July 4, 1939. H. M. BASCOM 2,164,731

TELEPHONE SYSTEM

Filed April 7, 1937 2 Sheets-Sheet 1

FIG. 1

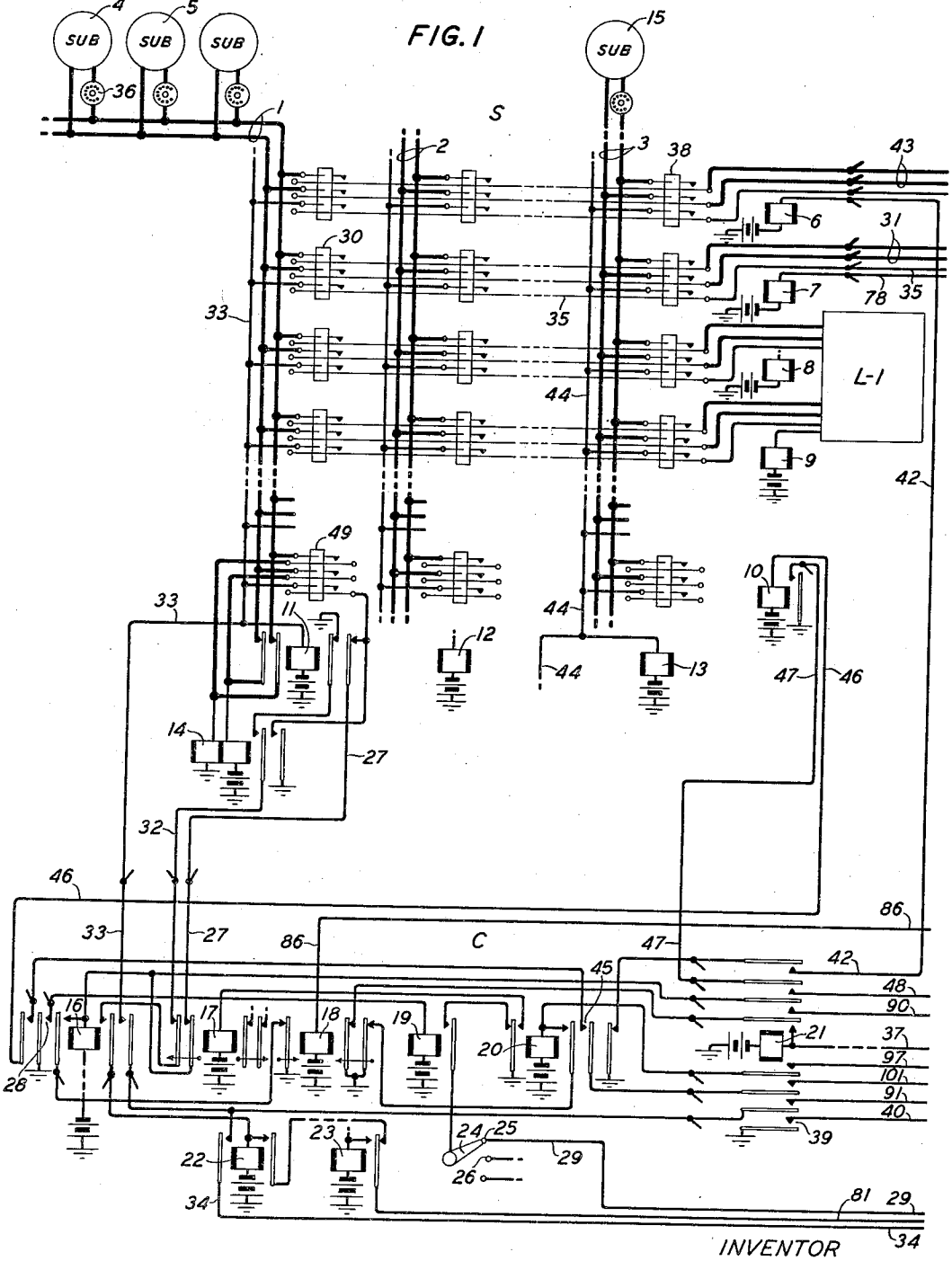

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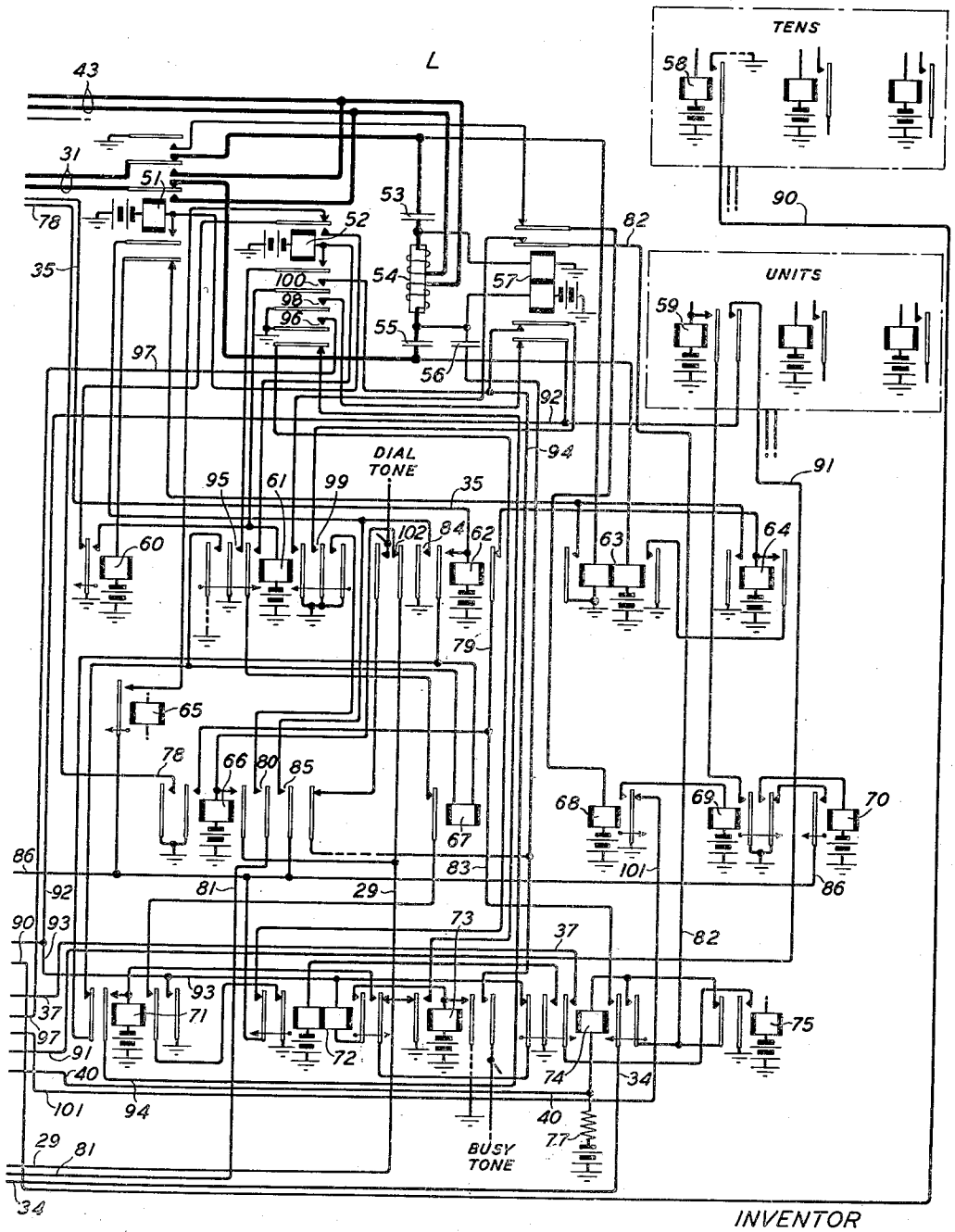
FIG. 2



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UNITED STATES PATENT OFFICE

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TELEPHONE SYSTEM

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Application April 7, 1937, Serial No. 135,433

8 Claims. (Cl. 179—17)

This invention relates to telephone systems and particularly to dial systems arranged for the establishment of revertive calls under the control of the subscribers.

The objects of the invention are to enable subscribers on the same line to converse without depriving other lines of the use of the common switching and controlling equipment; to simplify the individual subscriber's line equipment; and otherwise to improve systems of this character.

In systems of the prior art it has been common to release the switches and links as soon as a revertive call is established and to supply the necessary current for conversation and for supervision from the circuit individual to the line on which the revertive call is established. In most cases these prior arrangements have entailed added equipment for each subscriber's line, resulting in increased cost and also in some added complication of the circuit operation.

According to the present invention the objects above mentioned are attained by a dial system using cross-bar switches and common controlling mechanism for the establishment of connections, in which the switch and controlling mechanism are released upon the establishment of a revertive call on a subscriber's line, and in which the switch is reoperated to reconnect the line relay to the line through a set of switch contacts specially reserved for revertive calls on that particular line. This arrangement enables the use of a line circuit comprising only two electromagnets, one the usual line relay, and the other the hold magnet of the switch which is individual to the line and which also performs the functions of a cut-off relay. With the exception of these elements, the line relay, the hold magnet, and the single contact set, each of which is individual to the line, all parts are restored to normal. The line relay feeds current to the line and serves as the supervisory relay, and the hold magnet maintains the single set of contacts operated and prevents the operated line relay from setting up a calling condition in the common controlling mechanism.

The foregoing and other features of the invention will be described more fully in the following detailed description and also in the appended claims.

The drawings accompanying this specification disclose a portion of the circuit details of a small dial telephone system in which cross-bar switches are used for establishing the connections.

Fig. 1 of the drawings shows a part of one of the cross-bar switches in which subscribers' lines and link circuits terminate and also a part of a control mechanism common to all the lines and switches.

Fig. 2 discloses certain parts of one of the link circuits serving to interconnect subscribers' lines in the cross-bar switches.

The system may include one or more cross-bar switches, depending upon the number of subscribers' lines to be served. Each of these switches, such as the switch S, comprises a plurality of vertical rows of contacts and a plurality of horizontal rows of contacts, together with vertical and horizontal operating bars individual, respectively, to the different rows of contacts. Although not necessarily limited to any particular number of contact rows, it has been found that a switch having a capacity of ten vertical rows and ten horizontal rows is satisfactory for systems of this kind. In the switch S the horizontal or select bars are operated by the corresponding magnets, such as magnets 6, 7, 8, 9 and 10, and the vertical or hold bars are operated by individual magnets, such as magnets 11, 12 and 13. The subscribers' lines, such as lines 1, 2 and 3, appear respectively in the vertical rows of contacts of the switch S and similarly in other switches where the capacity of the system requires the use of more than one switch. The link circuits which serve to interconnect any two subscribers' lines appear in the horizontal rows of contacts, each link occupying two different horizontal rows. The link L, for example, appears in the upper two horizontal rows of the switch S, one of these rows serving to connect a calling line to the corresponding end of the link circuit and the other row serving to connect the link circuit to any one of the lines as a called line. If a plurality of switches S are provided, each link circuit appears in the horizontal rows of contacts in all switches in order that the link may be accessible to any line in the system. A second link L—1 is illustrated diagrammatically.

One horizontal row of contacts in each switch, the bottom row of switch S, is reserved for the purpose of revertive calls. The contact sets of this horizontal row are individual, respectively, to the ten subscribers' lines appearing in the switch, and the individual set of contacts for each line serves to connect the windings of the line relay of that line to the tip and ring conductors to feed talking current to the line during conversation, thus enabling all common equipment and link circuits to be restored to the use of other lines.

The common control and allotting circuit C serves to allot the link circuits for use and re-

sponds whenever a call is initiated on one of the subscribers' lines to identify the position of the calling line and to cause the finder end of the allotted link circuit to be connected to that line. Thereafter the subscriber dials the designation of the wanted subscriber, and the impulse series representing this designation are recorded on register relays in the connected link circuit. Following this the link circuit associates itself with the common control circuit and establishes a test circuit therethrough to test the condition of the called subscriber's line. If the called line is idle, the magnets are operated, and the other end, the connector end, of the allotted link circuit is connected to the called line to establish a talking connection. On a call of this kind, that is, a call between one subscriber's line and another subscriber's line, the link circuit is maintained in use as a part of the established connection for supplying talking current and supervision and the common control circuit is released after it has served its purpose and may be used thereafter by other subscribers' lines. For a more detailed disclosure of a system of this kind, reference is made to the copending application of Bowne et al., Serial No. 95,530, filed August 12, 1936, issued as Patent No. 2,104,449, Jan. 4, 1938.

If the subscriber at station 4 on the line 1 desires to call the subscriber at station 5 on the same line, he may do so, but the operation of the system at the central office differs from that above described. When the subscriber initiates his call by removing the receiver from the switchhook, the finder end of the allotted link circuit is connected to the subscriber's line through the selector switch S in the usual manner, and the subscriber dials the digits representing the called party on his own line. The link circuit upon receiving the designation connects itself to the control circuit and tests the called line. During the course of this test the call is found to be a revertive one, and thereupon a busy tone is applied to the line. The calling party hearing the busy tone replaces his receiver on the switchhook, causing the link circuit to apply ringing current to the line through the finder end thereof. When the called subscriber answers by removing his receiver, the link circuit disconnects itself from the line and through the common control circuit causes the operation of the select magnet 10, which is individual to the special row of contacts, and also causes the operation of the hold magnet 11, individual to the calling line. The subscriber's line 1 is now connected through the special set of contacts to the windings of the line relay 14 for supplying talking current and all common equipment is released.

A more detailed description of the operation of the system will now be given and for this purpose it is assumed that the subscriber at station 4 on line 1 wishes to make a call. The calling party removes his receiver from the switchhook, thereby bridging the line and operating line relay 14 in the usual manner through the left contacts and armatures on holding magnet 11. Relay 14 at its outer contact connects ground through right outer contact and armature on hold magnet 11 to lead 27 which is traced further through left inner contact and armature of relay 17, thence through winding relay 16 to battery. It will be understood that relay 16 is common only to the 10 lines appearing on the switch frame S. Other groups of 10 lines on other switches would each be provided with relays similar to relay 16 together with means for permitting the operation of only one of the said relays at a time. Assuming now that the call on frame S is given preference, relay 16 thereupon operates and at its left inner contact locks to ground at the left contact on relay 18. Relay 16 at contact 28 thus connects ground through the winding of relay 19 to battery causing said relay to operate and close an operating circuit for the link relay 66 shown on Fig. 2 of the drawings. Said circuit may be traced from ground at left armature and back contact on relay 20, make contact on relay 19, arm 24 and contact 25 of a link assignment switch, lead 29, through armature and break contact 102 on relay 62 to battery through winding relay 66. The assignment switch in this description may be assumed to represent any form of an allotter arrangement with undertakes to distribute calls evenly over all available supervisory links. The link L is assumed to be the next available idle link circuit for the purposes of this description. Relay 66 operates in said link and locks over lead 29 to the control circuit C for the purpose of connecting subscriber 4 of line 1 via cross-bar switch contacts 30 with the calling end 31 of said link circuit. Thus relay 66 at its left outer contact closes ground to lead 78, traced through selecting magnet 7 to battery, thereby placing the calling end 31 of the link L in a position to connect with any one of the idle lines on frame S. Relay 66 at its left inner contact connects ground to lead 79, traced through right contact on relay 62, thence to battery through winding relay 64. The latter relay at its left contact connects ground through the bottom outer break contact on relay 51 through winding of slow release holding relay 60 to battery. The latter relay, in turn, connects ground to the winding of slow operate relay 61 which in operating further prepares the link circuit for use by the calling subscriber by closing a locking ground through contact 39 on relay 66 over lead 81 for one of the ten relays indicated at 22, 23. Relay 61 at its right inner contact also closes ground through the top inner contact relay 57 to lead 82, thence through left outer contact on relay 75, winding relay 74 and resistance 77 to battery. Relay 74 operates in this circuit, in turn operating relay 72 by connecting ground through its left-hand winding to battery.

Referring again to the operation of relay 16, it will be observed that said relay at its right inner contact closes a path for operating line test relay 22. Said path is traced from battery through winding relay 22, right inner contact on relay 16, left outer break contact on relay 17, lead 32, right inner contact on operated line relay 14, to ground at right inner contact on holding magnet 11. Relay 22 upon operating locks over lead 81 previously traced and closes a path for operating the holding magnet 11 corresponding to the calling line 1. Said path is traced from battery through winding of holding magnet 11, over lead 33, right outer contact on relay 16, left contact on relay 22, lead 34, thence through right inner contact relay 74 to ground at left inner contact relay 66. The selecting magnet 7 being operated at this time as previously traced causes the switch contacts 30 to operate and to remain operated as long as magnet 11 is energized. The left contacts on magnet 11 open the circuit of the line relay 14 which releases. The subscriber's line, thus extended to the calling end 31 of the link L, may be further traced through normal contacts on relay 51 of the link and thence to ground and battery through the

windings of the calling supervisory relay 63. The latter relay operating prepares a holding path for previously operated relay 64 and at its left contact supplements the contact on relay 64 for holding relay 60 operated.

The subscriber now awaits a tone which will inform him that he may dial the called party number. This tone, known as dial tone, is sent to him in the following manner. The closure of switch contacts 30, referred to above, connects the ground on leads 33 and 34 that has been holding magnet 11 operated, to sleeve lead 35 of the link circuit, traced thence through the winding relay 62 to battery. The latter relay, operating, at its left inner contact closes a locking circuit for itself to ground traced through the left outer contact relay 71 and left outer contact of operated relay 61. It may here be observed that said locking ground being connected to leads 34 and 35 serves to hold magnet 11 independently of the operating ground received for said magnet over lead 33. The operation of relay 62 at contact 84 connects ground through contact 85 on relay 66 to lead 86 for operating relay 18 to battery. The latter relay at its left contact then releases the tens relay 16 in the control circuit. Relay 16, in turn, releases relay 19 which, in turn, opens the previously traced operating and holding circuit for relay 66. The release of relay 66 at contact 80 then opens the locking circuit over lead 81 for relay 22 which likewise releases. The release of relay 66 removes ground from lead 78, thus releasing all selecting magnets such as magnet 7. Relay 66 at its left inner contact removes ground from leads 79 and 83 thus opening the original operating ground circuit to magnet 11 which, however, continues to remain operated over lead 35 as previously described. At contact 85 relay 66 opens the operating circuit over lead 86 for the control release relay 18 and at its outer right contact closes a dial tone circuit to the calling subscriber. The latter circuit is traced from the dial tone source, through left outer contact on relay 62, right outer contact on relay 66, through a condenser 56 of low capacity, thence through transmission condenser 55 and back over the lower side of the talking circuit to the calling subscriber. Relay 18 releases and prepares circuits (not shown) for causing the link assignment switch arm 24 to move to the terminal of the next idle link and otherwise prepare the control circuit for connecting other incoming calls to other idle link circuits.

The calling subscriber 4 upon hearing dial tone, proceeds to operate dial 36 associated with his telephone set and it may further be assumed that he wishes to make connection with subscriber 15 on line 3. The operation of the dial causes the energization of the proper tens relay 58 and units relay 59 representing the called line. At the end of the last digit dialed, relay 75 operates as is the usual practice in systems of this kind. The operation of said relay causes link connecting relay 21 to operate over a path traced from battery through winding of relay 21, lead 37, left inner contact on relay 74 to ground at left inner contact on relay 75. As described in the Bowne et al. patent above referred to, the above ground path first actually operates two selective relays, not shown, in the control circuit to enable the link circuit L to associate itself with the control circuit C and lock out any other calling lines or links. For clearness, however, relay 21 is shown here as being operated directly from the ground contact on relay 75. The operation of relay 21 then enables the control circuit to function with this particular link circuit in making a busy test of the called line and the seizure of same at switch contacts 38 if the line is found to be idle. It also starts setting up the necessary circuit conditions in the link L for making a busy test of the called line by connecting ground at contact 39 to lead 40, the effect of which is to shunt out relay 74 through the common resistance 77 causing it to release. The operation of relay 21 at its top outer contact closes a ground path from the normal contact on relay 20, to lead 42 and thence through the winding of selecting magnets such as 6, associated with the terminating end 43 of the link circuit. Other circuits closed by relay 21 will also presently be described.

The release of relay 74 above described now prepares the link circuit for making a test on the called subscriber line to determine whether it is idle or busy. Assuming said line is idle, the associated sleeve lead 44 will be free of ground. The operation of relay 21 also closes a circuit from ground from the tens relay 58 on lead 90 and through a contact on relay 21 to the winding of the relay corresponding to relay 16 for the particular group of ten lines in which the called subscriber line is located. The latter relay operating in this circuit thereupon extends the called subscriber sleeve lead 44 through a contact on relay 21 to a lead similar to lead 91 in the same manner that sleeve lead 33 would be extended if the called party number were the same as the calling party number. Said sleeve circuit is further traced over lead 91 and right outer contact on units relay 59 corresponding to the unit number dialed by the calling subscriber. Said path is further traced over leads 92 and 93 to the windings of two relays; one through the right winding of relay 72 and its right inner contact to battery through winding relay 73; the other through the left outer contact on relay 74, right outer contact on relay 72 to battery through winding relay 71. Since the called line is idle, no ground is present on sleeve lead 44 so that neither relay 71 nor relay 73 operates. Although the release of relay 74 previously opened the circuit through the left winding relay 72, the latter relay did not release due to its slow releasing characteristics. The relay, however, not finding a ground circuit for its right winding presently releases, thereby connecting a ground from the left back contact relay 73 through its own right outer contact, through the left outer contact on relay 74 to lead 93, traced thence as previously described to the called subscriber's sleeve lead 44. Selecting magnet 6 being energized at this time, the operation of holding magnet 13 from lead 44 thus connects subscriber 15 on line 3 with the terminating end 43 of the link in the usual manner. A further description of the ringing of the called subscriber and ultimate connection of the transmission circuit through the link may be found in the patent to Bowne et al. previously cited.

Let it now be assumed that the called line 3 is busy when the sleeve 44 is extended through a contact on relay 21 to a lead corresponding to lead 91. The presence of ground in this case operates both relays 71 and 73 and prevents relay 72 from releasing. Relay 71 in operating provides a locking circuit for itself at its left inner contact, traced over lead 94, bottom inner contact relay 57 to ground at a contact on operated relay 61. Relay 71 at its right outer contact connects ground to lead 93, traced thence as pre-

viously described to the called subscriber's sleeve lead 44, thus guarding said sleeve against being freed at this test period. Relay 71 at its left outer contact also opens the short circuit around the winding of relay 67, thereby permitting the latter to operate in the locking ground circuit previously traced for relay 62, the winding of relay 67 being sufficiently low in resistance to continue to hold the calling line holding magnet 11 operated. Relay 73 at its right outer contact closes a busy tone path to condenser 56, traced thence through condenser 55 to the lower talking conductor previously traced to the calling subscriber 4 on line 1, thus informing the latter that the called line is busy. Presently slow relay 72 releases due to relay 73 at its right inner contact closing a locking circuit for itself to ground which in effect acts as a short circuit on the right winding of relay 72. The release of relay 72 now connects a ground path to lead 86 for operating control relay 18, said ground path being traced from left inner make contact on relay 73, bottom outer break contact on relay 52, and left outer contact relay 72. Relay 18 at its right inner contact removes ground that has been holding relay 21 operated, and at its left contact removes ground that has been holding the equivalent of relay 16 operated, thereby restoring the control circuit to normal and breaking all further connections to the called subscriber line. The calling subscriber upon hearing the busy tone restores his receiver to the switchhook, thus releasing supervisory relay 63 and restoring the link circuit to normal in the usual way.

There will now be described the manner in which the above busy test of the called subscriber line is made when said line happens to be the same as the line that is calling. This call may be termed a revertive call which means that subscriber 4, for example, is calling subscriber 5 on his own line No. 1. In this event subscriber 4 removes his receiver from the switchhook and when he has been connected with an idle link circuit he receives the customary dial tone. He then proceeds to dial the number of the called subscriber 5 all in a manner as previously described. Referring to that point in the description where the called line 3 is assumed to be busy, it will instead be assumed that the called line is line 1, the same as the calling line. Sleeve lead 34 instead of sleeve lead 44 is, therefore, extended through a contact on relay 21 to lead 91. The called line in this case always tests busy, due to ground at the left outer contact of relay 61 being connected to sleeve lead 33 through the left outer contact of relay 71, left inner locking contact of relay 62 and lead 35. Both relays 71 and 73 operate as before and relay 72 is momentarily held operated from the busy ground. Relay 71 locks as before and connects ground to lead 93 which is further traced over lead 92, right outer contact or units relay 56, lead 91, thence through a contact on relay 21 and right outer contact on relay 16, to sleeve lead 33. Since the sleeve 35 of line 1 is already connected to the link circuit over lead 35 to the winding of relay 62, it will be evident that the ground placed on sleeve lead 34 by the operation of relay 71 therefore serves to keep the winding of relay 67 short-circuited even when the operation of relay 71 at its left outer contact removes the direct short circuit on relay 67. Obviously then it will be evident that relay 67 always operates unless the called and calling lines are one and the same. Since the contact on relay 67 is connected in the operating path for relay 52 the latter relay, therefore, only operates on reverting calls. The operation of relay 73 on a reverting call performs the same functions as it does on the regular call, as previously described, so that the calling subscriber 4 hears the usual line busy tone. He expects, however, to encounter a busy tone when calling another subscriber on his own line and knows that he must hang up his receiver in order to start the central office circuits to ringing back his own line.

Assuming the calling subscriber has not as yet replaced his receiver on the switchhook, relay 72 in any case presently releases and connects ground to lead 86 for operating control release relay 18 as previously described for the regular busy test. The latter relay, however, is made sufficiently slow in operating to give time for relay 52 to operate. On the regular busy test the latter relay, of course, does not operate and therefore relay 18 eventually operates to release the control circuit. The operation of relay 52 on reverting calls, however, as will presently be described, opens at its bottom outer contact the previously described operating path for relay 18, thereby preventing same from being operated. The release of relay 72 also closes an operating circuit for relay 52 traced from ground at the contact of relay 72, right inner contact of relay 71, armature and contact of relay 67, left inner contact of relay 61, to battery through winding of relay 52. Relay 52 operates and at its bottom inner contact locks to ground at contact 95 on relay 61; opens the operating path at its bottom outer contact for the release relay 18; prepares a circuit at its top inner contact for operating ringing control relay 51; closes ground at contact 96 for operating relay 20 over lead 97 which is further traced through a contact on relay 21 to battery through winding of said relay; and at contact 98 maintains a ground for busy test purposes through the bottom outer contact on relay 57 and contact on relay 59 to lead 91 traced thence to sleeve lead 34 of line No. 1. Relay 20 of the control circuit C operating at this time registers the fact that this is a reverting call. It therefore opens the ground path at its right outer contact which is used on regular calls for operating selecting magnets such as magnet 6 associated with the terminating end of the link. It closes a locking circuit for itself at its right inner contact to ground at relay 18. Relay 20 at its left inner make contact connects ground through winding of relay 17 to battery. The latter relay upon operating thus serves to open leads 27 and 32 and prevent any momentary circuit effect from relay 14, the operation of which will presently be described.

The calling subscriber is now assumed to hang up which starts the link circuit ringing on the line. Supervisory relay 63 releases which in turn releases relay 64 and slow release guard relay 60. The latter relay at its back contact then closes a path from ground through the top inner armature and front contact of operated relay 52, thence through winding of relay 51 to battery. Relay 60 also removes its ground from the winding of relay 61 but the latter relay remains operated from ground at its own contact 99 traced through the bottom inner contact of relay 57, thence through contact 100 on relay 52. Relay 51 operating in the path traced above closes a locking circuit for itself at its bottom inner contact to ground at contact 84 on relay 62; at its bottom outer contact continues to hold open the

path through relay 60; and at its two top inner armatures disconnects line No. 1 from the calling end of the link and connects it to the called end 43 in order to permit relay 57 to act as the tripping relay, the same as it does on regular calls. Relay 51 at the top outer contact also connects ground through the top outer contact on relay 57, through winding of relay 68 to battery. The latter relay in operating, in turn operates relay 69 and then relay 70, thereby preparing the link for further functioning when the called subscriber answers. Relay 51 at other contacts, not shown, starts the link to sending out ringing current on line No. 1, the details of which may be found in the above mentioned patent to Bowne et al.

The called subscriber 5 on line No. 1 is now assumed to answer the ringing signal by removing his receiver from the switch-hook. The calling subscriber 4 noting that ringing has ceased also removes his receiver. This bridge on the line causes relay 57 to operate and remove the ringing current in the usual way. Relay 57 at its bottom outer contact opens one ground path through right outer contact on relay 59 and lead 91 that has been maintaining ground on sleeve lead 34 and holding magnet 11. The other ground path from relay 71 over leads 93 and 92 is also removed, due to the release of relay 71 when its holding path over lead 94 is disconnected from ground at the bottom inner contact on relay 57. The release, therefore, of holding magnet 11 at this time causes line No. 1 to be disconnected from the link at switch contacts 30 and the line relay 14 reoperates. When relay 57 operated it also released relay 61 by opening its holding circuit at the bottom inner contact previously traced. The operation of relay 57 at its top outer contact causes slow release relay 68 to start releasing, during which time the holding magnet 11 is caused to release as just described. In this same period relay 61 releases as above described, which obviously releases relay 52, relay 62, and in turn relays 51 and 57. Therefore, the only relays in the link circuit that remain operated at this time are relays 59, 68, 69 and 70.

When slow release relay 68 releases, it opens the ground circuit that has been holding relay 69 operated, and at its back contact closes ground to lead 101, traced through a contact on relay 21, contact 45 on operated relay 20, left outer contact on relay 16, thence over lead 46 through winding of selecting magnet 10 for frame S. The operation of said magnet then connects ground to lead 47 traced through a contact on relay 21 to lead 48, thence over lead 92, right outer contact of relay 59, lead 91, and through contact on relay 21, through right outer contact of relay 16, lead 33 to battery through winding of holding magnet 11. Cross-bar switch contacts 49 therefore operate and serve to connect the battery and ground windings of line relay 14 to the talking conductors of line No. 1, thereby feeding talking battery to subscribers 4 and 5. Relay 14 remaining operated under this condition, at its right outer contact, maintains a locking circuit for holding magnet 11 through one of the switch contacts 49 to sleeve lead 33.

Slow releasing relay 69 provides whatever time is necessary for the action in the preceding paragraph to take place. When said relay therefore releases, it opens the holding circuit for relay 59 and for a third slow release relay 70. Relay 69 at its right back contact closes ground through the make contact on relay 70 to lead 86 for operating relay 18, which releases the control circuit C. That is to say, relay 18 operated, opens ground at its left break contact to release relay 16. At its right inner contact it opens ground to release relay 21 and at its right outer contact it opens ground to release relay 20. Finally the slow release relay 70 of the link circuit releases and opens the ground path to lead 86 mentioned above, thus restoring the link circuit to normal.

Subscribers 4 and 5 thus continue to carry on conversation with only the line relay 14 locked to the line through switch contacts 49, thereby leaving the link circuit free for other calls between subscribers on different lines. At the end of conversation when both subscribers hang up their receivers, line relay 14 releases thereby releasing holding magnet 11 and opening the switch contacts 49 thus restoring the line circuit to normal.

What is claimed is:

1. The combination in a telephone system of a switch having sets of contacts, a subscriber's line appearing in the contacts of said switch, a line relay for said line, circuit means for connecting said line to said relay when the switch is in its normal condition, and circuit means effective when said switch is in its operated condition for connecting said line to said relay through an operated set of said switch contacts.

2. The combination in a telephone system of a switch, a subscriber's line, a line relay for said line normally connected thereto, and means effective when said switch is in its operated condition for opening said connection between the line and the line relay and for connecting said line to said relay through an operated set of said switch contacts.

3. In a telephone system, an automatic switch, a subscriber's line and a line relay therefor, a connecting circuit, means for operating the switch to extend the line to said connecting circuit and to disconnect the relay from the line, means for releasing said switch to disconnect the line from said connecting circuit, and means for reoperating said switch to connect the line to said relay through contacts of the switch without extending the line to said connecting circuit.

4. The combination in a telephone system of a switch having a plurality of contact sets and an operating magnet, a subscriber's line and a line relay therefor, means for energizing said magnet to extend the subscriber's line through one set of contacts of said switch and to disconnect the line relay from said line, and means controlled by the operation of said magnet for operating said switch to connect the subscriber's line to the line relay through another of said sets of switch contacts.

5. The combination in a telephone system of a switch having a plurality of sets of contacts, a magnet for operating said switch, a subscriber's line having a line relay normally connected thereto, means controlled by the operation of said magnet for closing a set of switch contacts to extend the subscriber's line, circuit contacts opened by the energization of said magnet for disconnecting the line relay from the subscriber's line, and means controlled by another operation of said magnet for closing a set of switch contacts to connect the subscriber's line to said line relay independently of said circuit contacts.

6. The combination in a telephone system of a cross-bar switch having a plurality of separately operable contact sets arranged in vertical and horizontal rows, subscribers' lines, each appearing in a vertical row of contacts of said switch, con-

necting circuits appearing in horizontal rows of contacts in said switch, switch operating magnets individual, respectively, to the vertical rows of contacts in said switch, line relays, each of said relays being normally connected to the corresponding line through circuit contacts on the corresponding magnet, means for operating one of said magnets to extend the corresponding line to a connecting circuit and to open said circuit contacts to disconnect the line relay from said line, and means controlled by another operation of said magnet for connecting the corresponding line relay through contacts of the switch to the subscriber's line.

7. The combination in a telephone system of a cross-bar switch having vertical and horizontal rows of contacts, subscribers' lines appearing, respectively, in the vertical rows of contacts, switch operating magnets individual, respectively, to the vertical rows of contacts, line relays for said lines normally connected to the corresponding lines through normal contacts of the corresponding switch magnets, each of said line relays appearing in a single set of switch contacts in the corresponding vertical row, means for operating a switch magnet to open the normal connection of the line relay to the corresponding line and for operating the switch to connect the line relay through the contacts of the switch in which it appears to the corresponding subscriber's line, and a holding circuit for the magnet extending through the closed contacts of the switch to a contact on said line relay.

8. The combination in a telephone system of a subscriber's line having a plurality of substations thereon, an automatic switch in which said line terminates, connecting circuits appearing in said switch, a line relay individual to said line and normally connected thereto, means for operating said switch to extend said line to one of said connecting circuits and to disconnect the line relay from said line, means effective when a subscriber on said line makes a revertive call for automatically releasing said switch to disconnect the line from the connecting circuit, and means effective for reoperating said switch to connect the subscriber's line to the line relay through contacts of the switch without extending the line to one of said connecting circuits.

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