May 29, 1928. 1,671,791

R. F. STEHLIK

AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 17, 1922 2 Sheets-Sheet 1

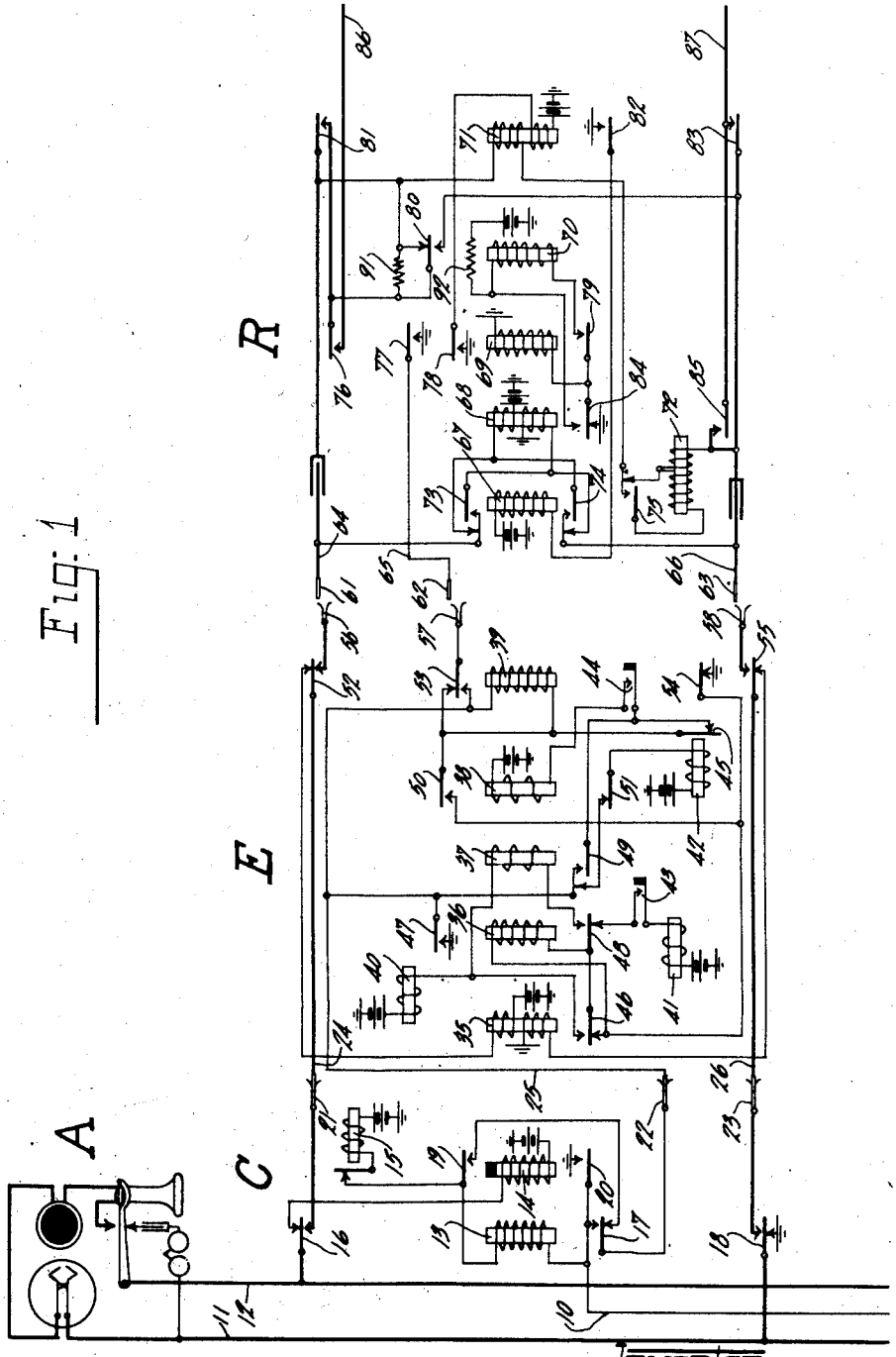


Fig. 1

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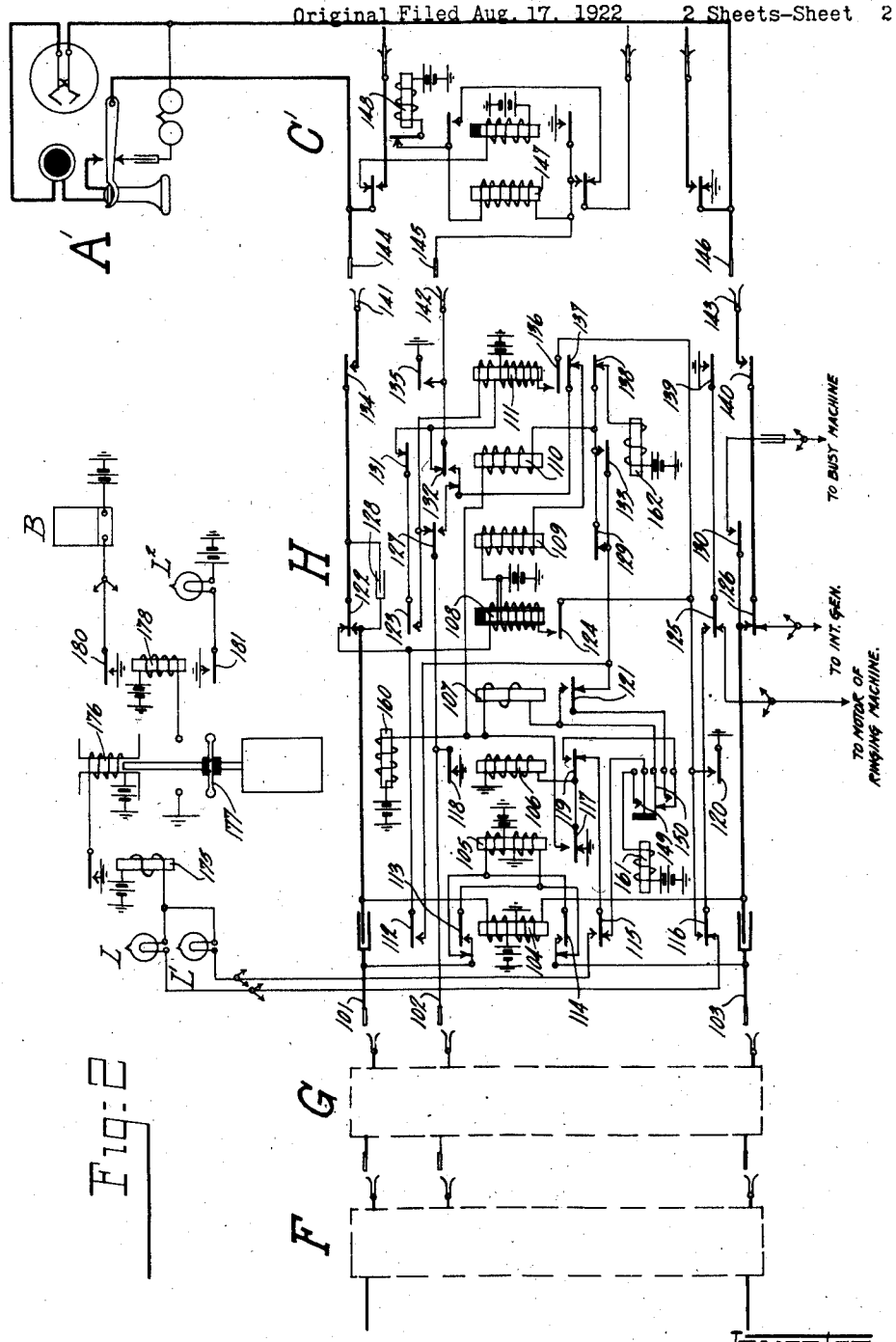


Fig: 2

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Patented May 29, 1928. 1,671,791

UNITED STATES PATENT OFFICE.

RUDOLPH F. STEHLIK, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO AUTOMATIC ELECTRIC INC., OF CHICAGO, ILLINOIS, A CORPORATION OF DELAWARE.

AUTOMATIC TELEPHONE SYSTEM.

Application filed August 17, 1922, Serial No. 582,333. Renewed October 24, 1927.

The present invention relates to automatic telephone systems in general, but is concerned more particularly with improved circuit arrangements for automatic switches and the principal object is the production of new and improved circuit arrangements, whereby automatic switches may be operated satisfactorily from lines of more widely different switch controlling characteristics than heretofore, such as, for example, from long lines having high resistance and low capacity or leakage and from short lines having low resistance and high capacity or leakage.

It is well known that the controlling armature of the line relay of an automatic switch having the conventional circuits, closes the circuit of the associated holding or release relay when the line relay is energized and closes a circuit for the operating magnet and the associated slow relay when the line relay deenergizes. In such circuits, the operating circuit is not closed until the armature of the line relay comes into engagement with its resting contact, and the circuit of the release relay is not closed until the armature of the line relay comes into engagement with its working contact. Consequently, the time that elapses while the armature is in mid-position is wasted, nothing being done to hold up the release relay of the switch or to maintain energized the slow relay of the operating circuit. Accordingly it is an object of the present invention to overcome this difficulty by suitably revising the circuits so that the circuit of the release relay remains closed until the armature of the line relay comes into engagement with its resting contact, and so that a path is provided whereby sufficient current flows through the operating circuit, until the armature of the line relay has come into engagement with its working contact, to maintain energized the slow relay of the operating circuit. By this arrangement both the release relay and the slow relay of the operating circuit are maintained energized independent of the armature of the line relay when said armature is not in engagement with either of its contacts.

Other objects which have to do mainly with the circuit details will become apparent upon a further perusal of the specification.

Referring now to the drawings which comprise Figs. 1 and 2, and which show by means of the usual circuit diagrams a sufficient amount of apparatus for a connection from the calling substation A to the called substation A′, Fig. 1 shows an automatic substation A, individual line switch C, first selector E, and the repeater R; and Fig. 2 shows the selectors F and G, denoted by the dotted rectangles bearing those reference characters, the connector H, the line switch C′, and the substation A′.

The substations A and A′ are of the usual automatic type and have the usual talking, signalling, and switch controlling instrumentalities.

The line switches C and C′ in which the lines of substations A and A′, respectively, terminate, are of the well known rotary type in which the wipers have no normal position and move in a forward direction only.

The selectors E, F and G, and the connector H are automatic switches of the well known vertical and rotary type, each having 100 sets of contacts arranged in 10 horizontal rows or levels.

The repeater R is provided primarily for the purpose of obviating the necessity of having three conductors in the associated inter-office trunk, and consequently, closes a holding circuit for the switch which seizes it. This repeater also repeats impulses over the associated trunk and relays the reverse battery supervision as is the common practice.

The control circuits of the numerical switches shown have been revised so as to embody the principles of the invention. Otherwise the circuits shown are much the same as prior circuits of the same general type.

In order to explain the operation of the improved circuits, it will be assumed that the subscriber at substation A desires to converse with the subscriber at substation A′. When the receiver is removed at substation A, line relay 14 of the line switch C energizes over the line conductors 11 and 12 and places ground on private normal conductor 10 at armature 20, thereby rendering the line of substation A busy to the connectors having access to it and closing a circuit for switching relay 13 and stepping magnet 15 in series, and at armature 19 connects test wiper 22 to the junction of switching relay 13 and stepping magnet 15. In case the trunk upon which the wipers of

the line switch are standing is idle, the latter operation has no effect and switching relay 13 energizes immediately. However, assuming the trunk to be busy, switching relay 13 is short circuited by the ground potential which is present on the test contact thereof, and the wipers 21—23, inclusive, are advanced step by step in search of an idle trunk by the buzzer like action of stepping magnet 15, which operates from ground through test wiper 22, which engages the grounded test contacts. When an idle trunk is reached, switching relay 13, being no longer short circuited, energizes in series with stepping magnet 15, stepping magnet 15 not energizing on account of the high resistance of switching relay 13. Upon energizing, switching relay 13 opens the test circuit and prepares the holding circuit at armature 17, thereby placing ground on test wiper 22 and making the seized trunk busy, and at armatures 16 and 18 disconnects conductors 11 and 12 from the winding of line relay 14 and from ground, and extends them by way of wipers 21 and 23, conductors 24 and 26, and armatures 52 and 55 and their resting contacts, to the windings of line relay 35 of the selector E. Line relay 35, upon energizing, closes a circuit at armature 46 as follows: from ground by way of the resting contact of armature 54 of switching relay 39 and said armature, release relay 36, armature 46 and its working contact, and vertical magnet 40 to battery. Release relay 36 energizes over this circuit but vertical magnet 40 does not energize on account of the comparatively high resistance of relay 36. Release relay 36, upon energizing, opens a point in the circuit of release magnet 41 and prepares a circuit for vertical magnet 40 at armature 48, and places ground on release trunk conductor 25 at armature 47, thereby closing the usual holding circuit for the line switch C before slow acting line relay 14 has had time to deenergize.

The calling subscriber now operates his calling device in accordance with the first digit in the desired number, whereupon the circuit of line relay 35 is opened a corresponding number of times at the calling substation. Each time line relay 35 deenergizes in response to one of the interruptions produced in its circuit, it opens the initial circuit of release relay 36 and closes the following circuit for vertical magnet 40: from ground by way of the resting contact of armature 54 and said armature, resting contact of armature 46 and said armature, armature 48 and its working contact, series relay 37, and vertical magnet 40 to battery. The resistance of series relay 37 is comparatively low and, consequently, vertical magnet 40 is energized upon each deenergization of line relay 35 and steps the wipers up opposite the desired level of bank contacts in the usual manner. It may be seen that relay 36 is locked up through armature 48 independent of the working contact of armature 46. Consequently, it does not start to deenergize when armature 46 breaks away from its working contact. When armature 46 comes into engagement with its resting contact, relay 36 is short circuited, thereby allowing the vertical magnet 40 and series relay 37 to energize as pointed out previously. Relay 36 is prevented from falling back immediately by the retarding effect of its short circuited winding, this action being well known. When the armature 46 is attracted again, the shunt is removed from around relay 36, thereby bringing about the deenergization of vertical magnet 40. With armature 46 in mid-position between the contacts, relays 36 and 37 are again in series and, consequently, both are held up during this time, although the adjustment of and the number of turns on the relay 37 are, in practice, usually such that it will not hold up indefinitely in series with relay 36, but will fall back after a short interval, at which time the current flow through it will have fallen very nearly to a value which is determined by the ohmic resistance of the circuit. In fact, it is not necessary for armature 46 to touch its working contact at all during the time it is vibrating under the control of the calling device. When armature 46 comes into engagement with its working contact, relay 37 is short circuited but is prevented from falling back immediately by its short circuited winding.

From the above, it will be seen that relays 36 and 37 are in series with each other and with the vertical magnet 40, and that relays 36 and 37 are alternately shunted by the line relay 35 in order to bring about the operation of vertical magnet 40.

Upon the energization of series relay 37 in response to the first impulse of current sent to the vertical magnet 40 as pointed out above, it closes a circuit for stepping relay 38 at armature 49, which circuit includes the off normal contacts 44, which are closed as soon as the switch shaft is raised from its normal position. Stepping relay 38, upon energizing, closes a locking circuit for itself at armature 50 and at armature 51 prepares a circuit for rotary magnet 42.

At the end of the vertical movement, armature 46 comes to rest in an energized condition, and series relay 37, being short circuited, eventually deenergizes, and at armature 49 opens the initial circuit of stepping relay 38 and completes a circuit for rotary magnet 42. Rotary magnet 42, upon energizing, advances the wipers 56—58, inclusive, into engagement with the first set of contacts in the level opposite which they are raised and at the end of its stroke opens the circuit of stepping relay 38 at inter-

rupter contacts 45. Relay 38, upon deenergizing, opens the circuit of rotary magnet 42 at armature 51, whereupon rotary magnet 42 deenergizes and again closes its interrupter contacts 45. In case the trunk terminating in the first set of contacts is idle, switching relay 39 energizes in series with the stepping relay 38. However, assuming the first trunk to be busy, switching relay 39 is short circuited by the ground potential which is present on the test contact thereof, and stepping relay 38, upon energizing from the same ground, closes the circuit of rotary magnet 42 at armature 51, whereupon the wipers are advanced into engagement with the next set of bank contacts. This alternate operation of stepping relay 38 and rotary magnet 42 continues until an idle trunk is reached, which trunk it will be assumed, is the one extending to the repeater R, whereupon switching relay 39, being no longer short circuited, energizes in series with stepping relay 38 over the following circuit: from ground by way of the working contact of armature 47 and said armature, switching relay 39, interrupter contacts 45, off normal contacts 44, and stepping relay 38 to battery. Stepping relay 38, however, does not energize at this time on account of the high resistance of switching relay 39. Switching relay 39 is so adjusted that armatures 52 and 55 break away from their resting contacts immediately, thereby disconnecting line relay 35. The armature of switching relay 39 is so adjusted that it then meets heavy spring tension and hesitates a fraction of a second before pulling all the way up. When line relay 35 is disconnected, armature 46 falls back and short circuits relay 36 so as to make it slow acting for a reason that, although it is well known, will be pointed out hereinafter. Incidentally, the short circuiting of release relay 36, closes the usual circuit for vertical magnet 40 through series relay 37. Switching relay 39, however, completes its stroke and opens the circuit of vertical magnet 40 and series relay 37 at armature 54 before either vertical magnet 40 or relay 37 has had time to energize. As a further result of the complete energization of switching relay 39, it opens the test circuit and prepares the holding circuit at armature 53, and at armatures 52 and 55 extends line conductors 24 and 26 by way of wipers 56 and 58, conductors 64 and 66 and the normally closed contacts controlled by armatures 73 and 74 of reversing relay 67 to the windings of line relay 68 of the repeater R. Line relay 68, upon energizing over the calling subscriber's loop, closes a circuit for release relay 69 at armature 84 in series with resistance 92. Upon energizing, relay 69 prepares a circuit for relay 70 at armature 79; closes a circuit for the lower winding of electropolarized relay 71 at armature 78; completes a bridge across conductors 86 and 87 at armature 76; and at armature 77 places ground on release trunk conductor 65, thereby establishing the usual holding circuit for the switches C and E before release relay 36 of selector E, which is slow acting at this time on account of being short circuited by armature 46 and its resting contact, has had time to deenergize.

The bridge across conductors 86 and 87, which was completed at armature 76 of release relay 69 is as follows: from conductor 87 by way of armature 85 of line relay 68 and its working contact, right hand winding of impedance 72, normally closed contacts controlled by armature 75, upper winding of electropolarized relay 71, resting contact of armature 80 and said armature, and armature 76 and its working contact to conductor 86. In response to the closure of this bridge, the line and release relays (not shown) of the selector F on the distant end of the trunk energize and prepare the switch for operation in the usual manner. It will be noted that current is flowing through both the upper and the lower windings of electropolarized relay 71 of the repeater R. This relay is not energized at this time, however, for the reason that the current flowing in either winding opposes the current flowing in the other. It may be stated also at this point that relay 71 is so adjusted that it cannot be energized by current flowing in either winding alone.

The calling subscriber now operates his calling device in accordance with the second digit in the desired number, whereupon line relay 68 of the repeater R deenergizes a corresponding number of times and upon each deenergization opens at armature 85 the circuit of the line relay (not shown) of the selector F in the distant office, whereupon the wipers thereof are raised opposite the desired level of contacts after which they are automatically rotated to pick out an idle third selector, the selector G for example. As a further result of each deenergization of line relay 68, it removes the shunt from the winding of relay 70 when armature 84 moves out of engagement with its working contact, and short circuits relay 69 when armature 84 comes into engagement with its resting contact. Relay 69 does not deenergize during the series of interruptions, however, owing to the retarding effect of its short circuited winding. Also, relay 70 energizes as soon as the shunt is removed from its winding and remains energized throughout the series of interruptions, its winding being short circuited and giving the usual retarding effect, each time armature 84 comes into engagement with its working contact. Relay 70, upon energizing, disconnects the upper talking condenser from

conductor 86 and closes the bridge across conductors 86 and 87 by way of a path which is exclusive of the upper winding of electropolarized relay 71 and the right hand winding of impedance 72 at armature 80, thereby improving the impulsing circuit in the well known manner. The resistance 91 is high enough to give all the results desired by the disconnecting of the upper talking condenser but allows enough current to pass to hold up the distant line relay while armature 80 is in mid-position. At the end of the series of interruptions, relay 70, being short circuited, falls back and restores the bridge across conductors 86 and 87 to its original path.

The calling subscriber now operates his calling device in accordance with the third digit in the desired number, whereupon the selector G, Fig. 2, in the distant office is operated in the usual manner to raise its wipers opposite the desired level of bank contacts. At the end of its vertical movement, the selector G rotates its wipers and picks out an idle trunk, which trunk it will be assumed, is the one extending to the connector H. When this occurs line relay 105 energizes over conductors 101 and 103 and closes a circuit for release relay 106 at armature 117 which circuit includes vertical magnet 160. Vertical magnet 160 is not energized at this time on account of the high resistance of release relay 106. Release relay 106, upon energizing, prepares a locking circuit for relays 108 and 111 at armature 120; opens a point in the circuit of release magnet 161 and prepares a circuit for vertical magnet 160 at armature 119; and at armature 118 places ground on release trunk conductor 102, thereby establishing the usual holding circuit for the selectors F and G.

When the calling subscriber operates his calling device for the fourth digit in the desired number, line relay 105 deenergizes a corresponding number of times. Each time armature 117 of line relay 105 breaks away from its working contact, the initial circuit of release relay 106 is opened. Release relay 106 however, does not deenergize at this time but is maintained energized over a circuit which, before the off normal springs have shifted, is as follows: from ground by way of release relay 106, armature 119 and its working contact, contact of off normal spring 150 and said spring, series relay 107, and vertical magnet 160 to battery. Series relay 107, however, does not energize in series with relay 106 on account of the high resistance of the latter. Each time armature 117 comes into engagement with its resting contact, it short circuits release relay 106, whereupon vertical magnet 160 and relay 107 energize in series, release relay 106 being maintained energized during this time by its short circuited winding. Each time armature 117 is attracted, the shunt is removed from release relay 106 as soon as armature 117 breaks away from its resting contact and vertical magnet 160 immediately deenergizes. Series relay 107, however, being adjusted with comparatively weak spring tension, is able to remain energized momentarily in series with release relay 106, the action being as explained in connection with series relay 37 of the selector E. Each time armature 117 comes into engagement with its working contact, series relay 107 is short circuited. It is held up for an interval, however, by its short circuited winding and, consequently, remains energized throughout the series of deenergizations of line relay 105. By the operation of vertical magnet 160, the switch wipers 141—143, inclusive, are raised opposite the desired level of bank contacts. Series relay 107, upon energizing, serves to maintain its own circuit and that of vertical magnet 160 intact at armature 121 after the off normal springs have shifted as they do upon the first vertical step. At the end of the vertical movement, line relay 105 comes to rest in an energized condition and series relay 107, being short circuited, deenergizes and at armature 121 shifts the operating circuit from the vertical to the rotary magnet.

It may be stated that relay 110 energizes in series with rotary magnet 162 when the first energizing circuit is closed for vertical magnet 160 and retains its armature attracted throughout the vertical movement owing to the leakage path to ground through relay 106 when armature 119 is attracted. The energization of relay 110, however, is merely incidental at this time. Rotary magnet 162 is not energized at this time, owing to the relatively high resistance of relay 110.

The calling subscriber now operates his calling device in accordance with the fifth and last digit in the desired number whereupon the line relay 105 deenergizes a corresponding number of times. Each time armature 117 breaks away from its working contact and before it comes into engagement with its resting contact, release relay 106 is held up over the following circuit: from ground by way of release relay 106, armature 119 and its working contact, normally open contacts controlled by off normal spring 150, armature 121 and its resting contact, resting contact of armature 129 and said armature, armature 138 and its resting contact, and rotary magnet 162 to battery. Rotary magnet 162, however, is not energized at this time on account of the high resistance of relay 106. A branch of this circuit extends by way of relay 110 and vertical magnet 160 to battery. Relay 110 may or may not energize over this branch circuit at this time, depending on its adjustment. When armature 117 comes into engagement with

its resting contact, relay 106 is short circuited whereupon rotary magnet 162 energizes. Also, relay 110 energizes in series with vertical magnet 160. Vertical magnet 160, however, is not energized at this time on account of the high resistance of relay 110. Each time armature 117 breaks away from its resting contact rotary magnet 162 deenergizes immediately. Relay 110, however remains energized in series with release relay 106. When armature 117 comes into engagement with its working contact, relay 110 is short circuited but retains its armature attracted momentarily owing to its short circuited winding, and, consequently, retains its armature attracted throughout the rotary movement. By the operation of rotary magnet 162, the switch wipers 141—143, inclusive, are advanced into engagement with the bank contacts of the line of substation A′, which are the bank contacts 144—146, inclusive. Relay 110, upon energizing, disconnects test wiper 142 from the upper winding of switching relay 111 at armature 132 and connects it to busy relay 109 by way of armature 137 and its resting contact, and at armature 133 places a shunt around armature 129 and its resting contact so as to maintain its own circuit and that of rotary magnet 162 intact independent of busy relay 109, which relay is energized in case test wiper 142 encounters grounded test contacts.

Assuming that the line of substation A′ is busy, in which case test contact 145 is grounded, busy relay 109 energizes when test wiper 142 arrives upon test contact 145; opens a point in the operating circuit at armature 129; and at armature 127 disconnects release trunk conductor 102 from the upper winding of switching relay 111, at the same time preparing a locking circuit for itself. Under these conditions, relay 110, upon deenergizing, disconnects itself and rotary magnet 162 at armature 133, and at the normally closed contacts controlled by armature 132 completes the locking circuit of busy relay 109 from release trunk conductor 102. Busy relay 109 remains locked up until the connection is released, thereby maintaining the busy lead in engagement with the lower talking conductor at armature 130 so as to give the calling subscriber the busy tone. The calling subscriber upon hearing the busy tone knows that he cannot obtain the desired connection for the time being and replaces his receiver, whereupon the connection releases in the usual manner.

Assuming now that the line of substation A′ is idle when called as described hereinbefore, busy relay 109 is not energized when the wipers of the switch come into engagement with the contacts of the called line, and relay 110, upon deenergizing, disconnects test wiper 142 from busy relay 109 and connects it to the upper winding of switching relay 111 at armature 132, thereby closing the following circuit: from ground by way of the working contact of armature 118 and said armature, armature 127 and its resting contact, upper winding of switching relay 111, resting contact of armature 132 and said armature, test wiper 142, test contact 145, switching relay 147 of the line switch C′, and stepping magnet 148 to battery. Switching relays 147 and 111 energize in series over this circuit and switching relay 147 disconnects the conductors of the called line from the winding of the associated line relay and from ground but, owing to the usual mechanical interlocking levice (not shown), does not operate its armature far enough to connect up the wipers of the line switch.

In the connector H, switching relay 111 upon energizing, closes a locking circuit for itself at its lightly adjusted armature 136; places direct ground on test wiper 142 at armature 135; places ground on the lead extending to the motor of the ringing machine by way of armature 125 and its resting contact at armature 139 thereby starting the ringing machine in operation; disconnects busy relay 109 from the contacts of relay 110 at armature 137; disconnects rotary magnet 162 at armature 138 so as to prevent a false operation of said magnet 162 when the subscriber replaces his receiver; and at armatures 134 and 140 connects up line wipers 141 and 143 whereupon ringing current is intermittently projected out over the lower talking conductor to the substation and returns over the upper talking conductor and the upper winding of ring cut off relay 108. The small condenser 128 which is bridged around armature 122 of relay 108 and its working contact, allows enough ringing current to leak back to give the calling subscriber an audible indication that the called subscriber's bell is being rung.

When the called subscriber 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 108 energizes and closes a locking circuit for itself at its lightly adjusted armature 124, places a shunt around the upper winding of switching relay 111 at armature 123, thereby connecting release trunk conductor 102 with test wiper 142; disconnects ground from the lead extending to the motor of the ringing machine and closes a circuit for the supervisory lamp L through armature 116 and its resting contact at armature 125, and at armatures 122 and 126 disconnects the wipers 141 and 143 from its own upper winding and the ringing lead, respectively, and extends them to the windings of back bridge relay 104. Back

bridge relay 104, upon energizing, over the called subscriber's loop, opens the circuit of the supervisory lamp L at armature 116, at the same time closing a locking circuit for relays 108 and 111 independent of armature 120 of release relay 106; opens a point in the circuit of release magnet 161 and prepares a circuit for the supervisory lamp L' at armature 115; connects up the upper winding of ring cut off relay 108 to the operating circuit at armature 112 for a reason which will be explained hereinafter; and at armatures 113 and 114 reverses the connection of line relay 105 to conductors 101 and 103 so as to reverse the current flow in the loop extending back to the repeater R.

In the repeater R, electropolarized relay 71 responds to the reversal of current flow caused by the energization of back bridge relay 104 of the connector H by energizing. Upon energizing, relay 71 places a shunt around armature 85 and its working contact at armature 83, places a shunt around armature 80 and its resting contact at armature 81, and at armature 82 closes a circuit for reversing relay 67. Reversing relay 67, upon energizing, reverses the direction of current flow in the calling line at armatures 73 and 74. This, however, does not have any particular function at this time but is used in certain cases to operate meters and the like. As a further result of the energization of relay 67 it includes the left hand winding of impedance 72 in the bridge across conductors 86 and 87 at armature 75. This is the well known expedient used to improve the talking circuit.

The calling and called subscribers may now converse with each other as desired, talking battery being supplied to the calling substation by line relay 68 of the repeater R, and talking battery being supplied to the called substation by back bridge relay 104 of the connector H.

When the conversation is finished the two subscribers replace their receivers. When the receiver is replaced at substation A', the circuit of back bridge relay 104 is opened. Upon deenergizing, relay 104 opens a point in the circuit of supervisory lamp L' and prepares a circuit for release magnet 161 at armature 115; closes a circuit for supervisory lamp L at armature 116; disconnects the upper winding of relay 108 from the operating circuit at armature 112; and at armatures 113 and 114 reverses the current flow in the conductors 101 and 103 to normal. When this occurs, polarized relay 71 in the repeater R deenergizes and opens the circuit of reversing relay 67, whereupon the current flow in the calling line is reversed to normal.

When the receiver is replaced at substation A, the circuit of line relay 68 of the repeater R is opened. Line relay 68, upon deenergizing, opens the circuit of the line relay 105 of the connector H at armature 85 and at armature 84 short circuits release relay 69. Incidentally, relay 70 energizes upon the deenergization of line relay 68 but this does not have any particular function at this time. Release relay 69, upon deenergizing, opens the circuit of the lower winding of electropolarized relay 71 at armature 78; opens the circuit of relay 70 at armature 79, whereupon relay 70 deenergizes; and at armature 77 removes ground from release trunk conductor 65 whereupon switching relays 13 and 39 of the line switch C and the selector E, respectively, deenergize. Switching relay 39 of the selector E, upon deenergizing, closes a circuit for release magnet 41 as follows: from ground by way of the resting contact of armature 54 and said armature, resting contact of armature 46 and said armature, armature 48 and its resting contact, off normal contacts 43, and release magnet 41 to battery. Release magnet 41, upon energizing, restores the selector E to normal in the usual manner, the circuit of release magnet 41 being opened at off normal contacts 43 by the switch shaft when the latter reaches normal position.

In the connector H, line relay 105, upon deenergizing in response to the opening of its circuit by the line relay of the repeater R, short circuits release relay 106 at armature 117, whereupon relay 110 energizes and disconnects release trunk conductor 102 from test wiper 142 at armatures 131 and 132. Release relay 106, upon deenergizing, opens the locking circuit of relays 108 and 111 at armature 120, whereupon said relays 108 and 111 deenergize; removes ground from release trunk conductor 102 at armature, 118, whereupon the selectors F and G are restored to normal in the usual manner; and at armature 119 opens the circuit of relay 110 and closes the following circuit for release magnet 161: from ground by way of the resting contact of armature 117 and said armature, armature 119 and its resting contact, armature 115 and its resting contact, off normal contacts 149, and release magnet 161 to battery. Release magnet 161, upon energizing, restores the shaft and wipers of the connector H to normal position in the usual manner.

In order to explain the function of certain circuit arrangements of the connector H and the repeater R not brought out fully in the foregoing description, it will be assumed that the subscriber at substation A' does not replace his receiver immediately at the end of the conversation as was assumed in the foregoing. That being the case, when the subscriber at substation A replaces his receiver, line relay 68 of the repeater R deenergizes as before and short circuits release

relay 69 at armature 84 but does not open the bridge across the conductors 86 and 87 owing to the fact that armature 85 and its working contact are shunted by armature 83 and its working contact. Armature 83 and its working contact, it may be stated, are provided for the purpose of preventing accidental deenergizations of line relay 68 from producing momentary openings in the bridge across conductors 86 and 87 after all the winding of impedance 72 is cut in by the operation of reversing relay 67, for the reason that under these conditions the line relay of the connector, if permitted to respond to momentary deenergizations of relay 68, might not be quick enough in picking up in series with impedance 72. Relay 70 is energized at this time and shunts the upper winding of relay 71 and impedance 72 at armature 80 but does not disconnect the upper talking condenser as is the case when relay 71 is not energized, owing to the fact that armature 80 and its resting contact are shunted by armature 81 and its working contact. Release relay 69, upon deenergizing, removes ground from release trunk conductor 65 at armature 77; opens the circuit of the lower winding of electropolarized relay 71 at armature 78; opens the circuit of relay 70 at armature 79; and at armature 76 opens the bridge across conductors 86 and 87, whereupon relays 71 and 67 deenergize.

In the connector H, line relay 105, upon deenergizing in response to the openings of its circuit by the repeater R as explained above, removes the shunt from around relay 110 and short circuits release relay 106 at armature 117. Release relay 106 remains energized for an interval owing to its short circuited winding. Relay 110, upon energizing, disconnects release trunk conductor 102 from grounded test wiper 142 at armatures 131 and 132. Release relay 106, upon deenergizing after an interval, removes ground from the locking circuit of relays 108 and 111 at armature 120. These relays, however, are maintained energized over a locking circuit which includes the attracted armatures 139, 125 and 116. As a further result of the deenergization of release relay 106, it opens at armature 119 the circuit of relay 110; closes a circuit for supervisory lamp L' at armature 119, by way of armature 115 and its working contact; and at armature 118 removes ground from release trunk conductor 102, whereupon the selectors F and G are restored to normal in the usual manner. Relay 110 does not deenergize immediately upon the opening of its circuit at armature 119 of release relay 106, owing to the fact that it and vertical magnet 160 which is in series with it are shunted at this time by the upper winding of ring cut off relay 108, which winding is connected to the operating lead through armature 112 of back bridge relay 105 and its working contact. The upper winding of ring cut off relay 108 has far less inductance than relay 110 and for that reason acts substantially like a non-inductive shunt around the latter. After an interval, which is sufficiently long to allow the switching relays (not shown) of the selectors F and G, which switching relays correspond to switching relay 39 of the selector E, to deenergize, relay 110 deenergizes and places ground on release trunk conductor 102 by way of armature 135 and its working contact, armature 132 and its resting contact, resting contact of armature 131 and said armature, armature 123 and its working contact, and the resting contact of armature 127 and said armature, thereby guarding the connector H against seizure. The connector H is held at this time, it will be understood, to prevent the line switch C' from operating to select an idle first selector when the calling subscriber hangs up.

Assuming now that the subscriber at substation A' replaces his receiver, back bridge relay 104, upon deenergizing, opens the locking circuit of relays 108 and 111 at armature 116, whereupon these relays deenergize, and at armature 115 closes the usual circuit for release magnet 161 whereupon the shaft and wipers of the switch are restored to normal position in the usual manner.

Regarding the common supervisory lamps L and L' and their associated equipment, it may be stated that the lamp L is used to give supervision to an attendant in case the calling subscriber fails to replace his receiver at the end of the conversation, and the lamp L' is used for the same purpose in case the called subscriber does not replace his receiver at the end of the conversation. In either case, the current is taken through the pilot relay 175 which relay, upon energizing, closes a circuit for the solenoid 176. When solenoid 176 is energized, the associated plunger starts to rise, slowly, however, owing to the oil dashpot on the lower end thereof. In case the circuit of the pilot relay is opened no alarm is given and the plunger immediately drops to normal. In case the lamp L, or L' as the case may be, remains lighted longer than the predetermined interval, wiper 177, upon reaching its contacts, closes a circuit for relay 178. Relay 178, upon energizing, lights the pilot lamp L^2 at armature 181, which lamp indicates the group from which the signal is coming, and at armature 180 closes a circuit for the exchange alarm buzzer B, thereby giving the correct indications to the attendant who may proceed to clear up the trouble.

What is claimed is:

1. In a telephone system, an automatic switch having a line relay energized in a

closed line circuit, said switch having also a release relay and a magnet connected in series, said release relay having sufficient resistance to prevent the operative energization of said magnet, means for deenergizing said line relay momentarily a desired number of times by interrupting the circuit thereof a corresponding number of times, and contacts controlled by said line relay for energizing said magnet upon each deenergization of said line relay by shunting said release relay.

2. In a telephone system, a line relay, a second relay, means for energizing and deenergizing said line relay, circuit connections such that said second relay is energized by said line relay when the latter energized and such that said second relay closes a locking circuit for itself exclusive of contacts on said line relay, and circuit connections such that said second relay is shunted by said line relay when the latter deenergizes.

3. In a telephone system, a first and a second relay, means for energizing and deenergizing said first relay, means responsive to the energization of said first relay for energizing said second relay, means responsive to the energization of said second relay for maintaining said second relay energized exclusive of contacts on said first relay, and means responsive to the deenergization of said first relay for short circuiting said second relay.

4. In a telephone system, an automatic switch, a line relay, a pair of control relays, and an operating magnet for said switch, a circuit including said control relays and said magnet in series, means controlled by the energization and deenergization of said line relay for alternately shunting said control relays, and windings for said control relays having resistances so proportioned that said magnet attracts its armature, when one of said control relays is shunted and retracts its armature when the other of said control relays is shunted.

5. In a telephone system, a trunk, a line relay and two control relays, means for energizing and deenergizing said line relay over the conductors of said trunk, said line relay having a pair of normally open and a pair of normally closed contacts, a circuit for energizing one of said control relays completed responsive to the closure of said normally open contacts, a circuit for energizing the other of said control relays completed responsive to the closure of said normally closed contacts, and circuit connections for maintaining both of said control relays energized in series independent of said contacts when neither pair is closed.

6. In a telephone system, an automatic switch having an operating magnet, a line relay for controlling said magnet, a release relay, a changeover relay, means for transmitting an impulse of current to said release relay responsive to each energization of said line relay and to said changeover relay responsive to each deenergization of said line relay, all of said impulses passing through said operating magnet, and means for shunting said release relay during the energization and said changeover relay during the deenergization of said line relay to make said release and changeover relays slow acting.

7. In an automatic switch, a line relay, a release relay, an operating magnet, means including front contacts on said line relay for energizing said release relay in series with said magnet, said magnet being non-responsive, and means including back contacts on said line relay for shunting said release relay and for energizing said magnet.

8. In an automatic switch, a line relay adapted to vibrate its armature to control the operation of said switch, two normally quick-acting auxiliary controlling relays, energizing circuits for said auxiliary relays closed alternately by said line relay while operating, shunt circuits for said auxiliary relays also closed alternately by said line relay in order to render said auxiliary relays slow to deenergize, and an operating magnet for said switch included in said energizing circuits.

9. In an automatic switch, a line relay having front and back contacts, an operating magnet, an auxiliary control relay, an energizing circuit for said magnet including said back contacts and said auxiliary relay in series, and a shunt circuit for said auxiliary relay including said front contacts.

10. In an automatic switch, a line relay, a vibrating spring for said relay having front and back contacts, a release relay, a changeover control relay, circuit connections for shunting said changeover relay responsive to the closure of said front contacts and for shunting said release relay responsive to the closure of said back contacts, a source of current, and circuit connections for connecting said release and changeover relays in series with said source when both front and back contacts are open.

11. In an automatic switch, a line relay, and a contact member controlled by said line relay having front and back contacts, a release relay, a changeover control relay, a circuit for said release relay closed at said front contacts, a circuit for said changeover relay closed at said back contacts, and a third circuit including said release and changeover relays in series and excluding both front and back contacts.

12. In an automatic switch, a line relay having front and back contacts, a release relay, a changeover control relay, a circuit for said release relay closed at said front con-

tacts, a circuit for said changeover relay closed at said back contacts, and a third circuit controlled by said release relay and including said release and changeover relays in series.

13. In an automatic switch, a line relay having front and back contacts, a release relay, a changeover control relay, a circuit for said release relay closed at said front contacts, a circuit for said changeover relay closed at said back contacts, and an operating magnet for said switch included in both of said circuits.

14. In an automatic switch, a line relay having front and back contacts, a release relay, a changeover control relay, a circuit for said release relay closed at said front contacts, a circuit for said changeover relay closed at said back contacts, said release relay having a relatively high resistance, and an operating magnet for said switch included in both said circuits but responsive only to the closure of the said second circuit.

15. In an automatic switch, primary and secondary operating magnets, each operating magnet having one of its terminals connected to the exchange battery, a line relay for controlling said magnets, and an auxiliary controlling relay normally connected to the other terminals of both of said magnets.

16. In an automatic switch, primary and secondary operating magnets, a line relay for controlling said magnets, a relay adapted to remain energized during the operation of said secondary magnet, and a circuit for said relay including said primary magnet.

17. In an automatic switch, primary and secondary operating magnets, a line relay for controlling said magnets, a relay adapted to remain energized during the operation of said primary magnet, a third relay adapted to remain energized during the operation of said secondary magnet, and circuits for said second and third relays including said primary magnet.

18. In an automatic switch, a line relay, a release relay, front contacts on said line relay, for initially energizing said release relay, means for maintaining said release relay energized independent of said front contacts, and back contacts on said line relay for shunting said release relay to deenergize the same.

19. In an automatic switch, a line relay, a release relay, front contacts on said line relay for energizing said release relay, a locking circuit for said release relay, and back contacts on said line relay for shunting said release relay to render said locking circuit ineffective.

20. In an automatic switch, a line relay, a release relay, an armature spring on said line relay having front and back contacts, an initial energizing circuit for said release relay closed at said front contact, contacts on said release relay for closing a self locking circuit, and a shunt circuit for said release relay closed at said back contact.

21. In an automatic switch, a line relay, a release relay, an operating magnet, a circuit including said release relay and said magnet, said magnet being non-responsive due to the resistance of the release relay, and a pair of contacts on said line relay for short circuiting said release relay to operate said magnet.

22. In an automatic switch, a line relay, a change-over control relay, a circuit including said change-over control relay, a release relay in said circuit having a sufficiently high resistance to prevent the operation of said change-over relay, and contacts on said line relay for shunting said release relay to permit the operation of said change-over control relay.

23. In an automatic switch, a line relay, primary and secondary operating magnets, a second relay controlling the secondary magnet, a circuit including said second relay and said primary magnet, a release relay also included in said circuit and having a sufficiently high resistance to prevent the operation of the second relay and the primary magnet, and contacts controlled by said line relay for shunting said release relay to operate said second relay and said primary magnet.

24. In an automatic switch, a line relay, a release relay, a change-over relay, shunt and energizing circuits for said release and change-over relays, and contacts on said line relay for closing and opening all said circuits.

25. In an automatic switch, a line relay, a release relay, a change-over relay, shunt and energizing circuits for said release and change-over relays, front contacts on said line relay for closing the shunt circuit of the change-over relay and the energizing circuit of the release relay, and back contacts on said line relay for closing the shunt circuit of the release relay and the energizing circuit of the change-over relay.

26. In combination, an operating magnet, a high resistance relay and a low resistance relay connected in series with said magnet, the magnet being operative when connected in series with the low resistance relay and inoperative when connected in series with the high resistance relay, and means for alternately shunting said relays.

27. In an automatic switch, an operating stepping magnet, a release relay and a change-over relay, means for alternately connecting said magnet in series first with one and then with the other of said relays, said magnet being operative when connected in series with one of said relays and inop-

erative when connected in series with the other of said relays.

28. In an automatic switch, an operating stepping magnet, a high resistance relay, and a low resistance relay, means for alternately connecting said magnet in series first with one and then with the other of said relays, and means for maintaining one of said relays shunted when the magnet is connected in series with the other relay.

29. In an automatic switch, an operating stepping magnet, a high resistance relay connected in series therewith, a low resistance relay, and means for periodically short circuiting the high resistance relay and simultaneously therewith connecting the low resistance relay in series with the operating magnet.

30. In combination, a line relay, a release relay and a third relay, an operating magnet, means controlled by the line relay for establishing a series circuit for said two relays, means controlled by the line relay for short circuiting said release relay and simultaneously therewith establishing an operating circuit for said magnet, the connections being such that the release relay is always in a closed circuit during the operation of the line relay, and means partly controlled by the third relay for rendering the line relay ineffective to operate the magnet.

31. In an automatic switch, a line relay, a release relay, means controlled by the line relay for establishing an operating circuit for the release relay, means controlled by the release relay for establishing a locking circuit for itself, and means controlled by the line relay for rapidly repeatedly short circuiting the release relay, the duration of the short circuit being less than the time required for the release relay to fall back due to the short circuit.

32. In an automatic switch, a line relay, a release relay, an armature spring on said line relay having a normal position and an operated position, an initial energizing circuit for said release relay closed by said armature spring in one of said positions, means for establishing a locking circuit for said release relay, and a shunt circuit for said release relay established by said armature spring in its other position.

33. In an automatic switch, an incoming line, a line relay responsive to two groups of digit impulses received over the line for controlling the operation of the switch, a primary magnet controlled by the line relay responsive to the first group of impulses, a secondary magnet controlled by the line relay responsive to the second group of impulses, a change-over relay connected in series with the primary magnet for switching the control circuit from the primary magnet to the secondary magnet, and circuit connections controlled by the line relay during the primary operation of the switch for short circuiting the change-over relay during each impulse of the first group of impulses, the duration of the short circuit being less than the time required for the change-over relay to release, whereby the change-over relay is maintained operated to prevent the control circuit being switched to the secondary magnet during the primary operation of the switch.

In witness whereof, I hereunto subscribe my name this 11th day of August, A. D., 1922.

RUDOLPH F. STEHLIK.