

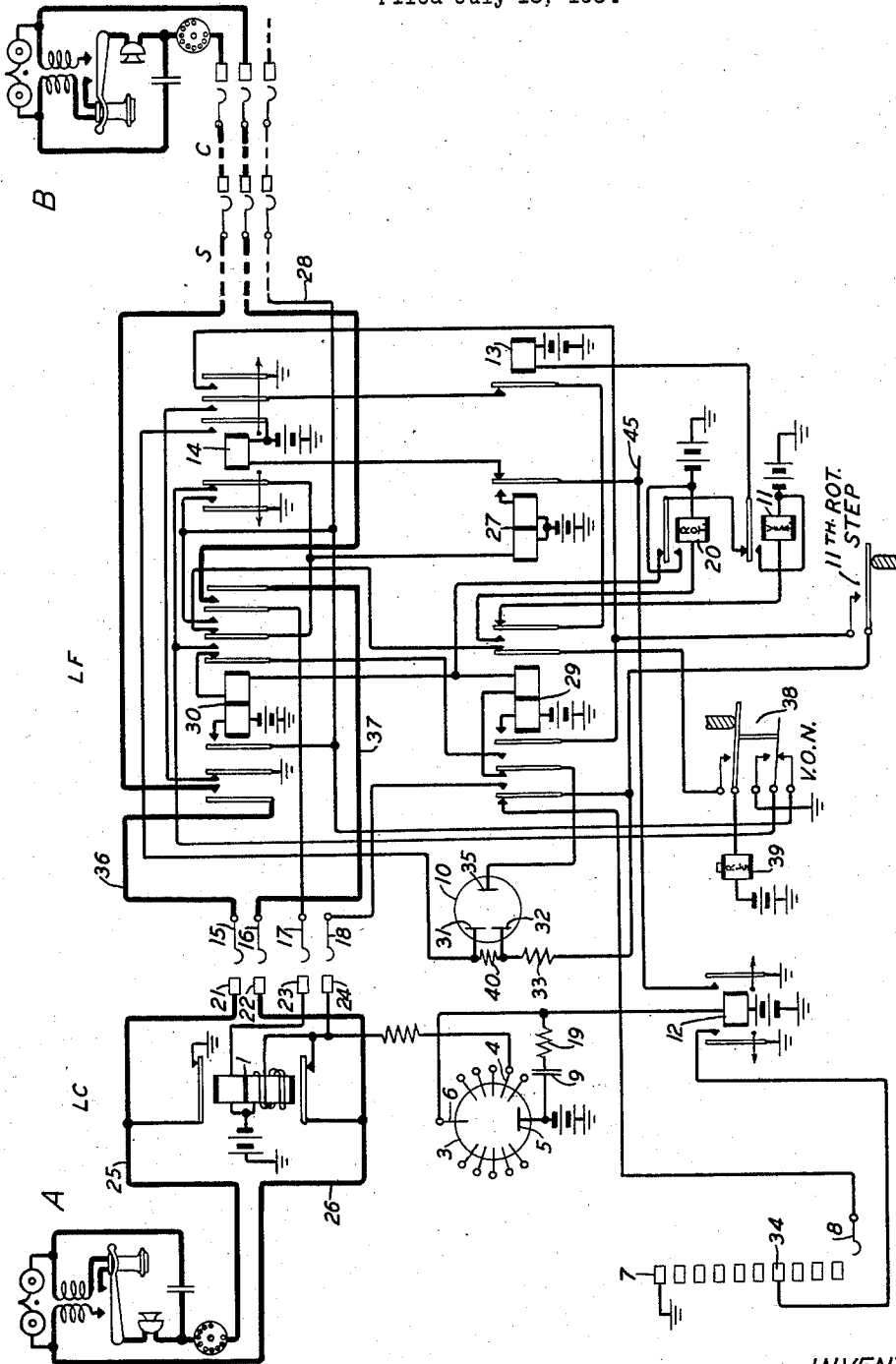
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T. L. DIMOND

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TELEPHONE SYSTEM

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INVENTOR
BY T. L. DIMOND

McManney
ATTORNEY

UNITED STATES PATENT OFFICE

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TELEPHONE SYSTEM

Thomas L. Dimond, Boonton, N. J., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

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This invention relates to telephone systems and particularly to those systems in which automatic switches are used for establishing connections.

5 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
10 a more reliable test for controlling the stepping action of the switch while hunting for a subscriber's line; and to otherwise improve systems of this character.

15 It has been proposed heretofore to eliminate the individual line relays and to replace them by a relay mechanism common to a group of lines. To accomplish this, it has been necessary to provide some sort of switching mechanism for associating the common relays with any one of the
20 lines when it calls.

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 subscribers' lines, thus
25 doing away with the individual line relays. An arrangement of this kind is subject to false operation due to the combined effect of several line leaks, and it does not lend itself readily to a positive and reliable test to enable the line finder
30 to distinguish and seize the particular line in the group that is calling.

According to the present invention these difficulties are overcome by means of a system in which a space discharge device having a multiplicity of control electrodes is provided in common to a group of subscribers' lines. The control electrodes are individual respectively to the subscribers' lines and serve to cause the discharge of the device when any one of said lines
35 initiates a call. The common discharge device 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 the closure of the line loop at the substation places a potential on the test terminal of the line in the finder switch at the same time that the potential of the individual control electrode is altered. This calling potential on the terminal of the finder permits the test
40 switch to distinguish the calling line from the other lines, and, since the several control electrodes are electrically isolated from each other, the calling condition on one line does not manifest itself on the terminals of any of the other
45 lines in the group.

Another feature of the invention is a line finder switch in which a space discharge device is used in circuit with the relay that controls the stepping action of the switch magnets. This relay closes the energizing circuits of the magnets
5 through one of its normal contacts, and the relay itself operates over a circuit through the discharged tube when the brushes of the switch reach the desired level or the desired contact in the level. This arrangement overcomes the
10 possibility of the switch taking a false step.

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.

15 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. It is to be understood, however, that
20 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 a calling subscriber's station A and the associated line circuit LC, a line finder switch LF, a selector switch S, a connector switch C, and a called subscriber's station B.

25 The subscribers' stations A and B 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
30 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
35 of the circuits of the selector and connector switches are shown that are required for a clear and complete description of this invention, the omitted portions of these circuits being indicated
40 by broken lines.

45 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 tube 3, having a
50 multiplicity of control electrodes, such as electrode 4, is associated with each group of line circuits. Tube 3 is of the type which breaks down and becomes conducting when the potential on any one of its control electrodes becomes suffi-
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ciently positive with respect to the cathode potential of the tube. Each individual line circuit of a group, such as line circuit LC, connects to one of the control electrodes of tube 3, and, when a call is originated by a subscriber, a potential change on the control electrode associated with that line circuit causes tube 3 to break down and cause the line finder switch LF to hunt for the calling line. Current flow in the line also places an identifying potential on the test terminal of 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 21, 22, 23 and 24. 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 21, 22, 23 and 24. These terminal sets are arranged in ten vertical levels, each level consisting of ten horizontal terminal sets, and are selectable by brushes 15, 16, 17 and 18, which, by means of a common shaft (not shown), are advanced vertically to the proper level and then horizontally to the terminals of the calling line under control of the vertical operating magnet 11 and the rotary operating magnet 20, respectively. Relay 13, which is connected in the anode circuit of a cold cathode type gaseous discharge tube 10, controls the operating circuits for magnets 11 and 20. The line finder is provided with a commutator 7 having ten conducting segments, one segment for each corresponding level of the line finder bank terminals. Associated with commutator 7 is a brush 8 which is mounted on the common brush shaft (not shown) and which advances simultaneously with brushes 15 to 18 inclusive, during vertical stepping. Tube 10, under control of commutator 7 and brush 8 during vertical stepping, and under control of test terminal 24 of the calling line and test brush 18 of the line finder during rotary stepping, breaks down when the proper level and the calling line terminals are encountered and causes relay 13 to operate and open the operating circuits for magnets 11 and 20 respectively, thereby preventing the line finder brushes from taking a false additional vertical or rotary step. 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 B.

The cathode 5 of tube 3 is connected to a source of negative potential, and the anode 6 is connected to a source of positive potential through the winding of relay 12. The potential difference between the anode and cathode of tube 3, while insufficient to cause the tube to break down, is sufficient to maintain ionization of the tube once it is broken down. Condenser 9 is connected in series with resistance 19 across the anode and cathode of the tube and is therefore charged to a potential equivalent to the potential difference between those points. The control grid 4 of the tube is connected to negative potential through resistance 2 and the lower winding of cut-off relay 1 of line circuit LC, this potential being of the same value as that connected to the cathode 5.

When the receiver is removed from the switch-hook at station A to originate a call, a circuit is completed from ground over the upper back contact of relay 1, tip conductor 25, loop of station A, ring conductor 26, to negative potential over the lower back contact and through the lower winding of relay 1. The resulting current

flow causes a reduction in the negative potential on the control electrode 4 of tube 3 and on test terminal 24 in the line finder terminal banks. Due to this reduction in potential, control electrode 4 becomes sufficiently positive with respect to cathode 5 that tube 3 breaks down and becomes conducting. Relay 12 operates in a circuit from positive potential through its winding, over the anode circuit of tube 3, to negative potential on the cathode of the tube. Immediately upon the breakdown of tube 3, condenser 9 starts to discharge over the anode-cathode circuit of the tube and, when its potential falls below the ionization value of the tube, tube 3 momentarily de-ionizes. Condenser 9 immediately recharges from the positive potential through the winding of relay 12 and, when its charge reaches the breakdown potential of the tube, tube 3 again ionizes and completes the operating circuit for relay 12 and the discharge circuit for condenser 9. This oscillatory action continues as long as the potential on the control grid 4 remains positive with respect to the potential on cathode 5. Relay 12 is of the slow-to-release type and remains operated even though the current through its winding is pulsating due to the aforementioned action of tube 3 and condenser 9.

Assume that terminals 21, 22, 23 and 24, associated with the line circuit of calling station A, are the fifth set of terminals in the fourth level of the line finder switch terminal banks. Tube 3 is common to all of the ten lines appearing in the fourth level of the terminal banks, each of these lines connecting to one of the ten control electrodes of the tube. Relay 12 is therefore common to all ten lines in the fourth terminal level and functions as a group start relay for all lines in that level. Relay 12, operating upon the aforementioned breakdown of tube 3 in response to the initiation of the call at station A, connects ground over its left front contact to the fourth conducting segment of commutator 7 which corresponds to the fourth level of the line switch terminal banks, and connects ground over its right front contact and over the back contact of relay 27 to battery through the winding of relay 14, operating that relay.

Relay 14, in operating, connects negative potential over its right inner front contact to electrode 31 of gaseous discharge tube 10, and operates vertical operating magnet 11 in a circuit from ground over the left back contact of relay 30, right middle front contact of relay 14, back contact of relay 13, right outer back contact of relay 29, to battery through the winding of magnet 11. Vertical magnet 11, in operating, operates relay 13 in a circuit from positive potential through the winding of relay 13 to negative potential over the armature and front contact springs of magnet 11, and, in addition, causes the line finder brushes 8, 15, 16, 17 and 18 to make one vertical step. The lower control electrode 32 of tube 10 is connected, in a circuit through resistance 33 and over the left outer back contact of relay 29, to the commutator brush 8. On the first vertical step of the brushes, brush 8 contacts the first conducting segment of commutator 7 but, since this segment is open, tube 10 does not function at this time. Relay 13, in operating, opens the operating circuit for magnet 11 which releases, in turn releasing relay 13. The release of relay 13 again closes the operating circuit for magnet 11 which causes the line finder brushes to make the second vertical step. The operation of

magnet 11 also operates relay 13 which opens the circuit for magnet 11. Magnet 11 releases, in turn releasing relay 13 which again operates magnet 11 and the line finder brushes make the third vertical step. Magnet 11, in operating, operates relay 13 which opens the circuit through magnet 11. Magnet 11 releases and releases relay 13 which closes the circuit for magnet 11. Magnet 11, in operating, operates relay 13 and advances the line finder brushes to the fourth level, brush 8 contacting the fourth conducting segment of the commutator 7.

A circuit is now closed from ground over the left front contact of relay 12, segment 34, brush 8, outer left back contact of relay 29, through resistance 33, to the lower or control cathode 32 of tube 10. Since negative potential is connected to the upper cathode 31 over the right inner front contact of relay 14, tube 10 breaks down due to the potential difference between cathodes 31 and 32. Upon the operation of magnet 11 for the fourth vertical step of the line finder brushes as has just been set forth, relay 13 operates and opens the circuit through magnet 11. Magnet 11 releases and completes the circuit from positive potential through the winding of relay 13, over the back contacts of magnets 11 and 20, through the right winding and over the left inner back contact of relay 29 to anode 35 of tube 10. Since tube 10 is broken down, as previously stated, relay 29 operates and relay 13 holds or, if already released, immediately reoperates, in the circuit just traced to the anode 35, to the previously traced negative potential on cathode 31. Relay 13, operated, holds the energizing circuit for vertical magnet 11 open, thereby preventing the line finder brushes from making a false additional vertical step.

The left inner armature and front contact springs of relay 29 are arranged to close before any of the back contacts open and relay 29, upon operating through its right winding, locks from battery through its left winding and over its left inner front contact, to ground over the right outer front contact of relay 14. Relay 29, in operating, opens the operating circuit for vertical magnet 11 and, over its right front contact, partially closes the operating circuit for rotary magnet 20. Relay 29, in operating, also transfers the circuit of anode 35 of tube 10 from positive potential over the previously traced circuit through the right winding of relay 29, to the same positive potential in a circuit traceable over the left middle front contact of relay 29, right inner back contact and right winding of relay 30, back contacts of magnets 20 and 11, and through the winding of relay 13. During the transfer time of the left middle armature of relay 29 from its back to its front contact, the anode circuit of tube 10 is momentarily opened, thereby causing the tube to de-ionize and become non-conducting and causing relay 13 to release. In addition, the operation of relay 29 transfers the circuit of control cathode 32 of tube 10 from commutator brush 8 to test brush 18.

Relay 13, in releasing, energizes rotary operating magnet 20 in a circuit from battery through the winding of that magnet, over the right front contact of relay 29, back contact of relay 13, right middle front contact of relay 14, to ground over the left back contact of relay 30. Magnet 20, in energizing, causes brushes 15 to 18 inclusive to make one rotary step and contact the first set of terminals in the fourth level of the line finder terminal banks. Since it has been assumed that

terminals 21 to 24 inclusive are the fifth set of terminals of the fourth level, the test terminal of the first four terminal sets are at the same potential as cathode 31 of tube 10. As test brush 18 encounters these test terminals, tube 10 does not function since both cathodes are at equal potential. Magnet 20, as it operates for each rotary step of the line finder brushes, operates relay 13 in a circuit from negative potential over its front contact, over the back contact of magnet 11, to positive potential through the winding of relay 13. Relay 13, in operating, opens the operating circuit for magnet 20 which releases and connects the positive potential, through the winding of relay 13 and the right winding of relay 30 over a previously traced circuit, to the anode 35 of tube 10. Since tube 10 does not break down when test brush 18 contacts the test terminals of the idle lines, relay 13 immediately releases upon each release of magnet 20 as the line finder brushes rotate across the first four sets of terminals in the fourth level of the terminal banks. Each release of relay 13 again closes the operating circuit for magnet 20 which energizes and advances the brushes to the succeeding set of terminals. Upon the fifth operation of magnet 20, brushes 15, 16, 17 and 18 contact terminals 21, 22, 23 and 24 respectively of the line circuit associated with the calling station A. As hereinbefore set forth, the potential on test terminal 24 is lower than the potential on the test terminal of idle lines due to the voltage drop caused by the flow of current in the lower winding of relay 1. As test brush 18 contacts terminal 24 this reduced voltage is impressed on control cathode 32 of tube 10 in the circuit over the left outer front contact of relay 29 and through resistance 33. Since cathode 31 is at full negative potential, the potential difference between cathodes 31 and 32 causes tube 10 to break down and become conducting.

The operation of magnet 20 for the fifth step of the line finder brushes operates relay 13 which, in turn, opens the circuit through the winding of the magnet. Magnet 20, in releasing, closes the previously traced circuit from the positive potential through the winding of relay 13 and through the right winding of relay 30 to anode 35 of tube 10. Since tube 10 is in the conducting condition, relay 30 operates and relay 13 remains operated or, if already released, immediately reoperates, in the aforementioned circuit, over the anode-cathode circuit of tube 10, to negative potential on cathode 31. Relay 13, operated, holds the energizing circuit for magnet 20 open and thereby prevents the line finder brushes from taking a false additional rotary step.

The left inner armature and front contact springs of relay 30 are so arranged that they close before any of the back contacts open, and relay 30, in operating, immediately locks in a circuit from battery through its left winding and over its left inner front contact to ground over the left front contact of relay 14. Relay 30, in operating, opens the circuit to the anode 35 of tube 10, thereby de-ionizing the tube and releasing relay 13. Relay 30 also opens the operating ground for magnets 11 and 20 over its left back contact, and closes the tip and ring conductors 36 and 37 from the line finder bank terminals 21 and 22 over its left and right outer front contacts respectively, to the succeeding selector circuit S. Relay 27 operates in a circuit from battery through its left winding, over the right inner front contact of relay 30, to ground over the lower armature and

front contact of the vertical off-normal springs 38 which previously operated upon the first vertical step of the line finder brushes. Relay 27 opens the circuit to the winding of relay 14 and may under certain conditions lock through its right winding to ground over the start wire 45. Cut-off relay 1 of line circuit LC also operates, upon the operation of relay 30, in a circuit from battery through its upper winding, over terminal 23 and brush 17, right middle front contact of relay 30, to ground over the left front contact of relay 14.

Relay 1, in operating, opens the circuit through its lower winding and, since the flow of current through that winding ceases, the potential on control electrode 4 of tube 3 assumes the full negative value and becomes equal to the potential on cathode 5. As previously set forth, condenser 9 has been charging and discharging over the anode-cathode circuit of tube 3 in an oscillatory action which has held relay 12 operated in the tube anode circuit. With no difference in the potentials on control cathode 4 and cathode 5, tube 3 de-ionizes and becomes non-conducting as its anode potential falls below the ionization value during the next discharge of condenser 9. With tube 3 in the non-conducting condition, relay 12 releases and removes the ground from segment 34 of commutator 7 and also opens the circuit through the right winding of relay 27.

When the tip and ring conductors 35 and 37 respectively, are extended to the selector switch S by the operation of relay 30, the selector S functions and returns a ground over lead 28 for the purpose of holding relays 1 and 30 operated. As previously stated, the operation of relay 27 opens the circuit through the winding of relay 14. Relay 14, being slow to release, maintains the holding ground for the left winding of relay 30 and for the upper winding of relay 1 until selector S functions and returns ground for this purpose over conductor 28. Relay 14 releases after an interval, and opens the circuit through the left winding of relay 29. Relay 29 releases and partially closes the future operating circuit for release magnet 39.

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 conversation, when the subscribers replace their receivers ground is removed from conductor 28 by the selector circuit S, thereby releasing relays 1 and 30. Relay 30, in releasing, opens the tip and ring conductors 35 and 37, and energizes the release magnet 39 in a circuit from battery through the winding of that magnet, upper armature and front contact of springs 38, right inner back contact of relay 29, right outer back contact of relay 30, left back contact of relay 14 to ground over the lower make contact of springs 38. Release magnet 39, in energizing, causes line finder brushes 8, 15, 16, 17 and 18 to restore to their normal position. As the brushes return to normal, the vertical off-normal springs 38 restore to normal thereby releasing magnet 39 and relay 27. Relay 27, in releasing, again closes the circuit from the winding of relay 14 to the right front contact of the group start relay 12, and the line finder is ready to hunt for another calling line. Relay 1, in releasing, connects ground over its upper back contact to the tip line conductor 25, and connects negative potential through its lower winding and over its lower back contact to ring line conductor 26

thereby restoring line circuit LC to its normal idle condition.

It will be noted that the circuit from the winding of relay 13 to the anode 35 of the tube 10 is carried over the back contacts of vertical magnet 11 and rotary magnet 20. During the vertical and horizontal stepping of the brushes, the anode circuit of tube 10 is therefore held open for an interval until the release of magnet 11 or 20, as the case may be, closes its back contact. This interval is provided to prevent relay 13 from operating too soon due to the overthrow of the brushes during stepping, at which time the brushes may momentarily contact the succeeding segment or set of line terminals before coming to rest in the proper position associated with the particular step taken. For example, during the third vertical step of the brushes, brush 7 may momentarily overthrow to segment 34 before coming to rest on the third segment. Tube 10 may break down momentarily but, since its anode circuit is open at the back contact of vertical magnet 11 which is not yet released, relay 13 can not operate and stop the vertical stepping prematurely. Similarly, during rotary stepping, the overthrow of brush 18 to test terminal 24 during the preceding rotary step may momentarily cause tube 10 to break down but in this case the operated rotary magnet 20 holds open the anode circuit and relay 13 can not operate to cause a premature stopping of rotary hunting. In either case, by the time that magnet 11 or magnet 20 releases and closes the anode circuit for tube 10, brush 7 or 18 will have come to rest on the proper segment or terminal.

Resistance 19 is provided in the discharge circuit for condenser 9 to limit the anode current through tube 3. Resistance 33 is provided to limit the current flow between the cathodes of tube 10. Resistance 40 serves to stabilize the potential of control electrode 32.

As hereinbefore set forth, condenser 9 provides for the oscillatory action of tube 3 which insures the release of relay 12 after the control cathode 4 of the tube assumes the same potential as cathode 5. The positive potential connected to cathode 5 may be supplied over the contacts of a high speed interrupter (not shown) in which case condenser 9 and resistance 19 are omitted. Relay 12, being slow-to-release, holds over the interruptions upon the breakdown of tube 3 and, after the control cathode potential returns to the same value as the potential on cathode 5, tube 3 de-ionizes and becomes nonconducting during the first open period of the interrupted positive potential on cathode 5. Tube 3, de-ionized, opens its anode circuit and releases relay 12.

What is claimed is:

1. The combination in a telephone system of lines, a discharge device common to a plurality of said lines and having a plurality of control electrodes, said electrodes being individual respectively to said lines, and switching means responsive to said discharge device.

2. In combination in a telephone system of subscribers' lines, a space discharge device common to a group of said lines, said device having a plurality of control electrodes individual respectively to said lines, means for altering the electrical condition of any one of said electrodes under the control of the corresponding line, a discharge circuit for said device, and current responsive means in said discharge circuit.

3. The combination in a telephone system of subscribers' lines, a space discharge device com-

mon to a group of said lines, a discharge circuit for said device, said device having a plurality of control electrodes individual respectively to said lines, means for maintaining a potential on each of said electrodes to prevent the flow of current in said discharge circuit, means for altering the potential of any one of said electrodes under the control of the corresponding line, and means in said circuit responsive to the flow of current therein.

4. In a telephone system, subscribers' lines, a space discharge tube common to a group of said lines, said tube having a plurality of control electrodes individual respectively to said lines, a line finder switch having a terminal bank in which the lines of said group appear, a circuit controlled by one of said lines when calling for altering the potential of the corresponding control electrode to cause the discharge of said tube and for altering the potential of the corresponding terminal in said finder switch, and means responsive to the discharge of said tube for setting said finder switch in operation to seize the terminals of the calling line.

5. 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, means controlled 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, and test means rendered effective when the finder switch reaches the ter-

minals of the calling line for stopping the movement of said switch.

6. The combination in a selective switch of a terminal bank and a set of brushes including a test brush, a magnet for stepping said brushes over said terminals, a stepping relay, an energizing circuit for said magnet extending through a normal contact of said relay, a space discharge device connected to said test brush, and a circuit through said discharge device for operating said relay.

7. The combination in a selective switch of a series of terminals and a set of brushes including a test brush, a magnet for stepping said brushes over said terminals, a stepping relay for controlling the stepping action of said magnet, an energizing circuit for said magnet, extending through a normal contact of said relay, an energizing circuit for said relay extending through a normal contact of said magnet, a space discharge tube in the circuit of said relay, and means for causing said tube to discharge when the brushes of said switch reach a desired set of terminals.

8. The combination with a plurality of lines of a discharge device having a plurality of control electrodes, said electrodes being individual respectively to said lines, means for altering the potential of one of said electrodes, means effective in response to the altered potential of one of said electrodes for causing said device to discharge repeatedly, and operating means responsive to the discharge of said device.

9. The combination with a plurality of lines of a gas-filled tube having a plurality of control elements, said elements relating respectively to said lines, means for altering the electrical condition of one of said elements, means effective in response to the altered condition of one of said elements for causing said tube to repeatedly and alternately discharge and quench, and means operative in response to the discharge of said tube.

THOMAS L. DIMOND.