

Oct. 7, 1941.

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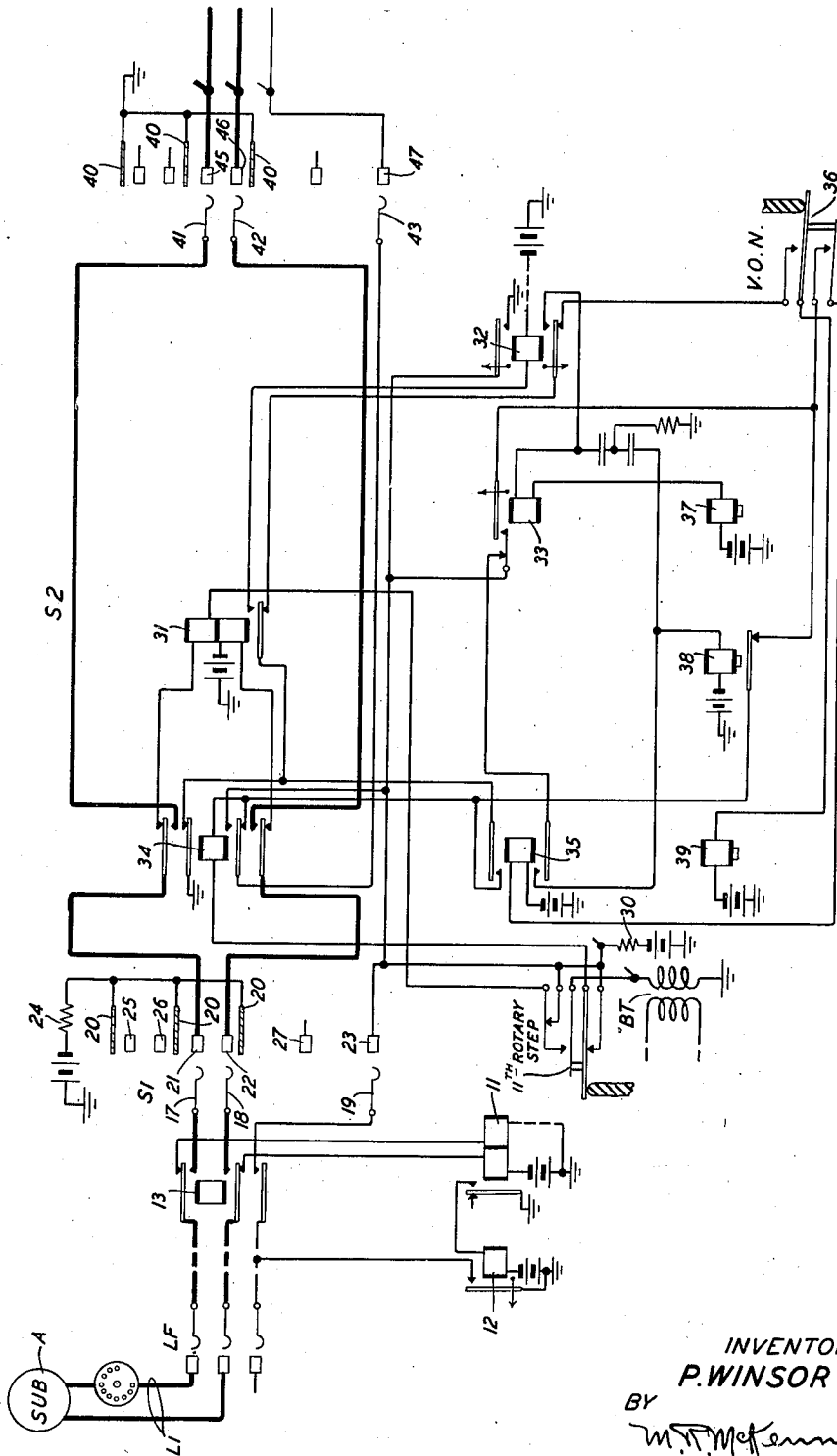
2,257,894

TELEPHONE SYSTEM

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4 Sheets-Sheet 1

FIG. 1



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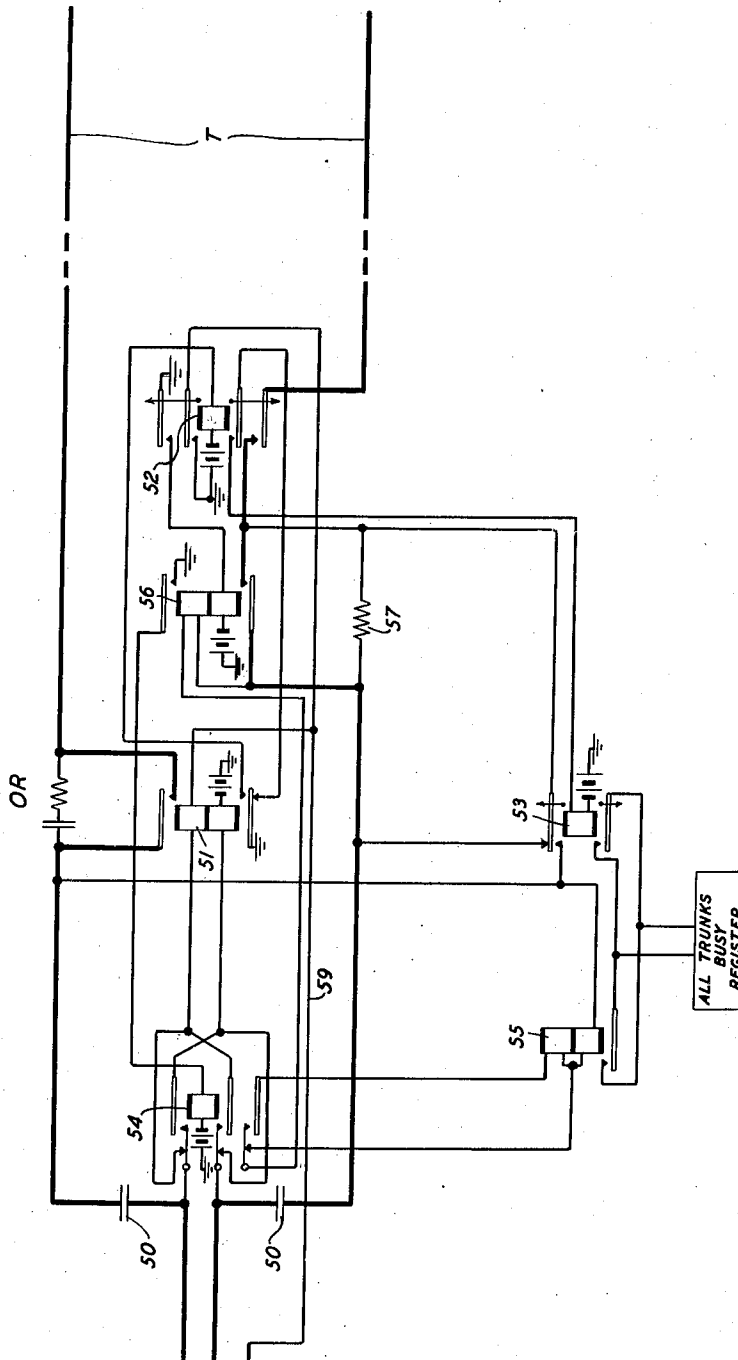
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TELEPHONE SYSTEM

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4 Sheets-Sheet 2

FIG. 2



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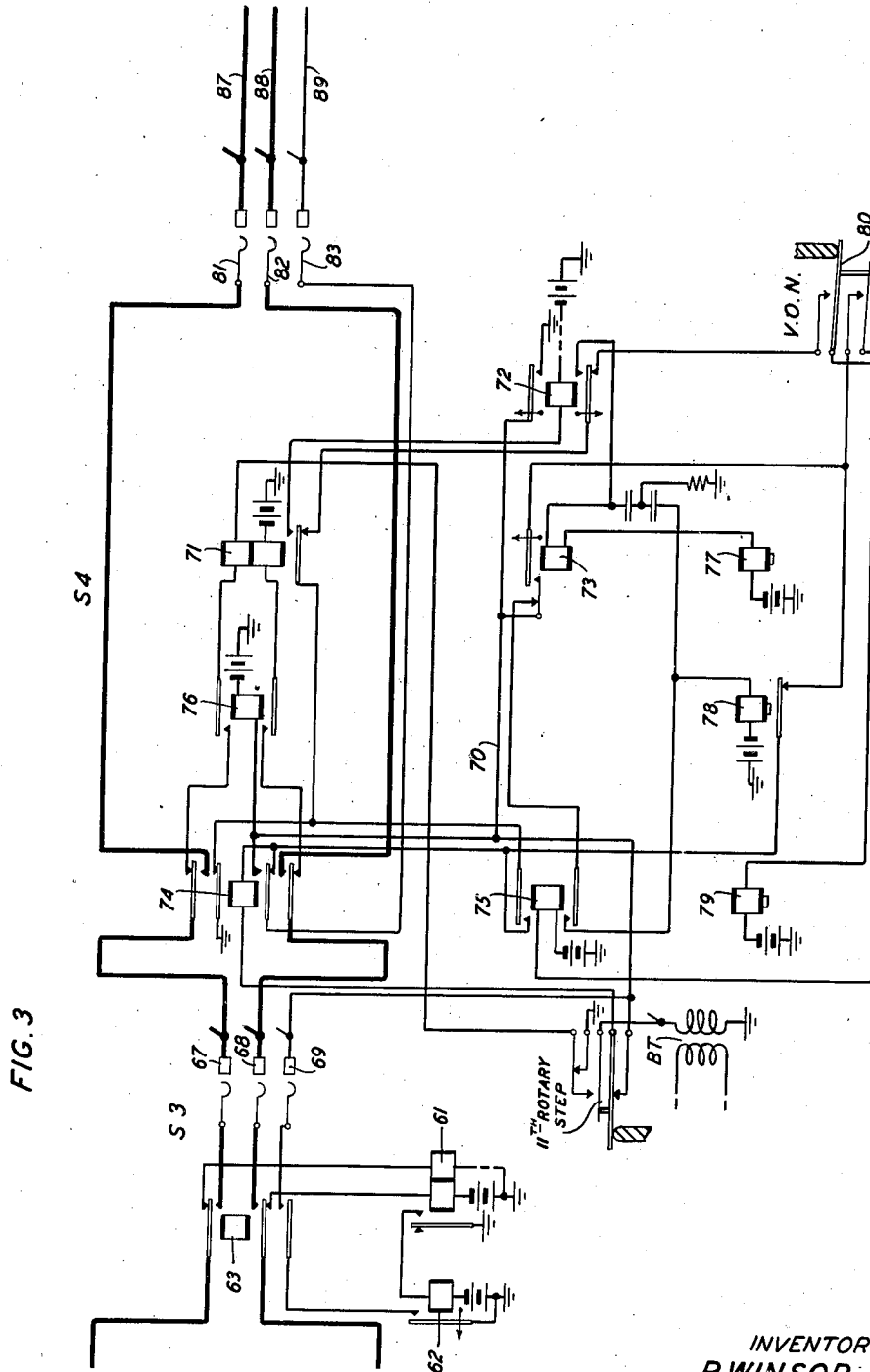
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TELEPHONE SYSTEM

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4 Sheets-Sheet 3



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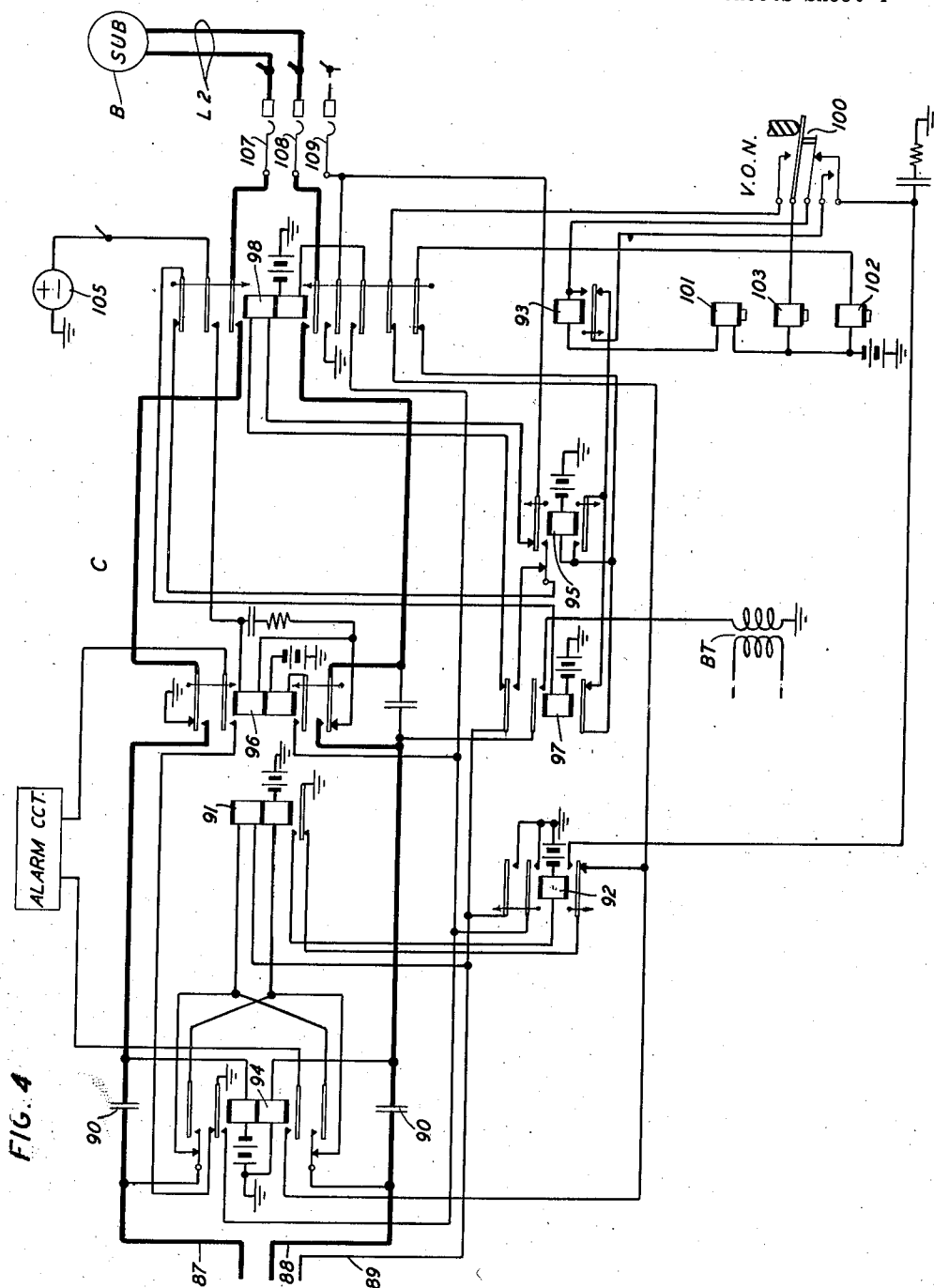
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TELEPHONE SYSTEM

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,257,894

TELEPHONE SYSTEM

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Application November 2, 1938, Serial No. 238,368

6 Claims. (Cl. 179—18)

This invention relates to telephone systems and particularly to systems comprising automatic switches.

It is the object of the invention to increase the reliability and increase the life of automatic switches in telephone or other communication and signaling systems, to reduce the cost of maintenance, and to prevent faulty operation and the disablement of the switching mechanism of such systems.

According to this invention each of the trunk, selector or connector circuits connected to the banks of an automatic switch comprising a set of brushes and a bank of terminals is arranged so as to eliminate or minimize the normally existing difference in potential between adjacent terminals in the bank. By eliminating or reducing this difference in potential, leakage currents are minimized and possible adverse effects on the insulation are prevented.

As applied to outgoing repeater circuits such, for instance, as are used in systems comprising switches of the well-known step-by-step type, the invention is a circuit arrangement whereby battery is normally connected through one winding of the line relay to one of the two terminals of a set to which the talking conductors of the circuit are connected, and the other talking terminal of this set is connected through another winding of the line relay to the sleeve or test terminal of the set, there being neither battery nor ground potential connected to the last-mentioned winding until the circuit is seized. Upon seizure of the circuit, the usual temporary connection of ground potential to the test terminal by the seizing switch to prevent seizure by another switch, is also effective to complete the circuit for operating the line relay of the seized circuit.

According to a further feature the circuit arrangement of a selector, connector or outgoing repeater is such that battery is normally connected through a high resistance to test terminals in the banks of switches having access thereto and through this resistance in series with one winding of the line relay of the circuit to one of the two talking terminals of the set to which the circuit is connected, battery also being directly connected to and through another winding of the line relay to the other of the two talking terminals. According to this feature all of the terminals, of a set to which a selector, connector or repeater circuit is connected, are normally at the same battery potential.

According to a further feature of the inven-

tion, the electrostatic shields separating adjacent levels of the bank comprising the talking terminals are connected through a high resistance to battery potential so as to minimize or eliminate any difference in potential between the talking terminals in adjacent levels.

For a further and complete description of the invention reference will be made to the drawings which show schematically a portion of an automatic system in which the various features of the invention are embodied. The invention is not limited to the particular system or type of switches shown in the drawings but is in general applicable to all automatic switching systems and to all switches comprising a set of wipers and a terminal bank.

Referring to the drawings:

Fig. 1 shows a calling subscriber's station A and line L1, a line finder LF and an associated first selector S1, and a second selector S2;

Fig. 2 shows an outgoing repeater circuit OR and trunk T;

Fig. 3 shows an incoming or third selector S3 and a fourth selector S4; and

Fig. 4 shows a connector C and a called subscriber's line L2 and station B.

Each of the subscribers' stations A and B is of the usual type employed in automatic telephone systems and is equipped with a dial or other impulse sender for use in controlling the operation of each of the selector and connector switches involved in establishing connection with a called subscriber's line. A line circuit, comprising the usual line and cut-off relay, is associated with each of lines L1 and L2, but is not shown in the drawings.

The line-finder switch LF, selector switches S1, S2, S3 and S4 and connector switch C are of the well-known two-motion step-by-step type. A description of the structure of such switches is found in "Automatic Telephony" by Smith and Campbell, 2nd edition. Each of the line-finder, selector and connector switches is represented by a set of brushes and one or more sets of terminals. All of the relays and other circuit apparatus associated with the line finder LF have been omitted; but a description of two-motion line-finder switches is to be found in the patent to R. L. Stokely No. 1,799,654 granted April 7, 1931. The line, release and cut-through relays of the first selector S1 are shown but the other circuit apparatus associated with switch S1 has been omitted. Reference may be had to "Automatic Telephony" aforementioned for a complete description of the operation of the selector S1.

The bank of the selector S1 differs from the usual bank assembly in that the electrostatic shields 20 separating the tip and ring terminals in each level from the ring and tip terminals in adjacent levels are connected through a high resistance to battery instead of being connected to ground.

The selector, repeater and connector circuits S2, OR, S4 and C, which are shown in detail in the drawings, differ from similar circuits heretofore known in that they are arranged in accordance with the various features of the invention to prevent deterioration of the insulation in the banks of switches having access to these circuits. The selector S2 is similar to the usual selector circuit in that battery is normally connected through one of the windings of its line relay 31 to the ring terminal 22 in the bank of the preceding selector S1; but, instead of ground being normally connected through the other winding of the line relay to the tip terminal 21 in the bank of the selector S1 and instead of the associated sleeve terminal 23 of selector S1 being normally connected neither to battery nor ground potential, the sleeve terminal 23 is connected through the upper winding of relay 31 to the tip terminal 21, and the sleeve terminal 23 is further connected through a high resistance 30 to battery. Thus, normally, the tip, ring and sleeve terminals 21, 22 and 23 are all normally connected to battery potential and, therefore, there is no leakage current through the insulation separating the tip and ring terminals. Since the sleeve terminals are in a separate bank unit from the tip and ring terminals, the high resistance connection of the sleeve terminal to battery may be omitted; and in this case, with the sleeve terminal 23 connected through the upper winding of relay 31 to the tip terminal 21, the terminals 21 and 22 are normally free of both ground and battery potential. However, the most complete protection is the normal connection of battery potential to the tip, ring and sleeve terminals together with the connection of battery potential to the electrostatic shields between the tip and ring terminals of adjacent levels.

The outgoing repeater OR differs from the usual circuit arrangement in that the upper winding of the line relay 51 is connected to the test conductor 59 instead of being connected to ground potential, so that normally the tip terminal of the sets of terminals to which the repeater is connected is normally connected neither to battery nor to ground potential. In this case the electrostatic shields 40 between the tip and ring terminals of adjacent levels in the bank of selector S2 may be connected to ground potential in usual manner as shown in Fig. 1. A high resistance may be added, however, for normally connecting battery potential to both the tip and test terminals, in which case the electrostatic shields may also be connected through a high resistance to battery potential.

The selector S4 differs from the usual selector arrangement in that the additional relay 76 is provided for normally disconnecting the windings of line relay 71 from the tip and ring terminals in the bank of selector S3. And the connector C differs from the usual connector arrangement in that the sleeve or test terminals in the banks of selectors having access thereto are connected through one of the windings of the line relay 91 to the tip terminals in the banks of these selectors, battery being connected 75

through the other winding of relay 91 to the ring terminals in the banks of these selectors. While not so shown in the drawing, a high resistance may be provided for connecting battery to the sleeve conductor; so that all three terminals of each set to which the connector C is connected are normally at the same potential.

To facilitate further explanation of the invention, the operation of these circuits will be described in establishing a connection between the calling station A and called station B.

When the call is originated at station A, a line finder LF hunts for and connects the line L1 to the associated first selector S1. In response to the dialing of the first digit of the called subscriber's number, the selector S1 is operated to select the level corresponding to the digit dialed and to hunt for and seize the first idle second selector S2 in the selected group, the cut-through relay 13 of selector S1 being operated to extend the connection from line L1 through brushes 17 and 18 in usual and well-known manner. The operation of relay 13 disconnects the windings of the line relay 11 of selector S1 from the calling line, and relays 11 and 12 are thereby successively released. But since relay 12 is slow in releasing, ground potential is temporarily connected through front contacts of relays 12 and 13 to the sleeve brush 19 and test terminal 23 to guard the seized selector S2 against seizure by another first selector before the guarding ground is supplied by the selector S2 as hereinafter described.

The connection of ground to brush 19 and terminal 23 by the operation of relay 13 of selector S1 completes a circuit for operating line relay 31 of selector S2. This circuit is traced from battery through the lower winding of relay 31, a back contact of relay 34, terminal 22, brush 18, a front contact of relay 13, middle brush of line finder LF, one of the conductors of line L1, through the calling station A, back through the other conductor of line L1, upper brush of line finder LF, another front contact of relay 13, brush 17, terminal 21, a back contact of relay 34, upper winding of relay 31, normally closed contact of the "11th rotary step" springs, thence through test terminal 23, brush 19 and the front contact of relay 13 to ground at the front contact of relay 12. The operation of relay 31 closes a circuit for operating the slow-to-release relay 32. Relay 32 connects ground through sleeve terminal 23 and brush 19 to hold the selector S1 and line-finder LF in operated position after relay 12 of selector S1 releases. When the calling subscriber dials the second digit of a called subscriber's number, relay 31 is alternately released and reoperated in response to each dial impulse. The first release of relay 31 closes a circuit for operating the vertical stepping magnet 37 and relay 33 in series. The operation of magnet 37 steps the brushes up to the first level of the bank. When the shaft and brushes move out of normal position the vertical off-normal springs 36 are actuated thereby closing a circuit including a front contact of relay 33 for operating relay 35. Relay 35 locks through the back contact of the rotary stepping magnet 38. When relay 31 reoperates, magnet 37 releases. Each succeeding release and reoperation of relay 31 causes the reoperation of magnet 37 to step the brushes to the next level. Since relay 32 is slow in releasing the release of relay 31 in response to dial impulses is ineffective to cause the release of relay 32. Relay 33 is also slow in releasing and remains oper-

ated until relay 31 has received all of the impulses in the train created by the dialing of the first digit. When all of the impulses in the train have been received and the brushes advanced to select the desired level, the release of relay 33 closes a circuit for operating the rotary stepping magnet 38 thereby advancing the brushes into engagement with the first set of terminals in the selected level. The operation of magnet 38 causes the release of relay 35 and the release of relay 35 causes the release of magnet 38. If this first set of terminals connects to a busy third selector or to a busy outgoing repeater, the sleeve terminal is marked by ground potential and as soon as magnet 38 releases the winding of relay 35 is connected to brush 43 to cause the reoperation of relay 35 and magnet 38 and thus advance the brushes to the next set of terminals. Thus relay 35 and magnet 38 control each other to continue the advance of the brushes until a set of terminals connecting to an idle selector or repeater is reached; and since the terminal then engaged by brush 43 is not connected to ground, relay 34 is operated in a circuit which includes the winding of relay 35. Relay 35 is marginal and does not reoperate in series with the winding of relay 34. Relay 34 disconnects the windings of relay 31 from the calling line and connects the calling line to the selected set of terminals, which we will assume to be terminals 45, 46 and 47 connected to the outgoing repeater OR. The release of relay 31 causes the release of relay 32 but relay 32 is slow in releasing so that it does not disconnect the holding ground potential from terminal 23 until a holding ground potential has been connected to terminal 47 by the seized repeater OR as hereinafter described. Before relay 32 releases, the ground connected to terminal 23 is further connected through a front contact of relay 34 to brush 43 to guard the repeater OR against seizure by another selector in the group having access to this repeater.

Upon seizure of repeater OR and temporary connection of ground through brush 43 to terminal 47, relay 51 is operatively energized by the current in a circuit traced from battery through the lower winding of relay 51, a back contact of relay 54, terminal 46, brush 42, a lower front contact of relay 34 thence through selector S1, line finder LF and the calling line L1 as above described, then through an upper front contact of relay 34, brush 41, terminal 45, a back contact of relay 54, upper winding of relay 51, test conductor 59, test terminal 47, brush 43, front contact of relay 34 to ground at a front contact of relay 32. Relay 51 closes a circuit for operating the slow-to-release relay 52. Relay 52 connects ground to conductor 59 and terminal 47 to hold relay 51 operated in series with the calling line, to hold relay 34 of selector S2 and to hold selector S1 and line finder LF in usual manner after relay 32 of selector S1 releases. The operation of relays 51 and 52 closes a bridge comprising the lower winding of relay 55 and upper winding of relay 56 across the conductors of trunk T to cause the operation of the line relay 61 of the incoming third selector S3 in the called office. Relay 52 also closes a circuit for energizing the lower, biasing winding of polarized relay 55; and the current through the upper winding of relay 56 is at this time in the direction which maintains the armature in its normal position. Relay 55 may or may not be operated by the energization of its lower winding alone. When the calling subscriber dials each of the remaining digits of

the called subscriber's number, relay 51 is alternately released and reoperated in response to each impulse. The release of relay 51 in response to the first impulse of each train causes the operation of relay 53 and being slow in releasing relay 53 remains operated until all of the impulses in the train have been received. While operated, relay 53 short-circuits the windings of relays 55 and 56 to insure proper response of the line relays of the succeeding switches to which the impulses are being repeated. Each release and reoperation of relay 51 opens and closes the bridge across the trunk T thereby repeating the impulses of each train in succession to the line relay of the next switch through which the desired connection is being established.

Assuming that the trunk T is connected to the incoming third selector S3 in the called office, closure of the bridge across trunk T upon seizure of repeater OR causes the operation of the line relay 61 of selector S3. Relay 61 closes a circuit for operating the slow-to-release relay 62. The first train of dial impulses repeated by relay 51 of repeater OR is received by relay 61 and effects the advance of the brushes of selector S3 to select a desired level. The brushes are thereafter advanced to select and seize an idle set of terminals in the selected level and the cut-through relay 63 is thereupon operated to extend the connection to a fourth selector S4 which is connected to the seized terminals. The operation of the cut-through relay 63 causes the successive release of relays 61 and 62; and, until relay 62 releases, ground is connected through a front contact of relay 63 and the test brush of selector S3 to the test terminal 69 to temporarily guard selector S4 against seizure by another third selector. The temporary connection of ground potential to terminal 69 causes the operation of relay 76 of selector S4. Relay 76 connects the windings of line relay 71 in series with windings of relays 55 and 56 of repeater OR; and relay 71 operates, closing a circuit for operating the slow-to-release relay 72. Relay 72 connects holding ground potential to terminal 69 to hold selector S3 after relay 62 releases. The vertical stepping magnet 77 of selector S4 is thereupon operated by the response of relay 71 to the next train of dial impulses received and repeated by relay 51 of repeater OR to select a desired group. The operation of relay 73 in series with magnet 77 and actuation of the vertical off-normal contacts 80 closes a circuit for operating relay 75. When relay 73 releases after all of the impulses in the train have been received by relay 71, the rotary stepping magnet 78 is operated to advance the brushes into engagement with the first set of terminals in the selected level. If the first set of terminals is busy, the magnet 78 is thereupon controlled by stepping relay 75 to advance the brushes to hunt for and seize the first idle set of terminals in the selected level. Upon finding an idle set of terminals, relay 74 is operated to extend the connection to the connector C which is connected to the seized set of terminals. The operation of relay 74 temporarily connects ground from the front contact of relay 72 through brush 83 to the test terminal to prevent seizure of connector C by another selector. The operation of relay 74 also causes the release of relays 71 and 72. Before relay 72 releases, holding ground potential is connected to conductor 69 and sleeve brush 83, as hereinafter described, to hold selectors S3 and S4.

When ground is connected through front con-

tacts of relays 72 and 74 and brush 83 to sleeve conductor 89, relay 91 operates in series with the windings of relays 55 and 56 of repeater OR. Relay 91 closes a circuit for operating slow-to-release relay 92. Relay 92 connects ground to conductor 89 to hold relay 91 and to hold the preceding switches S3 and S4 in usual manner after relay 72 of selector S4 releases. Each of the impulses created by the dialing of the next to the last digit of the called subscriber's number is repeated by relay 51 of repeater OR to cause the alternate release and reoperation of relay 91. The first release of relay 91 closes a circuit for operating relay 93 and the vertical stepping magnet 101 in series. The operation of magnet 101 steps the brushes up to the first level of the bank. When relay 91 reoperates magnet 101 releases but relay 93 is slow in releasing and remains operated until all of the impulses in the train have been received by relay 91. The vertical off-normal springs 100 are actuated as soon as the shaft and brushes move out of normal position, the circuit for reoperating magnet 101 being thereafter traced through the front contact of relay 93 and a front contact of springs 100 instead of through a back contact of springs 100. Being slow in releasing, relay 92 does not release during the response of relay 91 to dial impulses. Each succeeding release and reoperation of relay 91 due to impulses corresponding to the next to the last digit dialed, causes the brushes to be raised one step thereby selecting the level corresponding to the tens digit of the called number. When relay 93 releases at the end of the impulses of the tens digit, and relay 91 responds to the first impulse of the units digit of the called number, the rotary stepping magnet 102 is operated in parallel with relay 95. Relay 95 connects its winding and the winding of the rotary stepping magnet to the impulse contact of relay 91 independent of relay 97 and connects the winding of busy test relay 97 to test brush 109. The operation of magnet 102 advances the brushes one step into engagement with the first set of terminals in the selected level. When relay 91 reoperates at the end of the first impulse of the units digit, magnet 102 releases but relay 95 is slow in releasing and remains operated until all of the impulses have been received by relay 91. Each succeeding release and reoperation of relay 91 causes the operation and release of magnet 102 to advance the brushes one step. The brushes are thereby advanced into engagement with the terminals of the called line. If this line is busy, the sleeve terminal engaged by brush 109 will be connected to ground in usual manner and relay 97 operates before relay 95 releases. In this case relay 97 is locked operated, after relay 95 releases, to ground at a front contact of relay 92 and the busy tone source BT is connected through a talking condenser 90 to the ring conductor 88 to transmit a busy tone to the calling station. If, however, the called line is idle, relay 97 does not operate and when relay 95 releases after the last dial impulse has been received, relay 98 is operated by the energization of its upper winding in series with brush 109 and the cut-off relay (not shown) of the called line. Relay 98 locks through its lower winding under control of relay 92, connects ground to brush 109 to hold the cut-off relay of the called line, and closes a ringing circuit from source 105 through the upper winding and lower back contact of relay 96, inner lower front contact of relay 98, brush 102, called subscriber's line and through the ringer (not

shown) at station B, brush 107, inner upper front contact of relay 98, to ground at a back contact of relay 96. When the called subscriber answers the call, the current through the upper winding of relay 96 is increased sufficiently to cause the operation of this relay. Relay 96 locks under control of relay 92, opens the ringing circuit and closes the talking circuit, the windings of relay 94 being connected in series with the talking battery to line L2. Relay 94 operates interchanging the connections between conductors 87 and 88 and the windings of relay 91 so that the current through the windings of relays 55 and 56 of repeater OR is reversed and polarized relay 56 operates. Relay 56 closes a circuit for operating relay 54. Relay 54 includes both windings of relay 55 in the loop across trunk T and interchanges the connections between the calling line and the windings of relay 51 to reverse the current over the calling line as an answering supervisory signal. The switches LF, S1 and S2 in the originating office are held by ground from the front contact of relay 52 of repeater OR, the switches S3 and S4 are held under control of relay 92, and the connector switch C is held under the control of relay 92 and also under the control of relay 94.

When the called subscriber replaces the receiver, relay 94 releases causing a reversal of current over trunk T to release relays 55 and 54 of repeater OR. When the calling subscriber replaces the receiver, relay 51 releases thereby causing the release of relay 91 and the release of relays 55 and 56 if operated. The release of relay 51 causes the release of relay 52; and the release of relay 52 disconnects ground from sleeve terminal 47 thereby causing the release of relays 34 and 13 and the return of the line finder LF to normal in usual manner.

The release of relay 13 causes the return of selector S1 to normal in usual manner. The release of relay 34 closes a circuit for operating release magnet 39 and selector S2 is thereupon restored to normal. The release of relay 91 causes the release of relay 92, disconnecting ground from conductor 89 to cause the release of relays 76 and 74 and the return of selector S3 to normal in usual manner. The release of relay 74 closes the circuit for operating release magnet 79 and selector S4 is restored to normal. With both of relays 92 and 94 released, relays 96 and 98 release and release magnet 103 operates restoring connector C to normal.

What is claimed is:

1. In a telephone system, a switch comprising a set of wipers and two banks of terminals, two of the wipers being adapted to engage the terminals in one bank and a test wiper being adapted to engage the terminals in the other bank, each of said banks comprising a plurality of levels, means for operating said switch to select an idle set of terminals and for connecting ground potential to the test terminal of the selected set, a relay individual to the selected set of terminals, a grounded battery, the non-grounded terminal of said battery being normally connected through one winding of said relay to one of the terminals of said selected set, another terminal of said selected set being normally connected through the other winding of said relay to the test terminal of said set, electrostatic shields between the adjacent layers of insulation of adjacent levels of said one bank, and a high resistance connecting the non-

grounded terminal of the battery to each of said shields.

2. In a telephone system, a switch comprising a set of wipers and two banks of terminals, two of the wipers being adapted to engage the terminals in one bank and a test wiper being adapted to engage the terminals in the other bank, each of said banks comprising a plurality of levels, means for operating said switch to select an idle set of terminals and for connecting ground potential to the test terminal of the selected set, a relay individual to the selected set of terminals, a grounded battery, the non-grounded terminal of said battery being normally connected through one winding of said relay to one of the terminals of said selected set, another terminal of said selected set being normally connected through the other winding of said relay to the test terminal of said set, a high resistance normally connecting the non-grounded terminal of the battery to said test terminal, said non-grounded terminal of the battery also being connected through said high resistance and said other winding of said relay in series to said other terminal of the selected set, electrostatic shields between the adjacent layers of insulation of adjacent levels of said one bank, and a high resistance connecting the non-grounded terminal of the battery to each of said shields.

3. In combination in a switching system, a battery, a switch comprising a set of wipers and a bank of terminals, means for moving said wipers into engagement with any set of terminals in said bank, repeaters, each of said repeaters being connected to a different one of said sets of terminals, means associated with said switch and including the test wiper of said set of wipers for testing an engaged set of terminals and for seizing an idle set of terminals, a line relay for each of said repeaters, one terminal of each of said sets of terminals being normally connected through one winding of the line relay of the associated repeater to one pole of said battery, another terminal of each of said sets being normally connected to one end of another winding of the line relay of the associated repeater, and the test terminal of each of said sets being normally connected to the other end of the said other winding of the line relay of the associated repeater, and a circuit closed upon seizure of any of said sets of terminals by said switch for operating the line relay of the repeater connected to the seized terminals, said circuit including said battery, both windings of said relay, the terminal to which said one winding of the line relay is normally connected and including the test terminal to which the other winding of the line relay is normally connected.

4. In a telephone system, a switch comprising a set of wipers and a bank of terminals having a plurality of levels, means for operating said switch to select a desired level and for operating said switch to select an idle set of terminals in the selected level, means effective upon seizure of a set of terminals to connect ground potential to the test terminal, a relay individual to the selected set of terminals, a grounded battery, the

non-grounded terminal of said battery being normally connected through one winding of said relay to one of the terminals of said seized set, another terminal of said seized set being normally connected through the other winding of said relay to said test terminal, electrostatic shields between adjacent layers of insulation of adjacent levels of said bank, and a high resistance connecting the non-grounded terminal of the battery to each of said shields.

5. In combination, a switch having a bank of terminals, means for operating said switch to select a set of terminals in said bank, means effective upon selection of a set of terminals for connecting ground potential to the test terminal of the selected set, a relay individual to said selected set of terminals, a grounded battery, one terminal of said selected set being normally connected through one winding of said relay to the non-grounded pole of said battery, another terminal of said selected set being normally connected through another winding of said relay to the test terminal of said set, and means comprising a high resistance element normally connecting the non-grounded pole of said battery to said test terminal and also to and through said other winding of said relay to said other terminal of the selected set.

6. In combination in a switching system, a battery, a switch comprising a set of wipers and a bank of terminals, means for moving said wipers into engagement with any set of terminals in said bank, selectors, each of said selectors being connected to a different one of said sets of terminals, means associated with said switch and including the test wiper of said set of wipers for testing an engaged set of terminals and for seizing an idle set of terminals, a line relay for each of said selectors, one terminal of each of said sets of terminals being normally connected through one winding of the line relay of the associated selector to one pole of said battery, another terminal of each of said sets being normally connected to one end of another winding of the line relay of the associated selector, and the test terminal of each of said sets being normally connected to the other end of the said other winding of the line relay of the associated selector, a circuit closed upon seizure of any of said sets of terminals by said switch for operating the line relay of the selector connected to the seized terminals, said circuit including said battery, both windings of said relay, the terminal to which said one winding of the line relay is normally connected and including said other terminal and the test terminal to which the other winding of the line relay is normally connected, a high resistance element for each of said selectors normally connecting the non-grounded pole of said battery to the test terminal of the set to which the selector is connected and also normally connecting said pole of the battery to and through said other winding of the line relay of said selector to said other terminal of the set to which said selector is connected.

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