

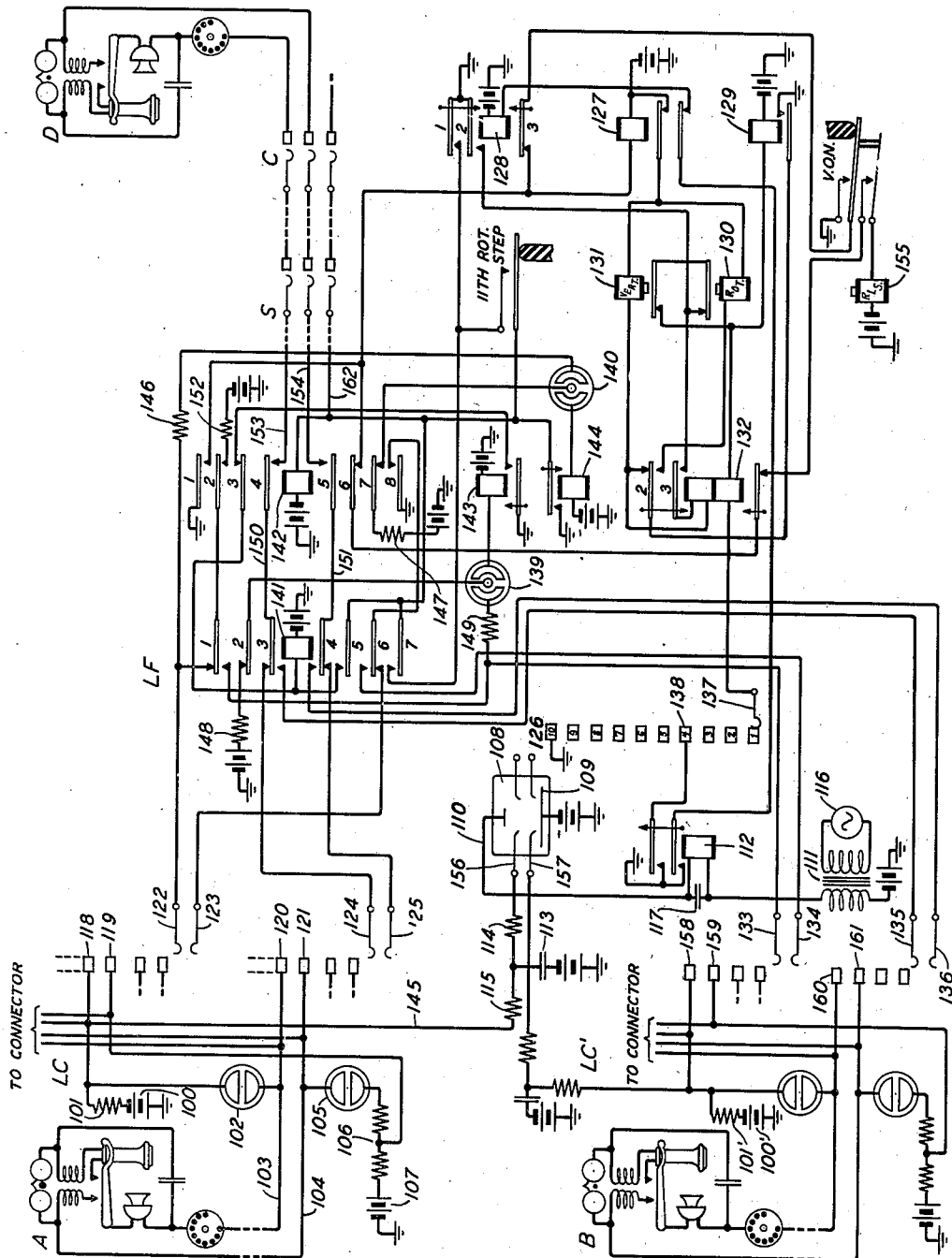
June 10, 1941.

L. G. SCHIMPF

2,245,160

TELEPHONE SYSTEM

Filed July 7, 1939



INVENTOR
BY L. G. SCHIMPF

P. C. Smith

ATTORNEY

UNITED STATES PATENT OFFICE

2,245,160

TELEPHONE SYSTEM

Luther G. Schimpf, St. George, N. Y., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

Application July 7, 1939, Serial No. 283,149

9 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 objects of the invention are to eliminate some of the individual equipment usually provided for subscribers' lines; to enable the automatic switches to select a subscriber's line by means of a simple and positive test; to provide a more reliable test for controlling the stepping action of the switch while hunting for a calling subscriber's line; and to otherwise improve systems of this character.

It has been proposed heretofore to eliminate the individual line and cut-off relays and to replace them by a relay mechanism common to a group of lines. To accomplish this, however, it would be necessary to provide some sort of switching mechanism for associating the common relays with any one of the lines when calling.

It has also been proposed to use a vacuum tube in common to a group of lines and to connect the control element through individual resistances to the respective subscriber's lines, thus doing away with the individual line relays. An arrangement of this kind, however, would be subject to false operation due to the combined effect of several line leaks, and would not lend itself readily to a positive and reliable test that would enable the line finder to distinguish and seize the calling line in the group.

According to the present invention, these difficulties are overcome by means of an electrical circuit in which a space discharge device having a multiplicity of control electrodes is provided in common to a group of subscribers' lines and in which a pair of space discharge devices are provided for each line. The control electrodes of the group device are individual, respectively, to the subscribers' lines and the electrical condition of each is altered in response to the discharge of the pair of line devices when a call is initiated. This change in the electrical condition of one of the control electrodes causes the discharge of the group device which, in turn, causes the starting of a line finder to hunt for the calling subscriber's line.

Another feature of the invention is a testing arrangement in which, as a result of the closure of the line loop at the substation and the discharge of the pair of line devices in consequence thereof, a potential is applied to the test terminal of the line in the finder switch bank at the same time that the potential of the individual control electrode is altered. This calling potential on the terminal of the finder bank permits

the switch to distinguish the calling line from the non-calling lines.

Another feature of the invention is a line-finder switch in which a space discharge device is used in circuit with one of the space discharge devices of the calling line whereby the potential applied to the test terminal by the latter is used for operating the former when the brushes of the switch reach the desired terminal in the desired level. This arrangement makes for a quick and accurate test.

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 drawing.

The drawing represents, 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 having two sets of terminal banks. 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 drawing, there are shown subscribers' stations A and B, the associated line circuits LC and LC', a line-finder switch LF, a selector switch S, a connector switch C, and a called subscriber's station D.

The subscribers' stations A and B which appear on corresponding levels in the upper and lower terminal banks to which the line-finder switches have access are provided with the usual subscriber's set, which is equipped with a dial for controlling the establishment of the desired connections. The selector switch S and the connector switch C are of the well-known step-by-step or Strowger type, and reference may be had to pages 53 to 67 inclusive of the 2nd edition of "Automatic telephony" by Smith and Campbell, for a detailed description of the operation of the circuits associated with these switches. Only those portions of the circuits of the selector and connector switches are shown as are required for a clear and complete understanding of this invention, the omitted portions of these circuits being indicated by broken lines.

The line circuits LC and LC' and the line-finder switch LF are shown in detail since the features of the invention apply specifically to these circuits. Each line circuit, as for instance line circuit LC, is provided with two cold cathode gaseous discharge tubes 102 and 105, one for each side 103

and 104 of the line, while each of two groups of lines, one appearing on the terminals of a level in the upper bank of which line A is representative, and the other appearing in the terminals of a corresponding level in the lower bank of which line B is representative, is provided with a cold gaseous discharge tube 108 having a number of control electrodes such as electrodes 156 and 157.

Cold cathode gaseous discharge tube 108 having a multiplicity of control electrodes, such as electrode 156, is associated with the two groups of line circuits, that is, the group of lines appearing in one terminal level in the upper bank, of which line A is representative, and the group of lines appearing in a corresponding terminal level in the lower bank of which line B is representative. Tube 108 is of the type which breaks down and becomes conducting when the potential on any one of its control electrodes becomes sufficiently positive with respect to the cathode potential of the tube. The line tubes 102 and 105 are of the type which break down and become conducting upon the application of a definite breakdown potential between its two electrodes.

Each individual line circuit of a group, such as line circuit LC, for example, connects to one of the control electrodes of tube 108 via the line tube 102 and when a call is originated by a subscriber, a potential change on the control electrode associated with that line circuit and caused by the breakdown of tube 102 causes tube 108 to break down and operate means whereby the line-finder switch LF is caused to hunt for the calling line. The breakdown of the line tube 102 also places an identifying potential on the test terminal of the calling line to enable the line finder to select the terminals associated with this line.

Each line circuit connects to a set of four terminals appearing in the terminal banks of the line-finder switch, as indicated by the individual line circuit LC which connects to terminals 118, 119, 120 and 121. The line-finder switch LF is of the well-known step-by-step type provided with two banks of one hundred sets of terminals each, such as the two sets composed of terminals 118, 119, 120 and 121 on the upper level to which line A is connected and terminals 158, 159, 160 and 161 on the lower level to which line B is connected. These terminal sets are arranged in ten vertical levels in each bank, each level consisting of ten horizontal terminal sets, and are selectable in the upper bank by brushes 122, 123, 124 and 125, and in the lower bank by brushes 133, 134, 135 and 136 which, by means of a common shaft (not shown), are advanced vertically under the control of vertical magnet 131 to the proper level and then horizontally under the control of rotary magnet 130 to the terminals of the calling line. The line finder is provided with a commutator 126 that has ten conducting segments, one segment for each two corresponding levels of the line-finder bank terminals. Associated with this commutator is a brush 137 which is mounted on the common brush shaft (not shown) and which advances simultaneously with brushes 122, 123, 124 and 125 and 133, 134, 135 and 136 during vertical stepping. Relays 144 and 143 are connected, respectively, to cold cathode gaseous discharge tubes 140 and 139 and one of these tubes breaks down and becomes conducting when the calling line terminals, on their respective levels, are encountered, each causing thereby the oper-

ation of circuits that immediately arrest further rotary magnet operations.

The operations of these circuits will now be fully set forth in detail in the following description of a call from station A to station D.

Negative battery 100 is normally applied through high resistance 101 to the cathode of tube 102 and positive battery 107 is normally applied through the two branches of high resistance 106 to the anode of tube 105. When the subscriber A removes his receiver from the switchhook to initiate a call, the line loop is closed in consequence of which the anode of tube 102 and the cathode of the other tube 105 are connected together to form one metallic conductor intermediate the dielectric medium which pervades the two separate electrodes connected, respectively, to the sources of potential 101 and 107. The additive effective of the two sources of potential is sufficient to break down the dielectric, resulting, in turn, in the ionization of the gases within the two tubes as a consequence of which they become conducting and cause a current to flow through the line loop that produces a voltage drop in high resistance 101 which is applied to the test terminal 118 of the line as a test potential that the line is calling, and another voltage drop in resistances 101, 115 and 114 which is applied to the control element 156 of multielement tube 108.

The cathode 109 of tube 108 is connected to a source of negative potential and the anode 110 is connected to a source of negative potential through the secondary of transformer 111 serially through the bridge formed by the winding of relay 112 and condenser 117. The primary winding of the transformer is connected to a source 116 of low frequency current. The potential difference between the anode and the cathode of tube 108 while insufficient to cause the tube to break down, is sufficient to maintain ionization therein once it is broken down. Each control element of the tube 108 is connected to its own condenser 113 intermediate the two series resistances 114 and 115 while the other side of the condenser is connected to negative battery. Normally, and when the associated line is not calling, there is negative battery connected to each side of the condenser, the other side having negative voltage applied thereto through resistance 101. When, however, the line loop is closed, the value of the potential applied to the side connected to resistances 114 and 115 becomes equal to the drop through resistances 101 and 115, whereupon the condenser begins to charge and the application of positive potential to the connected control element 156 is delayed until the condenser is fully charged to the potential difference between negative battery and the drop through resistances 101 and 115. The purpose of this delay is to prevent any operation of the tube 108 due to momentary surges and other transients, and the capacity of the condenser 113 may be adjusted to the value required to provide a time of charge equal to the longest surge duration. If the potential on conductor 145 persists, say, for a longer period than that required to charge the condenser 113, then the control element will be charged to the breakdown potential of the tube through resistance 114.

Mention has been made of the fact that the primary winding of transformer 111 is connected to the source 116 of a low frequency current. When a negative half cycle of the volt-

age wave is induced in the secondary winding, it will be added to the negative voltage of the battery connected thereto. Since the tube will not fire so long as negative potential is connected to the anode thereof, the presence of positive potential on the control element 156 of line A when said line calls will have no effect in breaking down the tube 108 until a positive voltage is induced in the secondary winding of transformer 111, at which time the total effect of the combined induced voltage and that of the battery voltage will be the application of positive voltage to the anode 110 of the tube 108. With one of the control elements at positive potential, the tube breaks down and becomes conducting, establishing a current flow from battery, cathode 109, anode 110, winding of relay 112, secondary winding of transformer 111, battery. Relay 112 operates in this circuit. As the induced voltage changes from positive to negative, due to the operation of source 116, tube 108 will cease to be conducting when the induced voltage reaches its negative peak, at which time current will cease to flow therethrough and, also, through relay 112. This relay, however, is made sufficiently slow to release so as to hold up during the negative half cycle of the potential wave. This may be done in any suitable manner as, for instance, by the use of a copper slug on the core of the relay or, as illustrated, by the connection across its winding of a condenser 117 which charges on the establishment of current flow through the tube and discharges through the winding of the relay when the current flow ceases, thereby tending to hold the relay up in the interval between successive positive potential waves that cause the tube 108 to fire repeatedly so long as the positive potential drop through resistance 114 is applied to the control element 156, which condition will prevail until the line finder LF establishes connection with the terminals of the calling line, as will be described shortly.

Assume that terminals 118, 119, 120 and 121 associated with the line circuit LC of the calling station A are the fifth set of terminals in the fourth level of the upper terminal banks of the finder switch. Tube 108 is common to all of the ten lines appearing in the fourth level of both terminal banks, each of these lines connecting respectively to one of the twenty control electrodes of the tube. Relay 112 is, therefore, common to all twenty lines in the fourth terminal levels and functions as a group start relay for all lines in these two levels. Relay 112 operating upon the aforementioned breakdown of tube 108 in response to the initiation of the call at station A, connects ground over its outer contacts to the fourth conducting segment of commutator 126 which corresponds to the fourth level of the line switch terminal banks, and connects ground through its inner contacts and through the outer contacts of relay 127 to battery through the winding of relay 128.

Relay 128, in operating, completes a circuit for relay 129 extending from ground through its No. 2 contacts, interrupter contacts of rotary and vertical magnets 130 and 131, respectively, winding of relay 129 to battery. Relay 129, in operating, operates the vertical stepping magnet 131 over the following path: ground through the contacts of relay 129, No. 2 back contacts of relay 132, winding of vertical magnet 131, inner contacts of relay 127 to battery. The vertical magnet takes a step and, in so doing, causes

the line-finder brush sets 122, 123, 124 and 125 and 133, 134, 135 and 136 to make one vertical step. In opening its interrupter contacts, vertical magnet 131 further opens the circuit of relay 129 which releases, in turn opening the circuit of the vertical magnet, causing it to fall back and reclose its interrupter contacts. The circuit of relay 129 is now reclosed and, upon the reoperation of this relay, the previously described circuit of vertical magnet 131 is once more made effective whereupon the magnet operates to advance the line-finder brush sets another step and again to open its interrupter contacts, whereupon the circuit of relay 129 is again opened, consequent to which the relay releases to cause the release of the vertical magnet and the reclosure of its interrupter contacts. These interacting operations between vertical magnet 131 and relay 129 will continue, causing the brush shaft to be raised a corresponding number of steps, until relay 132, the circuit of which is controlled over brush 127, operates. On the first vertical step of the brush sets, brush 137 contacts the first conducting segment of commutator 126 but, since this segment is open, no circuit path is completed for relay 132, and the same thing will be true for the next three steps since the segments corresponding to the second and third levels will likewise be devoid of ground connections. However, when the brush 137 contacts the fourth segment, the ground connected thereto over the outer contacts of relay 112 causes a circuit to be completed through brush 137, segment 138, lower winding of relay 132, winding of relay 129 to battery. In this circuit, relay 132 operates and relay 129 is held, the former locking in a circuit extending from battery through the inner contacts of relay 127, winding of vertical magnet 131, upper winding of relay 132 and the No. 3 contacts thereof, to ground on the No. 2 of relay 128. Relay 129, in its operated condition, extends ground over its contacts through the No. 2 front contacts of relay 132 to the winding of rotary magnet 130. The quantity of current flowing through the holding circuit of relay 132 and, therefore, through the winding of vertical magnet 131, is not sufficient to effect the operation of magnet 131 to open its interrupter contacts. Hence when the rotary magnet 130 operates for the first time, its circuit being completed to battery on the inner contacts of relay 127, the brush shaft is rotated in consequence of this operation and causes the engagement of the brush sets with the first terminals in the respective levels to which they have been stepped and the disconnection of brush 137 from the segment 138. Relay 132, however, will not release because of its locking circuit and relay 129 will hold through the interrupter contacts of magnets 131 and 130 to ground on the inner contacts of relay 128. Upon the completion of the first rotary step, rotary magnet 130 opens its interrupter contacts and relay 129 releases whereupon ground is disconnected from the winding of the rotary magnet, causing it to release and reclose its interrupter contacts. The circuit of relay 129 is now closed again and the reoperation of this relay again closes the rotary magnet circuit causing it to operate and rotate the line-finder brushes into engagement with the second set of terminals on their respective levels. This interaction between the operation of rotary magnet 130 and relay 129 will continue until the brushes are rotated into engagement

with the fifth set of terminals, at which time relay 142 is caused to operate over a circuit presently to be described, thereby causing the operation of relay 127 over an obvious circuit and the consequent removal of battery from the circuit of the rotary magnet. Relay 128 is caused to release in response to the operation of relay 127 and ground is removed from the circuit of relay 129.

It will be observed that the line-finder circuit is provided with two gas-filled three-element tubes, namely, tubes 139 and 140, the anode of the former being connected to a source of positive potential through the No. 2 contacts of relay 141 and resistance 148, and the anode of the latter to a source of positive potential through the No. 7 contacts of relay 142 and resistance 147. The cathode of tube 139 is connected to a source of negative potential through the winding of relay 143 and its control electrode is connected, via resistance 149, to brush 133 of the lower set of brushes. On the other hand, the cathode of tube 140 is connected to a source of negative potential through the winding of relay 144 and its control electrode is connected, via resistance 146, to brush 122 of the upper set of brushes.

When the brush sets 122-125 and 133-136 engage the first terminal sets on their respective fourth levels, upper brush 122 engages sleeve terminal 118 and lower brush 133 engages sleeve terminal 158. It has been assumed, however, that the calling line A is the fifth line on the upper fourth level so that brush 122 and brush 133, in testing the first four sleeve terminals on their respective levels, will find these terminals having negative battery through resistances 101 and 101' respectively applied thereto if the corresponding lines are idle. If a line is busy on an outgoing call, negative battery through low resistance 152 will be connected to test terminal 118 by the connecting line finder, via the No. 2 contacts of relay 142 which will be operated therein, No. 1 back contacts of relay 141 to brush 122 and terminal 118. This negative battery, extending through the multiple and applied to the control electrode of tube 140 will not affect said tube any more than battery through resistance 101 does. But when the brush 122 engages terminal 118 of the calling line A, the potential drop through resistance 101 will be connected thereto and will be applied to the control electrode of tube 140 via resistance 146. The value of the potential drop, being positive with respect to the negative potential on the cathode of the tube, causes said tube to break down and establish a circuit therethrough between negative battery through the winding of relay 144, space current between the cathode and anode of tube 140. No. 7 contacts of relay 142, resistance 147 to positive battery. Relay 144 operates in this circuit.

If the calling line had been line B which terminates on the corresponding level in the lower terminal bank tested by the lower brush set 133-136, terminal 158 of the line would have thereon the potential drop due to the resistance 101' established as a result of the closure of the calling line loop, and this drop would have been applied to the control element of tube 139 via brush 133 and resistance 149, causing the tube 139 to break down and a circuit to be completed from negative battery through the winding of relay 143, the cathode and anode of the tube 139, No. 2 contacts of relay 141 through 75

resistance 148 to positive battery. Relay 143 operates and completes a circuit for relay 141 via ground through the contacts of relay 143, No. 3 contacts of relay 142, winding of relay 141 to battery. Relay 141 operates and closes a locking path for itself through its No. 5 contacts to the sleeve conductor 162 to which ground will be connected by the first selector S to hold said relay before the circuit of relay 143 is disrupted. Over its No. 3 and No. 4 front contacts, relay 141 transfers the line conductors 150 and 151 from the upper brushes 124 and 125, respectively, to the lower brushes 135 and 136, respectively, while the remaining functions of relay 141, when operated, are the same as those of relay 142 which will be described shortly.

It has been assumed that the calling line A appears in the fourth level of the upper terminal bank. Therefore, relay 141 will not operate as above described under the assumption of a call being originated by line B but relay 142 operates in the manner described, causing the operation of relay 127 and the arresting of any further rotary operations as previously stated.

By the closure of its No. 2 contacts, relay 142 applies negative battery through low resistance 152 to brush 122 and terminal 118 via the No. 1 back contacts of relay 141 to establish a busy test to other hunting line finders, while, through its No. 8 contacts, it connects ground to brush 123 and terminal 119 via the No. 6 back contacts of relay 141. This ground is applied to the midpoint of high resistance 106 and short-circuits anode battery 107 connected to the line tube 105 causing both this tube and tube 102 to be reset. Relay 142 further connects line conductors 150 and 151 through its No. 4 and No. 5 contacts with conductors 153 and 154, respectively, which extend to the first selector S; at its No. 7 contacts it further removes positive battery from the anode of tube 140 causing this tube to be extinguished, in turn causing the release of relay 144 which, however, does not cause the release of relay 142 inasmuch as this relay is now held to ground connected to conductor 162 by the first selector S.

As already mentioned, the operation of relay 142 extends the line loop to the first selector S wherein a relay (not shown) bridged across conductors 153 and 154 and supplied with a source of current operates over the loop to cause the operation of another relay which connects ground to conductor 162 to hold relay 142 and also relay 141 if the calling line should happen to be located on the lower terminal bank as already explained.

Under the control of dial impulses from the calling station A, the first selector S and, possibly, a second selector (not shown) as well as a connector C function to complete the connection to the wanted subscriber's line D. Since these operations are well known and form no part of the invention, they are not described.

When line tube 102 is extinguished, ionizing potential is removed from the control element 156 of the group tube 108. When therefore, the low frequency source 116 causes the induction thereafter of a negative potential in the secondary winding of transformer 111, the potential of anode 110 is, of course, negative and the tube 108 ceases conducting whereupon, after a time interval for discharging condenser 117, relay 112 releases to remove ground from segment 138 of commutator 126. The tube 108 is now normal and ready to reoperate when any one of its

control electrodes is charged to a positive potential by the closure of the line loop connected to said control electrode. The tube then functions to operate relay 112 for the starting of another line finder as described.

When the call is completed and the subscriber on line A restores the receiver, this action causes the release of the selector train in the known manner and the consequent removal of ground from conductor 162 whereupon relay 142 releases. The release of relay 142 completes a circuit path for release magnet 155 extending from ground on the upper contact set of vertical off-normal springs VON which are closed as soon as the brush shaft moves off-normal, No. 3 contacts of relay 128, No. 6 contacts of relay 142, bottom contacts of relay 132, lower set of springs on the vertical off-normal springs VON, winding of release magnet 155 to battery. Magnet 155 operates and restores the brush shaft to its normal position.

While I have described my invention in connection with its specific application to an automatic line operating in conjunction with a known switch structure, 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 a telephone system, a subscriber's line, two space discharge devices for said line, means responsive to the initiation of a call from said line for discharging said devices, and means responsive to the discharge of said devices for producing a plurality of signaling potentials.

2. In a telephone system, a subscriber's line terminating in a group of terminals, a pair of space discharge devices for said line, one of said devices being connected to one of said terminals and one side of said line, means responsive to the initiation of a call from said line for discharging said devices to produce a current flow through said line and through said devices whereby said means are effective to apply a test potential on a terminal of said group of terminals, and other means connected to said terminal responsive to said current flow for producing a signaling potential.

3. In a telephone system, the combination with a switch and a telephone line connected to the terminals of said switch, said switch being adapted to operate in response to one potential for hunting for said terminals and to engage said terminals in response to another potential, of a pair of space discharge devices for said line, means responsive to a call initiated over said line for discharging said pair of devices to produce both of said potentials, and means in said switch responsive to said first potential for resetting said pair of devices upon the connection of said switch with said line terminals.

4. The combination in a telephone system of lines, a pair of space discharge devices for each of said lines adapted to discharge upon the initiation of a call from the associated line, another discharge device common to said lines and having as many control electrodes as there are lines, said electrodes being individual to said lines respectively and connected in operative relation to the pair of discharge devices of the associated lines, and switching means responsive to said other discharge device.

5. In a telephone system, the combination of

subscribers' lines, a pair of space discharge devices for each of said lines adapted to discharge upon the initiation of a call thereover, another space discharge device common to said lines, said common device having as many control electrodes as there are lines, means responsive to the discharge of a pair of line discharge devices for altering the electrical condition of the electrode in said common device assigned to the calling line, a discharge circuit for said common device and current responsive means in said discharge circuit.

6. In a telephone system, the combination of subscribers' lines, a pair of space discharge devices for each of said lines, a space discharge device common to said lines, a discharge circuit for said common discharge device, said common device having as many control electrodes as there are lines, an electrical network connecting each pair of line discharge devices with each control electrode respectively, means operative through each of said networks for maintaining a potential on each of said electrodes to prevent a flow of current in said common discharge circuit, means responsive to a call initiated on one of said lines for operating the associated pair of discharge devices whereby the potential on the control electrode in the common device associated with said line is altered through the connecting network, and means in said discharge circuit responsive to the flow of current therein.

7. In a telephone system, subscribers' lines, a pair of space discharge devices for each of said lines, a space discharge device common to said lines, said common device having a plurality of control elements individual respectively to said lines, a line-finder switch having a terminal bank in which said lines appear, means responsive to a call initiated from a line for operating the pair of discharge devices associated therewith, means responsive to said means for altering the potential of the corresponding control electrode in said common device to cause the discharge thereof, other means responsive to said first-mentioned means for altering the potential of a corresponding terminal in said finder switch, and means responsive to the discharge of said common device for setting said finder switch in operation to seize the terminals of said calling line.

8. The combination with a plurality of lines, of a gas-filled tube having a plurality of control elements, a cathode and an anode, said elements relating respectively to said lines, means responsive to one of said lines when calling for altering the electrical condition of one of said elements, a transformer having one side of its secondary winding connected to the anode of said tube and the other side to a negative source of potential, a source of alternating voltage connected to the primary winding of said transformer whereby, in response to the altered condition of one of said electrodes, the voltage induced in the secondary winding of said transformer combined with a negative voltage from said negative source of potential connected thereto causes said tube to repeatedly and alternately discharge and quench, and means operative in response to the discharge of said tube.

9. In a telephone system, a group of lines, a space discharge tube having a plurality of control electrodes individual respectively to said lines, a space circuit for said tube, a line-finder switch having a terminal bank in which said lines appear, means for maintaining a given potential on each of said control electrodes and on each

of the terminals of said lines in said finder switch, space discharge devices operative over the conductors of a calling one of said lines for altering the potential on the corresponding control electrode to cause the discharge of said tube and for altering the potential on the corresponding terminal of said line in the finder switch, a relay in said space circuit responsive to the discharge of said tube, means controlled by said relay for

starting said finder switch in operation, test means rendered effective when the finder switch reaches the terminals of the calling line, means responsive to said test means for stopping the movement of said switch, and means effective upon the operation of said means for quenching said space discharge devices.

LUTHER G. SCHIMPF.