

March 21, 1944.

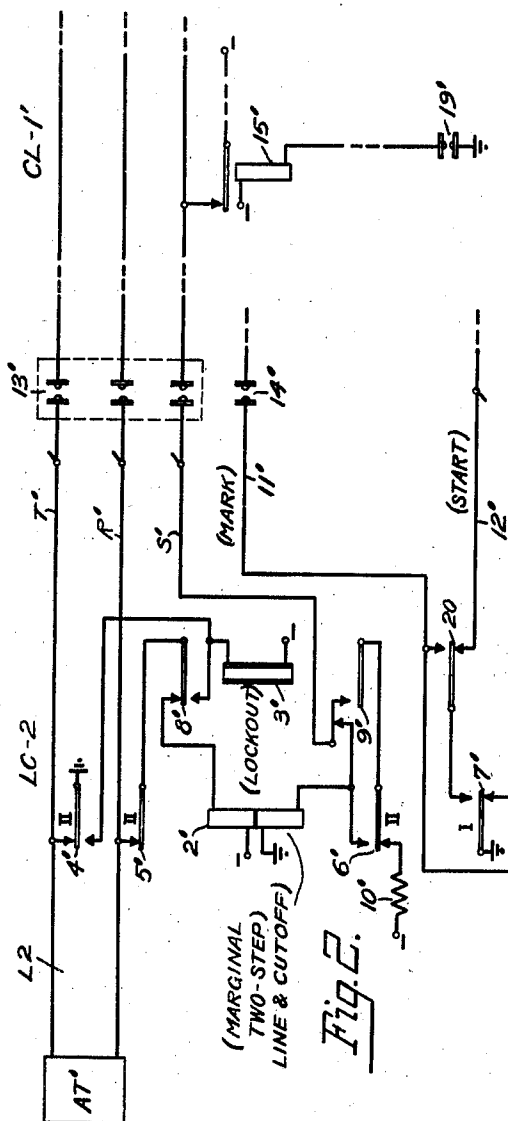
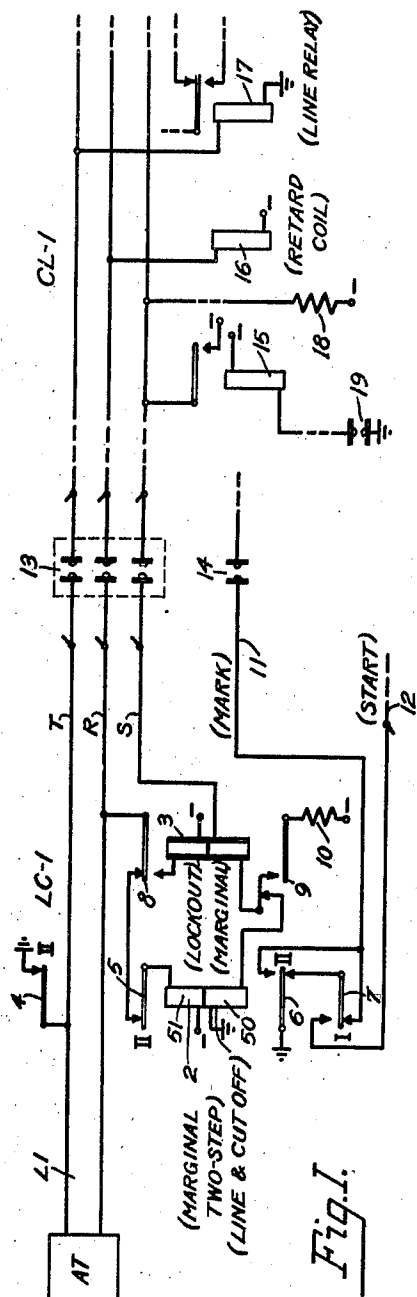
M. B. STASZAK

2,344,653

TELEPHONE LINE CIRCUIT

Filed April 10, 1941

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

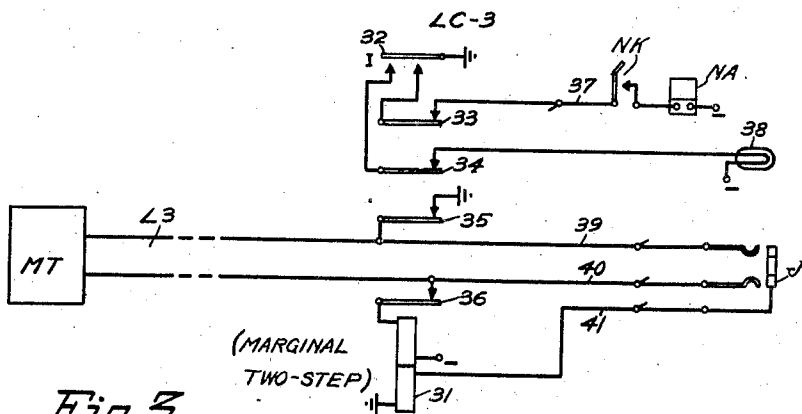


Fig. 3.

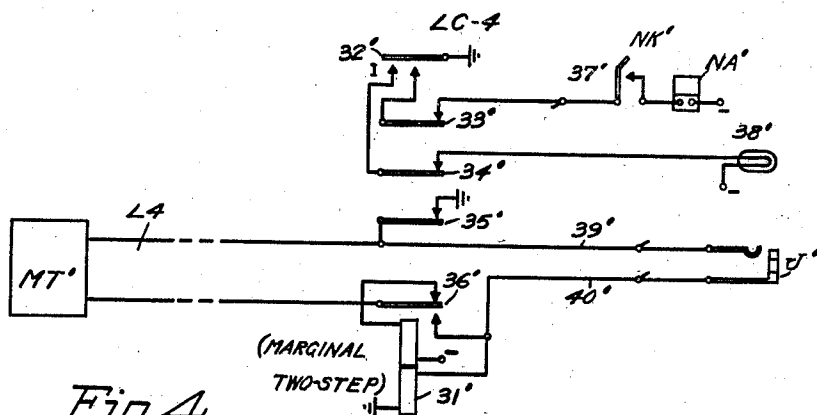


Fig. 4.

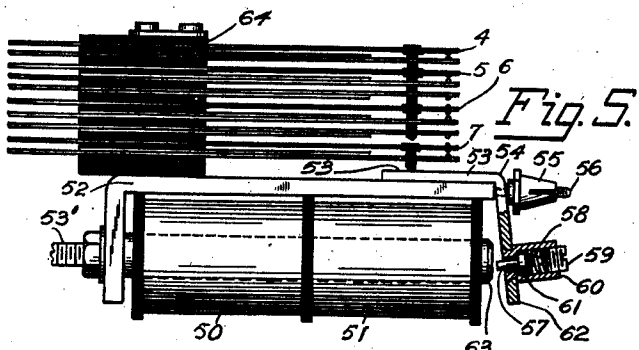


Fig. 5.

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UNITED STATES PATENT OFFICE

2,344,653

TELEPHONE LINE CIRCUIT

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Application April 10, 1941, Serial No. 387,928

6 Claims. (Cl. 179-18)

This invention relates to telephone line circuits and has for its general object the provision of a new and improved line circuit employing a minimum number of relays.

One specific object of the invention is the provision of a new and improved two-step relay especially adapted for use in telephone line circuits, while a further specific object is the provision of new and improved circuit arrangements employing such a relay to perform the functions of two relays.

A feature of the new and improved two-step relay mechanism is that the armature of the relay is provided with a spring-pressed stop which stops the armature movement at a definite point when the magnetic structure of the relay is only normally magnetized but yields to permit the armature of the relay to operate fully when the magnetic structure of the relay is additionally magnetized sufficiently to enable the spring associated with the definite stop to be overcome.

A further feature of the arrangement is that the stop-controlling spring of the two-step relay structure is readily adjustable to increase or diminish the tension applied to the said stop so as to require a greater or lesser additional magnetization of the relay structure to bring the armature from its first-step position to its fully-operated, or second-step, position.

A feature of the line circuit using the improved two-step relay is that line-relay, cutoff-relay, and lockout-relay functions, ordinarily performed by three separate relays, are performed by only two relays.

The foregoing and other objects and features of the invention will appear more fully as the description progresses.

GENERAL DESCRIPTION

In a telephone system, whether the switching or inter-connection of the lines for conversation be performed manually or automatically, it is common practice to provide each line with a line relay operable thereover to indicate that a call has been originated on the line, responsive to the removal of the receiver at the calling substation. It is also common practice to provide a cutoff relay in association with the line relay and ordinarily operable over the third wire of the switchboard multiple, usually referred to as the sleeve wire or lead. Additionally, in automatic telephone systems, and particularly those where the switchboard is largely unattended, it is common practice to provide an additional relay individual to the line, whose function is to operate

to lock the line out of normal service when it is determined that a trouble condition exists on the line which renders the line unfit for carrying the required switch-controlling impulses and voice currents.

In the present disclosure, two embodiments of a line circuit for use individual to an automatic telephone line are shown, in each of which the line and cutoff relay functions are performed by a two-step relay constructed in accordance with the invention; and two embodiments of a line circuit for use in association with a manual telephone line are disclosed, in each of which a single two-step relay constructed in accordance with the invention performs both the line-relay function and the cutoff-relay function.

The drawings

Referring now to the accompanying drawings, they show a sufficient amount of the circuit arrangements and the relay structure employed in telephone systems embodying the invention to enable the same to be understood.

Figure 1 shows circuit arrangements in an automatic telephone system including the two-relay line circuit LC-1;

Figure 2 shows the line circuit LC-2 and associated equipment, constituting a desirable modification of the arrangement shown in Figure 1;

Figure 3 shows the one-relay line circuit LC-3, associated with the manual telephone line L3, together with certain of the manual switchboard equipment;

Figure 4 shows the line circuit LC-4 similar to LC-3, Figure 3, but adapted to operate with a two-wire switchboard multiple; and

Figure 5 shows the physical structure of the new and improved two-step relay arrangement, together with an assembly of contact springs such as is employed with the two-step line and cutoff relay 2 of Figure 1.

DETAILED DESCRIPTION

The invention having been described generally, a detailed description will now be given.

Figure 5

Referring to Figure 5, the relay structure shown therein is of the type commonly used for telephone relays. The structure includes a core 63, of magnetic material, fastened to the L-shaped "heel" plate 52 by a nut threaded onto the screw-threaded portion 53' of reduced diameter. A pair of coil windings, 50 and 51, are shown between the customary spool heads on the

core 63, separated by the usual coil separator, the coil construction shown being that of the usual two-section coil.

The main portion of heel plate 52 lies parallel to the core and coil structure, and is customarily of magnetic material to provide a ready return path for the lines of force acting upon the armature. The armature, generally L-shaped, is indicated at 54, and it has a spring-actuating portion 53, normally lying parallel with the main portion of heel plate 52, and a main armature portion 62, attracted by the associated free end of the core 63 when one of the windings 50 and 51 is carrying current. Armature 54 is held pivotally in place on stem 56 by retaining nut 55.

The structure shown is assumed to be that required for relay 2 of Figure 1, and it, therefore, has the specific combination of springs in the contact assembly 64 required for relay 2, Figure 1. The contact-spring assembly 64 includes the armature springs 4, 5, 6, and 7, being so-called because they respond directly to the thrust imparted by movement of the armature. Each of the armature springs 4 to 7 has an associated back contact spring with which it is normally in engagement, while each of the armature springs 6 and 7 has, in addition, a front-contact spring engaged by the armature spring when moved a sufficient distance away from its back-contact spring.

In the particular circuit arrangement of relay 2, in Figure 1, it is required that armature spring 7 move away from its back contact and into engagement with its front contact when the relay is operated through its first step to perform its line-relay function, while armatures 4, 5, and 6 are to remain unaffected at this time. It is further required that armatures 4, 5, and 6 shall be actuated to break away from their respective back contacts and that armature 6 shall engage its associated front contact when the relay is actuated through its second step to perform its cut-off-relay function.

In order to cause the relay to selectively perform its two functions as set forth, winding 51 is arranged to produce only a mild magnetic energization of core 63, to thereby provide only a mild attraction of, or pull upon, the armature portion 62 when energized alone. When this occurs, the spring actuating portion 53, by operating the illustrated contact bushing member attached to armature spring 7, moves armature spring 7 out of engagement with its illustrated back contact and into engagement with its illustrated front contact, but the armature movement is insufficient to cause movement of armature springs 4 to 6. Positive means is provided to arrest the armature movement at this point. This result is accomplished by the plunger structure illustrated as attached to armature portion 62 of the armature structure 54.

The retainer 60 has a generally cup-like shape, as illustrated, with the diameter thereof reduced somewhat (near the bottom of the cup) to provide a reduced portion having a length substantially equal to the thickness of the armature portion 62. The reduced end may be driven into a hole provided in armature portion 62, against the shoulder following the reduced portion, and the parts may be staked together in the usual manner to hold parts 60 and 62 firmly in the illustrated assembled relationship. Part 60 is preferably of magnetic material to permit the magnetic circuit to pass therethrough from the exposed end of core 63 to the armature portion 62.

The plunger member 61 has a plunger portion 57 of reduced diameter which passes loosely through an opening in the bottom of the cup structure 60 and extends a desired distance beyond the exposed face of portions 60 and 62, to be the first part of the movable structure which engages the face of core 63. Plunger 61 is normally retained in its illustrated shouldered position by the retaining spring 58, held under a desired state of tension by adjusting screw 59, threaded into the inside of the retaining cup 60 for longitudinal adjustment. By turning the adjusting screw 59 further in or further out than the illustrated position, the force applied by spring 58 to urge the plunger 61 against the bottom of the cup structure may be increased or decreased as desired.

In the operation of the relay structure, a normal or moderate amount of energization of the core 63, by the flow of current through line winding 51, causes a sufficient pull on the armature portion 62 to rotate the armature structure in a clockwise direction around the free end of heel plate 52, as a pivot, until the forwardly extending end of plunger portion 57 strikes the core 63. The armature structure is arrested in this position, with armature spring 7 operated, and springs 4 to 6 unmoved because spring 58 is regulated by screw 59 to have sufficient tension to prevent the relative movement of plunger 61 and armature portion 62 responsive to the normal attractive pull then being exerted on armature portion 62.

In the event that an increased or excessive amount of energization is imparted to core 63, through cutoff winding 50, spring 58 is no longer able to retain plunger 61 in its illustrated advanced position with respect to armature 62, whereupon armature 62 moves forwardly to contact the end of core 63. Armature springs 4 to 6 are fully actuated by the additional movement imparted to the armature 54 when the armature portion 62 is thus moved through its second step, against the tension of spring 58.

Figure 1

Referring now particularly to Figure 1, the operation of the line circuit LC-1 shown therein will now be described.

An incoming call

Assuming now that substation AT on line L1 is called, connection may be completed with such line by the closing of a set of contacts such as 13, whereupon a guarding battery potential is applied to the so-called sleeve lead S, through a resistor such as 18 of the connecting link CL-1. When this occurs, a circuit is established for energizing the cutoff winding 50 of the combined line and cutoff relay 2, in series with the lower winding of the marginally adjusted relay 3. Relay 3 does not operate under this condition because of the current-limiting effect of the resistor 18. A further factor in preventing the operation of relay 3 at this time is that the lower winding thereof, now in circuit, preferably has only a comparatively small number of turns, to thereby limit the magnetizing effect thereof. The winding 50 of the marginal two-step, combined line and cut-off relay 2, however, is an efficient winding having a relatively large number of turns, developing sufficient magnetizing force to bring about the complete operation of the relay, through both its first and its second steps. This brings the armature portion 62,

Figure 5, all the way up against core 63, resulting in the actuation of each and every one of the armature springs 4 to 7.

At armature springs 4 and 5 and their respective back contacts, ground potential and the line winding 51 of relay 2 are respectively disconnected from the conductors of the line L1, thereby clearing the line for ringing and talking purposes. The operation of armature springs 6 and 7 is without overall effect at this time, for armature spring 6 operates to nullify the effect of the operation of armature 7.

When the established connection is broken, by the opening of contacts 13, relay 2 restores.

An outgoing call

When the receiver is removed at automatic telephone AT for the purpose of originating a call, a loop or bridge is thereby placed across the conductors of the line L1, extending ground potential from the upper conductor of the line, normally grounded at armature spring 4 and its back contact, to the lower conductor of the line, thereby completing a circuit through armature springs 8 and 5 and their back contacts for the line winding 51 of the combined line and cutoff relay 2. Winding 51 is preferably a comparatively inefficient winding, well able to energize the relay sufficiently to bring about a first-step operation thereof, but unable to energize the relay sufficiently to overcome the tension of spring 58, Figure 5, to secure operation of the relay through its second step. As a result, only the first step armature spring (termed "armature" hereinafter for convenience) 7 is operated at this time, armatures 4, 5, and 6 remaining unaffected. At its back contact, armature 7 disconnects the ground potential normally existing on individual marking conductor 11, thereby marking the line L1 as calling in the common finder mechanism. At its front contact, armature 7 applies ground potential, obtained through armature 6 and its back contact, to the common start conductor 12, to thereby cause the currently allotted line-finder mechanism to connect the associated connecting link, such as CL-1, to the calling line (marked by the absence of ground potential on the marking conductor 11, individual thereto). In the case of connecting link CL-1, the connection is made at the group of contacts 13.

When the connection is made from link CL-1 to the calling line, by way of leads T, R, and S, a guarding battery potential is applied from battery by way of resistor 18, to the sleeve lead S, closing a circuit for the lower windings of relays 2 and 3 in series. As before, relay 3 is unable to operate at this time because the current is limited somewhat by resistor 18. The efficient winding 50 of relay 2 is able, however, to energize the relay sufficiently to bring about second-step operation thereof, to operate armatures 4, 5, and 6. At armature 6, relay 2 now disconnects ground potential from the common start conductor 12 to prevent further operation of the finder mechanism, and it reapplies ground potential to individual marking conductor 11 to prevent any subsequently searching finder from making connection to the line.

Relay 2 also disconnects ground potential and its own upper winding, at armatures 4 and 5, respectively, from the talking conductors to clear the calling line for dialing and talking purposes.

In the connecting link, now in use, assumed to

be the connecting link CL-1, line relay 17 operates over the calling line in series with the balancing retard coil 16 to prepare the link circuit for operation to extend the calling line, in response to the dial pulses, generated by the usual type of calling device (not shown) at the automatic substation AT.

When the connection has been completed and the called subscriber has responded, conversation may ensue.

When the receiver is replaced at automatic telephone AT at the end of the conversation, the resulting restoration of line relay 17 of the connecting link CL-1 results in the usual clearing out of the connection and the opening of connecting contacts 13. When this occurs, the resulting removal of battery potential from sleeve lead S permits winding 50 of relay 2 to deenergize, whereupon relay 2 restores, and at armatures 4 and 5 reconnects ground and the line-relay winding 51 to the conductors of line L1.

Lockout operation

To facilitate the explanation of the operation of lockout relay 3, let it be assumed that the line L1 is looped, or bridged, accidentally, such as by the accidental removal of the receiver at automatic telephone AT, or by a shorted or similar condition of the conductors of the line L1. Under this condition, the resulting energization of line winding 51 causes relay 2 of the line circuit LC-1 to execute its first-step (line-relay) movement, previously described. The common finder mechanism is thereby caused to connect an idle connecting link, connecting link CL-1 for example, to the line circuit LC-1, through contacts such as 13, and by way of the tip, ring, and sleeve leads T, R, and S. When this connection to the sleeve lead S is made, the application of battery potential, through resistor 18, results in the energization of cutoff-relay winding 50 to operate relay 2 fully to clear the line L1 at the contacts 4 and 5, but marginal relay 3 is not operated at this time because of the current-limiting effect of resistor 18.

As previously explained, line relay 17 in the connecting link CL-1 now operates over the line L1, in series with retard coil 16, to prepare the link CL-1 for extension responsive to dial pulses. The current seizure of the link CL-1, however, was an unintended, accidental occurrence and is therefore not followed by the transmission of dialing pulses. Under this condition, the timing contacts 19 bring about the operation of the disconnect relay 15, which preferably occurs only after a sufficient interval has elapsed to permit the calling subscriber to start dialing in the normal course of an ordinary call.

When disconnect relay 15 operates through timing contacts 19, after the prescribed time interval has elapsed with no dialing having occurred, it applies battery potential, through the lower pair of the contacts 13, to the sleeve lead S, over a circuit path which by-passes the limiting resistor 18, thereby providing increased current through the lower windings of relays 3 and 2. Relay 2, being already fully operated, does not respond directly to the increased current flow, but the lower winding of marginal, lockout relay 3 is sufficiently energized to bring about the operation of the relay.

When relay 3 operates, it disconnects the lower conductor of the line L1 from the back contact of the now-actuated armature 5 of relay 2 and connects it to its own upper winding, there-

by establishing a holding circuit for this winding in parallel with retard coil 16 in the connecting link CL-1. At the same time, armature 9 of relay 3 applies battery potential to the sleeve lead S through the lower winding of relay 3, in a circuit path including the resistor 10, so as to maintain a guarding battery potential on sleeve conductor S after the connecting link CL-1 has been returned to common use, upon the subsequent opening of contacts 13. At the normally-closed contacts controlled by armature 9, cutoff-relay winding 50 of relay 2 is disconnected, permitting relay 2 to restore. At armature 4, ground potential is reapplied to the tip conductor T, but the line winding 51 remains disconnected, because armature 8 of relay 3 is operated.

In the link circuit CL-1, the placing of ground potential directly on the upper talking conductor T at armature 4 of the now-restored relay 2, shunts the energizing current away from line relay 17, to permit the relay to restore. When relay 17 restores, the connecting link may clear out in the usual manner, resulting in the opening of contacts 13 to free the link from the line L1 and line circuit LC-1, and return it to common use.

Lockout relay 3 remains operated over the line L1 as long as the abnormal or trouble condition continues thereon, its energization being maintained by current-flow through the upper winding thereof in a circuit including the operated armature 8 of relay 3, the line L1, and the restored armature 4 of relay 2.

When the abnormal condition is terminated, the circuit of the upper winding of lockout relay 3 is thereby broken, permitting relay 3 to restore. Upon restoring, relay 3 at armature 9 removes the guarding battery potential from lead S and reconnects relay 50, while at armature 8 it disconnects its own upper winding from the lower talking conductor and substitutes winding 51. The line L1 is now unguarded and the line circuit LC-1 is prepared for normal operation under the control of the line L1.

Figure 2

Referring now to Figure 2, the operation of the modified line circuit LC-2, associated with the subscriber line L2 and the automatic telephone substation AT', will now be explained.

It is to be observed that relays 2' and 3' correspond respectively to relays 2 and 3. Relay 2' has armature springs 4' to 7', corresponding structurally to armatures 4 to 7, respectively, of Figure 1. Relay 3' has armatures 8' and 9' corresponding, respectively, to armatures 8 and 9 of relay 3, and it has an additional armature 20, not present, on relay 3.

Conductors T', R', and S' correspond respectively to conductors T, R, and S of Figure 1, and conductors 11' and 12' correspond respectively to the marking and start conductors 11 and 12 of Figure 1. Similarly, contacts 13' and 14' correspond respectively to the contacts 13 and 14 of Figure 1.

Call incoming to line L2

When the line circuit LC-2 is seized over the leads T' to S', in the extension of a connection to the line L2 as a called line, the application of the usual battery potential to sleeve conductor S' closes a circuit through contact associated with armature 9' for the lower winding of relay 2', thereby energizing relay 2' fully, resulting in the complete operation of all its contact springs. At

armatures 4' and 5', the called line is cleared for ringing and talking purposes. At the same time, lockout relay 3' is actuated at armature 4'. Armature 20 thereupon nullifies the effect of the operation of armature 7' to avoid placing the line circuit LC-2 in calling condition. After the called subscriber has been signaled and has answered, and after the called and calling subscribers have replaced their receivers, the connection is broken. The resulting removal of battery potential from the sleeve lead S' permits relay 2' to restore, followed by the restoration of lockout relay 3'.

Call outgoing from line L2

Assuming that the receiver is removed at substation AT' for the initiation of a call, the ground potential normally applied to the upper conductor of line L2, at its armature 4', is thereby extended to the lower conductor, providing a circuit through armatures 5' and 8' for the upper winding of the marginal two-step line and cutoff relay 2'. Relay 2' is operated over this circuit only sufficiently to actuate its first-step armature 7', armatures 4' to 6' not being affected at this time because of the limited energization of relay 2', effected by the upper winding.

By the operation of armature 7, ground potential is removed from marking conductor 11' and is applied to the common start conductor 12' to cause a finder to connect an idle link circuit with the terminals of the calling line, by the closure of a contact group, such as 13'. When this occurs, a circuit is closed for the lower, or cutoff, winding of relay 2', from battery in the connecting link CL-1', by way of normally closed contacts of relay 15', the lower contact pair in group 13', conductor S', and normally closed contacts controlled by armature 9' of lockout relay 3'. Relay 2' becomes fully energized at this time thereby operating its remaining armature springs, 4' to 6'. At armature 6', relay 2' disconnects resistor 10' from armature 9' of relay 3' and prepares a locking circuit for the lower winding of relay 2', while armatures 4' and 5' disconnect ground potential and the upper winding of relay 2' from the associated line conductors to clear the conductor of the calling line in the usual manner.

Armature 4' also closes a local circuit for lockout relay 3', causing relay 3' to become operated immediately. At armature 20, relay 3' disconnects ground potential from the common start conductor 12' and reapplies it to the individual marking conductor 11' to thus terminate the calling indication of the line circuit LC-2.

Relay 3' also prepares a locking circuit for itself at armature 8', but this locking circuit is ineffective at this time because armature 5' is actuated. At armature 9', relay 3' opens the initial energizing circuit of the lower winding of relay 2', but at the same time establishes a new circuit for relay 2' which includes the actuated armatures 6' and 9' and the lead S' in series.

From the foregoing, it will be seen that the second-step operation of relay 2' and the described operation of lockout relay 3' occur successively in rapid order when the calling line circuit LC-2 is extended to a link circuit.

The calling line L2 is now extended to the connecting link CL-1, which may be prepared for operation in the usual manner, and may serve to extend the line L2 responsive to the usual calling-device operation at the calling automatic telephone AT'.

When the receiver is subsequently replaced at substation AT', the connecting link CL-1' clears

out in the usual manner, and contacts 13' open. The resulting removal of guarding potential from the sleeve lead S' opens the circuit of the lower winding of relay 2' permitting this relay to restore. At armature 4', relay 3' opens the local circuit relay 3, thus permitting relay 3 to restore, unless held over the associated line L2, as will be pointed out subsequently.

Upon the restoration of relay 3', the line circuit LC-2 is restored to its illustrated normal condition.

Lockout operation at line circuit LC-2

Let it be assumed now that the line L2 is unintentionally bridged or shorted. Under this condition, line relay 2' operates through its first step responsive to its partial energization by its upper or line winding over the line L2, following which a connecting link, such as connecting link CL-1', is associated with the calling line as before described. When this occurs, a circuit as previously traced, is closed from battery in the connecting link CL-1' over the sleeve lead S' for the lower winding of relay 2' to thus secure the complete energization and operation of relay 2'. When this occurs, the conductors of the line L2 are cleared at armatures 4' and 5', as previously pointed out, and lockout relay 3' is operated locally by armature 4'.

Since the operation of the line circuit LC-2 and the resulting extension of the connection, through contacts 13', to connecting link CL-1 is the result of an abnormal or trouble condition, no dialing occurs. After a predetermined time has elapsed without any dialing having occurred, the timing contacts 19' bring about the operation of disconnect relay 15'. Upon operating, relay 15' disconnects battery potential from the sleeve lead, thereby opening the circuit for the lower or cutoff winding of relay 2', which circuit at this time is through the actuated armatures 9' and 5' in series. Relay 2' thereupon immediately restores and again makes connection with the conductors of the line L2 at armatures 4' and 5'. At this time, since the line L2 is in a bridged or shorted condition when relay 2' restores, lockout relay 3' does not restore following the opening of its local circuit at armature 4', but remains operated over the bridged or shorted conductors of the line L2. The operating circuit is from ground at armature 4' and its back contact, through the bridge or short on the line L2, and thence to battery by way of the restored armature 5', the actuated armature 8', and the winding of lockout relay 3'. Relay 3' is thus held actuated over the line L2, for so long a time as the trouble condition remains thereon.

With relay 3' now held locked over the line L2, and relay 2' restored, a guarding battery potential is applied by way of resistor 10', the restored armature 6', and the actuated armature 9' to the sleeve conductor S', the cutoff winding of relay 2' being maintained disconnected from the sleeve lead to prevent its reoperation from this guarding potential.

Also, the line winding of relay 2' is maintained disconnected at the open back contact of the actuated armature 8'.

When the trouble condition on the line L2 is removed, relay 3' is permitted to restore, returning the line circuit LC-2 to its normal condition, reconnecting the windings of relay 2' and opening a further point in the previously established locking circuit of relay 3'.

Trouble test on each call

Lockout relays being actuated at armature 4' every time relay 2' operates (whether on a call outgoing from the line L2, or a call incoming to the line L2) the line L2 is tested by the relay 3' at the end of each call, when battery potential is removed from the conductor S' to permit relay 2' to restore. A trouble condition existing on the line L2 thus causes the lockout relay 3' to automatically lock out the line, by failing to restore when connected thereto at armatures 4' and 5', through the actuated armature 8'. Additionally, when the calling subscriber is the first to replace his receiver on a call to the line L2, and thus causes the connection to be released while the receiver is off the hook at substation AT', relay 3' remains operated over the line L2 through the restored armatures 4' and 5', and the actuated armature 8', until the receiver is replaced on the called line L2, thereby preventing an immediate reoperation of relay 2' as a line relay to cause the line L2 to be extended inadvertently as a calling line.

Figure 3

As previously mentioned, Figure 3 shows the improved two-step relay structure of Figure 5 (relay 31 in the line circuit LC-3) used as a combined line and cutoff relay in a manual telephone system using the usual three-conductor switchboard multiple. It will be understood, of course, that the number and arrangement of contact springs of the relay shown in Figure 5 is suitably varied as required.

With the upper conductor of line L3 normally grounded at armature 35, and the lower conductor normally connected to battery at armature 36, by way of the line winding of relay 31, the removal of the receiver at the manual telephone MT results in the closure of a circuit for the line winding of relay 31. This line winding is arranged to energize the relay only moderately, resulting only in the operation of the relay in its first step. Consequently, only the first step armature 32 is affected at this time. Upon operating, armature 32 places ground potential, by way of armature 33 on the common night-alarm conductor 37 so as to sound the night-alarm buzzer NA, in case the night key NK is closed. Relay 32 also extends ground potential by way of conductor 34 to the line lamp 38, to light this lamp, together with its multiples at any other positions, if such there be.

When the operator responds to the lighted condition of lamp 38, by inserting the answering plug of a cord circuit into the answering jack J, battery potential is applied, by way of the sleeve of the jack J, to the sleeve conductor 41 to thereby close a circuit for the cutoff winding of relay 31. Relay 31 is thereby operated fully to actuate all its second-step armatures, 33 to 36. At armatures 33 and 34, ground potential is disconnected from night alarm conductor 37 and lamp 38, respectively, to quiet night-alarm buzzer NA, if connected, and to extinguish the line lamp 38. At armatures 35 and 36, ground potential and the line winding of relay 31 are respectively disconnected from the conductors of the calling line L3, to clear the line for talking purposes. Relay 31 remains operated fully over conductor 41 as long as the plug remains in the jack J.

After the originated call has been disposed of and the subscriber at substation MT has replaced his receiver, the removal of the plug from the jack J results in the removal of the guarding

potential from conductor 41, and in the opening of the circuit of the lower winding of relay 31. Relay 31 thereupon restores, to return the line circuit LC-3 to its illustrated normal condition.

When a call is extended to a line L3, by way of multiples of the conductors 39 to 41, through a jack at one of the positions of the switchboard, the lower winding of relay 31 is energized from the battery potential then placed on conductor 41. Relay 31 operates fully, to clear the line L3 at armatures 35 and 36. Armatures 33 and 34 prevent armature 32 from operating the night-alarm buzzer NA and from lighting the lamp 38.

When the calling plug is subsequently removed, the consequent removal of potential from conductor 41 opens the circuit of the lower winding of relay 31, permitting relay 31 to restore and thus return the line circuit LC-3 to its normal condition.

Figure 4

As previously noted, the line circuit LC-4 is similar to the line circuit LC-3, except that it is especially adapted to employ the marginal two-step relay structure as a combined line and cutoff relay in a line circuit for use at a manual switchboard employing a two-wire multiple. It is to be observed that armatures 32' to 35' correspond, respectively, to armatures 32 to 35 of the line circuit LC-3, Figure 3, while armature 36', in addition to disconnecting the associated talking conductor from the line winding of the relay (as does armature 36), closes an open point in the talking circuit.

When the receiver is removed at substation MT' to originate an outgoing call, the upper winding of relay 31 is energized over the line L4 to effect the operation of armature 32' only, whereupon ground potential is applied through 33' to the night alarm conductor 37', and lamp 38' is lighted through armature 34'.

When the answering plug is placed in the jack J', battery potential is applied through the sleeve thereof to conductor 40' (serving both as a sleeve conductor and as a talking conductor). The lower winding of relay 31' is thereupon energized to operate the relay fully. Armatures 33' and 34' open the night-alarm and answering-lamp circuits while armatures 35' and 36' clear the conductors of the line L4 from ground and the line winding of relay 31'. Armature 36' also extends the lower talking conductor of the line L4 to the corresponding multiple conductor 40' to complete the talking circuit to the switchboard.

When the subscriber at substation MT' has replaced his receiver, and the operator has removed her plug from the jack J', the resulting removal of battery potential from conductor 40' permits the lower or cutoff winding of relay 31' to deenergize, whereupon relay 31' restores to place the line circuit LC-4 in its illustrated normal condition.

When a call is extended to the line L4, by way of the multiples of conductors 39' and 40', relay 31' is operated fully by the energization of the lower winding thereof from the battery potential placed on conductor 40'. By this operation, the talking conductors of the line L4 are cleared and cut through to conductors 39' and 40' to permit ringing and talking to take place thereover.

When the calling plug is removed, the consequent removal of battery potential from conductor 40' permits relay 31' to restore.

What is claimed is:

1. In a telephone system wherein switching

equipment is provided in common for interconnecting telephone lines, a line circuit for the individual use of one of said telephone lines, said line circuit including a two-step relay operable through its first step over the associated line to indicate the origination of a call thereon, means including a portion of said common switching equipment for extending a connection from the said telephone line, means operated over the said extended connection for fully energizing said two-step relay as a cutoff relay to clear the calling line for talking purposes and to terminate the indication of a calling condition thereon, a lockout relay associated with said two-step relay, means for operating said lockout relay over the extended connection when there is an abnormal or trouble condition on the calling line, and circuit means included in said lockout relay for disconnecting and restoring said two-step relay and for maintaining the lockout relay operated under the control of the associated line as long as the said abnormal or trouble condition continues.

2. In a telephone system wherein switching equipment is provided in common for interconnecting telephone lines, a line circuit for the individual use of one of said telephone lines, said line circuit including a two-step relay operable through its first step over the associated line to indicate the origination of a call thereon, means including a portion of said common switching equipment for extending a connection from the said telephone line, a lockout relay associated with said two-step relay, means operated over the said extended connection for bringing about the full energization of said two-step relay as a cutoff relay to clear the calling line for talking purposes and for bringing about the energization of said lockout relay, means effective when the said two-step relay is fully operated and the lockout relay is operated for terminating the indication of a calling condition on the line, means effective when there is an abnormal or trouble condition on the calling line for releasing the extended connection, and means responsive thereto for restoring said two-step relay, and circuit connections thereby rendered effective for maintaining the lockout relay operated over the associated line so long as the abnormal or trouble condition continues.

3. In a telephone system wherein switching equipment is provided in common for interconnecting telephone lines, a line circuit for the individual use of one of said telephone lines, said line circuit including a two-step relay operable through its first step over the associated line to indicate the origination of a call thereon, means including a portion of said common switching equipment for extending a connection from the said telephone line, a lockout relay associated with said two-step relay, means operated over the said extended connection for bringing about the full energization of said two-step relay as a cutoff relay to clear the calling line for talking purposes and for bringing about the energization of said lockout relay, means effective when the said two-step relay is fully operated and the lockout relay is operated for terminating the indication of a calling condition on the line, means effective when there is an abnormal or trouble condition on the calling line for releasing the extended connection, means responsive thereto for restoring said two-step relay, and circuit connections thereby rendered effective for

maintaining the lockout relay operated over the associated line so long as the abnormal or trouble condition continues, and circuit connections effective with the lockout relay operated and the associated two-step relay restored for marking the associated line as busy.

4. In a manual telephone system, a two-step line and cutoff relay and means for operating it over the associated line to execute its first-step movement to close circuits for a night alarm signal and a line signal, means controlled through an operator's cord circuit for further energizing said relay to execute its second-step movement to serve as a cutoff relay and to separately open the night-alarm and line-signal circuits.

5. In a telephone system wherein switching equipment is provided in common for interconnecting telephone lines, a line circuit for the individual use of one of said telephone lines, said line circuit including relay means operable thereover to indicate the origination of a call thereon, means including a part of said common switching equipment for extending a connection from the said telephone line, a lockout relay having an operating circuit controlled by said relay means, means operated over the said extended connection for further operating said relay means to clear the calling line for talking purposes and to close said operating circuit of the lockout relay, means effective when there is an abnormal or trouble condition on the calling line for releasing the extended connection, said

relay means restoring responsive thereto, and circuit connections thereby rendered effective for maintaining the lockout relay operated over the associated line so long as the abnormal or trouble condition continues.

6. In a telephone system wherein switching equipment is provided in common for interconnecting telephone lines, a line circuit for the individual use of one of said telephone lines, said line circuit including relay means operable thereover to indicate the origination of a call thereon, means including a part of said common switching equipment for extending a connection from the said telephone line, a lockout relay associated with said relay means, means operated over the said extended connection for further operating said relay means to clear the calling line for talking purposes and for operating said lockout relay, means effective when there is an abnormal or trouble condition on the calling line for releasing the extended connection, said relay means restoring responsive thereto, circuit connections thereby rendered effective for maintaining the lockout relay operated over the associated line so long as the abnormal or trouble condition continues, and circuit connections controlled jointly by said lockout relay and the restored relay means for marking the associated line as busy during the time the lockout relay is maintained operated thereover.

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