July 2, 1935. H. HOVLAND 2,006,354

TELEPHONE SYSTEM

Filed June 20, 1934 2 Sheets-Sheet 1

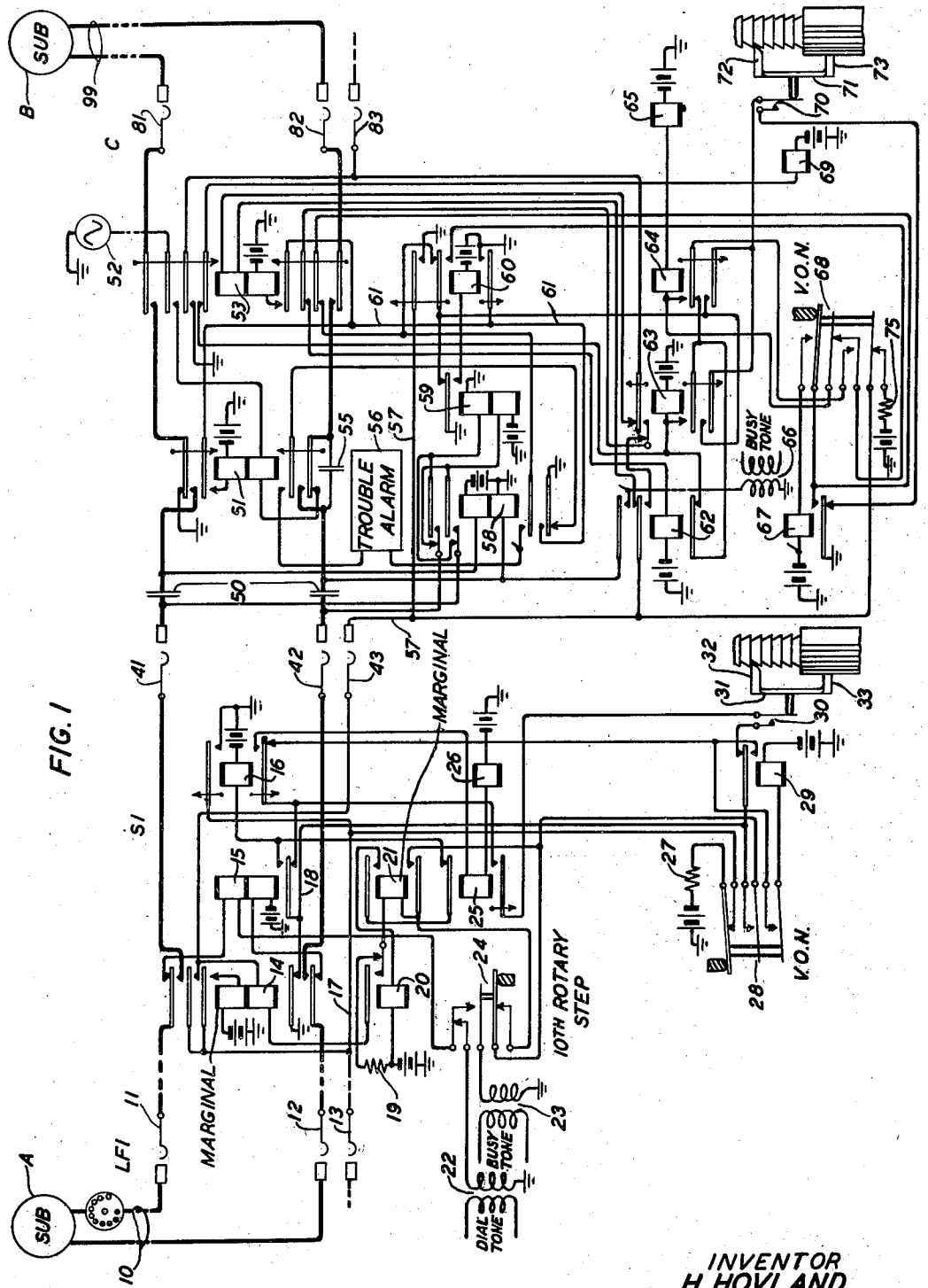

FIG. 1

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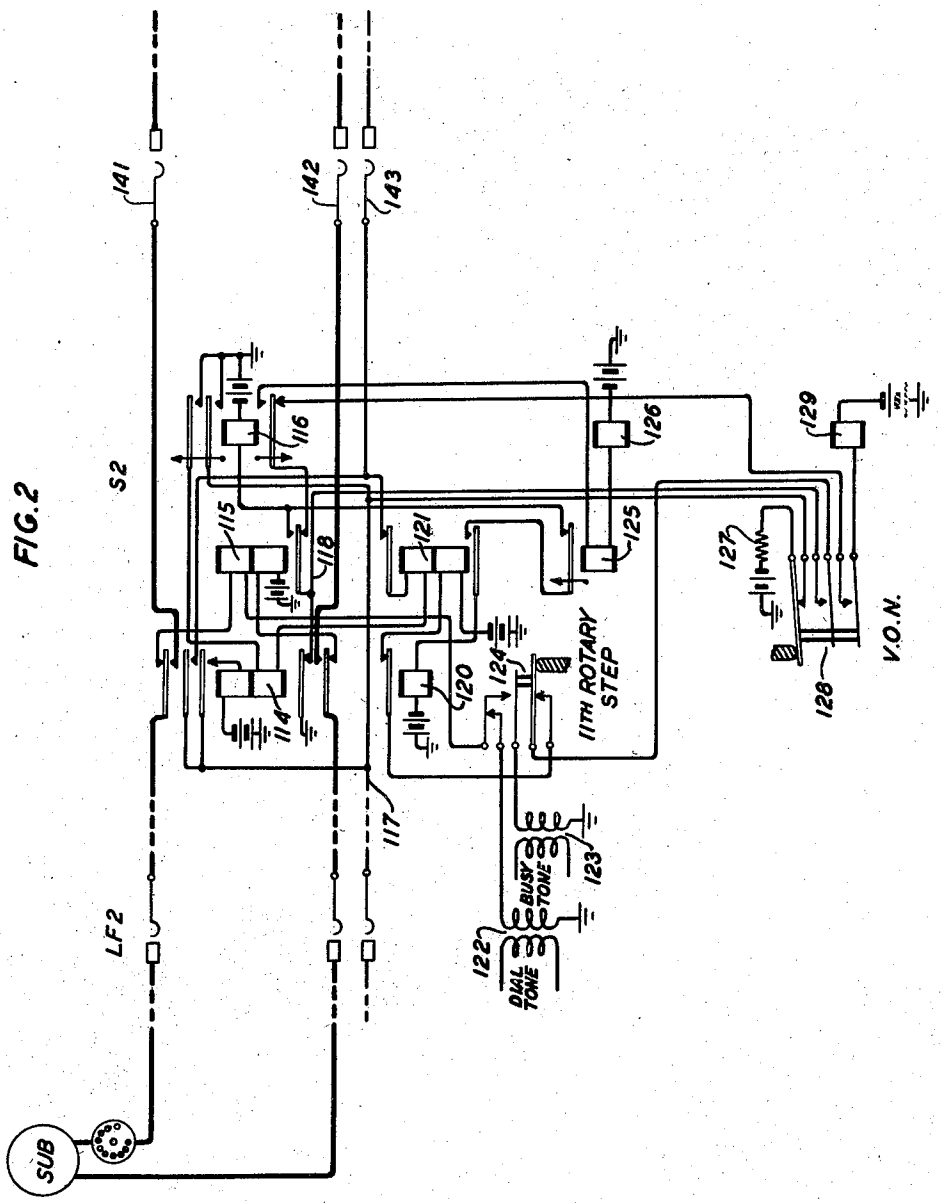
Filed June 20, 1934 2 Sheets-Sheet 2

FIG. 2



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Patented July 2, 1935 2,006,354

UNITED STATES PATENT OFFICE

2,006,354

TELEPHONE SYSTEM

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Application June 20, 1934, Serial No. 731,432

10 Claims. (Cl. 179—18)

This invention relates to telephone systems and more particularly to systems employing automatic switches of the step-by-step type.

The object of the invention is to provide a circuit arrangement for step-by-step switches which is more reliable in operation and which is capable of satisfactory operation when associated with lines or trunks which have a lower conductivity or a lower insulation resistance than has heretofore been found practicable. A further object of the invention is to provide a circuit arrangement in which the possibility of a trunk being simultaneously seized by two switches is eliminated.

According to this invention a circuit arrangement is provided for a switch of the step-by-step type wherein a holding circuit is closed for the stepping magnet as soon as the shaft and brushes begin to move out of one position until the next position is reached, thereby continuing the engagement of the stepping pawl with the ratchet long enough to prevent overstepping.

A feature of the invention is a two-motion step-by-step switch in which contact springs are actuated by the movement of the double dog at the beginning of the movement of the shaft out of any of its vertical positions of rest, thereby closing a holding circuit for the vertical-stepping magnet to insure the engagement of the vertical-stepping pawl with the vertical ratchet for a long enough interval to prevent overstepping. If the switch is directively operated in its rotary movement, the closing of the double dog springs at the beginning of each rotary step is effective to hold the rotary-stepping magnet operated and thereby insure the engagement of the rotary-stepping pawl with the rotary ratchet long enough to prevent overstepping.

A further feature of the invention is a new and reliable circuit arrangement for a step-by-step selector switch wherein the brushes are advanced during trunk-hunting until the test brush encounters a battery potential, sufficient resistance being included in the idle battery connection to insure against the seizure of the same trunk by two selectors at the same time. According to one embodiment of this feature, a back contact and one winding of a differentially wound stepping relay are included in the test circuit, whereby the test circuit is closed as soon as the stepping relay releases and without danger of overstepping. According to an alternative embodiment of this feature, the test circuit includes a continuity contact of the stepping magnet and the winding of a marginal stepping relay whereby the test circuit is closed as soon as the test brush engages the test terminal of each set to which the selector brushes are advanced.

The drawings which form a part of this specification represent a telephone system in which the invention is embodied, but the invention is not limited in its application to the specific arrangements shown.

Referring to the drawings,

Fig. 1 shows, schematically, subscribers' stations A and B, a line-finder LF1, a selector S1, and a connector C;

Fig. 2 shows an alternative circuit arrangement for a selector.

The subscribers' stations are of the type usually employed in automatic telephone systems and each includes a dial for use in obtaining connection with any other station. The line-finder, selector and connector switches are of the well known two-motion Strowger type. For a description of the general structure of such switches, reference may be had to pages 53 to 65 inclusive of the 2nd edition of "Automatic Telephony" by Smith and Campbell. The selector switch S1 shown in Fig. 1 differs from the selector switch described in "Automatic Telephony" by the addition of contacts operated by the double dog 31 while either of the vertical or rotary holding pawls 32 or 33 is riding up on a tooth of the vertical or rotary ratchets. In the selector S1, the added contact springs 30 are actuated by the movement of the vertical holding pawl 32 while the shaft is being stepped from one level to the next, or by the movement of the rotary holding pawl 33 while the shaft is being rotated from one position to the next. The closing of contacts 30 insures the continued operation of the vertical-stepping magnet 26 so that the vertical-stepping pawl is held in engagement with the ratchet long enough to prevent overstepping. The connector C also differs from the connector switch described in "Automatic Telephony" by the addition of contacts 70 operated by movement of the double dog 71 while either of the vertical or rotary holding pawls 72 or 73 is riding up on a tooth of the vertical or rotary ratchets. The vertical-stepping magnet 65 or rotary-stepping magnet 69 are each held operated by the closure of contacts 70 for a sufficient length of time to insure against overstepping if the line relay 59 reoperates before the stepping magnet is fully operated. This arrangement results in improved operation and permits the subscriber's line to be of higher resistance and to have a lower in-

sulation resistance without causing switch failures. The circuit arrangements of the selector S1 and the connector C are shown in full in the drawings and their operation will be set forth in detail. The line-finder switch is represented by the brushes and a single set of terminals, all associated apparatus having been omitted. Reference may be had to my Patent No. 1,711,682 granted May 7, 1929 for a description of the operation of a line-finder switch of the Strowger type.

Assuming a call to have been originated at station A, and that the line 10 has been extended through the brushes of line-finder LF1 to the first selector S1, a circuit is closed for operating the line relay 15. This circuit is traced from battery through the lower winding of relay 15, lowermost back contact of relay 14, brush 12 of line-finder LF1, over one conductor of line 10 and through the telephone at station A, back over the other conductor of line 10, through brush 11 of line-finder LF1, uppermost back contact of relay 14, upper winding of relay 15, upper normally closed contacts of the "10th Rotary step" springs 24 and through the right winding of the dial tone transformer 22 to ground. Relay 15 closes at its front contact a circuit through the winding of release relay 16. Relay 16 operates thereby connecting ground through its upper front contact to conductor 17 to hold the line-finder switch LF1 in operated position and to hold the cut-off relay (not shown) of line 10 all in well known manner. Dial tone is transmitted from transformer 22 to the calling subscriber and when the calling subscriber dials the first digit of the number of a station with which connection is desired, the line relay 15 of selector S1 is alternately released and reoperated as many times as there are units in the digit dialed. The first release of relay 15 closes a circuit from battery through the winding of the vertical-stepping magnet 26, winding of relay 25, lower front contact of relay 16, back contact of relay 15, and through the inner lower back contact of relay 14 to ground. The current in this circuit operates magnet 26 and operates relay 25. The operation of magnet 26 steps the shaft and brushes of selector S1 up to the first level of the terminal bank. The reoperation of relay 15 opens the above traced circuit through the windings of magnet 26 and relay 25, but these windings are held energized through the front contact of relay 25 and contacts 30, actuated by the movement of the vertical holding pawl 32 of double dog 31 while the shaft and brushes are being elevated, and through the back contact of release magnet 29, over conductor 18 to ground at the inner lower back contact of relay 14. By holding the magnet 26 operated while the shaft is moving between levels, the vertical driving pawl (not shown) is held in engagement with the vertical ratchet to prevent the shaft from being carried up by its momentum more than one step in response to one dial impulse. When the holding pawl 32 engages the ratchet to hold the shaft in its first vertical off-normal position, the contacts 30 are opened and the magnet 26 releases. Relay 16 is slow in releasing and remains operated during the receiving of dial impulses by relay 15. Relay 25 is also slow in releasing and remains operated until all of the impulses, corresponding to the first digit, have been received. Each succeeding release and reoperation of relay 15 is effective in similar manner to step up the shaft and brushes of switch S1 one step, overstepping being prevented by the closing of contacts 30 while each vertical step is being taken.

As soon as the shaft of switch S1 is moved out of normal position the vertical off-normal springs 28 are actuated thereby disconnecting the battery potential through resistance 27 from the test conductor 17. Were the selector S1 an intermediate selector instead of a first selector, the disconnection of this battery potential from conductor 17 would render the selector S1 nonselectable, by a preceding selecter, for use on another call. The actuation of the vertical off-normal springs 28 also closes a circuit for operating relay 21; this circuit is traced from battery through resistance 19, back contact of the rotary-stepping magnet 20, winding of relay 21, lower normally closed contacts of the "10th Rotary step" springs 24, middle contacts of the vertical off-normal springs 28, conductor 18, to ground at the inner lower back contact of relay 14. The release of relay 25, after the last impulse in the train created by dialing of the first digit has been received, closes a circuit for operating the rotary stepping magnet 20; this circuit is traced from battery through the winding of magnet 20, upper front contact of relay 21, back contact of relay 25, front contact of relay 15 to ground at the inner lower back contact of relay 14. The operation of magnet 20 rotates the brushes 41, 42 and 43 into engagement with the first set of terminals in the level of the bank selected in response to the dialing of the first digit as above described. The operation of magnet 20 also opens the operating circuit for relay 21 and connects the winding of relay 21 in series with the lower winding of relay 14 to the test brush 43. If the terminal with which test brush 43 is in contact is not connected to an idle-indicating potential, either on account of the test conductor of the trunk being open or due to the switch to which the trunk connects being off-normal or in use, relay 21 releases thereby causing the release of magnet 20. The release of magnet 20 disconnects the winding of relay 21 from the test brush 43 and again closes the operating circuit of relay 21. The reoperation of relay 21 causes the reoperation of magnet 20 thereby advancing the brushes of selector S1 to the next set of terminals in the selected level. Relay 21 and magnet 20 continue their cycle of operations until brush 43 encounters a test terminal which is connected to the idle-indicating potential or until the tenth and last set of terminals in the level is reached at which time the actuation of the "10th Rotary step" springs 24 prevents the reoperation of relay 21. If the switch is rotated to the 10th rotary position and the test terminal of the tenth set of terminals is not connected to the idle-indicating potential when brush 43 engages this terminal, the busy-tone source 23 is connected through the front contact of the springs 24, the upper winding of relay 15, the uppermost back contact of relay 14, and through brush 11 of line-finder LF1 to one of the conductors of line 10.

When the test brush 43 encounters a terminal which is connected to the idle-indicating potential, relay 21 is held operated and the lower winding of relay 14 is energized. Assuming the terminals in question to be connected to the connector switch C, the circuit for holding relay 21 operated, to prevent further advance of the

brushes of switch S1, is traced from battery through resistance 75 and the lowermost normally closed contacts of the vertical off-normal springs 68 of switch C, over conductor 57, through the test terminal and brush 43, lower winding of relay 14, front contact of magnet 20, winding and lower front contact of relay 21, middle contacts of the vertical off-normal springs 28, over conductor 18 to ground at the inner lower back contact of relay 14. Relay 14 is sufficiently energized by the current through its lower winding to close its inner upper front contact and thus cause the complete operation of this relay by energizing its upper winding. If the brush of more than one hunting selector should engage terminals connected to the same trunk, the drop in potential due to the resistance through which the idle-indicating battery potential is connected to the test terminals prevents the operation of the test relay in any of these selectors, thereby preventing a double connection. Should the test conductor connected to any set of terminals to which the brushes of switch S1 are advanced be open, relay 14 can not be operated and the release of relay 21 causes the advance of the switch to the next set of terminals. With relay 14 operated, a temporary busy-indicating ground potential is connected from the upper front contact of relay 16, over conductor 17, through the middle upper front contact of relay 14 and brush 43 to the test terminal of the seized trunk. The operation of relay 14 also causes the release of relays 21, 15 and 16 and the release of magnet 20. The line 10 is now connected through brushes 11 and 12 of line-finder LF1, the outermost front contacts of relay 14, through brushes 41 and 42 to the windings of line relay 59 of connector C. Relay 59 operates thereby causing the operation of relay 60. Relay 60 connects a busy-indicating and holding ground potential through its uppermost front contact, over conductor 57 to the test terminal with which brush 43 of selector S1 is in contact to hold relay 14 operated. This holding potential is further extended through the middle upper front contact of relay 14 and brush 13 of line-finder LF1 to hold the cut-off relay (not shown) of line 10 in well known manner.

When the subscriber at station A dials the next to the last digit of the number of the subscriber's station with which connection is desired, relay 59 is alternately released and reoperated in response to each of the dial impulses thus created. The first release of relay 59 closes a circuit from ground at its upper back contact, through the inner upper front contact of relay 60, upper normally closed contacts of the vertical off-normal springs 68, through the winding of relay 64 and winding of the vertical-stepping magnet 65 to battery. Relay 64 and magnet 65 both operate, the operation of magnet 65 being effective to step the shaft and brushes of the connector switch C up to the first level of the terminal bank. The vertical off-normal springs 68 are actuated as soon as the shaft is moved out of normal position, the circuit for operating magnet 65 and relay 64 being thereby changed to include the inner contact of relay 64 and the lower front contact of the vertical off-normal springs 68. The actuation of the vertical off-normal springs 68 also disconnects the idle-indicating battery potential from test conductor 57 to prevent seizure of the connector C by any other hunting selector until after the switch C has been restored to normal. The reoperation of relay 59 at the end of the first dial impulse of the train causes the release of magnet 65 unless the first impulse is not sufficiently long to insure proper switch operation, in which case the magnet 65 and relay 64 are held operated by the current in a circuit traced through the inner front contact of relay 64, lower front contact of the vertical off-normal springs 68, inner upper front contact of relay 60, lowermost front contact of relay 64, contacts 70 closed by the actuation of the double dog 71 while the shaft is moving between normal and the first level, to ground at the back contact of release magnet 67. Each succeeding release and reoperation of relay 59 in response to the impulses created by the dialing of the next to the last digit of the called subscriber's number causes the operation and release of magnet 65, the brushes 81, 82 and 83 being stepped up to the corresponding level of the terminal bank. The closing of the contacts 70 by the actuation of the double dog 71, while the shaft is being stepped from each level to the next, maintains the energization of magnet 65 in response to each release of relay 59 for a sufficient length of time to prevent overstepping. Relay 60 is slow in releasing and remains operated during the receipt of dial impulses by relay 59. Relay 64 is also slow in releasing and does not release until all of the impulses created by the dialing of the next to the last digit of the called subscriber's number have been received by relay 59.

When the last digit of the called subscriber's number is dialed, relay 59 is again alternately released and reoperated by each of the dial impulses thus created. The release of relay 59 in response to the first of these impulses closes circuits for operating relay 63 and the rotary stepping magnet 69; these circuits are traced from ground at the back contact of relay 59, inner upper front contact of relay 60, lower front contact of the vertical off-normal springs 68, back contact of relay 64, lower back contact of relay 62, thence through the winding of relay 63 to battery and through the upper back contact of relay 53 and the winding of magnet 69 to battery. The operation of magnet 69 steps the brushes 81, 82 and 83 into engagement with the first set of terminals in the selected level. The operation of relay 63 connects the winding of relay 62, in series with the inner lower back contact of relay 53, through the upper front contact of relay 63 to the test brush 83. The reoperation of relay 59 at the end of the first impulse opens the operating circuit for magnet 69, but magnet 69 is held operated while the shaft is moving from one rotary position to the next by the closing of a holding circuit through contacts 70 due to their actuation by the double dog 71; this holding circuit is traced from ground at the back contact of release magnet 67, through contacts 70, lowermost front contact of relay 63, to the inner upper front contact of relay 60, and thence to the windings of relay 63 and magnet 69 as hereinbefore described. The continued operation of magnet 69 by the circuit through contacts 70 insures against rotary overstepping. Relay 63 is slow in releasing and remains operated until all of the impulses corresponding to the last digit of the called number have been received by relay 59. Since the inner lower front contact of relay 63 is in parallel with the lower back contact of relay 62, a temporary operation of test relay 62 upon passing over a busy terminal does not interfere with the operation of magnet 69 in response to succeeding impulses received by relay 59. Each release and reoperation of

relay 59 is, therefore, effective to cause the operation and release of magnet 69 and thus advance the brushes of the connector into engagement with the set of terminals to which the called line is connected. If this line is busy, test relay 62 is operated due to the energization of its winding when brush 33 comes to rest on the grounded test terminal of the line; when relay 63 releases, relay 62 is held operated through the inner upper back contact of relay 63 and the inner upper front contact of relay 62 over conductor 57 to ground at relay 60, and a busy tone is thereupon transmitted from tone source 66 through the uppermost front contact of relay 62 through the lower condenser 50 to the calling subscriber. If the called line is idle, test relay 62 does not operate; and when relay 63 releases, a circuit is closed from ground at the uppermost front contact of relay 60, over conductor 57, upper back contact of relay 62, upper winding of relay 53, uppermost back contact of relay 63, brush 33 and test terminal, and through the winding of the cut-off relay (not shown) of the called line to battery. Relay 53 is sufficiently energized by the current through its upper winding to close its inner lower front contact and thus cause the complete operation of this relay by the energization of its lower winding. Relay 53 closes the ringing circuit from the generator 52, through the middle upper front contact of relay 53, lower winding and lower back contact of relay 51, lowermost front contact of relay 53, brush 82, over the lower conductor of the called line 99 through the ringer (not shown) at station B, back over the other conductor of line 99, brush 81, uppermost front contact of relay 53, to ground at the uppermost back contact of relay 51. Ringing tone is transmitted through condenser 55 to the calling station. When the receiver is removed at station B, relay 51 is sufficiently energized by the current through its lower winding to close its inner upper front contact and thus cause the complete operation of this relay due to the energization of its upper winding. Relay 51 completes the talking connection through its outermost front contacts and through condensers 50, talking current being supplied to the called station through the windings of relay 58. The operation of relay 58 while the line is closed at station B interchanges the connection between the calling line and the windings of relay 59, the resulting reversal of current being useful for supervision or call charging.

When the calling subscriber replaces the receiver on the receiver hook, relay 59 releases followed by the release of relay 60. The release of relay 59 causes a momentary operation of relay 63 before relay 60 releases. The release of relay 60 is followed by the release of relay 63 and the connection of conductor 57 through the upper back contact of relay 62, upper winding of relay 53, uppermost back contact of relay 63, to ground at the inner upper front contact of relay 53 as a guarding potential in place of the ground previously furnished at the uppermost front contact of relay 60. While relay 63 is operated after relay 59 releases, the sleeve conductor 57 is momentarily freed of any ground potential, thereby causing the release of relay 14 of selector S1 and the release and return to normal of the line-finder LF1. The release of relay 14 closes a circuit for operating the release magnet 29, and the brushes of switch S1 are restored to normal. The release magnet 29 is held operated until the vertical off-normal springs are restored to normal position, the holding circuit being traced from the winding of magnet 29, through the lower front contact of the vertical off-normal springs 28, front contact of magnet 29, over conductor 18, to ground at the inner lower back contact of relay 14. When the shaft reaches normal and springs 28 are in normal position magnet 29 releases, the idle-indicating battery potential being thereupon reconnected through resistance 27 to the sleeve conductor 17. If the called subscriber delays in replacing the receiver on the receiver hook, relays 51 and 53 are held operated under control of relay 58, and ground is connected through the upper back contacts of relays 59 and 60 and the inner lower front contact of relay 58 to cause the operation of a trouble alarm signal. When the receiver is replaced on the receiver hook at the called station, relay 58 releases followed by the release of relays 51 and 53. With relays 59, 60 and 53 all released, the release magnet 67 is operated. Magnet 67 locks through the upper front contact of the vertical off-normal springs 68. When the shaft reaches normal, magnet 67 releases and the idle-indicating battery potential is again connected through resistance 75 to the sleeve conductor 57 thereby rendering the connector C selectable for use on another call.

In Fig. 2 is shown an alternative arrangement of a selector for insuring against double connections. Upon extension of a calling line through the line-finder LF2 to the selector S2, the line relay 115 is operated in series with the calling line. The operation of relay 115 causes the operation of relay 116. Relay 116 connects ground to the sleeve conductor 117 to hold the line-finder LF2 and cut-off relay (not shown) of the calling line. When the calling subscriber dials the first digit of the number of a subscriber's station with which connection is desired, relay 115 is alternately released and reoperated, relay 125 and the vertical-stepping magnet 126 being operated in series upon the release of relay 115 in response to the first dial impulse. Magnet 126 releases when relay 115 reoperates, each succeeding release and reoperation of relay 115 being effective to cause a corresponding operation and release of magnet 126. Relay 125 is slow in releasing and remains operated until relay 115 reoperates after the last of the train of impulses has been received. Relay 116 is also slow in releasing and is operatively unaffected by the receipt of dial impulses. Each operation of magnet 126 raises the brushes 141, 142 and 143 one step, thereby selecting the level of terminals which corresponds to the digit dialed.

The actuation of the vertical off-normal springs 128 when the shaft of switch S2 moves out of its normal position opens the connection between resistance 127 and the test conductor 117 and closes a circuit for operating relay 121; this circuit is traced from battery through the lower winding of relay 121, back contact of the rotary-stepping magnet 120, lower normally closed contacts of the "11th Rotary step" springs 124, middle contacts of the vertical off-normal springs 128, over conductor 118, to ground at the inner lower back contact of relay 114. When relay 125 releases, after all of the impulses created by the dialing of the first digit have been received, a circuit is closed for operating the rotary-stepping magnet 120; this circuit is traced from battery through the winding of magnet 120, front contact of relay 121, back contact of relay 125, and through the front contact of relay 115 to ground at the inner lower back contact of relay 114. The

operation of magnet 120 steps the brushes into engagement with the first set of terminals in the selected level and causes the release of relay 121. The release of relay 121 causes the release of magnet 120. Upon release of relay 121, a testing connection is closed from ground at the uppermost front contact of relay 116, through the lower winding of relay 114, upper winding and back contact of relay 121, through brush 143 to the test terminal of the set with which the brushes are in engagement. If the succeeding switch to which this set of terminals is connected is busy, in which case the test terminal is connected to a guarding ground potential, or if the test conductor leading to this switch is open, there is no current through the lower winding of relay 114 and upper winding of relay 121; and relay 121 is reoperated due to the current through its lower winding and the back contact of magnet 120, so that magnet 120 and relay 121 continue their cycle of operations to step the brushes from one terminal to the next until brush 143 encounters a test terminal connected to battery potential as an idle-indicating condition. If all of the terminals in the selected level are non-selectable, the brushes are rotated to the 11th rotary position, in which position the "11th Rotary step" springs 124 are actuated to prevent further operation of the stepping relay 121 and a busy tone is transmitted to the calling line.

When brush 143 encounters the idle-indicating battery potential, the cut-through relay 114 is operated sufficiently by the current through its lower winding to close its inner upper front contact and thus cause the complete operation of this relay due to the current through its upper winding, but the stepping relay 121 can not reoperate since the current through its upper winding electromagnetically opposes the current through its lower winding. If the brushes of two selectors should simultaneously engage terminals connecting to the same trunk, the resistance in series with the idle-indicating potential source is sufficient to prevent the operation of the cut-through relay of either of these selectors and to permit the operation of the stepping relay in each of the selectors and thus prevent a double connection. The operation of relay 114 extends the connection from the calling line through its outermost front contacts and through brushes 141 and 142 to the selected trunk. Relays 115 and 116 release but relay 114 is held through its upper winding over sleeve conductor 117 through brush 143 to ground potential supplied by the succeeding switch in well known manner. When the connection is released by the calling subscriber this ground potential is disconnected from the terminal with which brush 143 is in contact and relay 114 releases. The release of relay 114 completes the usual circuit for operating the release magnet 129 and the brushes and shaft of switch S2 are thereupon returned to normal position. When the vertical off-normal springs 128 are restored to normal, the idle-indicating potential is again connected through resistance 127 and the uppermost contacts of these springs to the sleeve conductor. Were the selector S2 an intermediate selector connected to terminals in the banks of preceding selectors, this connection of battery potential over conductor 117 to the test terminals renders the selector S2 selectable for use on another call.

What is claimed is:

1. In a telephone system, a step-by-step switch comprising a shaft, a bank of terminals, a set of brushes mounted on said shaft and movable therewith into cooperative engagement with said terminals, a stepping magnet, a driving pawl for cooperation with a ratchet on said shaft, the operation of said magnet being effective to engage said pawl and ratchet to advance the shaft and brushes one step at a time, and a retaining pawl for holding said shaft in advanced position, an impulse receiving relay, a circuit closed by the release of said relay in response to each impulse received for operating said stepping magnet, and a circuit closed as soon as said shaft begins to advance out of one position and until it reaches the next off-normal position of rest for maintaining the energization of said magnet.

2. In a telephone system, a step-by-step selector comprising a shaft, a bank of terminals, a set of brushes mounted on said shaft and movable therewith into cooperative engagement with said terminals, and a stepping magnet, the operation of said magnet being effective to advance the brushes one step at a time, trunks connected to the terminals of said bank, the idle condition of a trunk being indicated by a battery potential connected over its sleeve conductor to the test terminal of the set to which the trunk is connected, means including a stepping relay and said magnet for advancing said brushes, a switching relay for operation to seize an idle one of said trunks, and a test circuit closed when the test brush is in engagement with the test terminal of a trunk, which circuit includes a winding of said switching relay and a winding of said stepping relay.

3. In a step-by-step selector switch, a magnet, the operation of said magnet being effective to move said switch one step, a circuit for operating said magnet, an impulse circuit, means for closing said operating circuit in response to an impulse in said impulse circuit, another circuit for energizing said magnet, and springs actuated upon each step of said switch for closing and maintaining said other circuit until said switch has stepped.

4. In a step-by-step selector switch, a magnet, the operation of said magnet being effective to move said switch one step, a circuit for operating said magnet, an impulse circuit, means for closing said operating circuit in response to the opening of said impulse circuit, another circuit for energizing said magnet, and springs actuated upon each step of said switch for closing and maintaining said other circuit until said switch has stepped.

5. In a numerical step-by-step selector switch, a stepping magnet, an impulse circuit, means responsive to an impulse in said circuit for operating said magnet to advance the switch one step, and springs actuated by the retaining pawl while sliding over a tooth of the ratchet on the switch shaft for maintaining the energization of said stepping magnet until the step has been completed.

6. In a numerical step-by-step switch, a vertical-stepping magnet and operating circuit therefor, a rotary-stepping magnet and operating circuit therefor, a double dog engaging the vertical and rotary ratchets on the shaft of said switch for maintaining the shaft in an off-normal position, an impulse circuit, means responsive to an impulse in said impulse circuit for closing the operating circuit of said vertical-stepping magnet, means responsive to another impulse in said impulse circuit for closing the operating circuit of said rotary-stepping magnet,

another circuit for energizing said vertical-stepping magnet, another circuit for energizing said rotary-stepping magnet, and contact springs actuated by the movement of said double dog while the shaft is being moved one vertical step for closing said other circuit for energizing the vertical-stepping magnet and actuated by the movement of the double dog while said shaft is being moved one rotary step for closing said other circuit for energizing the rotary-stepping magnet.

7. In a step-by-step selector comprising a bank of terminals, a set of brushes and a stepping magnet, trunks connected to the terminals of said bank, the idle condition of a trunk being indicated by a battery potential connected over its sleeve conductor to the test terminal of the set to which the trunk is connected, means including a stepping relay and said magnet for advancing said brushes one step at a time, a switching relay, and a circuit for operating said switching relay and for preventing the reoperation of said stepping relay when the brushes encounter the terminals of an idle trunk.

8. In a step-by-step selector comprising a bank of terminals, a set of brushes and a stepping magnet, trunks connected to the terminals of said bank, the idle condition of a trunk being indicated by a battery potential connected over its sleeve conductor to the test terminal of the set to which the trunk is connected, means including a marginal stepping relay and said magnet for advancing said brushes one step at a time, a switching relay, and a circuit for operating said switching relay as soon as the brushes encounter the terminals of an idle trunk, said circuit including the winding of said stepping relay and a front contact of said magnet.

9. In a step-by-step selector comprising a bank of terminals, a set of brushes and a stepping magnet, trunks connected to the terminals of said bank, the idle condition of a trunk being indicated by a battery potential connected over its sleeve conductor to the test terminal of the set to which the trunk is connected, means including a stepping relay and said magnet for advancing said brushes one step at a time, a switching relay, and a circuit for operating said switching relay and for holding said stepping relay when the brushes encounter the terminals of an idle trunk.

10. In a step-by-step selector comprising a bank of terminals, a set of brushes and a stepping magnet, trunks connected to the terminals of said bank, the idle condition of a trunk being indicated by a battery potential connected over its sleeve conductor to the test terminal of the set to which the trunk is connected, means including a stepping delay and said magnet for advancing said brushes one step at a time, a switching relay, an operating circuit for said stepping relay including one winding of said stepping relay and a back contact of said magnet, and a circuit including another winding and a back contact of said stepping relay for operating said switching relay to seize an idle trunk, the current through said other winding of said stepping relay being electromagnetically opposed to the current through said one winding.

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