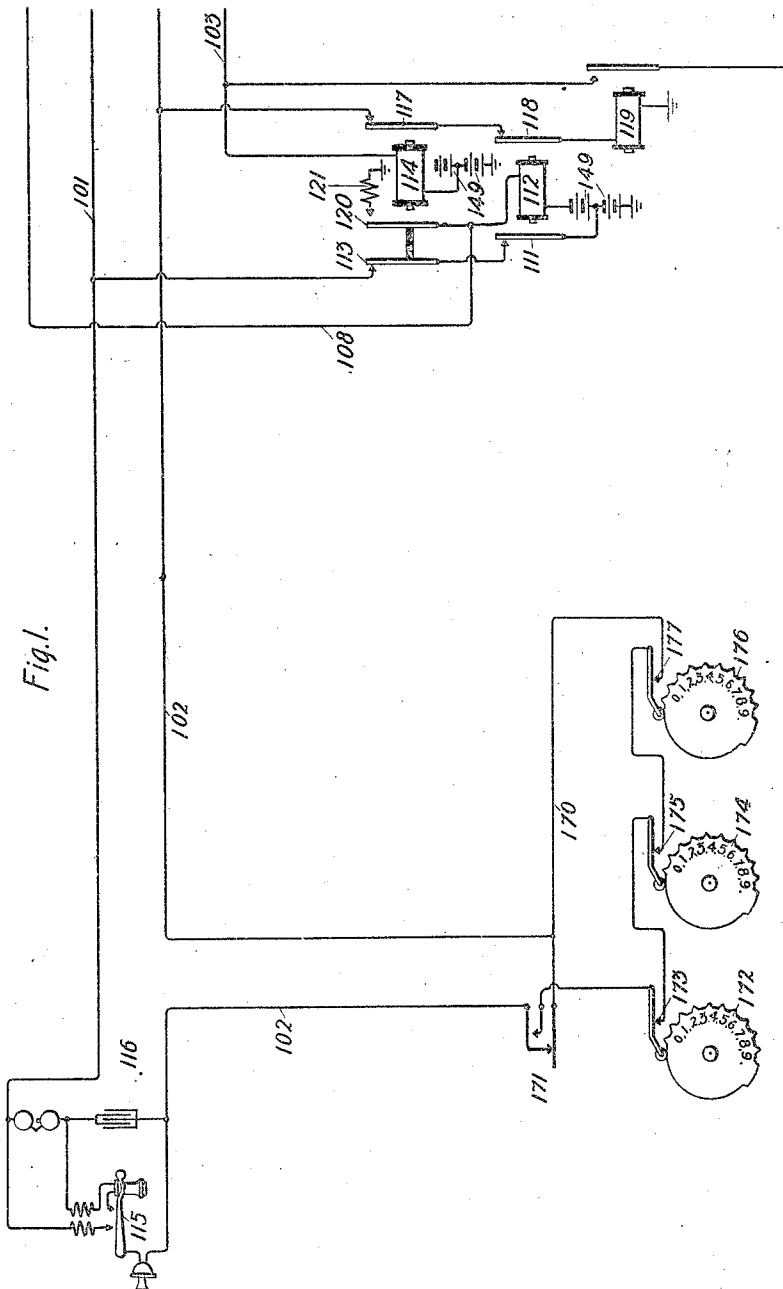


F. R. McBERTY.
 TELEPHONE EXCHANGE SYSTEM.
 APPLICATION FILED NOV. 10, 1910.

1,109,686.

Patented Sept. 8, 1914.

4 SHEETS-SHEET 1.



Witnesses:

F. J. Woodward
M. Washburn Jr.

Inventor:

Frank R. McBerty.

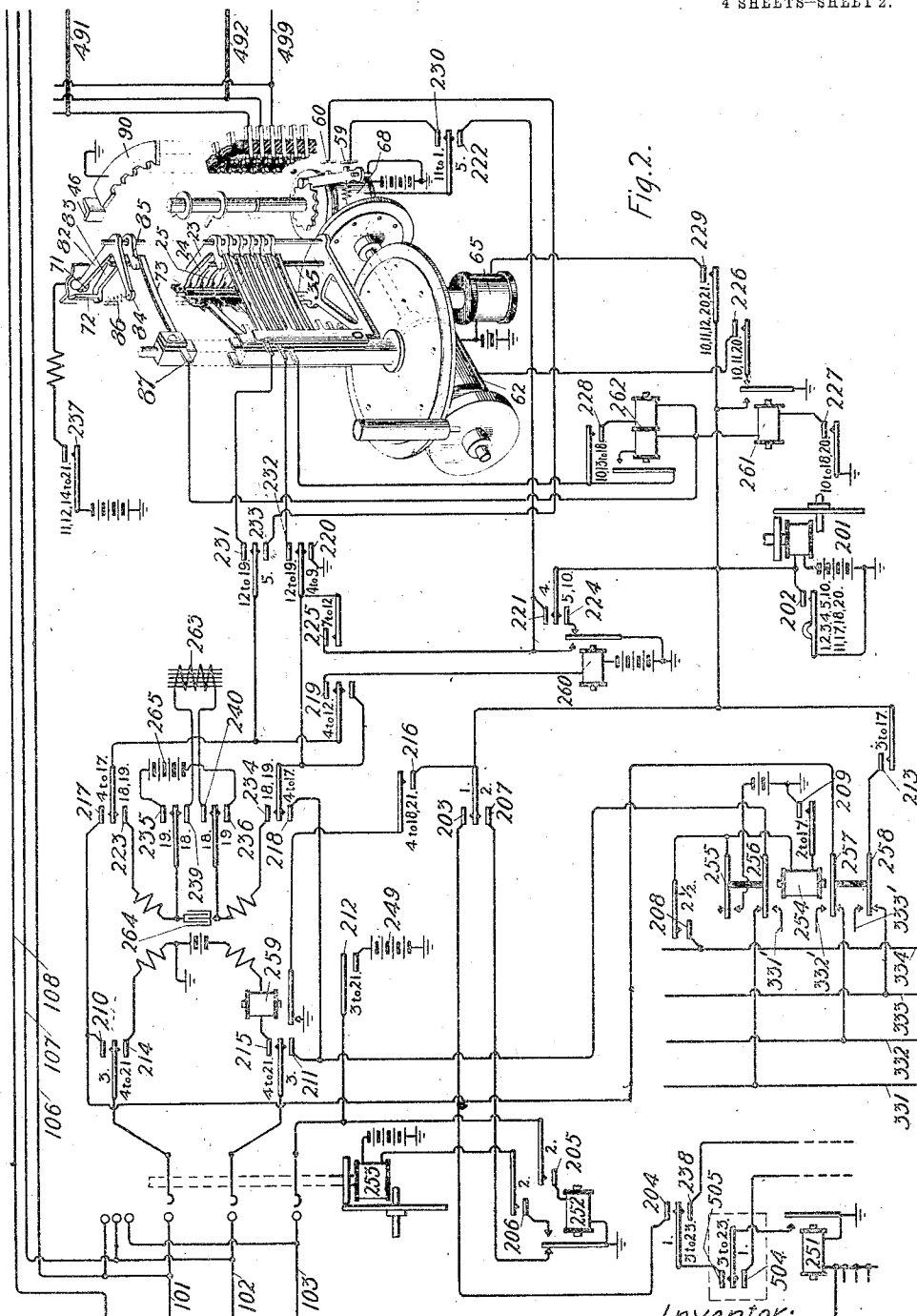
by *A. C. Manner* Atty.

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4 SHEETS—SHEET 2.



Witnesses:

J. F. Woodward
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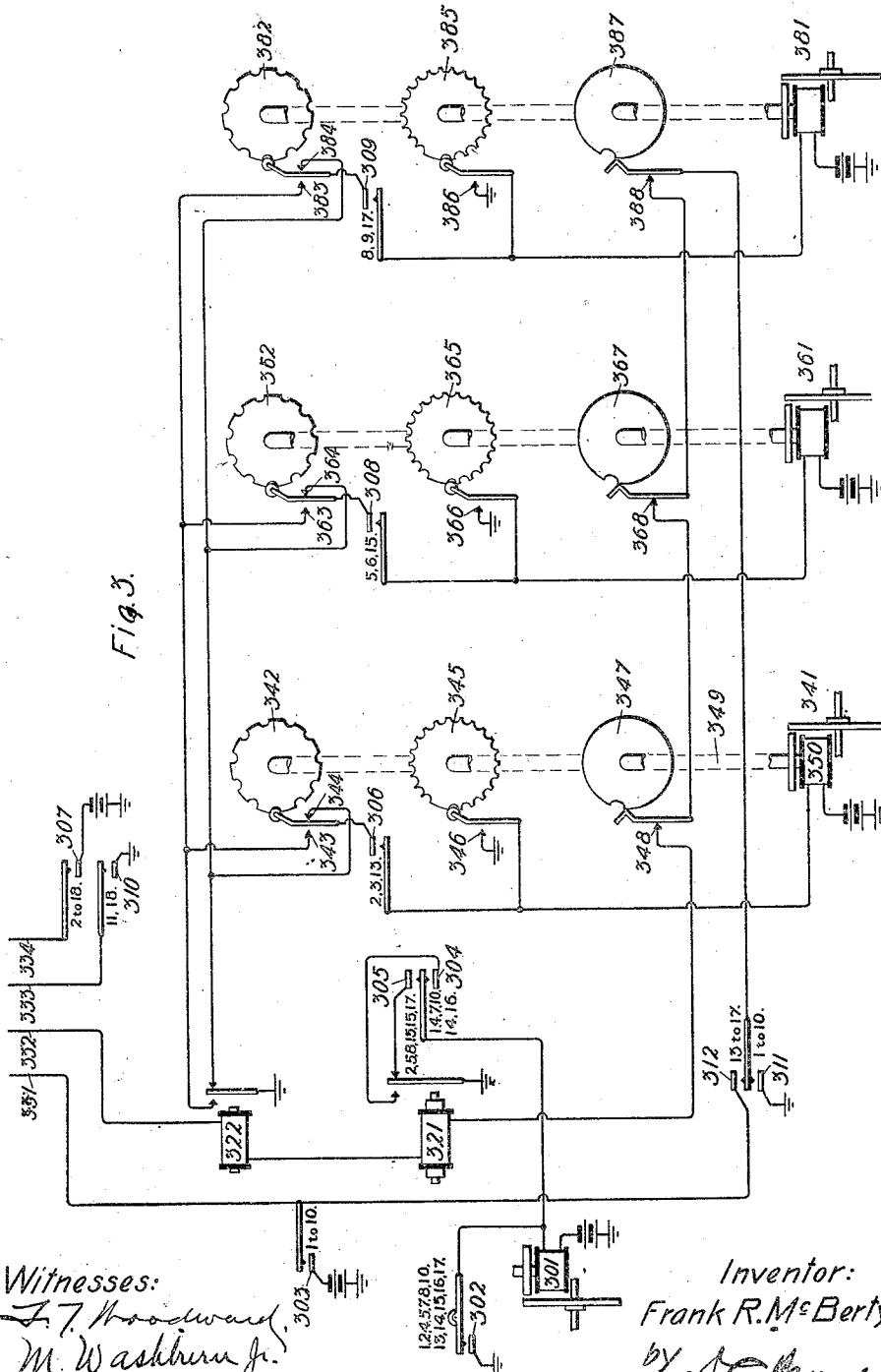
Frank R. McBerty.
by *Stannett*, Atty.

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4 SHEETS-SHEET 3.



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4 SHEETS—SHEET 4.

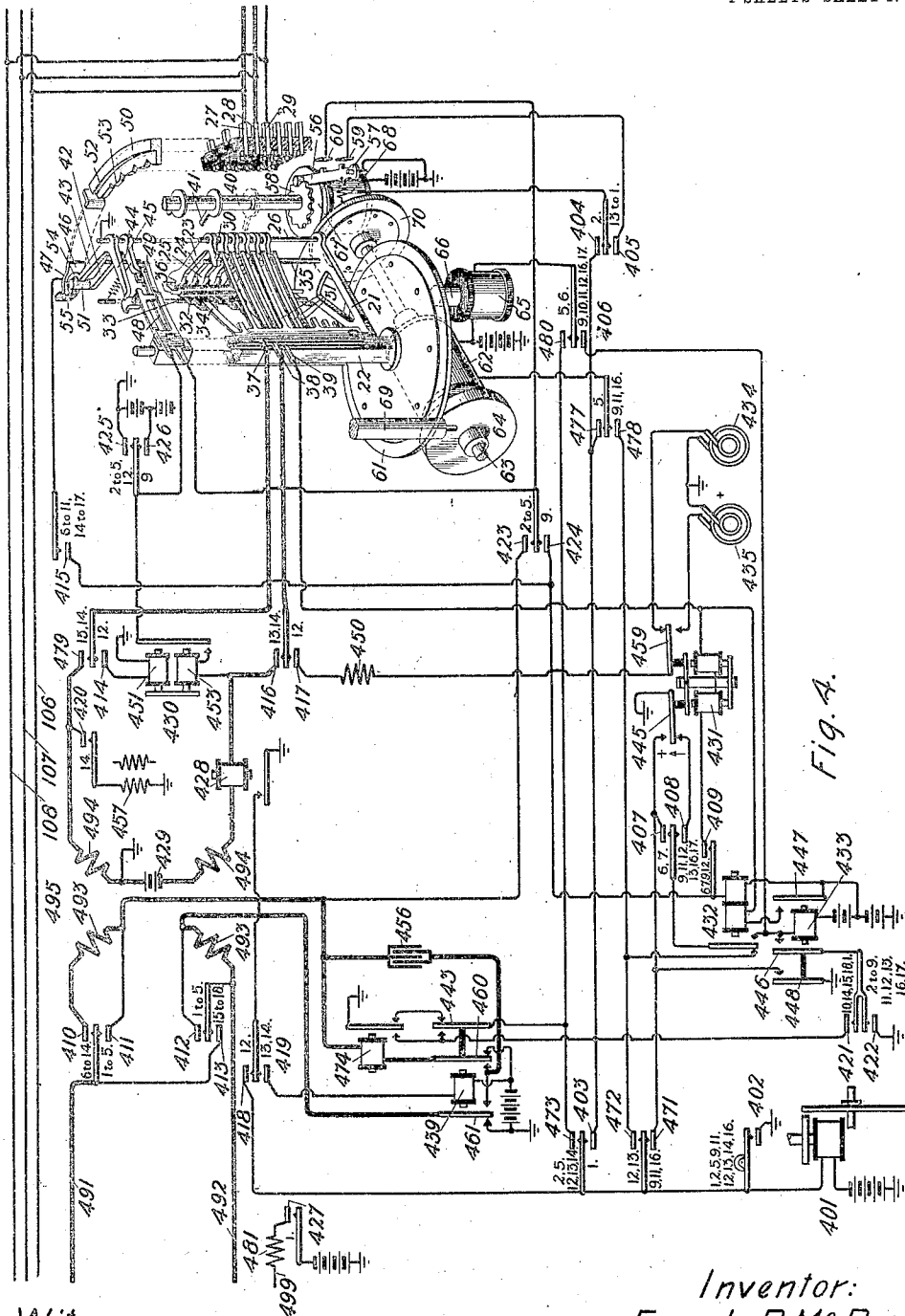


Fig. 4.

Witnesses:

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by *L. C. Bennett, Atty.*

UNITED STATES PATENT OFFICE.

FRANK R. McBERTY, OF NEW ROCHELLE, NEW YORK, ASSIGNOR TO WESTERN ELECTRIC COMPANY, OF NEW YORK, N. Y., A CORPORATION OF ILLINOIS.

TELEPHONE-EXCHANGE SYSTEM.

1,109,686.

Specification of Letters Patent.

Patented Sept. 8, 1914.

Application filed November 10, 1910. Serial No. 591,530.

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 Telephone-Exchange Systems, of which the following is a full, clear, concise, and exact description.

My invention relates to telephone exchange systems and contemplates in general an improved organization and arrangement of circuits and apparatus whereby the inter-connection of telephone lines and trunk lines may be controlled and accomplished speedily and with precision.

The object of my invention is to provide in a system involving mechanical switching apparatus, a controlling organization by which such mechanical switching apparatus may be governed in its operation to establish the desired connection, which controlling organization is in turn governed or set by distant so-called sender apparatus according to the designation of the desired line.

A further object of my invention is to provide a system in which a secondary controlling organization may be adjusted or set in controlling condition by impulses transmitted over long or short lines by a primary controller, and whereby such secondary controller may be automatically and quickly associated with the line or apparatus associated with the primary controller taken for use.

A further object of my invention is to provide in a system involving mechanical switching apparatus adapted to operate and be controlled according to what is known as the reverive impulse system of control, a secondary controlling organization adapted to be set by impulses received therein from a primary controller operated from a calling line, and having been so set to cooperate with such mechanical switching apparatus to accomplish through said apparatus the connection of the desired line.

More particularly my invention involves a system including automatic switching apparatus, a primary sender mechanism adapted to be manually set according to the designation of the line desired, and to transmit impulses in accordance with such designation, and a secondary controller adapted to

be set or adjusted in response to the receipt of the impulses from such primary controller, and when so set and adjusted to control the operation of the mechanical switching apparatus to produce the desired connection, such secondary controlling apparatus being adapted to be automatically connected to the circuit of the primary controlling apparatus and to be disconnected therefrom upon the completion of the desired connection.

My invention is shown as applied to a full automatic telephone exchange system, but it should be understood that while it is particularly adapted to and has been found especially efficient in connection with full automatic systems, my invention is not confined to use in such systems, but may be advantageously used in connection with any or all systems involving mechanical switching apparatus which must be rapidly and accurately controlled. I have furthermore shown my invention in connection with mechanical switching apparatus of a particular form, but it will be apparent that it is not confined to use in connection with switching apparatus of this type, but may be used with any switching apparatus of suitable or convenient structure and arrangement. Furthermore, while the mechanical switching apparatus in connection with which I have shown my invention is controlled according to what is known as the reverive impulse system of control, it must be understood that my invention is not limited to such system of control, but may, if desired, be used in connection with switching apparatus designed to be controlled by impulses received from the controlling apparatus, as will be hereinafter pointed out.

My invention also includes certain details of the construction and organization of the circuits and apparatus involved in my improved controlling system by which the foregoing results and operations, and other results and operations incidental to the proper and expeditious accomplishment of the inter-connection of telephone lines and trunk lines in systems of the character indicated may be best accomplished.

In the drawings, Figures 1, 2, 3 and 4 when placed together form a single diagram illustrating diagrammatically the circuits and apparatus involved in the full automatic exchange system comprising in-part a sys-

tem of control in accordance with my invention; the lines which extend to the edge of each sheet being continued on the neighboring sheet. The proper arrangement of the sheets for viewing the system as a whole is made by placing Fig. 2 to the right of Fig. 1, Fig. 3 immediately below Fig. 2, and Fig. 4 immediately to the right of Fig. 2.

Like parts are referred to by the same reference characters throughout the specification.

Line finders.—A part of the apparatus involved in the preferred form of my invention and as shown in the drawings herein comprises a series of line finders such as the one shown to the left of Fig. 2 on the upper part thereof. These line finders may be of any usual or convenient construction, but each comprises preferably a set of three brushes adapted to be rotated to sweep over any desired and convenient number of sets of line terminals, each such set of line terminals comprising three terminals, that is, two line terminals and a test terminal. The three brushes referred to may be driven in any preferred manner, but on the drawing they are shown as driven by the power magnet 253. This power magnet when energized will cause the rotation of the brushes over the terminals by means of an electromagnetic clutch such as is well known to the art and therefore need not be further described. So long as the power magnet is energized the brushes will move over the sets of terminals of the various lines until they come in contact with the terminals of the desired or calling line when, in a manner to be hereinafter described, the power magnet will be deenergized and the brushes will stop in contact with the terminals of such line. It should be further noted that the test brush as indicated on Fig. 2 is made of elongated form so that it will make contact with the test terminal of one set of terminals before breaking contact with the test terminal of the preceding set of terminals. The line brushes, however, will not bridge from one line terminal to the next. It will be furthermore noted that these line finders when not in use may rest upon the terminals of a line with which they were last operatively connected since in the normal condition of the apparatus associated therewith the various brushes are connected in no way to any electrical potential or ground and therefore cannot in any way affect the line on the terminals of which they are resting.

Sequence switches.—The local controlling circuits associated with the various parts of the exchange system disclosed herein, which local controlling circuits must be established in definite order at successive stages of the operation of such system to bring into service the different devices or parts as they

are required, are in the present embodiment of my invention established by automatic electromechanical switching appliances which are termed sequence switches. As will be noted by reference to the drawing, there is a sequence switch associated with the primary finder apparatus and the first selector, a sequence switch associated with the secondary controller apparatus, and a sequence switch associated with the final selector. Each of these sequence switches consists in its elements of a movable switch operating member, a number of circuit changers or contact devices actuated in sequence as said member is moved from one position to another, an electromagnet and a motor mechanism operated or controlled by said magnet for advancing said movable member through its successive positions.

The sequence switch may control any desired sequence of operation, whether of the same or different devices. In each position to which this movable member is advanced, a circuit is established whereby a given operation of the device or devices under control is made possible, and at the same time another circuit is established whereby the motor mechanism of the sequence switch may be actuated automatically when such operation of the device or devices under control has been completed; so that as each operation takes place the sequence switch will be automatically moved to the next position, in which position a new operation or another stage of the same operation will be brought about and so on. Finally the sequence switch establishes a condition whereby the apparatus under control is returned to its normal condition, and also establishes a circuit whereby the sequence switch will be returned to its normal position. In each such position, the apparatus and its associated sequence switch may be and are preferably so related that local reciprocal controlling circuits will be progressively established by said devices in their operation, in such a manner that when a normal operation of either is started both devices will be progressively carried through a complete cycle of operations which may be controlled and checked at different stages through the agency of energizing circuits established by some other portion of the apparatus for this purpose, but which unless so checked will terminate in the automatic return of both the sequence switch and its associated apparatus to normal condition. In case of a failure of current in such checking or controlling circuit, even immediately after a sequence switch and its associated apparatus have started in operation, such sequence switch and apparatus cannot become permanently displaced or stalled in an off normal condition but will complete their cycle of operations and be positively returned to

normal under control of circuits which are purely local.

In the circuit diagram herein illustrating my invention, the switch springs of the sequence switches are not shown in their actual arrangement, but are so located as to give the clearest arrangement of circuits. Furthermore, the operating cams are not shown. The positions of the rotary element of each sequence switch, in which any of its contacts are closed, are indicated by numbers placed adjacent to such contacts, each contact, except the special contacts which will be hereinafter referred to, being open in all positions except those indicated by the adjacent numbers. For convenience, the sequence switch contacts may be identified with their sequence switch power apparatus, indicated upon the diagrammatic showing, by the fact that the hundreds digit of the reference character applied to each sequence switch contact is the same as the hundreds digit of the reference character applied to the sequence switch of which it forms a part. It will furthermore be observed that the sequence switch contacts on any sheet are all controlled and operated by the sequence switch power apparatus shown upon the same sheet; for example, all sequence switch contacts the hundreds digit of whose reference character is 2, form a part of the sequence switch 201 which is shown upon the same sheet.

Each sequence switch has, however, as has been before noted, a special contact governing the local circuit of its motor magnet. As these special contacts, which are represented by the contacts 202, 302 and 402 on the respective sequence switches 201, 301 and 401, are closed only while the rotary element of the sequence switch is in transit from one stopping position to the next, the numbers are placed on the side of the switch lever opposite from the contact and indicate the positions in which such contact is open, such contact being closed at all times while the rotary element is in transit between the positions indicated by the numbers. The numbers adjacent to these special contacts of the various sequence switches indicate, therefore, the only positions in which their associated sequence switches are arranged to stop. Since, however, sequence switches of the character described are well known to the art, the particular structure and arrangement of the form used and shown in the preferred form of my invention need not be particularly described and any form thereof which may be suitable or convenient may be used.

Selector switches.—In the form of automatic switch shown in Fig. 4, the switch carriage or movable element is provided with a number of sets of multiple 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.

The switch carriage or brush carrying member is of the rotary type, the frame 21 of which is mounted upon a central standard or shaft 22. At the outer end of the frame a number of sets of contact brushes 23, 24, 25 are pivotally mounted upon but insulated from a rod 26, and from each other, in position to sweep over sets of line terminals 27, 28, 29. The brushes have inwardly extending arms 30, bearing against which, one for each brush, are springs 31. Latches 32 one for each set of three brushes, are pivotally mounted upon a rod 36 and arranged to normally hold the brushes from being rocked outwardly into line with the stationary terminals. Bearing against the inner ends of the latches are springs 34 which hold the latches firmly against a stop rod 33. This stop rod 33 serves to prevent the latches from being moved forward too far after the brushes have been released. A stop bar 35 serves to limit the outward movement of the brushes when the latches are withdrawn. The latches 32 and stop bar 35 are of insulating material so that the circuits connected with the brushes will not be crossed thereby. The springs 31 make electrical connection with the brushes; they are of sheet metal and form the teeth of combs which connect corresponding brushes in the several sets in multiple. Suitable wire clip terminals 37, 38 and 39 are provided for the circuit connections to the springs and brushes.

As the brush carriage is rotated to cause the brushes to sweep over the fixed terminals, the latches first pass by a tripping device or brush selector, by which any desired set of brushes may be released and caused to swing outwardly. This tripping device comprises a shaft 40 provided with radially extending fingers 41 arranged spirally about the surface of the shaft. This shaft is adapted by mechanism, to be presently described, to be rotated so as to bring the fingers one after another into the line of travel of the several latches on the brush carriage. Only one set of brushes is intended to be released in a given operation. The shaft is first rotated to bring a particular finger into position to engage the latch in the same level therewith and then the brush carriage is rotated. In passing, the outward edge of this latch strikes the end of the finger, allowing one set of three brushes to be released. Continued movement of the brush carriage brings the selected set of brushes into engagement with the rows of stationary terminals in the same level therewith, these brushes trailing over the terminals and making contact therewith in passing. The

brush carriage is finally caused to stop with the selected brushes in contact with some one set of stationary terminals. The other brushes not being released, are held out of contact with the terminals over which they pass. A further movement of the brush carriage in the same direction of rotation will carry the brushes over a restoring roller 69, which may be pivoted to the frame and which engages the free ends of the released set, causing them to be pushed back into their normal latched position. After making a full revolution, the brush carriage is brought to rest in its normal position again.

The brush selector and the brush carriage of this switch mechanism are arranged to be moved one following the other by suitable motor mechanisms which will impart to each a continuous movement. In order that the successive positions taken by each movable member may be stepped off or measured, each is provided with an interrupter device adapted to make and break a contact in the controlling circuit as the moving member passes the several positions at which it may be desired to cause said member to stop. This interrupter device for the brush carriage comprises a pair of contact springs 48, 49 secured to the shaft 22, but insulated from said shaft and from each other. The outer ends of these springs are engaged by inwardly extending arms 44 and 45 of a pair of levers 42, 43, which are pivotally mounted upon the rod 26. These levers 42 and 43 are insulated from the springs 48 and 49 by small insulating buttons at the ends of the arms 44 and 45, but are uninsulated from the rod 26 which is connected to ground through the frame of the selector mechanism. In the movement of the brush carriage a roller 51 on the free end of the lever 42 engages the teeth 53 of a cam plate 50, the roller engaging each tooth as the brushes are traversing the space between the successive terminals and dropping into the notches between the teeth as the brushes are centrally located in contact with said terminals. While the roller 51 is riding over the teeth of the plate 50 the curved end of the lever 43 is in engagement with the smooth edge 52 of that plate. A relative movement of the levers 42 and 43 is thus obtained by their engagement with the edges of plate 50 and this movement is, therefore, independent of slight variations in the radial distance between the plate and the axis of movement of the brush carriage. By this construction the duration of contact between the interrupter springs 48 and 49 is made uniform in the movement of the brush carriage, each make and each break corresponding to a particular position of the brushes with respect to the terminals.

In the normal position of the switch mechanism, the levers 42 and 43 rest in a

recess 47 of a normal stop plate 46. The entering edge 55 of this plate is covered with insulating material in order to prevent the free ends of the levers 42 and 43 from making electrical contact with the plate 46 before reaching the full normal position in which the ends of the levers drop into the recess 47.

The interrupter for the brush selector comprises an arm 56 pivoted to the frame at 57, engaging at its free end a toothed wheel or cam 58 which rotates with the shaft 40. This arm 56 is adapted in the rotation of the shaft to engage two contacts 59 and 60. These contacts may be springs, the free ends only of which are shown in the drawing. In its normal position the free end of the arm 56 lies in a notch of the cam 58 which is deep enough to insure an open connection with contact 59. When the shaft is away from its normal position, however, connection is made continuously with contact 59. The connection with contact 60 is intermittent, this contact being made when the arm 56 is lifted by each tooth of the cam. There are as many teeth on the cam as there are fingers 41 on the spindle 40 and therefore as many as there are sets of brushes.

The motor mechanism for causing rotation of the brush carriage comprises an annular iron friction disk 61 flexibly mounted at the lower end of the spindle 22, an electromagnet 62 which may be fixed in any suitable manner to the frame, and a constantly rotating shaft 63 carrying an iron driving roller 64. The disk 61, roller 64 and that part of the shaft 63 which extends through the center of the electromagnet 62 form the magnetic circuit of the electromagnet 62. When therefore current is passed through the winding of the magnet, the roller 64 attracts the disk 61 and causes the latter to rotate by frictional contact therewith. A holding electromagnet 65 having a pole piece 66 extending upwardly beneath the disk 61 is adapted when current is passed through its winding to engage the disk and hold it from movement. The power shaft 63 is extended as shown in the drawing to carry a flexibly mounted driving disk 70, which is adapted to engage a roller 67 carried by the spindle 40. An electromagnet 68 controls the engagement of disk 70 and roller 67 in the same manner that the electromagnet 62 controls the engagement of disk 61 and roller 64. These devices are in fact electromagnetic clutches, one to cause movement of the brush carriage and the other to cause movement of the brush selector.

The complete selector switch mechanism is not shown in the drawing, but the elements thereof appear in their proper relation to one another so as to make clear the manner in which the mechanism operates to

interconnect lines. There may be as many sets of brushes and stationary terminals as desired. For example, the switch mechanism may, as a whole, have ten sets of three, 5 brushes each and two hundred sets of fixed terminals arranged in ten levels of twenty sets each. For simplicity in the diagram there are shown only two sets of brushes, the 8th and 9th counting from the top down, 10 and six sets of stationary terminals in two levels corresponding to the two sets of brushes shown.

The selector switch structure shown in Fig. 2 is precisely the same as that shown in 15 Fig. 4 with the exception of the interrupter apparatus shown at the top thereof, the structure and operation of which is as follows:

In the normal position of the brush carriage, as shown in Fig. 2, a pair of levers 20 82, 83 engage at their free ends a normal stop plate 46. At the end of lever 82 is a roller 71 which lies in a recess of plate 46, and at the end of lever 83 is a right angle 25 extension arm 72 which makes electrical contact with said plate 46. A coil spring 86, acting upon an inwardly extending arm 84, serves to press the roller 71 with considerable force against plate 46 and thereby 30 holds the brush carriage securely in its normal position. A flat spring 73 engages an inwardly extending arm 85 of the lever 83 and serves to press this lever outwardly but with less force than that of the coil spring 35 86. The spring 73 also makes electrical contact with lever 83; it is secured to but insulated from the shaft 22 of the brush carriage and terminates in a wire clip 87.

As the brush carriage is moved to carry 40 the brushes over the stationary terminals, the roller 71 and the extension arm 72 engage the teeth of a cam plate 90. The roller 71 rides over the teeth while the brushes are passing between terminals and drops into a 45 notch as any released set of brushes is centrally located in direct contact with a set of terminals. The extension arm 72 follows behind the roller one tooth or notch and likewise engages a tooth as the brushes are 50 passing between successive terminals. It passes through the space between teeth, however, without touching the plate 90, as the released set of brushes is centrally located in contact with the terminals. The 55 stop bar 25 engages the inwardly extending arm 85 just as it does the arms 80 of the brushes and thus prevents the extension arm 72 of the lever 83 from touching the bottom of the notches between the teeth of plate 90, but permitting said arm 72 to touch and 60 make contact with the top of the teeth. The teeth and notches of plate 90 are so spaced and arranged with respect to the contact lever 83 that the extension arm 72 will 65 not break contact with a tooth of plate 90

until after the brushes make contact with the stationary terminals and the roller 71 is ready to drop into a notch. The circuit arrangement, as will presently appear, is such 70 that the motive power for driving the brush carriage cannot be cut off until the contact is thus broken between lever 83 and plate 90 and therefore not until the brushes are in position to make good contact with the stationary terminals. 75

Sender or primary controller.—The sender or primary controller forming a part of the system embodying my invention shown herein and which is located at the subscriber's station upon a calling line may 80 be of any desired structure or arrangement which will perform the desired functions hereinafter to be described. The preferred form, however, which form is well known to the art and will not therefore be described 85 in detail, comprises a series of circuit breaking dials and a master switch. The circuit breaking dials or digit dials, of which there are three shown, are adapted to be manually set by the subscriber to indicate when taken 90 together the designation of the desired line. When such dials have been set a power lever, not shown, will be operated to supply power for operating such digit dials. The first of the digit dials, herein shown as the 95 hundreds dial will then start to rotate and in such rotation will open and close the impulse sending circuit as the contact lever shown in association with such dial rides over the notches on such dial. The number 100 of times that the impulse sending circuit will be opened will depend upon the set position of the dial and the circuit will be opened briefly a varying number of times 105 according to the set position of the dial and then once opened for a comparatively longer period. The dial when it reaches its normal position will then stop. As soon as the 110 hundreds dial has reached its normal position, the tens digit dial will begin to move breaking the circuit briefly for a varying number of times according to the set position of the dial and then breaking the circuit for a comparatively longer period once 115 just before reaching its normal position. As soon as the tens dial comes to rest in its normal position the units dial will operate in a precisely similar manner.

The master switch above referred to may be and is preferably controlled by the power 120 lever which, as is above noted, is operated to furnish power for the operation of the respective digit dials. The first movement of the power lever will operate the master switch in such a manner that it will include 125 the impulse sending circuit which passes through the various contact devices of the digit dials in the line circuit of the associated telephone line. The structure of this switch, however, is so designed that the cir- 130

cuit will be closed through the impulse sending circuit before the line conductor is opened as is plainly indicated upon the drawings.

5 It should be observed that the digit numerals are placed upon the digit dials in such positions that the number of impulses sent over the impulse sending circuit is the complement of such numerals. That is to say, 10 if one of the digit dials is set for the No. 8, two impulses will be sent over the impulse sending circuit, one short and one long. Similarly, if one of the digit dials is set at 15 zero, ten impulses will be sent over the impulse sending circuit, nine of such impulses being short and the last one long. The object of this arrangement will clearly appear in the description of the operation of the system embodying my invention and depends in a word on the fact that the register 20 senders herein shown operate upon what is known as the complementary system of control.

25 In connection with the operation of the subscriber's substation apparatus including his sender or primary controller, the instructions given such subscriber for the proper operation of the system require that he should in making a call first remove his receiver from its switch hook and then proceed to set the sender or primary controller mechanism to the designation of the desired line. Then having set his primary controller, he will operate the power lever above 30 referred to. During the interval between the removal of his receiver from its switch hook and the operation of the power lever, ample time will elapse for the connection to his line of a finder device and of a register-sender or secondary controller hereinafter to be described.

It should be further noted that due to the presence of the master switch, the movement of the digit dials by the subscriber in setting 45 them will not in any way affect the line circuit and no impulses will be sent to the central station during such movement. When, however, the master switch is operated, the digit dials will move one after another and transmit impulses to the central station, as 50 has been hereinbefore referred to and as will be hereinafter more fully described.

Register sender or secondary controller.—

55 The secondary controller shown herein, of which there will be two associated with each group of lines and connecting circuits and whose association with a connecting circuit taken for use will sufficiently appear in the description of the operation of the system embodying my invention, comprises a slow release relay indicated at 321, a stepping relay 322, a sequence switch 301 and three register-senders 341, 361 and 381. Of this apparatus the register-senders need only be 65 described in detail. Each of these register-

senders—the one indicated at 341, for example, which will be hereinafter referred to as the hundreds register-sender, partakes somewhat of the nature of a sequence switch; that is to say, it comprises a shaft 70 349 which, like the shaft of the sequence switch hereinbefore described, is rotated when the register sender magnet 350 is energized. On this shaft are located the three switching operating disks 342, 345 and 347. 75

Considering first the switch operating disk 345 it will be observed that the periphery of this disk is divided into twenty-two parts. Each of twenty-one of these parts is recessed in such a manner that the contact arm of the switch 346, when it rests in such 80 recesses, will not make contact with its back contact, but when passing from one recess to the next will so ride upon the periphery of the disk that it will make contact with 85 such back contact. The one remaining portion of the periphery of this disk which is not recessed is, as shown, immediately adjacent to the recess in which the contact arm 346 is designed to rest when the register-sender 90 is in its normal position. The contact arm 346 associated with this disk 345 is similar in its operation to the special contacts 202, 302 and 402 heretofore referred to and well known to the art, such contact arm 95 being so connected to the operating magnet 350 of the hundreds register-sender that when the shaft 349 is moved out of a position in which the contact arm 346 rests in a recess, its movement will continue until the 100 contact arm 346 again rests in a recess of the disk 345.

The disk 342 of the hundreds register-sender is provided with eleven recesses similar to those on the disk 345 and located with 105 relation to the shaft correspondingly with the alternate recesses upon the disk 345. A contact arm operating contacts 343 and 344 is adapted to ride over the periphery of this disk and when resting in one of the recesses 110 thereon to close the contacts 344 and when resting upon the periphery of such disk between two of the recesses thereon to close the contact 343.

The third disk 347 of the hundreds register is provided with but one recess which 115 is elongated and is located with relation to the shaft 349 to correspond with the unrecessed portions of the disk 345. This disk also has a contact arm coöperating therewith and adapted to ride over its periphery, such contact arm maintaining the contacts 348 closed except when it rests in the elongated recess above referred to.

The hundreds register is adapted to stand 125 normally in the position in which it is shown in Fig. 3 and will be moved from such position and restored to its normal position in the manner which will be hereinafter described in the description of the operation 130

of the system embodying my invention. The tens register sender and the units register sender are of precisely similar form to the hundreds register sender just described.

3 *General description and operation.*—In describing the operation of the system embodying my invention, we will assume that the calling subscriber desires connection with a line of the exchange the designation
10 of which is, for example, 629. To accomplish this connection the subscriber first removes his receiver from its switch hook, which act closes a circuit from the battery
15 149 through the armature 111 and its back contact of the multiple cutoff relay 112, armature 113 and its back contact of the cutoff relay 114, line conductor 101, the now
20 closed switch hook 115 of the subscriber's apparatus 116, line conductor 102, master switch 171, line conductor 102, back contact and armature 117 of the cutoff relay 114, back contact and armature 118 of the multiple
25 cutoff relay 112, line relay 119 to ground and back to battery. The closure of this circuit energizes the line relay 119 which attracts its armature and closes a circuit from the battery 149 at its middle or neutral
30 point, through the cutoff relay 114, front contact and armature of the line relay 119, starting relay 251 to ground and back to battery. Current from battery 149 alone, through relays 114 and 251 in series, is insufficient to energize relay 114. It is only
35 when current from battery 249, in Fig. 2, is added to the current from battery 149, that relay 114 will be energized, as will be hereinafter described. The closure of this circuit energizes the starting relay 251, which
40 controls the primary selector sequence switch starting circuit and is common to the lines of the group of lines of which the calling line is one. The energization of this starting relay closes a circuit from battery
45 through the primary sequence switch 201, sequence switch contact 203, sequence switch contact 204, sequence switch contact 505 of the first connecting circuit and primary selector common to this group, which at this time is assumed to be busy, front contact
50 and armature of the starting relay 251 to ground and back to battery.

Before describing the operation of the primary sequence switch shown in response to the closure of the circuit just traced, attention is directed to the arrangement of
55 this circuit whereby the first idle connecting circuit and its associated selector apparatus will be picked up and operated upon the closure of the starting relay 251. This circuit normally is closed to the first primary
60 sequence switch through the sequence switch contact 504 of such sequence switch. When, however, this sequence switch moves from its idle position it opens the sequence switch
65 contact 504 and closes in its third position

the sequence switch contact 505 so that the starting circuit is extended to the second primary sequence switch so long as it is idle, through the sequence switch contact 505 of the first primary sequence switch, and the
70 sequence switch contact 204 of the second primary sequence switch. When now the second primary sequence switch reaches its third position in its operation, it has opened the sequence switch contact 204 and has
75 closed the starting circuit to the third primary sequence switch and its associated apparatus through the sequence switch contact 238. In this way the first idle primary sequence switch will be picked up upon the
80 energization of the starting relay 251. It will be furthermore observed in this connection that in the operation of the exchange each primary sequence switch when once
85 started will rapidly pass to its third position and no appreciable delay can occur owing to the circuit being open in the second position of any primary sequence switch.

The primary sequence switch 201 having been energized by the starting circuit, as
90 traced, moves into its second position, in this position closing a circuit for the finder control relay 252 so long as the brushes of the finder rest upon the terminals of an idle or non-calling line, which circuit may be traced
95 from battery 149 at its middle or neutral point through the cutoff relay 114, test conductor 103, test brush of the finder, sequence switch contact 205, finder control relay 252 to ground and back to battery. It should
100 be explained at this time that current through the circuit traced will energize the finder control relay 252 only so long as there is no shunt to ground upon such circuit. It should be further noted that the
105 current through the circuit traced will not energize the cutoff relay 114. When, however, the test brush rests upon the test conductor 103 to which there is already connected a circuit to ground through the armature and front contact of a line relay 119,
110 insufficient current will pass through this finder control relay 252 and such relay will be deenergized.

As will be hereinafter pointed out, the
115 finder control relay will find full battery potential for its energization on the test terminal of every line whether idle or busy, except calling lines. Upon the energization of the finder control relay 252 it attracts its
120 armature and closes a circuit from battery through the finder power magnet 253, sequence switch contact 206, front contact and armature of the finder control relay 252 to ground and back to battery. The energization of the finder power magnet 253
125 will cause the various brushes of the finder to rotate to make contact with the sets of terminals of the various lines terminating in this particular finder. It will be recalled
130

that the test brush is of such form that it makes contact with the test terminal of one set of terminals before breaking contact with the preceding test terminal, and therefore the circuit of the finder control relay will be maintained and the power magnet therefor energized so long as the finder brushes are in contact with the terminals of idle or non-calling lines. When, however, the finder brushes come in contact with the terminals of a line, the line relay 119 of which is energized, insufficient current will pass through the finder control relay to maintain it energized and such relay will retract its armature opening the circuit of the power magnet 253, thereby stopping the finder brushes in contact with the terminals of the calling line and also closing a circuit for the primary sequence switch through the sequence switch contact 207 and the back contact and armature of such relay 252. The primary sequence switch now moves into its third position.

While the primary sequence switch was passing from its second to its third position it caused a momentary closure of the sequence switch contact 208, this closure being indicated upon the drawings by the characters "2₃" adjacent the said contact. The closure of this sequence switch contact was for the purpose of testing the busy or idle condition of the first register-sender or secondary controller associated with the group of connecting circuits of which the circuit shown is one. For the time being we will assume that the first secondary controller so tested was idle and that therefore no change took place due to the closure of this sequence switch 208. As soon as the primary sequence switch reaches its third position it closes the sequence switch contacts 210 and 211 to prepare the impulse circuit for the receipt of the sending impulses from the subscriber's substation. This circuit will be traced hereinafter. As soon as the primary sequence switch reaches its third position it also closes the sequence switch contact 212, which places a battery potential upon the test conductor of the line with which the finder brushes are now in contact which will make such test conductor of sufficiently high potential to maintain energized the finder control relay 252 of any other finders which should pass over the terminals of this line. This will make the line test non-calling. The closure of the sequence switch contact 212 has furthermore placed sufficient battery in circuit to energize the cutoff relay 114, it being observed that in the circuit of this cutoff relay the batteries 149 and 249 are of the same polarity. The cutoff relay 114 will therefore pull up immediately that the primary sequence switch reaches its third position, and will by the attraction of its armatures 113

and 117 open the circuit of the line relay 119 which in turn will by the retraction of its armature open the circuit of the starting relay 251. The energization of the cutoff relay 114 has furthermore, by the attraction of its armature 120, closed a circuit for the cutoff relay 112 which will make this line test busy at all of the final selectors in which it appears, as will be hereinafter explained.

The impulse circuit over which the impulses from the primary controller or sender at the subscriber's station will be received and which is now established may be traced as follows:—From battery through the secondary controller sequence switch contact 303, conductor 331, armature 256 of the relay 254, primary sequence switch contact 211, conductor 102, master switch 171, which is as yet unoperated, conductor 102, receiver switch hook 115, conductor 101, sequence switch contact 210, armature 257 of the relay 254, conductor 332, stepping relay 322, slow release switching relay 321, contacts 348, 368 and 388, which are closed in the normal position of the register-senders, sequence switch contact 311 to ground and back to battery. The closure of this circuit will energize the stepping relay 322 and the slow release relay 321. This energization of the stepping relay 322 is without effect at this time, but the slow release relay 321 by the attraction of its armature has closed a circuit for the secondary controller sequence switch 301 from battery through such sequence switch, sequence switch contact 304, front contact and armature of the slow release relay 321 to ground and back to battery. The secondary controller sequence switch now moves into its second position closing the sequence switch contact 307 to place a busy guard upon this secondary controller and also closing the sequence switch contacts 305 and 306 to prepare the secondary controller for the receipt of the impulses from the subscriber's station.

When now the subscriber by the operation of the power lever referred to starts the movement of the various digits dials 172, 174 and 176, the master switch 171 is operated so that instead of the two portions of the conductor 102 being directly connected together, there are inserted in the circuit of this conductor the three switches 173, 175 and 177. Before the operation of the switch 171 the subscriber has set the various digits dials to indicate the designation of the desired line, in the case assumed, 629, that is to say, the end of the movable portion of the switch 173 is resting between the teeth on that portion of the digits dial 172 indicated at 6, the end of the movable portion of the switch 175 is resting between the teeth on that portion of the digits dial 174 indicated at 2, and the end of the movable portion of the switch 177 is resting be-

tween the teeth on that portion of the digits dial 176 indicated at 9. When therefore upon the operation of the power lever and the master switch 171 the hundreds digits dial 172 begins to move, it will first interrupt its impulse circuit briefly, three times and then interrupt it once for a comparatively longer time.

When the switch 173 is first operated by the movement of the hundreds digits dial 172 to open the circuit, the stepping relay 322 is immediately deenergized and closes a circuit from battery through the power magnet 350 of the hundreds register-sender 341, sequence switch contact 306, contacts 344, back contact and armature of the stepping relay 322 to ground and back to battery. The hundreds register-sender now moves the disks 342, 345 and 347 in a clockwise direction until the movable portion of the contacts 346 rest in the second recess upon the disk 345. It will be noted that immediately the hundreds register-sender began to move the contacts 344 were opened and the contacts 343 were closed, the movement of the register-sender into the proper position being accomplished by the closure of the switch 346. Before the slow release relay 321 can retract its armature, the contacts 173 are again closed by the movement of the hundreds digits dial 172 and the stepping relay 322 is again energized. This causes a renewed energization of the power magnet of the hundreds register-sender 341, this time through the contacts 343 which are now closed. The hundreds register-sender thereupon moves a second step opening the contacts 343 and closing the contacts 344 and coming to rest with the movable portion of the switch 346 in the third recess upon the disk 345. The continued movement of the hundreds digits dial 172 again opens and closes after a brief interval the impulse circuit, and in the manner just described the hundreds register-sender is moved until the movable portion of the switch 346 is in the fifth recess upon the disk 345. The third brief opening of the switch 173 due to the continued movement of the hundreds digits dial 172 in a precisely similar manner brings the hundreds register-sender into a position where the movable portion of the switch 346 rests in the seventh recess of the disk 345. The continued movement of the hundreds digits dial now opens the switch 173 for a comparatively longer period. Upon the opening of the switch 173 the stepping relay 322 is deenergized, and as before moves the hundreds register-sender one step so that the contacts 344 are opened and the contacts 343 are closed and the movable portion of the switch 346 rests in the eighth recess of the disk 345. At this time, however, the prolonged opening of the circuit which, it may be noted,

is only long in the sense that it is longer than the openings heretofore described, causes the release of the slow release switching relay 321 which retracts its armature and closes a circuit for the secondary controller sequence switch 301 through the sequence switch contact 305 and the back contact and armature of the slow release relay. This starts the secondary controller sequence switch in motion which now, under the control of its special contact 302, moves until it reaches its fourth position. It should be noted, however, that the sequence switch contact 306 is maintained closed in the third position of the secondary controller sequence switch, and the time relation between the movement of the hundreds digits dial 172, the slow release relay 321 and the sequence switch contact 301 is such that the impulse sending circuit will be closed again after the long opening thereof before the secondary controller sequence switch has passed through its third position, the stepping relay 322 being thereby energized and moving the hundreds register-sender another step by a circuit through the contacts 343 so that the movable portion of the switch 346 now rests in the ninth recess upon the disk 345. The sequence switch on coming into its fourth position will now find a circuit for itself closed through the front contact and armature of the slow release relay 321 and the sequence switch contact 304 and will therefore continue to move until it reaches its fifth position, having opened the sequence switch contact 306 on leaving the third position and closing the sequence switch contact 308 on reaching the fifth position.

The hundreds digits dial having completed its movement, the tens digits dial will now begin to move. This dial in its movement will open the circuit briefly seven times as is quite apparent and then once for a comparatively longer period. These openings and closures of tens digits dial will drive the tens register-sender 361 sixteen steps and bring this register-sender to rest with the movable portion of the switch 366 in the seventeenth recess upon the disk 365. It will be observed that the control of this tens register-sender is alternately shifted to the front and back contact of the stepping relay 322 by the contacts 363 and 364 in a manner precisely similar to the way in which the control of the hundreds register-sender was shifted by the contacts 343 and 344. Upon the eighth opening of the impulse circuit by the tens digits dial 174, which opening it will be remembered is for a comparatively longer period, the slow release switching relay 321 is deenergized and a circuit established through its back contact and the sequence switch contact 305 for the secondary controller sequence switch 301 to drive such

sequence switch under the control of its special contact 302 into its seventh position, it being again observed that the closure of the impulse circuit at the end of the longer tooth of the tens digits dial 174 will occur before the secondary controller sequence switch has left its sixth position, completing by the energization of the stepping relay the setting movement of the tens register-sender. Upon this closure of the impulse circuit, after all of the circuit interruptions due to the movement of the tens digits dial 174 have been completed, the slow release switching relay 321 will be again energized and close at its front contact a circuit for the secondary controller sequence switch 301, through the sequence switch contact 304, thereby driving the secondary controller sequence switch into its eighth position. The units digits dial 176 will now commence to move, but since it is set for the digit 9 it will open the impulse circuit but once, and this for a comparatively long period. This will cause the units register-sender 381 to move two steps and bring this register-sender to rest with the movable portion of the switch 386 in the third recess upon the disk 385. It will be observed from this case also that the control of this units register sender has been shifted from the back to the front contact of the stepping relay 322 as required by the contacts 383 and 384, and that furthermore owing to the fact that the sequence switch contact 309 is maintained closed in the ninth position, the closure of the impulse sending circuit after the comparatively long opening thereof, will occur to complete the movement of the units register-sender before the sequence switch contact 309 is opened. During this longer opening by the units digits dial 176 the slow release switching relay 321 has, of course, been deenergized and a circuit closed through its back contact and the sequence switch contact 305 for the secondary controller sequence switch 301, driving it into its tenth position. Upon reaching the tenth position, the impulse circuit having been closed, the secondary controller sequence switch will find a circuit for itself closed through the front contact of the slow release relay 321 and the sequence switch contact 304, which will drive the sequence switch out of its tenth position and it will continue to move under the influence of its special contact 302 until it reaches its thirteenth position. The impulse sending operations are now complete and the designation of the desired line is, in effect, stored up in the various register senders 341, 361 and 381. As the secondary controller sequence switch leaves its tenth position it opens the sequence switch contacts 303 and 311, removing battery and ground from the impulse circuit. As this sequence switch passes through its eleventh position it momentarily closes the

sequence switch contact 310 which closes a circuit for the primary sequence switch 201, from battery through such sequence switch, sequence switch contact 213, armature 258 of the relay 254, conductor 333, secondary controller sequence switch contact 310 to ground and back to battery. The establishment of this circuit causes the movement of the primary sequence switch from its third into its fourth position. This movement of the primary sequence switch opens the sequence switch contacts 210 and 211, destroying the original impulse circuit and closes the sequence switch contacts 214 and 215, completing thereby the talking circuit of the calling line. Furthermore, on coming into its fourth position the primary sequence switch closes the sequence switch contact 216, which will be hereinafter referred to, preparing the disconnect control circuit which is under the control of the supervisory relay 259 now included in the calling line, and which is at this time energized due to the fact that the subscriber's receiver has been moved from its switch hook. The movement of the primary sequence switch into its fourth position has also closed the sequence switch contacts 217, 218, 219, 220 and 221. When now the secondary controller sequence switch 301 comes into its thirteenth position and closes the sequence switch contact 312 the hundreds selection controlling circuit is now established, which circuit may be traced from battery through the primary selector line relay 260, sequence switch contact 219, sequence switch contact 217, armature 257 of the line relay 254, conductor 332, stepping relay 322, slow release switching relay 321, switch 348, switch 368, switch 388, sequence switch contact 312, conductor 331, armature 256 of relay 254, sequence switch contact 218, sequence switch contact 220 to ground and back to battery. The closure of this circuit energizes the line relay 260, the stepping relay 322 and the slow release switching relay 321, which all therefore attract their armatures. It will be observed at this time that owing to the fact that the secondary controller sequence switch runs idly through its twelfth position, the primary sequence switch 201 will be in its fourth position before the secondary controller sequence switch reaches its thirteenth position, and therefore immediately upon the secondary controller sequence switch coming into its thirteenth position the slow release relay 321 and the stepping relay 322 will be energized through their back contacts and the sequence switch contacts 305 and 306 respectively will not be closed at this time.

Referring now to the primary selector apparatus the energization of the line relay 260 has closed the circuit for the primary sequence switch 201 through the sequence switch contact 221 and the front contact

and armature of such line relay 260. This causes the primary sequence switch to move to its fifth position, in which position it closes the sequence switch contacts 222 and 233. A circuit is now closed from battery 5 through the brush selector rotary magnet 68, sequence switch contact 222, front contact and armature of the line relay 260 to ground and back to battery. Due to the energization of this brush selector rotary magnet 68, the latch-selecting spindle will move out of its normal position, first closing the off-normal contacts 59 and then closing the interrupter contacts 60 as it moves from its normal position into the position in which it will select and unlatch the first set of selector brushes. When these interrupter contacts 60 are closed, a shunt will be placed on the selection controlling circuit at the sequence switch contact 233 which will cause the deenergization of the stepping relay 322, but will maintain the line relay 260 energized. It will be furthermore observed that the closure of the interrupter contacts 25 60 and the consequent shunting of that portion of the hundreds selection controlling circuit including the stepping relay 322 and the slow release relay 321 while the latch-selecting spindle is moved from one position to the next, will not be sufficiently long to cause the deenergization of the slow release relay 321. However, the stepping relay 322 upon its deenergization has closed a circuit through its back contact, the contacts 344 and the sequence switch contact 306 for the power magnet of the hundreds register-sender, which will thereupon move one step, opening the contacts 344 and closing the contacts 343 and coming to rest with the movable portion of the switch 346 in the tenth recess on the disk 345. When, as the latch-selecting spindle reaches the position in which it will select the first set of selector brushes, the shunt on the hundreds selection controlling circuit is again opened, the stepping relay 322 will be again energized and close through its front contact, the contacts 343 and the sequence switch contact 306, a circuit for the power magnet of the hundreds register-sender 341. This register-sender thereupon moves another step, opening the contacts 343, closing the contacts 344 and coming to rest with the movable portion of the switch 346 in the eleventh recess upon the disk 345. For each subsequent closure of the contacts 60 by the rotation of the latch-selecting spindle, therefore, the stepping relay 322 will be briefly deenergized, moving the hundreds register-sender a step in a clockwise direction upon its deenergization and another step upon its energization. This will continue until upon the seventh closure of the shunting contacts 60 the hundreds register-sender in moving raises the movable portion of the switch 346 out of the twenty-first or last recess on the disk 345 when the register-sender, due to the closure of the switch 346, will continue to move uninterruptedly into its normal position. While this register sender is moving to its normal position, the movable portion of the switch 348 will move along the elongated recess on the disk 347, thereby opening the switch 348. When, therefore, the ground is removed from the selection controlling circuit by the opening of the shunting contacts 60, the line relay 260 will be deenergized, the shunt being removed and the selection controlling circuit being open at the switch 348. This deenergization of the line relay 260 will close a circuit for the primary sequence switch through the sequence switch contact 224 and the back contact and armature of the line relay 260 and drive the primary sequence switch into its tenth position. 70 75 80 85

Before describing the subsequent operation of the selector apparatus, it should be observed that the opening of the selection controlling circuit by the switch 348 has been of sufficient duration to cause the deenergization of the slow release switching relay 321, which thereupon retracted its armature and by a circuit established through its back contact and the sequence switch contact 304 drives the secondary controller sequence switch into its fourteenth position. When the switch 348 is again closed, as the hundreds register sender reaches its normal position, the hundreds selection controlling circuit is again closed, energizing the line relay 260, the stepping relay 322 and the slow release relay 321, which thereupon are energized and attract their armature. The energization of the stepping relay 322 is without effect at this time and the energization of the line relay 260 is without effect at this time except to prevent the closure of a circuit for the primary sequence switch through its back contact when such sequence switch reaches its tenth position. However, the energization of the slow release relay 321 has closed a circuit for the secondary controller sequence switch 301 through its front contact and the sequence switch contact 304 which drives such sequence switch into its fifteenth position and the register-sender is now ready to control tens selection. The hundreds selection controlling circuit, however, is maintained, first through the sequence switch contact 220 and then through the sequence switch contact 225 and the front contact and armature of the line relay 260, until the trunk hunting operation of the primary selector has been completed and the circuit has been extended to an idle final selector, no change being effected during this time in the secondary controller apparatus. 90 95 100 105 110 115 120 125

When the primary sequence switch reaches 130

its tenth position, a circuit is closed from battery through the carriage rotary magnet 62, sequence switch contact 226, back contact and armature of the test relay 261 to ground and back to battery. The brush carriage will now move, in the first portion of its movement passing the brush latches by the latch-selecting spindle which, by its projecting finger, will cause the latch of the selected set of brushes to move and release this set of brushes, so that they may come into cooperative contact with the sets of terminals of their cooperating bank of terminals in the selector. In the further movement of the brush carriage, the released brushes will make contact with the first set of terminals of their cooperating bank of terminals. If at this time the final selector connected to this set of terminals is idle, the final sequence switch contact 427 will be closed and the test relays 261 and 262 will be energized over a circuit from battery through the sequence switch contact 427, resistance 481, conductor 499, the test brush 25 of the selected set of brushes, sequence switch contact 228, right winding of the test relay 262, test relay 261, sequence switch contact 227 to ground and back to battery. It will be noted, however, that if some other selector has just previously made contact with the terminals upon the test terminal of this selector at all of the other primary selectors in which it appears, it will prevent the energization of the test relays 262 and 261 of subsequent primary selectors which may later make contact with the terminals associated with this particular final selector. Of course if the selector associated with this first set of terminals is in use, that is, its sequence switch is out of its first position, there will be no battery upon this test terminal and consequently there can be no energization of the test relays 262 and 261 at this time. If, therefore, this test terminal tests busy, the relays 262 and 261 will remain unenergized and the brush carriage will continue to move to bring the selected brushes into contact with the next set of terminals of their cooperating bank of terminals. The movement of the switch carriage will therefore continue until the test brush of the selected set comes into contact with a test terminal to which the full potential battery is connected, indicating that the final selector to which it is individual is idle. As soon as the test brush 25, therefore, comes in contact with such a test terminal, the circuit will be closed as heretofore traced to energize the test relay 262, which thereupon attracts its armature and closes a low resistance circuit through its left winding to place the test condition heretofore referred to upon the test terminal with which the test brush is now connected. The test relay 261, however, will not be energized until, when the selected brushes are centrally located

upon the terminals of the selected final selector, the extension 72 on the arm 43 is no longer in contact with the ground plate 50. The ground shunt around the test relay 261 will then be removed and such relay will be energized, attracting its armature and immediately opening the circuit of the carriage rotary magnet 62 at its back contact. This movement of the armature of the test relay 261 has also closed at its front contact a circuit for the holding magnet 65 through the sequence switch contact 229 and a circuit for the primary sequence switch 201 which will drive this sequence switch into its seventeenth position, the test relay 261 being maintained energized through the locked armature of the test relay 262 while the primary sequence switch is passing through its eleventh position.

As the primary sequence switch reaches its eleventh position it closes a restoring circuit for the latch-selecting rotary magnet 68 through the sequence switch contact 230, and the spindle will thereupon be moved again into its normal position, stopping in such position on account of the opening of the off-normal contacts 59. As the sequence switch came into its twelfth position the sequence switch contacts 231 and 232 were closed and on leaving its twelfth position the sequence switch contacts 219 and 225 were opened. It may be noted at this point that the sequence switch contact 220 was opened when the primary sequence switch left its ninth position. A circuit is now closed and was closed before the hundreds selection controlling circuit was opened from battery through the armature 460 and its back contact of the battery control relay 439, through the final line relay 474, final sequence switch contact 411, line conductor 491, selector brush 23, primary sequence switch contact 231, sequence switch contact 217, armature 257 of the relay 254, conductor 332, stepping relay 322, slow release switching relay 321, switch 348, switch 368, switch 388, secondary controller sequence switch contact 312, conductor 331, armature 256 of the relay 254, primary sequence switch contact 218, sequence switch contact 232, selector brush 24, line conductor 492, final sequence switch contact 412, armature 461 and its back contact of the battery control relay 439 to ground and back to battery. This is the tens selection controlling circuit. Upon the establishment of this tens selection controlling circuit the slow release relay 321 and the stepping relay 322 will remain energized and the final line relay 474 will be energized to attract its armature. Circuit will thereupon be established from battery through the final sequence switch 401, sequence switch contact 403, front contact and armature of the final line relay 474 to ground and back to battery. The final sequence switch

now moves into its second position, opening the sequence switch contacts 403 and 427.

In this second position of the final sequence switch a circuit is established from battery

5 through the latch-selecting rotary magnet 68, sequence switch contact 404, front contact and armature of the line relay 474 to ground and back to battery, and the latch-selecting spindle will begin to rotate, closing
10 its off-normal contacts 59 and intermittently closing the contacts 60. When the contacts 60 are closed by the movement of the latch-selecting spindle a shunt is placed upon the tens selection controlling circuit from
15 ground through such contacts 60 and the sequence switch contact 423 which will cut off battery from that portion of the tens selection controlling circuit including the stepping relay 322 and the slow release relay
20 321, but will maintain the final line relay 474 energized. The stepping relay 322 will thereupon retract its armature and since the secondary controller sequence switch 301 is in its fifteenth position and the sequence
25 switch contact 308 is closed, close a circuit through the contacts 364 to the power magnet of the tens register-sender to step such register sender one step in a clockwise direction, opening the contacts 364 and closing
30 the contacts 363. As has been before noted in connection with the description of the operation of the primary selector, the shunting of the relays at the register-sender apparatus by the closure of the ground connection
35 including the contacts 60 will not be of sufficiently long duration to deenergize the slow release relay 321, and when the latch-selecting spindle has brought its first finger 41 into latch-operating position the shunt
40 will be again opened and the stepping relay 322 again energized. The stepping relay 322 will thereupon retract its armature and cause a second step of the tens register-sender in a clockwise direction over a circuit
45 including the contacts 363. It will be recalled that in setting the tens register-sender this register-sender was driven eight steps due to the retraction of the armature of the stepping relay 322 and eight steps due to
50 the attraction of the armature of the stepping relay 322. When therefore tens selection control began, the movable portion of the switch 366 rested in the seventeenth recess on the disk 365. Therefore when the
55 shunt through the contacts 60 is connected for the third time to the tens selection controlling circuit, the tens register-sender will start to move and will continue to move uninterruptedly into its normal position where
60 it will again stop. When now again the interrupter contacts 60 opened the switch 368 will be also opened and the final line relay 474 will find itself without current and therefore be deenergized.

65 Immediately upon the deenergization of

the final line relay 474 circuit is established for the final sequence switch 401 through the sequence switch contact 473, armature 443, and its back contact of the battery control relay 439 and back contact and armature of the final line relay 474. The final
70 sequence switch thereupon moves into its fifth position and is ready for units selection.

When the switch 368 opened as above described, it remained open sufficiently long
75 for the slow release relay 321 to deenergize. Circuit was therefore closed for the secondary controller sequence switch 301 through the back contact of such relay and sequence switch contact 305 and secondary controller
80 sequence switch was driven into its sixteenth position. As soon as the secondary controller sequence switch comes into its sixteenth position and the switch 368 has closed the selection controlling circuit, which will
85 now be termed the units selection controlling circuit, is again closed and the final line relay 474, the stepping relay 322 and the slow release relay 321 are again energized, the energization of the slow release relay 321
90 attracting its armature and by a circuit through its front contact and a sequence switch contact 304 driving the secondary controller sequence switch into its seventeenth position. It may here be noted that
95 this will occur by the time the final sequence switch is coming into its fifth position.

When the final sequence switch reaches its fifth position a circuit will be closed from battery through the brush carriage rotary magnet 62 through the sequence switch contact 477, front contact and armature of the
100 final line relay 474 to ground and back to battery. The closure of this circuit will cause the brush carriage to move, in the first portion of its movement bringing the brush
105 latches past the latch-selecting spindle and thereby causing the unlatching of the selected set of brushes by the movement of their cooperating latch when it contacted with the finger 41 upon the latch-selecting spindle. In the second portion of its movement,
110 that is, as the selected brushes began to pass over the sets of terminals in their cooperating bank of terminals the interrupter apparatus at the top of the selector will intermittently connect ground to the units selection
115 controlling circuit through the sequence switch contact 423 thereby, as before, shunting that portion of the units selection controlling circuit including the stepping relay 322 and the slow release relay 321, but maintaining the final line relay 474 energized.
120 This shunt will be placed on the units selection controlling circuit once before the selected brushes come in contact with each of the respective sets of terminals in their cooperating bank of terminals. Each time
125 that this shunt is placed upon the units selection controlling circuit the units register-sender will be stepped one step over a
130

circuit including back contact of the stepping relay 322, the contacts 334 and the sequence switch contact 309, which is now closed. Each time that the shunt is removed the units register sender will be moved a step forward in a clockwise direction over a circuit including the front contact of the stepping relay 322, the contacts 333 and the sequence switch contact 309. In the case assumed, however, the units digits dial of the primary controller or sending apparatus at the subscriber's station having been set at 9, the units register sender after the operation of such dial was left in its third position, that is, with the movable portion of the switch 336 in the third recess upon the dial 335. It will therefore require nine shunting operations to drive the units register sender into its twenty-first position and the tenth shunting operation by the interrupter contacts 60 will drive the units register sender into its normal position, causing the opening in such movement of the switch 338 to deprive the final line relay 474 of current and cause the deenergization of the slow release switching relay 321.

The deenergization of the final line relay 474 by the simultaneous opening of the interrupter contacts 60 and the switch 338 on the units register sender has caused the retraction of its armature, opening immediately the circuit heretofore traced to the brush carriage rotary magnet 62 so that the selected brushes now stop and rest in contact with the terminals of the desired line. The retraction of the armature of the final line relay 474 has also closed a circuit for the final sequence switch 401 through the back contact and armature 443 of the battery control relay 439 and the sequence switch contact 473. The final sequence switch 401 now moves from its fifth position into its ninth position. Before considering the result of this movement of the final sequence switch 401, it will be observed that upon the deenergization of the slow release switching relay 321 by the opening of the switch 338, a circuit was closed for the secondary controller sequence switch 301 by the back contact of such relay and sequence switch contact 305, which starts this sequence switch in motion and it will move under the influence of its special contact 302 until it reaches its normal position. In moving out of its seventeenth position it has opened the sequence switch contacts 309 and 312, the opening of the sequence switch contact 312 permanently opening, so far as this operation of the secondary controller is concerned, the selection controlling circuit. As the sequence switch contact leaves its eighteenth position it opens the sequence switch contact 307 so that when it comes into its normal position the test guard on this particular secondary controller apparatus is removed, and this apparatus

may be utilized in establishing the desired connection for a subsequent call. The entire secondary controller apparatus shown in Fig. 3 is now again in its normal condition.

When the secondary controller sequence switch 301 was passing through its eighteenth position on its return to normal, it closed a circuit through the sequence switch contact 310 for the primary sequence switch 201 which may be traced as follows: from battery through the primary sequence switch 201, sequence switch contact 213, armature 258 of the relay 254, conductor 333, sequence switch contact 310 to ground and back to battery. The closure of this circuit causes the primary sequence switch to move out of its seventeenth position and come to rest in its eighteenth position. In this movement of the primary sequence switch the sequence switch contacts 209 and 213 are opened. The connecting circuit with which this primary sequence switch 201 is associated need now no longer be associated in any way with the secondary controller apparatus which has controlled the desired connection herein described. Therefore, by this same movement of the primary sequence switch the contacts 217 and 218 have been opened and the contacts 223 and 234 have been closed. The opening of the sequence switch contacts 217 and 218 has destroyed the selection controlling circuit and closure of the contacts 223 and 234 has completed the talking circuit at the primary selector end of the trunk line, and so far as the primary selector is concerned the apparatus is now ready for conversation. It will be further observed that for purposes to be hereinafter described the sequence switch contacts 239 and 240 have been closed to include a retardation coil 263 in shunt of the condenser 264, and this closure will have taken place before the final sequence switch has reached its twelfth position.

Referring again to the operation of the final selector and its associated apparatus, it will be recalled that the final sequence switch 401 is now moving from its fifth to its ninth position. In this movement the desired line is tested first in the sixth and seventh positions of the final sequence switch, and again in the ninth position of the final sequence switch. The first test is made from the middle or neutral point of the battery through the right winding of the test relay 432, polarity test relay 431, test brush 25 to the test terminal of the desired line. If the desired line is an ordinary line and is not busy, it will be noted by reference to Fig. 1 that full potential of positive battery will be upon the test terminal of this line from battery 149 through the multiple cut-off relay 112 and the multiple test conductor 108 and the test relay 432 and the polarity test relay 431 will both be energized. It

will be here noted that the polarity test relay normally stands in the position shown in Fig. 4 and when energized by positive battery upon the test terminal of the desired line its armatures move in a clockwise direction, returning to the position shown upon the deenergization of the relay. The energization of these two test relays 432 and 431 has closed a circuit for the test relay 433 which may be traced from battery through such relay, front contact and armature of the test relay 432, sequence switch contact 407, back contact and armature 445 of the test relay 431 to ground and back to battery. The test relay 433 is thereupon energized and establishes for itself a locking circuit including its front contact and armature 446 and the sequence switch contact 422. It may be here observed that the sequence switch contacts 421 and 422 are arranged in such a manner that the sequence switch contact 421 will be closed as the primary sequence switch comes into its tenth position before the sequence switch contact 422 is opened by the primary sequence switch 401 leaving its ninth position. Similarly the sequence switch contact 422 will be closed as the sequence switch comes into its eleventh position before the sequence switch contact 421 is opened by the sequence switch leaving its tenth position, and so on as clearly indicated upon the drawing. The energization of the test relay 433 has furthermore closed a circuit to the test brush 25 through its armature 447 and the left winding of the test relay 432 in shunt of the right winding of test relay 432 and the polarity test relay 431 which circuit is of substantially lower resistance than the circuit which heretofore existed to the test brush and places a test guard upon the test terminal of the line with which the selected brushes are now in contact, in all the final selectors in which the terminals of such line appear. Furthermore the multiple cut-off relay 112 of the called line will now be operated upon the establishment of this circuit and attract its armatures 111 and 113, thereby opening the circuit of the line relay 119 of the called line and removing all bridges from the transmission circuit of such called line.

When the final sequence switch 401 reaches its ninth position no further test is necessary, in the case assumed, since the test relay 433 has already been locked up and will be maintained locked up in its ninth position. A circuit is therefore established by such relay for the final sequence switch through the sequence switch contact 471 and the front contact and armature 448 of such test relay 433. The final sequence switch therefore continues to move and will again come to rest in its twelfth position being energized and its motion thereby continued in the eleventh position by the same

circuit that started it from its ninth position. Upon coming into the twelfth position the final sequence switch 401 again closes what was heretofore described as the test circuit through the polarity test relay 431 by means of the sequence switch contact 409. This relay again operates, in spite of the closure of the circuit through the left winding of the test relay 432, and closes a ringing circuit from ground through the source of positive pulsating current 435, front contact and armature 459 of the test relay 431, resistance 450, sequence switch contact 417, selected brush 24, selected terminal 28, multiple line conductor 107, line conductor 102, master switch 171, the condenser and bell of the called subscriber's substation apparatus 116, conductor 101, multiple line conductor 106, terminal 27 (all of the called line), selected brush 23, sequence switch contact 414, winding 451 of the ringing control relay 430 to ground and back to battery. The closure of this circuit will cause the ringing of the bell at the called subscriber's substation, but on account of the nature of the circuit, in that it includes the condenser and bell at the substation, insufficient current will pass to energize the ringing control relay 430.

It may be here noted that for convenience I have shown but a single subscriber's line, and that in the description of my invention I have considered the line shown on Fig. 1 as both the calling and the called line. This of course is for convenience only and it will be so understood.

When the called subscriber removes his receiver from the receiver switch hook he closes the low resistance circuit around the condenser and bell of his substation apparatus and sufficient current will now pass over the ringing circuit to energize the ringing control relay 430. This relay thereupon attracts its armature and closes for itself a locking circuit which may be traced from the battery 429 through one winding 494 of the repeating coil 495, called supervisory relay 428, winding 453 of the ringing control relay 430 and the front contact and armature of such relay, sequence switch contact 425 to ground and back to battery. This locking circuit for the ringing control relay 430 also energizes the called supervisory relay 428 which attracts its armature and closes a circuit through the sequence switch contact 418 to drive the final sequence switch 401 into its thirteenth position. This is the talking position of the final selector apparatus.

In the thirteenth or talking position of the final sequence switch the sequence switch contacts 479 and 410 are closed completing the talking circuit of the called line and the entire talking circuit is now complete from the calling subscriber to the called sub-

scriber, the sequence switch contact 410 having been closed in the sixth position of the final sequence switch. It will be furthermore observed that the ringing circuit was opened at the sequence switch contacts 414 and 417 as the final sequence switch left its twelfth position.

It will be recalled that the circuit through the retardation coil 263 at the primary selector was closed before the final sequence switch reached its twelfth position. This was for the purpose of energizing the final line relay 474 over a circuit including the trunk line and the armatures 460 and 461 and their back contacts of the battery control relay 439. This energization produced no effect at that time. When now, however, the final sequence switch comes into its thirteenth position due to the energization of the called supervisory relay 428, this relay will be maintained energized in this position so long as the switch hook of the called subscriber remains closed. On coming into the thirteenth position therefore the circuit will be closed for the battery control relay including the front contact and armature of the called supervisory relay 428 and the sequence switch contact 419. The battery control relay 439 will therefore be energized, in its energization opening the circuit of the final line relay 474 at its armatures 460 and 461. The deenergization of the line relay 474 will therefore be substantially simultaneous with the energization of the battery control relay 439, and, it may be here noted, upon the deenergization of the battery control relay 439 the final line relay 474 will be practically simultaneously energized. So long therefore as these two relays are not at the same time either in a deenergized condition or at the same time in an energized condition, the final sequence switch 401 will remain in its thirteenth position. As above described therefore, in the thirteenth position of the final sequence switch the battery control relay 439 is energized and the final line relay 474 is deenergized. Conversation will now take place.

It may be here noted that on coming into its thirteenth position the final sequence switch closed a restoring circuit for the latch-selecting rotary magnet 68 through the sequence switch contact 405 and the off-normal contacts 59. The latch-selecting spindle will therefore be returned to its normal position where, due to the opening of the off-normal contacts 59, it will come to rest.

When conversation is over it will be assumed that the calling subscriber returns his receiver to its switch hook. The immediate result of this act is a deenergization of the calling supervisory relay or disconnect relay 259 due to the opening of its energizing circuit at such switch hook. The

deenergization of this relay closes at the back contact of its armature a circuit through the sequence switch contact 216 for the primary sequence switch 201 and causes it to move into its twentieth position. As the primary sequence switch leaves its eighteenth position not only is the sequence switch contact 216 opened but the sequence switch contacts 239 and 240 are also opened removing the retardation coil 263 from the shunt around the condenser 264 in the trunk circuit. As the primary sequence switch comes into its nineteenth position, however, the sequence switch contacts 235 and 236 are closed which places the battery 265 in the trunk circuit to energize the final line relay 474 for purposes which will be hereinafter described. As the primary sequence switch comes into its twentieth position it opens the trunk circuit at the sequence switch contacts 223, 234, 231 and 232. It also at this time closes the sequence switch contacts 226, 229 and 227. By the closure of the sequence switch contact 226 a circuit is established for the carriage rotary magnet 62 through the back contact and armature of the test relay 261. It may be here observed that the test relays 261 and 262 were deenergized as the primary sequence switch left its eighteenth position by the opening of the sequence switch contacts 227 and 228, and that when the sequence switch contact 227 closed in the twentieth position of the final sequence switch no energizing circuit was closed through these relays. In response to the energization of the carriage rotary magnet 62 the brush carriage now returns to its normal position, at which time a circuit is closed from battery through the sequence switch contact 237 through the plate 46, arm 72, contact spring 73, test relay 261, sequence switch contact 227 to ground and back to battery. The closure of this circuit causes the energization of the test relay 261 which by the attraction of its armature opens the energizing circuit for the carriage rotary magnet 62 and closes the circuit of the holding magnet 65 through the sequence switch contact 229. In this manner the brush carriage is brought positively to a stop in its normal position.

The energization of the test relay 261 has furthermore closed a circuit through its armature and front contact for the primary sequence switch 201 which now moves out of its twentieth position and comes to a stop in its first or normal position. In this movement of the primary sequence switch all of the apparatus associated with this sequence switch and this primary selector is restored to its normal condition and is ready to be operated in connection with a call from some other line or a subsequent call from the same line.

Referring now to the apparatus associated

with the final selector shown in Fig. 4, it will be recalled that while the primary sequence switch was passing through its nineteenth position, battery was connected in the trunk circuit to energize the final line relay 474. It will also be recalled that in the thirteenth position of the final sequence switch the battery control relay 439 was energized. Both of these relays therefore were energized through such nineteenth position of the primary sequence switch and a circuit was closed for the final sequence switch through the sequence switch contact 473, armature 443 and its front contact of the battery control relay 439 and the front contact and armature of the final line relay 474. When the final sequence switch reaches its fourteenth position, as soon as the called subscriber replaces his receiver upon the hook the called supervisory relay 428 will be deenergized and the battery control relay 439 will be deenergized. At this time, however, the circuit of the trunk line has been opened at the primary selector and the final line relay 474 will be deenergized. A circuit will therefore be completed for the final sequence switch 401 through the sequence switch contact 473, the armature 443 and its back contact of the battery control relay 439 and back contact and armature of the final line relay 474, moving the final sequence switch from its fourteenth position to come to rest in its sixteenth position.

In passing through the fifteenth position it will be observed that no circuit exists at this time for the test relay 433, the final line relay and the battery control relay both being deenergized. The test relay 433 therefore retracts its armatures and the test condition upon the test terminal of the called line is removed and the multiple cut-off relay 112 is deenergized. Furthermore the sequence switch on leaving its fourteenth position has opened the sequence switch contacts 479 and 416, and the called line is therefore free from all connection which might in any way affect its further use, and it may be from this time on used as either a calling or a called line without interference from the apparatus which has been described as connected therewith in the call assumed. When this final sequence switch reaches its sixteenth position a circuit is closed for the carriage rotary magnet 62, which includes the sequence switch contact 476, back contact and armature of the relay 432, which is now deenergized, sequence switch contact 408 and front contact and armature 445 of the polarity test relay 431. This energizes the carriage rotary magnet 62 and the brush carriage thereupon returns to its normal position, in which position a circuit is closed for the test relay 432, which may be traced from the middle or neutral point of the battery through the right wind-

ing of such relay, sequence switch contact 415, plate 46, levers 44 and 45 to ground through the frame of the switch carriage and back to battery. The test relay 432 therefore attracts its armature, opening the circuit of the carriage rotary magnet and closing the circuit of the holding magnet 65 through the front contact of its armature and the sequence switch contact 406. This causes the final selector positively to stop in its normal position. The energization of the test relay 432 at this time has also closed a circuit through the sequence switch contact 408 and the front contact and armature 445 of the polarity test relay 431 for the test relay 433, which thereupon attracts its armatures closing a locking circuit for itself through its armature 446 and the sequence switch contact 422, and also closes through its armature 448 and the sequence switch contact 471 a circuit for the final sequence switch 401, which causes such sequence switch to leave its sixteenth position coming to rest in its first or normal position, in such movement closing the sequence switch contacts 411, 412, 427 and 403 and opening all the other sequence switch contacts associated therewith except the sequence switch contact 405. The final selector apparatus and its associated sequence switch are now in normal condition.

Assuming now that at the end of conversation, the called subscriber first replaces his receiver upon its switch hook. This will cause the battery control relay 439 to be deenergized by the deenergization of the called supervisory relay 428 and the final line relay 474 will be at the same time energized. The apparatus will now await the opening of the trunk circuit at the primary selector apparatus in the twentieth position of the primary sequence switch, at which time both of the relays 474 and 439 will be deenergized and restoration will take place precisely as has been hereinbefore described. Assuming now that the line with which connection was desired had tested busy in the sixth and seventh positions of the final sequence switch. This being the case the test relay 432 will find insufficient potential on the test terminal of the desired line to cause its energization. The line, however, being an ordinary line, sufficient positive potential will exist upon the test terminal of such line, even though it is now in use, to cause the operation of the polarity test relay 431. It may be here observed that whether the desired line is in use as a calling or a called line, the potential will have been reduced in such use to such an extent that the test relay 432 will not be energized. This result is accomplished, if the line desired is a called line, by the establishment of a comparatively low resistance circuit from the test terminal of such line through

the right winding of the test relay 432 and the front contact and armature 447 of the test relay 433. If, on the other hand, the line desired is in use as a calling line, the energization of the cut-off relay 114 of such line has connected the multiple cut-off relay 112 of such line to ground through the armature 120 and its front contact of the cut-off relay 114 and the resistance 121, reducing thereby the potential upon the multiple test terminal of such line in all the final selectors in which it appears to such an extent that the line will test busy.

Since the test relay 432 was not energized in the sixth and seventh positions of the final sequence switch the test relay 433 will not be energized at this time. When now the final sequence switch comes into its ninth position the test relays 432 and 433 are still unenergized but the polarity test relay 431 will be again energized over the circuit including the sequence switch contact 409 and the right winding of the test relay 432. A circuit is now established for the final sequence switch 401 through the sequence switch contact 471 and the back contact and armature 445 of the polarity test relay 431, and the final sequence switch now moves into its eleventh position. In passing through the tenth position of the final sequence switch the energizing circuit for the polarity test relay 431 was opened at the sequence switch contact 409 and therefore when the eleventh position of the final sequence switch is reached a circuit is closed for the carriage rotary magnet 62 through the sequence switch contact 478, back contact and armature of the test relay 432, sequence switch contact 408, and front contact and armature 445 of the polarity test relay 431. The brush carriage of the final selector, therefore, will move and will continue to move until it reaches its normal position. Upon reaching its normal position, however, a circuit is established from the middle or neutral point of the battery through the right winding of the test relay 432, sequence switch contact 415, plate 46, arms 42 and 43 to ground through the frame of the brush carriage. This circuit being of low resistance causes the energization of the test relay 432, which thereupon attracts its armature opening the circuit, heretofore traced, of the carriage rotary magnet 62, and closing the circuit for the holding magnet 65 through the sequence switch contact 406. The attraction of the test relay 432 has also closed a circuit for the test relay 433 through the front contact and armature of the test relay 432, sequence switch contact 408 and the front contact and armature 445 of the polarity test relay 431. This causes the energization of the test relay 433, which closes a locking circuit for itself through its ar-

mature 446 and the sequence switch contact 422, and also closes a circuit through its armature 448 and the sequence switch contact 471 which moves the final sequence switch out of its eleventh position. On coming into its twelfth position the final sequence switch will find closed for itself an energizing circuit through the sequence switch contact 472, back contact and armature of the test relay 432, the circuit for which is now opened at the sequence switch contact 415, sequence switch contact 408, and front contact and armature 445 of the polarity test relay 431. This circuit being also maintained in the thirteenth position of the final sequence switch, such sequence switch will move until it reaches its fourteenth position. This is the busy back position. In this position it will be observed that the sequence switch contact 420 has closed a circuit for the busy tone 457, which may be of any usual or preferred construction and such circuit being established from ground through such busy tone, sequence switch contact 420, one winding 494 of the repeating coil 495 and back to ground. This tone will be transmitted over the trunk line by means of the windings 493 of the repeating coil 495 and the repeating coil associated with the trunk line at the primary selector and will be heard by the calling party who will therefore know that his call has been unsuccessful. It may at this time be noted that since the final selector has been before this returned to its normal position the connection of the busy tone on the called side of the repeating coil 495 will in no way affect or interfere with the lines already busy appearing upon this final selector. Upon the receipt by the calling subscriber of this busy tone he will know, as stated, that his call is unsuccessful, and will return his receiver to its switch hook. Disconnection will now take place precisely as before except that the disconnection of the final apparatus will await the opening of the trunk circuit at the primary selector, at which time the final line relay 474 and the battery control relay 439 will both be de-energized and disconnection will proceed as has been described. It may be here noted that since connection has never been made to the called line, the called supervisory relay 428 has not been energized.

It will be observed that the final selector and its associated apparatus shown on Fig. 4 of the drawings hereof are capable of various other functions and operations which have not been described. Since, however, these functions and operations form no essential part of my invention herein, and since furthermore they have been described in my pending application Serial No. 573,517, filed July 23rd, 1910, it is not necessary that they should be described herein. It will also be

observed that both the switching apparatus shown on Fig. 2 and the switching apparatus shown on Fig. 4 are arranged to be positively and accurately returned to their normal condition upon any premature disconnection on the part of the calling subscriber, such disconnection being accomplished by the retraction of the armature of the calling supervisory relay 239. In response to the deenergization of this relay the disconnect circuit through the sequence switch contact 216 will be closed and the primary sequence switch 201 will be moved to its twentieth position, from which position the restoration to normal of the primary selector apparatus and the final selector apparatus will take place, as has been heretofore described. It will be furthermore observed that when the primary sequence switch had moved out of its twenty-first position the busy potential will be removed from the test conductor 103 of the calling line, and the apparatus individual to such line as shown on Fig. 1 will be restored to its normal position.

It may be here observed that the apparatus shown on Fig. 1 of the drawings herein is all that is individual to the lines terminating in the exchange, the rest of the apparatus shown in the drawings hereof being common to groups of lines. It will be of course understood that the arrangement and number of lines in the groups of lines in an exchange embodying my invention may be according to any desired or preferred percentage basis, such as may be convenient or necessary to carry the traffic of such system. Furthermore, that the number of connecting circuits associated with the two secondary controllers whose leads terminate in the contacts of the relay 254 may be such as will use these secondary controllers at their highest efficiency and still have a calling line always find one of these secondary controllers in its idle condition. In the ordinary installations it will be found that two secondary controllers are sufficient in all circumstances to perform the necessary controlling operations for a group of 100 lines and ten connecting circuits and still have each calling line find one of such secondary controllers in its idle condition. Under unusual circumstances, however, it may be necessary to associate two secondary controllers of the character described and shown with a less number of connecting circuits, but such arrangement and construction is of course within the scope of my invention.

It will be observed that the second secondary controller associated with the relay 254 will be in all respects precisely similar to the one shown on Fig. 3 with the exception that the conductor 334 and the sequence switch contact 307 are unnecessary. The

conductors 331', 332' and 333' and their associated apparatus are in all respects precisely similar to the conductors 331, 332 and 333 and their associated apparatus. If when the primary sequence switch was passing from its second to its third position, in response to the connection of the brushes of its associated line finder to a calling line, the sequence switch contact 307 of the first secondary controller associated with the relay 254 had been closed indicating that this controller was busy, a circuit would have been established from battery through such sequence switch contact 307, conductor 334, sequence switch contact 208, relay 254, sequence switch contact 209 to ground and back to battery. This relay would thereupon have been energized and closed for itself a locking circuit from battery through the front contact and its armature 255, through the winding of such relay 254, sequence switch contact 209 to ground and back to battery. This relay 254 therefore would remain locked in its energized condition until the primary sequence switch 201 had passed out of its seventeenth position opening sequence switch contact 209. At this time it will be observed the selecting operations are entirely complete and the connection of the secondary controller apparatus with the trunk circuit and the apparatus associated with the primary sequence switch and primary selector is no longer necessary. Therefore if, as stated, the sequence switch contact 307 of the first secondary controller had been found closed, as the primary sequence switch passed from its second to its third position, the impulse circuit hereinbefore traced would be connected to the conductors 331' and 332' through the armatures 256 and 257 and their front contacts of the relay 254, and the sequence switch contact 213 would be connected to the conductor 333' through the armature 258 and its front contact of the relay 254, instead of these respective conductors being connected to the conductors 331, 332 and 333, as hereinbefore described. The operation of the apparatus from this time on until the completion of the selection, successful or unsuccessful, then takes place precisely as has been hereinbefore described.

It will be observed that the final selector apparatus, shown on Fig. 4 will maintain the test terminals associated with the conductor 499 individual thereto in all the primary selectors in which such terminals appear of such electrical character that this final selector will test busy until the final sequence switch 401 upon coming into its first or normal position closes its sequence switch contact 427. This will prevent any primary selector from selecting and making contact with the terminals connected with

this final selector apparatus while the final selector is in any off-normal position.

The particular system shown herein is of 1000 lines capacity, but it will be obvious 5 that my invention is not limited to use in connection with systems of such capacity but may be embodied in systems of any desired capacity, such obvious changes only being necessary as an introduction into the 10 system of such additional selector switches and corresponding register-senders and digits dials as may be necessary to extend the system to the desired capacity. The system shown herein furthermore embodies 15 what is known as the revertive impulse system of selection control, but it will be obvious that my invention is not limited to such system of control and may be used in connection with any desired or convenient 20 system of control.

While there are shown in the drawings various sources of current as separate batteries, it will be understood that this showing is for convenience only and in the actual installation of a system embodying my 25 invention such separate batteries, where they are of the same character and potential and located in the same exchange may be and preferably are one and the same battery.

It will be understood that the various portions of the apparatus illustrated as forming a part of the system embodying my operation may be operated at any desirable speed but are adapted to and will preferably be 30 operated at high speed, such speed in no way detracting from their accuracy and efficiency.

Having described my invention what I claim is:—

1. In a telephone system exchange, the combination of a plurality of lines terminating in a central exchange, a call-storing register at said central exchange, means for automatically connecting the same to a calling line, of automatic switching apparatus at the central exchange for extending the calling line, said automatic switching apparatus being controlled by said call-storing register, and means under the control of the 50 automatic switching apparatus for returning said call-storing device to normal.

2. In a telephone exchange system, the combination with automatic switching apparatus at a central station, of a primary 55 controller at a distant station operating to send current impulses over a connecting line to said central station, a secondary controller at said central station controlled in its adjustment by such impulses and when adjusted controlling said switching apparatus, and impulse sending means operated in the movement of said switching apparatus to restore said secondary controller to normal condition. 60

3. In a telephone exchange system, the combination with automatic switching apparatus at a central station, of a primary controller at a distant station, a secondary controller at the central station controlled in its adjustment by said primary controller 65 and when adjusted controlling said switching apparatus, and impulse sending means operated in the movement of said switching apparatus to restore said secondary controller to normal condition. 70 75

4. In a telephone exchange system, a plurality of lines terminating at a central station and provided with impulse sending mechanism, call-storing registers, less in number than the number of lines, located at 80 said central station and responsive to impulses from said lines, means for automatically connecting an idle one of said registers with a calling line, automatic switching apparatus located at said central station, and 85 controlled by the selected call-storing register.

5. In a telephone system, a central station, a plurality of lines each provided with impulse sending means terminating thereat, 90 automatic switching apparatus at said central station for extending the calling line and a plurality of call storing registers common to said switching apparatus and arranged to be controlled by said impulse 95 sending means, said switching apparatus being controlled by an automatically selected call storing register.

6. In a telephone system, a central station, lines provided with impulse sending mechanism terminating thereat, automatic switching apparatus at said central station, call storing registers controlled in adjustment by impulses from said lines common to said switching apparatus, said registers being 105 less in number than the number of lines, means for connecting an idle one of said registers to a calling line, and means whereby said register controls the operation of said switching apparatus. 110

7. In a telephone exchange system, the combination with lines terminating in a central station, of a plurality of connecting circuits at such central station less in number than the number of said lines, a plurality of controlling organizations at such central station less in number than the number of said connecting circuits, automatic means for connecting one of said connecting circuits with a line taken for use, automatic 120 means for connecting one of said controlling organizations with a connecting circuit taken for use and subsequently disconnecting it therefrom, and automatic switching apparatus controlled by such controlling 125 organization when connected with one of said connecting circuits.

8. In a telephone exchange system, the

ombination with lines terminating in a central station, of a manually operable primary controller individual to each said line, a plurality of connecting circuits at such central station less in number than the number of said lines, a plurality of secondary controllers at such central station less in number than the number of said connecting circuits and each controlled in its adjustment by the

operation of a primary controller when connected therewith, automatic means for connecting an idle one of said connecting circuits with a line taken for use, automatic means for connecting an idle one of said secondary controllers with a connecting circuit connected with a line taken for use, and automatic switching apparatus controlled by such secondary controller when connected with one of said connecting circuits.

9. In a telephone exchange system, the combination with lines terminating in a central station, of a primary controller adapted to be associated with a line taken for use at the distant end thereof, a plurality of connecting circuits at such central station less in number than the number of said lines, a plurality of secondary controllers at such central station less in number than the number of said connecting circuits and each controlled in its adjustment by the operation of said primary controller when connected therewith, means for connecting an idle connecting circuit with a line taken for use, means for connecting an idle secondary controller with a connecting circuit connected with a line taken for use, and automatic switching apparatus controlled by said secondary controllers.

10. In a telephone exchange system, a sending device, a call storing register capable of being set to various adjusted positions and controlled in its adjustment by said sending device, and automatic switching mechanism controlled by said call storing register according to its set condition.

11. In a telephone exchange system, a substation, a sending device thereat, a call storing register at the central station controlled in its adjustment by said sending device, switching apparatus, and means for effectively associating said switching apparatus with said call storing register whereby connection to a desired line is effected.

12. In a telephone exchange system, a substation, a sending device thereat, a call storing register at the central station controlled in its adjustment by said sending device, and switching mechanism controlled in its operation by the return to normal of said call storing register.

13. In an automatic telephone system, a central station, automatic switching apparatus thereat, a distant station, a call initiating device thereat, a call registering device

at the central station controlled in its adjustment by said call initiating device, means for returning said call registering device to normal in synchronism with the movement of said automatic switching apparatus and means for stopping the movement of said switching apparatus upon the return to normal of said call registering device.

14. In a telephone system, a central station, a line terminating thereat, a primary controller associated with said line external to said central station, a connecting circuit at said central station, means for uniting said connecting circuit to said line, a secondary controller comprising a plurality of call register devices associated with said connecting circuit, means whereby said devices may be set by the operation of said primary controller, and a series of switches for extending said connecting circuit, the switches of said series being controlled by said register devices.

15. In a telephone system, a central station, lines terminating thereat, a primary controller associated with each of said lines external to said central station, a group of connecting circuits at said central station, means for uniting a connecting circuit to one of said lines, a plurality of secondary controllers associated with said group of connecting circuits and common thereto, each secondary controller comprising a plurality of call register devices, means whereby the devices of a secondary controller may be set by the operation of a primary controller, and a series of switches for extending any one of said connecting circuits, the switches of said series being controlled by said register devices.

16. In a telephone circuit, a central station, a group of subscriber's lines terminating thereat, a primary controller associated with each of said lines external to said central station, a group of connecting circuits at said central station, means for uniting one of said connecting circuits to a calling line, a secondary controller comprising a plurality of call register devices, means for associating said secondary controller with any one of said group of connecting circuits, means whereby said register devices may be set by the operation of a primary controller, and a series of switches for extending said connecting circuit, the switches of said series being controlled by the successive operation of said register devices.

17. In a telephone system, a central station, a group of lines terminating thereat, a primary controller associated with each of said lines external to said central station, a group of connecting circuits at said central station, means for uniting one of said connecting circuits to a calling line, secondary

controllers common to said connecting circuits, each secondary controller comprising a plurality of call register devices, means for associating a secondary controller with a
5 connecting circuit united to a calling line, means whereby said register devices may be set by the operation of said primary controller, and a series of switches for extending said connecting circuit, the switches of

said series being controlled by said register 10 devices.

In witness whereof, I, hereunto subscribe my name this 9th day of November, A. D. 1910.

FRANK R. McBERTY.

Witnesses:

F. T. WOODWARD,
IRVING MACDONALD.