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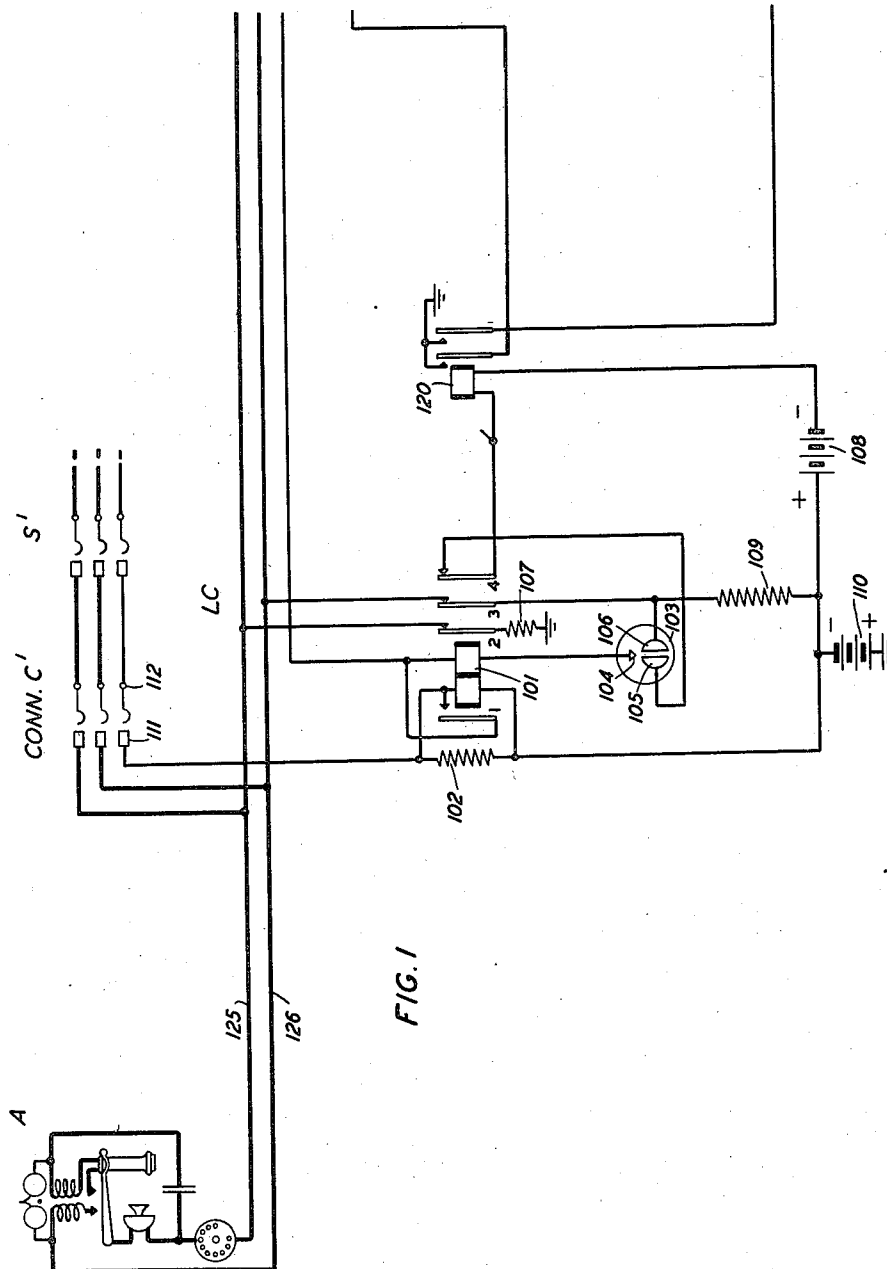
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2,302,334

TELEPHONE SYSTEM

Filed March 30, 1940

2 Sheets-Sheet 1



INVENTOR
M.A. LOGAN
BY *P.C. Smith*
ATTORNEY

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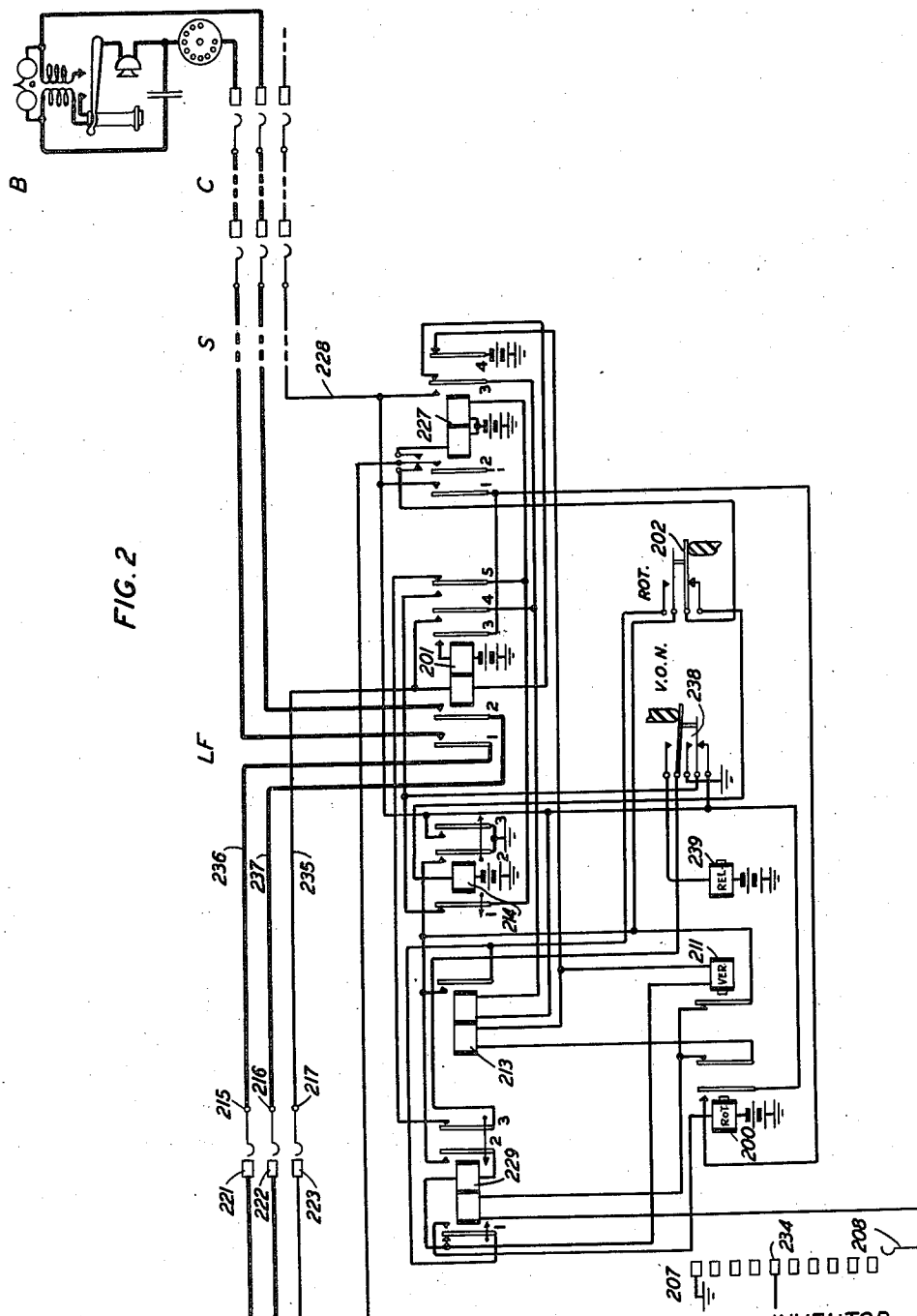
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INVENTOR
M. A. LOGAN
BY *P. C. Smith*
ATTORNEY

UNITED STATES PATENT OFFICE

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TELEPHONE SYSTEM

Mason A. Logan, Summit, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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6 Claims. (Cl. 179—18)

This invention relates to telephone systems and particularly to those systems in which automatic switches are used for establishing connections. The object of the invention is to eliminate the individual line relay usually provided for a subscriber's line and to enable the automatic switches to select a subscriber's line by means controlled over a space discharge or other form of electronic device which is responsive to the initiation of a call over said line.

According to one feature of the present invention a space discharge device having two control electrodes and a cathode is provided for each subscriber's line. One of these electrodes is under the control of the subscriber's line and, when the line initiates a call, a conductive discharge is caused to be established through said electrode and cathode whereby through means included in the circuit of which the discharge path then forms a part, a line finder is caused to operate and hunt for the calling subscriber's line.

According to another feature of the invention the cutoff relay of the line is under the control of the other electrode of the space discharge device, and when a discharge path is established between the first control electrode and the cathode consequent to the initiation of the call, the breakdown potential required to produce another discharge path between said other electrode and the cathode is reduced below what the breakdown potential would be if the first discharge path were not previously established. This reduction in breakdown potential serves as a discriminating test for the hunting line finder which may thus reliably pass over terminals of idle lines whose respective space discharge devices are in a non-conducting state and engage the terminals of the calling line whose space discharge device is already conductive between one of its electrodes and its cathode.

According to another feature of the invention, the disablement of the space discharge device is under the control of the line cut-off relay which, as a result of its operation consequent to the establishment of a second discharge path through said space discharge device, locks over an independent circuit completed over the holding conductor of the selector train and removes, by its operation, the battery supply to the cathode of the device, thus rendering it non-conductive in both of its discharge paths.

According to another feature of the invention, a test circuit is established through the second discharge path of the space discharge device and responsive equipment in the line-finder switch operates at the time said finder switch engages

the terminals of the calling line whereby the talking conductors of the connection are extended to the succeeding switching stage and the operation of said line-finder switch is stopped.

According to another feature of the invention, the finder switch both tests and holds the terminals of the calling line over the same conductor, thereby causing the utilization of a finder switch having but three brushes instead of four, which latter have been necessary in telephone switching systems that employ electronic devices as part of the subscriber's line equipment.

The foregoing and other features of the invention will be described in detail in the following specification which should be taken in conjunction with the accompanying drawings, in which:

Fig. 1 shows the calling line A, the line circuit LC and the terminals thereof extending to the banks of connector C' through which said connector gains access to the line for calls incoming over a selector train including selector S'; and

Fig. 2 shows the line finder LF in combination with a schematic showing of a selector S, a connector C, and a called line B.

The drawings represent, schematically, a telephone system in which the features of the invention are embodied and which employs automatic switches of the well-known two-motion step-by-step type. It is to be understood, however, that the embodiment of the invention in this particular system is given by way of illustration only and that the invention may be applied to automatic telephone systems employing other types of switches.

Referring to the drawings, there are shown a calling line A and the associated line circuit LC, a line-finder switch LF, a selector switch S, a connector switch C and a called line B. In Fig. 1 there is also shown, in schematic form, the usual means for establishing calls to line A over a switching train comprising the connector C' and the selector S'.

The subscribers' stations A and B are provided with the usual subscriber set, which is equipped with a dial for controlling the establishing of the desired connections. The selector switches S and S' and the connector switches C and C' are of the well-known step-by-step or Strowger type, and are shown only schematically since they form no part of the present invention, and therefore reference may be had to pages 53 to 67, inclusive, of the second edition of Automatic Telephony by Smith and Campbell for a detailed description of the operation of the circuits associated with these switches.

The line circuit LC and the line-finder switch LF are shown in detail since the features of the invention apply specifically to these circuits. A cold cathode gaseous discharge device or tube 103 having a cathode 105, a control anode 106 and a main anode 104 is associated with each line circuit. The device 103, which is of the type disclosed in Patent 1,965,589 granted to T. E. Foulke on July 10, 1934, is provided with two gaps, a control gap between anode 106 and cathode 105 which breaks down and ionizes into a conducting path when a definite potential difference is applied between said cathode and said anode, and a main gap between main anode 104 and cathode 105 which ionizes and becomes conducting on a certain potential difference between said main anode and said cathode when the control gap is not ionized and on a lower potential difference when said control gap is ionized. Each line circuit, such as line LC, for example, has its control electrode 106 connected to the ring conductor 126 of the line and when a call is originated at station A the closure of the line loop causes a change of potential to be applied to the control electrode that causes the control gap of the space discharge device 103 to break down and complete a circuit which controls means for causing the line finder LF to hunt for the calling line. As a result of the ionization of the control gap, the potential difference required to ionize the main gap, between the cathode 105 and the main anode 104, is reduced, and since the main anode is connected to one side of the right winding of the cut-off relay 101 and the other side of this winding of said relay is connected to the test terminal of the line on the finder bank, the reduced potential difference now required to ionize the main gap of the device acts as a discriminating potential for the calling line that will enable the line finder to identify and select the terminals associated with this line.

Each line circuit connects to a set of three terminals appearing in the terminal banks of the line-finder switch, as indicated by the individual line circuit LC which connects to terminals 221, 222 and 223. The line-finder switch LF is of the well-known step-by-step type provided with a bank of one hundred sets of terminals, such as the set composed of terminals 221, 222, 223. These terminal sets are arranged in ten vertical levels, each level consisting of ten horizontal terminal sets and each selectable by brushes 215, 216 and 217 which, by means of a common shaft (not shown), are advanced vertically to the proper level, then horizontally to the terminals of the calling line under control of the vertical operating magnet 211 and the rotary operating magnet 200, respectively. Relay 213 controls the operating circuits for magnets 211 and 200. The line finder is provided with a commutator 207 that has ten conducting segments, one segment for each corresponding level of the line-finder bank terminals. Associated with commutator 207 is a brush 208 which is mounted on the common brush shaft (not shown), and which advances simultaneously with brushes 215 to 217, inclusive, during vertical stepping. Relay 229, which is under the control of brush 208, operates when the proper level is reached while relay 201 operates when the calling line terminals are encountered and causes relay 213 to release and open the circuits for magnets 211 and 200, respectively, thereby preventing the line-finder brushes from taking a false additional vertical or rotary step.

The operation of these circuits will now be fully

set forth in detail in the following description of a call from station A to station B.

The cathode 105 of space discharge device 103 is connected to a source of negative potential 108 through the winding of relay 120 while the control anode 106 is connected to a source of positive potential through resistance 109. The potential difference between the control anode and the cathode of the tube or device 103, provided by battery 108, is insufficient to maintain ionization of the gap between the cathode and control anode of the tube. The main anode 104 of the tube is connected to one side of the operating winding of cut-off relay 101.

Normally, when station A is not calling, negative potential is applied to cathode 105 over a path which extends from the negative pole of battery 108, the winding of group start relay 120, the No. 4 contacts of cut-off relay 101 to said cathode 105. The control anode 106 of said device is connected to the positive pole of battery 108 and to the negative pole of battery 110, both through resistance 109 one of whose terminals is connected to the mentioned poles of said batteries and the other connected to the control anode 106. The potential difference established between the cathode and the control anode under the assumed circuit conditions is such, however, as to maintain the electronic device 103 in a non-conducting condition. When, however, the receiver is removed from the switchhook at station A, a current path is established which extends from the negative pole of battery 110, resistance 109, No. 3 contacts of cut-off relay 101, conductor 126, over the line loop of station A, conductor 125, No. 2 contacts of said cut-off relay, resistance 107 to ground. The current flowing through this circuit produces an alteration of the potential applied to the control anode 106 which is measured by the potential drop across resistance 109, thereby establishing a difference of potential between control anode 106 and cathode 105 which is sufficient to ionize the control gap between said control anode and cathode, the effect of which is to establish a current flow through group start relay 120 in the circuit traced from ground through battery 110 and battery 108, winding of said relay, No. 4 contacts of cut-off relay 101, the ionized control gap of the device 103, No. 3 contacts of cut-off relay 101, over the line loop as traced, No. 2 contacts of cut-off relay 101, resistance 107 to ground. Relay 120, which is common to all the lines in one terminal bank level of the line-finder frame, operates to initiate the operation of the line finder LF.

Assume that terminals 221, 222 and 223 associated with the line circuit of calling line A are the fifth set of terminals in the sixth level of the line-finder switch terminal banks. Relay 120, therefore, is common to all of the ten lines in the sixth terminal level and functions as a group start relay for all lines in that level. Relay 120, operating upon the aforementioned breakdown of tube 103 in response to the initiation of the call at station A, connects ground through its No. 1 contacts to the sixth conducting segment 234 of commutator 207 which corresponds to the sixth level of the line switch terminal banks and connects ground through its No. 2 contacts, the normally made No. 2 contacts of relay 227, the normally made contacts of the rotary 11th terminal contacts (ROT) 202 to battery through the winding of slow-release relay 214, operating said relay.

Relay 214, in operating, applies ground to

sleeve conductor 228 over its No. 3 contacts and, over its No. 2 contacts, completes a circuit for relay 213, which circuit is traced from ground through the No. 2 contacts of relay 214, interrupter contacts of vertical magnet 211, interrupter contacts of rotary magnet 200, left winding of relay 213, No. 4 contacts of relay 227, to battery. Relay 213, in operating, completes an operating path for vertical magnet 211 which extends from ground through the No. 2 contacts of relay 214, contacts of relay 213, No. 1 back contacts of slow-operate relay 229, winding of vertical magnet 211, to battery through the No. 4 contacts of relay 227. Vertical magnet 211 operates and causes the line-finder brushes 208, 215, 216 and 217 to make one vertical step and closes the vertical off-normal contacts 238. On the first vertical step of the brushes, brush 208 engages the first conducting segment of commutator 207 but since this segment is open nothing occurs as a result thereof. Vertical magnet 211, on operating, further opens its interrupter contacts and, in doing so, opens the circuit of relay 213 which, releasing in turn, opens the circuit of the vertical magnet. With magnet 211 in a released position, that is, with its interrupter contacts closed, the previously traced circuit through the left winding of relay 213 is reestablished, causing this relay to operate and reclose the circuit of magnet 211, which now operates and lifts the line-finder vertical brushes 208, 215, 216 and 217 another vertical step. With the operation of magnet 211, the circuit of relay 213 is open once more, thereby opening, in turn, the circuit of the magnet, the two operations continuing and the brushes 208, 215, 216 and 217 being lifted a step with each operation of the magnet until commutator brush 208 engages the sixth commutator segment 234 to which ground has been applied through the No. 1 contacts of relay 120 as before described.

The engagement of the sixth segment 234 of commutator 207 by brush 208 and the application of ground to said brush completes a circuit for relay 229 which is traced from ground on brush 208, left winding of relay 229, interrupter contacts of rotary magnet 200, left winding of relay 213 to battery on the No. 4 contacts of relay 227. Relay 229 operates and when vertical magnet 211 releases and closes its interrupter contacts, it completes a locking circuit from ground through the No. 2 contacts of relay 214, No. 2 contacts of relay 229, right winding of said relay, winding of vertical magnet 211 to battery through the No. 4 contacts of relay 227. The current flowing through this circuit is sufficient to lock relay 229 but insufficient to operate the vertical magnet 211 which, therefore, remains in a released condition. Thus at the time that vertical magnet 211 is taking its last stroke and brush 208 engages grounded segment 234, relay 213 is no longer released but held over the operating circuit of relay 229 as above described so that, after 229 operates, an operating circuit is completed for the rotary magnet 200 which extends from battery through the winding of said magnet, No. 1 front contacts of relay 229, contacts of relay 213, to ground through the No. 2 contacts of relay 214. Magnet 200, in energizing, causes brushes 215 to 217, inclusive, to make one rotary step and engage the first set of terminals in the sixth level of the line-finder terminal banks. Since it has been assumed that terminals 221 to 223, inclusive, are the fifth set of terminals of the sixth level, the test terminals 223

of each of the preceding five terminal sets are either grounded as having been made busy by another line-finder switch, or else are free of any potential inasmuch as each of said terminals 223 would be connected to one terminal of the operating (right) winding of the cut-off relay 101, the other terminal of said relay being connected to anode 104 of the electronic device 103 which, under the assumed condition of a free line, would be in a non-conducting state. Hence, when brush 217 engages terminal 223 of the first terminal set, no electric circuit is closed over said brush either by virtue of ground on said terminal or because of the non-ionized condition of corresponding line tube 103.

Now when the rotary magnet 200 operates to advance the brushes one terminal, as described above, it breaks the circuit of relay 213 at its interrupter contacts in consequence of which said relay releases, opening in turn the circuit of rotary magnet 200 which thereby releases also. With the release of the magnet, however, the circuit of relay 213 is reestablished which, in operating, recloses the aforetraced circuit of rotary magnet 200 which now operates to advance brushes 215 to 217, inclusive, another step. I have found from tests made of subscribers' line circuits arranged according to Fig. 1 that the rotary hunting circuit may sometimes cause the breakdown of the main gap of the tube of an idle line to the test terminal 223 of which brush 217 is momentarily engaged and thereby cause the hunting line finder LF to stop falsely on the terminals of the non-calling line. This is due to the fact that when the rotary magnet 200 breaks its normally made contacts and opens the circuit through the left winding of relay 213, a voltage is induced in the right winding of said relay which is sufficiently high at times to break down the gap between the main anode 104 and the cathode 105. The right winding of relay 213 is connected to ground on the one side through the No. 3 contacts of relay 214 and, on the other side, to brush 217 via the left winding of relay 201 and the No. 3 back contacts of relay 227. Inasmuch as negative potential is permanently applied to cathode 105 of tube 103, the main gap of said tube may be ionized (when the control gap is not ionized) if the induced positive voltage applied to terminal 223 is of the proper value. This condition, however, is easily neutralized by expedients well known to the electrical arts as, for instance, by placing a condenser of suitable capacity across the left winding of relay 213, or by connecting a non-inductive resistance in parallel with said left winding, to mention but two of the more prominent means which may be used to reduce the quantity of induced voltage below the limit that will ionize the main gap of the tube.

The above operations continue until brush 217 engages terminal 223 of the fifth terminal set assigned to the calling line A. Since the control gap of electronic device 103 of this line is ionized, the potential required to ionize the main gap between cathode 105 and main anode 104 is reduced so that, when brush 217 engages terminal 223, positive potential applied to said terminal over a circuit shortly to be described, and the negative potential applied to cathode 105 through the winding of relay 120 establishes a potential difference between these two electrodes that will be sufficient to break down the gap between them, causing it thus to become ionized and thereby establish a conducting path between cathode 105

and main anode 104. The positive potential above referred to is applied over a circuit extending from brush 217, left winding of relay 201, No. 3 back contacts of relay 227, right winding of relay 213 to ground or positive side of the battery through the No. 3 contacts of relay 214. This potential thus applied to terminal 223 and, therefore, to the main anode 104 through the operating winding of cut-off relay 101, is, as said before, sufficient to ionize the main gap between anode 104 and cathode 105 of the device 103 whereby a conducting path is established through said gap that completes the series circuit of relays 120, 101, 201 and 213 as above traced. The quantity of current flowing through this circuit will be sufficient to cause relay 213 to remain operated and thus hold the rotary magnet operated, but is only sufficient to cause the closure of the No. 1 contacts of cut-off relay 101, and only sufficient to cause the closure of the No. 3 contacts of relay 201 which relay, however, on the closure of said contacts, becomes fully energized over a circuit completed from battery through its right winding and No. 3 contacts, make contacts of rotary magnet 200 which is energized over its previously described circuit, to ground on the No. 3 contacts of relay 214. Relay 201 now fully operates and, over its No. 5 make contacts, completes an operating circuit for relay 227 which circuit extends from battery through the right winding of said relay, No. 5 make contacts of relay 201, to ground on the lower alternate contacts of vertical off-normal springs 238. Over its Nos. 1 and 2 contacts, relay 201 extends the talking conductors 236 and 237 from the line-finder bank terminals 221 and 222 to the succeeding selector circuit S, while over its No. 4 contacts and the No. 3 make contacts of relay 227 which is now operated, the sleeve conductor 235 from the line-finder terminal bank 223 is connected to the sleeve conductor 228 extending to the selector S. The ground on sleeve conductor 228 from the No. 3 contact of relay 214 now passes through brush 217, terminal 223, closed No. 1 contacts of partially operated relay 101, through the left winding of relay 101 to negative battery 110. The current in this circuit completely operates the cut-off relay 101. When conductors 236 and 237 are extended to the selector S, a relay (not shown) is operated therein which causes a ground to be applied to conductor 228 to hold relay 201 via the No. 1 contacts of relay 227, No. 3 contacts of relay 201, right winding of said relay, battery; and, also, to hold the cut-off relay 101 operated, as will be shortly described.

Relay 227 operated, besides performing the functions above described, advances the start wire over the armature of its No. 2 contacts to the next idle line-finder switch available to the line group, releases relay 214, and removes battery from the windings of relays 213 and 229 and causing said relays to release.

Relay 101 is so designed that, on operating, it closes its No. 1 contacts before it breaks any of its other contact sets. In so doing, it connects negative battery 110 through its left winding in parallel with resistance 102 through said contacts to bank terminal 223 where it completes a current path to ground on sleeve conductor 235 to operate and to hold said relay operated. When relay 101 fully operates, the opening of the No. 4 contacts opens the cathode circuit which extinguishes the conductivity of the main and control gaps through device 103 which, as stated above, were started and maintained by the differ-

ence of potential applied between control anode 106 and cathode 105 and main anode 104 and cathode 105. With potentials on these electrodes restored to their original values, applied thereto when the line A is not calling, tube 103 deionizes and becomes non-conducting. With tube 103 in the non-conducting state, relay 120 releases and removes ground from segment 234 of commutator 207 and also opens the circuit through the left winding of relay 229.

When the tip and ring conductors 236 and 237 are extended to the selector switch S upon the operation of relay 201, the selector S functions and returns a ground over conductor 228 for the purpose of holding relays 201 and 101 operated, as above described. As previously stated, the operation of relay 227 removes ground from the winding of relay 214. Relay 214, being slow to release, maintains holding ground for the right winding of relay 201 and for the left winding of relay 101 until selector S functions and returns ground for this purpose over conductor 228. Relay 214 releases after an interval and opens the circuit through the left winding of relay 229. Relay 229 releases and partially closes the future operating circuit for release magnet 239.

Under control of dial impulses from the calling station A, the selector switch S and connector switch C function and complete the connection to the called station B.

At the conclusion of the call, when the subscribers replace their receivers, ground is removed from conductor 228 by the selector circuit S, thereby releasing relays 101 and 201. Relay 201, in releasing, opens the tip and ring conductors 236 and 237 and energizes the release magnet 239 in a circuit from battery through the winding of said magnet, upper set of contacts of the vertical off-normal contacts 238, No. 3 contacts of relay 229, No. 5 back contacts of relay 201, No. 1 contacts of relay 214, lower alternate contacts of vertical off-normal contacts 238, to ground. Release magnet 239 in energizing causes line-finder brushes 215, 216 and 217 to restore to their normal position. As the brushes return to normal, the vertical off-normal contacts 238 restore to normal, thereby releasing magnet 239 and relay 227. Relay 227, in releasing, again closes the path from the winding of relay 214 to the No. 2 contacts of group start relay 120, and the line-finder is ready to hunt for another calling line. Relay 101, in releasing, connects ground through resistance 107 over its No. 2 contacts to the tip line conductor 125 and connects negative potential through resistance 109 and its No. 3 contacts to the ring conductor 126, thereby restoring line circuit LC to its normal idle condition.

In the event that a call is incoming for station A, say over an inward connection completed by connector C' which is of identical construction to connector C, the usual test is made on the sleeve terminal 111 of the called line over the brush of the connector to determine the condition of the line. If a ground is found on said terminal, due to the fact that the line is busy and, as a consequence, relay 101 is operated and ground on terminal 223 is applied to terminal 111 over the No. 1 contacts of said relay or from brush 112 of another connector, busy tone is returned to the calling subscriber in the known manner. If, on the other hand, the line is not busy, the ground through the winding of a relay (not shown) in the connector C' completes a circuit through the left winding of cut-off

relay 101 over a path that includes said left winding in parallel with resistance 102 to battery 110. Relay 101 operates to disconnect the device 103 from the line and the connector C' functions to place direct ground on brush 112, thereby locking relay 101 and causing said ground to make the line test busy to other connectors. When the call is completed, ground is removed from brush 112, causing thereby the release of relay 101 and the restoration of the line circuit to normal for the next succeeding call.

While I have described my invention and the method and means utilized for practicing the same in connection with its specific application to a line-finder switch structure of known construction, it is to be understood that various other applications and embodiments thereof may be made by those skilled in the art without departing from the spirit of the invention as defined within the scope of the appended claims.

What is claimed is:

1. In combination, a finder switch, a telephone line appearing in said switch, a discharge device individual to said line, means controlled over said line for establishing a circuit through said discharge device, responsive means in said circuit for starting said switch in operation, a test circuit closed through said discharge device when said switch engages said line, and means in said test circuit for terminating the operation of said switch.

2. In combination, a finder switch, a telephone line appearing in said switch, a discharge device individual to said line, a cut-off relay for said line, means controlled over said line for establishing a circuit through said discharge device, responsive means in said circuit for starting said switch in operation, a test circuit including said cut-off relay closed through said discharge device when said switch engages said line for operating said cut-off relay to disable said discharge device, and means in said test circuit for terminating the operation of said switch.

3. In combination, a finder switch, a telephone line appearing in said switch, a discharge device individual to said line, a cut-off relay for said line having contacts through which said discharge device is connected to said line, means controlled over said line for establishing a circuit through said discharge device, responsive means in said circuit for starting said switch in operation, a test circuit including said cut-off relay closed through said discharge device when said switch engages said line for operating said cut-

off relay to disconnect said discharge device from said line, and means in said test circuit for terminating the operation of said switch.

4. In combination, a finder switch, a telephone line appearing in the terminals of said switch, a discharge device individual to said line, means controlled over said line for establishing a circuit through said discharge device, responsive means in said circuit for starting said switch in operation, a test circuit closed through said discharge device when said switch engages the terminals of said line, whereby current is caused to flow in said test circuit in response to the energized condition of said device, and means in said test circuit for stopping the operation of said switch.

5. In combination, a finder switch, a telephone line having two talking conductors and a single control conductor appearing in the terminals of said switch, a discharge tube for said line, means controlled over said line for establishing a first discharge circuit through said discharge tube, responsive means in said circuit for starting said switch in operation, means including said control conductor and responsive to said switch engaging the terminal of said line to which said control conductor is connected for causing current to flow in a second discharge circuit through said tube, and means operated in said second discharge circuit for stopping the operation of said switch.

6. In a telephone system, a group of lines each comprising three conductors, three-terminal line-finder banks on which said group of lines terminate, line-finder switches accessible to said terminals, a discharge device for each of said lines adapted to provide two discharge paths therethrough, a start relay controlling the operation of said line-finder switches common to one discharge path in each of said devices, a cut-off relay for each line in the other discharge path of the associated discharge device, means responsive to the initiation of a call on any one of said lines for operating the discharge path in the associated device whereby said start relay is operated to start a line-finder switch in search for the terminals of a calling line, and electromagnetic means in said line-finder switch responsive to the engagement of said switch with the terminals of said calling line for operating the other discharge path through the associated line discharge device whereby said cut-off relay is operated.

MASON A. LOGAN.