Jan. 18, 1927. 1,614,593

J. I. BELLAMY

AUTOMATIC TELEPHONE SYSTEM

Filed March 9, 1925 5 Sheets-Sheet 1

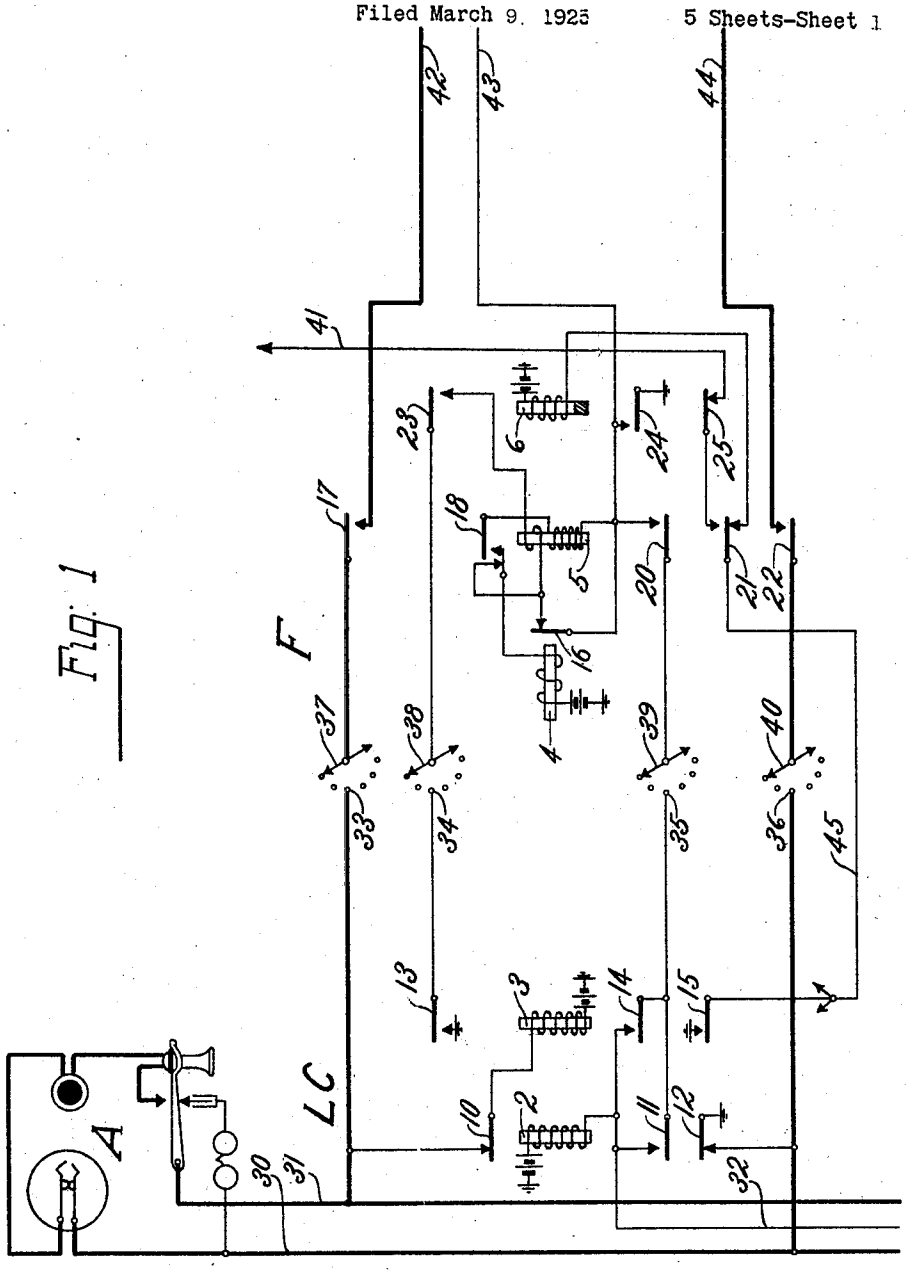

Fig. 1

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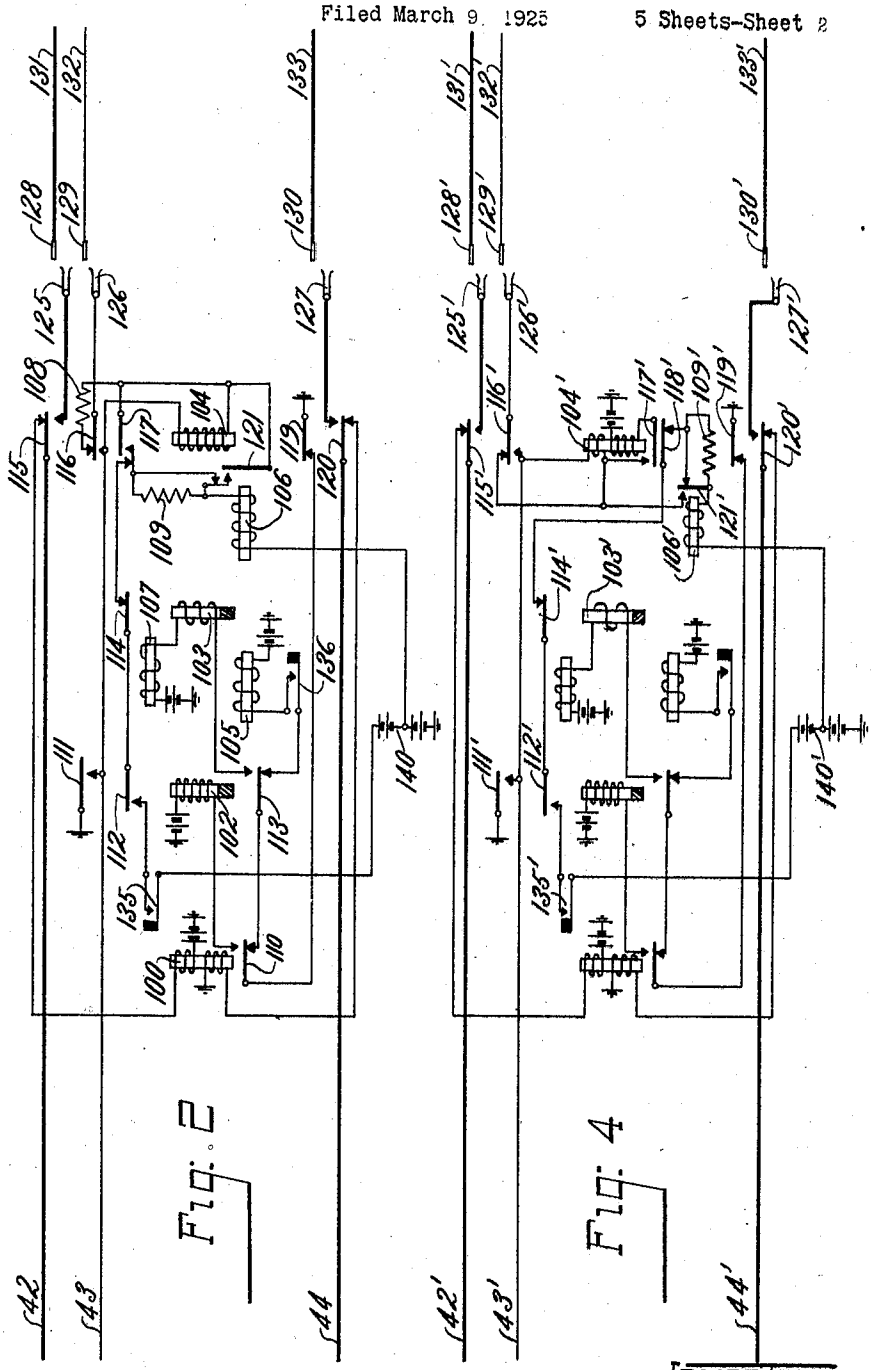

Fig. 2

Fig. 4

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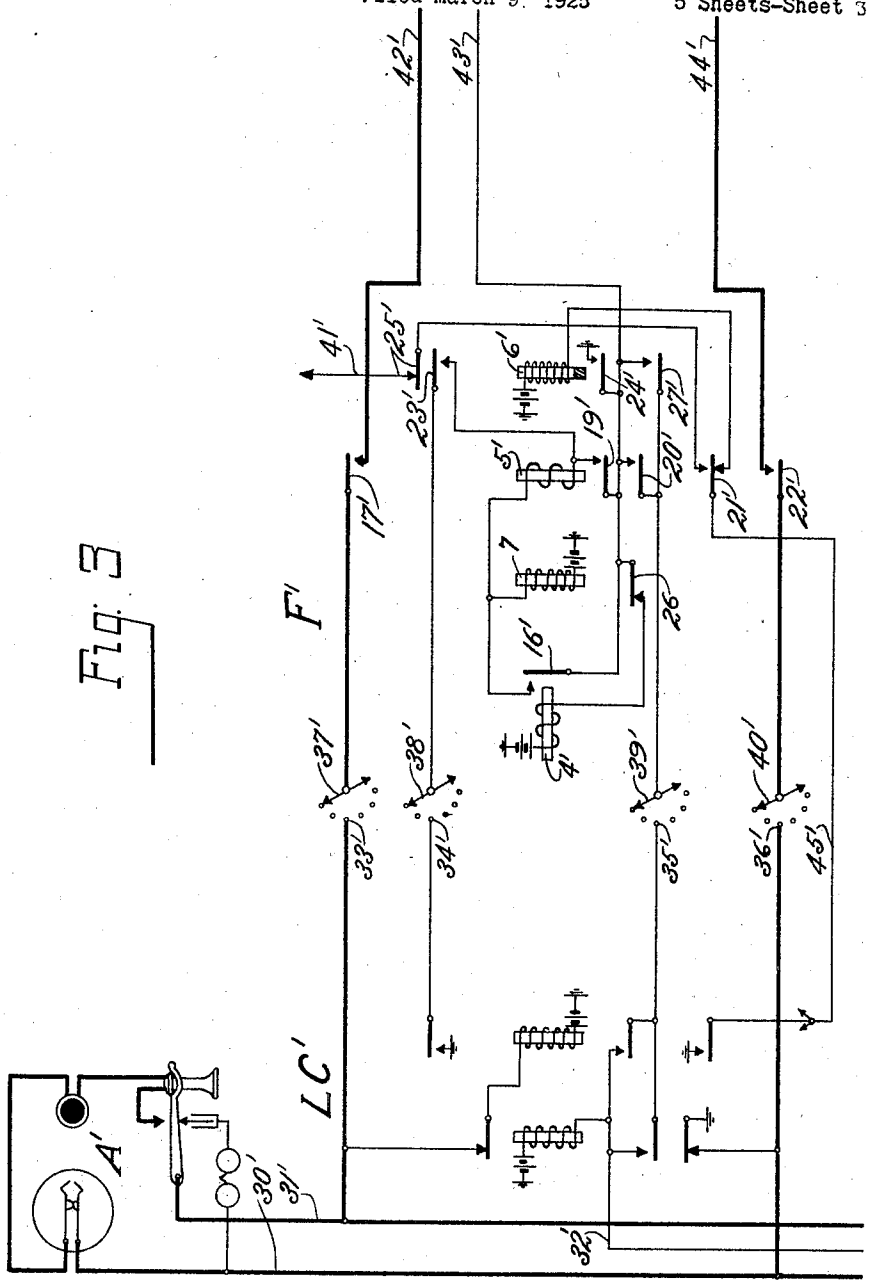

Fig. 3

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Fig. 5

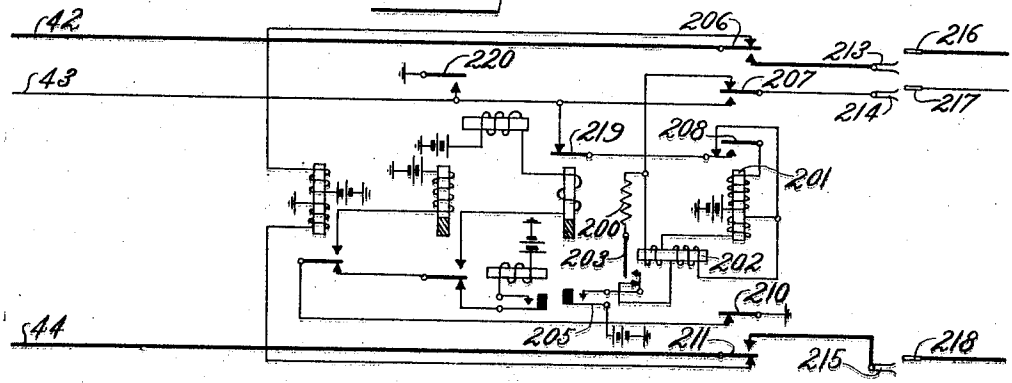

Fig. 6

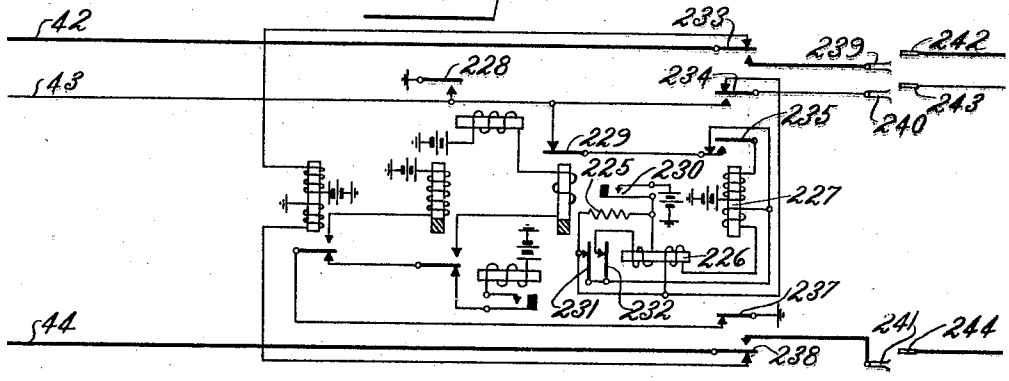

Fig. 7

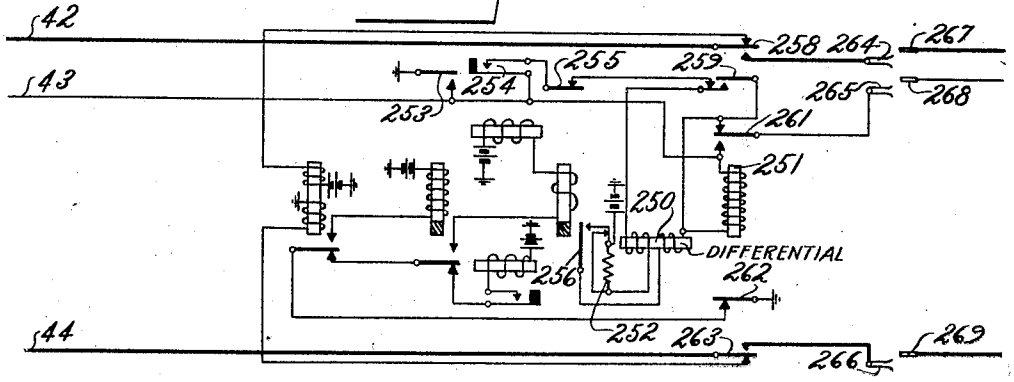

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Fig. 8

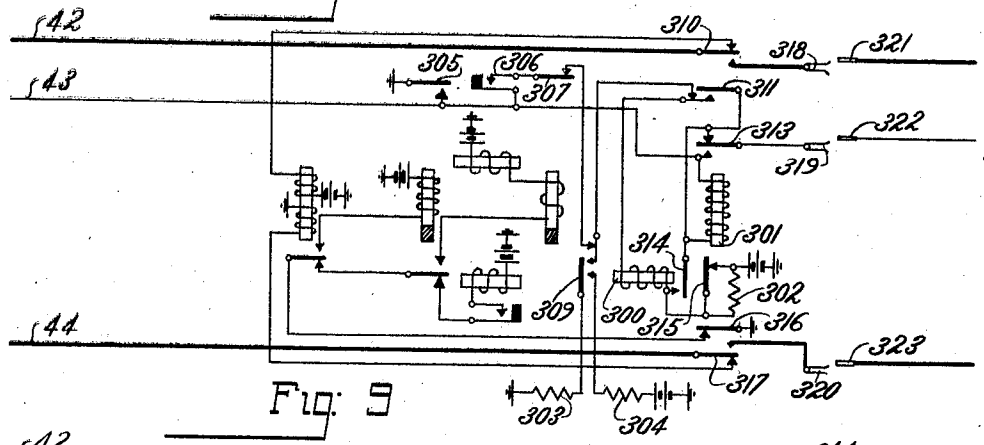


Fig. 9

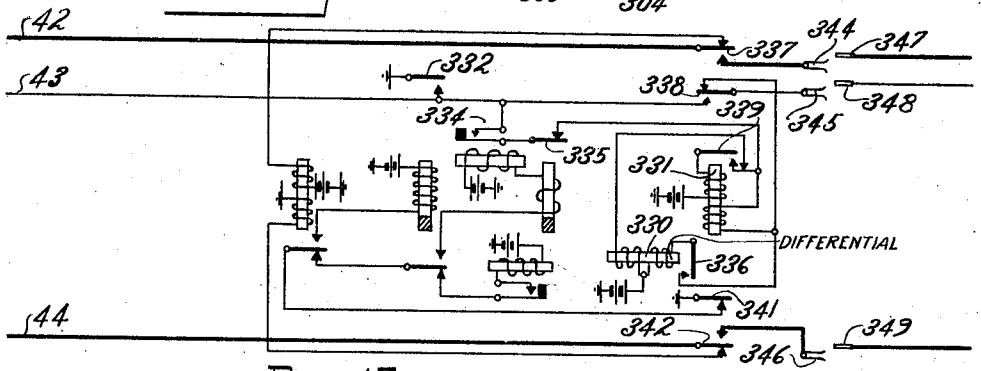
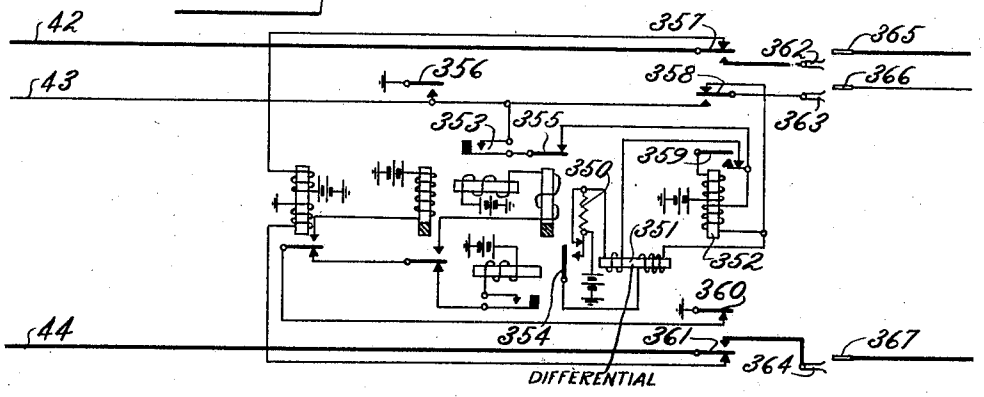


Fig. 10



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UNITED STATES PATENT OFFICE.

JOHN I. BELLAMY, OF BROOKFIELD, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO AUTOMATIC ELECTRIC INC., OF CHICAGO, ILLINOIS, A CORPORATION OF DELAWARE.

AUTOMATIC TELEPHONE SYSTEM.

Application filed March 9, 1925. Serial No. 13,961.

The present invention relates, generally stated, to automatic telephone systems and presents new and improved means for making the operation of switches, used in such systems, more reliable.

Specifically, my invention contemplates a positive stop arrangement for trunk hunting switches having an operating magnet which is operated in a local circuit.

One object of my invention is to produce an efficient circuit arrangement for a finder switch of the single-motion rotary type in which the wipers are operated on the forward stroke of the magnet in hunting for a calling line, the calling condition of the line being characterized by the presence of ground upon the test contact. When such grounded test contact is reached, I do not merely disconnect the magnet in order to prevent its further operation, but lock the magnet in its operated position until such circuit changes have taken place which insure against any possibility of advancing the wipers beyond the desired position.

In accordance with another object of my invention, I apply the same general principle—although differing in details from the former arrangement—to a finder switch in which the wipers are advanced on the back stroke rather than on the forward stroke of the stepping magnet.

A further object of my invention resides in modifications of the general principle with the view of producing circuits similar to those described above, adapted for use in connection with switches which test for the absence of ground upon the test contacts. Selector switches of the two-wire type are arranged to test in this manner. Accordingly, this phase of the invention is shown as applied to selector switches, and I have shown a number of modifications illustrating various ways in which the invention may be carried out, each method having its own particular adaptation.

In explanation of the principle of the circuits, it may be pointed out that in the past when a magnet has been operated in a local circuit to effect the trunk hunting movement of the wipers, great difficulty has been experienced in disconnecting the magnet quick enough to prevent an extra step being taken after an idle trunk was reached. In the present case no such difficulty is encountered on account of the fact that when the calling line is reached (in case of a finder switch) or when an idle trunk is reached (in case of a selector) the stepping magnet is locked energized. It is obvious that the magnet cannot fall back to take another step as long as it is maintained energized over a locking circuit, which is broken only after the switching relay has been operated and locked in its operated position, cutting off the stepping magnet completely, or producing certain other circuit changes before the magnet has any possible chance to advance the wipers an extra step.

Although the circuits are shown in connection with finder switches and selectors only, it will be obvious that they can be adapted for use in any circuit where a free hunting movement is desired.

The stated objects and other objects and features of my invention will be apparent as the description progresses, which should be read in connection with the appended drawings forming a part of this specification.

Referring now to the drawings, I have shown by means of the usual circuit diagrams, sufficient parts of switching apparatus to enable the invention to be thoroughly understood.

In Fig. 1, I have shown a finder switch of the single-motion rotary type advancing its wipers on the forward stroke of the stepping magnet, and Fig. 3 illustrates a finder switch which operates its wipers on the back stroke, but may to equal advantage be used for a finder operating the wipers on the forward stroke, as will appear clear from the detailed description which is yet to follow. At the left side of the drawings of Figs. 1 and 3, I have shown the usual subscriber substation and line equipment, consisting of the substation apparatus A and A′, and the line circuits LC and LC′, individual to the respective substations and located at the central office.

In Figs. 2, and 4–10, inclusive, I have shown circuits for selector switches of the type which advance the wipers first in a vertical plane to select a group and then in a horizontal plane to automatically select a trunk in the selected group.

It will be understood that the finder

switches shown in Figs. 1 and 3 may be substituted for each other. Likewise, the selectors shown in Figs. 2 and 4 to 10, inclusive, illustrate only modifications of the principle of the invention. They may be exchanged at will and used one in place of the other. In other words, the finder switch shown in Fig. 1, as well as the one shown in Fig. 3, may be used in connection with any of the selectors illustrated in Figs. 2 and 4–10, inclusive, the use of the switches in practice being merely determined by consideration of the merits of each of the circuits shown.

Having described my invention in general terms, I shall now discuss, more in detail, the operation of the switches shown in the drawings.

For the purpose of conveniently explaining the operations of the circuits, it shall be assumed that the finder switch shown in Fig. 1 operates in connection with the selector shown in Fig. 2, while the finder switch shown in Fig. 3 is assumed to be in operative relation to the selector illustrated in Fig. 4. However, I desire it to be expressly understood that the switches may be interchanged or substituted for one another at will, as has been explained in the preceding paragraph.

Referring now to Fig. 1, it will be assumed that the subscriber at substation A desires to make a call and, accordingly, removes the receiver from the switchhook.

When the receiver is removed at substation A, a circuit is closed over line conductors 30 and 31 for the line relay 3. Relay 3 energizes and operates armatures 13, 14 and 15. Armature 13, upon being attracted, connects ground to the test contact 34 of the finder bank to permit the finder to test for the calling line; armature 14 prepares a circuit for the cut-off relay 2 which will be completed when wiper 39 of the finder switch F reaches the bank contact 35; and armature 15 connects ground to the start conductor 45. Line relay 6 of the finder switch energizes upon ground being connected to start conductor 45, and completes a circuit for the stepping magnet 4 over the normally closed contacts controlled by armature 18, back contact and armature 16, front contact and armature 24 to ground. As will be remembered, the finder switch F is of the kind which advances its wipers on the forward or energizing stroke of the stepping magnet. Accordingly, the wipers 37–40, inclusive, are now advanced one step. Upon energizing, the stepping magnet attracts its armature 16, thus opening its own circuit. In deenergizing the circuit is closed again over armature 16 and the wipers advance another step. The finder switch, in this buzzerlike manner, operates very rapidly and moves its wipers over the bank contacts. When the calling line is reached, that is, when wiper 38 reaches bank contact 34, ground is encountered which has been connected to test contact 34 through armature 13 and a circuit is completed for the switching relay 5 in series with the stepping magnet 4 over armature 23 and its front contact, upper winding of switching relay 5, normally closed contacts controlled by armature 18, stepping magnet 4 to battery.

The upper winding of switching relay 5 is of low resistance and permits the stepping magnet to remain energized. The finder switch is, therefore, positively and very effectively stopped and it is apparent that no additional step can possibly be taken. The switching relay 5, having been energized over its upper low resistance winding in series with the stepping magnet 4 attracts its armatures and completes a holding circuit for itself over its lower high resistance winding and armature 18 and its front contact to battery over stepping magnet 4. The stepping magnet upon being connected in series with the high resistance winding of switching relay 5 does not receive sufficient current to keep its armature in operated position and releases, while the switching relay remains energized. Accordingly, the armature 16 and the mechanism advancing the wipers assume their normal positions. Stepping magnet 4 cannot be operated again because of its energizing path being opened at the normally closed contacts controlled by armature 18. At armature 20, the switching relay connects the grounded release trunk conductor 43 to wiper 39; connects up wipers 37 and 40 at armatures 17 and 22; and at armature 21 opens the circuit of line relay 6 and prepares the extension of the common start conductor 45 through armature 25 and its resting contact and conductor 41 to the next finder switch. Line relay 6, being slow acting, however, does not release for an interval.

The cut-off relay 2 of the line circuit LC, operates through armature 14 and working contact responsive to the grounding of wiper 39, and disconnects the line relay 3 and ground from the calling line at its armatures 10 and 12, and connects its own winding into a locking circuit at its armature 11. Line relay 3 deenergizes thereupon and removes ground from the test contact 34 at its armature 13, and disconnects ground from the common start conductor 45 at its armature 15. Armature 14 is opened also, but the holding circuit of the cut-off relay 2 is maintained over armature 11, which also maintains a ground potential upon the private normal conductor 32 terminating in a connector switch, for marking the line busy in accordance with the usual practice.

Upon the line conductors being connected through at armatures 17 and 22 of the

switching relay 5 as above pointed out, the line relay 100 of the selector, Fig. 2, operates over the calling line and completes a circuit for the release relay 102 over its armature 110 and its front contact. The release relay 102 energizes and, by means of its armature 111, connects ground to the release trunk conductor 43 before the slow-acting line relay 6 of the finder switch has had time to deenergize. Armature 112 prepares a circuit for the rotary magnet 106, and armature 113 prepares at its front contact a circuit for the vertical magnet 107, and at the same time disconnects the release magnet 105.

The calling subscriber's substation is now connected to the selector switch and he may operate his dial to transmit the first digit of the desired party's telephone number.

Responsive to the interruptions of the line circuit, the line relay 100 deenergizes a number of times, and upon each deenergization completes a circuit for the vertical magnet 107 in series with relay 103 over front contact and armature 113, back contact and armature 110 to ground at armature 119. Series relay 103, being slow acting, operates in this circuit, but does not release during the transmission of the digit due to its sluggish action, and, in operating its armature 114, opens a point in the circuit of the rotary magnet 106 to prevent its premature operation. Relay 102, which is slow to release, likewise remains energized during the transmission of impulses.

Upon the termination of the first digit, line relay 100 energizes for a relatively long period of time, and relay 103, its circuit being opened at armature 110, deenergizes and completes the circuit for rotary magnet 106, which circuit includes the off normal contacts 135 operated in the usual manner upon the first vertical step, front contact and armature 112, armature 114 and its back contact, normally closed contact controlled by armature 117, normally closed contact controlled by armature 121, winding of the rotary magnet 106 to a neutral point of battery 140. It will be seen that I have shown a neutral point tapped off from the regular exchange battery and that the circuit traced above includes only the upper part of said battery. It will, of course, be understood that the rotary magnet 106 must be suitably wound to respond to this arrangement. The rotary magnet 106, upon energizing, advances the wipers 125–127, inclusive, one step and positions them on the first set of bank contacts in the selected level, and at the same time attracts its armature 121, thereby connecting switching relay 104 to the rotary magnet circuit and inserting the resistance 109 in series with the rotary magnet. If the first trunk is idle the rotary magnet 106 remains energized through resistance 109 and the switching relay 104 operates immediately (over a circuit to be pointed out later), seizing the trunk.

Assuming the first set of contacts to be busy, however, ground is encountered by test wiper 126; the switching relay is, therefore, short circuited; and a circuit is completed for the rotary magnet 106 in opposite direction to the energizing circuit traced above. This new circuit includes the lower part of the exchange battery 140, center of the battery, rotary magnet 106, front contact and armature 121, resistance 108, back contact and armature 116, wiper 126, and ground at the busy test contact. It will be seen that, with the initial circuit of magnet 106 still established, except for the inclusion of resistance 109, and with the new circuit established through resistance 108, the direction and strengh of current flow through magnet 106 depends upon the relative values of the resistances 108 and 109. Resistance 109 is relatively high and resistance 108 is relatively low. Resistance 109 allows just enough current to pass to maintain magnet 106 operated in case the new circuit is not established, and the resistance 108 merely high enough to prevent an excessive current flow during the instant when the three contacts of the magnet are all closed together. Accordingly, since resistance 108 is lower than the resistance 109, the rotary magnet 106 is de-magnetized under the influence of opposed current flow and retracts its armature 121.

As soon as the normally closed contacts controlled by armature 121 close, resistance 109 is short circuited, and the initial current flow is re-established, notwithstanding the fact that the circuit through armature 121 and its working contact is still intact. Nevertheless, the backward stroke of the armature of the magnet continues, due to the usual spring tension, and to the acquired momentum until armature 121 opens the switching relay circuit, and until the backward limit is reached, because of the appreciable time required for the current flow through the magnet to reach its maximum value.

As soon as the current flow increases sufficiently, magnet 106 operates its armature again, thereby advancing the wipers to the second trunk line.

The wipers are advanced in this manner until an idle trunk is found. Assume this idle trunk to be the one shown in the drawing and comprising the trunk conductors 131, 132 and 133. When wiper 126 reaches the ungrounded contact 129, the rotary magnet 106 remains energized in series with resistance 109 because no ground potential is encountered by the wiper 126 to bring about its deenergization. The rotary mag-

net is in this manner held in its operated position and prevented from taking an extra step.

With magnet 106 operated, and with wiper 126 ungrounded, switching relay 104 (whose lower terminal is connected to the junction of resistance 109 and magnet 106, and whose upper terminal is connected with the grounded release trunk conductor 104) energizes and locks itself over armature 117 and its front contact to the mid tap of battery in series with resistance 109 and the rotary magnet 106, at the same time disconnecting the high voltage battery lead from the rotary magnet circuit. The rotary magnet 106 is now disconnected from the upper terminal of the battery 140 and it accordingly falls back. It is true that the falling back of rotary magnet 106 is hastened somewhat due to the fact that the relatively small amount of current required to operate relay 104 is now flowing through magnet 106 in a direction opposite to the direction of the initial current flow through the magnet, but this effect is so small as to be practically negligible. Accordingly, it will be understood that magnet 106 now falls back and does not operate again for the remainder of this connection.

Incidentally, magnet 106 places a local shunt around the resistance 109 when it falls back, and it also opens at armature 121 the initial circuit of relay 104 leaving switching relay 104 locked up at armature 117.

As a further result of its operation, switching relay 104 opens the test circuit and prepares the usual holding circuit at armature 116; it removes ground from armature 110 at armature 119, thereby opening the release relay circuit and opening a point in the release magnet circuit; and at armatures 115 and 120 it disconnects line conductors 42 and 44 from line relay 100 and extends them by way of wipers 125 and 127 and conductors 131 and 133 to the line relay of the switch to which the seized trunk extends.

The line and release relays (not shown) of the seized switch now pull up and the latter places ground on release trunk conductor 132, thereby establishing the usual holding circuit before the slow acting release relay 102 has had time to fall back. A circuit is prepared for the release magnet 105 after the line relay 100 and the release relay 102 have restored, which circuit includes the armatures 110 and 113 and the off normal contact 136. However, release magnet 105 cannot energize at present due to its circuit having been opened at armature 119 upon the energization of the switching relay 104.

The succeeding switches are now set in the usual manner to complete the connection to the desired subscriber's line.

I shall explain now the release of the selector and of the finder switch, shown in Figs. 2 and 1, respectively. When the subscribers have completed their conversation and have restored their receivers, ground is removed from the release trunk conductor 132 shown in Fig. 2. Ordinarily all the relays connected with the release trunk conductor of an established connection obtain their battery from the same battery tap, and they all deenergize when ground is removed from the release trunk conductor. However, in the present case, the switching relay 104 of the selector shown in Fig. 2 is not connected with the regular exchange battery lead but is connected instead to a tap taken out of the middle of the exchange battery, while the holding circuits of the finder F and the line circuit LC obtain their battery supply from the entire exchange battery. Accordingly, even after the ground potential is removed from the release trunk conductor 132, a circuit for the holding relays of the finder F and the line circuit LC is still established through the upper portion of the exchange battery. For example, assuming the direction of the current flow in this case to be from the mid-tap of the battery 140 through rotary magnet 106 of the selector shown in Fig. 2, the current flow takes a path including the normally closed contacts controlled by armature 121, working contact and armature 117, and switching relay 104 to the release trunk conductor 43 of the selector. From this point, the current flow continues over the release trunk conductor to the exchange battery tap by way of the two paths. One path includes the lower winding of switching relay 5 of the finder F, armature 18 and its working contact, and the stepping magnet 4. The other path includes the working contact and armature 20, wiper 39, bank contact 35, armature 11 and its working contact, and cut-off relay 2. Accordingly, it may be assumed that relays 2 and 5 do not fall back responsive to the mere removal of the ground potential from the release trunk conductor 43, but remain energized in parallel with switching relay 104, Fig. 2.

The conditions at relay 104, however, are not the same as at the two holding relays above mentioned. The relay 104 which was initially energized through the lower half of the exchange battery, is now energized through the upper half of the exchange battery, with the result that the current flow through it at this time is in a direction opposite to the initial current flow. This being the case, relay 104, not only does not hold up because of this new current flow but it is actually de-magnetized and caused to fall back because of the opposed current flow. Upon falling back, relay 104 disconnects its lower terminal from the rotary

magnet circuit at armature 117; current ceases to flow through its winding, and relays 2 and 5, Fig. 1, fall back.

As a further result of its deenergization, relay 104 completes at its armature 119 the circuit of the release magnet 105, which restores the shaft carrying the wipers 125–127, inclusive, in the usual manner. The off-normal contacts 135 and 136 will be opened upon the shaft reaching its normal position.

Referring to Fig. 1, the restoration of the finder switch F and of the line circuit LC takes place simultaneously with the release of the selector. Switching relay 5 of the finder, and switching relay 2 of the line circuit deenergize as above pointed out, and, as can readily be seen, restore the normal conditions, i. e., the line conductors 30 and 31 are again connected to ground and to the line relay 3, respectively, over the armatures 10 and 12, the wipers 37 and 40 of the finder switch are disconnected from the trunk conductors 42 and 44, and wiper 39 from the release trunk conductor 43, while the start conductor 45 is again connected to the line relay 6 by way of armature 21. The wipers will not be advanced but remain positioned on the bank contacts 33—36, respectively.

It is apparent from the foregoing description of the finder switch F shown in Fig. 1, and of the selector shown in Fig. 2, that both switches are bound to stop positively on the proper contacts representing a line in the case of the finder and a trunk in case of the selector, and that no extra step can possibly be taken due to the fact that the stepping magnet remains locked upon the proper set of contacts being reached.

I shall next explain the operation of a finder switch F′, shown in Fig. 3, which is assumed to operate together with the selector switch shown in Fig. 4.

Referring now to Fig. 3, it will be seen that the line circuit LC′ is in every respect similar to that shown in Fig. 1. I shall, therefore, refrain from repeating the description of the operation of the line circuit LC′, but limit myself to pointing out the operation of the finder F′ as far as it differs from that of the finder switch already explained.

The finder switch circuit F′ is particularly designed for finder switches which advance the wipers on the back stroke. However, as will be pointed out hereinafter, it can equally be used for finder switches of the other type advancing the wipers on the forward or energizing stroke and will be found to be especially useful in connection with a switch of the latter type, if a stepping magnet is employed which requires a great amount of current for operating and holding. The circuit of the stepping magnet of finder switch F′ is entirely local, whereas the holding circuit of the stepping magnet shown in Fig. 1 includes, as will be remembered, the test wiper of the switch. In cases where it is not desired for one reason or another to carry the holding circuit of the stepping magnet over a wiper, the finder as shown in Fig. 3 will be very useful.

For the purpose of explaining the operation it will first be assumed that the finder switch F′ is one which advances its wipers on the back stroke, and that the subscriber at substation A′ desired a connection and accordingly removed the receiver from the switchhook. Start relay 6′ energizes upon ground being connected to start wire 45′ and completes at its armature 24′ a circuit for the stepping magnet 4′ which circuit includes armature 26 of a relay 7. The stepping magnet, upon energizing, attracts its armature 16′ thereby closing a circuit for relay 7 parallel to its own circuit. Relay 7 energizes and opens at its contact 26 the circuit of stepping magnet 4′. The stepping magnet deenergizes and advances the wipers 37′–40′, inclusive, in the usual manner, one step, positioning them on the next set of bank contacts, and at the same time opens at its armature 16′ the circuit for relay 7 which deenergizes thereupon and starts a new cycle at armature 26.

The wipers are thus advanced over the bank contacts, and arrive on the contact set of the calling line with relay 7 energized, and with magnet 4′ falling back to effect the movement of the wipers. When the back stroke of magnet 4′ is complete, wiper 38 is positioned on contact 34′ and the local circuit of relay 7 is open at armature 16′. Relay 7 does not fall back at this time, however, because of a new circuit established for it through test wiper 38′ from the grounded test contact 34′ which circuit includes armature 23′ and its front contact, and switching relay 5′. Therefore relay 7 cannot fall back to close the stepping magnet circuit at armature 26, and switching relay 5′ energizes.

The switching relay 5′, at its armatures 17′ and 22′ extends the line conductors to the selector switch over conductors 42′ and 44′, disconnects line relay 6′ at armature 21′, and at the same time locks itself and relay 7 at armature 19′ to the grounded release trunk conductor 43′. Armature 20′ upon being attracted, extends the release trunk conductor 43′ back to the line circuit LC′ over wiper 39′ and bank contact 35′. The holding circuit of switching relay 5′ and relay 7 includes at this time armatures 19′ and 24′ to ground. Start relay 6′, being a slow-acting relay does not deenergize before the lapse of a sufficient period of time to permit the selector switch to connect ground to the release trunk in the usual manner.

It will next be assumed that the finder switch F′ is one which advances the wipers

upon the forward or energizing stroke. The wipers are advanced in the same buzzerlike manner through the action of stepping magnet 4′ and relay 7. The only difference in operation which must be considered is that, whereas the testing operation took place in the former case immediately upon the arrival of the wipers upon the contacts of the calling line, the testing operation in this case is delayed until magnet 4′ falls back and opens its armature 16′, after having advanced the wipers to the calling line.

The selector switch shown in Fig. 4, which is assumed to operate together with the line finder switch F′ shown in Fig. 3, is, as may be seen from the drawing, very similar to that shown in Fig. 2.

Upon the line conductors of the calling substation being extended over the trunk conductors 42′—44′, the line relay energizes and causes the operation of the release relay. The release trunk is thereby connected to ground before the slow-acting start relay of the finder switch has had time to deenergize, and the circuit for the series relay and for the vertical magnet is prepared. The wipers will be raised now opposite a certain level in response to the first digit in a manner described previously.

Upon the termination of the digit, series relay 103′ deenergizes and completes at its armature 114′ the circuit for the rotary magnet 106′, which circuit includes the off normal contacts 135′, front contact and armature 112′, armature 114′ and its back contact, armature 118′ and its back contact, back contact and armature 121′, and winding of the rotary magnet 106′. Current is drawn from the upper part of the battery. The rotary magnet operates and positions the wipers on the first set of bank contacts, and, if this set of contacts is idle, the switching relay operates. Assuming the first set to be busy, however, ground is encountered by wiper 126′ at the test contact and the switching relay 104′ cannot operate due to its upper winding being short-circuited at armature 111. Current is reversed in the winding of the rotary magnet, causing it to de-magnetize quickly, the circuit including the grounded test contact, wiper 126′, armature 116′ and its back contact, front contact and armature 121′, winding of the rotary magnet 106′, and the lower part of the battery 140′.

When the wipers are positioned on an idle set of bank contacts which it is assumed to be the one comprising conductors 131′–133′, inclusive, no ground but open circuit will be encountered instead, and a circuit results for the switching relay 104′. Current for energizing switching relay 104′ is drawn from the entire exchange battery and the circuit includes off normal contact 135′, armatures 112′, 114′, 118′, resistance 109′, armature 121′, and its front contact, upper winding of switching relay 104′ to ground at armature 111′. The rotary magnet 106′ being tapped off at a neutral point will, of course, be connected in a holding circuit, during testing, as can easily be seen from the drawing. The switching relay, after having been operated over its upper winding, locks itself over both windings at its armature 117′ to ground at the release trunk. The rotary magnet is disconnected at armature 118′; the release trunk conductor extended at armature 116′; and the trunk conductors 42′ and 44′ are extended to the conductors 131′ and 133′ over armatures 115′ and 120′.

The connection to the desired party is completed in the usual manner. The release operations of the selector, Fig. 4, and of the line finder F′ and line circuit LC′ shown in Fig. 3 are substantially the same as the restoration of the selector Fig. 2 and the finder switch disclosed in Fig. 1 with the exception that, since relay 104′ is held up over the entire exchange battery in this case instead of over only half, as in the preceding case, all the relays connected to the release trunk conductor fall away in the usual manner.

It will be apparent from the above description of the finder switch F shown in Fig. 1 and of the selector shown in Fig. 2, as well as from the operation of the finder switch F′ shown in Fig. 3 and selector shown in Fig. 4 that either one of the finders may be used in connection with either of the selectors, or vice versa. Every one of the switches has its special merits. However, it may be said that the selector disclosed in Fig. 2 shows a preferred arrangement over that shown in Fig. 4, in view of the fact that the switching relay 104 requires only one winding as compared with switching relay 104′ of the selector shown in Fig. 4 which has two windings. In all cases the principal object of my invention, viz., to accomplish a positive stop of the stepping magnet and to prevent it from taking an extra step, has been attained in a simple manner.

I shall next describe the selector switches shown in Figs. 5–10, inclusive, in succession. For the purpose of explaining the operation of the various selectors, it will be assumed that the selectors are to be substituted for that shown in Fig. 2, i. e., they are, in the course of the description, assumed to operate together up with the line finder switch shown in Fig. 1.

The operations of all the selectors to be described, as well as of the selectors shown in Figs. 2 and 4, are identical up to the point where the rotary magnet starts to operate. As these operations have already been described in detail in connection with the selector shown in Fig. 2, I shall explain only the modifications concerning the circuits of the rotary magnet and of the switching re-

lay. The restoration of the selector is also the same as explained in connection with Fig. 2. The description of the selector Fig. 2 may be consulted for details of the above operations.

Referring now to Fig. 5, a circuit for the rotary magnet 202 is completed when the series relay deenergizes upon the termination of the first digit, which circuit includes the off-normal contact 205, normally closed contact controlled by armature 203, right hand winding of the rotary magnet 202, normally closed contact controlled by armature 208, armature 219 of the series relay to ground at armature 220. The rotary magnet operates and advances the wipers 213–215, inclusive, into engagement with the first set of bank contacts in the desired level. If this trunk is idle, the switching relay 201 energizes immediately. Assuming the trunk to be busy, however, the switching relay 201 is short-circuited over the left hand holding winding of the rotary magnet 202 by ground encountered by the test wiper 214 and does not operate. The rotary magnet, upon energizing, attracts its armature 203, thereby opening the normally closed contact. The rotary magnet, having the circuit of its right hand operating winding interrupted and its left hand holding winding short-circuited, deenergizes now, thereby closing the circuit for its operating winding again. The operation of the rotary magnet continues thus until an idle trunk is reached, which trunk it is assumed is the one terminating in the bank contacts 216–218, inclusive. The switching relay 201 being not short-circuited at this time now operates over its lower winding in series with the left hand holding winding of rotary magnet 202 and resistance 200. The switching relay, upon energizing, extends the line conductors and the release trunk in the usual manner and locks itself to ground at the release trunk over its upper winding and armature 208, thereby opening the normally closed contact and disconnecting the holding and operating windings of rotary magnet 202.

It is obvious that the rotary magnet, being locked in its operated position during the operation of the switching relay, cannot take another step but is positively stopped with the wipers positioned on the bank contacts of the idle trunk. It will be observed that the holding winding of the rotary magnet is short-circuited during its de-energization. This arrangement has, of course, a slight retaining effect, but, considering the relatively high tension of the armature of the rotary magnet, it is thought to be of negligible importance.

It will further be observed that the armatures 203 of the rotary magnet controlling the normally closed contact, requires an accurate adjustment to insure proper operation. Though the adjustment of this armature can be maintained in practice without any difficulties, I have shown in Fig. 6 a modification which, as far as the operation is concerned, is substantially the same as that shown in Fig. 5, but does not need an accurate adjustment in view of the simplicity of the contact arrangement.

Assuming the selector shown in Fig. 6 substituted for that shown in Fig. 5, the wipers will be raised opposite a certain level in the usual manner. The series relay deenergizes upon the termination of the vertical impulses to close a circuit for the rotary magnet 226. It will be observed that the lower winding of the switching relay 227 and the right hand holding winding of the rotary magnet 226 are connected in series to battery over resistance 225 and off-normal contact 230. The switching relay, however, does not operate responsive to the closure of armature 229 because of a short circuit at armature 231 of the rotary magnet. The rotary magnet operates now over its left hand winding and its interrupter armature 232 and advances the wipers 239–241 inclusive, into engagement with the first set of bank contacts. In case the trunk on which the wipers are resting now is idle, switching relay 227 energizes over its lower winding and the right hand holding winding of the rotary magnet in series with resistance 225, because of the short-circuit having been removed at armature 231 upon the energization of the rotary magnet. The rotary magnet is thus locked during the operation of the switching relay and prevented from taking an additional step. The switching relay, upon energizing, attracts its armatures and extends the line and the release conductors in the usual manner and locks itself over its upper winding and armature 235, thereby also de-energizing the rotary magnet. Assuming the first trunk to be busy ground is encountered by wiper 240 keeping the lower winding of the switching relay and the right hand holding winding of the rotary magnet further short-circuited, though the short-circuit at armature 231 has been removed upon energization of the rotary magnet, because of ground from armature 228 connected to the lower winding of the switching relay by way of armature 229 and the normally closed contact controlled by armature 235. The rotary magnet deenergizes and advances the wipers to the next set of bank contacts and continues with this operation until an idle trunk is reached.

Fig. 7 shows a selector switch having a differentially wound rotary magnet. The latter energizes initially over its left hand winding upon the closure of armature 255 after the wipers have been positioned opposite a certain level, the circuit including the armature 253 and its front contact, off

normal contact 254, armature 255 and its back contact, normally closed contact controlled by armature 259, left hand winding of rotary magnet 250, and shunt around resistance 252 at the normally closed contact controlled by armature 256. The wipers 264–266, inclusive, are thereby advanced to the first set of bank contacts and the shunt around resistance 252 is removed, while the armature 256 connects the right hand winding to battery. Now, if the trunk on which the wipers are resting is idle, the rotary magnet remains operated through resistance 252, and the switching relay 251 energizes immediately. Assuming the trunk to be busy, ground is encountered by test wiper 265, and the switching relay cannot operate because it is short circuited, but a circuit results over the right-hand winding of the rotary magnet. The right-hand winding opposes the other winding and causes the rotary magnet to deenergize. Armature 256 opens thereby the circuit for the right hand winding and closes the shunt around resistance 252 to restore the original operating circuit. The wipers are advanced in this manner until an idle trunk is found. When an idle trunk is reached no ground is encountered by test wiper 265 and switching relay 251 energizes in series with the right hand winding of the rotary magnet. The resistance of switching relay 251 is sufficiently high to prevent differential action of the rotary magnet. The latter will, therefore, remain locked during testing, over its left hand winding. In energizing, the switching relay extends the line and release trunk in the usual manner and disconnects at armature 259 the energizing path of the left hand winding of the rotary magnet and locks itself in series with the latter over its armature 259. The rotary magnet now deenergizes because of the high resistance of the switching relay.

In Fig. 8, I have shown a selector switch with the circuits of the rotary magnet and of the switching relay very similar to that shown in the Figs. 2 and 4, respectively. Instead of having a neutral point tapped off from the battery, I employ a derived neutral tap. The operation is as follows:

The series relay deenergizes and closes its armature 307 upon the wipers being positioned opposite a certain level. A circuit is completed now for the rotary magnet 300 which includes the armature 305 and its front contact, off normal contact 306 which had been closed upon the first vertical step of the switch, armature 307 and its back contact, normally closed contact controlled by armature 309, normally closed contact controlled by armature 311, winding of the rotary magnet 300, and short-circuit around resistance 302 at armature 315 and its back contact. The rotary magnet thereupon energizes and advances the wipers 318—320 into engagement with the first set of bank contacts. If this set of contacts is idle, switching relay 301 operates. Assuming this set to be busy, however, ground is encountered by the test wiper 319. It will readily be seen that the switching relay cannot energize at this time because of being short-circuited at armature 305. The rotary magnet 300, upon energizing, opens its original energizing circuit at the normally closed contact controlled by armature 309 and connects by means of the same armature, battery and ground to the rotary magnet over the resistances 303 and 304. The current flow in the winding of the rotary magnet 300 is now reversed, and the rotary magnet 300 releases, closing its original energizing circuit again. This latter circuit may be traced from ground at the test contact, wiper 319, armature 313 and its back contact, armature 314, winding of the rotary magnet, normally closed contact controlled by armature 311 and armature 309 to battery over resistance 304. The short-circuit around resistance 302 is removed, during testing, at armature 315. The operation of the rotary magnet continues in this manner until an idle trunk is found which trunk it is assumed is the one terminating in the bank contacts 321–323, inclusive. No ground is present at the test contact at this time, and the switching relay, being no longer short-circuited, energizes in the following circuit:—from ground at the armature 305 and its front contact, winding of the switching relay 301, armature 314 of the rotary magnet and its front contact, resistance 302 to battery. The rotary magnet is being locked while the switching relay energizes, the locking current flowing in the positive direction from ground at resistance 303, armature 309, normally closed contact controlled by armature 311, winding of the rotary magnet 300, resistance 302 to battery. The switching relay, in energizing, extends the trunk conductors as usual and locks itself over its armature 311 in series with the rotary magnet 300 to battery, at the same time disconnecting the holding circuit of the rotary magnet at the normally closed contact controlled by armature 311. The rotary magnet deenergizes because it is short circuited through armatures 311 and 314, and it does not operate again on account of the high resistance of the switching relay.

In Fig. 9, I have shown a modification of the selector switch shown in Fig. 7. The rotary magnet 330 is also differentially wound, the switching relay 331, however, has two windings instead of one, and the operation of the switch is accordingly slightly different. It will also be observed that the contact arrangement 336 is different from that shown in Fig. 7 and designated through

the numeral 256, and that I have avoided the use of a resistance such as 252 shown in Fig. 7.

To proceed with the description of the operation of the switch shown in Fig. 9, the series relay de-energizes as usual upon the termination of the vertical movement of the switch and closes at its armature 335 a circuit for the left hand winding of the differentially wound rotary magnet 330. This circuit includes armature 332 and its front contact, off normal contact 334, armature 335 and its back contact, and the normally closed contact controlled by armature 339. The rotary magnet thereupon energizes and moves the wipers into engagement with the first set of bank contacts. If the first trunk encountered is idle, the switching relay 331 energizes immediately. Assuming the trunk to be busy, however, ground is encountered by the test wiper 345, and a circuit is completed for the right hand winding of the rotary magnet from ground at the test contact, wiper 345, armature 338 and its back contact, and front contact of armature 336. The lower winding of the switching relay 331 is, as will be seen, short-circuited at this time, and, therefore, prevented from operating. The circuit through the right hand winding which is opposed to the left hand operating winding causes the restoration of the rotary magnet and, consequently, the disconnection of the opposed winding at armature 336, whereupon the rotary magnet energizes again to advance the wipers further. The operation continues thus until an idle trunk is encountered, the test contact of which is not connected to ground.

Assuming the contacts of the idle trunk to be the contacts 347—349, inclusive, when the wipers 344—346 are positioned on these contacts, a circuit is completed for the lower winding of the switching relay 331 in series with the right hand winding of the rotary magnet 336. The rotary magnet is kept energized during the operation of the switching relay over its left hand winding, due to the resistance of the lower winding of the latter which does not permit a differential action of the rotary magnet. Upon energizing, the switching relay disconnects the left hand winding of the rotary magnet at the normally closed contact controlled by armature 339 and connects its upper winding in a locking circuit to ground at the release trunk. The line conductors and the release trunk are extended in the usual manner by way of armatures 337, 338 and 342. The rotary magnet, its left hand operating winding being disconnected at the normally closed contact controlled by armature 339 restores its original position and cannot energize again as long as the switching relay is operated.

In Fig. 10, I have shown still another modification of a selector having a differentially wound rotary magnet. It will be seen from the drawing that I use the same arrangement of armatures at the rotary magnet as that shown in Fig. 7, but the switching relay has two windings instead of one. Accordingly, the operation is somewhat different from the operation of the selectors shown in Figs. 7 and 9.

Upon the de-energization of the series relay a circuit for the rotary magnet 351 is completed which includes the normally closed contact controlled by armature 354, short-circuit around resistance 350, left hand operating winding of the rotary magnet 351, the normally closed contact controlled by armature 359, back contact and armature 355, off normal contact 353, back contact and armature 356 to ground. The rotary magnet energizes in this circuit and advances the wipers in the usual manner positioning them on the first set of bank contacts. Armature 354 of the rotary magnet closes its contact and opens the normally closed contact thereby removing the shunt around resistance 350 and connecting this resistance in series with the left hand operating winding, while the right hand, opposed winding, is connected to battery. If the trunk on which the wipers are resting is idle the switching relay 352 operates. Assuming the trunk to be busy, however, ground is encountered by test wiper 363 and the switching relay is prevented from energizing because of a short-circuit to ground at armature 356. A circuit is closed instead for the right hand winding of the rotary magnet over armature 358 and its back contact. The rotary magnet having both its windings connected to current restores because of the differential action and closes its original operating circuit again to advance the wipers another step. When an idle trunk is reached no ground is present at the test contact, and the switching relay 352 being no longer short-circuited, energizes now over its lower winding in series with the right hand winding of the rotary magnet. No differential effect takes place, however, because of the high resistance of the lower winding of the switching relay, and accordingly the rotary magnet is locked during the operation of the switching relay in the same manner as already described. The switching relay, in addition to its usual function, locks itself over its upper winding and armature 359 to the release trunk.

It will be obvious from the foregoing description that my invention is capable of receiving a great variety of expressions some of which I have described and illustrated in the drawings. It will also be seen that the invention may be embodied in systems varying widely in structural details from that shown, and, accordingly, it will

be understood that I do not intend to be limited to the particular forms of carrying out my invention which I have disclosed, but the appended claims may be consulted for what I consider new and desire to have protected by Letters Patents.

What is claimed is:

1. In an automatic hunting switch, a stepping magnet, a test wiper, means including said test wiper for energizing and de-energizing said magnet to drive the switch over busy lines, and means for holding said magnet energized when an idle line is reached.

2. In an automatic hunting switch, a stepping magnet, a test wiper, a circuit including said test wiper for intermittently energizing and de-energizing said magnet to drive the switch over busy lines, and a locking circuit for holding the magnet energized when an idle line is reached.

3. In an automatic hunting switch, a stepping magnet, a circuit for intermittently energizing and de-energizing said magnet to drive the switch over busy lines, a locking circuit for holding the magnet energized when an idle line is reached, and a shunt circuit including the test wiper of said switch for rendering said locking circuit ineffective as long as said wiper engages busy test contacts.

4. In an automatic hunting switch, a stepping magnet, a circuit for intermittently energizing and de-energizing said magnet to drive the switch over busy lines, a locking circuit for holding the magnet energized when an idle line is reached, a shunt circuit including the test wiper of said switch for rendering said locking circuit ineffective as long as said wiper engages busy test contacts, and a switching relay energized in said locking circuit when the same becomes effective.

5. In an automatic hunting switch, a stepping magnet, a circuit for intermittently energizing and de-energizing said magnet to drive the switch over busy lines, a locking circuit for holding the magnet energized when an idle line is reached, a shunt circuit including the test wiper of said switch for rendering said locking circuit ineffective as long as said wiper engages busy test contacts, a switching relay energized in said locking circuit when the same becomes effective, a locking circuit for said relay, and contacts on said relay for breaking said magnet circuits.

6. In an automatic hunting switch, a stepping magnet for driving the switch, and means for operating said magnet by intermittently reversing its polarity.

7. In an automatic hunting switch, a magnet controlling selection of an idle line, a circuit for energizing said magnet, a switching relay, a circuit for energizing said relay, a test wiper, and a circuit including said test wiper for shunting said relay and for de-energizing said magnet.

8. In an automatic hunting switch, a magnet for controlling advance of the switch, a circuit for energizing said magnet, a second circuit including said magnet for rendering said first circuit ineffective, and means for operating said magnet by closing and opening said second circuit.

9. In an automatic hunting switch, a magnet, a circuit for energizing said magnet to advance the switch wipers into engagement with a line, a test wiper, and a circuit including said test wiper and the said magnet for de-energizing the magnet in case the engaged line is busy.

10. In an automatic hunting switch, a magnet, a circuit for energizing said magnet to advance the switch wipers into engagement with a line, a test wiper, a circuit including said test wiper and the said magnet for de-energizing the magnet in case the engaged line is busy, and means for breaking said second circuit when the magnet is de-energized to render the first circuit again effective to advance the wipers to the next line.

11. In an automatic hunting switch, a magnet controlling selection of an idle line, said magnet having only a single winding and means for operating said magnet by intermittently reversing the direction of current flow in said winding.

12. In an automatic hunting switch, a magnet, a circuit including a winding of said magnet for energizing the same, a second circuit including said winding but carrying current through the same in the opposite direction, and means controlled by said magnet when energized for closing said second circuit.

13. In an automatic hunting switch, a magnet, a circuit including a winding of said magnet for energizing the same to advance the switch wipers into engagement with a line, and a second circuit closed only in case the engaged line is busy for reversing the direction of current flow in said magnet winding to de-energize the magnet.

14. In an automatic hunting switch, an electro-magnet, a circuit for energizing said magnet to advance the switch wipers into engagement with a line, a second circuit for reversing the polarity of said magnet to de-energize the same, and means for closing said second circuit in case the engaged line is busy.

In witness whereof, I hereunto subscribe my name this 5th day of March, A. D., 1925.

JOHN I. BELLAMY.