April 5, 1927. 1,623,230

J. I. BELLAMY

TELEPHONE SYSTEM

Original Filed Oct. 12, 1921 3 Sheets-Sheet 1

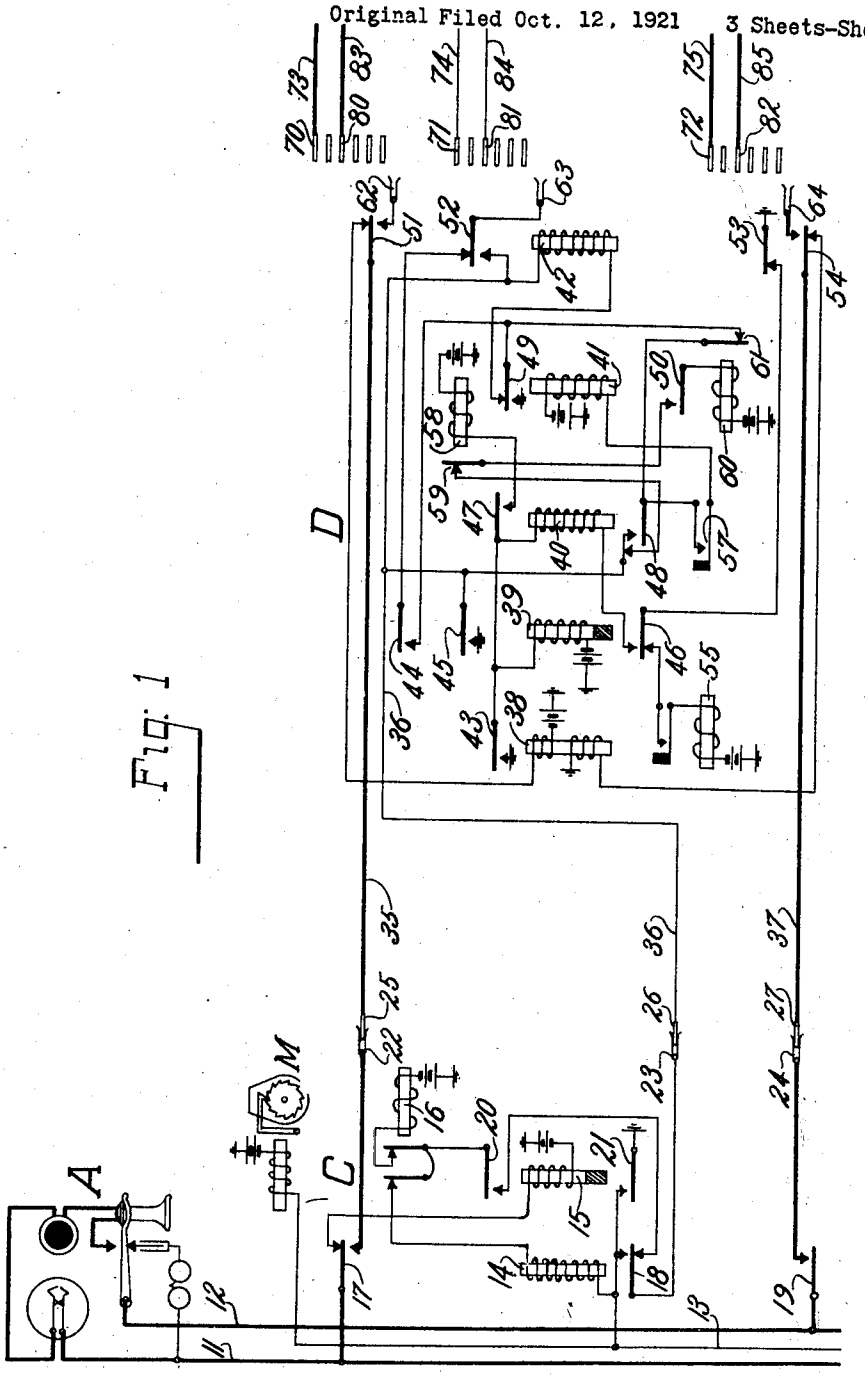


Fig. 1

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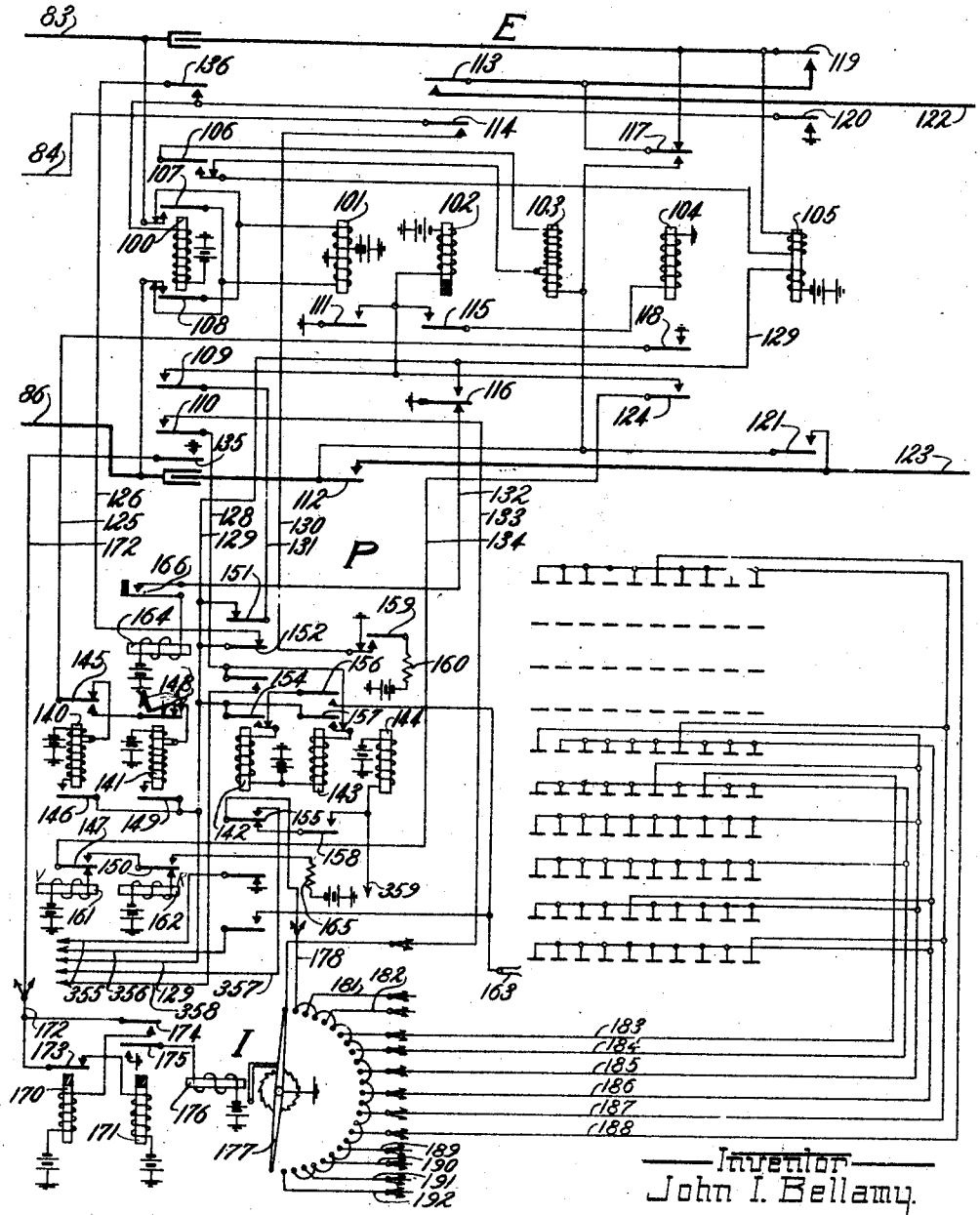
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TELEPHONE SYSTEM

Original Filed Oct. 12, 1921 3 Sheets-Sheet 2

Fig. 2



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TELEPHONE SYSTEM

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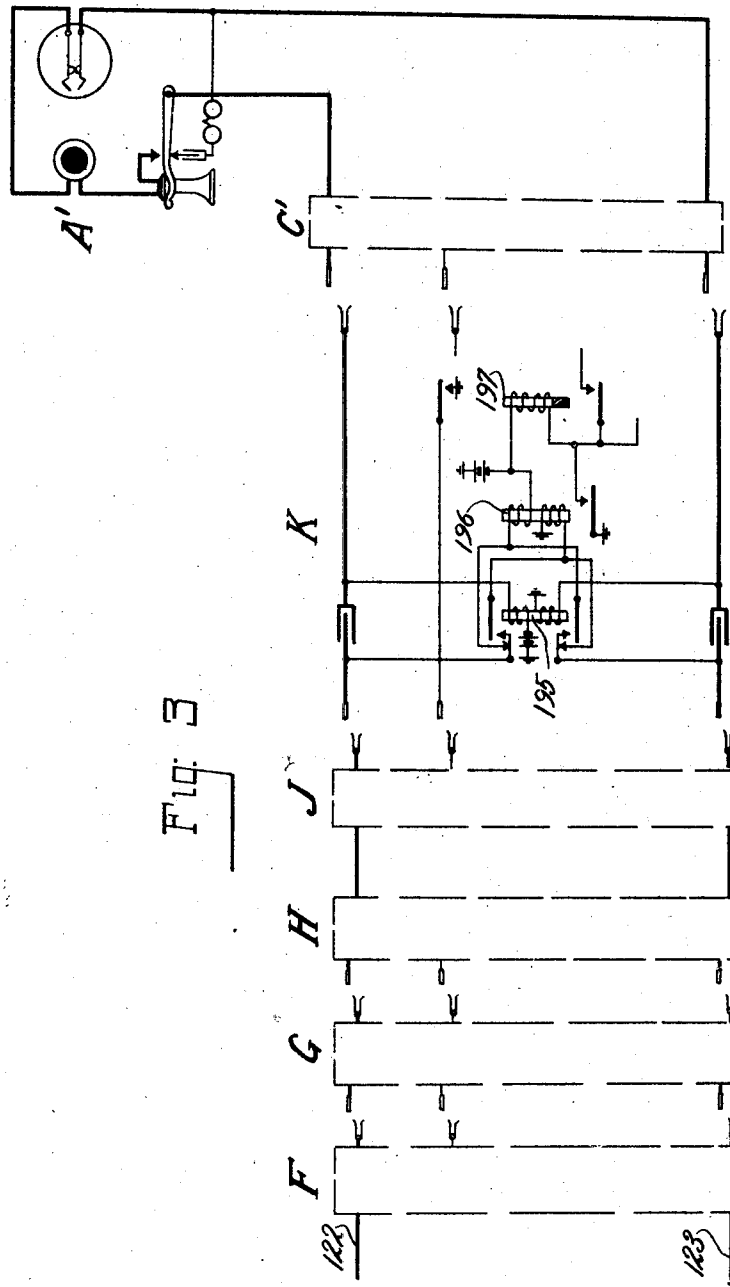


Fig. 3

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Patented Apr. 5, 1927. 1,623,230

UNITED STATES PATENT OFFICE.

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

TELEPHONE SYSTEM.

Original application filed October 12, 1921, Serial No. 507,182. Divided and this application filed October 23, 1925. Serial No. 64,301.

The present invention relates in general to telephone systems, but is particularly concerned with the provision of improved switch and switch control circuits for use in such systems.

Among the objects of the invention are: to provide directive controlled automatic switches and repeaters with improved switch control circuits, and to improve and make more positive the automatic hunting operation of automatic switches.

The present invention is a division of my copending application, Serial No. 507,182, filed October 12, 1921, which discloses and claims other features not shown in the instant application.

In the present disclosure Figs. 1, 2, and 3, when placed with their corresponding lines in alignment represent sufficient of the circuits of a telephone system to enable the invention to be understood.

The substation A, Fig. 1, is an ordinary automatic substation having the usual talking, signaling, and impulse sending instrumentalities.

The line switch C, Fig. 1, is mechanically of the well known rotary type in which the wipers have no normal position and move in a forward direction only.

The selector D, Fig. 1, is mechanically of the well known vertical and rotary type. The circuits of this switch are shown complete and will be explained fully hereinafter.

The automatic repeater E, Fig. 2, is fundamentally an ordinary repeater of a two-wire type, which is in common use. The circuits have been improved, however, as will be explained hereinafter. This repeater is used primarily to avoid the necessity of having three conductors to the associated trunk line which extend to the next office.

In explaining the various features of the invention it will be assumed that the subscriber at substation A, Fig. 1, desires to obtain connection with a subscriber at station A′ in another office.

When the receiver is removed at the calling substation, a circuit is closed over the line conductors 11 and 12 for the line relay 15 of the line switch C. Line relay 15, upon energizing, closes at armature 21 a circuit for switching relay 14 and stepping magnet 16 in series and at armature 20 connects the test wiper 23 to a point in the circuit between the switching relay 14 and the stepping magnet 16. From this point the operation depends upon whether the trunk line upon which the wipers of the line switch are standing is busy or idle. If it is busy there is a ground potential on test contact 26, switching relay 14 is short circuited and the stepping magnet 16 which interrupts its own circuit is operated in the manner of a buzzer to advance the switch wipers step by step in search of an idle trunk line. In the present case, however, we shall assume that the trunk line upon which the wipers of the line switch are standing is idle. That being the case, switching relay 14 is not short circuited and stepping magnet 16 is not energized on account of the high resistance of switching relay 14. Switching relay 14, however, is energized and at armature 18 disconnects the test wiper 23 from the point between its own winding and that of stepping magnet 16 and connects it to the grounded private normal conductor 13. As a further result of the energization of switching relay 14, it disconnects the line conductors 11 and 12 from the winding of line relay 15 and ground, respectively, and extends them by way of armatures 17 and 19 and their working contacts, wipers 22 and 24, bank contacts 25 and 27, trunk conductors 35 and 37, and armatures 51 and 54 and their resting contacts to the upper and lower windings of the double wound line relay 38 of the district selector D. Line relay 38 now energizes over the calling subscriber's loop and at its armature 43 closes a circuit for the slow acting release relay 39. Release relay 39, upon energizing, connects up test wiper 63 at armature 44; opens a point in the circuit of release magnet 55 and prepares a circuit for relay 40 at armature 46; and at armature 45 places ground on release trunk conductor 36, thereby establishing a holding circuit for the line switch C. By means of this ground potential on test contact 26 and its multiples in the banks of the other line switches which have access to the selector D, the seized trunk line is maintained busy in the usual manner. A branch of this holding circuit extends by way of

private normal conductor 13 to multiple test contacts in the banks of the connector switches having access to the calling line, thereby guarding it against intrusion in the usual manner.

The calling subscriber now operates his calling device in accordance with the first digit 4 of the desired number, thereby producing four interruptions in the cicuit of line relay 38 of the district selector D. As soon as line relay 38 deenergizes in response to the first of these interruptions, relay 40, which heretofore has been short circuited, energizes in series with the release relay 39. Upon energizing, relay 40 connects vertical magnet 58 in muiltiple with release relay 39 at armature 47. Vertical magnet 58, however, is not energized at this time on account of the high resistance of relay 40. As a further result of the energization of the relay 40 it opens a point in the circuit of rotary magnet 60 and prepares a circuit for stepping relay 41 at armature 48. When line relay 38 energizes following the first interruption, it closes a direct circuit for slow acting release relay 39 and vertical magnet 58 in multiple, at the same time short circuiting relay 40. Relay 40, being short circuited, is slow to deenergize and consequently is maintained energized throughout the series of interruptions. Vertical magnet 58, upon energizing, raises the wipers 62–64, inclusive, opposite the first level of bank contacts, whereupon the off normal springs 57 close thus completing the circuit of stepping relay 41. Stepping relay 41, upon energizing, closes a point in the circuit of rotary magnet 60 at armature 50 and at armature 49 closes a locking circuit for itself independent of relay 40. When line relay 38 deenergizes in response to the second interruption produced in its circuit, vertical magnet 58 deenergizes on account of the high resistance of relay 40 and is energized again when line relay 38 energizes. By the subsequent operation of vertical magnet 58, the shaft and wipers of the selector D are raised step by step until the latter stand opposite the desired level of bank contacts which in this case is the fourth, or the level in which the trunk line comprising conductors 83–85, inclusive, terminates. After line relay 38 had come to rest in an energized condition at the end of the series of interruptions, relay 40, being short circuited, finally deenergizes; opens the circuit of vertical magnet 58 at armature 47; and at the normally closed contacts controlled by armature 48 opens the initial circuit of the stepping relay 41 and closes a point in the circuit of rotary magnet 60. Just as the armature of vertical magnet 58 comes to rest, the contacts 59 are closed, thereby completing the circuit of rotary magnet 60. It may be explained at this point that the circuit of the rotary magnet is held open by the contacts 59 controlled by the armature of the vertical magnet so as to allow the switch shaft to become settled before the rotary magnet energizes. Rotary magnet 60, upon energizing, advances the wipers 62–64, inclusive, into engagement with the first set of contacts in the level opposite which they are raised and at its interrupter contacts 61 opens the circuit of stepping relay 41. Stepping relay 41, upon deenergizing, opens another point in its circuit and prepares a circuit for switching relay 42 at armature 49 and at armature 50 opens the circuit of rotary magnet 60. Rotary magnet 60, upon deenergizing, closes its interrupter contacts 61 again.

From this point the operation depends upon whether the trunk line terminating in the first set of contacts is busy or idle. If it is busy, stepping relay 41 energizes again over the following circuit: From ground by way of the test contact with which test wiper 63 is in engagement, test wiper 63, armature 52 and its resting contact, armature 44 and its working contact, interrupter contacts 61, off-normal contacts 57, and stepping relay 41 to battery. Stepping relay 41, upon energizing, disconnects switching relay 42 and closes a locking circuit for itself at armature 49 and at armature 50 completes the circuit of rotary magnet 60 again. This alternate operation of the stepping relay and rotary magnet continues as long as test wiper 63 engages grounded contacts. In this case, we shall assume that the trunk line comprising conductors 83–85, inclusive, is the one first found to be idle. That being the case, when the wipers of the selector D arrive upon the bank contacts 80–82, inclusive, there is no ground potential on test contact 81 and consequently stepping relay 41 does not energize. With this condition existing, switching relay 42 energizes over the following circuit: from ground by way of release trunk conductor 36, switching relay 42, resting contact of armature 49 and said armature, interrupter contacts 61 off normal contacts 57, and stepping relay 41 to battery. Stepping relay 41, however, does not energize over this circuit on account of the relatively high resistance of switching relay 42. Switching relay 42, upon energizing, removes ground from armature 46 of release relay 39 at armature 53; disconnects test wiper 63 from the point between switching relay 42 and stepping relay 41 and connects it to ground by way of release trunk conductor 36 at armature 52, thus making the seized trunk busy immediately; and at armatures 51 and 54 disconnects the line conductors 35 and 37 from the windings of line relay 38 and extends them by way of the working contacts of these armatures,

wipers 62 and 64, bank contacts 80 and 82, trunk conductors 83 and 85 and the normally closed contacts controlled by armatures 107 and 108 to the upper and lower windings of line relay 101 of the repeater E. Line relay 101 now energizes over the calling subscriber's loop and at armature 111 closes the circuit of release relay 102. Release relay 102, upon energizing prepares a circuit for relay 104 at armature 115 and places ground on release trunk conductor 84 at armature 114, thereby establishing the usual holding circuit for the switch D and the line switch C before the slow acting relay 39 of selector D has had time to deenergize.

Returning now to the repeater E, as a still further result of the energization of release relay 102 it places ground on the conductor 129 at armature 116, thereby closing the circuit of the lower or polarizing winding of the electro-polarized relay 105. This winding alone, however, consisting of few turns of high resistance, is not able to effectively energize the relay. As a still further result of the energization of release relay 102, it completes at armature 113 a bridge across the trunk conductors 122 and 123 as follows: from conductor 123 by way of the working contact of armature 112 and said armature, lower winding of impedance 103, normally closed contacts controlled by armature 106, upper winding of electro-polarized relay 105, resting contact of armature 117 and said armature, and armature 113 and its working contact to conductor 122. In response to the closure of this bridge the line and release relays of the office selector F in the distant office energize and prepare the switch for operation in the usual manner. Electro-polarized relay 105, however, is not energized at this time owing to the fact that the current flowing in either winding is in a direction opposite to that flowing in the other winding.

The calling subscriber now operates his calling device in accordance with the next digit of the called number. Each time line relay 101 deenergizes, it opens the circuit of the line relay of the selector F in the distant office at armature 112, and at armature 111 removes the short circuit from around relay 104. Relay 104 energizes immediately in series with release relay 102 and, being short circuited each time line relay 101 energizes, retains its armatures attracted throughout the series of interruptions. At armature 117 relay 104 completes the bridge across trunk conductors 122 and 123 by a more direct path excluding the lower winding of impedance 103 and the upper winding of relay 105. This is the usual expedient made use of in order to obtain first class switch control.

The selector F in the distant office in response to the interruptions produced in the circuit of its line relay, raises its wipers to the desired level and rotates them in search of an idle trunk line leading to a selector G.

The calling subscriber may now operate his calling device in accordance with the remaining digit or digits of the called number to complete the connection by way of selectors G, H, J, and connector K, the connector initiating the intermittent transmission of ringing current out over the called line in the well known manner to ring the bell at station A'.

Before going further, the operation of the repeater E, together with the operation of its associated equipment will be explained more in detail. It will be remembered that relay 104 is maintained energized throughout each series of interruptions and that it falls back at the end of each series of interruptions. Relay 104, upon energizing, in response to the first digit dialled after the connection is extended to the repeater E, which is the second digit of the called number, closes at armature 118 a circuit for the upper winding of the marginally adjusted relay 140 of the switch P. This winding, however, is composed of a small number of turns of high resistance and consequently the relay is energized just enough to bring armature 146 into engagement with its working contact, but not enough to operate either armature 145 or armature 147. It will be noted that armature 146 is connected with the grounded conductor 129 and consequently the lower winding of relay 140 is short circuited at this time. As a further result of the energization of relay 104 it closes at armature 124 a point in the circuit of vertical magnet 161 of the switch P. Each time line relay 101 energizes following an interruption produced in its circuit, it closes a circuit for vertical magnet 161 as follows: from ground by way of armature 111 and its working contact, working contact of armature 124 and said armature, conductor 134, armature 147 and its resting contact, and vertical magnet 161 to battery. By the operation of the vertical magnet the switch shaft and wiper 163 are raised step by step until the latter stands opposite the desired level of bank contacts. At the end of the series of interruptions, relay 104 deenergizes; opens the circuit of vertical magnet 161 at armature 124; and at armature 118 opens the initial circuit of the upper winding of relay 140, thereby removing the short circuit from around the lower winding of the said relay 140. Relay 140 now pulls all the way up, the lower winding being composed of a large number of turns having a relatively low resistance. Upon operating fully, relay 140 transfers the impulsing cir-

cuit from the vertical to the rotary magnet at armature 147 and at armature 145 transfers the energizing circuit from its own upper winding to the upper winding of relay 141.

When relay 104 energizes in response to the calling of the next digit 2, it prepares a circuit for the rotary magnet 162 at armature 124 and at armature 118 closes the circuit of the upper winding of relay 141, which upper winding is similar to the upper winding of relay 140. Relay 141 is accordingly energized just sufficiently to bring armature 149 into engagement with its working contact, but not sufficiently to operate armature 148 or armature 150. By the operation of the rotary magnet 162 which is energized following each interruption in the circuit of line relay 101, the wiper 163 is advanced into engagement with the second bank contact in the fourth level. At the end of the series of interruptions, relay 104 deenergizes and at armature 118 removes the short circuit from around the lower winding of relay 141, whereupon relay 141 completely energizes; opens another point in the initial circuit of its upper winding at armature 148; and at armature 150 disconnects the impulsing conductor 134 from rotary magnet 150 and connects it to resistance 165.

The repeater E functions as hereinbefore described to repeat the impulses to the switches ahead during the calling of the remaining digits in the desired number, but does not cause any further movement of the wiper 163 of the switch P.

When the called subscriber responds by removing his receiver, the source of intermittent ringing current is removed from his line and the current flow in the incoming trunk conductor 122 and 123 is reversed in the well known manner.

In the repeater E the two windings of electro-polarized relay 105 which heretofore have opposed each other, now assist each other in energizing the said relay 105. Upon energizing, relay 105 at armature 119 places a shunt around armature 117 and its resting contact, at armature 121 places a shunt around armature 112 and its working contact, and at armature 120 closes the circuit of reversing relay 100. Reversing relay 100, upon energizing, at armatures 107 and 108 reverses the conductors 83 and 85 as regards their connection with the upper and lower windings of relay 101. This reversal of current flow in these conductors may be used in certain cases to operate supervisory signals and the like.

As a further result of the energization of relay 100, starting ground is placed on conductor 172 at armature 135. The application of ground to conductor 172 causes various operations to take in the various circuits and apparatus associated with switch P, causing relay 144 to operate and substitute booster battery for ground on conductor 130. This in turn causes the operation of the calling subscriber's meter as described in the previously mentioned application.

The talking circuit is now complete and the calling and called subscribers may converse with each other as desired over the heavily outlined conductors.

After the conversation is finished the two subscribers replace their receivers upon the switch hooks. When the receiver is placed at the substation A′ of the distant office, the current flow in the entire connection is reversed back to normal and relays 100 and 105 of the repeater E are deenergized. When the receiver is replaced at the substation A, the circuit of line relay 101 is opened. Line relay 101, upon deenergizing, opens the bridge across trunk conductors 122 and 123 at armature 112, whereupon the connection extending forward is released in the usual manner. As a further result of the deenergization of relay 101 it opens the circuit of release relay 102 at armature 111. Relay 104 now energizes in series with release relay 102 and at armature 124 places the relatively low resistance 165 in multiple with the said release relay 102 so as to shunt the latter and allow it to deenergize. Release relay 102, upon deenergizing, opens the circuit of relay 104 at armature 115 and at armature 116 removes ground from locking conductor 129, whereupon this relay also deenergizes. As a further result of the deenergization of relay 102, it closes the circuit of release magnet 164 at armature 116. By the operation of release magnet 164 the shaft and wiper of the switch P are restored to normal position in the usual manner, the circuit of release magnet 164 being opened at off normal contacts 166 by the switch shaft when it reaches normal position. The entire connection is now released and the switches engaged therein are ready for another call.

It will be convenient to explain at this time the function of a special circuit arrangement that is used in both the line switch C and the selector D. It frequently occurs that while booster battery is connected to a particular release trunk conductor so as to operate a subscriber's meter, a switch such as the selector D rotates over a set of contacts in which that release trunk conductor is multipled. The result is that some current flows through the switching relay of the hunting switch. The current is limited, however, by the resistance coil which is between the release trunk conductor and booster battery, and the stiffly adjusted switching relay does not have time to energize before it is completely short circuited by the pulling up of the stepping relay

after which the wipers are stepped on to the next set of bank contacts and the short circuit is removed from around the switching relay. If the release trunk conductor connected with this set of contacts also is connected to booster battery the switching relay which, due to the sluggish effect of placing a short circuit around it, has not lost all the magnetism obtained from the kick it received on the previous set of contacts, it is likely to energize fully at this time with the result that the rotary movement is stopped and the connection is extended to a busy trunk. In case the energization of the switching relay does not occur on this trunk it is likely to occur on one of the following trunks if the release trunk conductors thereof happen to be connected to booster battery. This difficulty is obviated in the present invention by arranging the circuit so that the switching relay 42 is not short circuited by the stepping relay 41 when it energizes, but is disconnected at armature 49, thereby allowing the built up lines of force in the switching relay to collapse between the testing of one contact and the testing of the other. It will be noted also that the circuit of switching relay 14 of the line switch C is opened each time stepping magnet 16 energizes. This is done for the same reason.

It will be noted that the armatures of the line relays throughout the drawings do not have the usual resting contacts through which the change over relay or both the change over relay and the operating magnets have been controlled formerly and that not only the release relay, but also the operating magnets and the change over relay as well, are controlled by a single pair of contacts on the line relay. This makes unnecessary the former practice of dividing the impulsing cycle between the resting and working contacts and consequently allows the switch to be adjusted to operate under more severe line conditions.

The features of the invention having been described and ascertained, will now be pointed out in the appended claims.

What is claimed is:

1. In an automatic switch having a directively controlled primary movement and a secondary movement, a line relay, a release relay, a relay for controlling the change over from primary to secondary movement, and a single pair of contacts on said line relay directly controlling said release and change over relays.

2. In an automatic switch having a directively controlled primary movement and a secondary movement, a line relay, a release relay, a relay controlling change over from primary to secondary movement, means for operating said switch in its primary movement, and a single pair of contacts on said line relay for directly controlling said release and change over relays and said operating means.

3. In an automatic switch having a directively controlled primary movement and a secondary movement, a line relay, a release relay, a relay controlling the change over from primary to secondary movement, a primary operating magnet, and a single pair of contacts on said line relay for directly controlling said release and change over relays and said primary operating magnet.

4. In an automatic switch having a directively controlled primary movement and a directively controlled secondary movement, means for operating said switch in its primary movement, means for operating said switch in its secondary movement, a line relay, a release relay, a change over relay, and a single pair of contacts on said line relay for controlling said primary operating means, said secondary operating means, and said release and change over relays.

5. In a trunk hunting switch, "a stepping relay", a "switching relay", a circuit for energizing said switching relay in series with said stepping relay said circuit including a pair of normally closed contacts on said stepping relay.

6. In a trunk hunting switch, a switching relay and a stepping magnet winding connected in series, a test circuit connected to a point between the said switching relay and said winding for energizing said winding, a pair of contacts controlled by said winding opening the winding circuit between the said winding and the point where the test circuit is connected, and another pair of contacts controlled by said winding for opening the circuit of the said switching relay between the winding of said relay and the point where the said test circuit is connected.

7. In a telephone system, a subscriber's line, an automatic switch having directive primary and automatic secondary movements, a line relay in said switch, and a single pair of contact springs on said line relay for exercising all necessary control over said switch in operating and releasing the same.

8. In a switch control circuit, a line relay, a change over relay, self locking contacts on said change over relay, and contacts on said line relay for short circuiting said change over relay.

9. In a switch control circuit, a line relay, a release relay, and a change over relay, contacts on said line relay for closing an operating circuit for said release relay, and contacts on said release relay for closing an operating circuit through said change over relay exclusive of any line relay contacts.

10. In a switch control circuit, a line relay, a release relay, a change over relay, con-

tacts on said line relay for completing an operating circuit for said release relay, and contacts on said release relay completing a circuit for said change over relay and including the winding of said release relay.

11. In a switch control circuit, line, release, and change over relays, respectively, contacts controlled by the line relay for causing the energization of said release and change over relays, and circuits exclusive of said line relay contacts for maintaining said release and change over relays energized.

12. In combination, a first relay, a second relay, means for operating and restoring said first relay, circuit connections for operating the second relay responsive to the operation of the first relay, contacts on the second relay for closing a self locking circuit, and means responsive to the restoration of the first relay for placing a shunt around the second relay to bring about its restoration.

13. In an automatic switch, a control relay, a line incoming to said switch, means controlled over said line for closing an energizing circuit for said relay, contacts on said relay for closing a self-locking circuit when the relay is energized, and means controlled over said line for shunting said relay to bring about its deenergization.

14. In an automatic switch, an operating magnet and a control relay, a line incoming to said switch, means controlled over said line for closing an operating circuit for said relay, contacts on said relay for closing a self locking circuit including said operating magnet, and means controlled over said line for shunting said control relay, whereby said operating magnet is operated.

15. In an automatic switch, an operating magnet and a control relay, a line incoming to said switch, means controlled over said line for closing an operating circuit for said control relay, contacts on said control relay for closing a self locking circuit including said operating magnet, and means controlled over said line for operating said operating magnet any desired number of times by momentarily shunting said control relay, whereby said control relay remains operated as long as it is shunted only momentarily and falls back to open the operating magnet circuit and its own locking circuit in case it is shunted for a longer period.

16. In an automatic switch, an incoming line, first and second control relays, means controlled over said line for operating the first control relay, contacts on the first control relay for closing a self locking circuit including the second control relay, whereby the second control relay is operated in series with the first control relay when the initial circuit is opened, and contacts on the second control relay for shunting the first control relay.

17. In an automatic switch, an incoming line, first and second control relays, means controlled over said line for operating the first control relay, contacts on the first control relay for closing a self locking circuit including the second control relay, whereby the second control relay is operated in series with the first control relay when the initial circuit is opened, contacts on the second control relay for shunting the first control relay, the proportion between the resistance of the relay windings and said shunt being such that the first relay remains operated as long as the initial circuit is opened only momentarily, and the second control relay operates responsive to the first momentary opening of the initial circuit and remains operated as long as the initial circuit is reestablished only momentarily.

18. In a switch control circuit, a line relay, a second relay and a third relay, an operating magnet, contacts on the line relay closed when the line relay is operated to close a circuit for the second relay, contacts on the second relay for closing a self locking circuit for the second relay including the third relay, contacts on the third relay closed when the third relay is operated due to the opening of the initial circuit for the second relay to place the operating magnet in multiple with the second relay, whereby the operating magnet is operated upon the reclosure of the initial circuit of the second relay.

19. In a switch control circuit, a control relay and an operating magnet, a pair of contacts on said control relay, means for operating said relay to close said contacts, means responsive to a closure and subsequent opening of said contacts for preparing a circuit for said operating magnet including said contacts, whereby said operating magnet is operated upon reclosures of said contacts.

20. In an automatic switch, a control relay and an operating magnet, means for closing a circuit including said relay and magnet in series, the proportion of the winding turns between the relay and magnet being such that the relay is operated and the magnet is non-operated and is furthermore unable to remain operated in series with the relay, and means for operating said magnet a desired number of times by momentarily shunting said relay each time it is desired to operate the magnet, and control contacts on said relay operated to exercise control over said switch in case the relay is shunted for longer than a predetermined time.

21. In an automatic switch having a directed primary movement and a free-hunting secondary movement, an operating magnet for effecting the primary movement and a second operating magnet for effecting the secondary movement, a line relay for said switch, circuit arrangements associated there-

with such that the operating magnet is operated on each reoperation of the line relay after it has been operated and momentarily released, a change-over relay for opening the circuit of the primary magnet and for closing a circuit for the secondary magnet when the line relay remains reoperated for longer than a predetermined interval, and contacts on the primary magnet for maintaining the circuit of the secondary magnet open until the primary magnet has fallen back.

22. In an automatic switch, an operating magnet and a control relay, means for connecting said control relay and said magnet in series, the design of the two being such that the relay is operated and the magnet is non-operated when the connection is effected, means for momentarily shunting said relay a variable number of times, whereby the relay remains operated and the magnet is operated each time the relay is shunted, means for again shunting said relay a variable number of times, an alternate circuit path including said relay, and means operated between the first and second shuntings for transferring the relay to said alternate path so that no further operation of the operating magnet takes place when the second series of shuntings of the relay is produced.

In testimony whereof I have hereunto set my hand this 21st day of October, 1925.

JOHN I. BELLAMY.