

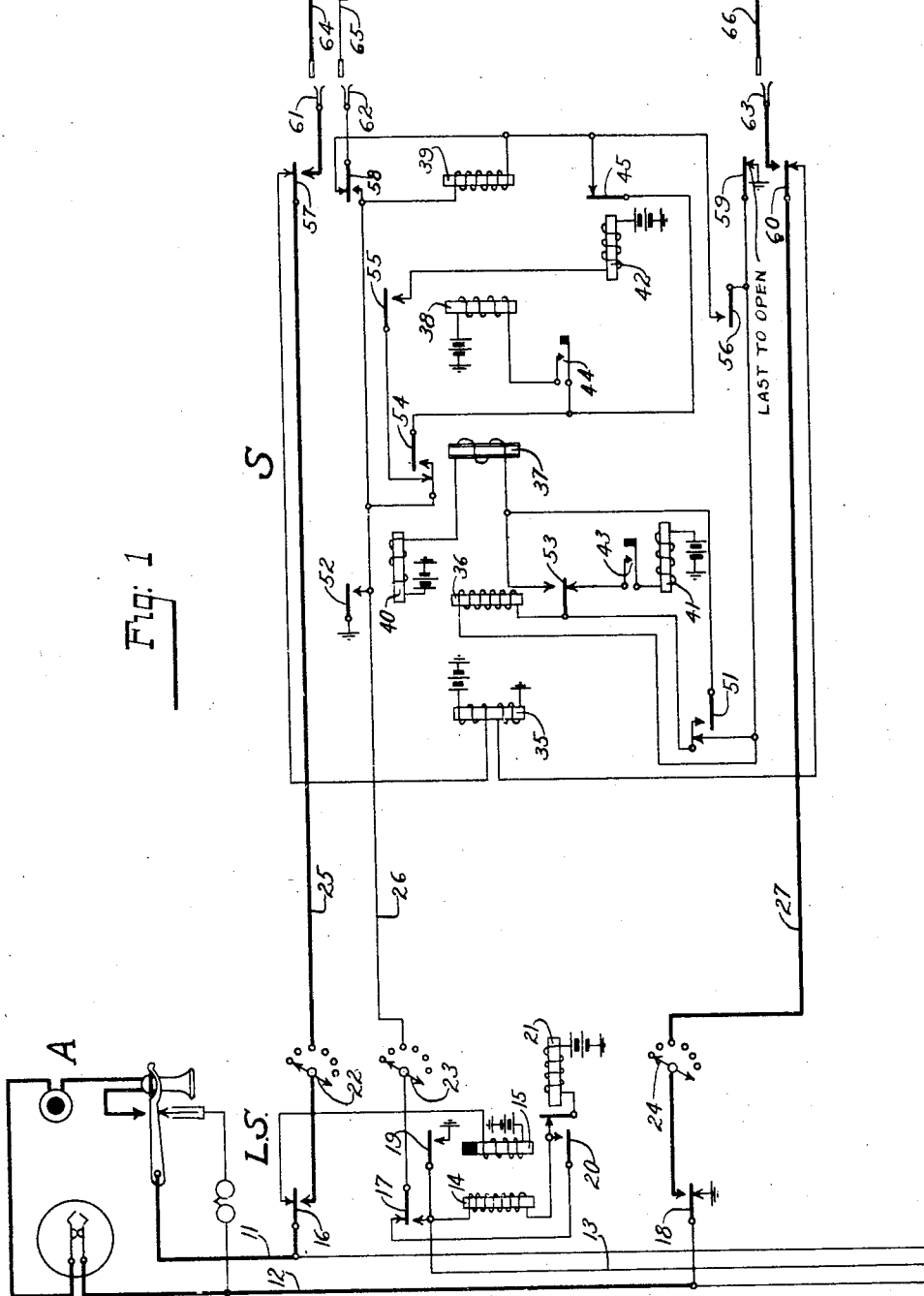
Nov. 27, 1928.

1,693,124

R. F. STEHLIK

AUTOMATIC TELEPHONE SYSTEM

Original Filed May 29, 1924 2 Sheets-Sheet 1



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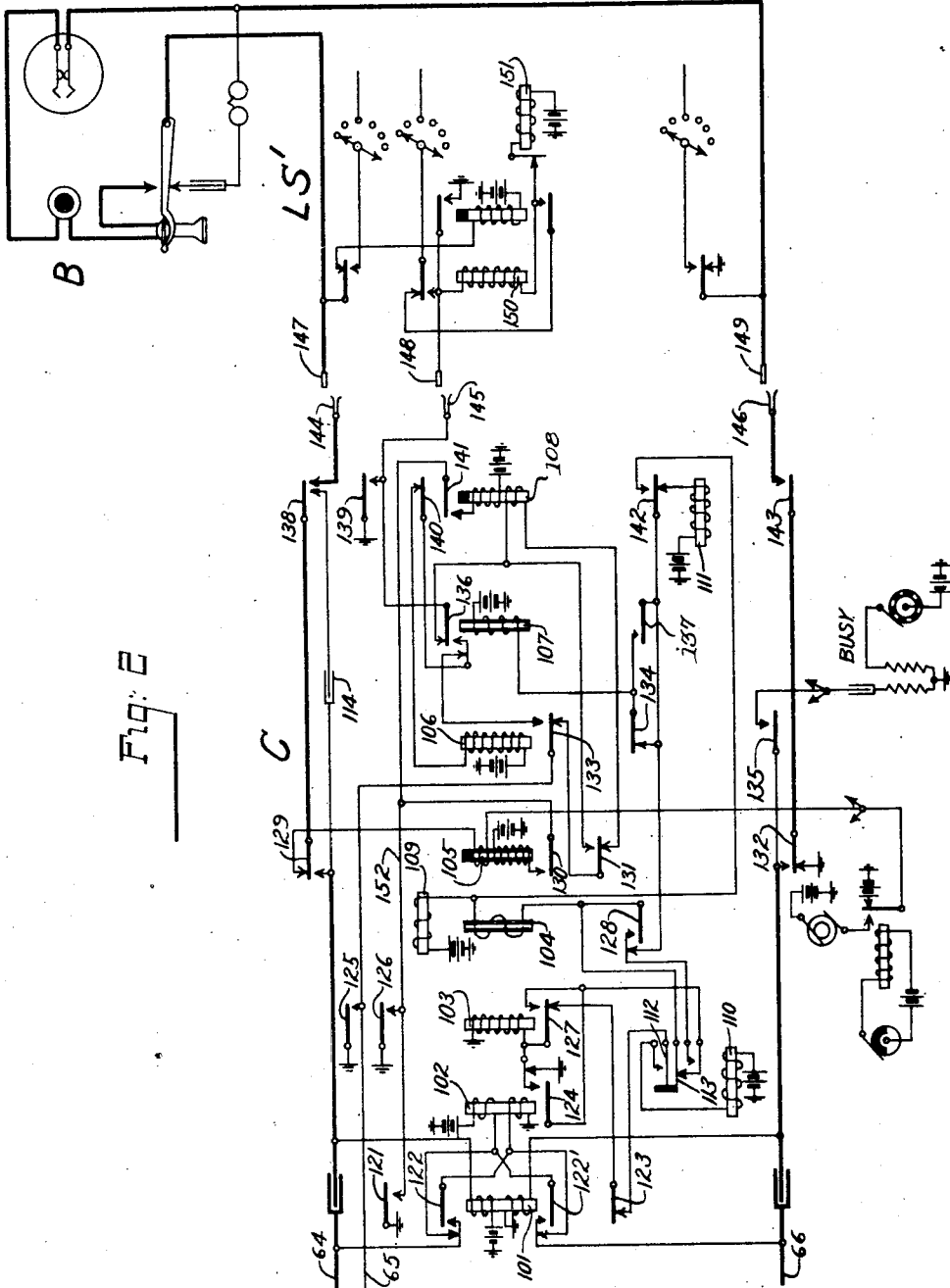
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UNITED STATES PATENT OFFICE.

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AUTOMATIC ELECTRIC INC., OF CHICAGO, ILLINOIS, A CORPORATION OF DELA-
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AUTOMATIC TELEPHONE SYSTEM.

Application filed May 29, 1924, Serial No 716,577. Renewed February 27, 1928.

The present invention relates in general to automatic telephone systems, but is concerned more particularly with improved circuit arrangements for the automatic switches that are employed in telephone systems; and the principal object is the production of new and improved circuit arrangements whereby automatic switches may operate with a better margin of safety and with less likelihood of failure when used in connection with lines having adverse characteristics as regards their use in controlling automatic switches.

It is a further object of the invention to simplify, as much as possible, the circuits of the automatic switches in order to permit the controlling relays to be made with a smaller number of springs so as to facilitate their operation and to permit a more ready response to the currents sent through their windings.

There are various other objects, having to do mainly with the circuit details necessary for carrying out the objects set forth above. These latter objects, together with the previously mentioned ones, will be readily understood from a further perusal of the specification.

Attention is directed to my co-pending application, Serial No. 582,333, filed August 17, 1922, on which the present case may be considered an improvement.

Referring now to the accompanying drawings comprising Figs. 1 and 2, they show by means of the usual circuit diagrams a sufficient amount of equipment employed in an automatic telephone system embodying the principles of the invention to enable the invention to be understood and its utility appreciated.

Fig. 1 shows the substation A and the associated line which terminates at the exchange in the line switch LS, together with the selector S which is accessible to the line switch LS; and Fig. 2 shows the connector C which is accessible to the selector S, Fig. 1, and which has access to the line of substation B with which there is associated the line switch LS'.

The substations A and B are of the usual automatic type; the line switches LS and LS' are of the well known rotary type, mechanically, and their wipers have no normal position and are moved in a forward direction

only; and the selectors S, together with the connector C, is mechanically of the well known vertical and rotary type of switch. Accordingly, its bank contacts are arranged in horizontal rows or levels.

In the drawings the relays that are slow acting have been indicated in two ways. Certain of these relays have copper collars around the armature ends of their cores. Such copper collars are indicated by making the upper section of the core solid black, the upper end of the relay being assumed to be the armature end. Other relays have copper sleeves or tubes around the full length of the iron cores. Such relays have been indicated in the conventional manner by drawing two extra lines through the core to indicate the thickness of the copper sleeve. Among such relays may be mentioned the relays 104, Fig. 2, and the relay 105, which latter relay has both a copper sleeve around the core and a copper collar upon the armature end of the core.

The apparatus, having been described generally, will now be described more in detail, and for this purpose it will be assumed that the subscriber at substation A, desiring to converse with the subscriber at substation B, removes his receiver.

When the receiver is removed at substation A, a circuit is closed over line conductors 11 and 12 for the line relay 15 of the line switch LS. Line relay 15 thereupon energizes and places ground upon private normal conductor 13 at armature 19, thereby making the calling line busy to the connectors having access to it and closing a circuit for the switching relay 14 and stepping magnet 21 in series. Line relay 15 also connects test wiper 23 to the junction of switching relay 14 and stepping magnet 21 at armature 20. Assuming, however, that the trunk upon which the wipers of the line switch are standing is idle, this latter operation does not have any particular utility at this time and switching relay 14 energizes immediately, but, on the other hand, assuming that the said trunk is busy, the test conductor thereof is grounded and the ground potential is applied through test wiper 23, armature 17 and its resting contact, and armature 20 and its working contact to the junction of relay 14 and magnet 21, short circuiting relay 14 and preventing it from ener-

gizing. Stepping magnet 21 energizes from this ground potential, and, being self-interrupting, operates in a buzzer-like manner to advance the wipers 22-24, inclusive, step by step in search of an idle trunk.

When an idle trunk is reached, which trunk it will be assumed is the one comprising conductors 25-27, inclusive, switching relay 14 is no longer short circuited on account of the fact that test wiper 23 engages an ungrounded contact. Accordingly, relay 14 energizes in series with stepping magnet 21, but stepping magnet 21 does not energize at this time on account of the high resistance of switching relay 14. Upon energizing, switching relay 14 disconnects the line conductors 11 and 12 from the winding of line relay 15 and ground and extends them by way of wipers 22 and 24, conductors 25 and 27, and armatures 57 and 60 to the upper and lower windings, respectively, of line relay 35 of the selector S. Line relay 35 now energizes over the calling line and at armature 51 removes the short circuit normally around relay 36 and closes a circuit for the relay 36 as follows: from ground by way of the resting contact and armature 59 of relay 39, release relay 36, working contact and armature 51, series relay 37, and vertical magnet 40 to battery. Release relay 36 energizes over this circuit, but vertical magnet 40 and series relay 37 are not operatively energized on account of the high resistance of release relay 36. It is true that, while the three contacts 35 of line relay 35 are all together, a circuit is closed for relay 37 and magnet 40 independent of the normally short circuited release relay 36, but this condition exists for such an extremely short time that relay 37 and magnet 40 do not have time to operate before relay 36 is cut into the circuit.

Relay 36, upon energizing responsive to the above closure of its circuit, opens a point in the circuit of release magnet 41 and closes a locking circuit for itself at armature 53, independent of armature 51 and its working contact, and at armature 52 places ground upon release trunk conductor 26 thereby closing the usual holding circuit through wiper 23 and armature 17 and its working contact for switching relay 14 of the line switch LS before the slow acting line relay 15 has had time to fall back.

The above operations have all taken place responsive to the removal of the receiver at the calling substation, and the circuits are now in readiness for the first digit in the desired number to be dialled. When the subscriber at substation A manipulates his calling device in accordance with the first digit in the desired number, the circuit of line relay 35 of the selector S is opened a corresponding number of times. Line relay 35 deenergizes each time its circuit is opened and at the normally closed contacts of armature 51 replaces

the short circuit around the release relay 36, whereupon vertical magnet 40 and series relay 37 energize over the following circuit: from ground by way of the resting contact and armature 59, normally closed contacts controlled by armature 51, armature 53 and its working contact, series relay 37, and vertical magnet 40 to battery. Relay 36 remains energized through the series of deenergizations of relay 35 because the current continues to flow through its short circuited winding for a time after it is removed from the main circuit, maintaining the relay 36 energized in the well understood manner. By the operation of vertical magnet 40, which energizes each time relay 36 is short circuited, the wipers 61-63, inclusive, of the selector are raised step by step and come to rest opposite the desired level of bank contacts. Relay 37 is energized in series with vertical magnet 40 and, being slow acting, maintains its armature attracted throughout the vertical movement. As soon as the off normal contacts 44 are closed upon the first vertical step of the switch, a circuit is closed from the grounded release trunk conductor 26 through the working contact and armature 54, and the off normal contacts 44 for stepping relay 38. Relay 38, thereupon energizes; prepares circuit for rotary magnet 42 at armature 55; and at armature 56 closes a locking circuit for itself which includes the resting contact and armature 59 and the interrupter contacts 45.

At the end of the vertical movement, the relay 37 falls back and completes the circuit of rotary magnet 42 at the normally closed contacts controlled by armature 54. Rotary magnet 42 thereupon energizes through armature 55 and its working contact and advances wipers 61-63, inclusive, into engagement with the first set of bank contacts in the selected level, and, near the end of its stroke, opens the locking circuit of stepping relay 38 at interrupter contacts 45. When this occurs, stepping relay 38 deenergizes and opens the circuit of rotary magnet 42 at armature 55, whereupon rotary magnet 42 deenergizes also and closes its interrupter contacts again.

The further operation depends upon whether the trunk terminating in the first set of bank contacts is busy or idle. If it is idle, switching relay 39 energizes immediately, seizing the trunk. Assuming the trunk to be busy, however, switching relay 39 is short circuited by the ground potential encountered on the busy test contact by test wiper 62 and does not energize. Also, stepping relay 38 energizes through test wiper 62 and through the interrupter contacts 45 and again closes the rotary magnet circuit at armature 55, at the same time again closing its locking circuit at armature 56. When this occurs rotary magnet 42 energizes again and advances the wipers of the selector into

engagement with the next set of bank contacts.

This alternate operation of stepping relay 38 and rotary magnet 42 continues as described until an idle trunk is reached, which trunk, it will be assumed, is the one comprising conductors 64-66, inclusive. When this idle trunk is reached, switching relay 39, being no longer short circuited, energizes in series with stepping relay 38 through the interrupter contacts 45 and off normal contacts 44, and from the grounded release trunk conductor 26. Stepping relay 38, however, does not energize at this time on account of the high resistance of switching relay 39. Switching relay 39, upon energizing, disconnects conductors 25 and 27 from the windings of line relay 35 at armatures 57 and 60. The adjustment of the relay is such that these armatures 57 and 60 are operated immediately and break away from their back contacts an appreciable length of time before armature 59, which is the last to operate, breaks away from its resting contact. Responsive to line relay 35 being disconnected at armatures 57 and 60, the said line relay deenergizes immediately, on account of the fact that it is an impulse relay and has a very accurate adjustment, and again short circuits the release relay 36 so as to make it slow acting to permit it to hold up during the switching period, thereby closing the usual circuit for series relay 37 and vertical magnet 40. However, before the said relay 37 and magnet 40 can operate, armature 59 of switching relay 39 breaks away from its resting contact, thereby opening the circuit of relay 37 and vertical magnet 40. To complete the description of the operation of relay 39 it may be stated that armature 58 opens the testing circuit and prepares the holding circuit, and armatures 57 and 60 extend the line conductors 25 and 27 through wipers 61 and 63, the bank contacts upon which they are standing, conductors 64 and 66, and the normally closed contacts controlled by armatures 122 and 122' to the upper and lower windings, respectively, of the line relay 102 of the connector C. Line relay 102, upon energizing, closes at armature 124 a circuit for the normally short circuited release relay 103, at the same time removing the normal short circuit from around release relay 103. The circuit of release relay 103 at this time is as follows: from ground by way of relay 103, working contact and armature 124, contact of off normal spring 113 and said spring, series relay 104, and vertical magnet 109 to battery. Owing to the high resistance of relay 103 neither relay 104 nor magnet 109 is operatively energized at this time. It is true that, after armature 124 engages its working contact and before the normally closed contacts controlled by armature 124 open, a circuit is closed momentarily for relay 104 and rotary magnet 109, independent

of relay 103. However, this condition exists for such an extremely short time that neither relay 104 nor magnet 109 has time to operate. Upon energizing, relay 103 opens a point in the circuit of release magnet 3 and closes a locking circuit for itself at armature 127; grounds the local locking conductor 152 at armature 126; and at armature 125 places ground upon the release trunk conductor 65, thereby closing a holding circuit which includes test wiper 62 and armature 58 and its working contact of the selector S for switching relay 39 of the selector S and switching relay 14 of the line switch LS before the slow acting relay 36 of the selector S has had time to deenergize.

When the calling subscriber manipulates his calling device in accordance with the second digit in the desired number, line relay 102 of the connector C deenergizes a corresponding number of times and upon each deenergization, closes at the normally closed contacts controlled by armature 124 a circuit for vertical magnet 109, the circuit at the time of the first closure being as follows: from ground by way of the normally closed contacts controlled by armature 124, armature 127 and its working contact, contact of off normal spring 113 and said spring, relay 104, and vertical magnet 109 to battery. By the operation of vertical magnet 109 the wipers 144-146, inclusive, of the connector, are raised step by step and come to rest opposite the desired level of bank contacts. Relay 104 is energized in series with vertical magnet 109 and, being slow acting, maintains its armature attracted throughout the vertical movement. Relay 104 maintains its own circuit and that of vertical magnet 109 intact at armature 128 after the off normal springs have shifted as they do upon the first vertical step. At the end of the vertical movement, relay 104 deenergizes and shifts the impulse circuit from the vertical magnet to the rotary magnet.

The calling subscriber now manipulates his calling device in accordance with the third digit of the desired number, whereupon line relay 102 deenergizes a corresponding number of times and, upon each deenergization, closes a circuit for rotary magnet 111 as follows: from ground by way of the normally closed contacts controlled by armature 124, armature 127 and its working contact, normally open contacts controlled by off normal spring 113, normally closed contacts controlled by armature 128, armature 142 and its resting contact, and rotary magnet 111 to battery. By the operation of rotary magnet 111 the wipers of the connector are rotated step by step into engagement with the bank contacts 147-149, inclusive, of the line of substation B. Relay 107 is energized in multiple with rotary magnet 111 and, being slow acting, maintains its armature attracted

throughout the rotary movement. Upon energizing, relay 107 disconnects test wiper 145 from the lower winding of switching relay 108 and connects it instead to busy relay 106 through armature 140 and its resting contact. Relay 107 also places a shunt around armature 134 and its resting contact at armature 137 so as to maintain its own circuit intact in case busy relay 106 energizes during the rotary movement due to test wiper 145 passing over busy test contacts.

At the end of the rotary movement relay 107 deenergizes. Assuming that the called line is busy, the busy relay 106 is energized from ground on the busy test contact engaged by wiper 145, and at the time that relay 107 deenergizes, becomes locked up over the following circuit: from ground by way of grounded release trunk conductor 65, armature 133 and its working contact, normally closed contacts controlled by armature 136, armature 140 and its resting contact, and busy relay 106 to battery. With busy relay 106 energized and with relay 107 deenergized, the said relay 107 is disconnected from the operating lead at armature 134 so as to prevent it from energizing again to retest the line and open the locking circuit of busy relay 106 in case the calling subscriber again manipulates his calling device. However, it is not necessary to disconnect the rotary magnet 111 because, even though a further operation of the calling subscriber's calling device results in the further operation of rotary magnet 111, no harm can result because busy relay 106 remains locked up and switching relay 108 cannot energize even though the wipers are rotated into engagement with an idle line. Busy relay 106 also connects the common busy signalling conductor to the lower heavy talking conductor at armature 135 so as to transmit a busy tone back to the calling subscriber. Upon hearing this tone after his calling device has come to rest the calling subscriber knows that the called line is, for the time being, inaccessible, and he replaces his receiver, resulting in the switches being released in a manner to be described hereinafter.

It will now be assumed that the line of substation B is idle when called. In this case, busy relay 106 is not energized when the wipers of the connector come to rest upon the bank contacts of the called line, and relay 107, upon deenergizing at the end of the rotary movement, closes a circuit through the lower winding of switching relay 108 as follows: from ground by way of the grounded release trunk conductor 65, armature 133 and its resting contact, armature 131 and its resting contact, lower winding of relay 108, resting contact and armature 136, test wiper 145, test contact 148, switching relay 150 of the line switch LS', and stepping magnet 151 to battery. Relay 150 energizes over this circuit, but stepping magnet 151 is unable to

energize due to the high resistance of switching relay 150. Relay 150, on the other hand, is able to energize only part way on account of the usual inter-locking device (not shown) between its armature and that of the associated line relay. Accordingly, relay 150 opens all its back contacts but does not close any of its front contacts.

In the connector C, switching relay 108 energizes over the above traced circuit; closes a locking circuit for its upper winding at armature 141; disconnects busy relay 106 at armature 140; directly grounds test wiper 145 at armature 139; and at armatures 138 and 143 connects up the wipers 144 and 146, at the same time connecting up the small "ring back" condenser 114 at armature 138. Relay 108 also disconnects the operating conductor from rotary magnet 111 at armature 142 so as to prevent the wipers from being rotated further in case the calling subscriber again manipulates his calling device, thereby removing rotary magnet 111 from in shunt of relay 107. Ordinarily this would permit relay 107 to energize in series with release relay 103, but in order to prevent this armature 142 connects the operating lead to vertical magnet 109. Accordingly, if the calling device is turned again vertical magnet 109 will be energized, but, since the shaft carrying the wipers has been rotated, the stationary dog is in between two of the teeth on the shaft, thus mechanically preventing any further vertical motion of the shaft, even though the vertical magnet 109 energizes.

Ringing current is now intermittently applied to the called line through the upper winding of ring cut-off relay 105 and over wiper 146 to operate the bridged bell at the called substation, and returns over the other side of the line and wiper 148 to ground through armature 132 and its resting contact. The small condenser 114 which is connected up at armature 138 permits a sufficient amount of ringing current to leak back to the upper heavy talking conductor to inform the calling subscriber that ringing current is being applied intermittently to the called line.

When the subscriber at substation B responds to the ringing of his bell by removing his receiver, a direct current bridge is closed across the conductors of his line, whereupon ring cut-off relay 105 energizes through its upper winding; closes a locking circuit for its lower winding at armature 130; switches the back contact of armature 133 from the lower terminal of the lower winding of relay 108 to the upper terminal of the said winding at armature 131 for a purpose to be explained fully hereinafter; and at armatures 129 and 132 disconnects the wipers 144 and 146 from the ringing current source and from ground respectively and extends them to the upper and lower windings of the double wound back bridge relay 101. Relay 101, upon en-

energizing, reverses the current flow in conductors 64 and 66 at armatures 122 and 122'. This reversal does not have any particular utility in connection with the equipment shown, but, as is well known, may be used when desired to operate meters and the like. Relay 101 also places a multiple ground upon the local locking conductor 152 at armature 121, and at armature 123 opens a further point in the circuit of release magnet 110 for a purpose to be described hereinafter. The calling and called subscribers may now converse with each other as desired.

When the conversation is terminated, the two subscribers replace their receivers. When the receiver is replaced at substation B, back bridge relay 101 deenergizes and reverses the current flow in the calling loop to normal, at the same time removing the multiple ground from the locking conductor 152 at armature 121, and closes at armature 123 a point in the circuit of release magnet 110.

Assuming now that the calling subscriber does not hang up his receiver immediately, the circuits remain as they are until he does replace his receiver. When his receiver is finally replaced at substation A, line relay 102 of the connector C deenergizes and short circuits release relay 103 at the normally closed contacts controlled by armature 124, grounding the impulse conductor, which results in a circuit being closed over the impulse lead and through armature 142 of switching relay 108 and its working contact for vertical magnet 109. Vertical magnet 109 thereupon energizes but its energization does not have any particular utility at this time. Relay 107 is energized at this time in multiple with vertical magnet 109 but does not produce any particular result at this time. The slow acting release relay 103 deenergizes after the interval for which it is adjusted; removes ground from the locking conductor 152 at armature 126, whereupon relays 105 and 108 deenergize; removes ground from the impulse conductor and closes the release magnet circuit at armature 127; and at armature 125 removes ground from the release trunk conductor 65. Release magnet 110 now energizes over the following circuit: from ground by way of the normally closed contacts controlled by armature 124, armature 127 and its resting contact, armature 123 and its resting contact, off normal contacts 112, and release magnet 110 to battery. Upon energizing, release magnet 110 restores the wipers 144-146, inclusive, of the connector C to normal in the usual manner, whereupon the circuit of release magnet 110 is opened at off normal contacts 112.

Responsive to the removal of the ground potential from the release trunk conductor 65, switching relay 14 of the line switch LS and switching relay 39 of the selector S deenergize. Upon the deenergization of switching relay 39, a circuit is closed at contacts 59 for release magnet 41 which includes the normally closed contacts controlled by armature 51, armature 53 and its resting contact, and off normal contacts 43. Accordingly, the selector S is restored to normal in the usual manner. The entire connection is released and the apparatus used therein is in readiness to be used again.

It will now be assumed that the subscriber at substation B does not replace his receiver immediately upon the termination of the conversation, as hereinbefore assumed, but leaves his receiver off the hook for a time. In that case, when the subscriber at substation A replaces his receiver, line relay 102 falls back, as hereinbefore described, resulting in a circuit being closed for vertical magnet 109 and relay 107 in multiple, whereupon relay 107 energizes and disconnects the grounded test wiper 145 from the release trunk conductor 65 at armature 136 so as to permit relay 103 to remove ground from release trunk conductor 65 prior to the deenergization of relays 105 and 108. In this case, when release relay 103 deenergizes it removes ground from the release trunk conductor 65 at armature 125, permitting the selector S to be released in the hereinbefore described manner, but the local locking conductor 152 is maintained grounded at armature 121 of the back bridge relay 101 and the circuit of release magnet 110 is maintained open at armature 123.

Responsive to the removal of ground from the operating conductor upon the deenergization of release relay 103, the slow acting relay 107 falls back after the interval for which it is adjusted and replaces ground upon the release trunk conductor 65 at armature 136, the ground potential now being applied to release trunk conductor 65 at armature 139 and through armature 136 and its resting contact, working contact and armature 131, and the resting contact and armature 133. Accordingly, the connector C is guarded against seizure for the time being.

It will be noted that the lower winding of relay 108 is not merely short circuited in order to get the ground potential by this winding, but its circuit is opened so as to prevent the winding from being short circuited and thereby giving the relay additional slowness when its circuit is opened upon the release of the connection. Otherwise, the wipers might remain connected up during the releasing movement, with consequent annoyance to subscribers conversing on the lines over which the wipers pass.

Assuming now that the subscriber at substation B replaces his receiver, back bridge relay 101 deenergizes and closes the release magnet circuit at armature 123, at the same time removing ground from the local locking conductor 152 at armature 121. Responsive

to the removal of ground from conductor 152, relays 105 and 108 deenergize and relay 108 removes ground from the release trunk conductor 65, thereby rendering the switch
 5 idle. Responsive to the closure of the release magnet circuit at armature 123 of relay 101, the wipers of the switch are restored to normal in the usual manner.

Certain points in connection with the operation of the selector S and the connector C will now be considered more in detail and attention will be directed toward the novel means employed for obtaining the desired results. Considering first the circuit involving relays 36 and 37 and vertical magnet 40
 15 of the selector S, the contacts of line relay 35 through which the vertical magnet 40 is operated are of the "make-before-break" type. The contacts are arranged in this manner in order to insure that the vertical magnet 40 is
 20 left in the circuit for a maximum length of time, i. e., its circuit is closed almost as soon as the armature of relay 35 starts to fall back and remains closed until the armature has almost
 25 completed its forward stroke again. This insures that the magnet will get sufficient current to respond on a very momentary deenergization of the line relay 35. Also, since the circuit of vertical magnet 40 is not
 30 opened by the armature spring 51 directly, the liability of intense sparking (at the contacts controlling the vertical magnet circuit) upon the back stroke of the armature of line relay 35 is entirely removed, owing to the
 35 fact that the armature spring 51 takes up the rebound of the armature proper of the relay (not shown) and does not permit the armature proper of the relay to rebound far enough to again open the vertical magnet circuit while the relay 35 is deenergized. This
 40 undesirable result is often encountered when the circuit of the vertical magnet is closed through an armature spring and a cooperating back contact, but, as pointed out above,
 45 is not found with the present arrangement.

Another novel result is obtained by the present circuit arrangement which is not found in prior circuit arrangements of this general nature. It has been commonly recognized for some time that a make-before-break spring combination for controlling the operating magnet circuit of a selector or other switch is superior to the ordinary spring combination for reasons pointed out hereinbefore. However, the circuits using the make-before-break spring combination heretofore
 50 have been open to the objection that, if a calling line becomes leaky or defective to such an extent that a connection is extended through to a first selector, but the leaky condition exists only enough to operate the line relay of the selector far enough to close the make contacts of the spring combination but not sufficiently to open the break contacts,
 55 the release relay energizes and closes a circuit

for the vertical magnet, causing the vertical magnet to overheat and become seriously damaged or ruined in a comparatively short time. In the present case, however, the circuit arrangement is such that the release relay 36 does not energize if the armature spring 51 is brought into engagement with its contact but is not moved far enough to open the normally closed contacts. It is true that a circuit is closed for vertical magnet 40 at such a time, but since release relay 36 is not energized, no holding circuit is provided for the seized line switch, which promptly releases, freeing the selector. Of course, if the condition still exists on the line
 70 in trouble, the line switch operates again and again seizes the selector, and the same operation is repeated over and over until the trouble is cleared up. The vertical magnet 40 is energized momentarily each time the selector is seized. However, the design of the vertical magnet is such that it can withstand an indefinite series of momentary energizations without becoming dangerously hot.

Considering now the series relay 37, it will be noted that this relay is made slow acting by means of a copper sleeve which covers the core over its entire length. This method of making the relay slow acting has been chosen in order to insure that the relay will energize and remain energized throughout a series of extremely short impulses. Owing to the fact that the copper sleeve extends over the entire winding space provided on the core, all lines of force traversing the core must pass through the copper sleeve and are then effective in maintaining the armature of the relay attracted after the circuit of the relay is opened. Of course, the usual copper collar placed on one end or the other of the relay could be used in this case, but, when a copper collar is placed upon a relay, it tends to prevent a quick building up of magnetic flux in the portion of the core covered by the copper collar with the result that the lines of force in the remaining portion of the core bypass the portion of the core covered by the copper collar through the air when the relay is first energized, and the building up of the lines of force through the copper collar is a gradual process, relatively speaking, and is forced only by the magnetic reluctance of the surrounding air, which forces the lines of force to eventually penetrate the copper collar after the relay has been energized for a sufficient length of time. On the other hand, with the copper sleeve around the entire length of the core and actually under the winding itself, the entire magnetomotive force generated by the winding is effective in driving lines of force through the core under the copper sleeve which will be effective in maintaining the armature of the relay attracted after the circuit is opened.

A further point in connection with the operation of the selector S and the connector C will now be considered more in detail and attention will be directed toward the novel means employed for obtaining the desired results. Considering first the circuit involving relays 36 and 37 and vertical magnet 40 of the selector S, the contacts of line relay 35 through which the vertical magnet 40 is operated are of the "make-before-break" type. The contacts are arranged in this manner in order to insure that the vertical magnet 40 is left in the circuit for a maximum length of time, i. e., its circuit is closed almost as soon as the armature of relay 35 starts to fall back and remains closed until the armature has almost completed its forward stroke again. This insures that the magnet will get sufficient current to respond on a very momentary deenergization of the line relay 35. Also, since the circuit of vertical magnet 40 is not opened by the armature spring 51 directly, the liability of intense sparking (at the contacts controlling the vertical magnet circuit) upon the back stroke of the armature of line relay 35 is entirely removed, owing to the fact that the armature spring 51 takes up the rebound of the armature proper of the relay (not shown) and does not permit the armature proper of the relay to rebound far enough to again open the vertical magnet circuit while the relay 35 is deenergized. This undesirable result is often encountered when the circuit of the vertical magnet is closed through an armature spring and a cooperating back contact, but, as pointed out above, is not found with the present arrangement.

eration of relay 37 is that the amount of slowness imparted to the relay by the copper sleeve does not need to be as great as it does in the ordinary circuit owing to the fact that when relay 35 cuts the release relay in the circuit upon energizing, a high resistance circuit remains established through relay 37, having a tendency to enable the armature to be attracted for a short interval. In fact, this tendency is so marked that when the selector is used in connection with lines having a high resistance, the copper sleeve may be omitted and relay 37 will operate as a plain relay, because, on long lines, line relay 35 does not become so strongly energized and fails back quickly and remains back longer, with the consequent result that relay 35 does not remain energized so long between the successive deenergizations, and release relay 36 is cut into the impulsing circuit for a shorter period of time.

Referring now to the magnet operating circuit of connector C, it will be noted that this circuit is identical with that of the selector S as regards the spring combinations of the line and release relays 102 and 103, respectively. The principal difference is that arrangements are made for switching the operating circuit from the vertical magnet to the rotary magnet, as has been described hereinbefore, the series relay 104 operating in identically the same manner as the corresponding relay of the selector, and the relay 107 operating in a similar manner except that it is in multiple with the associated magnet 111 instead of in series.

What is claimed is:

1. In a telephone system, a connector switch having wipers, a test conductor for said switch, a relay for connecting said wipers to said switch, a winding on said relay, circuit connections controlled by said relay for grounding said test conductor through said winding, a circuit for applying ringing current to a wiper of said connector, a second relay for opening said ringing circuit, and contacts on said second relay for connecting the ground potential to said test conductor over a path independent of said winding and for removing said winding from the circuit.
2. In a telephone system, a switch controlling combination comprising a line relay, a release relay, a change-over relay, and an operating magnet, contacts on said line relay for energizing said release relay in series with said change-over relay and said magnet when said line relay operates, contacts on said release relay for shunting said line relay contacts and other contacts on said line relay for shunting said release relay to operate said change-over relay and said magnet when said line relay restores.
3. In a telephone system, a switch controlling combination comprising a line relay, a release relay, and an operating magnet, normally open contacts on said line relay for energizing said release relay when said line relay operates, normally closed contacts on said line relay for energizing said magnet when the line relay restores, all said contacts being closed when the armature of said line relay is in mid-position and circuit arrangements for shunting said release relay when all said contacts are closed.
4. In a switching device having motion in two directions, a magnet for operating said device in one direction, a second magnet for operating said device in the other direction, a relay connected in series with said first magnet when said device is operated in said one direction, means for connecting said relay in series with said second magnet at the completion of the operation of said device in said one direction, and means for disconnecting said relay from said second magnet and for reconnecting said relay in series with said first magnet at the completion of the operation of said device in said other direction.
5. In a two-motion connector switch, an impulse circuit having two branches extending to the secondary operating magnet and a "change-over" relay, respectively, and means responsive to the switch being operated to connect with a busy line for opening the change-over relay branch without opening the other branch.
6. In a two-motion connector switch, an impulse circuit having two branches extending to the secondary operating magnet, and a change-over relay respectively, and means for disconnecting each branch independent of the other.
7. In a telephone system, an automatic switch, driving magnet, a subscriber's line accessible to said switch, means for operating said switch, to connect with said line, a relay in said switch, means for operating said relay and said magnet in parallel, means for testing said line for the busy or idle condition, and means controlled by said testing means for disconnecting said relay independent of said magnet when said line is found busy.
8. In a two-motion connector switch, an impulse circuit having two branches extending to the secondary operating magnet and a "change-over" relay, respectively, means responsive to the switch being operated to connect with a busy line for opening the change-over relay branch without opening the other branch, and means for disconnecting said magnet independent of said relay when said line is found idle.
9. In an automatic switch, a line relay, a release relay, an operating magnet, a "make-before-break" spring combination on said line relay for controlling said release relay and said magnet, and a circuit arrangement such that the release relay is prevented from energizing in case the line relay is partially

energized so as to close the make contacts without opening the break contacts.

10. In an automatic switch, a line relay, a release relay, an operating magnet, a "make-before-break" spring combination on said line relay for controlling said release relay and said magnet, the make contacts controlling said relay and the break springs controlling said magnet, and circuit arrangements controlled by said release relay for automatically releasing the said switch in case the line relay is operated for enough to operate the make contacts but not far enough to operate the break contacts.

11. In an automatic switch, a line relay, a release relay, an operating magnet, a "make-before-break" spring combination on said line relay for controlling said release relay and said magnet, and circuits such that an incomplete operation of said spring combination will cause the release of the switch and thus prevent overheating of said magnet.

12. In an automatic switch, an impulse responding relay, an operating magnet, a release relay which is rendered slow to release by being short circuited by normally closed contacts controlled by the impulsing relay, and a change-over relay which is rendered slow to release by separate and distinct means such as a copper sleeve, said change-over relay being operated in series with said magnet.

13. In a telephone system, a connector, a release conductor for the connector, a switching relay in said connector, a winding for said relay, means for energizing said winding over a circuit including said conductor, a ring cut-off relay in said connector, and means

controlled by said ring cut-off relay and said switching relay jointly for applying a characteristic potential to said conductor over a path independent and exclusive of said winding.

14. In a telephone system, a connector, a release conductor for the connector, a switching relay having a winding one terminal of which is normally connected to said conductor, means for energizing said winding to operate said relay, contacts on said relay for grounding the other terminal of said winding, a ring cut-off relay in said connector, and means controlled by said ring cut-off relay for disconnecting said conductor from one terminal of said winding and connecting it to the other terminal of said winding.

15. In a telephone system, a switch, a first and a second magnet, means for successively operating said magnets to position said switch, a release relay for maintaining said switch in position, and means for energizing said relay in series with said magnets successively.

16. In a telephone system, a switch, a first and a second magnet for controlling the operation of said switch, a release relay in said switch, and means for energizing said relay in series with one of said magnets during the operation of the switch, and in series with the other of said magnets at the completion of the operation of the switch.

In witness whereof, I hereunto subscribe my name this 23d day of May, A. D. 1924.

RUDOLPH F. STEHLIK.