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TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED JULY 23, 1910.

1,075,430.

Patented Oct. 14, 1913.

5 SHEETS—SHEET 1.

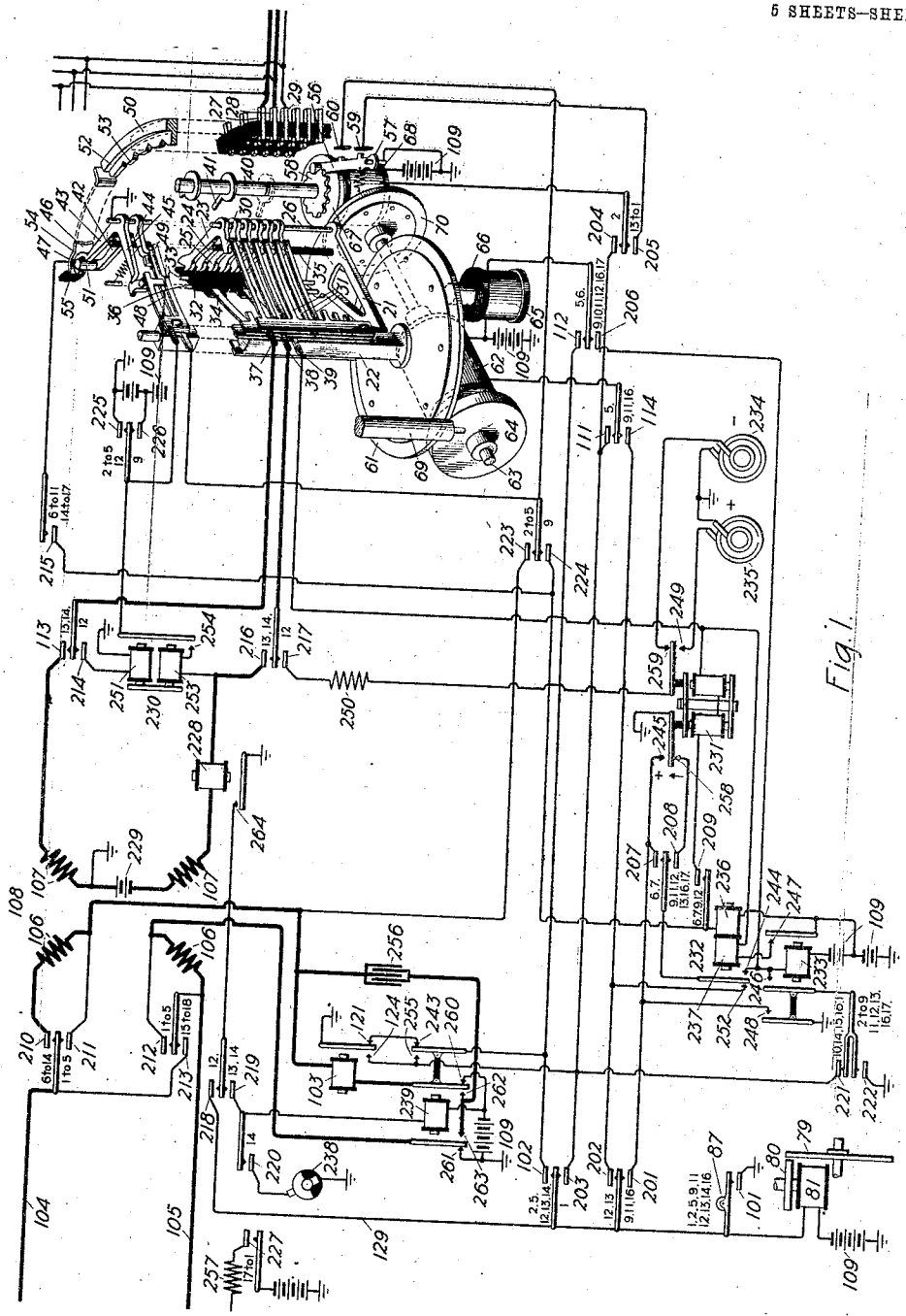

Fig. 1.

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5 SHEETS—SHEET 2.

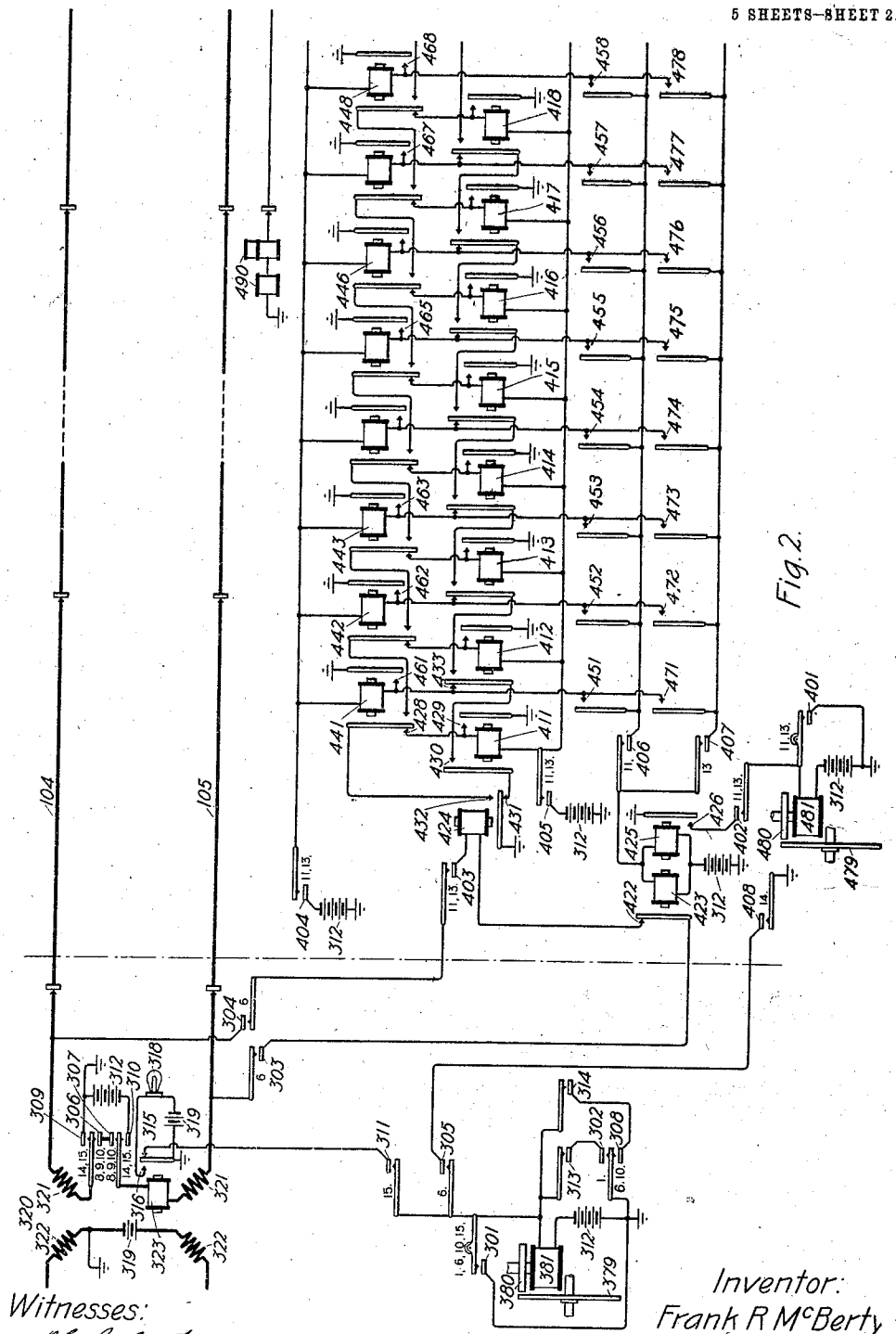

Fig. 2.

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5 SHEETS—SHEET 3.

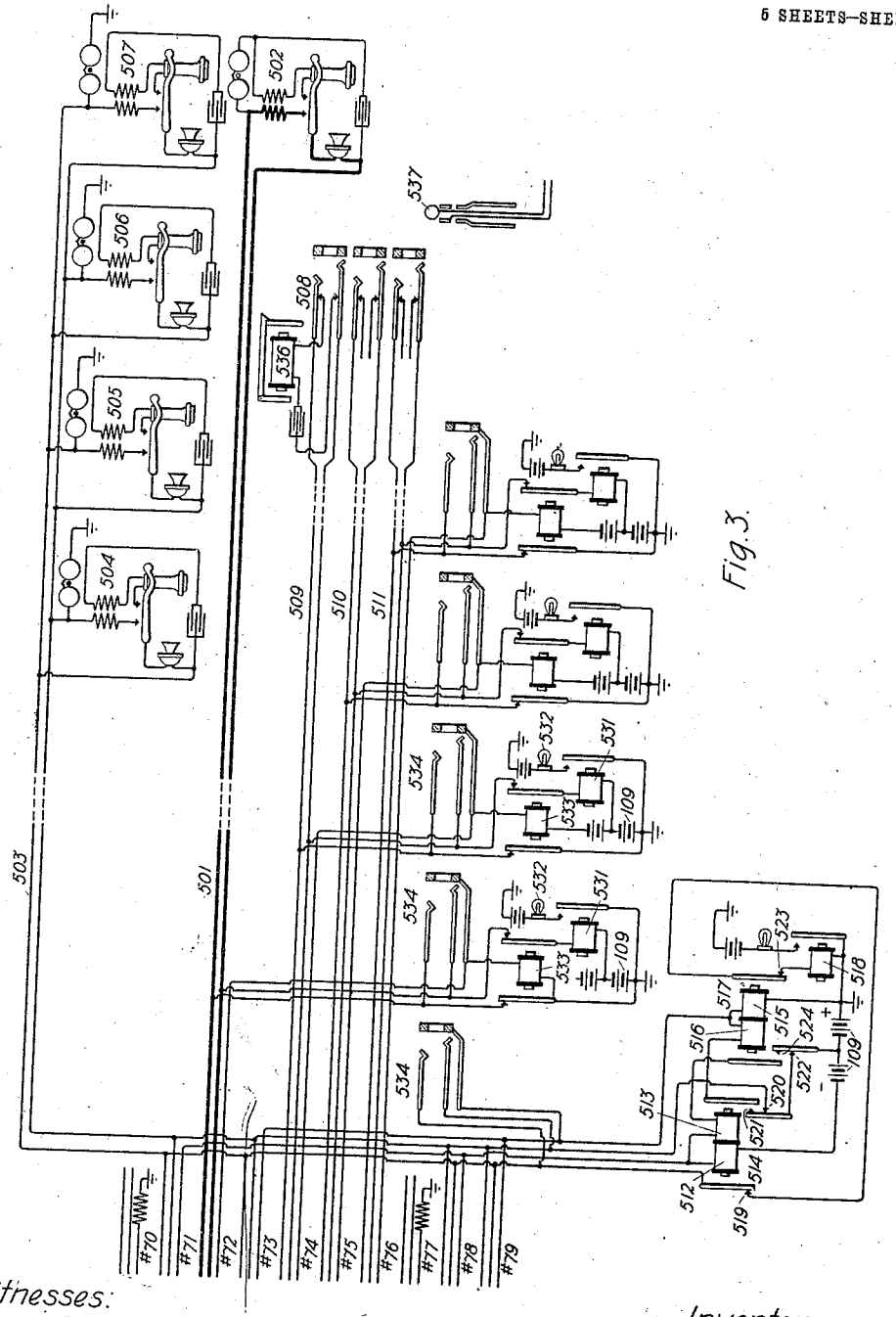

Fig. 3.

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5 SHEETS—SHEET 4.

Fig. 4.

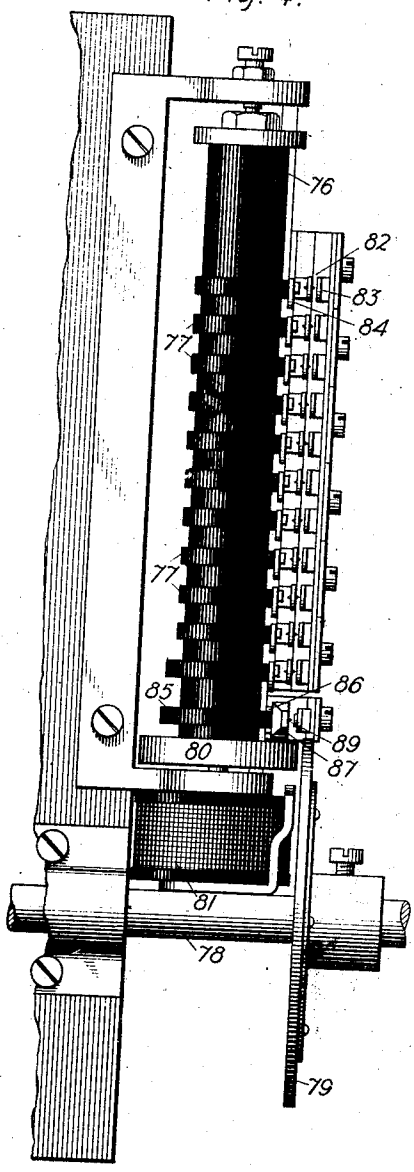
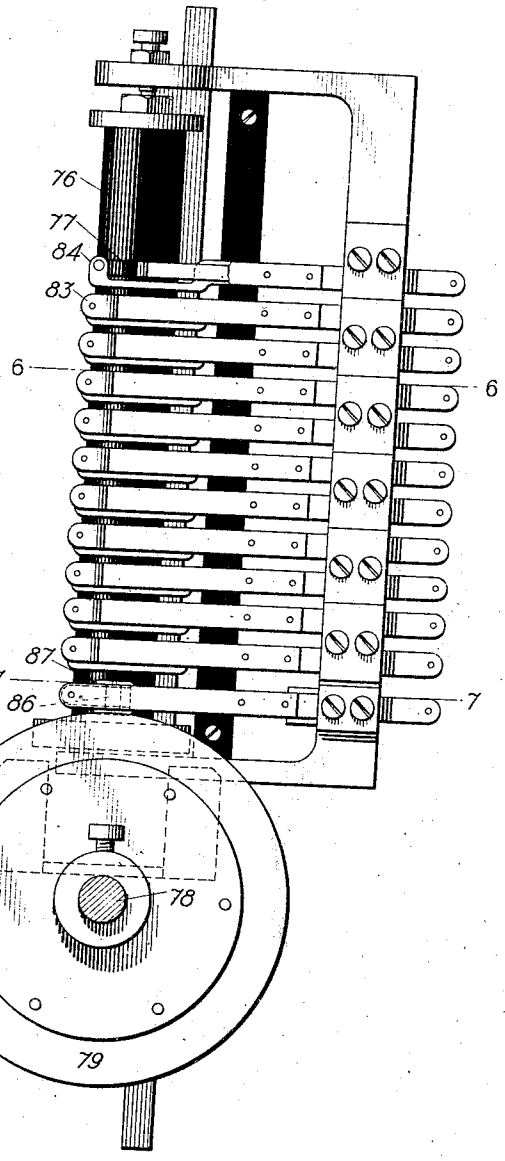


Fig. 5



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5 SHEETS—SHEET 5.

Fig. 6.

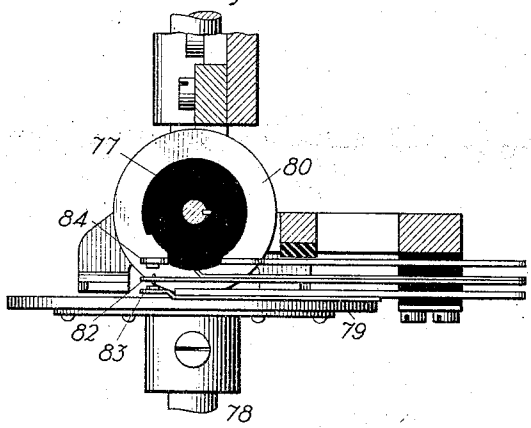
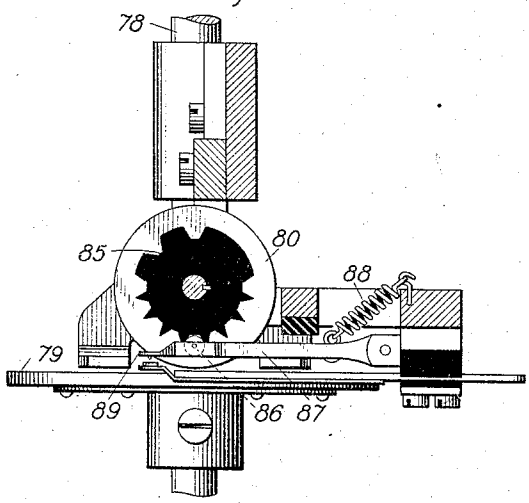


Fig. 7.



Witnesses:

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UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE SYSTEM.

1,075,430. Specification of Letters Patent. Patented Oct. 14, 1913.

Application filed July 23, 1910. Serial No. 573,517.

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.

This invention relates to telephone exchange systems of the type in which automatic switches or selectors are used for the interconnection of telephone lines, and it has for its object in general to provide improved means associated with the selectors thereof for governing their operation.

More particularly the invention has for its object the provision of an improved arrangement of apparatus associated with the final switches or selectors whereby various kinds of lines, such as ordinary and private branch exchange lines, may be interconnected.

In telephone systems of the kind to which this invention particularly relates, the lines of any private branch exchange may be connected to successive terminals in a row on the final switch, the test terminals thereof being connected differently from the test terminals of ordinary lines and the test circuit associated with the final switch being provided with responsive means adapted to discriminate between the different classes of lines. The apparatus should also be arranged in such a manner that if all of the lines leading to any private branch exchange to which connection is desired, are busy, the response of the final switch, upon connection being made with the terminals of the line following the last line of the group, will be the same as or similar to the response thereof when connection is made with the terminals of an ordinary line. With such an arrangement the final switch will, if connection is made to any of the group of private branch exchange lines, test such line, making connection thereto if it is not busy but passing on to the terminals of the next line if it is busy. If all the private branch exchange lines of the group are found busy, the switch will move on to the terminals of the line following the last private branch exchange line of the group and will then respond in the same manner as though the connection had been made to a busy ordinary line, that is to say, it will set into operation the busy back signaling apparatus to notify the operator or the calling subscriber that the desired connection cannot be secured.

One feature of the present invention contemplates improved means of selectively signaling the several substations of party lines, this means being combined and operating in harmony with the means for discriminating between ordinary lines and private branch exchange lines.

Another feature of the invention contemplates improved means for controlling the "busy back" signaling apparatus to indicate that a line or group of lines to which connection may be desired is busy.

These features of the invention and others to be described and pointed out in the claims, although capable of separate embodiment in telephone exchange systems, are, in the particular system herein set forth combined in one system and embodied in the apparatus of a single final switch, whereby such switch may perform the several functions required in an orderly and efficient manner.

An arrangement of the apparatus at the final switch or selector in accordance with the above mentioned features of invention may be briefly set forth as follows: All of the test terminals of private branch exchange lines, including the last terminal in each group, are connected to a source or sources of current of the same character, and the test terminals of all ordinary subscribers' lines are connected to a source or sources of current of a different character from that of the private branch exchange lines. The test circuit of the final switch or selector is provided with electro-responsive means, preferably in the form of a relay controlling the selector mechanism to cause hunting of the brushes over the terminals of private branch exchange lines in succession, and if all of the lines represented thereby are busy, to cause the brushes to pass beyond the group of private branch exchange terminals and to make temporary connection to the line terminals next succeeding the terminals of said group, the selector mechanism being thereupon caused to give a busy back signal to the operator or waiting subscriber. The temporary connection is made without disturbing in the

least the circuit conditions already existing at the terminals of that line, which may be busy or idle, the mechanism in either case operating as stated to give a busy signal, indicating in this case that all of the private branch exchange lines of the group tested are busy.

The test terminals of private branch exchange lines are each connected to a source of current having a different characteristic from the source of current to which the test terminals of ordinary lines are connected. Preferably the sources of current of the two kinds of lines are characterized by a difference in polarity, that is to say, the test terminals of private branch exchange lines may be connected to negative battery and the test terminals of ordinary lines to positive battery. This enables the testing apparatus associated with the selector or final switch to discriminate between the two kinds of lines.

The connection to party lines and the means for selectively signaling over such lines are provided for in the system herein described in a manner which completely harmonizes with the means for discriminating between ordinary and private branch exchange lines. These party lines may have four substations each, the signal bells at two of the stations being connected from one side of the line to ground and those of the other two stations being connected from the other side of the line to ground; this being an arrangement well known in the art. Connections of these lines to the terminals of final switch mechanisms are made in such a manner that each substation of a party line has its individual set of terminals. Each such set may be located at any point in the system which corresponds to the number assigned to that substation. The arrangement in this respect is similar to the well known "jack per station" arrangement in manual switchboards. The terminals of two of the sets of terminals of each four-party line are connected to the line wires in reverse order to that of the terminals of the other two sets; and the test terminals of one of each of said two sets are connected to a source of current of the opposite polarity to that to which the test terminals of the other two sets are connected. Thus the polarity of the test terminals enables the testing apparatus of the final switch to determine which of two ringing generators (positive and negative pulsating) shall be connected in the line circuit; while the reverse connection of the line wires enables the selected generator to be applied to one side or the other of the telephone line. The arrangement is therefore one in which the selector may be caused to make connection with a set of terminals individual to each substation of a party line and upon making such connection to connect a ringing generator in circuit so as to operate the bell of the desired substation without operating the bells at the other substations of the line. The testing apparatus at the final switch in the system of the invention is thus required to distinguish between two kinds of lines only—those in which the test terminals are connected to positive battery and those in which the test terminals are connected to negative battery. The presence of positive battery means an ordinary line or either one of two of the substations of a party line, while the presence of negative battery means a special or private branch exchange line or either one of the other two substations of a party line. It will only be necessary in considering the operation of the final switch while hunting over private branch exchange terminals and testing at the line terminals next succeeding, to refer to ordinary and special or private branch exchange lines. It will tend to avoid confusion if the party lines are disregarded with respect to such operation. It will be understood, however, that the line terminals next succeeding the group of private branch exchange terminals may be the terminals of an ordinary line or those of a party line which have positive battery connected to the test terminals thereof. It will also be understood that when connection is made to a party line and at a test terminal thereof which is connected to negative battery, the operation of the final switch will be the same as that which follows the connection to a private branch exchange line; that is, if the line is busy the brushes of the selector will be caused to advance to the line terminals next succeeding the terminals of the line desired just as the brushes are caused to hunt over terminals of busy private branch exchange lines. The only requirement in the connection of the various kinds of lines to the terminals at the final switch is that there shall be a positive test terminal next succeeding each negative test terminal of a party line and next succeeding each row of negative test terminals of a group of private branch exchange lines.

The method employed of controlling the operation of the final switch mechanism to discriminate between private branch exchange lines and ordinary lines involves an arrangement of apparatus, whereby a double test follows each selecting operation. This double test is provided for by maintaining the test circuit closed during two periods, one preferably closely following the other, means being provided to change the mode of control so that the selector mechanism is adapted with like line conditions to respond in a different manner under the influence of the second test than under that of the first.

If the line selected is an ordinary subscriber's line, the first test definitely determines the subsequent operation of the selector, but if the line selected is one of a group of private branch exchange lines, the second test instead of the first determines the subsequent operation. The period of the second test would in such case include the time in which the selector is hunting over the terminals of the group of private branch exchange lines. In case all of the lines of that group are busy, the test circuit finally becomes closed (still during the second test period) to a line test terminal next succeeding the test terminals of the group of private branch exchange lines, and the operation of the selector, resulting from this closure of the test circuit, must necessarily be different from that which follows the first closure of the test circuit to the terminal of a selected ordinary subscriber's line.

Considering the operation more in detail, the selector mechanism responds upon the first test, when an ordinary line is selected to stop the selector if that line is idle, with the brushes in contact with the terminals of that line, and to make the connections required to signal the subscriber wanted; but if such line is busy, the selector will under the influence of the first test cause a "busy back" signal to be given to the operator or waiting subscriber. On the other hand, the selector mechanism will respond under the second test, when the line selected is one of a group of private branch exchange lines, to advance the brushes to the terminals of the first idle line of the group, or in case all of the lines of that group are busy to advance the brushes to the terminals of the next succeeding line, whereupon, whether that line is idle or busy, the busy signal will be given.

The testing means for securing the method of operation hereinbefore referred to may comprise a relay in the test circuit, which relay is responsive to current of a distinctive character and which controls the local circuit of a locking relay, which in turn determines the operation of the selector mechanism. And the mode of control of the local circuit of the locking relay by the relay in the test circuit may be changed by a switching device in the local circuit in such a manner that if the relay does not respond in the first test period, it will be irresponsive to the test relay in the second test period when it meets that condition at the test terminal which would have caused it to respond during the first test period. This switching device may be a sequence switch which also maintains the test circuit closed during the two test periods.

There are preferably two test relays in the test circuit, each relay being responsive to current of a particular characteristic. It has been found desirable to have one of these relays responsive to current of a given direction, and the other to current of given strength. The first mentioned relay may thus serve to discriminate between different kinds of lines, such as ordinary lines and private branch exchange lines, while the second relay may serve to discriminate between lines which are busy and those which are idle. The first mentioned relay may also serve as it does in the system herein described to determine the kind of generator to be connected for selectively signaling the subscribers of party lines. When the test circuit is equipped with two test relays, the third or locking relay is made responsive under the first test only upon energization of both of the test relays and responsive under the second test upon the energization of the current strength relay alone, but not upon the energization of both test relays, the local circuit of the locking relay being shifted between the two test periods to change the mode of control thereof for the purpose heretofore stated. The locking relay may serve to close a shunt path which is of low resistance in the test circuit, which path includes a second winding of the current strength relay, the closing of this shunt path causing the line to which connection has been made to test busy thereafter to other selectors. The main function of this locking relay, however, is to control the operation of the selector mechanism. It does this when energized, in part by closing a circuit for the motor magnet of a sequence switch, the sequence switch being thereupon caused to advance to the "talking" position. It furthermore serves as a means of testing the condition of the distant controlling apparatus, so that under certain circumstances, if the call has not been properly or completely transmitted, or if the operator should open the controlling circuit to "wipe out" the connection which she had started, this locking relay would respond by releasing its armature and cause the selector mechanism to be returned to normal condition. To provide for this testing operation, the local circuit of the locking relay is preferably connected to a switch spring of the sequence switch mechanism, this spring playing between contacts, one of which is connected in circuit with a contact of a line relay in the controlling circuit. If the controlling circuit is open at any of the times when the locking relay circuit is thus switched, the locking relay will be released with the result stated, that is, the return of the mechanism to normal.

A further feature of the present invention contemplates special means employed for automatically operating the signal bell of the called subscriber and for actuating switching mechanism upon the response of

said subscriber to disconnect the calling generator and to complete the talking circuit. According to this feature of the invention, an electro-responsive device or relay arranged to be energized by current from the ringing generator when the subscriber responds, is provided with two windings—one in the line circuit and one in a local circuit, this local circuit including a normally open contact of said relay and a controlling device for said switch mechanism. This switch mechanism is preferably a part of the sequence switch and it may be arranged not only to disconnect the generator and complete the talking circuit, but also to disconnect the electro-responsive device or relay from the line circuit in order that the line may be free from connections which would in any way interfere with the efficient transmission of voice currents. The local circuit referred to is a locking circuit which thereby insures the operation of the sequence switch upon a momentary closure of the line circuit. The switching mechanism, however, quickly opens the locking circuit again and releases and disconnects the ringing control relay.

The system of apparatus and circuits herein described embodies certain features of invention which are not claimed in this application. These are made the subject-matter of other applications for patent by me, of which may be mentioned the following: Serial No. 516,769, filed September 8, 1909. Serial No. 515,933, filed September 2, 1909. Serial No. 531,369, filed December 4, 1909. Serial No. 573,516, filed July 23, 1910. Serial No. 533,928, filed December 18, 1909.

There is shown in the drawings which accompany this application, a single selector or switch mechanism and the apparatus associated therewith and entering into the control thereof. The selector shown is the final switch, the last one of a series of similar switches which operate in succession in an actual exchange to interconnect telephone lines.

In the drawings—Figure 1 shows the circuits and apparatus which are directly associated with the final switch mechanism; Fig. 2 shows the mechanism and circuits of a trunk line and a suitable controlling apparatus which may be associated and connected with the final switch of Fig. 1 by means of a trunk line; Fig. 3 shows the circuits of various kinds of subscribers' lines to which connection may be made by the final switch of Fig. 2. These three figures when placed side by side—Fig. 2 to the left and Fig. 3 to the right of Fig. 1—form a complete circuit diagram of the final switch, the apparatus entering into the operation and control thereof and the subscribers' lines adapted to be connected thereby. Figs. 4, 5, 6 and 7 show in detail the structure of a sequence switch mechanism by which the circuits of the selector, the trunk line and the controlling apparatus in each case are governed. Figs. 4 and 5 are front and side elevations respectively of the sequence switch, while Fig. 6 is a view in cross section on line 6—6 of Fig. 5, and Fig. 7 is a view in cross section on line 7—7 of Fig. 5.

In the form of automatic switch shown in Fig. 1, 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 33 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 36. This stop rod 36 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, as shown in Fig. 1, 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 contiuously 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 car-

ried 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 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, and six sets of stationary terminals in two levels corresponding to the two sets of brushes shown.

The circuits at the final switch, as shown in Fig. 1, and those at the controller and at the distant end of the trunk line, as shown in Fig. 2, are preferably governed in each case by a sequence switch. In general the function of the sequence switch is to establish in a definite order at successive stages of the operation the various circuits required to bring into service various devices or parts in proper sequence. The sequence switch consists in its elements of a movable switch operating member, a number of circuit changers actuated in sequence as said member is moved from one position to another, an electromagnet, and motor mechanism operated or controlled by said magnet for advancing said movable member. In each position to which a movable member of the sequence switch is advanced, a circuit or set of circuits is established by which a given operation of the device under control is made possible, and at the same time another circuit is placed in a condition whereby the motor magnet of the sequence switch may be subsequently actuated so that the sequence switch will then be automatically advanced to the next position, until a new set of circuits is established, bringing about a new operation or electrical condition of the device or devices under control, and so on.

In the form of sequence switch shown in Figs. 4 to 7 inclusive, the movable member is a vertical rotary shaft 76 carrying a number of switch operating cams 77, said shaft being arranged to be driven by power applied through the agency of an electromagnetic clutch. The constantly driven power shaft 78 carries a friction driving disk 79 which is adapted to be drawn into engagement with a friction roller 80, carried upon the shaft 76, by the action of a clutch magnet 81. The roller 80 and the disk 79 are of iron, and the motor magnet 81 is adapted when excited to magnetize said roller 80, which serves as a rotary pole piece for said magnet; whereby the driving disk 79 is attracted into engagement with said roller, the rotation of the shaft 76 thus continuing as long as the motor magnet 81 remains excited.

The cams 77 carried by the rotary shaft 76 are arranged to operate switch springs 82, forcing said springs into engagement with outer contacts 83, or allowing them to engage their alternate inner contacts 84, according to the positions of said cams. As many cams and switches may be provided as the particular apparatus to be controlled may require. Certain of the switch contacts operated in the successive positions of the movable switch element may control circuits for the motor magnet 81. A special switch, such as shown in Fig. 7, is also preferably provided to control a local circuit for said motor magnet, whereby after the initial energizing circuit is broken by one or the other switches the motor magnet may still be excited by current in the local circuit until the next intended stopping position of the rotary element is fully reached. As shown in Fig. 7, the cam 85 for operating the "local" switch is adapted to be engaged by a cam roller 86 carried by a pivoted switch lever 87. A spring 88 is arranged to act upon said pivoted lever 87 so as to press the cam roller 86 against the edge of the cam 85. When the roller 86 rides upon a tooth or high part of the cam 85, said lever 87 closes a contact 89 which controls the local circuit for the motor magnet. The teeth of the cam 85 have inclined edges, so that the cam roller 86, after riding over the point of a tooth, is forced down the opposite slope by the action of the spring 88, and this tends to push against the cam to continue the rotation thereof until the roller 86 reaches the bottom of the following notch. The rotary element is thus brought to rest accurately in each of the positions where it is intended to stop. In the operation of the device, the circuit will first be closed for the motor magnet through one of the springs 82 and one or the other of the contact anvils 83 or 84 of such spring. Then, as the motor magnet is excited and the shaft of the sequence switch begins to rotate, the contact through which the motor magnet was initially excited may be broken, but the local circuit will be maintained for the motor magnet through the contact 89 closed by the cam 85, and the rotary element will thus continue to advance until the cam roller 86 reaches the bottom of the next notch of the cam 85.

The switch springs of the sequence switches do not appear in their actual arrangement in the circuit diagrams, but are so located as to give a clear arrangement of the circuits; and the operating cams are not shown. In Fig. 1 the clutch or motor mechanism 81, its driving disk 79 and friction roller 80 are shown in their structural arrangement, while the contacts 101, 102, 111 to 114, inclusive, and 201 to 227, inclusive, operated thereby, are shown merely in their proper circuit positions without regard to structural arrangement. The positions of the rotary elements of each sequence switch in which any of its contacts, except contact 101, are closed, are indicated by numbers placed adjacent to such contacts; each contact being open in all positions except those indicated by reference numbers. For example, contact 102 is closed in the 2nd, 5th, 12th, 13th and 14th positions as indicated by the numbers 2, 5, 12, 13 and 14 placed adjacent thereto. In the case of the special contact 101 operated by cam 85, the numbers are placed on the opposite side of the switch lever from its contact anvil and indicate the positions in which the contact is opened, said contact being closed continuously while the rotary element of the sequence switch is in transit between the positions indicated. It will therefore be understood that the special contact 101 is closed continuously between positions 1 and 2, 2 and 5, 5 and 9, 9 and 11, 11 and 12, 12 and 13, 13 and 14, 14 and 16 and 16 and 1. There may be say eighteen positions of the sequence switch and the cams thereof will be caused to make one complete revolution in passing from normal through the eighteen positions and back to normal again.

The sequence switch spring which operates contacts 221 and 222 is of slightly different construction from the others, in that it is adapted to make either of said contacts before the other is broken. It may be called a "continuity" switch. The reason for this continuity operation of these contacts will appear presently.

In addition to the sequence switch mechanism there are associated with the final switch of Fig. 1 the following relays: 103 is a line relay, the operation of which is controlled by current in the circuit of the trunk line 104, 105 leading to the controlling apparatus of Fig. 2; 239 is a battery control relay, one of the functions of which is to control the connection of battery 109 in the circuit of the trunk line; 228 is a supervisory relay which is included in that part of the trunk line which leads from battery 229 through windings 107 of a repeating coil 108 to the brushes 23 and 24 of the switch mechanism; 230 is a ringing control relay, its function being to cause the operation of the sequence switch upon the response of the called subscriber to a ringing signal; 231, 232 and 233 are test relays, their main function being to discriminate between the different kinds and different conditions of subscribers' lines to which connection may be made by the switch mechanism. Relay 231 is of comparatively high resistance and is polarized. It is responsive to positive current only flowing from the test brush 25. Relay 232 is responsive only to current of a given strength, it has two windings 236 and 237, the former being of somewhat higher resistance than the latter. The winding 236 is in a branch of the test circuit which includes the winding of relay 231, while winding 237 is in a branch adapted to shunt relay 231 and winding 236. Relay 233 is in a local circuit controlled by relays 231 and 232.

Contact 220 of the sequence switch controls the connection of an interrupter 238, the function of which is to give a "busy-back" signal to the waiting subscriber or operator. It operates directly upon the battery control relay 239, which in turn alternately closes the trunk line with and without the inclusion of battery 109.

Battery 109 is shown in the diagram, Fig. 1, in various positions merely for convenience. The positive pole of the battery is connected to ground. Certain connections are made from the free or negative pole and certain other connections to a middle point in the battery which may be called the neutral terminal of the battery.

The polarity test relay 231 is arranged to control the application of negative and positive pulsating current generators 234 and 235 to the connected line, a resistance 250 being interposed in the ringing circuit to regulate the flow of current therein. A resistance 257 is included in a local circuit controlled by sequence switch contact 227. A condenser 256 is placed in shunt of the line relay 103 in order to eliminate the impedance of said relay in the talking circuit.

The following are given as suitable resistance values for the various relays and electromagnet windings shown in Fig. 1: line relay 103, 1200 ohms; battery control relay 239, 1000 ohms; supervisory relay 228, 25 ohms—preferably with a non-inductive shunt; ringing control relay 230, each winding 250 ohms; polarity test relay 231, 250 ohms; marginal current test relay 232, 100 ohms in winding 236 and 50 ohms in winding 237; motor magnet 81 of the sequence switch 500 ohms; and the motor magnets 62 and 68 of the switch mechanism and holding magnet 65, each 500 ohms. The resistances 250 and 257 may each be of 300 ohms; the battery 109 may be of 48 volts potential, the two parts thereof on either side of the neutral point being of 24 volts, and battery 229 may be of 24 volts. These resistances and voltage may be widely varied in practice, the

values given being merely those which have proved suitable in practice.

Referring to Fig. 2, it will be noted that the trunk line conductors 104, 105 are represented as extending through three sets of switch contacts. These are merely intended to indicate selector mechanisms which, in a large telephone exchange system, would be operated in succession before the final switch of Fig. 1. The trunk line circuit at the distant or controlling end includes windings 321 of a repeating coil 320 and a relay 323. The coöperating windings 322 of this repeating coil may be connected in circuit with a battery 319 and through suitable mechanism to a calling telephone line. Associated with the trunk line and controlling the connections thereof is a sequence switch mechanism similar to that associated with the final switch. There are shown for this sequence switch a motor magnet 381, its driving disk 379 and friction roller 380 and contacts 301 to 311 inclusive. Contact 301 is a special contact operating similarly to contact 101 of the final switch; it is arranged to be closed while the sequence switch is being moved between the positions 1 and 6, 6 and 10, 10 and 15, and 15 and 1, as indicated. In addition to the sequence switch contacts there are shown in the circuit contacts 313 and 314 which may be manipulated in any desired manner to assist in the control of the sequence switch operation. Relay 323 has a back contact 315 leading to sequence switch contact 311 and a front contact 316 controlling the operation of a lamp signal 318 which is included in a local circuit with battery 319. Battery 312 serves as the source of current for various circuits associated with the trunk line controlling apparatus.

A suitable arrangement of controlling apparatus is shown in Fig. 2. This apparatus may comprise a plurality of counting relays and a plurality of controlling switches or keys, together with a stepping relay for operating the counting relays in succession and a cut-off relay adapted, when its circuit is closed simultaneously at one of the counting relays and at the particular switch or key which is operated, to open the controlling circuit and stop the movement of the selector. The circuits of the controlling apparatus may be governed by a sequence switch, such a sequence switch being represented in Fig. 2 by a motor magnet 481, its driving disk 479 and roller 480 and contacts 401 to 408 inclusive. Contact 401 is a special contact operating similarly to contact 101 of the selector sequence switch. It may be arranged as indicated to maintain the circuit of the motor magnet 481 closed continuously while passing from position 11 to position 13 and then from position 13 to position 11. Only so much of the controlling apparatus is shown as enters into the operation of the final switch mechanism. In a large system employing a series of selector switches operated in succession, the sequence switch for the controller would be provided with various other contacts than those shown and the contacts shown would be arranged to be closed in other positions than those indicated. In the operation of the final switch alone, however, but two selecting operations are required—one to govern the operation of the brush selector and the other to govern the operation of the brushes in moving over the terminals. Each of the sequence switches shown in Fig. 2 may have eighteen positions in all.

Two series or strings of counting relays are shown in Fig. 2. One, the main series, comprises relays 441 to 448 inclusive; these are adapted when energized to close contacts 461 to 468 inclusive, each of which is in series with one of the switches or keys 451 to 458 inclusive and also with one of the switches or keys 471 to 478 inclusive. Any one of these contacts of the main counting relays when closed conjointly with a corresponding key or switch is adapted to complete a circuit for a cut-off relay 423 and a sequence switch controlling relay 425. A second or auxiliary series of counting relays 411 to 418 inclusive is arranged to cooperate with the main counting relays; these are adapted under the control of the stepping relay 424 to be brought into circuit and energized in alternate succession with the main counting relays. The two series of counting relays may be extended in an obvious manner to include any desired number.

As will presently appear the stepping relay 424 is adapted to be energized and de-energized intermittently while the selector mechanisms of the final switch are being advanced from position to position. Upon the first energization of stepping relay 424, a circuit is completed from battery 312 by way of sequence switch contact 405, winding of auxiliary counting relay 411, contact 428 of main counting relay 441 and front contact 432 of the stepping relay 424, whereupon relay 411 is energized and closes a locking circuit for its winding by way of contact 429. Relay 411 when energized also closes contact 430 which places the first main counting relay 441 in position to be operated by the stepping relay when it is de-energized, a circuit being then completed from battery 312 through sequence switch contact 404, relay 441, contact 433 of the second auxiliary counting relay 412, said contact 430 of the first auxiliary counting relay 411 and back contact 431 of the stepping relay. Relay 441 is thereupon energized and it, like the relay 411, closes a locking circuit for its winding by way of contact 461. As heretofore stated, contact 461 would

also be in circuit with relays 423 and 425 if the corresponding key or switch 451 was closed at this time, and the energization of relay 441 would in such case cause the cut-off relay 423 to be operated and this relay in turn would open the circuit of the stepping relay 424 at its back contact 422. Relay 425 would also be operated at this time, if key 451 were actuated, and close a circuit for the motor magnet 481 of the sequence switch by way of its contact 426 and sequence switch contact 402. The sequence switch may be considered as resting in the 11th position at this time and it would therefore be advanced to the 13th position. In passing the 12th position, the locking circuits for the counting relays 441 and 411 would be opened at sequence switch contacts 404 and 405 and the circuit of the stepping relay 424 would also be opened in the 12th position at sequence switch contact 403 but closed again in position 13. Sequence switch contact 406, which was closed in the 11th position, is open in the 13th, while contact 407, which was open in the 11th, is now closed in the 13th. The two strings of counting relays are therefore in position for operation again under the control of the stepping relay 424 and the second series of keys or switches 471, 478. It will be noted that the number of impulses of current for intermittently operating the stepping relay 424 which may flow over the trunk circuit before the circuit is opened at back contact 422 of the cut-off relay depends upon the particular key which is actuated. If, for example, key 453 had been actuated, the circuit of the cut-off relay 423 would not be closed until main counting relay 443 had been energized, and this would happen after three impulses of current in the trunk line circuit.

It has been stated heretofore that the switch mechanism shown in Fig. 2 was arranged to make connection with various kinds of subscribers' lines. In Fig. 3 the circuits of such lines are shown in diagrammatic form. An ordinary single party line is indicated by line wires 501 leading to a substation 502. A four-party line is indicated by conductors 503 leading to four substations 504 to 507 inclusive. The signal bells at the substations of this party line are of high resistance and are connected in a well known way two from one side and two from the other side of the line to ground, one bell on each side of the line being responsive to positive pulsating ringing current and the other bell on each side of the line being responsive to negative pulsating ringing current. A private branch exchange is indicated at 508, this exchange being connected with the switch mechanisms at the main exchange by lines 509, 510 and 511, terminating at suitable springjack switches 535 and drop signals 536. A plug 537 may be used to extend the circuit of any one of said lines 509, 510, 511 to any one of the local stations at the private branch exchange 508. The ordinary single party line and the private branch exchange lines are connected to apparatus at the main exchange according to a well known arrangement, each line being provided with a springjack 534, a line relay 531, a lamp signal 532 and a cut-off relay 533, the latter being connected in a third wire connected to a test terminal 29 of the final switch mechanism. By reason of the usual multiple wiring, this test terminal and the line wire terminals would be connected also to other test terminals of other switches having access to such lines. It will be noted that the test wire of the ordinary single party line is connected through the cut-off relay 533 to the positive pole of battery 109, while the test wires of the private branch exchange lines are connected through cut-off relays to the negative pole of that battery. It is this difference in the manner of connecting the test terminals of these lines which enables the testing apparatus of the final switch mechanism to distinguish between ordinary lines and private branch exchange lines.

A somewhat different arrangement of circuits is provided for party lines. It has already been stated that each substation of a party line has its own set of terminals at the final switch. The test terminals for two of the substations of the party line 503 are connected together by one test wire which leads through winding 512 of a cut-off relay 514 to the negative pole of battery 109, while the test terminals for the other two subscribers of the party line are likewise connected together by a test wire but through a winding 515 of a cut-off relay 517 to the positive or ground pole of battery 109. The connections of the line terminals 27 and 28 for the two substations whose signal bells are connected to one side of the line are made in reverse order to those of the line terminals for the other two substations—this in order that the ringing generators may, in each instance, be connected by way of the same brush 28 for ringing the bells at every one of the four substations. Either cut-off relay 514 or 517 is adapted to open the normal circuit of the line conductor 503 to a line relay 518 and to ground. If connection is made to a test terminal leading to either one of these cut-off relays, a local circuit will be closed by that relay which will reduce the potential at the test terminals leading to the other cut-off relay. This is accomplished without causing the energization of said other cut-off relay. The local circuit referred to includes a second winding of said other cut-off relay. Let it be considered, for example, that connection is

made to the test terminal leading to winding 512 of cut-off relay 514. The energization of this relay will open the circuit of the line at contacts 519 and 520, one on one side of the line and one on the other, and will at the same time close contact 521, completing a local circuit from the neutral point of the battery 109 by way of normal contact 522 of cut-off relay 517, said contact 521, winding 516 of relay 517, and winding 515 of the same relay to the ground pole of the battery. Current flows in winding 516 in this circuit in an opposite direction to that of the current flowing in winding 515 and relay 517 is not energized. In the same manner, if connection should be made to the test terminal leading to winding 515 of relay 517, this relay would open the line circuit at contacts 523 and 522 and close a local circuit at contact 524 which would include windings 512 and 513 of relay 514. The resistances of these windings which have been found suitable in practice are as follows: Windings 512 and 515, 100 ohms each, and windings 513 and 516, 50 ohms each. The number of turns is approximately the same in the two windings of each cut-off relay. It will thus be seen that the local circuit closed by either cut-off relay through the windings of the other will materially change the potential at the test terminals connected to said other cut-off relay. It may be stated here that the windings of the cut-off relays 533 of the ordinary subscribers' and private branch exchange lines may also be of 100 ohms each.

The several sets of conductors leading to the left in Fig. 3 are individual to the several subscribers of ordinary and party lines and to the several lines of a private branch exchange and may be considered as connected to successive sets of terminals in a single row at the final switch mechanism of Fig. 2. The 2nd, 4th, 9th and 10th sets counting from the top down, are connected to the party telephone line 503 and represent subscribers Nos. 71, 73, 78 and 79. The 3rd set is connected to the ordinary single party line 501, subscriber No. 72; the 1st and 8th represent other ordinary single party lines, subscribers Nos. 70 and 77, the circuits therefor being not shown in the drawing. However, the 5th, 6th and 7th sets are connected to the private branch exchange lines 509, 510 and 511 respectively, subscriber No. 74. The third wire of each set of conductors is connected to one of the test terminals 29 at the final switch. It will be noted that each test terminal of a party telephone line which is connected to the negative pole of the battery 109 has a test terminal beyond it in the line of travel of the test brush 25, which is connected to the positive pole of the battery; also that the test terminals of the three private branch exchange lines are arranged in succession in a row on the final switch and are followed by a test terminal leading to positive battery. The test brush 25 of a final switch will accordingly be caused to make contact with negative test terminals of party lines and of private branch exchange lines, and if the party line or the group of private branch exchange lines is busy, the test brush will be caused immediately thereafter to make contact with a positive test terminal of some other line, whereupon the signal will be given that such party line, or such group of private branch exchange lines is busy.

Before describing in detail the operation of the system of Figs. 1, 2 and 3, it may be stated that the several positions which the sequence switches assume are characterized in each instance by a particular condition or operation of the mechanism governed thereby; and these positions may conveniently be defined by such conditions or operations. Thus the selector sequence switch positions are as follows: 1, normal; 2, that in which the brush selector is advancing and transmitting impulses over the trunk line; 5, that in which the brush carriage is advancing for line selection and is transmitting impulses; 6 and 7, those in which the test is made for positive line; 9, that in which a retest is made for negative line and in which a further advance of the switch carriage may occur for private branch exchange hunting; 10, test of trunk line for wipe-out operation; 11, that in which the sequence switch may run to "busy back" position; 12, the ringing position, 13, the talking position; 14, the busy back position; and 16, that in which the selector is caused to return to normal. Similarly the positions of the trunk line sequence switch may be defined as follows: 1, normal; 6, that in which the controller is connected to the trunk line for brush and line selection; 10, the talking position; 11 and 15, positions in which the selector may be caused to return to normal; and 15, also that in which the trunk line sequence switch awaits the return of the selector.

The controller sequence switch positions are: 11, brush selection, and 13, line selection.

The operation of the system will be described under several headings as follows:

1. Selection of non-busy ordinary line.
2. Selection of non-busy private branch exchange line.
3. Selection of busy ordinary line.
4. Selection of busy private branch exchange line, and
5. Return of mechanism on wipe-out or knock-down operations.

It will be understood that the operation of the switch which occurs in the selection

of a party line subscriber is either the same as that which occurs in the selection of an ordinary line, or as that which occurs in the selection of a private branch exchange line. This is because the test terminals of party line subscribers are connected either to positive battery, as are those of an ordinary line, or to negative battery as are those of a private branch exchange lines.

Selection of non-busy ordinary line.—Let it be assumed that the terminals of an ordinary line (subscriber No. 72) to which connection is desired, are located in the 8th level from the top of the final switch, and in the 3rd range counting from left to right in the direction of the travel of the brushes. The operator, having received instructions from a calling subscriber to establish this connection, will first close switches 458 and 473, the first (458) to control the impulses for brush selection and the second (473) to control the impulses for line terminal selection. Switch 313 may then be operated, closing a circuit for motor magnet 381 and starting the operation of the trunk line sequence switch, which thereupon advances from the first or normal position to the 6th position in which contacts 303, 304 and 305 are closed. A circuit is then completed over the trunk line as follows: battery 109, back contact 260 of the battery control relay 239, winding of relay 103, sequence switch contact 211, conductor 104, the trunk line sequence switch contact 304, the controller sequence switch contact 403, winding of stepping relay 424, back contact 422 of the cut-off relay 423, the trunk line sequence switch contact 303, conductor 105, sequence switch contact 212 and back contact 261 of the battery control relay 239 to the ground pole of the battery 109. This circuit causes the energization of the stepping relay 424 at the controller and of the line relay 103 at the final switch. The energization of the stepping relay 424 completes a circuit heretofore traced for auxiliary counting relay 411, one-half step being thus taken in the movement of the controlling apparatus. The energization of line relay 103 causes a circuit to be completed for the motor magnet 81 of the selector sequence switch (Fig. 1) by way of sequence switch contact 203 and the front contact 124 of the line relay 103. The selector sequence switch thereupon advances to the 2nd position.

In the second position of the selector sequence switch a circuit is closed for the motor magnet 68 of the brush selector by way of sequence switch contact 204 and the front contact 124 of the line relay, whereupon the shaft 40 is rotated, causing an intermittent closing of its interrupter arm 56 and contact 60. This contact is closed once for each position in which the shaft 40 is adapted to be placed for selecting a set of brushes. Upon the first and each subsequent closure of this contact, a shunt circuit of the trunk line is completed by way of sequence switch contact 223. The stepping relay 424 is thus intermittently deënergized in the movement of the shaft 40, while the line relay 103 and motor magnet 68 remain energized continuously. At each deënergization of relay 424 a circuit is completed for one of the main counting relays 441 to 448, these relays operating in succession in a manner already described. When relay 448 is energized a circuit is completed for the cut-off relay 423 and the sequence switch controlling relay 425 by way of sequence switch contact 406, key 458 and front contact 468 of counting relay 448. Relay 423 thereupon opens the trunk line circuit at its back contact 422 and the brush selector upon reaching its 8th position from normal is caused to stop in that position, the circuit of the motor magnet 68 being opened at the front contact 124 of the line relay 103, which is deënergized upon the 8th interruption of the shunt path at contact 60. The controller sequence switch is now advancing to the 13th position and a circuit is completed for the motor magnet 81 of the selector sequence switch by way of sequence switch contact 102, back contact 243 of the battery control relay 239 and back contact 121 of the line relay 103. In the position taken by the shaft 40 of the brush selector, one of its fingers 41—the 8th from the top in this instance—is pointing inwardly in line to engage a latch 32, holding the 8th set of brushes 23, 24 and 25 normally retracted. The selector sequence switch now advances from the 2nd to the 5th position in which a circuit is completed for the motor magnet 62 of the brush carriage by way of sequence switch contact 111 and front contact 124 of the line relay, the line relay having been energized again by reason of the reclosing of the trunk circuit at contacts 403 and 422, while the selector sequence switch was advancing to the 5th position. In the first stage of rotation of the brush carriage, the inwardly projecting finger 41 on the shaft 40 engages the edge of the latch 32 and releases the set of brushes 23, 24, 25, which are in line with the row of terminals that includes the terminals of the wanted line. As the brushes approach the first set of terminals the levers 42, 43 of the brush carriage interrupter engage the cam plate 50, and when the roller 51 at the free end of the lever 42 engages the first tooth 53 of said cam plate, a short circuit of the sender circuit and its stepping relay 424 is closed by way of sequence switch contact 223, interrupter contact springs 48 and 49 and sequence switch contact 225. A series of interruptions between contact springs 48 and 49 follow as roller 51 drops into the notches be-

tween teeth on the plate 50, the brushes at the same time engaging successive sets of line terminals. The controller key 473 having been depressed, three such interruptions will follow before the circuit of relays 423 and 425 is again closed, the circuit being completed in this instance by the energization of relay 443. Relay 425 is energized as before and the controller sequence switch is thereupon caused to advance from the 13th position around to the 11th position again; and the line relay 103 being deënergized, its front contact 124 is opened and its back contact 121 is closed again, whereupon the circuit of the motor magnet 62 is opened and a circuit for the holding magnet 65 is closed by way of sequence switch contact 112, back contact 243 and said back contact 121 of line relay 103. The brush carriage is thus caused to stop with the brushes in contact with the third set of terminals in the 8th level. The sequence switch motor magnet 81 is energized at the same time in a circuit completed by way of sequence switch contact 102, back contact 243 and back contact 121, and the sequence switch moves from the 5th to the 9th position. The controller sequence switch in passing the 14th position in the meantime closes contact 408 which completes a circuit for the motor magnet 381 of the trunk line sequence switch, this circuit being completed from battery 312 by way of the winding of said motor magnet 381, sequence switch contact 305 and sequence switch contact 408. The trunk line sequence switch thereupon advances to the 10th position. It will be noted that the trunk line circuit is closed, however, as soon as the sequence switch reaches the 8th position and remains closed in the 9th and 10th positions.

In advancing from the 5th to the 9th position the selector sequence switch introduces various changes in the circuit by which the selected line is given a double test. In passing the 6th and 7th positions the first test is made, the circuit being closed from the neutral point of battery 109 through winding 236 of the marginal current test relay 232, sequence switch contact 209, winding of polarity test relay 231, test brush 25, test terminal 29 and cut-off relay 533 of the ordinary subscriber's line 501 to the positive or ground pole of battery 109. Under the present assumption that this line is not busy, this circuit will receive current from the full potential of the positive portion of battery 109 and relays 232 and 231 will be energized, whereupon a circuit is closed for energizing relay 233, this circuit being by way of battery 109, winding of relay 233, front contact 244 of relay 232, sequence switch contact 207 and front contact 245 of relay 231. Relay 233 then becomes locked in a circuit from battery 109, winding of relay 233, contact 246 of said relay and sequence switch contact 222. Relay 233 also closes a path in the test circuit by way of its contact 247 and winding 237 of relay 232, this path shunting windings 236 of relay 232 and the winding of relay 231. By reason of the low resistance of the shunt path just referred to, the potential at the test terminal 29 of the selector and other test terminals of other selectors connected in multiple therewith will be substantially lowered, thus creating a condition under which the line to which connection is now made will test busy to other selectors. The second test takes place while the sequence switch is in the 9th position, but, as under the present assumption, the locking relay 233 was operated in the first test period, nothing further happens during the second test period to determine the operation of the selector mechanism. In passing out of the 6th position the sequence switch opens the circuit of the holding magnet 65 of the selector, which circuit had been closed in the 5th position through the back contact 121 of the line relay. Before the 9th position is reached by the selector sequence switch, the trunk line is closed at contacts 306 and 307 so that line relay 103 is energized. Relay 233 having been locked in circuit as stated, a circuit is closed in the 9th position for the motor magnet 81 by way of sequence switch contact 201 and contact 248 of relay 233, the sequence switch thereupon advances to the 12th position, the circuit just traced being the means also of moving the sequence switch past the 11th position. In the 12th position of the sequence switch, the circuit for relay 231 is again closed at sequence switch contact 209—this in order to determine the polarity of ringing current when selection is made to a party telephone line. Under the present assumption this relay 231 would be energized in the 12th position, opening contact 259 and closing contact 249 connected to the positive pulsating current generator 235. A circuit is now completed from the positive pulsating generator 235 through said contact 249, resistance 250, sequence switch contact 217, brush 24, terminal 28, one wire of line 501, the signal bell and condenser at station 502, the return wire of said line, terminal 27, brush 23, sequence switch contact 214 and winding 251 of the ringing control relay 230. Current from this generator will operate the signal bell, but is too feeble to cause the energization of said relay 230. Upon the response of the subscriber to this signal, however, the current is strengthened by the closing of the low resistance path through the telephone apparatus at the substation and relay 230 is energized, whereupon a circuit is closed from battery 109 through sequence switch contact 225, contact 254 of relay 230, lock-

ing winding 253 of said relay, supervisory relay 228, winding 107 of the repeating coil 109 and battery 229 to ground, relay 230 remains energized in said circuit until the sequence switch passes out of the 12th position. The supervisory relay 228 is energized, completing a circuit for the motor magnet 81 of the sequence switch by way of sequence switch contact 218 and contact 264 of the supervisory relay 228. The sequence switch thereupon moves out of the 12th position and into the 13th or talking position, the supervisory relay 228 remaining energized in the circuit of the called line which is closed in the 13th position at contacts 216 and 113.

In the 13th position of the sequence switch, contact 219 is closed, thereby completing a circuit for the battery control relay 239, which removes battery 109 from the circuit of the trunk line and closes this circuit again without battery through its front contacts 262 and 263. The circuit of the trunk line being now free from battery, line relay 103 is deënergized. In fact, relays 239 and 103 are practically operated together, the former opening contact 243 and closing contact 255, while the latter opens contact 124 and closes contact 121. The circuit of the motor magnet 81 is, therefore, not affected and the sequence switch remains in the 13th position.

The talking circuit may be traced as follows: One section leads from battery 319 through windings 322 of repeating coil 320 to the calling telephone line (this line not being shown); the trunk section includes relay 323, winding 321 of repeating coil 320, conductor 105, winding 106 of repeating coil 108, contacts 263 and 262 of battery control relay 239, line relay 103 shunted by condenser 256, another winding 106 of repeating coil, 108, sequence switch contact 210, conductor 104, another winding 221 of repeating coil 320 and sequence switch contacts 306 and 307, this section being free from any source of steady current, but inductively united by repeating coils with the other sections. The third section of the talking circuit may be traced as follows: battery 229, winding 107 of repeating coil 108, supervisory relay 228, sequence switch contact 216, brush 24, terminal 28, one wire of line 501, telephone apparatus at substation 502, return wire of line 501, terminal 27, brush 23, sequence switch contact 113 and another winding 107 of repeating coil 108 to ground. In this 13th position of the sequence switch, the brush selector is returned to normal position, a circuit being completed for the motor magnet 68 through sequence switch contact 205, contact 59 and arm 56. When the shaft 40 reaches normal position the free end of the arm 56 drops into the deep notch in the star wheel and opens the circuit at contact 59, whereupon the shaft comes to rest.

When the called subscriber replaces his receiver on its switch hook at the end of the conversation the line circuit is opened, causing supervisory relay 228 to be deënergized, whereupon the circuit of the battery control relay 239 is opened at contact 264 of said supervisory relay, battery 109 is again included in the circuit of the trunk line, and line relay 103 is energized. Relay 323 at the controller end of the trunk line is also energized and closes the local circuit of the supervisory lamp signal 318. This indicates to the operator that the called subscriber has hung up his telephone. In response to the lighting of supervisory lamp signal 318, the operator may cause switch 314 to be closed, which completes a circuit for motor magnet 381 by way of sequence switch contact 308. The sequence switch for the trunk line thereupon moves out of the 10th position and advances to the 15th. In passing out of the 10th position the circuit of the trunk line is opened at contacts 306 and 307, whereupon line relay 103 at the selector is deënergized. The battery control relay 239 being also deënergized at this time, a circuit is completed for the motor magnet 81 of the selector sequence switch by way of sequence switch contact 102, back contact 243 of the battery control relay 239 and back contact 121 of line relay 103. The sequence switch thereupon advances to the 16th position, the circuit for the motor magnet 81 just traced being the means also of causing the sequence switch to pass by the 14th position. Upon entering the 14th position, the circuit for the locking relay 233 will be opened at sequence switch contact 222. It will be noted that, although contact 221 is closed before contact 222 is opened, there is no path completed for relay 233 by way of contact 221 in this instance, for the reason that line relay 103 is deënergized and its front contact 124 is at this time open. The deënergization of relay 233 causes the opening of the test circuit through winding 237 of relay 232 so that this relay is also deenergized. The immediate result of the opening of the test circuit is the removal of the busy test condition at the line of the connected subscriber. Upon reaching the 16th position, the sequence switch closes a circuit for the selector motor magnet 62 by way of sequence switch contact 114, back contact 257 of relay 232, sequence switch contact 208 and contact 258 of relay 231. The brush carriage of the selector is thereupon moved around to normal position and when this position is reached, a circuit is closed for relay 232 from neutral point of battery 109, winding 236 of relay 232, sequence switch contact 215, the normal stop plate 46 of the selector and levers 42 and 43

to ground through the frame of the selector, whereupon relay 232 is energized, opening the circuit of the motor magnet 62 at its back contact 252 and closing a circuit for the holding magnet 65 at its front contact 244, this latter circuit being completed by way of sequence switch contact 206. The energization of relay 232 also completes a circuit for relay 233, this circuit including battery 109, front contact 244 of relay 232, sequence switch contact 208 and contact 258 of relay 231. Relay 233 thereupon closes a circuit for the motor magnet 81 of the sequence switch by way of sequence switch contact 201 and contact 248 of relay 233. The sequence switch is thus caused to move out of the 16th position and to be returned to normal. The holding magnet remains energized in the 16th and 17th positions of the sequence switch. In passing out of the 17th position, the circuit for relay 232 is opened at sequence switch contact 215. Relay 233 is released in the 18th position by the opening of sequence switch contacts 208 and 222.

It will be noted that the sequence switch contacts 211 and 212 maintain their circuits about the windings 106 of repeating coil 108 during the periods (positions 2 and 5) in which the impulse sending operations occur. The trunk line conductors 104 and 105 are closed by way of windings 106, while the sequence switch is in positions 6 to 14 inclusive, one side, conductor 104, being closed during this period by way of contact 210. Upon leaving the 14th position, a short circuit of the trunk line is closed at sequence switch contact 213. This short-circuit serves to prevent the closure of contacts 309 and 310 of the trunk line sequence switch from causing the operation of line relay 103 at the selector. Upon leaving the 18th position, the short circuit is removed and relay 323 at the controlling end of the trunk line is energized, whereupon a circuit is established for motor magnet 381 of the trunk line sequence switch by way of sequence switch contact 311 and the back contact 315 of said relay 323. The sequence switch thereupon moves out of the 15th position and returns to normal. When the selector sequence switch reaches the 17th position, a local test wire circuit is closed at sequence switch contact 227, this circuit including resistance 257 and certain electromagnetic devices 490 which may be associated with a selector immediately preceding the final switch and which may be the means of starting the restoring operation for such selectors.

Selection of non-busy private branch exchange line.—Let it now be assumed that the operator had caused the actuation of controlling switches 458 and 475 for the purpose of causing the final switch mechanism to make connection with one of a plurality of lines, say line 509 leading to private branch exchange 508 (subscriber No. 74). The terminals for this line are located in the 8th level and in the fifth range on the final switch and the mode of operation of the mechanism up to the time that the selector sequence switch leaves the fifth position is the same as that already described except that the brushes 23, 24 and 25 will be caused to move to the fifth set of line terminals in the 8th level instead of the third set as under the previous assumption. The test terminal 29 of this set is connected to the negative pole of battery 109 and as it is assumed that the line is not busy, the potential existing at that terminal when the test brush 25 makes connection therewith is high. Therefore, as the sequence switch is passing the 6th and 7th positions (the first test period), in which the test circuit is closed at contact 209, relay 232 is energized, but relay 231 is not energized, the latter being unaffected by negative current. The local circuit for locking relay 233 is therefore not closed. When, however, the sequence switch reaches the 9th position the second test period begins the test circuit being again closed at contact 209, and a circuit is completed for relay 233 by way of front contact 244 of relay 232, sequence switch 208 and normal contact 258 of relay 231. Relay 233 is therefore energized and becomes locked in a circuit closed at front contact 246 of said relay 233 and sequence switch contact 222. The connected line 509 is now caused to test busy to other selectors by reason of the closure of the low resistance shunt path in the test circuit by way of contact 247 or relay 233 and winding 237 of relay 232. The opening of back contact 257 of relay 232 prevents the motor magnet 62 of the selector from being energized to advance the selector for hunting over the terminals of the other lines leading to the private branch exchange 508. The sequence switch is now caused to leave the 9th position by reason of the closure of contact 248 of relay 233 and the mode of operation which follows is the same as that previously described, when the connection had been assumed to be made to a non-busy ordinary line, except that in the 12th, the ringing position of the sequence switch, the polarity test relay 231 is not energized and the negative pulsating generator 234 instead of the positive pulsating generator 235 is included in the ringing circuit of the called line. It may be noted in this connection that the modes of operation of the switch mechanism which would occur upon selection of non-busy party line subscribers are precisely the same as those which occur upon the selection of non-busy ordinary lines and non-busy private branch exchange lines, because

the test terminals for certain subscribers (for example Nos. 73 and 79) of party lines are connected to positive battery like the test terminals of ordinary lines and the test terminals of certain other subscribers (for example, Nos. 71 and 78) of party lines are connected to negative battery like the test terminals of private branch exchange lines. The operation or non-operation of the polarity test relay 231 in the 12th position of the sequence switch is made use of in party line ringing to connect a generator adapted to operate selectively the signal bell of the wanted party line subscriber.

Selection of busy ordinary subscriber's line.—Let it now be assumed that the selected line is that of a busy ordinary subscriber. The test terminal 29 would therefore have a low positive potential, and when the test circuit is closed in the 6th and 7th positions (the first test period) and the 9th position (the second test period) of the sequence switch, relay 232 does not receive sufficient current to cause its energization. Relay 231, however, is energized and when the sequence switch reaches the 9th position, a circuit is closed for the motor magnet 81 of the sequence switch by way of contact 201 and front contact 245 of relay 231, whereupon the sequence switch advances from the 9th to the 11th position. In the 10th and 11th positions of the sequence switch the circuit of relay 231 is open at sequence switch contact 209 and said relay 231 is therefore deenergized so that in position 11, a circuit is completed for the motor magnet 62 of the brush carriage by way of sequence switch contact 114, back contact 252 of relay 232, sequence switch contact 208, and normal contact 258 of relay 231. The brush carriage of the selector is thereupon caused to move around to its normal position, a circuit then being closed for relay 232 from the neutral pole of battery 109, through winding 236 of relay 232, sequence switch contact 215, the normal stop plate 46 of the selector and levers 42 and 43 thereof to ground through the frame of the switch mechanism. Relay 232 is energized in this circuit and operates to complete a circuit for relay 233 by way of its front contact 244, sequence switch contact 208 and normal contact 258 of relay 231. Relay 233 is therefore energized and closes its locking circuit by way of contacts 246 and 222. Contact 248 of relay 233 is also closed, whereupon a circuit is completed for the motor magnet 81 of the sequence switch by way of sequence switch contact 201. The opening of back contact 257 of relay 232 breaks the circuit for the motor magnet 62 of the brush carriage and the closing of front contact 244 of said relay 232 closes at the same time a circuit for the holding magnet 65, this latter circuit being completed by way of sequence switch contact 206, said front contact 244, sequence switch contact 208 and normal contact 258 of relay 231. The switch carriage is thereupon caused to stop in its normal position, the function of the holding magnet being as before to check the movement of the brush carriage suddenly upon the removal of motor power for driving it. The circuit of the holding magnet 65 remains closed while the sequence switch is passing positions 11 and 12. A circuit for the motor magnet 81 being closed by relay 233, the sequence switch advances from the 11th to the 14th position in which a busy back signal is given to indicate that the line desired is busy. In the 12th and 13th positions of the sequence switch, the circuit of relay 232 is open at sequence switch contact 215. This relay is therefore deënergized when the sequence switch leaves the 11th position. Relay 233, however, remains energized in its locking circuit by way of its front contact 246 and sequence switch contact 222 until the sequence switch arrives at the 14th position wherein relay 233 may remain energized for a moment in the circuit completed by way of its front contact 246, sequence switch contact 221 and front contact 124 of line relay 121. Upon reaching the 13th position, the sequence switch closes contact 205 to return the brush selector to normal. In the 14th position relay 232 is again energized in the circuit heretofore traced, which is completed by way of sequence switch contact 215. Finally, in the 14th position of the sequence switch, the busy back interrupter 238 is brought into circuit with the battery control relay 239 by the closing of sequence switch contact 220. This interrupter causes intermittent energization of said relay 239, whereupon current from battery 109 is intermittently applied to the circuit of the trunk line conductors 104 and 105. The battery control relay 239 and the line relay 103 are affected practically in unison so that the operation of the sequence switch is not effected to cause its advance from the 14th position. The intermittent application of current in the trunk line merely causes flashing of the supervisory lamp signal 318. The local circuit for test relay 233 will be opened at the front contact 124 of the line relay 103 and said relay 233 will be deenergized as soon as the busy back interrupter closes the circuit of the battery control relay 239.

In response to the flashing of the supervisory lamp signal 318 the operator may bring about restoration of the apparatus by causing switch contact 314 at the controller end of the trunk line to be closed. This completes a circuit for motor magnet 381 by way of sequence switch contact 308 and causes the sequence switch associated with the trunk line to be moved from the 10th to

the 15th position thereof. Upon leaving the 10th position, the circuit of the trunk line is opened at contacts 306 and 307, whereupon line relay 103 at the selector end of the trunk line will not be energized by current from battery 109 when the busy back interrupter 238 next opens the circuit of battery control relay 239, and a circuit will be established for motor magnet 81 of the selector sequence switch by way of sequence switch contact 102, back contact 243 of relay 239 and back contact 121 of line relay 103. The selector sequence switch is thus caused to move out of the 14th position and is returned to normal.

In passing the 16th position, a circuit is closed for the motor magnet 81 by way of sequence switch contact 201 and contact 248 of relay 233, this relay being energized at that time in a circuit completed by way of front contact 244 of relay 232, sequence switch contact 208 and normal contact 258 of relay 231. Said relay 232 was energized in the 14th position by reason of the closure of sequence switch contact 215. The restoration of the sequence switch mechanism at the controller end of the trunk line follows in the manner heretofore described.

Selection of busy private branch exchange line.—Let it be assumed now that selection is made to connect the brushes with the terminals of the first line 509 of a group of lines leading to private branch exchange 508 and that this line is busy. The potential at the test terminal 29 would therefore be low negative and the closing of the test circuit in the 6th, 7th and 9th positions of the sequence switch would fail to cause the energization of either of the test relays 231, 232. Therefore in the 9th position a circuit is established for the motor magnet 62 of the brush carriage by way of sequence switch contact 114, back contact 252 of relay 232, sequence switch contact 208 and normal contact 258 of relay 231. The brush carriage thereupon moves the brushes over the next succeeding terminals of the group of private branch exchange lines. This occurs while the sequence switch remains in the 9th position and therefore during the second test period, the operation being referred to as "private branch exchange hunting." The test circuit remains closed by way of sequence switch contact 209 and each line is tested as brush 25 makes contact with the test terminal 29 of such line, the movement of the brush carriage continuing until a non-busy line is reached. Such a line would have high negative potential at the test terminal so that relay 232 would be energized and cause the brush carriage to stop, by opening the circuit of motor magnet 62 at its back contact 252 and closing a circuit of the holding magnet 65 at its front contact 244. Thus if any one of the lines leading to the private branch exchange is idle, connection will be made to that line. The mode of operation which follows is the same as that which occurs when connection is made to the first private branch exchange line. In case all of the lines leading to a private branch exchange to which connection is desired are busy, the movement of the brush carriage will continue until the brushes pass beyond the last set of private branch exchange terminals, whereupon connection will be made by said brushes to the terminals of a line leading to some other substation. According to the arrangement heretofore outlined and represented in Fig. 3, the terminals next succeeding a group of private branch exchange terminals will be those of an ordinary line or those of a party line, the test terminal of which is connected to the ground or positive pole of the battery. Obviously the line to which connection is thus made may be in the busy or idle condition, but in either case it is necessary and the apparatus is so arranged that the switch carriage will be caused to stop momentarily with the brushes resting upon said terminals, but without causing a disturbance in the circuit of said line. And the apparatus is arranged so that the brush carriage will almost immediately, however, be returned to normal position and the busy back signal given to indicate that the group of private branch exchange lines are busy. Let it be assumed first that the potential at the line test terminal next succeeding the terminals of a group of busy private branch exchange lines is high positive, this being the condition when the line is idle. It will be remembered that the test circuit is closed at contact 209 in the 9th position of the sequence switch. Relays 231 and 232 will therefore be energized the moment the test brush 25 touches the test terminal 29 of such a line. Relay 233, however, is not energized because contact 258 of relay 231 is open. The energization of relays 231 and 232 will cause the brush carriage to be stopped momentarily by opening the circuit of the motor magnet 62 at contacts 252 and 258. And the energization of relay 231 will also cause a circuit to be closed for the motor magnet 81 of the sequence switch by way of contact 201 and contact 245 of relay 231, whereupon the sequence switch is caused to move from the 9th to the 11th position, in which a circuit is again closed for the motor magnet 62 of the sequence switch by way of back contact 252 of relay 232, sequence switch contact 208 and normal contact 258 of relay 231. Relays 231 and 232 were deënergized upon the opening of the test circuit at contact 209 when the sequence switch left the 9th position. The brush carriage is now returned to normal position, the busy back signal given, the remain-

ing operations being the same as those which occur upon the selection of a busy ordinary line. If the test terminal next succeeding the terminals of the group of busy private branch exchange lines should have a low positive potential, which condition would exist if the line were busy, relay 232 would not be energized upon the closing of the test circuit, but relay 231 would be energized, opening the circuit of motor magnet 62 of the brush carriage at contact 258 and closing the circuit for motor magnet 81 of the sequence switch at contact 245. The sequence switch would therefore be caused to move out of the 9th position and the remaining operations would be the same as those which occur upon the selection of a busy ordinary line.

The apparatus associated with the final switch is arranged not only to cause restoration of the switch in the event of a selected line being busy, or after a successful connection has been obtained, but also to cause restoration under certain other conditions which will be considered under the following headings:

1. Restoration before ringing.
2. Restoration during ringing period.
3. Restoration during conversation period.

Restoration before ringing.—If the operator, after setting up a condition at the controller adapted to cause a particular selecting operation to take place, should desire to reset the controller, for the purpose say of correcting the mistake, she may prevent the final switch mechanism from completing the operation which had been started and cause the switch and its apparatus to be returned to normal condition; in other words, she may "wipe out" a connection already set up and establish a new condition at the controller adapted to cause a new series of selecting operations to take place. The simple act of opening the trunk line circuit under the several conditions to be considered will accomplish the restoration desired. Let it be assumed, for example, that the operation at the final switch had proceeded up to the time that the brush selector was in motion and that the operator then caused switch contact 314 to be closed, thereby causing the sequence switch to leave the 6th position and to open the circuit of the trunk line at contacts 303 and 304. The immediate result will be the deenergization of line relay 103, whereby the circuit of the motor magnet 68 of the brush carriage will be open at front contact 124 of the line relay and the circuit of the motor magnet 81 of the sequence switch will be closed by way of back contact 121 of said relay, back contact 243 of the battery control relay 239 and sequence switch contact 102. It will be remembered that the sequence switch was in the second position during brush selection, so that it will now be moved out of that 2nd position and into the 5th. Upon reaching the 5th position, the circuit for the motor magnet 81 will remain closed by way of contacts 102, 243 and 121, the line relay 103 not being energized again while the sequence switch is moving from the 2nd to the 5th position, as it is under normal operating conditions. The sequence switch will therefore not stop at the 5th position, but will advance to the 9th. In the 6th position, relay 232 is energized in a circuit from the neutral pole of battery 109, winding 236 of said relay 232, sequence switch contact 215, normal stop plate 46 and levers 42 and 43 to ground, and relay 232 will remain energized in this circuit until the sequence switch leaves the 11th position. In the 9th position, a circuit will be closed for relay 233 by way of front contact 244 of relay 232, sequence switch contact 208 and normal contact 258 of relay 231. Relay 233 will thereupon be energized and close a circuit for the motor magnet 81 of the sequence switch by way of sequence switch contact 201 and contact 248 of said relay 233. The movement of the sequence switch will thus continue past the 9th position and in the same way it will be caused to move past the 11th position. In the 12th and 13th positions, the circuit for relay 232 is open at sequence switch contact 215 so that this relay closes its back contact 257 and the sequence switch is caused to move past the 12th and 13th positions by the closure of a circuit for motor magnet 81 through contact 202, back contact 252 of relay 232, sequence switch contact 208 and normal contact 258 of relay 231. It will be noted that a second path may be closed for motor magnet 81 in the 12th and 13th positions, this path being completed by way of sequence switch contact 102 and back contacts 243 and 121 of relays 239 and 103 respectively. This latter circuit is the means of causing the sequence switch to move past the 14th position. In positions 14 to 17 inclusive the circuit previously traced for relay 232 is closed by sequence switch contact 215. In the 16th position, relay 233 is again energized in a circuit closed by way of front contact 244 of said relay 232, sequence switch 208 and contact 258 of relay 231. The sequence switch is therefore moved past position 16 by the closing of a circuit for its motor magnet 81 as sequence switch contact 201 and contact 248 of said relay 233. After passing the 16th position, the sequence switch runs to normal under the control of the special contact 101. It should be noted that the brush selector was sent to normal in the manner before described when the sequence switch reached the 13th position. Under the condition assumed, the brush carriage did not leave its normal position.

It may be that the circuit of the trunk line is opened at contacts 303 and 304, while the brush carriage is in motion. In such event the brush carriage may be caused to stop with the brushes resting in contact with the terminals of any one of the several kinds of subscribers' lines; and these lines may be either idle or busy. The test terminal of such a line may therefore be under one of four conditions. Its potential may be high positive, high negative, low positive or low negative. If the potential is high positive, the operation will be as follows: The opening of the trunk line circuit causes line relay 103 to be deënergized and as the sequence switch is in the 5th position during the movement of the switch carriage, a circuit will be closed for the motor magnet 81 of the sequence switch by way of sequence switch contact 102, back contact 243 of relay 239 and back contact 121 of relay 103 and the sequence switch will advance to the 9th position. The test circuit is closed at contact 209 in the 6th, 7th and 9th positions and the testing operations follow in the same manner as in the normal operation of selecting an idle ordinary subscriber's line. In the 9th position, a circuit is closed for motor magnet 81 of the sequence switch by way of sequence switch contact 201 and contact 248 of relay 233. In the 10th position the locking circuit of relay 233 would ordinarily remain closed by way of sequence switch contact 221 and the front contact 124 of line relay 103, but in the present instance line relay 103 is deënergized, its front contact 124 being open, and relay 233 is therefore released. Relay 232 is also released by the opening of contact 247 of relay 233 and when the sequence switch reaches the 11th position a circuit is completed for motor magnet 62 of the brush carriage by way of sequence switch contact 114, back contact 257 of relay 232, sequence switch contact 208 and normal contact 258 of relay 231. The switch carriage is thereupon caused to move around to normal position, the remaining operations being the same as those which follow the testing of a busy line, except that when the sequence switch reaches the 14th position, it does not stop to give a busy back signal, but continues its advance movement to normal. The circuit of this motor magnet 81 is closed in the 14th position by way of the circuit previously traced, including the back contact 121 of line relay 103. Substantially the same sequence of events occurs in case the brush carriage is prematurely stopped with the test brush in contact with a test terminal having high negative potential. On reaching the 9th position, the motor magnet 81 of the sequence switch remains energized in a circuit closed at contact 248 of relay 233 and the whole apparatus is restored to normal in the manner already described. If the brush carriage had been caused to stop prematurely with the test brush in contact with a test terminal having low positive potential, the motor magnet 81 of the sequence switch would remain energized in a circuit including contact 245 of relay 231 and sequence switch contact 201. The sequence switch would then advance to the 11th position wherein the circuit for the motor magnet 62 of the brush carriage would be closed as before and the apparatus restored to normal. If the brush carriage has been stopped prematurely with the test brush in contact with a test terminal having low negative potential, this being the condition which would ordinarily cause private branch exchange hunting, the sequence switch will advance to the 9th position as before. Relays 231 and 232 will not be energized, however, and a circuit for the motor magnet 62 of the brush carriage will be closed by way of sequence switch contact 114, back contact 252 of relay 232, sequence switch 208 and normal contact 258 of relay 231. The result will be a movement of the brushes over the terminals just as in private branch exchange hunting, the brush carriage presently being stopped with the test brush thereof in contact with a test terminal which has one of three conditions, viz., high positive, high negative and low positive. The sequence switch will thereupon in any case be caused to move out of the 9th position, because either relay 232 or relay 231 or both will be energized and a circuit will be established for the motor magnet 81. In the 10th position, relay 233 will be deenergized by reason of the open front contact 124 of line relay 103. The restoration of the apparatus follows in the manner already described.

Restoration during ringing period.—If the ringing generator is connected in circuit with the called line but the subscriber has not answered the call, the sequence switch being at the time in the 12th position, restoration of the apparatus will follow the closing of switch contact 314 at the controller end of the trunk line in the following manner: A circuit is closed for the motor magnet 381 of the trunk line sequence switch and said sequence switch will be advanced from the 10th to the 15th position. The opening of the trunk line at contacts 306 and 307 when the sequence switch leaves the 10th position will cause line relay 103 to be deenergized, whereupon a circuit will be closed for motor magnet 81 by way of sequence switch contact 102, back contact 243 of relay 239 and back contact 121 of line relay 103. The sequence switch will then advance to the 16th position in which the switch carriage will be returned to normal, in the usual way.

Restoration during the conversation pe-

riod.—During the conversation period the sequence switch of the selector is in the 13th position, battery control relay 239 is energized and line relay 103 is deënergized, the circuit of the trunk lines 104 and 105 being free from flow of battery current. If at this time switch contact 314 is closed to restore the apparatus, the trunk line sequence switch will run from the 10th to the 15th position. Upon leaving the 10th position nothing will happen at the final switch, but when the 14th position is reached, current from battery 312 will flow over the trunk line by way of the following circuit: from battery 312, through contact 310, winding of relay 323, winding 321 of repeating coil 320, conductor 105, winding 106, repeating coil 108, contacts 263 and 262 of battery control relay 239, winding of relay 103, winding 106 of repeating coil 108, sequence switch contact 210, conductor 104, winding 321 of repeating coil 320 and sequence switch contact 309 to the ground pole of battery 312. Line relay 103 will thereupon be energized and a circuit will be closed for the motor magnet 81 by way of sequence switch contact 102, front contact 255 of relay 239 and front contact 124 of relay 103. The restoration of the apparatus will follow in the manner already described.

I claim:

1. The combination with a selector, a test circuit therefor, means for closing said test circuit during two periods to make a double test, and mechanism for controlling said selector adapted to respond in a different manner to current flow in said circuit during said two periods.

2. The combination with a selector, a test circuit therefor and a responsive device included in said circuit, of an apparatus controlled in two modes by said responsive device, means for closing said test circuit, and means for governing the mode of control of said apparatus by said responsive device.

3. The combination with a selector, a test circuit therefor and a responsive device included in said circuit, of an apparatus controlled by said responsive device, means for maintaining said test circuit closed during several periods, and means operating to change the mode of control of said apparatus by said responsive device in one of said periods.

4. The combination with a selector, a test circuit therefor and two responsive devices included in said circuit, of an apparatus jointly controlled by said responsive devices, means for maintaining said test circuit closed during several periods, and means operating to vary the mode of control of said apparatus by said responsive devices in said periods.

5. The combination with a selector, a test circuit therefor and two responsive devices included in said circuit, each of said devices being responsive to current of a particular characteristic, of an apparatus controlled jointly by said responsive devices, means for closing said test circuit, and means adapted to change the mode of control of said apparatus by said responsive devices.

6. The combination with a selector, a test circuit therefor and two responsive devices included in said circuit, each of said devices being responsive to current of a particular characteristic, of a local circuit controlled jointly by said responsive devices, an apparatus included in said local circuit, means for closing said test circuit and switching mechanism adapted to change the condition of said local circuit to vary the mode of control of said apparatus by said responsive device.

7. The combination with a selector and a test circuit therefor including a relay, of a local circuit controlled by said relay, and a switch adapted to change the condition of said local circuit during the closure of said test circuit to vary the mode of control of said local circuit by said relay.

8. The combination with a selector, a test circuit therefor and two relays included in said circuit, of a switching device adapted in its operation to maintain said test circuit closed during several periods, a local circuit jointly controlled by said relays, and means operating in unison with said switching device and adapted to change the condition of said local circuit during the closure of said test circuit to vary the mode of control of said local circuit by said relays.

9. The combination with a selector, a test circuit therefor and two relays included in said circuit, of a switching device adapted in its operation to maintain said test circuit closed during two periods, a local circuit jointly controlled by said relays, and means operating in unison with said switching device adapted to change the condition of said local circuit in one of said periods to reverse the mode of control thereof by one of said relays.

10. The combination with a selector, a test circuit therefor and two relays included in said test circuit, one of said relays being responsive to current of one direction and the other to current of a given strength, of a switching device adapted to maintain said test circuit in operative condition during several periods, and a local circuit jointly controlled by said relays, said switching device having an element adapted in its movement to change the condition of said local circuit.

11. The combination with a selector, a test circuit therefor and two relays included in said circuit, of a device jointly controlled by said relays, and switching mechanism adapted in its movement to maintain said

test circuit closed during several periods and to change the mode of control of said device by one of said relays in one of said periods.

12. The combination with a selector, a test circuit for said selector and two test relays included in said circuit, of a sequence switch adapted in its operation to maintain said test circuit closed during several periods, a local circuit jointly controlled by said relays, and a third relay controlled by said local circuit, said sequence switch having an element adapted in the movement of the switch to change the condition of said local circuit in said periods, whereby the mode of control of said third relay by said test relays is different in the several periods.

13. The combination with a selector having stationary test terminals and a movable test terminal, of a source of current of positive potential connected to some of said stationary terminals, a source of current of negative potential connected to other of said stationary terminals, a test circuit conductor connected to said movable terminal, a polarized relay included in said circuit, switching mechanism adapted to maintain said conductor closed during several test periods, a device controlled by said relay, and means adapted to change the operative relation of said relay to said responsive device, whereby the mode of control of said device is different in said test periods.

14. The combination with a selector and a test circuit therefor including a relay, of a second relay, a sequence switch and an operating magnet for said sequence switch, said second relay and said operating magnet being arranged to be controlled in local circuits closed by the energization of the first mentioned relay, and said sequence switch being adapted to change the condition of said local circuits to shift the control of said second relay from said first mentioned relay to said operating magnet.

15. The combination with a selector, a motor magnet therefor and a test circuit, of two test relays in said circuit, a sequence switch, a motor magnet for said sequence switch, a locking relay, a local circuit for said locking relay adapted in one position of said sequence switch to be closed upon the joint energization of said two test relays, a local circuit for the selector motor magnet and a local circuit for the sequence switch motor magnet, said last mentioned local circuits being adapted in other positions of said sequence switch to be closed through alternate contacts respectively of one of said test relays.

16. The combination with a selector, a test circuit therefor and a test relay in said circuit, of a local circuit controlled by said relay, said local circuit having a plurality of branches, a locking relay in one branch of said local circuit, a sequence switch, a motor magnet for said sequence switch in another branch of said local circuit, said sequence switch being arranged to close said test circuit and to change the local circuit during said closure to reverse the mode of control of said locking relay by said test relay and also to place said motor magnet under the control of said test relay and of said locking relay.

17. The combination with a selector, a test circuit of high resistance, a polarity test relay and a marginal test relay, each of said relays having a winding included in said circuit, of a locking relay jointly controlled by said test relays, and a low resistance path controlled by said locking relay adapted to be placed in shunt of said test circuit.

18. The combination with a selector, a test circuit of high resistance, a polarity test relay and a marginal current test relay, each of said relays having a winding included in said circuit, a locking relay jointly controlled by said test relays, and a low resistance path controlled by said locking relay adapted to be placed in shunt of said test circuit, said low resistance path including a winding of said marginal test relay.

19. The combination with a selector, a test circuit therefor and two test relays, each of said relays having a winding included in said circuit and each being adapted to respond to current of a particular characteristic, of a third relay in a local circuit jointly controlled by said test relays, a ringing generator, means under the control of said third relay adapted to bring into operation said ringing generator, a "busy back" device, and means under the control of one of said test relays adapted to bring into operation said busy back device.

20. The combination with a selector, a test circuit therefor and two test relays, each having a winding included in said circuit and each being responsive to current of a particular characteristic, of a locking relay in a local circuit jointly controlled by said test relays, a "busy back" device and a ringing generator, means actuated by one of said test relays when energized adapted to bring into operation said busy back device, and means actuated by said locking relay when energized to prevent the operation of said busy back device and to bring into operation said ringing generator.

21. The combination with a trunk line, a selector for extending the circuit of said trunk line to other lines, a test circuit for said selector and a relay included in said circuit, of a restoring device for said selector controlled by said relay through a back contact thereof, a sequence switch adapted to be controlled by a circuit including the front contact of said relay, and a busy back signaling apparatus adapted to be brought into operation by said sequence switch.

22. In a telephone exchange system, the combination with a selector adapted to make connection with ordinary and special lines, of means for causing said lines to test busy to said selector, a busy signal and means adapted to bring said busy signal into operation upon connection being made by the selector to an idle ordinary line after a test of a group of busy special lines.

23. In a telephone exchange system, the combination with a selector adapted to make connection with ordinary and special lines, of test terminals for said lines, the connections to the test terminals of all ordinary lines being of one kind and of all special lines of another kind, a test conductor and test brush associated with the selector, said conductor being arranged to form a test circuit with any of said connections upon contact of said test brush with the corresponding test terminal, means for causing the selector to test in succession and to move the test brush by the test terminals of a group of busy special lines, and means for preventing the selector from completing a connection with an ordinary line after testing said group of special lines.

24. In a telephone exchange system, the combination with a selector adapted to make connection with ordinary and special lines, of test terminals for said lines, the connections of the test terminals of all ordinary lines being to a source of current of opposite potential to that of the test terminals of all special lines, a testing device adapted to be brought into circuit with the test terminals of said lines, motor mechanism for said selector, said testing apparatus being adapted upon connection being made to a busy ordinary line to operate said busy signal and upon connection being made to a busy special line to operate said motor mechanism to cause the selector to hunt for an idle special line, and means under the control of said testing apparatus upon connection being made to either a busy or an idle ordinary line, after hunting for an idle special line, to operate said busy signal.

25. In a telephone exchange system, the combination with a selector adapted to make connection with the terminals of subscribers' lines and terminals of a group of trunk lines leading to a sub-exchange, of means for causing said lines to test busy to said selector, a busy signal, and means adapted to bring said busy signal into operation upon connection being made by the selector to the terminals of an idle one of said subscribers' lines after the terminals of said group of trunk lines have been tested and the trunks found busy.

In witness whereof, I hereunto subscribe my name this 22nd day of July A. D. 1910.

FRANK R. McBERTY.

Witnesses:
MORGAN WASHBURN, JR.,
GUY M. CAMPBELL.