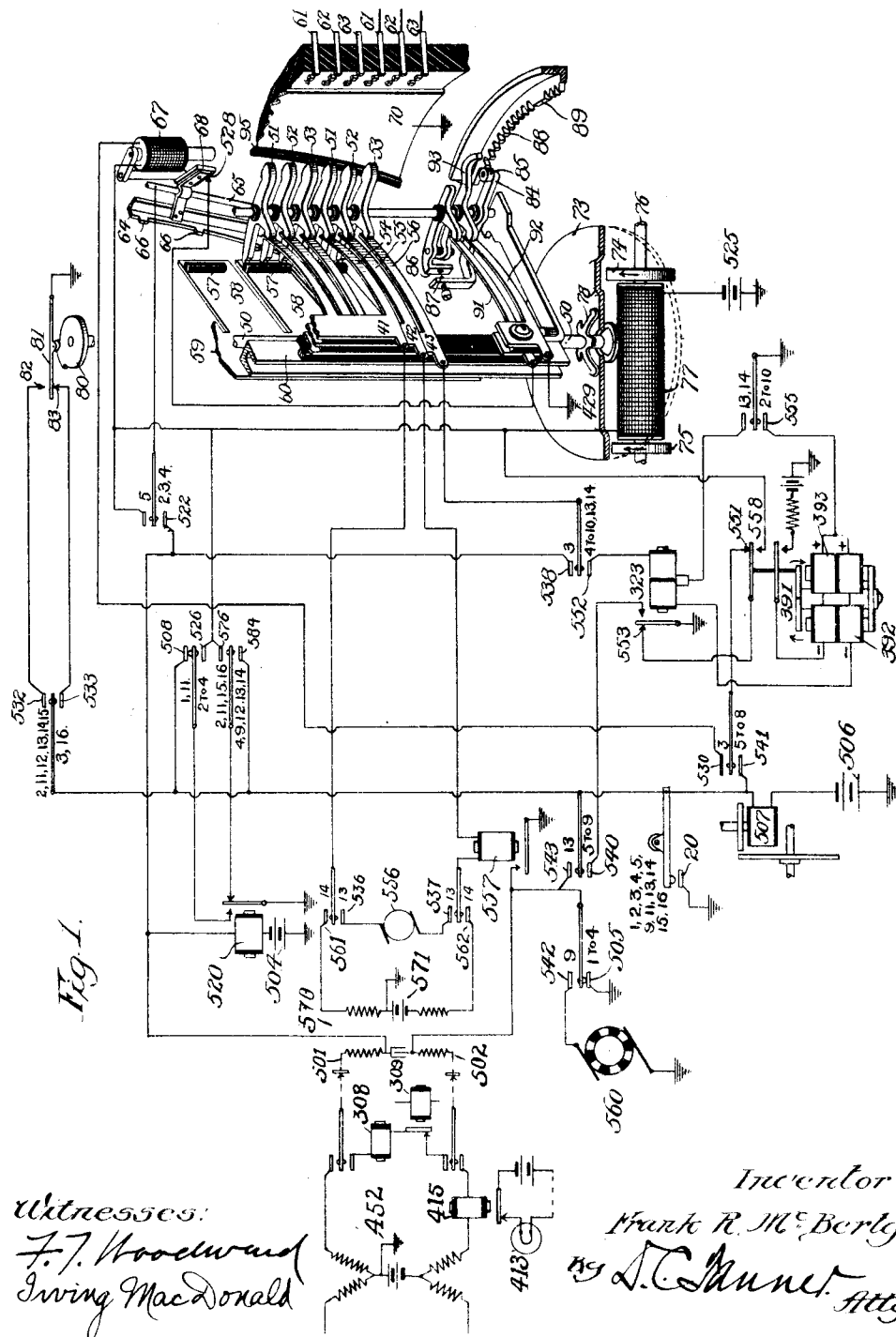


F. R. McBERTY.
 AUTOMATIC TELEPHONE EXCHANGE APPARATUS.
 APPLICATION FILED APR. 20, 1909.

1,117.212.

Patented Nov. 17, 1914.

4 SHEETS—SHEET 1.



Witnesses:

F. J. Woodward
 Irving MacDonald

Inventor:

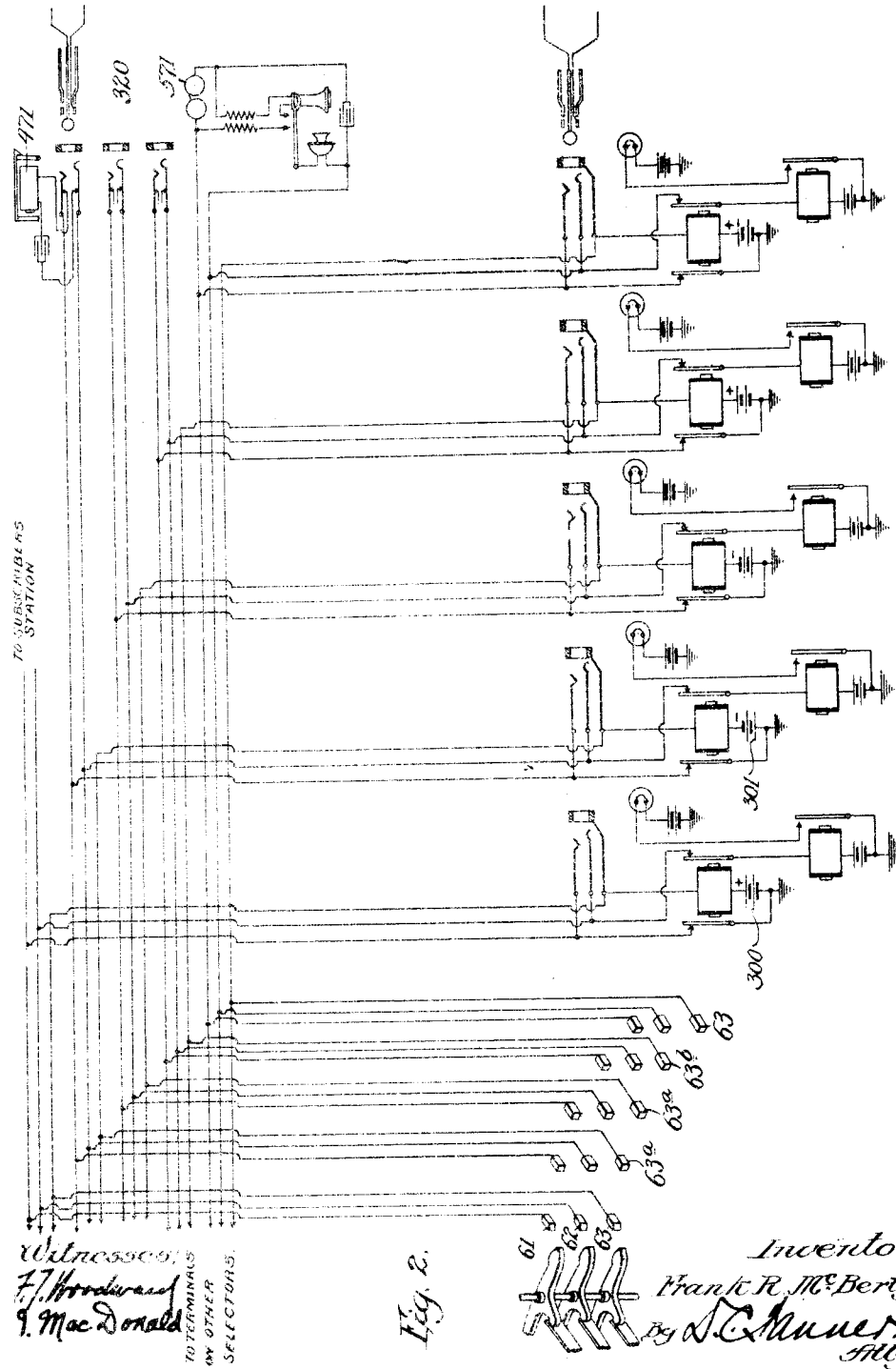
Frank R. McBerty
 by S. C. Munnet, Att'y.

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4 SHEETS—SHEET 2.



Witnesses:
 F. J. Woodward
 J. Mac Donald
 BY OTHER
 SELECTORS

Fig. 2.

61
 62
 63
 63a
 63b
 63c

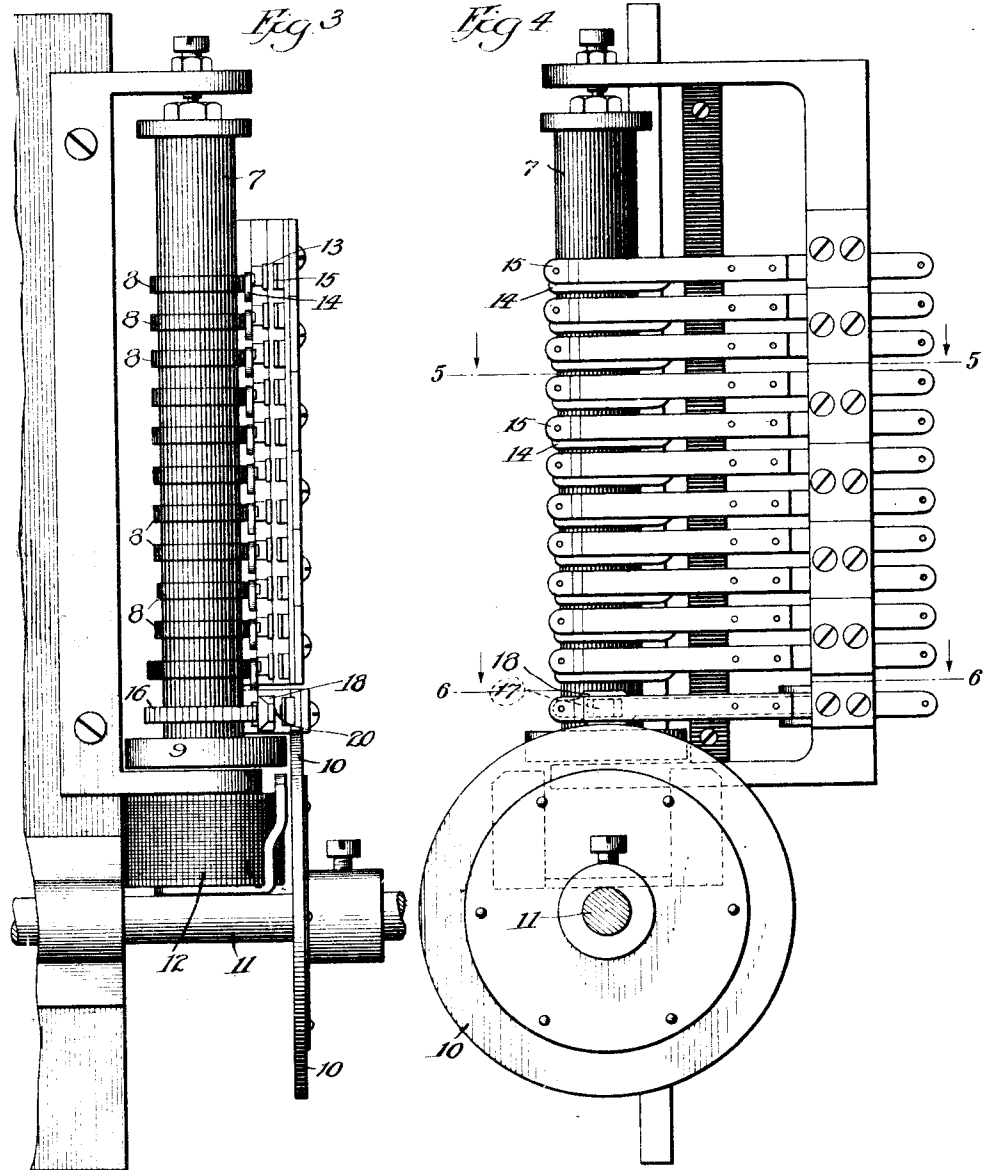
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 Frank R. McBerty
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4 SHEETS-SHEET 3.



Witnesses:

F. J. Woodward
 Irving Mac Donald

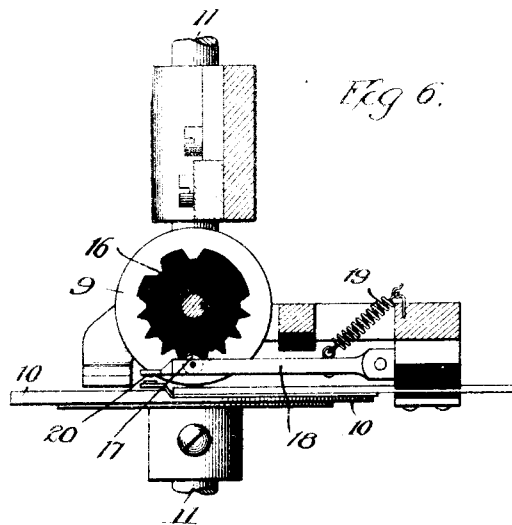
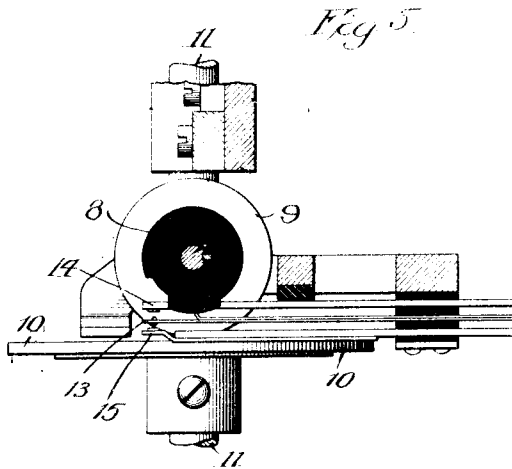
Inventor:

Frank R. McBerty
 By J. C. Munnell Atty.

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AUTOMATIC TELEPHONE EXCHANGE APPARATUS.
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1,117,212.

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4 SHEETS-SHEET 4.



Witnesses.
F. J. Woodward
Irving Mac Donald

Inventor:
Frank R. McBerty
By A. C. Munsterfeld

UNITED STATES PATENT OFFICE.

FRANK E. MCBERTY, OF NEW ROCHELLE, NEW YORK, ASSIGNOR TO WESTERN
ELECTRIC COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

AUTOMATIC TELEPHONE-EXCHANGE APPARATUS.

1,117,212.

Specification of Letters Patent.

Patented Nov. 17, 1914.

Application filed April 20, 1909. Serial No. 491,043.

To all whom it may concern:

Be it known that I, FRANK R. MCBERTY, citizen of the United States, residing at New Rochelle, in the county of Westchester and State of New York, have invented a certain new and useful Improvement in Automatic Telephone-Exchange Apparatus, of which the following is a full, clear, concise, and exact description.

My invention relates to telephone exchange systems and contemplates an arrangement of circuits and apparatus whereby all the operations incident to testing, connection and restoration in a final selector are performed automatically, speedily and with absolute certainty.

One feature of my invention is concerned with the provision of improved and simple automatic means for testing a selected line, transmitting a busy signal to the calling station under the proper circumstances or completing connection to such selected line, applying ringing current thereto, establishing telephonic transmission circuits upon the response of the called party, maintaining a busy test upon the multiple terminals of such line during connection, and finally restoring the apparatus and circuits to normal condition; these operations being accomplished with precision, in definite order, and without the necessity of controlling action at the distant sending apparatus.

More particularly, my invention contemplates an arrangement of apparatus and circuits whereby a calling line may not only be connected with the particular line selected, but if such selected line is busy and there are other lines which will as well serve the purpose of the calling line, connection will be established without any further controlling act with one of such lines, if one be idle, or, if all are found busy, a busy signal will be automatically operated.

The features of my invention are manifestly applicable both to systems of the purely automatic type, wherein the selecting switches are controlled by apparatus at the subscribers' stations, and to systems of the semi-mechanical type, wherein the selecting switches are controlled by an operator at the exchange who has received the call as in a manual system.

In accordance with one feature of my

present invention, the final selector, through which connection is to be made between a calling and a called line, is adapted to accommodate both ordinary subscribers' lines and groups of trunk lines. By this means direct access is possible by the calling line with either class of line. The selector is in itself provided with means whereby a discriminative test is made in such a manner that the further action of the selector will depend upon which class of line has been tested; the selector being provided with means whereby, if an ordinary subscriber's line is selected by the external control, the connecting circuit from the calling line will be connected to the line selected, if idle, and ringing current automatically placed upon the selected line; or if the line be busy, the selector will cause a busy signal to be sent back over the connecting circuit, but will not permit connection to be made between the connecting circuit and the desired line, the apparatus being thereafter restored to normal. When, however, the line selected and tested is one of a group of trunk lines, other than the last of such group, if it is found busy the selector, instead of transmitting a busy signal, will proceed to test each of the trunk lines of that group until one is found which is idle, and will then connect therewith; or if none of such lines are idle, it will, after testing the last trunk line of the group, then establish a busy signal, as in the case of a busy subscriber's line.

My invention also involves means whereby, after a line is tested and found free, and the selector has completed a circuit to such line, it will establish a busy test condition upon all of the other terminals of such line to prevent the seizure of this line by any other selector.

My invention also involves means whereby talking current is supplied to the called subscriber from a central battery, as is required by modern practice, the supply of such talking current being under the control of two relays located in, and individual to, the final selector, one of said relays being controlled by the called subscriber.

My invention also includes certain details of construction and organization of the apparatus and circuits associated with the selector by which the foregoing operations

and other operations incidental to the proper establishment of connections may be best accomplished.

The accompanying drawings which illustrate the preferred form of my invention, show in addition various features which form no part of my present invention and are not claimed in this application. These features, however, are claimed in my applications for Letters Patent as follows: Serial No. 418,123, filed February 27, 1908; Serial No. 418,124, filed February 27, 1908; Serial No. 418,126, filed February 27, 1908; Serial No. 451,867, filed September 5, 1908; Serial No. 451,868, filed September 5, 1908; and Serial No. 452,539, filed September 11, 1908.

In the drawings Figure 1 is a diagram illustrating an automatic selector or connector and its associated controlling apparatus and circuits; Fig. 2 is a diagram illustrating a few of the line terminals upon the selector, together with the lines of different classes connected to the respective terminals; the connections being such as to enable the testing apparatus associated with the selector to discriminate between the different classes of lines and to govern the operation of such selector and its associated signaling apparatus accordingly; Fig. 3 is a view in elevation of one form of sequence-switch which I prefer to employ for controlling the local operating circuits of the selector and its associated apparatus; Fig. 4 is a side view of the sequence-switch; Fig. 5 is a sectional plan view thereof on line 5-5 of Fig. 4; and Fig. 6 is a sectional plan view on line 6-6 of Fig. 4.

The same reference characters are used to designate the same parts wherever shown.

In the form of selector shown, the switch carriage or movable element of the selector is provided with a number of multiple sets of brushes, any particular set of which may be selected for service, and the switch carriage then advanced over a series of sets of line terminals until the selected brushes are brought into engagement with the terminals of a desired line. In case the terminal so selected represents the first of a group of lines, such as trunks to a private branch exchange, any one of which will serve the purpose of a calling subscriber, the selector, in accordance with my invention, is enabled to make a further advance over the series of line terminals representing such group, under the control of local testing mechanism, until the selected set of brushes reaches a set of line terminals representing an idle line of the desired group.

To describe in detail the mechanism of the particular selector shown, the switch carriage, or brush carrying member, is of the rotary type, the frame 60 being mounted upon a vertical rotary shaft 50. At the outer end of the frame a number of con-

tact brushes 51, 52, 53, are mounted in position to sweep over sets of line terminals 61, 62, 63, which are fixed in an insulating frame concentric with the shaft. The contact brushes are pivotally mounted so that their free ends may be rocked outwardly into position to engage the ends of the line terminals which they pass over, or rocked inwardly so that they will not contact with such terminals. Spring tongues 54, 55, 56, respectively, press against projecting arms of the brushes, and besides making electrical connection therewith, tend to rock the brushes on their pivots in a direction to throw their forward or contact ends outwardly. The brushes are electrically multiplied in sets of three, and each set is normally latched against the thrust of the spring tongues 54, 55, 56, by a catch 57 which is normally held in the path of movement of the rear ends of said brushes. As shown, the catches 57 are insulating bars mounted on spring latch-arms 58, which are the free ends or tongues of a spring metal plate 59 fixed to the rotary frame 60. In order to bring any set of brushes into position to engage the contacts over which they travel, they must be released by tripping the corresponding catch 57 to allow the brushes to be rocked upon their pivots by their springs 54, 55, 56. This tripping of the brushes is accomplished by a trip-bar 64 which is pivotally mounted on an axis 65 and has at its edge a series of projecting lugs 66 in position to be moved into the path of the respective latch-arms 58 when the trip-bar is rocked on its axis.

It is intended that only one of the several sets of brushes shall be selected and tripped in a given operation, and the trip-bar is therefore inclined at an angle so that the tripping lugs will face positions successively reached in the rotation of the brush carrier frame. The trip-bar will be actuated to thrust forward its tripping lugs only for a moment when the end of the latch-arm controlling the desired set of brushes reaches an angular position just in advance of that occupied by the particular lug which is at the proper height to engage that arm. The movement of the trip-bar may be accomplished by a tripping-magnet 67, the movable armature 68 whereof is mechanically connected to said bar.

A segmental metallic plate 70 is mounted in position to be engaged by the contact ends of the brushes as they are tripped, this plate extending to the end of the "trip range"—that is, through the arc traversed by the brushes as one set after another through the series is brought into position to be tripped. At the end of the trip range the bank of line terminals 61, 62, 63, begins. These terminals are arranged in sets of three, corresponding in relative positions to

the relative positions of the brushes by which they are to be traversed, and the different sets are arranged in an arc in position to be successively reached in a point-to-point rotary advance of the brushes. To restore the brushes to their latched position when the selector returns to normal, an insulating bar 95 is arranged to be passed over by the brushes in their return journey, the brushes in passing over this bar being raised thereby against the tension of their springs, until their beveled rear ends slip over the catches 57.

The motor mechanism for rotating the brush carrier frame may be as follows: An iron plate 73 is mounted to rotate with the shaft 50, but in such manner that it may be given a flat wise or tilting movement into engagement with one or the other of two iron friction-driving rollers 74, 75, which are located on either side of its axis, said rollers being mounted upon a constantly-driven power-shaft 76. An electromagnet 77, which I term the clutch magnet or power magnet, is arranged to magnetize the driving rollers 74 and 75 to cause them to attract the iron plate 73. Said plate is provided with cam surfaces, so that in the normal position of the apparatus the surface of the plate on one side of the axis 50 will be closer to the driving wheel 75 than the surface on the other side of said axis is to the driving wheel 74. Normally, therefore, when the power magnet is excited the plate 73 will be drawn into engagement with roller 75 to receive motion therefrom, and the carrier shaft 50 will be rotated in a direction to advance the brushes. After the brushes have been advanced the distance required, the power magnet will be deenergized, the plate 73 will be released from its engagement with driving roller 75, and said plate will recover from its tilted position by the action of a spring washer 78. The cam surface of the plate being now angularly displaced from the axis of the driving rollers, the body portion of the plate will be nearer to the "return" roller 74 which is of larger diameter than the roller 75, so that when the power magnet is again energized the plate will be engaged by roller 74, and the shaft 50 will be rotated thereby in a direction to return the rotary carrier to normal position.

A cam 80 is carried by the rotary element of the selector to operate a switch. On the first rotary movement, and while the brushes are passing the trip range, the cam forces said spring 81 against an anvil 82, and at the end of the trip range the cam allows the spring 81 to recede from contact 82 and engage the alternate anvil 83. A make and break contact device or interrupter is also arranged to be operated as the brush-carrier of the selector rotates. As shown, an in-

terrupter arm 84 is pivoted in the carrier-frame similarly to the brushes 51, 52, 53, and carries at its forward end a roller 85 which is adapted to travel over a toothed segment 88, thereby causing the arm to vibrate. As the roller rides up on each tooth, it rocks the arm 84 in a direction to close a contact 86, 87, and this contact remains closed until the roller has passed over the tooth and has nearly reached the bottom of the following notch. A spring tongue 91 which is mounted upon but insulated from the frame 60, presses against and makes continuous electrical connection with the contact arm 86. A pivoted arm 93, the foot of which rides upon the smooth rim of the toothed segment 88, has a rearward extension which engages an insulating stud carried by the arm 86, to hold said arm against the tension of the tongue 91. By this construction the relative positions of the contacts 86 and 87 in any position of the brush-carrier frame depend solely upon the relative distance of the roller 85 from the rim of the toothed segment upon the edge of which it rides, and are independent of slight variations in the radial distance between said toothed segment and the axis of rotation of the brush-carrier frame. The making and breaking of contacts 86 and 87 as the brush-carrier frame rotates, is thus accurately regulated according to the cutting of the notches in the segment 88. A spring tongue 92, mounted upon but insulated from the brush-carrier frame, and also insulated from tongue 91, bears upon the arm 93, and serves to make electrical connection to the contact point 87, through said arm 93, the rim of the metallic segment 88 upon which it rides, the roller 85 riding upon the edge of said segment, and arm 84 carrying said contact point. The terminal wires of the circuit to be interrupted by said contact 86, 87, are therefore soldered or otherwise connected to the tongues 91 and 92 respectively.

The brushes 51, 52, 53, are electrically connected in multiple sets by the terminal plates 41, 42, 43, the plate 41 having tongues 54 making contact with all the brushes 51, the plate 42 having tongues making contact with all the brushes 52, and plate 43 having tongues 56 making contact with all the brushes 53. The two line wires and the test wire of the circuit leading to the selector may be soldered or otherwise permanently connected to the plates 41, 42 and 43, respectively, and these three circuit wires may thus be electrically connected to any set of three stationary terminals 61, 62, 63, in any horizontal level by first tripping the multiple set of brushes which travels over the required level, and then causing the brush-carrier to rotate until the selected brushes reach the desired set of terminals in that level. There may be as many sets of brushes (within rea-

sonable limits) as desired, and as many line terminals as desired in each level. The particular selector shown will have, for example, ten sets of brushes, and say ten sets of line terminals in each level; but for simplicity in the diagram there are illustrated only two of the ten sets of brushes and a few of the line terminals in each level.

The local controlling circuits at each selector which must be established in definite order at successive stages of the operation to bring into service different devices or parts, as desired, are, in the system in question, established by automatic switching appliances which I term sequence-switches, or electro-mechanical relays. There is a sequence-switch for each selector, which consists in its elements of a movable switch operating member, a number of circuit-changers actuated in sequence as said member is moved from one position to another, an electromagnet, and motor mechanism operated or controlled by said magnet for advancing said movable member. In each position to which the movable member of the sequence-switch is advanced, a set of circuits is established by which a given operation of the device under control is made possible, and at the same time another circuit is established, whereby the motor magnet of the sequence-switch may be actuated, so that the sequence switch will then be automatically advanced to the next position, in which a new set of circuits is established, bringing about a new operation or electrical condition of the device or devices under control, and so on.

In the form of sequence-switch mechanism shown in Figs. 3 to 6 inclusive, the movable member is a vertical rotary shaft 7 carrying a number of switch operating cams 8, said shaft being arranged to be driven by power applied through the agency of an electromagnetic clutch. The constantly driven power shaft 11 carries a friction driving disk 10 which is adapted to be drawn into engagement with a friction roller 9, carried upon the shaft 7, by the action of a clutch magnet 12. The roller 9 and the disk 10 are of iron, and the motor magnet 12 is adapted when excited to magnetize said roller 9, which serves as a rotary pole piece for said magnet; whereby the driving disk 10 is attracted into engagement with said roller, the rotation of the shaft 7 thus continuing as long as the motor magnet 12 remains excited. The cams 8 carried by the rotary shaft 7 are arranged to operate switch springs 13, forcing said springs into engagement with outer contacts 15, or allowing them to engage their alternate inner contacts 14, according to the positions of said cams. As many cams and switches may be provided as the particular apparatus to be controlled may require. Certain of the switch contacts operated in the succes-

sive positions of the movable switch element may control circuits for the motor magnet 12. A special switch, such as shown in Fig. 6, is also preferably provided to control a local circuit for said motor magnet, whereby after the initial energizing circuit is broken by one or the other switches the motor magnet may still be excited by current in the local circuit until the next intended stopping position of the rotary element is fully reached. As shown in Fig. 6, the cam 16 for operating the "local" switch is adapted to be engaged by a cam roller 17 carried by a pivoted switch lever 18. A spring 19 is arranged to act upon said pivoted lever 18 so as to press the cam roller 17 against the edge of the cam 16. When the roller 17 rides upon a tooth or high part of the cam 16, said lever 18 closes a contact 20 which controls the local circuit for the motor magnet. The teeth of the cam 16 have inclined edges, so that the cam roller 17, after riding over the point of a tooth, is forced down the opposite slope by the action of the spring 19, and thus tends to push against the cam to continue the rotation thereof until the roller 17 reaches the bottom of the following notch. The rotary element is thus brought to rest accurately in each of the positions where it is intended to stop. In the operation of the device, the circuit will first be closed for the motor magnet through one of the springs 13 and one or the other of the contact anvils 14 or 15 of such spring. Then, as the motor magnet is excited and the shaft of the sequence-switch begins to rotate, the contact through which the motor magnet was initially excited may be broken, but the local circuit will be maintained for the motor magnet through the contact 20 closed by the cam 16, and the rotary element will thus continue to advance until the cam roller 17 reaches the bottom of the next notch of the cam 16.

In the diagram Fig. 1 the switch springs of the sequence switch are not shown in their actual arrangement, but are so located as to give a clear arrangement of the circuits; and the operating cams are not shown. The positions of the rotary element of each sequence-switch in which any of its contacts (except contact 20) are closed, are indicated by numbers placed adjacent to such contacts; each contact being open in all positions except those indicated by reference numbers. For example, contact 508 is closed in the first position, and in the 11th position, as indicated by the numbers 1, 11, placed adjacent thereto, and is open in all other positions. In the case of the special contact 20 operated by the cam 16, the numbers are placed on the opposite side of the switch lever 18 from its contact anvil, and indicate positions in which the contact is open, said contact be-

ing closed continuously while the rotary element of the sequence-switch is in transit between the positions indicated. It will be noted that the numbers are not consecutive between 5 and 13, but run "5, 9, 11, 13", and so forth. It will therefore be understood that the contact 20 is closed continuously from the time the sequence-switch leaves the 5th position until it reaches the 11th, not stopping in the 6th, 7th or 8th positions. Said contact is also closed continuously from the time the sequence-switch leaves the 9th position until it reaches the 11th, and also from the time it leaves the 11th position until it reaches the 13th. In the 5th, 9th, 11th and 13th positions, however, (and in all other positions the numbers of which appear) the contact 20 is open to permit the sequence-switch to come to rest in the positions so indicated.

I have not illustrated in detail the "sending apparatus" for determining the selecting operation: but I have diagrammatically indicated certain switches for making changes in the electrical condition of the main circuit at a distant point, such as would in fact be made by the controlling or sending apparatus. For the purposes of this invention, it is immaterial how connection is made from the calling line to the trunk line 501, 502, which terminates in the selector; and it is likewise immaterial what type of sending apparatus is used to control the selector. During selection such control is effected from the different points by the mere opening and closing of the circuit 501, 502, which terminates in the selector; and this circuit may be considered as a mere extension of the circuit from the calling line. After selection the control is effected by a ground connection associated with the conductor 501. This connection is shown diagrammatically at 452. It will therefore be unnecessary to set forth the circuits, apparatus, and mode of operation of the complete telephone exchange: sufficient information being given herein to enable one skilled in the art to apply the present invention to an automatic exchange system of any desired type.

The apparatus and circuits to which I wish to direct particular attention are the two test relays 323 and 391, with their connections and associated mechanism, and the connections of the test terminals of the lines shown in Fig. 2.

Referring first to Fig. 2, it will be noted that of the five sets of line terminals shown, the first set, (reading from left to right) represents an ordinary subscriber's line. The second, third and fourth sets of terminals represent three trunk lines respectively, leading to a private branch exchange, and the fifth set of terminals represents another ordinary subscriber's line. It will be noted

that the test terminals 63 of ordinary subscribers' lines are connected, through the cut-off relays of such lines, to the positive pole of a battery 300, the negative pole whereof is grounded. The same is true of the test terminal 63^a of the last of the group of three trunk lines leading to the private branch exchange 320. The test terminals 63^a of all the trunks except the last are connected, through the cut-off relays of such trunks at the central office, to the negative pole of a battery 301, the positive pole whereof is grounded.

Referring now to Fig. 1, it will be noted that two test relays 323 and 391 are arranged to be connected in series in a test circuit which is completed from the test brushes 53 of the selector to earth, in certain positions of the sequence switch. The relay 323 is a neutral relay, responding to current of either polarity; but it is of the marginal type, being adjusted to respond only when receiving the full current from the battery 300 or 301, through the cut-off relay of a line. When the test brush 53 of the selector is in contact with the test terminal of a line which already has a connection at some other set of terminals, the test relay 323 will not receive the full current, since it is shunted by the bath already established from another multiple terminal of the line tested, at the previously established connection. In testing a busy line, therefore, the marginal test relay 323 will not respond. The relay 391 is polarized, and will respond only to current of the polarity which is derived from the test terminals 63^a of all trunk lines except the last in each group; the last trunk line of each group having a potential applied to its test terminal of the same polarity as that which is applied to the test terminals 63 of ordinary lines. The polarized test relay 391 will respond to current received from the test terminal of a line, whether such line is busy or not. The polarized relay 391 has, in addition to its main winding 392, which is included with the relay 323 in the test circuit, a locking winding 393 of feeble energizing power. This locking winding is sufficient to hold up the relay armature while the brush is passing from one test terminal to the next, but is so adjusted with respect to the winding 392 that upon the passage of current of the opposite polarity through the winding 392, the polarized test relay will be immediately de-energized and the armature retracted. As will hereafter be described in detail, the two relays 323 and 391 in the testing circuit act in combination to determine whether the selector shall seize the line tested and transmit a ringing or calling signal to the called station, or whether a "busy" signal shall be sent back to the dis-

tant calling or controlling point; or whether the selector shall further advance its brushes to the next set of line terminals in their path, or an intermediate trunk line, of a group leading to the same private branch exchange.

The operation of the selector and its associated apparatus is as follows: When the circuit of the trunk line 501, 502, is completed at the distant calling or controlling point, a line relay 520 is excited by current from the free pole of grounded battery 504, through the winding of said line relay, through one winding of a repeating coil 570, which inductively unites the two parts of the trunk line 501, 502, permitting the inductive transmission of telephone currents between the two sections thereof, to line conductor 501, and thence to the distant controlling point, where said conductor may be connected through a stepping relay 308 of a sending apparatus, and through the back contact of a stop relay 309 of the sending apparatus, to the other line conductor 502, thence through another winding of the repeating coil 570, and through a normally closed contact 505 of the sequence-switch associated with the selector, to earth. The line relay 520, when thus excited, closes at its front contact a circuit from earth through a contact 508 of the sequence switch, closed in the 1st or normal position, through the motor magnet 507 of said sequence-switch, to the free pole of the grounded battery 506. The sequence-switch is thereby moved to its 2nd position, in which contact 526 is closed, whereby the line relay 520, which remains excited, completes at its front contact a circuit from earth through said contact 526 and power-magnet 77 of the selector to the free pole of the grounded battery 525. The magnet 77 causes the power plate 73 of the selector to be drawn into engagement with the friction driving disk 75, which is constantly rotating, so that the rotary element or brush-carrier of the selector is driven thereby, to advance the brushes. As soon as the brush-carrier begins to rotate, the cam 80 forces the contact spring 81 into engagement with the contact anvil 82, and thereby completes a circuit from ground through said contact 81, 82, through contact 532 of the sequence-switch to the motor magnet 507 of said sequence-switch, and free pole of grounded battery 506. The sequence-switch is thus moved to the 3rd position, in which a set of brushes may be tripped. As the roller 85 of the interrupter rides over the toothed segment 88, the contact 86, 87, is alternately made and broken, and at each step a short circuit is thereby completed from line relay 520, through contact 522 of the sequence-switch, back contact 528 of the trip magnet 67, and interrupter contact 86, 87, to earth,

short-circuiting the distant stepping magnet 308. Impulses are thus delivered to the stepping magnet 308 at the distant controlling point as the brush carrier of the selector rotates, and these impulses may be used to control the selecting operation, by causing a step-by-step mechanism at the sender to operate in unison with the point-to-point advance of the selector.

When the sending apparatus has taken a predetermined number of steps, it may cause the stepping circuit 501, 502, to be broken, as by a relay 309. The breaking of this main circuit will cause the line relay 520 at the selector to be released. This will leave the trip magnet 67 connected in series with the power-magnet 77, over a circuit to ground through contacts 530, 551 and 553, said trip magnet having been short-circuited by the path through contact 526 of the sequence-switch and front contact of the line relay 520, until said line relay was released. As the brush-carrier frame of the selector continues to rotate after the trip magnet 67 is excited by the removal of the short circuit controlled at the front contact of the line relay, the first of the latch arms to reach one of the tripping lugs 66 which have been thrust into the path of said latch arms by the trip magnet 67, will be engaged by such lug and detained sufficiently to release the three brushes normally held by such latch arms. These brushes will thus be rocked upon their pivots by their springs 54, 55, 56, and their outer ends thrust into contact with the grounded metal plate 70. The particular set of brushes which is thus brought into service will depend upon the number of steps through which the selector had advanced before the trip magnet was excited; that is to say, upon the number of steps which the sending apparatus took in unison with the selector before breaking the line circuit which released the line relay and caused the set of brushes to be tripped.

When the test brush 53 of the set which is tripped makes contact with the grounded metallic segment 70 of the selector, a circuit is completed from battery 504, through the line relay 520, contact 538 of the sequence-switch, plate 43 (which is connected through the tongues 56 to all the test brushes 53 in multiple) through the test brush 53 of the particular set which was tripped to the metal segment 70 and earth. This circuit causes the relay 520 to be again excited, re-establishing the short circuit of the trip magnet at the front contact of said relay.

When the rotary element of the selector has advanced to such an extent that all the brushes have been carried beyond the range of the tripping lug (although no more brushes can be tripped because the trip magnet has been released and its armature in recovering has retracted the trip bar 64) the

cam 80 allows the spring 81 to return into contact with anvil 83. This completes a circuit from ground through spring 81 and contact 83, contact 553 of the sequence-switch to the motor magnet 507 thereof, whereby said sequence-switch is moved to its 4th position. In this position the trip magnet is permanently cut out of circuit by the opening of contact 530.

In the type of selector shown in the drawing, the segment 88 is provided with an extra notch in advance of the notches representing positions in which the selector brushes rest upon the line terminals. As the brushes leave the segment 70 at the end of the trip range, the interrupter roller 85 rides up on a long tooth 89 of the segment 88, and by closing contact 86, 87, maintains a circuit for the line relay 520, through contact 522 of the sequence-switch. As the interrupter roller 85 passes down from the long tooth into the first notch in advance of the series of notches corresponding to line connecting positions of the selector brushes, the circuit controlled by the interrupter contact 86, 87, is broken, and the first of a new series of selecting impulses is applied to the main conductor 501 leading back to the distant controlling point. The circuit will have been again completed at the sender or controlling point by this time, so that the sending apparatus will be again in condition to receive and respond to selecting impulses, as before.

When the selector has advanced its brushes to the terminals of the desired line (this advance having been measured off at the sending apparatus by the impulses received from the selector) the circuit 501, 502, will be opened at the sending apparatus, as by the action of a stop relay 309, and as the interrupter roller 85 enters the notch in the toothed segment 88 corresponding to the position of the brush carrier in which the selected set of brushes rest upon the terminal of the desired line, the contact 86, 87, is opened, and the line relay 520 is released.

Before, however, the line relay 520 has been released, a test circuit has been completed at the contact 552 of the sequence-switch, which circuit, under conditions to be hereinafter described, will energize a relay to close an alternative circuit to maintain the energization of the power magnet 77 and continue the movement of the brush-carrier frame. This test circuit may be traced from the test terminal of the line upon the terminals of which the brushes rest, and to which a potential is supplied through the cut-off relay of such line, to the test brush 53 of the selector, contact 552 of the sequence-switch, windings of the test relay 323, winding 392 of the polarized test relay, contact 555 of the sequence-switch, to earth. The alternative circuit referred to may be traced from bat-

tery 525, power-magnet 77, front armature contact 558 of the polarized test relay 391, and back contact 553 of the test relay 323 to earth. This alternative circuit will only be closed at such times as the polarized test relay 391 is energized and the test relay 323 is deenergized. Upon the release of the line relay 520, the circuit through the contact 526 of the sequence switch to the power magnet 77 is broken, and unless the alternative circuit to the power magnet has been closed, the brush-carrier frame will cease to rotate and the selected set of brushes will be brought to rest upon the desired set of line terminals.

As the armature of the line relay 520 reaches its back contact a circuit is completed from ground through the contact 584 of the sequence-switch, to the motor magnet 507 and battery 506, whereby the sequence switch is moved to fifth position. The test circuit which was completed in the fourth position of the sequence-switch is maintained in the fifth position. If the line selected, and upon which the brushes rest when the relay is released, is an ordinary subscriber's line and is busy, neither test relay will have responded and the alternative circuit for energizing power magnet 77 will not be closed, since the current through the test circuit is not of the proper polarity to energize the polarized relay 391. If the line tested is an ordinary subscriber's line and is not busy, the test relay 323 alone will respond; in either of these cases the alternative circuit to the power magnet 77 not having been closed, the brush carrier frame will move no farther. If the line tested is the first trunk line, or any intermediate trunk line of a group, any one of which will serve the purpose of the calling subscriber, as in case of a group of trunks leading to a private branch exchange, the polarized test relay 391 will have responded. The marginal test relay, however, will respond only in case the line tested is free, and therefore if the line tested is free the energization of the test relay 323 will have prevented the closure of the alternative circuit to the power-magnet 77 and the brush-carrier frame will stop. If, however, the line tested is busy, the polarized test relay having been energized has closed the alternative circuit to the power magnet 77, and the brush-carrier frame will continue to move until the brushes rest upon the next set of terminals, at which time, and before the power-magnet 77 has been allowed to deenergize, the test operation will be repeated. If the line tested is the final trunk line in a group of trunk lines, the test operation will be the same as for an ordinary subscriber's line and need not be again described.

As the sequence switch reaches its 5th position, in which the busy test is made, a cir-

cuit is completed for the motor magnet 507 of the sequence-switch, either through contact 541 and the back contacts 551 and 553 of the test relays 391 and 323, respectively, or through contact 540 of the sequence-switch and front contact of the test relay 323, according as said test relay 323 is inert or excited. The sequence-switch is arranged to run through to its 9th position, under control of the circuit through contact 541 and back contacts of the test relays unless sufficient current is received from the terminal of the tested line to energize the relay 323, or unless the line tested is a trunk line from the test terminal whereof a potential is derived of a polarity suitable to operate the polarized relay 391.

In the 9th position of the sequence-switch, in which it is stopped in case neither of the test relays is excited, a contact 542 is closed in which the free pole of the busy tone interrupter 560 is applied to the trunk line 502, to give a busy signal at the distant calling or controlling point in a well known manner. In case the line tested is a trunk line to the test terminal 63^a whereof a negative potential is applied, which is the case with each trunk line except the last in each group, the polarized test relay 391 will be excited and will break the circuit for the motor magnet 507 before the sequence-switch can leave the 5th position. If now the marginal test relay 323 does not respond, as in case the line tested is busy, the alternative circuit hereinbefore described will be completed from battery 525, through power-magnet 77 of the selector, contact 558 of the polarized test relay and back contact 553 of the marginal test relay, to earth. This circuit has been established before the power-magnet 77 has released the power plate 73, and the brushes will not be allowed to stop upon the terminals of the trunk line so tested, but the rotation of the brush-carrier will be continued until the test brush reaches the terminal of a trunk line of the group which is free, or until said test brush reaches the terminal of the last trunk line of the group. This last trunk line has its test terminal connected to battery of the same polarity as an ordinary line, and if it is busy neither test relay 323 nor 391 will be excited, and the circuit for the motor magnet of the sequence-switch will be completed through contacts 541, 551 and 553 in series, causing the sequence-switch to run through to the 9th or busy back position, in which it will stop.

Immediately after the conclusion of each selecting operation which is determined by the opening of the circuit 501, 502, at the distant controlling point, a ground is placed upon the conductor 501, to cause the line relay 520 at the selector to be excited, this relay remaining excited during the connection. This ground connection for control-

ling the line relay 520 is located at the distant controlling point and need not be described, as it forms no part of this invention, but is shown diagrammatically at 452. When, as in the case of the failure to get a connection and the receipt of a busy signal at the controlling point, the connection with the trunk line 501, 502, at the controlling point is taken down, the ground connection 452 will be opened and the line relay 520 will be released and will cause the selector to be restored to normal condition, as will hereafter be described. In case the line tested is free, however, the test relay 323 in its response will close a circuit from ground through its front contact and contact 540 of the sequence-switch, to the motor magnet of said sequence-switch, and battery 506. The contact 540 remains closed from the 5th to 9th positions inclusive, of the sequence-switch, so that the latter does not stop in the 9th or busy back position, but runs through to the 11th position, the local contact 20 being closed while the sequence-switch is in transit between the 9th and 11th positions.

In the 11th position a circuit for the motor magnet 507 may be completed through contact 508 and the front contact of the line relay 520; and unless the connection has been prematurely taken down at the distant controlling point the line relay 520 will still be excited, and the sequence-switch will continue to advance from the 11th position to the 13th, contact 20 being closed while the switch is in transit.

In the 13th position the contacts 536 and 537 are closed, connecting the poles of the ringing generator 556 to the line brushes 51 and 52 of the selector, thus applying ringing current to the called line. This ringing current will operate the call bell 571 at the substation of an ordinary subscriber's line, or it will operate the annunciator drop 471 which is normally connected in the circuit of each trunk line at the private branch exchange. Upon the response of the called party in the usual way, the closure of the circuit of the called line through the low resistance telephone apparatus at the called station causes an increased flow of current through the supervisory relay 557, causing said relay to attract its armature. This completes a circuit from ground through the front contact of said supervisory relay, contact 543 of the sequence-switch to motor magnet 507 thereof and battery 506; whereby the sequence-switch is moved to the 14th position. In this position the contacts 561 and 562 are closed, completing the telephone transmission circuit for the trunk line from the repeating coil 570 through to the called line. Responsive to the operation of the two relays, that is, the supervisory relay 557 and the selector sequence-switch, as just de-

scribed, talking current is supplied to the called party from battery 571.

When the connection is taken down at the distant calling or controlling point, and the ground connection of the trunk conductor 501 opened, the line relay 520 is released, and closes a circuit from ground through the back contact of said line relay, contact 584 of the sequence-switch to motor magnet 507 thereof, and battery 506. The sequence-switch is therefore moved to the 15th position, in which contacts 561 and 562 are opened, and contact 576 closed, the latter completing a circuit from battery 525, through the power-magnet 77 of the selector, contact 576 and back contact of the line relay 520 to earth. The power-magnet 77 is thus excited, and as the rotary element of the selector is now displaced from its normal position, the surface of the power plate 73 will be nearer to the return roller 74 than it is to the driving roller 75, so that said plate 73 will be attracted into engagement with the return roller 74, and the brush-carrier is rotated back toward its normal position. When the cam 80 in this return movement closes contact 81, 82, a circuit is completed from ground through contact 532 of the sequence-switch to the motor magnet 507 of said sequence-switch and battery 506, whereby the sequence-switch is moved to its 16th position. As the rotary element of the selector reaches its normal position the cam 80 allows the spring 81 to close against contact anvil 83, thereby completing a circuit from ground through contact 533 of the sequence-switch to the motor magnet thereof, whereby the sequence-switch is moved on to its normal position, having completed a full revolution. The whole apparatus has now been restored to normal condition. It will therefore appear that the terminals located in the selector may be divided into two classes or groups, first, those at which the movement of the brush-carrier must stop, such as those associated with ordinary subscribers' lines and the last trunk line of a group of trunk lines, and those at which, if busy, it is desirable that the brush-carrier should continue in motion. It should be noted that in practice the cut-off relays connected to all of the first class or group of terminals are connected to one battery of the proper polarity, and all of those connected to the other class or group are connected to another battery of the opposite polarity.

It will be observed that the supervisory relay 415 controls the supervisory lamp 413 and is in turn itself controlled by alternative circuits through the busy back and through the armature of the relay 557. The lamp 413 consequently serves at various times to indicate that the line called is busy, that the party upon the line called has an-

swered or that a disconnection is desired. This arrangement being simple and well understood will not be further described. It will also be observed that the arrangement whereby the line relay 520 and the test relay 323 control alternative controlling circuits at their front and back contacts, respectively, not only simplifies the circuits and reduces the amount of necessary apparatus, but also renders the operation of such circuits and apparatus unerring and positive. This is particularly apparent in the case of the test relay, wherein the circuits which control the only two alternative operations necessary or possible at the time the test relay is brought into service are closed by the armature of the relay at its front and back contacts, respectively, depending upon whether or not the relay is energized. A false or imperfect operation of the apparatus at this important stage in the operation is, therefore, manifestly impossible. The same conditions exist in hardly less degree in connection with the line relay 520 and the circuits controlled by it.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. In a telephone exchange system, the combination with a selector having access both to ordinary subscribers' lines and to groups of trunk lines, of contact brushes, means for advancing said brushes into contact with the terminals of the desired line, a circuit controlling the further advance of said brushes, a test circuit, a test relay energized when the test circuit includes the test contact of one of a group of trunk lines other than the last of the group to close said circuit to further advance said brushes, a locking winding on said relay in a local circuit and means for deenergizing said relay when the test circuit includes the test terminals of an ordinary subscriber's line or the last trunk line of a group.

2. In a telephone exchange system, the combination with an automatic selector, of lines terminating therein comprising ordinary subscribers' lines and groups of trunk lines, a test terminal for each line, a source of current connected with the test terminals of the ordinary subscribers' lines and the last trunk line of each group of trunks, a source of current of opposite polarity connected with the test terminals of the trunk lines other than the last of the group, contact brushes in said selector, means for driving said brushes, a test circuit including the contact brush adapted to contact with the test terminals, and a polarized relay having two windings, one of said windings being included in the test circuit, the other of said windings being of feeble energizing power and included in a local locking circuit, said windings being such that the relay will be

initially energized only when the test brush is in contact with a test terminal connected to the second mentioned source of current and such that when the test brush is in contact with a test terminal connected to the first source of current, the energization due to said locking winding will be over-balanced and the armature retracted.

3. In a telephone system the combination with a calling line, of a connector switch containing terminals of trunk lines and of ordinary subscribers' lines, test terminals for said lines divided into two classes by reason of their being connected to sources of current of different polarity, a source of ringing current, a busy back, a sequence switch, a movable contact member for the connector switch, a test circuit, means including an electromagnetic clutch for advancing said contact member into engagement with a predetermined line terminal so as to complete said test circuit, means for causing said sequence switch to move into busy back position when a busy line is encountered whose test terminal is of one class, means for preventing such a movement of the sequence switch if the test terminal encountered is of the other class, and for completing a circuit for the electromagnetic clutch whereby the movable contact of the connector switch may be advanced to test in succession a group of trunk lines until either an idle one is found or a test terminal of the first class again encountered, and means for thereupon advancing the sequence switch either to ringing or busy back position depending on whether or not an idle trunk has been found.

4. In a telephone system the combination with a calling line, of a connector switch containing terminals of trunk lines and of ordinary subscribers' lines, test terminals for said lines divided into two classes by reason of their being connected to sources of current of different polarity, a source of ringing current, a busy back, a sequence switch, a movable contact member for the connector switch, a test circuit, means including an electromagnetic clutch for advancing said contact member into engagement with a predetermined line terminal so as to complete said test circuit, means for causing said sequence switch to move into busy back position when a busy line is encountered whose test terminal is of one class, means for preventing such a movement of the sequence switch if the test terminal encountered is of the other class, and for completing a circuit for the electromagnetic clutch whereby the movable contact of the connector switch may be advanced to test in succession a group of trunk lines until either an idle one is found or a test terminal of the first class again encountered, and means for interrupting said last named circuit upon the happening of either event and permitting the

sequence switch thereupon to advance either to ringing or busy back position depending on whether or not an idle trunk has been found.

5. In a telephone system the combination with a calling line, of a connector switch containing terminals of trunk lines and of ordinary subscribers' lines, test terminals for said lines divided into two classes by reason of their being connected to sources of current of different polarity, a movable contact member for the connector switch, a source of ringing current, a busy back, a sequence switch having ringing and busy back positions, a test circuit including a marginal test relay and a polarized test relay, and circuits adapted to be completed in contacts of said test relays to determine, in accordance with the condition of the engaged test terminal, whether the sequence switch shall remain in testing position or go either to ringing or busy back position.

6. In a telephone system the combination with a calling line, of a power driven connector switch containing terminals of trunk lines and of ordinary subscribers' lines, test terminals for said lines divided into two classes by reason of their being connected to sources of current of different polarity, a source of ringing current, a busy back, a sequence switch, a movable contact member for the connector switch, a test circuit including a marginal test relay and a polarized test relay, means including an electromagnetic clutch for advancing said contact member into engagement with a predetermined line terminal so as to complete said test circuit, circuits adapted to be completed in contacts of said test relays to determine, in accordance with the condition of the engaged test terminal, whether the sequence switch shall remain in testing position or go either to ringing or busy back position, and, while maintaining said sequence switch in testing position, to also complete a circuit for the electromagnetic clutch whereby the movable contact member may be advanced until an idle trunk is found or all of them have been tested.

7. In a telephone exchange system the combination with an automatic switch, of trunks and individual lines to be tested thereby, a sequence switch, a differentiating test means for determining, first, whether the trunk or line to which the switch has been directed is busy or idle, and if idle to cause said sequence switch to move to ringing position, second, if said trunk or line be busy to determine whether the contact is that of a trunk or of an individual line, and if of a trunk to cause said automatic switch to test the trunk contacts one after another in search of an idle trunk, and when an idle trunk is found to then cause said sequence switch to move to ringing position, third, if

said line is a busy individual line or if no idle trunk line was found, to cause said sequence switch to move to busy back position.

8. In a telephone exchange system, the combination with a selector, of a motor magnet therefor, a busy signal appliance, a ringing generator, a marginal test relay, a polarized test relay, and local circuits for said motor magnet, busy signal appliance and ringing generator controlled jointly by said relays.

9. In a telephone exchange system, the combination with a selector, of a motor magnet therefor, a busy signal appliance, a ringing generator, test terminals and a test

brush for said selector, sources of current of different character adapted to be connected to said test terminals, two test relays connected to said brush adapted to discriminate between the different sources of current, and local circuits for said motor magnet, busy signal appliances and ringing generator controlled jointly by said relays.

In witness whereof, I hereunto subscribe my name this 19th day of April A. D., 1909.

FRANK R. McBERTY.

Witnesses:

D. C. TANNER,
F. T. WOODWARD.