instrument thereat is removed from its hook, thereby to complete a circuit, which is substantially identical to the previously traced circuit for projecting ringing current over the called subscriber line 12, for energizing the lower winding of the ring cut-off relay R270. When the lower winding of the ring cut-off relay R270 is thus energized, this relay partially operates to close the "X" contacts associated with RA271 in order to complete a holding circuit for energizing the upper winding of R270. The latter circuit extends from ground, at RA221, by way of RC223, C260, RA271, and the upper winding of R270 to battery. When energized over the above-traced holding circuit the ring cut-off relay R270 fully operates, thereby to interrupt, at RA272, at RA273 and RC278, and at RA276 and RC278, points in the circuit for projecting ringing current over the called subscriber line 12, to interrupt, at RA272, a point in the circuit for returning ring-back-tone current over the loop circuit including the calling subscriber line 11 extending to the substation A, and to complete, at RA273 and RC274, and at RA276 and RC277, a loop circuit between the back bridge relay R260 and the subscriber substation B. This loop circuit extending between the back bridge relay R260 and the substation B extends from

ground, at one terminal of the lower winding of R260 by way of the lower winding of R260, C256, RC274, RA273 and RA287 to the line conductor C254 of the trunk line 252, and from battery, at one terminal of the upper winding of R260 by way of the upper winding of R260, C257, RC277, RA276 and RA288, to the line conductor C255 of the trunk line 252, the line conductors C254 and C255 of the trunk line 252 being connected to the line conductors C330 and C331, respectively, of the called subscriber line 12, and the telephone instrument at the substation B being included in a bridge circuit extending between the line conductors C330 and C331 of the called subscriber line 12, as previously noted. When energized over the above-traced loop circuit the back bridge relay R260 operates to complete, at RA261, an obvious multiple path for applying ground potential to the control conductor C260, thereby to complete multiple holding circuits for the transfer relay R240, the ring cut-off relay R270, and the busy relay R280. At this time, talking battery is supplied to the loop circuit including the calling subscriber line 11 extending to the substation A from ground and battery potentials appearing at the line relay R210; and talking battery is supplied to the loop circuit including the called subscriber line 12 extending to the substation B from ground and battery potentials appearing at the back bridge relay R260. Furthermore, the loop circuit including the calling subscriber line 11 extending to the substation A is connected to the loop circuit including the called subscriber line 12 extending to the substation B by way of the voice frequency condensers 247 and 248. More specifically, the line conductor C107 of the trunk line 105 is connected by way of the condenser 247, C212, RC274, RA273 and RA287, to the line conductor C254 of the trunk line 252; and the line conductor C108 of the trunk line 105 is connected by way of the condenser 248, C213, RC277, RA276 and RA288 to the line conductor C255 of the trunk line 252. At this time, the substations A and B associated, respectively, with the subscriber lines 11 and 12 are interconnected by way of the first link comprising the first portion of the finder switch 51 and the first portion of the connector switch 56, and the control apparatus 200 associated with the first link for two-way communication therebetween.

The release of this established connection is primarily under the control of the calling party. When the subscriber at the substation B replaces the receiver of the telephone instrument thereat upon its hook, the loop circuit extending between the back bridge relay R260 and the substation B is interrupted, thereby to cause the back bridge relay R260 to restore. Upon restoring, the back bridge relay R260 interrupts, at RA261, one of the multiple paths for applying ground potential to the control conductor C260. However, the holding circuits for the transfer relay R240, the ring cut-off relay R270 and the busy relay R280 are retained completed at this time due to the operated condition of the hold relay R220. Accordingly, the finder switch 51 and the connector switch 56 included in the first link are retained in their operated positions at this time, and the subscriber line 12 is still marked as busy to the connector switches of the links having access thereto until the connector switch 56 is released.

When the subscriber at the substation A re-

places the receiver of the telephone instrument thereat upon its hook, the loop circuit extending between the line relay R210 and the substation A is interrupted, thereby to cause the latter relay to restore. Upon restoring, the line relay R210 interrupts, at RA211 and RC212, the previously mentioned circuit for energizing the hold relay R220. Shortly thereafter the hold relay R220, being of the slow-to-release type, restores to interrupt, at RA221 and RC223, the holding circuits for energizing the transfer relay R240, the ring cut-off relay R270 and the busy relay R280, thereby to cause the latter relays to restore. Also, the hold relay R220 completes, at RA221 and RC222, a circuit for energizing in multiple the release magnets M306 and M316 of the minor switches 300 and 310, respectively, this circuit extending from ground, at RA221 and RC222, to the control conductor C215, one branch of this circuit extending from C215 by way of the switch springs S307, and the winding of M306 to battery, and the other branch of this circuit extending from the control conductor C215 by way of the switch springs S317 and the winding of M316 to battery. When energized over the above-traced circuit the release magnet M306 operates, thereby to release the wipers 301 and 303 of the minor switch 300, and to cause these wipers to be returned to their normal positions. Similarly, when the release magnet M316 is energized it operates, thereby to release the wipers 311 and 313 of the minor switch 310 and to cause these wipers to be returned to their normal positions. When the wipers 301 and 303 of the minor switch 300 are returned to their normal positions, the switch springs S307 are actuated into disengagement, thereby to interrupt the branch circuit for energizing the release magnet M306; and when the wipers 311 and 313 of the minor switch 310 are returned to their normal positions, the switch springs S317 are actuated into disengagement, thereby to interrupt the branch circuit for energizing the release magnet M316.

Upon restoring, the transfer relay R240 interrupts, at RA245, a further point in the circuit for energizing the test relay R255, interrupts, at RA246, a further point in the circuit for returning busy tone current over the loop circuit including the calling line, interrupts, at RA244, a further point in the holding circuit for energizing the upper and lower windings thereof, prepares, at RA243, a point in the circuit for energizing the lower winding thereof, prepares, at RA242, a point in the circuit for energizing the lower winding of the transfer relay R230, and prepares, at RA241, a point in the holding circuit for energizing the upper and lower windings of the transfer relay R230. Upon restoring, the ring cut-off relay R270 interrupts, at RA271, a further point in the holding circuit for energizing the upper winding thereof, prepares, at RA272, a point in the circuit for returning ring-back-tone current over the calling subscriber line, interrupts, at RA273 and RC274, and at RA276 and RC277, further points in the loop circuit including the called subscriber line 12 extending to the substation B, and prepares, at RA273 and RC275, and at RA276 and RC278, points in the circuit for projecting ringing current over the called subscriber line. When the busy relay R280 restores it interrupts, at RA289, a further point in the holding circuit for energizing the upper winding thereof, interrupts, at RA281 and RC282, a point in the circuit for re-

turning ring-back-tone current over the calling subscriber line, prepares, at RA281 and RC283, a point in the circuit for returning busy tone current over the calling subscriber line, prepares, at RA285 and RC286, a point in the circuit for energizing the test relay R255, interrupts, at RA287 and RA288, further points in the loop circuit including the called subscriber line 12 extending to the substation B, and interrupts, at RA284 and RA285, a point in the holding circuit for energizing the magnet L12.

When the holding circuit for energizing the magnet L12 is interrupted, the latter magnet restores, thereby to cause both the contact strips and contact rods of the fully operated elementary switch 600 illustrated to be returned to their normal positions. Further, the magnet L12 prepares, at 12LA1 and at 12LA2 and 12LC4, points in the bridge circuit for energizing the lower winding of the line relay R350 included in the line circuit 360 individually associated with the subscriber line 12. At this time, the connector switch 56 of the first link is completely released, and battery potential at the winding of the magnet L12 appears upon the control conductor C332 of the subscriber line 12, thereby to mark the subscriber line 12 as idle to the connector switches of the links having access thereto.

Also, when the hold relay R220 restores it interrupts, at RA224, a point in the pulsing circuits for energizing the rotary magnets M305 and M315 of the minor switches 300 and 310, respectively, prepares, at RA226 and RC227, a point in the circuit for energizing the relay R120 in the distributor 100, thereby to condition the latter relay to be operated in order to assign the first link to the use of a calling line when the reset relay R150 in the distributor 100 is again operated. Finally, the hold relay R220 interrupts, at RA225 and RA226, a point in the holding circuit for energizing the winding of the magnet L11, thereby to cause the latter magnet to restore. Upon restoring, the magnet L11 causes both the contact strips and contact rods of the illustrated elementary switch 600 to be returned to their normal positions. Further, the magnet L11 interrupts, at 11LA2 and 11LC3, a point in the holding circuit for energizing the cut-off relay R170, and prepares, at 11LA2 and 11LC4, and at 11LA1, an alternative circuit for reenergizing the cut-off relay R170 in the event another call is initiated at the subscriber substation A prior to the restoration of the slow-to-release cut-off relay R170 and to the complete release of the finder switch 51 of the first link. In the event that a call is not immediately initiated at the substation A, the above-mentioned alternative circuit for energizing the winding of the cut-off relay R170 is not completed, and shortly thereafter the cut-off relay R170 restores to interrupt, at RA171 and RC171, a point in the previously mentioned alternative circuit, to interrupt, at RA174, a further point in the holding circuit for energizing the winding thereof, and to prepare, at RA171 and RC173, the bridge circuit for energizing the lower winding of the line relay R160 included in the line circuit 180 individually associated with the subscriber line 11. At this time, the finder switch 51 of the first link is completely released, and battery potential derived at the winding of the magnet L11 appears upon the control conductor C183 of the subscriber line 11, thereby to mark the subscriber line 11 as idle to the connector switches of the links having access thereto.

At this time, both the finder switch 51 and the connector switch 56 of the first link, and the control apparatus 200 associated with the first link, are completely released for further use, and the first link will be reassigned to the use of a calling line when the reset relay R150 in the distributor 100 is again operated. Furthermore, each of the subscriber lines 11 and 12 are marked as idle to the connector switches of the links having access thereto and may be seized upon a call being routed thereto. Furthermore, the line circuits 180 and 360 individually associated with the subscriber lines 11 and 12, respectively, are conditioned to be operative in response to the initiation of a call thereat, thereby to cause the distributor 100 to operate and assign an idle one of the links to the use of the calling line.

From the foregoing description of the operation of the system incident to the extension of a call from the subscriber substation A to the subscriber substation B, it will be understood that a call from any one of the subscriber substations is initiated and extended to any one of the other substations, in a manner similar to that described.

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

What is claimed is:

1. In a signaling system, a group of signal lines, unitary switching apparatus including a finder switch and a connector switch, each of said switches having access to each of said signal lines, a first operating element associated with said finder switch, a second operating element associated with said connector switch, a plurality of operating members, each of said operating members being associated with only one of said signal lines, a link circuit, means controlled by the joint operations of said first operating element and one of said operating members for causing said finder switch to seize in said group of signal lines the signal line corresponding to said one operating member and to connect the seized signal line to said link circuit, impulse responsive means included in said link circuit for selecting any one of said signal lines, means included in said link circuit for causing said second operating element to be operated and for causing the idle or busy condition of the selected signal line to be tested, means included in said link circuit and controlled by said last-mentioned means only in the event the selected signal line is tested idle for causing the one of said operating members corresponding to the selected signal line to be operated, and means controlled by the joint operations of said second operating element and said one operating member for causing said connector switch to seize in said group of signal lines the selected signal line and to connect the seized signal line to said link circuit.

2. In a signaling system, a group of signal lines, unitary switching apparatus including a number of finder switches and a number of connector switches, each of said switches having access to each of said signal lines, a plurality of first operating elements, each of said first operating elements being associated with only one of said finder switches, a plurality of second operating elements, each of said second operating elements being associated with only one of said connector switches, a plurality of operating members, each

of said operating members being associated with only one of said signal lines, a number of link circuits, each of corresponding ones of said finder and connector switches being associated with only one of said link circuits, means controlled by the joint operations of one of said first operating elements and one of said operating members for causing the one of said finder switches corresponding to said one first operating element to seize in said group of signal lines the signal line corresponding to said one operating member and to connect the seized signal line to the associated link circuit, impulse responsive means included in each of said link circuits for selecting any one of said signal lines, means included in each of said link circuits for causing the one of said second operating elements corresponding to the associated connector switch to be operated and for causing the idle or busy condition of the selected signal line to be tested, means included in each of said link circuits and controlled by said last-mentioned means therein in the event the selected signal line is tested idle for causing the one of said operating members corresponding to the selected signal line to be operated, and means controlled by the joint operations of one of said second operating elements and one of said operating members for causing one of said connector switches corresponding to said one second operating element to seize in said group of signal lines the signal line corresponding to said one operating member and to connect the seized signal line to the associated link circuit.

3. In a signaling system, a group of signal lines, unitary switching apparatus including a number of finder switches and a number of connector switches, each of said switches having access to each of said signal lines, a plurality of first operating elements, each of said first operating elements being associated with only one of said finder switches, a plurality of second operating elements, each of said second operating elements being associated with only one of said connector switches, a plurality of operating members, each of said operating members being associated with only one of said signal lines, a number of link circuits, each of corresponding ones of said finder and connector switches being associated with only one of said link circuits, means controlled by the joint operations of one of said first operating elements and one of said operating members for causing the one of said finder switches corresponding to said one first operating element to seize in said group of signal lines the signal line corresponding to said one operating member and to connect the seized signal line to the associated link circuit, impulse responsive means included in each of said link circuits for selecting any one of said signal lines, normally effective control means included in each of said link circuits and operative to cause the one of said second operating elements corresponding to the associated connector switch to be operated and to cause the idle or busy condition of the selected signal line to be tested, means included in each of said link circuits and controlled by said last-mentioned means therein in the event the selected signal line is tested idle for causing the one of said operating members corresponding to the selected signal line to be operated, means included in at least one of said link circuits for rendering ineffective said control means included in at least another of said link circuits when said control means in said one link circuit is operated, and means controlled by the joint operations of one

of said second operating elements and one of said operating members for causing one of said connector switches corresponding to said one second operating element to seize in said group of signal lines the signal line corresponding to said one operating member and to connect the seized signal line to the associated link circuit.

4. In a signaling system, a group of signal lines, unitary switching apparatus including a number of finder switches and a number of connector switches, each of said switches having access to each of said signal lines, a plurality of first operating elements, each of said first operating elements being associated with only one of said finder switches, a plurality of second operating elements, each of said second operating elements being associated with only one of said connector switches, a plurality of operating members, each of said operating members being associated with only one of said signal lines, a number of link circuits, each of corresponding ones of said finder and connector switches being associated with only one of said link circuits, normally effective first control means responsive to the creation of a calling condition on any one of said signal lines for causing the one of said first operating elements corresponding to one of said finder switches associated with an idle one of said link circuits to be operated and for causing the one of said operating members corresponding to said one signal line to be operated, means controlled by the joint operations of one of said first operating elements and one of said operating members for causing the one of said finder switches corresponding to said one first operating element to seize in said group of signal lines the signal line corresponding to said one operating member and to connect the seized signal line to the associated link circuit, impulse responsive means included in each of said link circuits for selecting any one of said signal lines, second control means included in each of said link circuits and operative to cause the one of said second operating elements corresponding to the associated connector switch to be operated and to cause the idle or busy condition of the selected signal line to be tested, means included in each of said link circuits and controlled by said last-mentioned means therein in the event the selected signal line is tested idle for causing the one of said operating members corresponding to the selected signal line to be operated, means included in each of said link circuits for rendering ineffective said first control means, and means controlled by the joint operations of one of said second operating elements and one of said operating members for causing the one of said connector switches corresponding to said one second operating element to seize in said group of signal lines the signal line corresponding to said one operating member and to connect the seized signal line to the associated link circuit.

5. In a signaling system, a group of signal lines, unitary switching apparatus including a number of finder switches and a number of connector switches, each of said switches having access to each of said signal lines, a plurality of first operating elements, each of said first operating elements being associated with only one of said finder switches, a plurality of second operating elements, each of said second operating elements being associated with only one of said connector switches, a plurality of operating members, each of said operating members being associated with only one of said signal lines, a number of link

circuits, each of corresponding ones of said finder and connector switches being associated with only one of said link circuits, normally effective first control means responsive to the creation of a calling condition on any one of said signal lines for causing the one of said first operating elements corresponding to one of said finder switches associated with an idle one of said link circuits to be operated and for causing the one of said operating members corresponding to said one signal line to be operated, means controlled by the joint operations of one of said first operating elements and one of said operating members for causing the one of said finder switches corresponding to said one first operating element to seize in said group of signal lines the signal line corresponding to said one operating member and to connect the seized signal line to the associated link circuit, impulse responsive means included in each of said link circuits for selecting any one of said signal lines, normally effective second control means included in each of said link circuits and operative to cause the one of said second operating elements corresponding to the associated connector switch to be operated and to cause the idle or busy condition of the selected signal line to be tested, means included in each of said link circuits and controlled by said last-mentioned means therein in the event the selected signal line is tested idle for causing the one of said operating members corresponding to the selected signal line to be operated, means included in each of said link circuits for rendering ineffective said first control means, means included in at least one of said link circuits for rendering ineffective said second control means included in at least another of said link circuits when said second control means in said one link circuit is operated, and means controlled by the joint operations of one of said second operating elements and one of said operating members for causing the one of said connector switches corresponding to said one second operating element to seize in said group of signal lines the signal line corresponding to said one operating member and to connect the seized signal line to the associated link circuit.

6. In a signaling system, a number of lines arranged in groups, and unitary switching apparatus having access to each of said lines, said switching apparatus comprising, in combination, a plurality of operating elements, each of said operating elements being associated with only one of said groups of lines, a plurality of operating members, each of said operating members being associated with only one of said lines, a plurality of groups of elementary switches, each of said groups of elementary switches being operatively associated with only one of said operating elements, each of said elementary switches being operatively associated with only one of said operating members, each of said elementary switches being partially operative under the control of the operation of the operating element and under the control of the operation of the operating member associated therewith and being fully operative only in the event the associated oper-

ating element and operating member are operated in a predetermined order, each of said elementary switches being fully operative to select from the group of lines corresponding to the associated operating element the line corresponding to the associated operating member, and means for selectively controlling the operations of said operating elements and said operating members.

7. In a signaling system, a number of lines arranged in groups, and unitary switching apparatus having access to each of said lines, said switching apparatus comprising, in combination, a plurality of operating elements, each of said operating elements being associated with only one of said groups of lines, a plurality of operating members, each of said operating members being associated with only one of said lines, a plurality of groups of elementary switches, each of said groups of elementary switches being operatively associated with only one of said operating elements, each of said elementary switches being operatively associated with only one of said operating members, each of said elementary switches being partially operative under the control of the operation of the operating element and under the control of the operation of the operating member associated therewith and being fully operative only in the event the associated operating element is operated prior to the operation of the associated operating member, each of said elementary switches being fully operative to select from the group of lines corresponding to the associated operating element the line corresponding to the associated operating member, and means for selectively controlling the operations of said operating elements and said operating members.

8. In a signaling system, a number of lines arranged in groups, and unitary switching apparatus having access to each of said lines, said switching apparatus comprising, in combination, a plurality of operating elements, each of said operating elements being associated with only one of said groups of lines, a plurality of operating members, each of said operating members being associated with only one of said lines, a plurality of groups of elementary switches, each of said groups of elementary switches being operatively associated with only one of said operating elements, each of said elementary switches being operatively associated with only one of said operating members, each of said elementary switches being partially operative under the control of the operating element and under the control of the operating member associated therewith and being fully operative under the joint control of the associated operating element and operating member, means for restraining each of said elementary switches in its fully operated position under the sole control of the associated operating member, each of said elementary switches being fully operative to select from the group of lines corresponding to the associated operating element the line corresponding to the associated operating member, and means for selectively controlling said operating elements and said operating members.

JOHN WICKS.