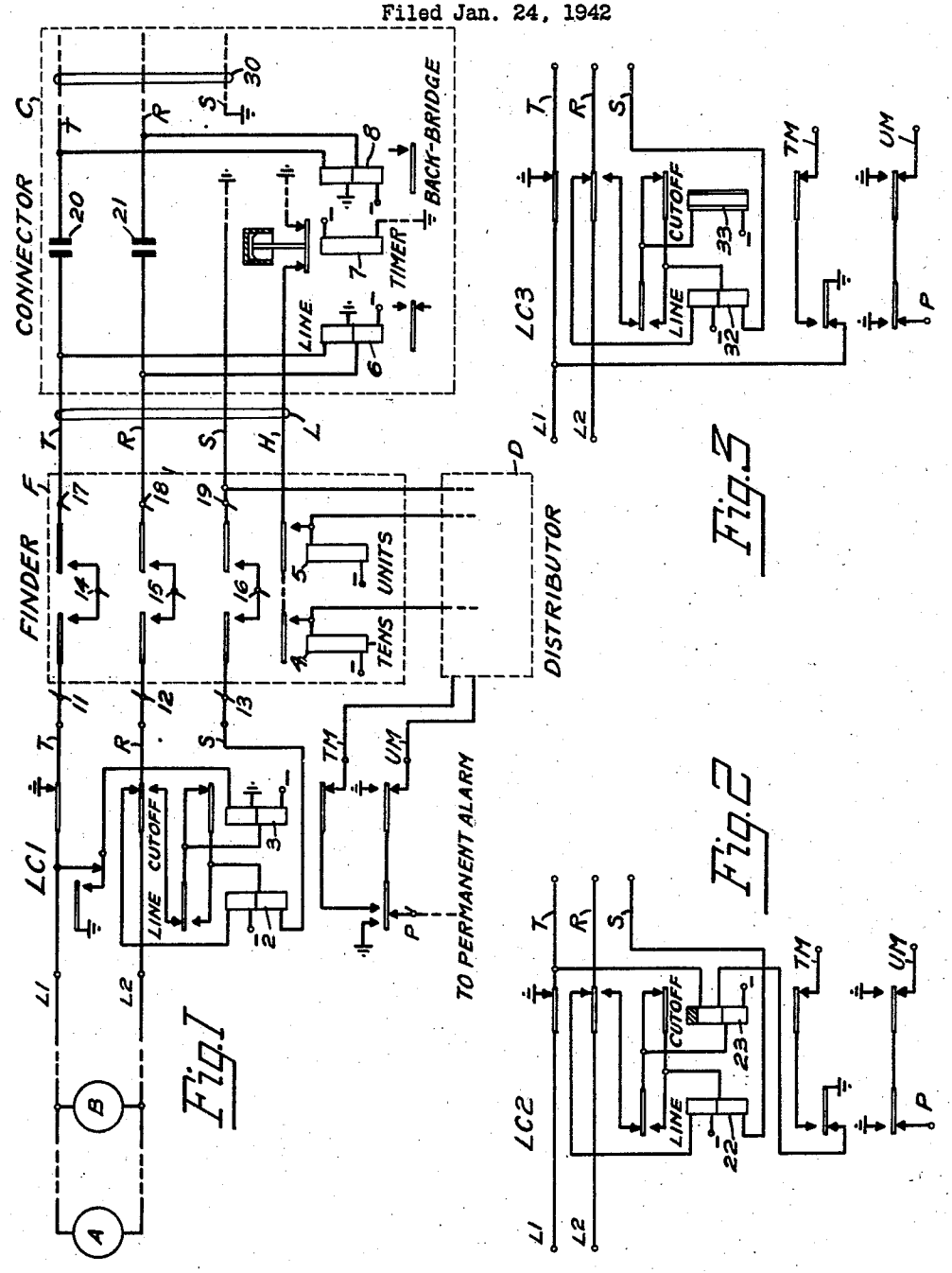
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LOCKOUT TELEPHONE LINE CIRCUIT

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## LOCKOUT TELEPHONE LINE CIRCUIT

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This invention relates to lockout telephone line circuits. Its object is the provision of a new and improved line circuit in which the number of relays ordinarily required is reduced without a corresponding reduction in the functions accomplished by the line circuit.

A specific object is the production of a lockout telephone line circuit in which the cutoff relay serves also as a lockout relay to lock the associated line out of normal service under certain conditions of operation.

A further object is the production of a lockout telephone line circuit including a line relay and a cutoff relay which cooperate to perform the functions normally requiring the use of a line relay, a cutoff relay, and a lockout relay, it being a specific object to provide a line circuit of this character in which the line and cutoff relays are each of simple construction, requiring no special mechanical or marginal provisions, as, for example, relays with mechanically interlocked spring combinations or relays of the "two-step" variety.

### General Description

In many automatic telephone exchange systems, some or all of the subscriber lines are each provided with a three-relay lockout line circuit, the relays of the line circuit including a line relay, a cutoff relay, and a lockout relay. The line and cutoff relays are usually operable separately to perform their line and cutoff functions, while the lockout relay is arranged to be operated in combination with the line relay, with the cutoff relay restored, to lock the associated line out of service so long as there is either a trouble condition thereon, or a reverting-call conversation is taking place thereover. The addition of the lockout relay to each line circuit greatly increases the cost per line of the exchange equipment, as it adds a relay to each individual line circuit to which the lockout feature is applied.

Numerous attempts have been made heretofore to provide a two-relay lockout line circuit, but all such prior attempts have been more or less unsuccessful, so far as applicant is aware, for the reason that each of them has required that at least one of the relays be of special mechanical or marginal construction to provide what is referred to as two-step operation (partial operation at one time and full operation at another time), or a mechanical interlocking arrangement has been required between the armature structure of one of the relays and some of the contacts of the other relay, which special construction is more or less expensive to manufacture and often requires considerable maintenance adjustment.

With the applicant's improved arrangement, the two relays provided (the line relay and the cutoff relay) are each of simple construction. The line relay operates normally as a line relay when a call is originated over the associated line, and is held operated in the sleeve circuit when the cutoff relay is operated over a connection extended from the line, the operation of the cutoff relay serving to terminate the calling condition. The line relay is arranged to restore quickly when the sleeve circuit is opened, but the cutoff relay is arranged to remain operated for a slight interval. Upon the restoration of the line relay, the cutoff relay is connected to the line, and remains operated thereover to lock the associated line out of service if a bridged or grounded condition thereof obtains. Ordinarily, the associated line is clear when the sleeve circuit is opened, and the restoration of the line relay is followed by the restoration of the cutoff relay to return the line circuit to normal condition.

When a terminating connection is extended to the associated line, both relays of the line circuit operate, the cutoff relay at the time serving to clear the line and to prevent the operation of the line relay from bringing the line circuit into calling condition. The operation of the line relay at this time prevents the operation of the cutoff relay from bringing the line circuit into lockout condition.

### *The drawing*

Referring now to the accommodating drawing, comprising Figs. 1 to 3, it shows sufficient of the apparatus employed in a telephone system embodying the features of the invention to enable the invention to be understood:

Fig. 1 shows the preferred embodiment of the invention applied to a line circuit associated with a party line over which reverting calls may be made, together with a diagrammatic showing of a portion of the common equipment of the automatic telephone exchange;

Fig. 2 shows a desirable modification of the line circuit of Fig. 1;

Fig. 3 shows a simplified embodiment of the line circuit, especially adapted for use where trouble-lockout operation is desired, but no reverting calls are to be provided for.

Referring now particularly to Fig. 1, the line circuit LC1 is individual to the associated party

line having party-line substations A and B thereon, as well as many other party-line substations as may be desired. The line circuit LC1 comprises line relay 2 and cutoff relay 3. These two relays coact to place the line circuit into any one of the four following conditions:

1. Both relays normal—normal condition;
2. Relay 2 operated alone—calling condition;
3. Relay 3 operated alone—lockout condition;
4. Both relays operated—connected condition.

The tip, ring, and sleeve conductors T, R, and S of the line circuit LC1 extend to terminals 11, 12, and 13 respectively, whereat they multiple into a number of finders such as F, and into a number of connectors such as C.

The finder F is illustrated as of the 100-line relay type, comprising ten tens relays, such as 4, and ten units relays, such as 5, through the medium of which the tip, ring, and sleeve conductors T, R, and S of the link L may be connected respectively to the tip, ring, and sleeve conductors of any one of a hundred line circuits, such as LC1. The tens relay 4 may have nine other sets of contacts similar to the tip, ring, and sleeve contact pairs shown, each such set of contacts being associated with a different line. The conductors extending between the contacts of the tens and units relays 4 and 5 are multipled at points 14, 15, and 16 to the similar contacts of the other tens relays, while the conductors T, R, and S in the link L are multipled at contacts 17, 18, and 19 to the contacts of the other units relays. This arrangement, of course, is well known, and the showing of the finder F has been greatly abbreviated as the finder forms no part of the invention.

The connector C is linked to the finder F through the conductors T, R, S, and H of the link L and is arranged to be operated under the control of a calling device on the calling line to extend the connection to any desired called line by suitably extending the conductors T, R, and S of the group 30. As in the case of the finder F, only a fragmentary portion of the connector C has been shown. This portion includes line relay 6, slow-acting timer relay 7, back-bridge relay 8, and the usual talking condensers 20 and 21.

Fig. 1 indicates also the distributor D which has access to the finder F and to the finders of the other finder-connector links of the switchboard. The distributor D is arranged to be controlled from any calling line circuit to select an idle finder and to operate the tens and units relays thereof to extend the connections from the calling line to the associated connector.

## Detailed Description

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

### *An originating call*

Let is be assumed that the subscriber at substation A, for example, on the line associated with line circuit LC1, desiring to make a call to some other line, removes his receiver at a time when the associated line and line circuit LC1 are in the illustrated normal condition.

When the receiver (not shown) is removed at substation A, the associated line conductors, connected to terminals L1 and L2 of the line circuit LC1, are thereby bridged in the usual manner. A circuit is thereby closed over the two conductors of the calling line in series, from ground at the upper contacts of cutoff relay 3, and through the middle upper armature and back contact of cutoff relay 3 for the upper winding of line relay 2. Line relay 2 thereupon operates as a result of the energization of its upper winding. At its inner upper and upper armatures, line relay 2 opens circuit connections associated with the windings of cutoff relay 3 to prevent these windings from being connected to the line conductors upon the operation of cutoff relay 3, which is to occur subsequently. At the front contact of its inner uper armature, line relay 2 shunts the associated contacts of cutoff relay 3 to prevent cutoff relay 3 from opening the associated sleeve connection when it subsequently operates.

At its lower armature and front contacts, line relay 2 applies ground potential, through contacts of cutoff relay 3, to the associated tens and units conductors TM and UM, leading to the distributor D. The grounding of these two conductors constitutes the calling condition of the line circuit LC1, causing the distributor D (which contains the usual control and distributing relays) to select an idle finder and to operate a tens relay and a units relay therein to cause such idle finder to make connection with the calling-line circuit. In this case, assuming the finder F to be the one selected, the distributor D responds to the grounding of the tens and units conductors TM and UM of the line circuit LC1 by closing temporary circuits for the tens and units relays 4 and 5 respectively of the finder F. Upon operating, each of the relays 4 and 5 prepares a locking circuit for itself over the hold conductor H in the link L, which is subsequently completed to ground in the connector C through contacts of timer relay 7, following which the temporary operating circuits of relays 4 and 5 are opened by the distributor D.

As a further result of the operation of relays 4 and 5, the tip, ring, and sleeve terminals T, R, and S of the line circuit LC1 are extended, through the contacts of relays 4 and 5, the tip, ring, and sleeve conductors T, R, and S of the link L to the connector C.

In the connector C, the lower winding of line relay 6 now operates in parallel with the upper winding of line relay 2 of the line circuit LC1, as a result of which the associated release relay (not shown) operates to ground hold conductor H to lock relays 4 and 5 operated, and to apply ground potential to the sleeve conductor S of the link L, thereby extending ground potential through contacts of relays 5 and 4 to the sleeve terminals S of the line circuit LC1.

With ground potential on the sleeve terminal S of the line circuit LC1, an energizing circuit is closed, through the inner upper contacts of the operated line relay 2 (in parallel with the associated contacts of the unoperated relay 3) for the lower windings of relays 2 and 3 in series. Relay 2 being already operated, the energization of its lower winding is of no immediate effect. Relay 3 operates as a result of the energization of its lower winding. At its inner lower contacts, relay 3 opens a point in the sleeve circuit, leaving the sleeve circuit intact, however, through the lower contacts of the operated line relay 2. At its inner lower and lower armatures, cutoff relay 3 disconnects ground potential from terminals TM and UM, thereby terminating the calling condition of the line circuit LC1.

At its upper and inner upper armatures, cutoff relay 3 disconnects ground potential and the

upper winding of line relay 2 respectively from the line conductors connected to terminals L1 and L2, thereby clearing the calling line for dialing and talking purposes, line relay 2 being held in operated condition, through its own inner upper contacts, over the sleeve circuit in series with the lower winding of cutoff relay 3. The line circuit is now in "connected" condition, with both relays operated over the sleeve circuit.

Following the described operation of cutoff relay 3, the two windings of line relay 6 of the connector C are energized in series over the calling line.

The calling subscriber may now dial the digits in the desired number, resulting in conductors 30 of the connector C being extended to the corresponding conductors of the called line.

When the calling subscriber at substation A subsequently replaces his receiver, the resulting restoration of line relay 6 of connector C causes ground potential to be removed from the sleeve and hold conductors S and H of the link L. Relays 4 and 5 of the finder F are unlocked and restored responsive to the removal of ground potential from hold conductor H, while the sleeve circuit through the lower windings of relays 2 and 3 is opened as a result of the removal of ground potential from conductor S of the link L. Relays 2 and 3 thereupon restore, returning the line circuit LC1 to its illustrated normal condition.

*A terminating call*

When the line associated with the line circuit LC1 is called, by the connection of the tip, ring, and sleeve conductors of the calling connector (such as those at 30 of the connector C) respectively to multiples of terminals 11, 12, and 13, the resulting extension of ground potential to the sleeve terminals S of the line circuit LC1 results in the closure of an operating circuit for the lower windings of relays 2 and 3 in series, through the inner upper contacts of cutoff relay 3. Relay 2 operates slightly ahead of relay 3, for relay 3 is retarded because the upper winding thereof is normally short-circuited (ground to ground) through the upper contacts of relays 2 and 3. Upon operating, relay 2 at the front contacts of its inner upper armature shunts the inner upper contacts of relay 3 to prevent a disruption of the sleeve circuit.

The operation of relay 3 closely follows the operation of relay 2. With both relays operated, the associated line is cleared for talking purposes, the line circuit then being in the same connected condition as when found by the finder F as a result of a call originated on the line, hereinbefore described.

The line circuit LC1 clears out and returns to normal condition as hereinbefore described when the call has been answered and the parties thereto have replaced their receivers.

*Trouble lockout*

Let it be assumed now that a trouble condition arises on the line associated with the line circuit LC1, such as the accidental upsetting of a telephone to cause the line to be bridged, or an accidental shorted condition of the conductors thereof. In this event, line relay 2 of the line circuit LC1 is operated through the medium of its upper winding as hereinbefore described to place the line circuit in calling condition.

It may be assumed that the resulting grounding of the tens-mark and units-mark terminals TM and UM of LC1 causes the distributor D to select and operate the finder F as previously described. In this event, the grounding of the extended sleeve conductor in the connector C results in the operation of cutoff relay 3 through its lower winding, line relay 2 being held operated by its lower winding, in series with the lower winding of relay 3 after the upper winding of the line relay is disconnected by cutoff relay 3.

In the connector C, by well-known circuit arrangements not illustrated, the operation of the line relay 6, which now occurs as in a regular call, results in a closure of an energizing circuit for timer relay 7. This relay may be rendered slow operating by any desired construction, as by the illustrated dash-pot method. The circuit of timer relay 7 is arranged to be opened when the dialing of the desired number has been accomplished, which ordinarily occurs before timer relay 7 has had time to operate.

In the present assumed example, the line circuit LC1 operated as a result of trouble on the line, rather than as a result of a call. In this event, no dialing occurs, and timer relay 7 is not disconnected, but is allowed to operate fully. Upon operating fully, slow-acting timer relay 7 opens the associated hold lead H, thereby unlocking and restoring the relays 4 and 5 of the finder F. By this operation, the tip, ring, and sleeve conductors of the extended connection are opened, permitting the connector C to clear out. In the line circuit LC1, line relay 2 immediately restores responsive to the opening of the sleeve circuit. The restoration of relay 2 occurs before relay 3 restores, because line relay 2, at its upper armature, maintains the free terminal of the upper winding of cutoff relay 3 grounded as long as the line relay is operated, thereby short-circuiting such winding and rendering relay 3 slow restoring.

With line relay 2 in its illustrated restored condition, and with cutoff relay 3 in operated condition, the two windings of relay 3 are connected respectively to the two talking conductors of the associated line. Since the line has a trouble condition thereon (as assumed), the two windings of cutoff relay 3 are now energized in series over the associated line by way of the following circuit: from ground, through the upper winding of cutoff relay 3, upper contacts of the restored line relay 2, terminal L1, the upper conductor of the associated line, through the trouble point to the lower line conductor, terminal L2, middle upper armature and front contact of relay 3, back contact of the inner upper armature of the restored line relay 2 and said armature, and thence to battery through the lower winding of cutoff relay 3. Cutoff relay 3 is thus maintained operated over the associated line as long as the trouble condition endures.

With line relay 2 disconnected and restored, the trouble condition on the associated line cannot cause a calling condition to be impressed on the line circuit LC1, whereby all of the common exchange equipment remains free for other use. During this time, the line circuit LC1 is guarded from seizure by way of a connector such as C, for the sleeve lead is maintained open at the inner upper contacts of the operated cutoff relay 3. The connectors such as C are commonly so arranged that they return a busy signal and refuse a connection to any called line whose sleeve conductor is open.

Additionally, with line relay 2 restored and cutoff relay 3 operated, the operated lower ar-

mature of cutoff relay 3 extends ground potential through the closed lower contacts of line relay 2 to the associated permanent-alarm conductor illustrated as connected to terminal P. This conductor may be connected in common to the similar terminals of a number of line circuits and may extend to a slow-acting permanent-alarm device, arranged to sound an alarm after half an hour, for example. Since the permanent-alarm arrangement external to the line circuit LC1 is well known and forms no part of the invention, it has not been further illustrated.

When the trouble condition on the line associated with the line circuit LC1 has been cleared, the circuit through the two windings of cutoff relay 3 in series is thereby opened, whereupon cutoff relay 3 restores, thereby returning the line circuit LC1 to its illustrated normal condition.

A result similar to that hereinbefore described occurs when the trouble condition on the line associated with the line circuit LC1 constitutes a ground connection to the lower or ring conductor thereof. In this event, the upper winding of line relay 2 operates over the lower conductor of the associated line to ground at the trouble point. Later, when the line circuit LC1 is brought into lockout condition by the subsequent restoration of line relay 2 with cut off relay 3 operated, the lower winding of cutoff relay 3 is maintained operated over the lower line conductor to ground at the trouble point, the upper winding of cutoff relay 3 then being not effective.

*Reverting-call lockout*

It is assumed that the connector C is provided with the usual arrangement to enable one party-line subscriber to call another subscriber on the same line, and is arranged to clear itself out when the reverting call is answered. Under this condition, the line circuit LC1 operates to lock the associated line out of normal service during the time the reverting-call conversation is occurring, thereby avoiding the tying up of common switching equipment while two subscribers are conversing on the same line.

Let it be assumed now that the subscriber at substation A has removed his receiver, resulting in operations as previously described to cause the connection to be extended by way of the finder F to the connector C, line and cutoff relays 2 and 3 in the line circuit LC1 being both in an operated condition following the extension of the connection.

Let it be assumed further that the subscriber at substation A desires to call the subscriber at substation B on the same line. Under this condition, when the digits in the desired number have been dialed, the connector C extends the tip, ring, and sleeve conductor T, R, and S of the group 30 to the corresponding conductors of the line circuit LC1, through multiples of terminals 11, 12, and 13 respectively.

Since the called line is also the calling line, such line tests busy, and the connector C returns the usual busy signal to the calling line. Upon hearing this busy signal, the subscriber at the calling substation A, pursuant to instructions, replaces his receiver. When this occurs, the resulting restoration of line relay 6 in the connector C is arranged to cause the removal of ground potential locally from the conductor S of the link L, pursuant to the making of the usual reverting-call test. Since the called line is also the calling line, the ground potential extended forward over conductor S of the group 30 to the sleeve lead of the called line reaches the sleeve conductor S in the group L through contacts of relays 4 and 5 of the finder F, thereby conditioning the connector C for the making of the reverting call. This extended ground potential maintains the sleeve terminal S of the line circuit LC1 grounded, thereby maintaining relays 2 and 3 in the line circuit LC1 operated.

In the connector C, one result of the successful reverting-call test is the removal thereupon of ground potential from hold conductor H of the link L, causing relays 4 and 5 of the finder F to restore, clearing out the finder. The connector C thereupon applies ringing current in the usual manner to the conductors of the called line (also the calling line), thereby signalling the subscriber at the called substation B.

When the subscriber at B answers the call (by removing his receiver), the line is again bridged, causing the connector C to terminate the ringing operation. With the connector C having been placed in reverting-call condition, the connector thereupon clears out in the usual manner, disconnecting its conductors T, R, and S in group 30 from the corresponding conductors of the line circuit LC1. When this occurs, the resulting removal of ground potential from the sleeve terminal S of the line circuit LC1 opens the sleeve circuit through the lower windings of relays 2 and 3. Relay 2 thereupon restores and connects the upper and lower windings of cutoff relay 3 to the associated line over the circuit hereinbefore traced. Since the associated line has been bridged by the previously described removal of the receiver at substation B, cutoff relay 3 remains operated over the associated line to supply talking current to substations A and B.

With line relay 2 restored, and with cutoff relay 3 operated, the sleeve lead is maintained open in the line circuit LC1 to guard the reverting-call conversation against intrusion as previously discussed in connection with the trouble lockout operation.

When the subscriber at substation A, having allowed time for the subscriber at substation B to answer, again removes his receiver, the subscribers at substations A and B may converse with each other as desired, talking current being supplied to their substation instruments through the upper and lower windings of the operated cutoff relay 3.

When the reverting-call conversation has been terminated, and the subscribers at substations A and B have both replaced their receivers, cutoff relay 3 restores to return the line circuit LC1 to its illustrated normal condition.

*Lockout following receipt of a normal call*

Another situation in which the line circuit LC1 is brought into lockout condition occurs when the associated line has been called from another line (relays 2 and 3 having operated over the sleeve circuit as hereinbefore described). In this case, if the called subscriber (at substation A, for example) is slow about replacing his receiver, the clearing out of the connection responsive to the receiver being replaced at the calling substation, and the resulting removal of the ground potential from the sleeve terminal S of the line circuit LC1, permits line relay 2 to restore and connect the upper and lower windings of cutoff relay 3 to the associated line to hold the cutoff relay operated through the called substation A, at which the receiver has not yet been replaced.

Cutoff relay 3 remains operated over the associated line to maintain the lockout condition until the receiver is subsequently replaced at substation A, whereupon cutoff relay 3 restores to return the line circuit LC1 to normal condition.

*Line circuit LC2*

The line circuit LC2 of Fig. 2 is generally similar to the line circuit LC1 of Fig. 1, in that it has line and cutoff relays 22 and 23 corresponding respectively in function to relays 2 and 3 of the line circuit LC1. Additionally, the line circuit LC2 has line terminals L1 and L2; switchboard-multiple terminals T, R, and S; tens-mark and units-mark terminals TM and UM; a permanent alarm terminal P, all corresponding respectively to the similarly designated terminals of the line circuit LC1.

The principal difference between the line circuit LC2 and line circuit LC1 is that cutoff relay 23 of line circuit LC2 is provided with a conducting collar around one end of its core as is intended to be indicated by the shaded upper portion of relay 23. The relay 23 is thereby rendered slow-restoring, avoiding the necessity of short-circuiting one of the windings of relay 23 by contacts of relay 22, as described in connection with relays 3 and 2 of Fig. 1. A simpler contact arrangement on line relay 2 is thereby made possible. The make-before-break combination of relay 2 (the upper armature thereof and the associated normally closed pair of contacts) is replaced in Fig. 2 by a back contact on the inner lower armature of relay 22, thus reducing the number of line-relay contact springs from ten to nine.

When a call is originated on the subscriber line associated with the line circuit LC2 and connected to terminals L1 and L2 thereof, the ground potential normally maintained on terminal L1 through the upper contacts of cutoff relay 23 is returned over the calling line to terminal L2, reaching the upper winding of line relay 22 through the middle upper armature of cutoff relay 23 and its back contact. Line relay 22 thereupon operates responsive to the resulting energization of its upper winding over the associated calling line. At this time, it operates to extend ground potential through contacts of the cutoff relay 23 to terminals TM and UM. The upper winding of cutoff relay 23 (normally short-circuited, ground to ground, through contacts of relays 22 and 23), is ungrounded at the back contact of the middle lower armature of relay 22 to prepare for clearing the line when cutoff relay 23 operates.

When the calling line is found (by a finder such as F) and ground potential is applied to the sleeve terminal S of the line circuit LC2, the lower windings of relays 22 and 23 are energized in series, line relay 22 remaining operated and cutoff relay 23 operating. Upon the operation of cutoff relay 23, the calling line is cleared at the upper and inner upper armatures thereof, while at the middle lower and lower armatures of relay 23 terminals TM and UM are ungrounded to terminate the calling condition of the line circuit. Relays 22 and 23 remain operated by their lower windings, through the inner upper contacts of relay 22 after the corresponding contacts of relay 23 have opened.

If the call being made is a normal call, the line circuit LC2 clears out at the completion thereof when ground potential is removed from sleeve terminal S responsive to the receiver being replaced on the calling line. At this time, line relay 22 restores immediately, while cutoff relay 23 (being retarded somewhat by the conducting collar around the upper portion of its core) restores a moment later, to return the line circuit to its normal condition.

When a connection is extended to the associated line as a called line, through the terminals T, R, and S of the line circuit LC2, the extension of ground potential to the sleeve terminal S results in the closure of a circuit, through the inner upper contacts of cutoff relay 23, for the lower windings of relays 22 and 23 in series. Line relay 22 operates slightly ahead of cutoff relay 23 to complete the sleeve circuit at the inner upper contacts of line relay 22 before it is opened at the corresponding contacts of relay 23, for the operation of relay 23 is retarded both by the indicated copper collar and by the short-circuited condition of relay 23 prior to the operation of relay 22.

When relay 23 operates, the associated line is cleared for talking and ringing purposes.

Considering now the lockout operation of the line circuit LC2 (which may occur under any one of the conditions explained in connection with Fig. 1), when line relay 22 restores ahead of cutoff relay 23 at a time when the associated line is bridged, cutoff relay 23 does not restore but is held operated over the following circuit: from ground, through the inner lower armature of relay 22 and its back contact, upper winding of relay 23, line terminal L1, the corresponding conductor of the associated line, the bridge across the line conductors, the lower conductor of the line, line terminal L2, middle upper armature of cutoff relay 23 and its front contact, back contact of the upper armature of line relay 22 and the said armature, and through the lower winding of cutoff relay 23, to battery.

During the continuance of the lockout condition, terminals TM and UM are maintained ungrounded, while terminal P is maintained grounded through the operated lower armature of relay 23 and the restored lower armature of relay 22, pursuant to the eventual giving of a permanent alarm if the lockout condition persists, as discussed in connection with Fig. 1.

*The line circuit of Fig. 3*

The line circuit LC3 of Fig. 3 is a simplified modification of the line circuit LC2 of Fig. 2. This simplified circuit arrangement is suitable for use wherever lockout operation is required, provided no reverting calls are to be made.

Relays 32 and 33 correspond respectively to relays 22 and 23, but the upper winding of relay 33 has been eliminated, and the back contact of the middle lower armature of line relay 32 connected directly to the upper line conductor. The operation in Fig. 3 is similar to that in Fig. 2.

As indicated, cutoff relay 33 may be a sleeved relay; that is, a relay whose core is surrounded by a conducting sleeve, the winding being placed over this sleeve. The relay is thereby rendered slow-acting to permit relay 32 to restore first when the sleeve circuit is opened, and to operate first when the associated line is called. This sleeve arrangement for retarding the cutoff relay is not permissible in line circuit LC2 of Fig. 2, which is employed for supplying talking current during reverting-call conversations, as the conducting sleeve underlying the battery feed coils largely destroys the impedance of these coils to voice currents, greatly lowering the talking efficiency of the line. It is particularly for this

reason that the slow-restoring cutoff relay 23 of Fig. 2 is provided with a conducting collar lying to one side of the winding zone (at the end of the relay core, for example), as the impedance of the portion of the relay core encircled by the windings is not then materially impaired.

I claim:

1. In a lockout telephone line circuit, a line relay and a cutoff relay individual to a line, said line having a switchboard multiple including a sleeve conductor, a sleeve circuit including said conductor and an energizing winding on each of said relays, said circuit being effective to operatively energize both of said relays when connection is made with said line by way of said multiple either as a called line or as a calling line, said line relay being normally operable to indicate a calling condition on the associated line, said cutoff relay being effective, when operated, to disassociate the line relay from the line and to disable the operated line relay from indicating a calling condition, said cutoff relay being further effective, when operated, to prepare a holding circuit for itself over the associated line, means including a short-circuited second winding on the cutoff relay for insuring that the line relay restores first when a connection made to the line is cleared out, said line relay being effective, when restored, to complete said prepared holding circuit for the cutoff relay over the associated line subject to the line being in a condition other than its normal idle condition.

2. In a lockout telephone line circuit, a line relay and a cutoff relay individual to a line, said line having a switchboard multiple including a sleeve conductor, a sleeve circuit including said conductor and an energizing winding on each of said relays, said circuit being effective to operatively energize both of said relays when connection is made with said line by way of said multiple either as a called line or as a calling line, said line relay being normally operable to indicate a calling condition on the associated line, said cutoff relay being effective, when operated, to disassociate the line relay from the line and to disable the operated line relay from indicating a calling condition, said cutoff relay being further effective, when operated, to prepare a holding circuit for itself over the associated line, means insuring that the line relay restores first when a connection made to the line is cleared out, said line relay being effective, when restored, to complete said prepared holding circuit for the cutoff relay over the associated line subject to the line being in a condition other than its normal idle condition, means controlled jointly by said relays for opening a point in said sleeve circuit to guard the line against seizure while said cutoff relay is being held operated thereover.

3. In a lockout telephone line circuit, a line relay and a cutoff relay individual to a line, said line having a switchboard multiple including a sleeve conductor, a sleeve circuit including said conductor and an energizing winding on each of said relays, said circuit being effective to operatively energize both of said relays when connection is made with said line by way of said multiple either as a called line or as a calling line, said line relay being normally operable to indicate a calling condition on the associated line, said cutoff relay being effective, when operated, to disassociate the line relay from the line and to disable the operated line relay from indicating a calling condition, said cutoff relay being further effective, when operated, to prepare a holding circuit for itself over the associated line, means insuring that the line relay restores first when a connection made to the line is cleared out, said line relay being effective, when restored, to complete said prepared holding circuit for the cutoff relay over the associated line subject to the line being in a condition other than its normal idle condition, means controlled jointly by said relays for impressing a signal condition on said line circuit indicative of an abnormal line condition while said cutoff relay is held operated over the associated line.

4. In a lockout line circuit including a line relay and a cutoff relay for use with a telephone line having a switchboard multiple including a sleeve conductor, the line relay having a line winding normally connected to the line, a call-circuit connection closed by the line relay responsive to energization of its line winding over the line, each relay having a sleeve winding, a sleeve connection for operating both relays responsive to a switchboard connection to said multiple, said sleeve connection including the sleeve conductor and both sleeve windings in series, with normally closed contacts of the sleeve relay interposed between the windings, a contact member for the line relay having a back contact and a front contact, said contact member and its front contact being connected in shunt of said normally closed contacts of the cutoff relay to maintain the sleeve connection intact with both relays operated, the cutoff relay having contacts for disconnecting the line winding of the line relay and for opening said call-circuit connection, means for maintaining the sleeve relay operated momentarily after the line relay restores upon severance of the switchboard connection, said line relay opening the sleeve connection at the front contact of its said contact member, and means including said contact member and its back contact for connecting the sleeve winding of the cutoff relay to the line by way of normally open contacts of the sleeve relay, whereby the sleeve relay remains operated over the line if the latter is in calling condition when the switchboard connection is broken.

5. In a lockout line circuit including a line relay and a cutoff relay for use with a telephone line comprising first and second line conductors and having a switchboard multiple including such conductors and a sleeve conductor, (*a*) a line winding, a sleeve winding, and front and back contact pairs for each relay, the line circuit being in normal condition when both relays are restored; being in calling condition when the line relay is operated alone; being in connected condition when both relays are operated; and being in lockout condition when the cutoff relay is operated alone, (*b*) first and second line connections to said first and second line conductors, respectively, effective responsive to a calling condition of the line when the line circuit is in normal condition for operating the line relay over the line to place the line circuit in calling condition, each such connection including a separate back-contact pair of the cutoff relay, the first line connection being direct, while the second includes the line winding of the line relay, (*c*) a sleeve connection controlled over the sleeve conductor responsive to a switchboard connection to said multiple when the line circuit is in normal condition, and when it is in calling condition, for bringing the line circuit into connected condtion, the sleeve

connection including in series both sleeve windings and a back-contact pair of the cutoff relay, a front-contact pair of the line relay being connected in shunt of such back-contact pair, whereby the sleeve connection is normally intact, but is opened during the lockout condition to impose a guarding condition on the sleeve conductor, (*d*) the line winding of the cutoff relay being shunted by a front-contact pair of the line relay when the line circuit is in lockout condition, rendering the cutoff relay slow-restoring, whereby the line relay restores first when a switchboard connection is opened, thereby placing the line circuit temporarily in lockout condition, and (*e*) circuit connections effective when the line circuit is in lockout condition for energizing both windings of the cutoff relay in series over the line conductors, provided the line is then in calling condition, whereby the lockout condition of the line circuit is maintained until the calling condition of the lne is termnated.

6. In a lockout line circuit including a line relay and a cutoff relay for use with a telephone line comprising first and second line conductors and having a switchboard multiple including such conductors and a sleeve conductor, (*a*) a line winding, a sleeve winding, and front and back contact pairs of reach relay, the line circuit being in normal condition when both relays are restored; being in calling condition when the line relay is operated alone; being in connected condition when both relays are operated; and being in lockout condition when the cutoff relay is operated alone, (*b*) first and second line connections to said line conductors, respectively, effective responsive to a calling condition of the line when the line circuit is in normal condition for operating the line relay over the line to place the line circuit in calling condition, each such connection including a separate back-contact pair of the cutoff relay, the first line connection being direct, while the second includes the line winding of the line relay, (*c*) a sleeve connection controlled over the sleeve conductor responsive to a switchboard connection to said multiple when the line circuit is in normal condition, and when it is in calling condition, for bringing the line circuit into connected condition, the sleeve connection including in series both sleeve windings and a back-contact pair of the cutoff relay, a front-contact pair of the line relay being connected in shunt of such back-contact pair, whereby the sleeve connection is normally intact, but is opened during the lockout condition to impose a guarding condition on the sleeve conductor, (*d*) a further line connection to the first line conductor including a back-contact pair of the line relay and the line winding of the cutoff relay, such winding being normally shunted by said direct first line connection, whereby the cutoff relay does not normally respond to line control and is rendered slow-operating to permit the line relay to respond first to a switchboard connection, (*e*) the line winding of the cutoff relay being shunted by a front-contact pair of the line relay when the line circuit is in connected condition, rendering the cutoff relay slow-restoring, whereby the line relay restores first when a switchboard connection to the line is opened, thereby placing the line circuit temporarily in lockout condition, and (*f*) circuit connections effective when the line circuit is in lockout condition for energizing both windings of the cutoff relay in series over the line conductors, provided the line is then in calling condition, whereby the lockout condition of the line circuit is maintained until the calling condition of the line is terminated.

7. In a lockout line circuit including a line relay and a cutoff relay for use with a telephone line comprising first and second line conductors and having a switchboard multiple including such conductors and a sleeve conductor, (*a*) a line winding, a sleeve winding, and front and back contact pairs for each relay, the line circuit being in normal condition when both relays are restored; being in calling condition when the line relay is operated alone; being in connected condition when both relays are operated; and being in lockout condition when the cutoff relay is operated alone, (*b*) first and second line connections to said first and second line conductors, respectively, effective responsive to a calling condition of the line when the line circuit is in normal condition for operating the line relay over the line to place the line circuit in calling condition, each such connection including a separate back-contact pair of the cutoff relay, the first line connection being direct, while the second includes the line winding of the line relay, (*c*) a sleeve connection controlled over the sleeve conductor responsive to a switchboard connection to said multiple when the line circuit is in normal condition, and when it is in calling condition, for bringing the line circuit into connected condition, the sleeve connection including in series both sleeve windings and a back-contact pair of the cutoff relay, a front-contact pair of the line relay being connected in shunt of such back-contact pair, whereby the sleeve connection is normally intact, but is opened during the lockout condition to impose a guarding condition on the sleeve conductor, (*d*) a conducting member surrounding a portion of the magnetic circuit path of the cutoff relay to render such relay slow-restoring, whereby the line relay restores first when a switchboard connection to the line is opened, thereby placing the line circuit temporarily in lockout condition, said conducting member being displaced from the winding section of the magnetic path to minimize the resulting reduction of the impedance to voice currents of the windings of the cutoff relay during lockout condition of the line circuit, and (*e*) circuit connections effective when the line circuit is in lockout condition for energizing both windings of the cutoff relay in series over the line conductors, provided the line is then in calling condition, whereby the lockout condition of the line circuit is maintained until the calling condition of the line is terminated.

8. In a lockout line circuit including a line relay and a cutoff relay for use with a telephone line having a switchboard multiple including a sleeve conductor, (*a*) a line winding and a sleeve winding for the line relay, a sleeve winding for the cutoff relay, front and back contact pairs for said relays, the line circuit being in normal condition when both relays are restored; being in calling condition when the line relay is operated alone; being in connected condition when both relays are operated; and being in lockout condition when the cutoff relay is operated alone, (*b*) a line connection, including a back-contact pair of the cutoff relay and the line winding of the line relay, effective responsive to a calling condition of the line when the line circuit is in normal condition for operating the line relay to place the line circuit in calling condition, (*c*) a sleeve connection controlled over the sleeve

conductor responsive to a switchboard connection to said multiple when the line circuit is in normal condition, and when it is in calling condition, for bringing the line circuit into connected condition, the sleeve connection including in series both sleeve windings and a back-contact pair of the cutoff relay, a front-contact pair of the line relay being connected in shunt of such back-contact pair, whereby the sleeve connection is normally intact, but is opened during the lockout condition to impose a guarding condition on the sleeve conductor, (*d*) the cutoff relay being of the slow-restoring type, whereby the line relay restores first when a switchboard connection is opened, thereby placing the line circuit temporarily in lockout condition, and (*e*) circuit connections effective when the line circuit is in lockout condition for energizing the cutoff relay over the line, provided the line is then in calling condition, whereby the lockout condition of the line circuit is maintained until the calling condition of the line is terminated.

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