Dec. 28, 1937. N. H. SAUNDERS 2,103,301

TELEPHONE SYSTEM

Filed Oct. 21, 1935 2 Sheets-Sheet 1

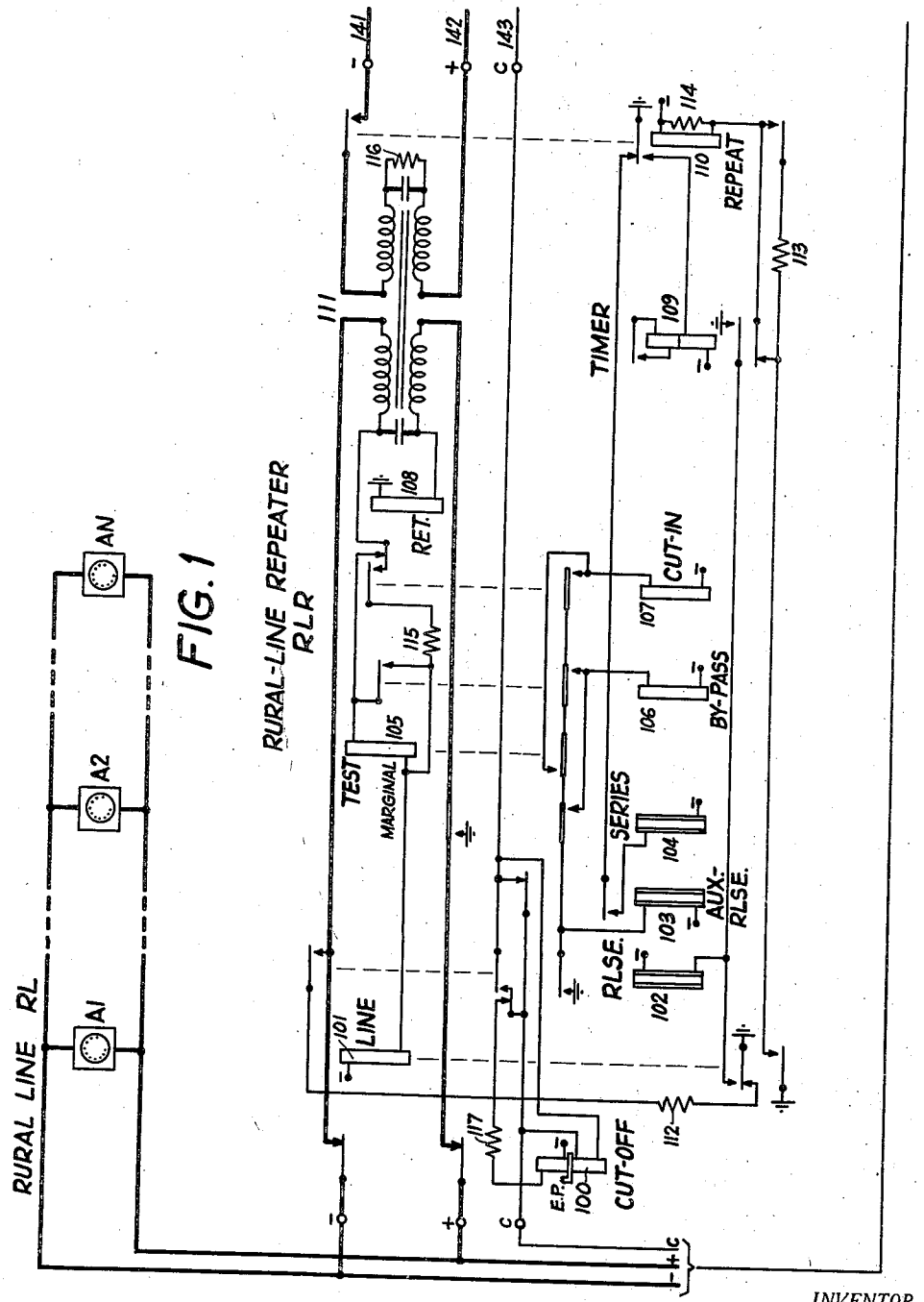


FIG. 1

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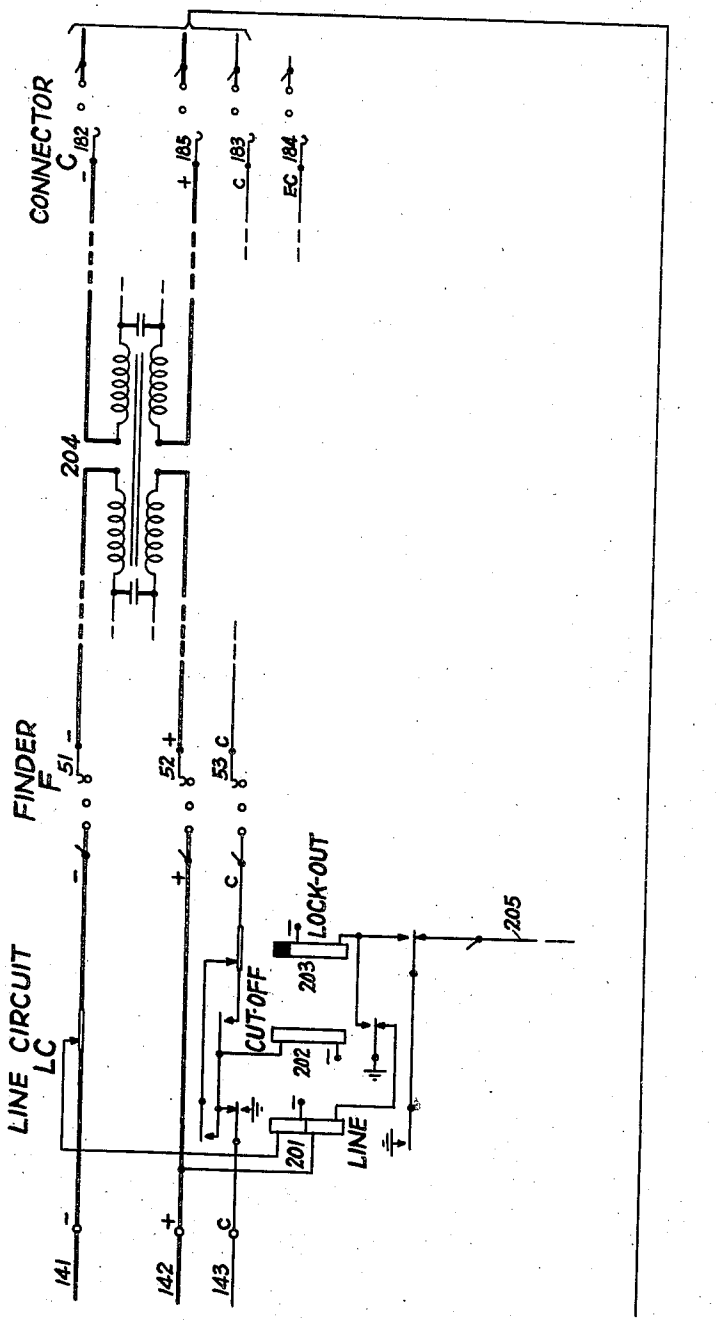
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FIG. 2



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2,103,301

UNITED STATES PATENT OFFICE

2,103,301

TELEPHONE SYSTEM

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9 Claims. (Cl. 179—16)

The present invention relates to telephone systems, but is concerned more particularly with telephone systems which give service to rural communities through the medium of automatic switching apparatus.

The broad general object of the invention is the production of new and improved control circuits for enabling automatic service to be given more satisfactorily from lines of widely differing characteristics. A more specific object of the invention is the production of a new and improved repeater which may be inserted in a rural subscriber line to respond to the dialling impulses generated thereon to repeat satisfactory impulses to the switching apparatus.

General description

As is well known, in many rural communities and towns, some of the lines radiating from the telephone exchange are relatively short town lines connecting with nearby subscribers' stations; other lines extend to stations of nearby rural subscribers; and still other lines extend along rural routes to serve subscribers' stations located at various distances from the exchange. Because of the variation in line resistance afforded by the different lines entering the exchange, which condition is complicated somewhat by the fact that the longer lines usually have many substations connected thereto, it is quite difficult to secure an adjustment of the line relays of the automatic switching apparatus which will enable the apparatus to operate satisfactorily from all of the lines of the exchange.

Although circuit arrangements are known which substantially extend the normal range of characteristics of lines over which automatic switching apparatus may be operated, it has been found in practice that some rural lines impose so much more severe impulsing conditions than a majority of the lines that it is often economical to provide certain lines with individual repeaters. Then the impulse-responding apparatus of the switches used in common by all lines may be adjusted with special reference to more nearly normal line characteristics, while the severe conditions imposed by the few lines are more or less compensated for by the respective repeaters individual thereto.

Repeaters have been used before individual to certain rural lines of an exchange. Each of these prior repeaters, however, has proved to be unsatisfactory in one or more respects in giving the service required in modern unattached community automatic exchanges. The following patents are cited as showing the state of the art: 1,502,168, John Wicks, July 22, 1924, 1,502,877, A. J. Ray, July 29, 1924, and 1,681,015, N. H. Saunders, Aug. 14, 1928.

It is an object of the invention to provide a repeater for the individual use of a rural line, which automatically adjusts itself to the length of line included when a subscriber is calling, according to the remoteness of the calling substation.

A further object of the invention is to provide an individual-line repeater which permits of all the services normally provided for in a standard community exchange. A special problem arose in handling reverting calls while permitting satisfactory switch-hook recalling of a called operator, which problem was solved by circuit arrangements including a polarized cut-off relay, as will be brought out in detail hereinafter.

Referring now to the accompanying drawings comprising Figs. 1 and 2, they show by means of the usual circuit diagrams a sufficient amount of the apparatus involved in a telephone system embodying the invention to enable the invention to be understood.

Fig. 1 shows the rural-line repeater RLR, individual to the multi-station rural line RL, being inserted between the called terminals of the rural line and the individual line circuit LC, Fig. 2, both of which are located in the exchange. The rural line RL is also associated with calling terminals comprising the terminals indicated at the left-hand portion of Fig. 2. Three substations (A1, A2, and AN) are shown connected to the line RL. There are assumed to be several more.

Fig. 2, in addition to the individual line circuit LC, shows one finder-connector link composed of the finder F and the associated connector C, which is one link of a number provided to handle the traffic in the community automatic exchange. For a full disclosure of the finder-connector link partially shown in Fig. 2, reference may be had to my prior Patent 1,999,788, granted April 30, 1935.

As pointed out in my prior patent, each of the lines is provided with a line circuit such as LC, Fig. 2. Except for a few of the longest lines, or lines in a poorly maintained condition, each line terminates directly in the line conductors of its individual line circuit, as disclosed in my prior patent above referred to. The rural line RL, however, is assumed to be one of the lines which presents unusually severe impulsing con-

ditions and is therefore provided with the individual repeater RLR. This repeater, as is shown in the drawings, is inserted between the associated line RL and the line circuit LC, being connected therewith by means of the talking conductors 141 and 142 and the third or control conductor 143.

In order to control the connection of the repeater RLR to the call terminals there is associated with these call terminals switching means in the form of a cut-off relay 100 which operates to disconnect the line from the repeater when a subscriber on the line RL is called, thereby to avoid interference during the ringing operation.

Detailed description

The disclosure having been described generally, a detailed description of the operation of the apparatus disclosed will now be given.

Calling the rural line RL

The operations involved when the rural line RL is called will first be described. It may be assumed that the finder F has found a calling line and that the connector C has been operated in the usual manner in accordance with the number assigned to the rural line RL and has been conditioned to supply ringing current to signal a desired station on the rural line. It is to be noted that the C conductor of the rural line RL is normally connected by way of the contacts of auxiliary release relay 103 of the rural-line repeater RLR to the line circuit LC. Negative potential is normally impressed on the C conductor of the line RL by way of the cut-off relay 202 of the line circuit LC and also by way of the upper winding of cut-off relay 100 of the repeater RLR. This negative potential marks the rural line RL as idle in the bank of the connector C and the other similar connectors to which the line is multipled.

Now, when the rural line RL is seized by the connector C, by way of wipers 182, 185, and 183, ground potential is placed on the C conductor of the line RL through the C wiper 183 of the connector. When this occurs, cut-off relay 202 of the line circuit LC is operated, but without any particular function at this time. In addition, the cut-off relay 100 of the repeater RLR is operated through the resistor 117 and contacts of relay 102 to disconnect the talking conductors of the line RL from the repeater RLR. These two cut-off relays remain operated over the C conductor of the called line as long as the connection remains established, and cut-off relay 100 maintains the line RL cleared from the repeater RLR.

When the connection is broken down upon the restoration of the connector C, Fig. 2, the removal of ground potential from the C conductor of the called line results in the restoration of the cut-off relays 100 and 202, thereby returning the circuits associated with the called line to normal condition.

At this point it may be mentioned that the cut-off relay 100 is of the well-known three-pole construction exemplified in Patent 1,673,884, granted June 19, 1928, to Harold C. Pye. The lower winding of relay 100 is the one nearest the "heel" end of the relay, while the upper winding of the relay is the one nearest the armature of the relay.

Originating a call on the rural line RL

The operations involved in setting up a connection from the rural line RL to a desired other line will now be described. For this purpose it may be assumed that the subscriber at substation A2 on the rural line RL removes his receiver, thereby closing a bridge across the conductors of the line. In the exchange, the line RL extends by way of contacts of the normally restored cut-off relay 100 to the left-hand windings of the repeating coil 111 of the repeater RLR. The lower left-hand winding of the repeating coil RL extends to ground by way of the balancing retard coil 108, while the upper left-hand winding of the repeating coil 111 extends to the negative, ungrounded pole of the exchange battery by way of line relay 101, through contacts of cut-in relay 107 and the marginal test relay 105. The purpose of the marginal test relay 105 will be discussed subsequently.

Line relay 101 energizes over the calling line when the receiver is removed at substation A2. Upon energizing, it closes a circuit for release relay 102 at its inner armature, while at its lower armature it closes a circuit for repeating relay 110 through contacts of timer relay 109. Repeating relay 110 operates and closes a locking circuit for itself at its lower contacts by way of resistor 113, while at its inner upper armature it closes the circuit of timer relay 109. Timer relay 109 opens the initial circuit of repeating relay 110 at its lower armature, leaving repeating relay 110 operated through resistor 113 and the lower contacts of the relay. Timer relay 109 also closes a local circuit for its upper winding to render the relay slow releasing, and it closes a multiple circuit for release relay 102.

When release relay 102 operates, it prepares a priming circuit by way of resistor 112 for the line relay. Release relay 102 also places a second shunt around the lower winding of cut-off relay 100 and disconnects the upper winding of relay 100 to prevent operation of relay 100 when ground potential is retained on the C lead by the line circuit LC. Auxiliary release relay 103 now operates through contacts of release relay 102 and prepares a circuit for series relay 104 at its inner contacts, while at its upper contacts it removes the normally existing shunt from around the lower winding of cut-off relay 100 for a purpose to be later brought out, but at this time a new shunt has been closed around its lower winding at contacts of release relay 102.

Testing the resistance of the subscriber loop

One of the features of the repeater RLR is that it tests the calling loop to determine whether the resistance thereof is above or below a predetermined value, as indicated by the current flow over the loop and makes a compensation when the loop impedance is different from the predetermined value in one sense, i. e., higher or lower, and more particularly when the resistance thereof is below a minimum value, thereby equalizing the loop resistance somewhat, which arrangement narrows the range of impulsing conditions under which the repeater is required to operate. The current-flow or resistance test is made by the marginal test relay 105, which is normally in circuit in series with line relay 101. When the calling substation is one located relatively near the exchange, (A1 for example) the current flow is sufficient to operate test relay 105, but when the calling substation is near the end of the line, (AN for example) and the resistance is great as a result, the current flow is reduced sufficiently that test relay 105 does not operate. When test relay

105 does operate, it closes a circuit for cut-in relay 107, from ground at the inner contacts of release relay 102. Cut-in relay 107 thereupon operates and locks itself independent of the contacts of test relay 105. Cut-in relay 107 transfers the circuit of line relay 101 so that it includes the resistor 115 instead of the low resistance test relay 105, thereby increasing the loop resistance to compensate for the low loop resistance afforded by a substation relatively near the exchange.

Taking an idle link for use

As a further result of the energization of repeating relay 110 (responsive to the operation of line relay 101), the right-hand windings of repeating coil 111 are bridged across the conductors 141 and 142, leading to the line circuit LC. When this occurs, line relay 201 operates over conductors 141 and 142 and through resistor 116, as the upper winding of line relay 201 is connected between the negative pole of the exchange battery and conductor 141 by way of the upper contacts of cut-off relay 202, and the lower winding of the line relay is connected between the positive conductor 142 and ground, by way of the lower contacts of the cut-off relay. Upon energizing, line relay 201 disconnects the C conductor 143 from cut-off relay 202 and connects it to ground, thereby extending a guarding potential through the middle contacts of the operated release relay 102 to the C conductor associated with rural line RL and extending to the connector banks. The line RL is thereby guarded against seizure by the connectors.

As a further result of this operation, the line relay 201 connects the winding of cut-off relay 202 at its upper contacts through contacts of lockout relay 203 to the C lead extending to the banks of the finder F and the other finders which have access to the line circuit LC, thereby marking the line circuit LC as calling in the finder banks. The line relay 201 also extends ground potential by way of contacts of lockout relay 203 to start conductor 205, thereby causing a finder to be started in the usual manner.

It may be assumed that the finder F is the one which responds to the grounding of start conductor 205, in which case the wipers 51—53 are rotated in search of the calling line. When these wipers arrive on the contacts assigned to the line circuit LC, the rotation is stopped by the closure of a test circuit from ground through the C wiper 53 in series with cut-off relay 202, through the upper contacts of relay 201. Cut-off relay 202 locks itself to the associated C lead extending to the finder bank, at the same time disconnecting line relay 201 from in bridge of the talking conductors and closing a circuit for lockout relay 203. Lockout relay 203 now operates and remains operated as long as cut-off relay 202 is held operated. Line relay 201 now restores and extends the incoming C conductor 143 through contacts of the operated cut-off relay 202 to the now grounded C lead extending to the finder bank. Start conductor 205 becomes ungrounded upon the operation of lockout relay 203 and the restoration of start relay 201.

The connector C is now prepared in the usual manner to respond to the digits of the desired number, the operating circuit for the line relay (not shown) of the connector being over conductors 141 and 142 and through the upper contacts of repeater relay 110.

Repeating the digit impulses

When the calling subscriber turns his calling device in accordance with the first digit in the desired number, the calling loop is interrupted one or more times upon the return of the calling device to normal position. Each time the calling loop is interrupted, the resulting cessation of current flow results in the momentary restoration of the line relay 101, and line relay 101 controls repeating relay 110 to cause the interruptions to be repeated at the upper contacts of the repeating relay into the loop extending to the connector shown in Fig. 2, thereby securing the operation of the connector. Each reoperation of line relay 101 is assisted and hastened by the primary circuit closed through resistor 112.

The first time it is restored, the repeating relay 110 closes a circuit at its inner upper armature through contacts of the operated auxiliary relay 103 for the winding of slow-releasing series relay 104. Series relay 104 places ground potential on the lower talking conductor to remove the lower winding of the repeating coil and the retard coil 100 from circuit in order to lower the impedance of the line during dialling. Series relay 104 also closes a circuit from ground at the inner contacts of release relay 102 for by-pass relay 106. By-pass relay 106 thereupon operates and closes a locking circuit for itself to maintain it operated after the series relay has restored, and at its upper contacts it by-passes the marginal test relay 105 so as to remove this relay from circuit after the dialling has begun, whether the associated cut-in relay 107 has been operated or not.

Also, when relay 110 restores, it further disconnects itself from circuit, as timer relay 109 is in an operated condition and the repeating relay 110 has been maintained operated after the operation of relay 109 only through the resistor 113 and the lower contacts of the repeating relay. The circuit of the lower winding of timer relay 109 is opened each time repeating relay 110 restores, permitting relay 109 to restore at the end of the interval for which it is adjusted. Timer relay 109 is adjusted to insure at least a minimum circuit opening at the upper contacts of repeating relay 110.

When it finally restores, timer relay 109 again prepares a circuit for repeating relay 110 at its lower armature, thereby again placing relay 110 under the control of line relay 101. It is to be particularly noted that repeating relay 110 cannot reoperate before timer relay 109 restores, even though the line relay 101 reoperates almost immediately after it restores, as the repeating relay 110 disconnects itself as above pointed out when it restores.

With timer relay 109 restored, when line relay 101 reoperates (whichever occurs last), a circuit is closed through the lower contacts of relays 101 and 109 for reoperating repeating relay 110. Repeating relay 110 again locks itself through resistor 113; again closes the loop circuit extending to the connector C and it again opens the circuit of series relay 104 and recloses the circuit of timer relay 109. Timer relay 109 has the circuit of its upper winding normally open so as to avoid a retardation of the operating time of the relay, with the result that the relay reoperates very quickly. Upon the reoperation of timer relay 109, the initial circuit of repeating relay 110 is again opened at the lower contacts of the timer relay. The resistor 113 limits the current flow through relay 110 to a low value so that the relay restores quickly when the circuit of the repeating

relay is next opened by line relay. Resistor 114, of a relatively high value, reduces sparking at the lower contacts of relay 101.

By the foregoing arrangement, a minimum line opening is repeated to the connector upon each restoration of line relay 101, however, momentary, responsive to a break in the calling line at the calling device, which minimum opening is sufficient to secure satisfactory operation of an operating magnet. It is to be noted that timer relay 109 assists line relay 101 in maintaining slow acting release relay 102 operated throughout impulsing.

At the end of the series of impulses, line relay 101, repeating relay 110, and timer relay 109 all come to rest in an energized condition. Series relay 104 now restores as its circuit is maintained open at the contacts of repeating relay 110. Series relay 104 disconnects ground potential from the incoming positive conductor at its upper contacts so as to restore the normal balanced condition to the line, while at its inner contacts it opens the initial circuit of by-pass relay 106, but this relay remains operated at its locking circuit, closed through its inner contacts.

Relays 101, 110, 109, and 104 reoperate as described in the repeating of each subsequently dialled series of impulses.

When the connection has been set up by way of the finder F and the connector C to the desired called line, and the called subscriber has responded, conversation may take place in the usual manner.

When the calling subscriber replaces his receiver at the end of the conversation, relays 101, 110, and 109 restore, and repeating relay 110 opens the circuit extending to the impulsing apparatus of the connector C. With relays 101 and 109 restored, the holding circuit of release relay 102 is opened and release and auxiliary-release relays 102 and 103 restore successively. Series relay 104, which is operated incidentally through contacts of the restored repeating relay 110 and contacts of auxiliary relay 103, restores responsive to the restoration of relay 103. By-pass and cut-in relays 106 and 107 are unlocked at the inner contacts of release relay 102 when the circuit of auxiliary release relay 103 is opened.

Responsive to the opening of the control circuit at the upper contacts of repeating relay 110, the connector C and the finder F are permitted to clear out and ground potential is removed from the C lead of the line circuit LC, wherein cut-off relay 202 has been held operated over the C lead, and lock-out relay 203 has been maintained operated through contacts of cut-off relay 202. Cut-off relay 202 now restores and permits the slow acting lock-out relay 203 to restore a moment later, returning the line circuit LC to normal condition. The rural line RL is now marked idle in the connector bank upon the disconnection of ground potential from the C lead thereof and the reapplication of the negative potential to the C lead through the winding of cut-off relay 202 and the upper winding of cut-off relay 100, which is now reconnected to the C lead through contacts of the restored release relay 102. It may be pointed out that cut-off relay 100 normally does not operate when a connection is cleared out, as the ground potential is usually removed from the C lead at the finder connector link by the time release relay 102 restores and reconnects the upper winding of relay 100 to the C lead.

A reverting call

As explained in my prior Patent 1,999,788, hereinbefore referred to, when the subscriber on a rural line desires to converse with another subscriber on the same line he calls the directory number of the desired subscriber, with the result that the connector in use attempts to make connection with the calling line but finds it busy and impresses a busy tone signal on the calling line in the usual manner. Upon hearing this signal, the calling subscriber replaces his receiver, whereupon the connector (responsive to a circuit closed from the C wiper 183 of the connector, over the C lead of the called line, to the C wiper of the finder) signals the called subscriber by sending out his ringing code, following which the two subscribers remove their receivers and converse, while the exchange apparatus is released and the rural line is held guarded from the line circuit.

The way in which the rural line repeater RLR, Fig. 1, participates in the making of a reverting call as outlined above will now be pointed out more particularly.

The action resulting from the removal of the receiver at the calling station and from the dialling of the desired number are as described hereinbefore. It will be recalled that relays 101—103, 105, 109, and 110 are energized after the number has been called, while cut-in relay 107 has been energized or not depending upon the result of the resistance test made by the marginal test relay 105. It will be recalled also that the cut-off and lockout relays 202 and 203 are in energized condition in the line circuit LC, and that the C lead of the calling line is extended through the line circuit to the finder-connector link which finder connector link may be assumed to be the one illustrated in part. Now, when the wipers 182, 185, and 183 of the connector encounter the negative, positive, and C leads of the calling line, because of the grounded condition of the C lead, the C wiper 183 of the connector encounters ground potential and the connector therefore sends back the usual busy-tone signal to the calling line. The calling subscriber now replaces his receiver, whereupon relays 101, 110, 109, 102, and 103 restore in the order named, thereby clearing out the repeater RLR. At this time the connector C and the finder F do not restore responsive to the opening of the control circuit at the upper contacts of repeating relay 110; ground potential is therefore maintained on the C lead. At the time release relay 102 restores it reconnects the upper winding of the electro-polarized cut-off relay 100 to the C lead, through resistor 117, and it inserts the lower winding of relay 100 in series with the C lead, whereby current flows momentarily through the lower winding of the relay to enable the C conductor to be tested as to the direction of current-flow thereover. At this time, with ground potential applied to the C conductor by wiper 183 of the connector current flow over the C lead passes to the negative pole of the exchange battery through cut-off relay 202. The direction of current-flow through the lower winding of cut-off relay 100 is such that the energization of the relay responsive to current flow in the upper winding is not interfered with, and the cut-off relay 100 operates as before stated.

Auxiliary release relay 103 (as before noted) restores a moment later responsive to the opening of its circuit at contacts of release relay 102,

and recloses the shunt around the lower winding of relay 100, terminating the polarity test.

The negative and positive conductors of the called line are now cleared for the application of ringing current.

When the two subscribers remove their receivers after the ringing operation, they may converse with each other over the line RL. The finder-connector link is cleared out by the operation of cutting off the ringing current when the called subscriber replies, thereby removing ground potential from the C conductor of the line RL and the C conductor of the line circuit LC. When this occurs, cut-off relay 100 of the repeater RLR and cut off relay 202 of the line circuit LC both restore. The repeater RLR is thereby again connected to the line RL, and the line relay 201 is again bridged across the associated talking conductors of the line circuit. Relays 101, 110, and 109 reoperate in the repeater RLR, and at the same time release and auxiliary relays 102 and 103 operate responsive to the operation of line relay 101. Cut-off relay 100 is disconnected upon the operation of release relay 102.

In the line circuit LC, line relay 201 energizes responsive to the energization of repeating relay 110 of the repeater RLR. It grounds the C lead to mark the line busy to the connectors. At this time the slow-releasing lockout relay 203 is still in operated condition because it has been held operated by the now restored cut-off relay 202. Under this condition, when line relay 201 operates it closes a locking circuit for lock-out relay 203 to maintain it operated and thereby prevent the grounding of start conductor 205 at the same time. With lock-out relay 203 operated and cut-off relay 202 restored, the associated C conductor which extends to the bank of the finder F and the other finders is maintained disconnected from the winding of cut-off relay 202; therefore the line circuit LC is not marked calling in the bank of the finder F, whereby the finding of the line circuit LC by a finder started from some other line is prevented.

When the subscribers on the line RL have finished their conversation and replaced their receivers, the repeater RLR clears out as before pointed out, and line relay 201 in the line circuit LC restores when its circuit is opened at the contacts of repeating relay 110. Lock-out relay 203 restores when its circuit is opened by line relay 201. The circuit equipment associated with the line RL is thereby returned to its normal condition.

Outgoing toll calls

The way in which the rural-line repeater RLR functions in an outgoing toll call to avoid an inadvertent operation of cut-off relay 100 will now be explained.

It is a standard requirement in an automatic telephone system that, when connection is extended through the automatic switching apparatus to a toll switchboard, the connection established through the automatic switching apparatus be held subject to disconnection on the part of the operator at the toll switchboard, which arrangement permits the calling automatic subscriber to "flash" the operator at the toll switchboard by moving his switchhook in the usual manner. It was explained in my prior patent before referred to that the finder connector link is held when a connection is extended to a manual switchboard, and that the finder maintains ground potential on the C conductor of the calling line in order to maintain the cut-off relay operated in the line circuit associated with the calling line. Assume now that the illustrated link has been operated to extend a connection from the rural line RL by way of the connector C to a toll switchboard by way of trunk equipment as illustrated in the prior patent, ground potential is maintained on the C lead of the line circuit LC by the finder F under the control of a switchboard operator, and the connection is therefore not released in the event that the bridge is opened on the calling line. It may be assumed now that the calling subscriber desires to recall the toll operator and that he depresses his switchhook one or more times for this purpose. When the switchhook is depressed, the relays 101 and 110 restore to secure the signalling of the operator, responsive to the opening of the upper contacts of repeating relay 110. If the switchhook is depressed longer than momentarily, release relay 102 also restores, as in the case when a calling subscriber replaces his receiver at the end of conversation. When it restores, release relay 102 reconnects the upper winding of cut-off relay 100 to the associated C lead, as in a normal clearing out operation. At this time, relay 100 must not be permitted to operate, for it would disconnect the line from the repeater and thereby open the talking circuit if permitted to operate. The operation of relay 100 is prevented at this time by the flow of current in an opposing direction in the lower winding of the relay. The two windings of relay 100 are in series, with relay 102 restored and with the slow releasing auxiliary release relay 103 still operated, for ground potential is applied by the finder F to the C lead by way of the line circuit LC. The current-flow through the lower winding of relay 100 is in reverse direction with respect to the current that flows through this winding when the receiver is replaced to permit ringing in a reverting call, as at that time ground potential is supplied to the C lead of the line RL at the left-hand C terminal of repeater RLR by the connector instead of by way of the line circuit and a finder as it now is. The releasing time of auxiliary release relay 103 is adjusted so that relay 103 does not restore following the restoration of relay 102 in normal recalling, as the switchhook is then depressed each time for only an instant.

When the hookswitch is again permitted to rise and the line circuit is again closed, relays 101, 110, and 109 reoperate, and relay 102 reoperates responsive to the operation of relay 101, again removing the lower winding of relay 100 from the circuit and disconnecting the upper winding of the relay. The flashing signal to the operator is terminated at the upper contacts of the repeating relay 110.

In the event that the calling subscriber holds the hook switch down too long or replaces his receiver during a call to the toll switchboard, the restoration of auxiliary release relay 103 recloses the shunt around the lower winding of electro-polarized relay 100, permitting relay 100 to operate responsive to current flow in its upper winding.

It may be here pointed out that release relay 102 is adjusted to restore in about the same time required for the release relay of a finder-connector link to restore so as to reconnect cut-off relay 100 in a reverting call and permit it to reoperate and clear the line by the time the ring-back operation has started responsive to the restoration of the release relay in the link.

In the event that it is desired that cut-off relay 100 be not permitted to operate even though the calling subscriber replaces his receiver in a call to the toll switchboard, the free terminal of the winding of auxiliary release relay 103 may be disconnected from the armature of release relay 102 and connected to the associated C lead, in which case auxiliary release relay 103 does not fall back responsive to the restoration of release relay 102, but remains operated as long as ground potential is maintained on the C lead, thereby maintaining the lower winding of relay 100 in circuit to prevent operation of the cut-off relay. With this arrangement, a subscriber who has called the toll operator will not become disconnected during flashing in the event that he inadvertently holds the switchhook down longer than is normally intended.

What is claimed is:

1. In an automatic telephone system, a subscriber line, calling terminals individual to said line, an impulse repeater inserted between said line and said calling terminals, automatic switching apparatus for extending connections from subscriber lines, switching means for connecting said automatic switching apparatus with the said line by way of the calling terminals thereof, called terminals individual to said line and connected thereto between the line and the repeater, said automatic switching apparatus being operative to extend connection to said line by way of said called terminals, a cut-off relay associated with the called terminals and means for operating it to disconnect the line from the said repeater when it is called, means for guarding the line from seizure by way of said called terminals when a call is originated thereover, and means for preventing the operation of the said cut-off relay when a call is originated over the line and the line is guarded from seizure through the called terminals thereof.

2. In an automatic telephone system wherein the operation of the automatic switches in testing lines is controlled over a third or control conductor according to potentials impressed thereon, a subscriber line having individual called terminals and individual calling terminals, the said called terminals being associated directly with the line, an impulse repeater inserted in the line between the called terminals and the calling terminals of the line, a control conductor included in the repeater, and means effective when a call is originated on said line for joining the control terminal in the group of calling terminals to the control terminal in the group of called terminals by way of said control conductor.

3. In an automatic telephone system, a subscriber line having individual called terminals and calling terminals, the said called terminals being directly associated with the line, line equipment associated with the calling terminals, an impulse repeater inserted in the line between the called terminals and the calling terminals thereof, means associated with said called terminals for disconnecting said line from said repeater when said line is called, and a control conductor extending from the line circuit associated with the calling terminals through said repeater to the called terminals of the line to carry guarding potential between the calling and called terminals of the line.

4. In an automatic telephone system, a subscriber line having called and calling terminals, an impulse repeater interposed between the called and calling terminals of the line to repeat switch-operating impulses, a cut-off relay controllable from the called terminals of the line to disconnect the impulse repeater when the line is called, means effective when a call is originated over the line for disconnecting the cut-off relay to avoid its operation when guarding potential is placed on the called terminals of the line, and means effective when a connection has been set up which is held from the called end thereof for preventing operation of the cut-off relay when it is reconnected during switchhook signalling periods.

5. In an automatic telephone system, a subscriber line having called terminals connected thereto and calling terminals associated therewith, an impulse repeater interposed in the said line between the called and calling terminals thereof to repeat switch operating impulses in calls originating on the same line, a cut-off relay operable over the usual control conductor associated with the said terminals of the line to disconnect the repeater when the line is called, circuit arrangements effective in one type of call which can be set up from said line for enabling the calling subscriber to signal over the established connection by operating his switchhook, a second polarizing winding included in said cut-off relay to prevent operation thereof when energized, and means for inserting said polarizing winding in circuit during the switchhook signalling operation to prevent operation of the said cut-off relay.

6. In an impulse repeater, a line relay, a repeating relay, and a timer relay, means for energizing the repeating relay depending upon the energization of the line relay, means for energizing the timing relay dependent upon the energization of the repeating relay, said timing relay being slow releasing to insure the repeating of an impulse of minimum length, and circuit arrangements controlled jointly by the timer relay and said repeating relay for preventing the re-operation of the repeating relay following the restoration thereof until the timer relay has restored, and impulse repeating contacts on said repeating relay to repeat open-circuit impulses received by said line relay.

7. In combination, an impulse repeater including a line relay having contacts for repeating received impulses, means for energizing said line relay and for delivering impulses to it over circuits of various resistances, a marginal test relay in circuit with said line relay operable when the circuit of the line relay is closed over a circuit of relatively low resistance, and means associated with said marginal test relay effective when the test relay operates to insert a resistance element in the circuit of the line relay to compensate for the relatively low resistance of the circuit over which it is taken for use.

8. In combination, an impulse repeater including a line relay having contacts for repeating received impulses, means for energizing said line relay and for delivering impulses to it over circuits of various resistances, a marginal test relay in circuit with said line relay operable when the circuit of the line relay is closed over a circuit of relatively low resistance, and means associated with said marginal test relay effective when the test relay operates to adapt the repeater to repeat impulses received over the low resistance circuit.

9. In combination, an impulse repeater includ-

ing a line relay comprising means for repeating received impulses, circuits of various impedances adapted to deliver control impulses to said line relay, a marginal test relay operable when the impedance of the circuit to said line relay is different, in one sense, from a predetermined value, and means associated with said marginal test relay and effective when the test relay operates for adapting the repeater to repeat impulses received over circuits having impedances different, in said one sense, from said predetermined value.

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