F. R. McBERTY.

TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED DEC. 4, 1909.

1,108,383.

Patented Aug. 25, 1914.

5 SHEETS—SHEET 1.

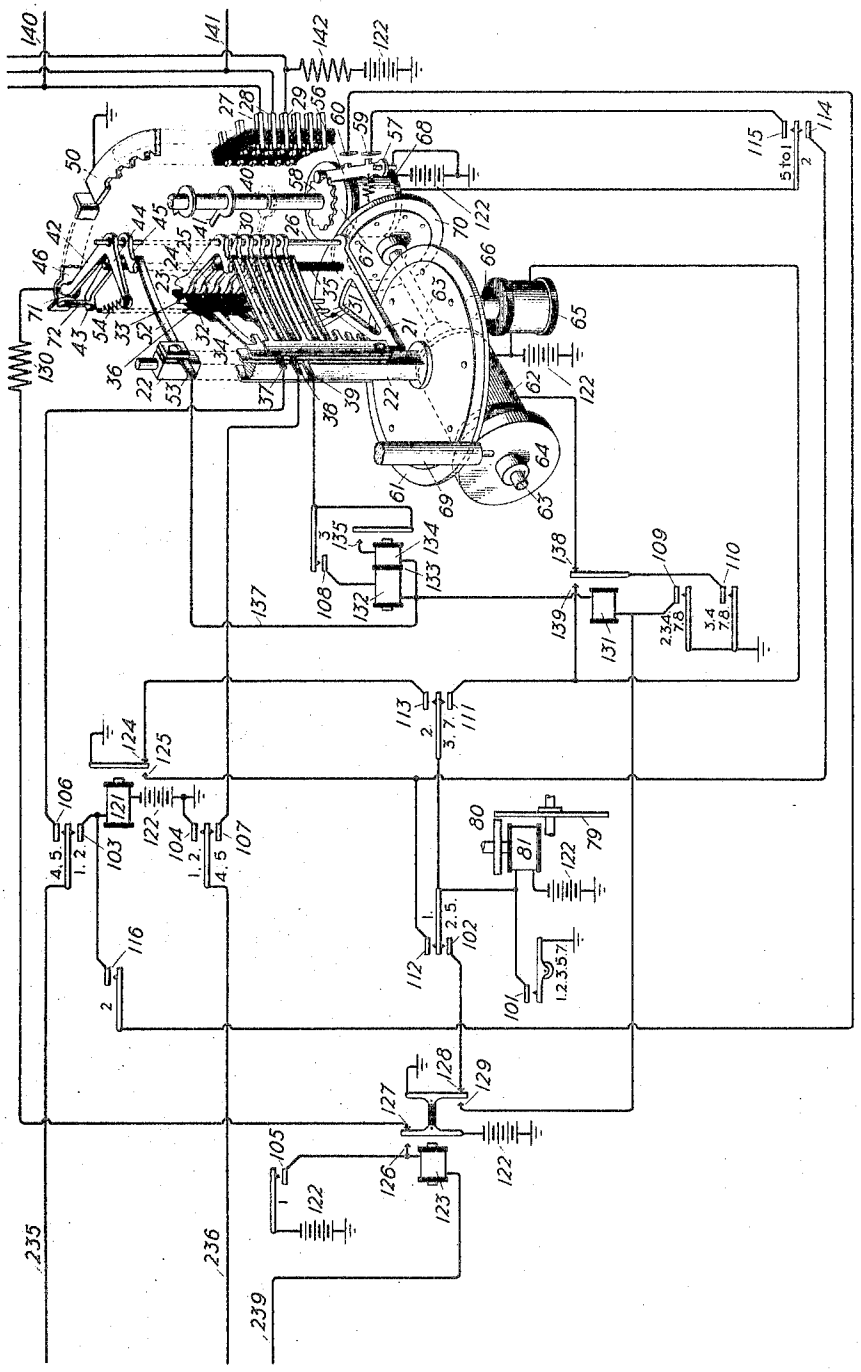

Fig. 1.

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5 SHEETS—SHEET 2.

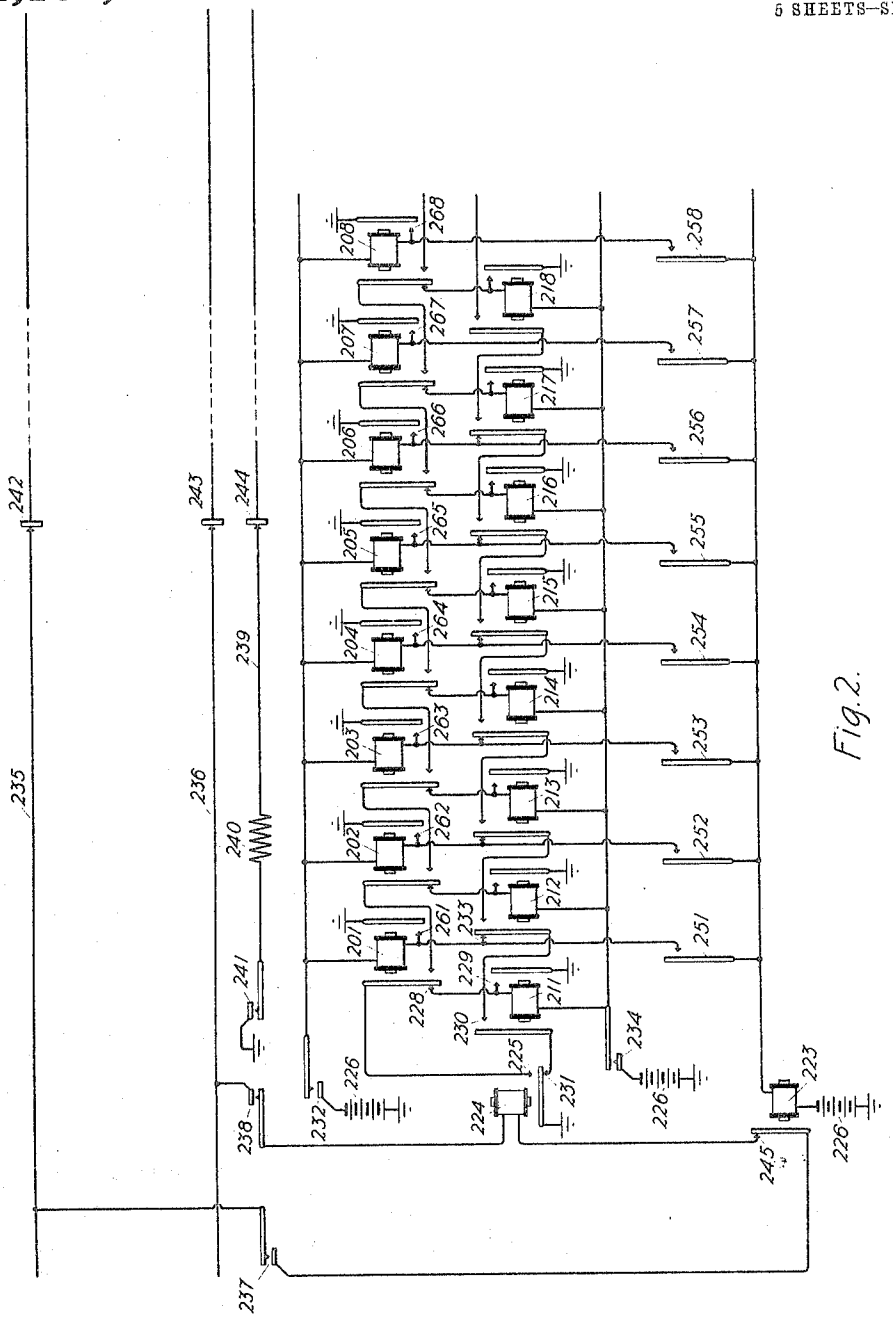

Fig. 2.

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5 SHEETS—SHEET 3.

Fig. 3.

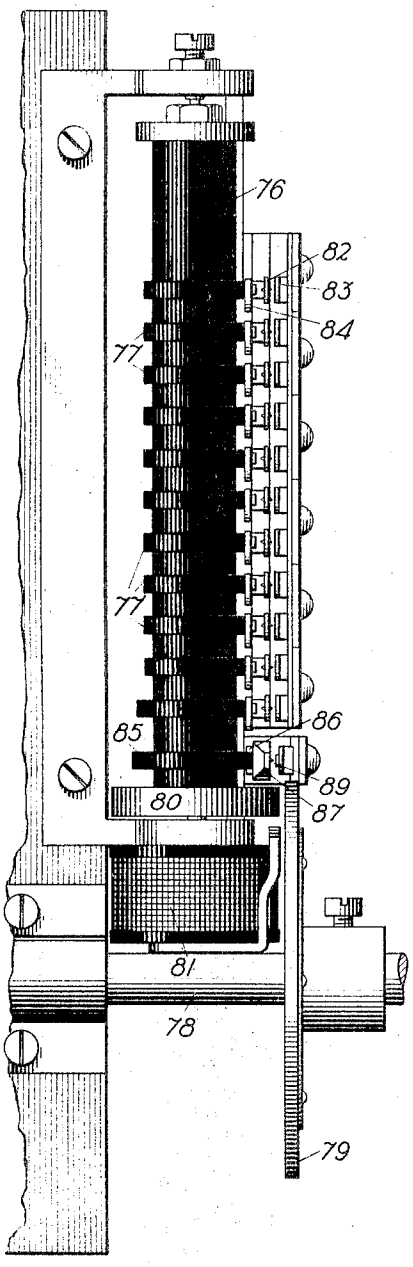
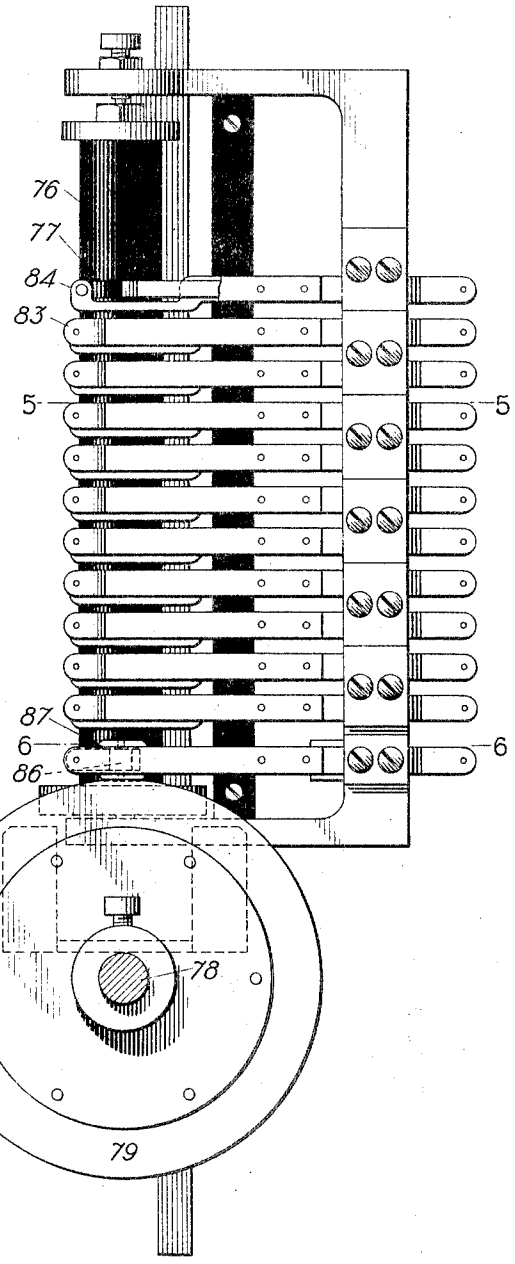


Fig. 4.



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5 SHEETS—SHEET 4.

Fig. 5.

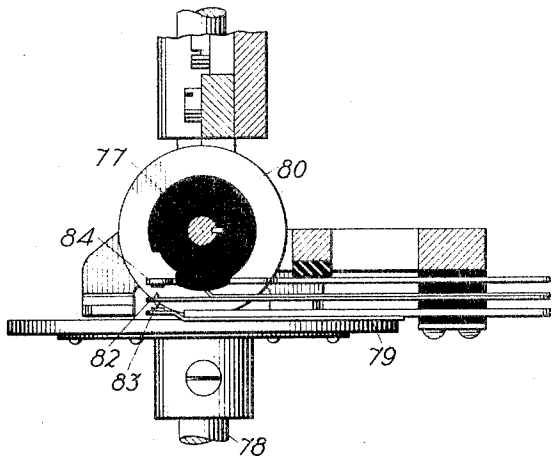
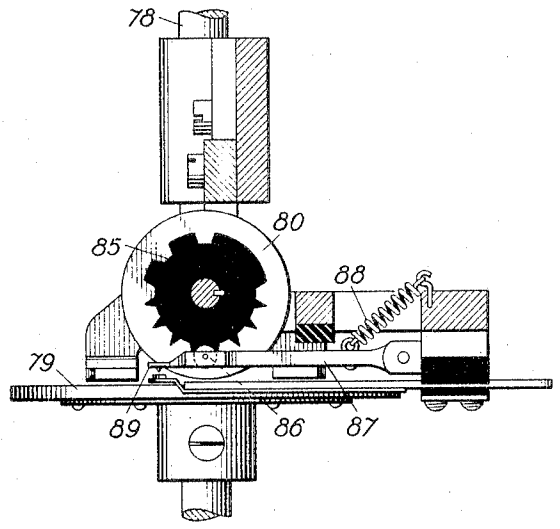


Fig. 6.



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5 SHEETS—SHEET 5.

Fig. 7.

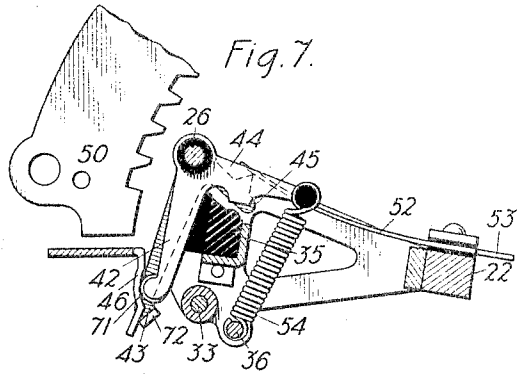


Fig. 9.

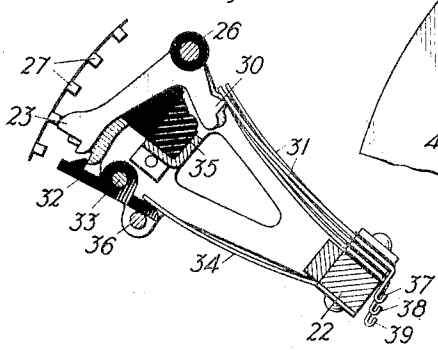


Fig. 8.

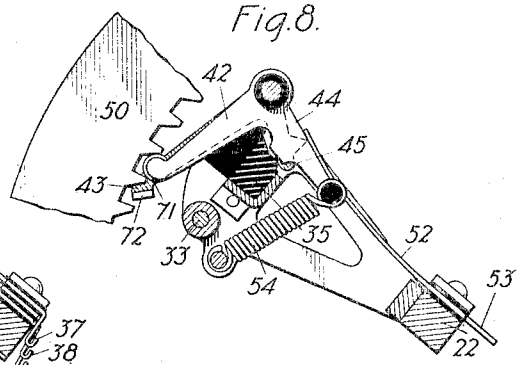


Fig. 11.

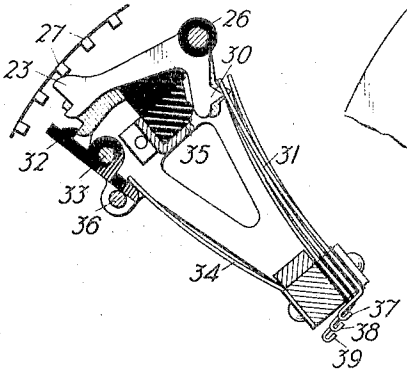
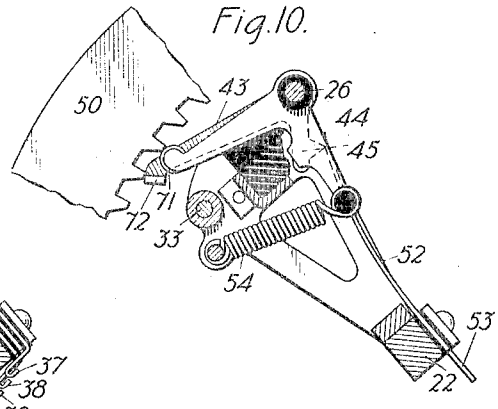


Fig. 10.



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UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE SYSTEM.

1,108,383. Specification of Letters Patent. Patented Aug. 25, 1914.

Application filed December 4, 1909. Serial No. 531,369.

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 employed for the interconnection of telephone lines, and it has for its object in general to provide improved means associated with the switch mechanisms thereof for governing their operation.

According to a well known method of operation in automatic and in semi-automatic telephone exchange systems, a series of selector switch mechanisms are arranged and controlled to operate successively in making any desired connection, each of said switch mechanisms, by means of suitable controlling apparatus, being caused first to associate itself with a particular one of a plurality of groups of lines and then to operate automatically to find and make connection to an idle line of that group. These lines may be trunks adapted to form intermediate connections between the subscribers' lines, or they may be a group of subscribers' lines extending to a single substation, such as a private branch exchange. They are ordinarily connected to multiple terminals of a plurality of selectors.

The present invention relates more particularly to means associated with such selectors to govern their operation in finding and making connection to idle lines in groups, although it may be applied, if desired, to the control of selectors for performing other operations than that of connecting lines.

One feature of the invention has for its object to provide testing means which does not disturb the circuits of busy lines when test connections are temporarily made thereto by the selectors in search of an idle line, but which shall instantly create a busy test condition at the terminals of an idle line when the test connection is made thereto. The testing means for this purpose in accordance with the invention comprises a circuit having parallel paths of high and low resistances, respectively, the high resistance path being closed during the test of busy lines, and the low resistance path becoming closed only when connection is made to an idle line. The closure of the low resistance path is preferably under the control of flow of current in the high resistance path. The high and low resistance paths in the test circuit may be the windings of a test relay, the low resistance path forming a locking circuit to maintain that path closed. The test circuit may be connected to a test brush of the selector, which brush is caused in the movement of the selector to trail over a row of test terminals associated with the group of lines to be tested. Each test terminal of such selector is connected to a suitable resistance device through which the test circuit is completed as the brush touches that terminal and, as each such terminal is connected in multiple to corresponding terminals of other selectors, if the line being tested is busy, a circuit would have been established through its resistance device and a low resistance path would already have been connected in the circuit. The electrical condition of the test terminal would therefore have been changed and upon the test connection being made subsequently by a selector hunting an idle line in the group, the flow of current in the test circuit would be too small either to cause a disturbance in the circuit already established at that terminal, or to cause the operation of the test relay, and the selector would move the test brush to the next terminal in the row and so on. Finally when the test circuit is closed through a resistance device to which connection has not already been established, the test relay of such selector would respond and close the low resistance path, causing the line associated with that test terminal to thereafter test busy to other selectors.

Another feature of the invention has for its object to provide means for governing the movable part of the selector to stop it quickly and hold it in proper position to make the desired connection, whereby the selecting operation may take place at high speed. Accordingly a relay is arranged to control a motor magnet and a stop magnet or brake in alternate positions of its armature, and this relay may be in turn controlled by flow of current in the test circuit

so that at the moment the proper position of the movable member of the selector has been reached for making connection to an idle line, or for performing any other desired function, the relay will respond, cut out the motor magnet and cut into circuit the stop magnet. The relay, being a very sensitive instrument, will thus cause the immediate removal of the motive power and the instant application of brake power when the desired position is reached by the movable member of the selector.

A third feature of the invention has for its object to provide means in the testing circuit which will delay stopping the movable member of the selector until the brushes thereof are centrally located in contact with the terminals of an idle line. According to this feature of the invention, the relay for controlling the energization of the motor magnet is placed under the control of an interrupter actuated in the advance movement of the selector, the arrangement being such that the relay is rendered irresponsive to flow of current in the test circuit, except at periodic intervals which correspond to the positions in which it may be desired to cause the selector to stop. This relay for controlling the energization of the motor magnet of the selector and the test relay heretofore referred to which has high and low resistance windings are preferably included serially in the test circuit, a shunt path for the first mentioned relay being closed by the interrupter while the test brush is traversing the spaces between successive test terminals and opened momentarily while said brush is centrally located in contact with each of said test terminals. The motor control relay is preferably of low resistance and is made irresponsive to flow of current in the test circuit by way of the high resistance winding of the test relay when the test brush is in contact with terminals of busy lines; it is, however, adjusted so as to respond quickly to flow of current in the test circuit when the low resistance shunt path is closed about the high resistance winding of the test relay.

For the purpose of illustrating the invention, there are shown in the drawings which accompany this application a single selector and the apparatus associated therewith for governing its operation. It will be understood that in the construction of a large telephone exchange system there would be several such selectors operated successively in the establishing of any one connection. The invention herein described and claimed may be applied to the control of any one of such selectors. The one shown is an "office switch" and is the second of a series in an actual exchange.

In the drawings—Figure 1 shows the circuits and apparatus which are directly associated with a single selector switch mechanism; Fig. 2 shows the circuits of a suitable controlling apparatus connected over trunk wires to the selector, the two figures when placed side by side, No. 2 to the left of No. 1, forming a complete circuit diagram of the selector and its controlling apparatus. Figs. 3, 4, 5 and 6 show in detail the structure of a sequence switch by which the circuits of the switch mechanism are partly controlled. Figs. 3 and 4 are front and side elevations respectively of the sequence switch, while Fig. 5 is a view in cross section on line 5—5 of Fig. 4, and Fig. 6 is a view in cross section on line 6—6 of Fig. 4. Figs. 7 to 11 inclusive are detail views of parts of the switch mechanism, Fig. 7 showing a contact device in the normal position of the switch, Figs. 8 and 10 the same in different off-normal positions and Figs. 9 and 11, the brushes of the switch in off-normal positions corresponding respectively to those of Figs. 8 and 10.

The same reference characters are used to indicate the same or like parts in the several drawings.

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 an idle 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.

In the normal position of the brush carriage, as shown in Figs. 1 and 7, a pair of levers 42, 43 pivoted upon the rod 26, the latter being insulated therefrom, engage at their free ends a normal stop plate 46. At the end of lever 42 is a roller 71 which lies in a recess of plate 46, and at the end of lever 43 is a right angle extension arm 72 which makes electrical contact with said plate 46. A coil spring 54, acting upon an inwardly extending arm 44, serves to press the roller 71 with considerable force against plate 46 and thereby holds the brush carriage securely in its normal position. A flat spring 52 engages an inwardly extending arm 45 of the lever 43 and serves to press this lever outwardly but with less force than that of the coil spring 54. The spring 52 also makes electrical contact with lever 43; it is secured to but insulated from the shaft 22 of the brush carriage and terminates in a wire clip 53. As the brush carriage is moved to carry the brushes over the stationary terminals, the roller 71 and the extension arm 72 engage the teeth of a cam plate 50. The roller 71 rides over the teeth while the brushes are passing between successive terminals and drops into a notch (Fig. 8) as any released set of brushes is centrally located in direct contact with a set of terminals (Fig. 9). The extension arm 72 follows behind the roller one tooth or notch and likewise engages a tooth as the brushes are passing between successive terminals. It passes through the space between teeth, however, without touching the plate 50 (Fig. 8) as the released set of brushes is centrally located in contact with the terminals. The stop bar 35 engages the inwardly extending arm 45 just as it does the arms 30 of the brushes and thus prevents the extension arm 72 of the lever 43 from touching the bottom of the notches between the teeth of plate 50, while permitting said arm 72 to touch and make contact with the top of the teeth. The teeth and notches of plate 50 are so spaced and arranged with respect to the contact lever 43 that the extension arm 72 will not break contact with a tooth of plate 50 (Fig. 10) until after the brushes make contact with the stationary terminals (Fig. 11) and the roller 71 is ready to drop into a notch. The circuit arrangement, as will presently appear, is such that the motive power for driving the brush carriage can not be cut off until the contact is thus broken between lever 43 and plate 50 and therefore not until the brushes are in position to make good contact with the stationary terminals. The brush selector is also provided with an interrupter or make and break contact device comprising an arm 56 pivoted to the frame at 57, engaging at its free end a toothed wheel or cam 58 which rotates with the shaft 40. This arm 56 is adapted in the rotation of the shaft to engage two contacts 59 and 60. These contacts may be springs, the free ends only of which are shown in the drawing. In its normal position the free end of the arm 56 lies in a notch of the cam 58 which is deep enough to insure an open connection with contact 59. When the shaft is away from its normal position, however, connection is made continuously with contact 59. The connection with contact 60 is intermittent, this contact being made when the arm 56 is lifted by each tooth of the cam. There are as many teeth on the cam as there are fingers 41 on the spindle 40 and therefore as many as there are sets of brushes.

The motor mechanism for causing rotation of the brush carriage comprises an annular iron friction disk 61 flexibly mounted at the lower end of the spindle 22, an elec-

tromagnet 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 stop 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 stop its movement. The power shaft 63 is extended as shown in the drawing to carry a flexibly mounted driving disk 70, which is adapted to engage a roller 67 carried by the spindle 40. An electromagnet 68 controls the engagement of disk 70 and roller 67 in the same manner that the electromagnet 62 controls the engagement of disk 61 and roller 64. These devices are in fact electromagnetic clutches, one to cause movement of the brush carriage and the other to cause movement of the brush selector.

The complete selector switch mechanism is not shown in the drawing, but the elements thereof appear in their proper relation to one another so as to make clear the manner in which the mechanism operates to interconnect lines. There may be as many sets of brushes and stationary terminals as desired. For example, the switch mechanism may, as a whole, have ten sets of three 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 eighth and ninth counting from the top down, and six sets of stationary terminals in two levels corresponding to the two sets of brushes shown.

Some of the circuits of the selector are controlled by a sequence switch and there is ordinarily one such sequence switch for each selector. 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. 3 to 6 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. 6, is also preferably provided to control a local circuit for said motor magnet, whereby after the initial energizing circuit is broken by one or the other switches the motor magnet may still be excited by current in the local circuit until the next intended stopping position of the rotary element is fully reached. As shown in Fig. 6, the cam 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 ro-

tation 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.

In Fig. 1 the switch springs of the sequence switch are not shown in their actual arrangement, but are so located as to give a clear arrangement of the circuits; and the operating cams are not shown. The clutch or motor magnet 81, its driving disk 79 and roller 80 are shown together with the various sequence switch springs and contacts 101 to 116 inclusive, the motor magnet, switch springs and said contacts being located in the drawing in their proper circuit positions without particular regard to their structural arrangement as shown in Figs. 3 to 6. 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 second and fifth positions as indicated by the numbers 2 and 5 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 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 3, 3 and 5, 5 and 7, and 7 and 1, but opened when the sequence switch is either resting in or passing by any one of these positions. There may be, say eight positions of the sequence switch, and the cams thereof will be caused to make one complete revolution in passing from normal (position 1) through the eight positions and back to normal again.

A suitable arrangement of controlling apparatus for the selector mechanism is shown in Fig. 2. This apparatus comprises a series of counting relays and a series of controlling switches or keys, together with a stepping relay for operating the counting relays in succession to close contacts in circuit with switches or keys and a cut-off relay adapted when the circuit is closed simultaneously by one of the counting relays and the particular switch or key depressed, to open the controlling circuit and stop the movement of the selector. As shown, there are two series of counting relays. One series, comprising relays 201 to 208 inclusive, are adapted respectively to close contacts 261 to 268 in circuit with the keys 251 to 258 and the cut-off relay 223. The other series of counting relays 211 to 218 inclusive serve the purpose of closing circuits for relays 201 to 208 and are caused to operate in alternate succession with said relays 201 to 208. These two series of relays may be extended in an obvious manner to include any desired number. The stepping relay 224 is arranged to be energized and deënergized intermittently in the movement of the selector, as will be presently explained. Upon the first energization, it closes its front contact 225, which completes a circuit from battery 226 through contact 234, auxiliary counting relay 211 and back contact 228 of counting relay 201, whereupon relay 211 is energized and closes a locking circuit by way of its contact 229. Relay 211 also closes contact 230. Then when the stepping relay is deënergized, its armature falls back, closing contact 231, thereby completing a circuit for counting relay 201 by way of battery 226, contact 232, winding of relay 201, contact 233 of the second auxiliary counting relay 212, and contact 230 of the first auxiliary relay 211. Relay 201 is thereupon energized and it, like relay 211, closes a locking circuit by way of contact 261. As before stated, however, contact 261 is also in circuit with the cut-off relay 223 and the first of a series of controlling switches or keys 251, so that if this key had been depressed, the operation of the first counting relay 201 would cause the cut-off relay 223 to open the circuit of the stepping magnet 224. It therefore follows that the number of impulses of current flowing through the winding of the stepping relay 224 before the cut-off relay 223 shall open the circuit of the stepping relay depends upon the particular controlling switch or key which had been depressed.

The stepping relay 224 is included in a loop which may be associated with the trunk line conductors 235 and 236 leading to the selector switch mechanism shown in Fig. 1, suitable switch contacts 237 and 238 being provided for making the connection when it is desired to cause the selector to perform a particular switching operation. The trunk line conductors 235 and 236 may have associated therewith a third conductor 239 in-

cluding a resistance 240 and a switch contact 241, which contact may also be closed at or about the time the contacts 237 and 238 are closed.

The selector mechanism shown in Fig. 1 may or may not be the first switch to be controlled in the operation of connecting subscribers' lines and there are indicated in the trunk line conductors 235, 236 and the associated conductor 239 switch contacts 242, 243 and 244 which indicate contacts of another selector that may be interposed in the circuit when the selecting operation which is about to be described takes place.

Referring now to Fig. 1, which shows the apparatus and circuits associated with the selector switch mechanism, it will be noted that the trunk line conductors 235 and 236 are normally, that is, when the sequence switch is in position 1, connected through sequence switch contacts 103 and 104 to form a loop circuit with a line relay 121 and a battery 122; also that conductor 239 is connected through a trunk relay 123 and a normal contact 105 of the sequence switch to battery 122. Contacts 103 and 104 of the sequence switch are closed in the first and second positions thereof, while contacts 106 and 107 thereof are closed in the fourth and fifth positions, to extend the circuit of the trunk line to the brushes 23 and 24 of the selector mechanism. The line relay has a back contact 124 and a front contact 125 which are adapted to complete certain local circuits entering into the control of the selector and the sequence switches, as will presently appear. The trunk relay 123 is adapted when energized to close a locking circuit for its winding by way of contact 126 and battery 122 and at the same time to open contacts 127 and 128 and close contact 129. Contact 127 is connected through a resistance 130 to the normal stop plate 46 of the selector mechanism, and contact 129 is connected to the winding of a motor control relay 131, this relay being adapted in the third position of the sequence switch to be included in a test circuit by way of a high resistance winding 132 of a test relay 133 and contact 108 of the sequence switch. The test circuit terminates in the test brush 25 of the selector switch mechanism. It may be closed to ground by way of contact 109 of the sequence switch, this contact being in parallel relation to the front contact 129 of the trunk relay. A low resistance shunt winding 134 of the test relay 133 is adapted to be closed by its front contact 135. Leading from the conductor joining relays 132 and 133 is a conductor 137 which is connected by way of spring 52 to the contact lever 43 of the switch mechanism. When the selector is in normal position, this switch lever is resting in contact with the normal stop plate 46, but when the brush carriage moves the brushes over the terminals, the lever 43 makes contact intermittently with the teeth of plate 50 which is connected to ground. It will thus be seen that the circuit completed through conductor 137 excludes the test relay 133 when the selector is in normal position and intermittently excludes the motor control relay 131 by shunting it when the brushes are trailing over the terminals. The motor control relay 131 closes at its back contact 138 a circuit for the motor magnet 62 of the selector, this circuit including also sequence switch contact 110 closed in the third, fourth, seventh and eighth positions; it also closes at its front contact 139 a circuit for the stop magnet 65 of the selector and a circuit for the motor magnet 81 of the sequence switch, the latter circuit including a sequence switch contact 111 closed in the third and seventh positions. It will be noted also that while the sequence switch is in its normal position, the circuit of its motor magnet 81 may be closed by way of the front contact 125 of the line relay 121 and sequence switch contact 112; and that in the second position, the circuit may be closed through the back contact 124 of the line relay 121 and sequence switch 113. In the second position of the sequence switch, a circuit may also be closed for the motor magnet 68 of the brush selector by way of the front contact 125 of the line relay and sequence switch contact 114. While the sequence switch is in positions 5 to 1 inclusive, the local circuit is closed for this motor magnet 68 of the brush selector by way of sequence switch contact 115 and contact 59, this latter contact being closed at all positions of the brush selector except normal.

It will be understood that the primary function of the selector switch shown in Fig. 1 is to interconnect lines for telephonic communication. As before stated, these lines may be trunks forming intermediate connecting links between the subscribers' lines. Thus the conductors 235 and 236 may be extended to the left in Fig. 2 through suitable mechanism and conductors to a calling subscriber's line and conductors 140 and 141, which are connected to terminals 27 and 28 of the selector, may be extended to the right in Fig. 1 through suitable mechanism and conductors to a called subscriber's line. Terminal 29 is connected through a resistance 142 to the free pole of battery 122. It will be understood that the terminals 27, 28 and 29 of the selector switch may and would ordinarily be connected in multiple to the corresponding terminals of other selectors.

The battery 122 is shown in several positions in the circuit diagram of Fig. 1 merely for clearness in illustrating the circuits, and it will be understood that these several representations of battery are to be considered as meaning a single battery, al-

though, if desired, several batteries may be employed. This battery may be one having a potential of say forty-eight volts. The following resistance values have been found suitable for the test relays and resistance 142 in the test circuit: relay 131, 50 ohms; winding 132 of relay 133, 1000 ohms; winding 134, 50 ohms; and resistance 142, 300 ohms.

The operation of the system is as follows: An operator desiring to establish a particular connection by means of the selector switch mechanism will close one of the keys or controlling switches 251 to 258. It may be assumed that the eighth key, 258, is closed. This will result, as will presently appear, in an operation of the selector, whereby the eighth set of brushes 23, 24 and 25 are tripped and the brushes are moved over the terminals until connection is made with an idle line. Contacts 237, 238 and 241 are first closed, however, to bring the controlling apparatus into operative relation to the selector. These, and also contacts 232 and 234, may be operated manually, but preferably by a sequence switch mechanism of the same general construction as that shown in Figs. 2 to 5. It is merely for the sake of simplicity in the illustrative diagram that such sequence switch mechanism is omitted in Fig. 2. The closing of contact 241 completes a circuit for the trunk relay 123 by way of sequence switch contact 105, conductor 239 and resistance 240. In operating, the trunk relay closes a locking circuit by way of its own contact 126. It will thus be noted that the trunk relay will remain energized independently of the sequence switch contact 105, but that it is under the control of contact 241 so that whenever contact 241 is opened subsequently the trunk relay will be deënergized. The closing of contacts 237 and 238 bring the stepping relay 224 into circuit with the line relay 121 over the following path: battery 122, winding of relay 121, sequence switch contact 103, conductor 235, contact 237, back contact 245 of cut-off relay 223, the winding of stepping relay 224, contact 238, conductor 236 and sequence switch contact 104. The closing of this circuit causes the energization of relays 224 and 121. Relay 224 closes a circuit for the first auxiliary counting relay 211 by way of battery 226, contact 234, winding of relay 211, back contact 228 of the first counting relay 201 and front contact 225 of the stepping relay 224. Relay 211 thereupon becomes locked in a circuit closed by way of its own contact 229. It furthermore closes contact 230 which places the first counting relay 201 into a partially completed circuit which may be subsequently made complete when the stepping relay is deënergized and closes its back contact 231. The energization of line relay 121 of the line relay, and the sequence switch from its first or normal to its second position. That is to say, the motor magnet 81 is brought into circuit by way of sequence switch contact 112 and the front contact 125 of the line relay, and the sequence switch advances under the control of its special contact 101 to the second position in which contact 112 is open. In the second position of the sequence switch, a circuit is closed for the motor magnet 68 of the brush selector by way of sequence switch contact 114 and the front contact 125 of the line relay, whereupon the shaft 40 is rotated and a series of contacts are made between the arm 56 and contact 60. A circuit is formed upon the making of each such contact from battery 122, line relay 121, sequence switch contact 116 and contact 60 to ground through the arm 56 and frame of the selector. This circuit is in shunt of the path for the line relay through the trunk line conductors 235 and 236 and stepping relay 224 of the controller apparatus. The stepping relay is therefore deënergized intermittently in the advance movement of the brush selector. The first deënergization causes a circuit to be closed for the first counting relay 201 by way of battery 226, contact 232, the winding of relay 201, back contact 233 of the second auxiliary counting relay 212, front contact 230 of the first auxiliary counting relay 211 and back contact 231 of the stepping relay 224. After the first closing of the shunt circuit by way of sequence switch contact 116 and contact 60, the shunt is opened and the stepping relay 224 is again energized, whereupon the second auxiliary counting relay 212 is energized. Upon the second closing of the shunt circuit, the second counting relay 202 is energized. Thus the counting relays are successively energized and are locked in local circuits by the alternate energization and deënergization of the stepping relay 224 controlled by the intermittent shunt circuit of the trunk line circuit by way of contact 60 of the brush selector. Upon the energization of counting relay 208 a circuit will be closed by way of contact 268 of relay 208, the eighth controlling switch or key 258 and the winding of cut-off relay 223, whereupon the circuit of the trunk line will be opened at contact 245. This operation of the cut-off relay will occur upon the eighth closure of the shunt circuit by way of contact 60. The line relay 121 remains energized, however, until the shunt circuit is broken by the arm 56 dropping into the eighth notch of the star wheel 58. The eighth finger 41 is at this time pointing inwardly in position to engage a latch 32. The line relay 121 is now deënergized, the two circuits therefor—one by way of the trunk line and the other by way of contact 60—being open. Current is cut off from

motor magnet 68 at the front contact 125 and a circuit is closed for the motor magnet 81 of the sequence switch by way of sequence switch contact 113 and the back contact 124 of the line relay 121, whereupon the sequence switch moves from the second to the third position. In passing out of the second position into the third, contacts 103, 104, 114, 116, 113 and 102 are opened and contacts 108 and 110 are closed. The arrangement above set forth whereby the controlling apparatus is reversely controlled in the advance movement of the brush selector, does not form a part of the present invention, but is made the subject-matter of a separate application by me, Serial No. 528,293, filed November 16, 1909. The sequence switch is now in the third position wherein a circuit is completed for the motor magnet 62 of the selector by way of the back contact 138 of the motor control relay 131 and sequence switch contact 110, whereupon the brush carriage of the selector is moved first past the brush selector and then over the rows of terminals. In passing the brush selector, a finger 41 thereof trips the latch 32, allowing a set of brushes 23, 24 and 25 to be swung outwardly on the pivotal rod 26. These brushes therefore will trail over and make contact with the three rows of terminals in the same level. The brush 25 is now connected in a test circuit partially completed through sequence switch contact 108, the high resistance winding 132 of the test relay 133, the winding of the motor control relay 131 and sequence switch contact 109. If the line connected to the first set of terminals is not busy, the selector will stop with the brushes in contact with those terminals, but if the line is busy, the potential at the test terminal 29 will be reduced sufficiently to prevent the energization of test relay 133. The brush carriage will therefore continue to move the brushes over the terminals as long as the lines connected to those terminals are busy. When, however, the test brush 25 makes contact with the test terminal 29 of a line which is not busy, a circuit will be formed from battery 122 through resistance 142, terminal 29, test brush 25, sequence switch contact 108, high resistance winding 132 of the test relay 133, conductor 137, wire clip 53, spring 52, contact lever 43 and plate 50 to ground. The circuit will be completed by way of conductor 137 instead of by way of the motor control relay 131 because as the test brush touches the edge of the terminal 29, the arm 43 has not yet broken contact with a tooth of plate 50. Test relay 133 is thereupon energized, closing its low resistance locking winding 134 by way of contact 135 in shunt of the high resistance winding 132. This low resistance path creates a flow of current through resistance 142, which is sufficient to materially reduce the potential at the test terminals 29 of all the selector switches connected in multiple therewith, so that the line to which connection is being made will be caused instantly to test busy to other switches. A moment later the contact lever 43 drops into the space between the teeth on the plate 50 and opens the shunt about the motor control relay 131, whereupon this relay is energized, opening the circuit of the motor magnet 62 for the brush carriage at back contact 138, and closing a circuit for the stop magnet 65 by way of sequence switch contact 110 and front contact 139 of said relay 131. The brush carriage is therefore stopped suddenly and held by the magnet 65 for a moment. The brushes 23, 24 and 25 are now in contact with the terminals 27, 28 and 29 of a non-busy line. The closing of contact 139 of the motor control relay 131 also completes a circuit for the motor magnet 81 of the sequence switch by way of sequence switch contact 111, said contact 139 and sequence switch contact 110. The sequence switch thereupon moves out of the third position and into the fifth, it being under the control of the special switch contact 101 in passing the fourth position. The fifth is the talking position of the sequence switch; that is to say, the circuit of the trunk line conductors 235 and 236 is now closed to the brushes 23 and 24 by way of sequence switch contacts 106 and 107 respectively. In this position the local circuit for the motor magnet 68 of the brush selector is closed by way of sequence switch contact 115 and the brush selector, having no further function to perform with respect to the connection being made, is returned to its normal position. It is caused to stop in its normal position by the opening of this local circuit at contact 59 when the free end of the arm 56 drops into the deep notch in the star wheel 58.

To restore the apparatus to its normal condition, contacts 241, 237, 238, 232 and 234 may be opened. The opening of contacts 232 and 234 releases the counting relays by opening their local locking circuits. The opening of contacts 237 and 238 disconnects the stepping relay from the trunk line circuit and this is preferably done before the circuit is used for telephonic communication. The opening of contact 241 releases trunk relay 123, whereupon contacts 127 and 128 are closed and contacts 126 and 129 opened. The closing of contact 128 completes a circuit for the motor magnet 81 of the sequence switch by way of sequence switch contact 102. The sequence switch thereupon advances to the seventh position. The opening of contact 129 causes the motor control relay 131 to be deënergized, whereupon its back contact 138 is closed, and when the sequence switch reaches the seventh posi-

tion a circuit for the motor magnet 62 of the selector is closed by way of this back contact 138 and sequence switch contact 110. It should be noted that the test relay 133 also became deënergized upon the opening of contact 129, so that the path through the low resistance locking winding 134 is now open at contact 135. The path through the high resistance winding 132 had become opened at sequence switch contact 108 when the sequence switch passed out of the third position. The switch carriage is moved around under the control of the motor magnet 62 until it reaches its normal position, whereupon contact is made between the lever 43 and the normal stop plate 46, and a circuit is closed for the motor control relay 131 by way of sequence switch contact 109, the winding of relay 131, conductor 137, contact lever 43, normal stop plate 46, resistance 130 and the back contact 127 of trunk relay 123 to battery. The motor control relay 131 is energized in this circuit and opens the circuit of the motor magnet 62 at contact 138. The closing of the front contact 139 of relay 131 completes circuits as before, one to the stop magnet 65 and one to the motor magnet 81 of the sequence switch, the latter circuit being by way of sequence switch contact 111. The sequence switch thereupon leaves the seventh position and returns to the first or normal position. Upon reaching this normal position, sequence switch contacts 103, 104 and 105 are again closed, placing the apparatus in condition for another series of selecting operations.

It should be noted that sequence switch contact 102 is closed in the second position as well as in the fifth. It is therefore possible for the operator, by opening contact 241 at the controlling apparatus, to send the sequence switch out of the second position and to restore the whole selector mechanism to normal without permitting it to select and make connection to a non-busy line. It will be remembered that in this second position, current impulses are being received at the stepping relay by the advance movement of the brush selector. If the operator should open the contact 241 while the sequence switch is in the second position for the purpose of wiping out a connection already started, the sequence switch would pass into the third position, whereupon a circuit would be established for the motor control relay 131 by way of sequence switch contact 109, the winding of relay 131, conductor 137, contact lever 43, the normal stop plate 46, resistance 130 and back contact 127 of the trunk relay 123 to battery. Upon entering the third position, circuit would be closed for the motor magnet 81 of the sequence switch by way of sequence switch contact 111, front contact 139, of relay 131 and sequence switch contact 110. The sequence switch therefore would not stop in the third position, but would continue to the fifth, and in the fifth a circuit for the motor magnet would be closed by way of sequence switch contact 102 and the back contact 128 of the trunk relay. In the seventh position, the circuit for the motor magnet 81 would be again closed by way of sequence switch contact 111, front contact 139 of relay 131 and sequence switch contact 110. The sequence switch would therefore be moved in one continuous operation from the second position to normal while the selector switch remains in normal position.

I claim:

1. The combination with a selector, of a test circuit therefor having a path of high resistance closed during the testing operation and a path of low resistance open during the testing operation, and means controlled by flow of current in said high resistance path for closing said low resistance path.

2. The combination with a selector, of a test circuit therefor having a path of high resistance including the winding of a relay and another path of low resistance including a normally open contact of said relay.

3. The combination with a selector, of a relay, a test circuit for said selector including a high resistance winding of said relay, and a low resistance normally open shunt of said high resistance winding controlled by said relay.

4. The combination with a selector, of a relay having high and low resistance windings, a test circuit for said selector having two paths including said high and low resistance windings respectively, and a contact controlled by said relay for closing the path through the low resistance winding.

5. The combination with a selector, of a relay, a test circuit for said selector having two paths, one of said paths being of high resistance and including a winding of said relay, and another of said paths being of low resistance and including a second winding and a normally open contact of said relay, means included in said circuit for governing the advance and return of said selector, and a switch arranged to close said high resistance path only during the advance movement of the selector.

6. The combination with a selector, of a motor magnet and a stop magnet therefor, a test relay for said selector, and a relay controlled by said test relay for effecting successive operation of said magnets in alternate positions respectively of its armature.

7. The combination with a selector, of a forward driving device and a forward movement stopping device therefor, electromagnets for controlling the operation of said devices, circuits for said electromagnets, a test relay, and means operative upon the

actuation of said relay for so altering said circuits as to render said driving device ineffective and said stopping device effective.

8. The combination with a selector, of a driving device therefor and a quick stop device for preventing overrun thereof, electromagnets for controlling the operation of said devices, circuits for said electromagnets, a test relay, and means operative upon the actuation of said relay to alter said circuits whereby said driving device is rendered ineffective and said stop device is rendered effective.

9. The combination with a selector, of a test circuit therefor having parallel paths, one of said paths being of high resistance and including the winding of a relay, and another of said paths being of low resistance and controlled by a contact of said relay, a motor magnet and a stop magnet for said selector, and a relay included in an undivided portion of said test circuit adapted to effect the operation of said magnets in alternate positions respectively of its armature.

10. The combination with a selector having a test brush and a row of terminals adapted to be traversed thereby, of means for changing the electrical condition of said terminals, a conductor including a testing device adapted to respond upon contact of said test brush with a terminal having the unchanged electrical condition, and a motor magnet and a stop magnet for said selector arranged to respond in succession under the control of said testing device.

11. In a telephone exchange system, the combination with a selector switch, a circuit therefor including a testing device adapted to respond when connection is made by said switch to an idle line, a motor magnet for said selector, a sequence switch, a motor magnet for said sequence switch, said testing device being adapted in its response to open the circuit of the selector motor magnet and to close the circuit of the sequence switch motor magnet, and said sequence switch being adapted in its response to close a contact in the line circuit leading to said selector.

12. In a telephone exchange system, the combination with an automatic selector, a test circuit therefor including a high resistance relay and a low resistance relay in series, a motor magnet controlled by said low resistance relay, a low resistance shunt of said high resistance relay, and means for closing said shunt when connection is made by the selector to an idle line.

13. In a telephone exchange, a selector having a brush, circuit terminal contacts traversed by said brush, a test circuit for said selector, a relay in said circuit for controlling the advance movement of the selector, and an interrupter operating in said movement to short circuit said relay each time said brush is in transit from one contact terminal to the next.

14. The combination with a selector having a test brush and a row of terminals adapted to be traversed thereby, of a test circuit connected to said test brush, a relay in said circuit, said relay being adapted to control the advance movement of said selector, and an interrupter operating intermittently to short circuit said relay in the advance movement of the selector.

15. The combination with an automatic selector having a test brush and a row of terminals adapted to be traversed thereby, of a test circuit connected to said brush, two relays included in said circuit, one of said relays having a high resistance winding, and being adapted when connection is made to the terminal of an idle line to close a low resistance shunt path about its winding, the other of said relays being arranged to control the advance movement of said selector, and a switching device actuated in the movement of the selector to intermittently render the last mentioned relay irresponsive to flow of current in said test circuit.

16. The combination with an automatic selector having a test brush and a row of terminals adapted to be traversed thereby, of a test circuit including two relays in series, one of said relays being adapted to change the electrical condition of said terminals, and the other of said relays being arranged to control the advance movement of the selector, and an interrupter actuated in the movement of the selector to intermittently close a shunt circuit about the last mentioned relay while the test brush is traversing the spaces between adjacent terminals.

17. The combination with an automatic selector having a test brush and a row of terminals adapted to be traversed thereby, of a test circuit including two relays in series, one having a high resistance winding and a low resistance winding in parallel paths, said low resistance winding being normally open at a contact of said relay, the other of said relays being arranged to control the advance of the selector, and an interrupter controlling a shunt of the last mentioned relay, said interrupter being actuated in the movement of the selector to open said shunt when the test brush is in contact with each of said terminals.

18. In a telephone exchange, a selector having a brush, circuit terminal contacts traversed by said brush, a test circuit for said selector including electrically actuated means for controlling the advance movement of the selector, and means operable during said movement to short circuit said electrically actuated means each time said brush is in transit from one contact terminal to the next.

19. The combination with a plurality of selectors comprising test terminals multiplied on the several selectors and test brushes adapted to trail over said terminals, of a high resistance test conductor and a low resistance conductor adapted to be connected to each of said brushes, and switch mechanism arranged to connect the high resistance conductor in circuit when the brushes are trailing over terminals and the low resistance conductor in circuit when the brushes are resting in connection with any of said terminals.

20. The combination with a plurality of selectors comprising test terminals multiplied on the several selectors and test brushes adapted to trail over said terminals, of a high resistance test conductor arranged to be connected to each of said brushes when trailing over terminals and a low resistance conductor arranged to be connected to each of said brushes when resting on any terminal.

21. The combination with a plurality of selectors comprising test terminals multiplied on the several selectors and test brushes adapted to trail over said terminals, of a relay for each selector having high and low resistance windings, switching mechanism adapted to connect said high resistance winding in circuit with the test brush of said selector when trailing over said terminals, and a contact of said relay adapted to be closed to include said low resistance winding in circuit with said brush when resting upon any terminal.

22. The combination with a selector having fixed and movable contacts, of a test relay having a high resistance winding and a low resistance locking winding, switching mechanism for connecting said high resistance winding in circuit with a movable contact when moving, means for closing said low resistance locking winding when said brush is resting upon any fixed contact, means for advancing and restoring said movable contact, and a sequence switch associated with said means and operating to open the circuit of said locking winding to restore said relay.

23. The combination with a selector, of a test circuit therefor having a path of high resistance closed during the testing operation and a path of low resistance open during the testing operation, means controlled by flow of current in said high resistance path for closing said low resistance path, a motor magnet for advancing said selector, a restoring circuit for said selector and a motor-control relay in said low resistance path and controlling at its back contact said restoring circuit.

24. In combination, a power-driven trunk-hunting switch, having a magnetic clutch adapted to advance the same, of a test relay having a high and a low resistance winding, the high resistance winding being included in a circuit during the testing operation and the low resistance winding when connection is established with an idle trunk, and a motor-control relay in circuit with said low resistance winding and controlling at a back contact the circuit of the magnet clutch.

In witness whereof, I, hereunto subscribe my name this third day of December, A. D., 1909.

FRANK R. McBERTY.

Witnesses:
IRVING MACDONALD,
EDGAR F. BEAUBIEN.