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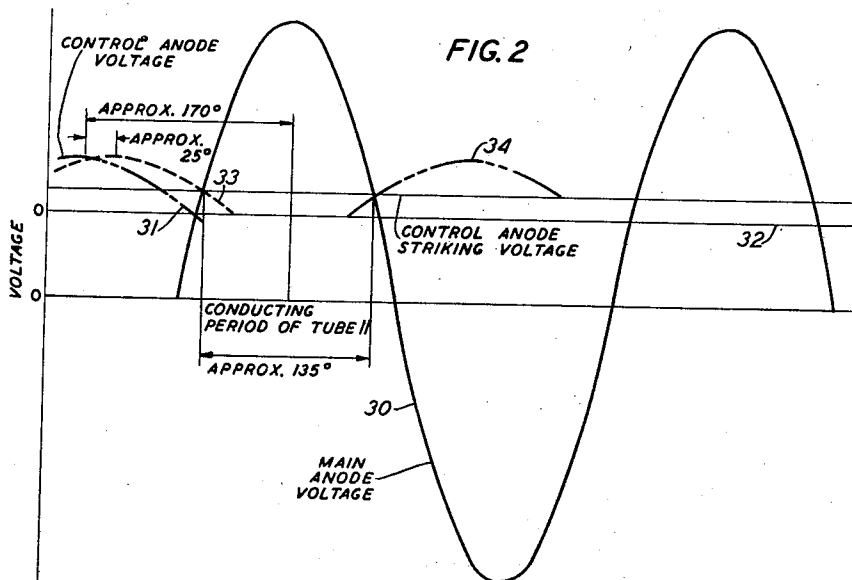
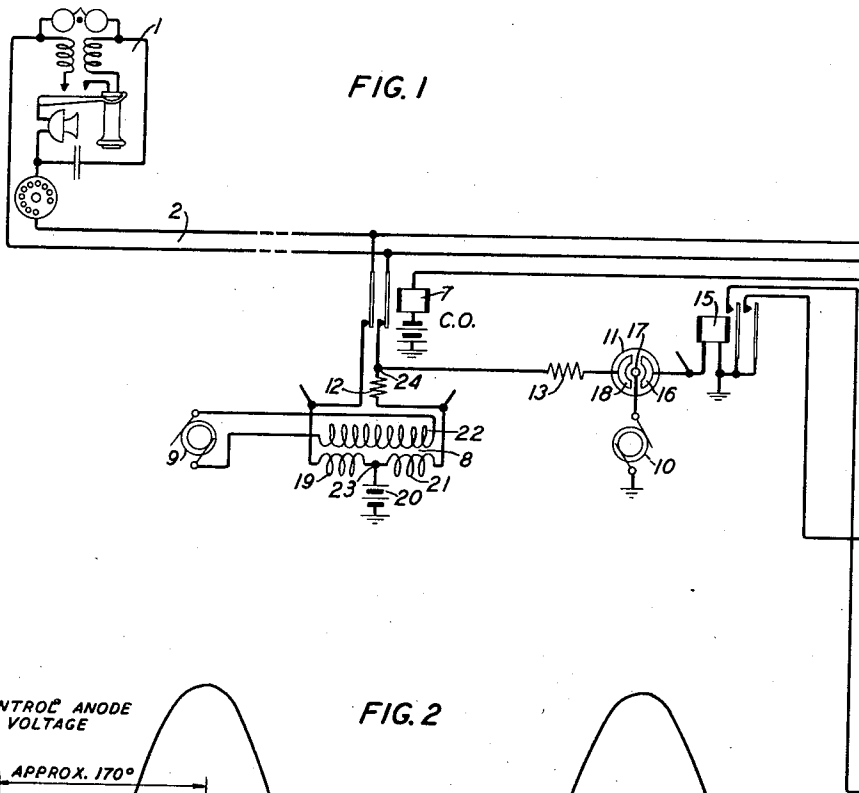
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2,238,469

SIGNALING SYSTEM

Filed Aug. 9, 1939

2 Sheets-Sheet 1



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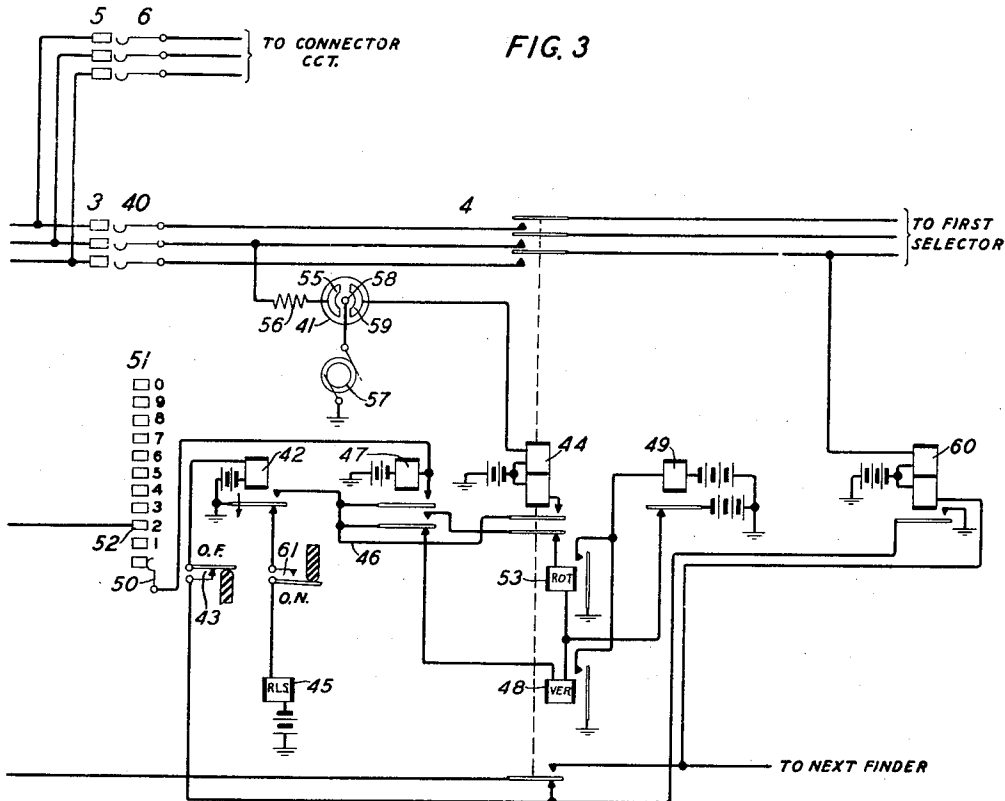
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2 Sheets-Sheet 2



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## UNITED STATES PATENT OFFICE

2,238,469

## SIGNALING SYSTEM

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Application August 9, 1939, Serial No. 289,147

8 Claims. (Cl. 179-18)

This invention relates to signaling systems and particularly to signaling in telephone systems.

This application is a continuation in part application of my application Serial No. 246,794, filed December 20, 1938.

An object of the invention is to improve the signaling over telephone lines in response to closing of a connection between the line conductors at a substation.

Another object is to eliminate as far as possible the disturbing line conditions that may be present while signaling over a telephone line.

Another object is to improve central office equipments in automatic telephone systems by substituting a simplified and more efficient signal responsive circuit arrangement in place of the usual line relay, and by simplifying the testing equipment for line finders.

Heretofore systems have been employed in which the closing of a connection between the line conductors at a substation causes the operation of a line relay or similar apparatus at the central office to initiate telephone connections. In such systems any line attenuations such as station ground, potentials, or other leakages may disturb or interfere with the proper functioning of the line relay, that is, the relay may respond or release at irregular intervals due to current changes caused by such disturbances on the line.

This invention relates to arrangements for eliminating disturbances while signaling over telephone lines and it is a feature of the present invention to substitute in place of the usual line relay, a circuit arrangement at one end of the line whereby a start relay or other signaling devices may be operated in response to a change in reactance of the line when a connection is closed between the line conductors at the opposite end of the line.

Another feature of the invention is an arrangement whereby signaling is effected by a phase shift of the ionizing voltage on a control electrode of a cold cathode tube in response to a change in reactance of a telephone line when a connection is established between the line conductors thereof.

Another feature is a method of signaling over a telephone line in response to a discharge of a cold cathode tube comprising subjecting of the tube to an ionizing voltage condition that is normally out of phase with respect to the discharge voltage of the anode to normally prevent the discharge of the tube to take place and shifting the phase of said ionizing voltage to cause a discharge to take place through the tube when

the effective discharge voltage is present on the anode. The arrangement may be such that this phase shift is accomplished by the change in reactance resulting from closure of the line at a subscriber's station.

Another feature of this invention relates to a line-finder circuit arrangement including means for testing for the calling line over the talking circuit to cause the line finder to stop on the terminals of the calling line. It includes a cold cathode tube associated with one of the talking conductors which is caused to discharge when the calling line is found by the line finder and circuit means controlled by said tube to stop the line finder.

This invention has been illustrated in the accompanying drawings in which:

Figs. 1 and 3 show an automatic telephone system in schematic form with the applicant's invention applied thereto. Fig. 1 shows a line circuit in which a circuit equipment according to the applicant's invention is substituted for the usual line relay to operate a start relay and Fig. 3 shows a line finder including a testing equipment in accordance with the applicant's invention.

Fig. 2 is a sine wave diagram indicating voltage and phase shift conditions to illustrate the functions in this respect of the applicant's invention.

Referring now to the drawings, Figs. 1 and 3 show a telephone set 1 and a line 2 leading to a central office where the line is connected to the terminals 3 of a line finder 4 and to the terminals 5 of a connector 6. The usual cut-off relay 7 is connected to the sleeve terminal of the line finder and connector and the line extends through contacts of this relay to the equipment provided for the substitution of a line relay comprising a repeating coil 8, alternating current sources 9 and 10, cold-cathode discharge tube 11, resistances 12 and 13 and a common start relay 15. This relay may be operated when the subscriber at station 1 removes his receiver from the switchhook to close the usual start circuit for causing the line finder 4 to function to extend a connection from the subscriber's line 1 to the usual automatic equipment for establishing a connection to a called line by the operation of the dial at substation 1. When calls come in over the connector 6, the cut-off relay 7 is operated to remove this equipment from the line and a connection may be established to a subscriber's line 1 in the usual manner.

This equipment for operating the start relay

15 when a subscriber removes his receiver from the switchhook is so arranged that the discharge tube 11 is connected in a circuit that normally prevents the tube from breaking down, but permits a breakdown to take place to close an operating circuit for the relay 15 when the line circuit is closed. This circuit arrangement utilizes a resistance-impedance series combination in which normally a resistance factor only is employed to prevent the tube from discharging and both resistance and impedance factors are employed to permit the tube to discharge. The resistance factor is a resistance element normally in the circuit and the impedance factor is furnished or represented by the line when closed at a substation. With this arrangement a system is provided that permits the relay 15 to operate more or less independently of earth potentials or station ground connections, or leakances, or other characteristics of the line.

To this end the tube 11 has one element, that is, the cathode 16, connected through the winding of the relay 15 to ground and another element, that is the main anode 17, connected to one terminal of the alternating current source 10, the other end of which is connected to ground. The third element, that is the control electrode 18, is connected to resistance 13. This resistance 13 is coupled to a resistance-impedance circuit comprising two branches. One branch includes the two conductors of line 2 through the subscriber's loop over the contacts of relay 7 and one winding 19 of the repeating coil 8 to the positive side of the direct current battery 20, the negative side of which is connected to ground. The other branch includes the high resistance 12 and another winding 21 of the repeating coil 8 to the positive side of the direct current battery 20. Another winding 22 of the repeating coil 8 is connected in series with the alternating current source 9.

In general, the operation of this device is as follows: normally with the line opened the alternating current source 10 establishes an effective voltage drop on the main anode 17 and the alternating current source 9 establishes an effective voltage drop on the control electrode 18. These effective potentials on the main anode 17 and control electrode 18 are normally out of phase. That is to say, the effective voltage on the control electrode 18 to ionize the tube 11 will not occur at the same time as the effective voltage on the main anode 17 occurs which would therefore prevent the tube from operating under normal conditions. On the other hand, when the line conductors 2 are closed at the substation, the resistance-impedance circuit provided thereby will operate to change the phase of the effective voltage on the control electrode 18, so that it occurs at the same time as the effective voltage on the main anode 17. Consequently, the tube will operate under these conditions to cause a current to flow through the tube from the main anode 17 to the cathode 16 through the winding of relay 15. While the phase relation between the voltages on the control electrode 18 and the main anode 17 is normally fixed by the resistance-impedance circuit when the line is opened, this phase relation may vary considerably due to line conditions when the line is closed and yet cause the tube to operate. Although it is, of course, necessary in order to cause the tube to operate to move the phase of the voltage on the control electrode 18 sufficiently close to that on the main anode 17 to cause the ionization of the tube to take place within the interval when the voltage on the

main anode 17 is effective to cause the tube to break down.

More specifically, this device operates as follows: The operating current sources 9 and 10 are so controlled that the waves produced by these sources normally bear a definite phase relation. However, due to the resistance 12 and the reactance of the line 2 in the circuits for the control electrode 18, the phase of the voltage applied on this electrode is caused to lag behind the phase of the voltage applied on the main anode 17. The control electrode voltage drop is that effected between the points 23 and 24. Furthermore, this voltage on the control electrode 18 is normally sufficiently biased by the connection at point 23 of the positive terminal of the direct current source 20. Thus the tube 11 is prevented from operating due to the fact that the voltage supplied by the alternating current source 10 on the main anode 17 cannot cause a discharge to take place between this anode and the cathode 16 during its effective period as the control electrode voltage will not be sufficiently positive in respect to the cathode 16 to cause ionization of the tube during this effective period. In other words the main anode voltage is not sufficiently positive to cause the discharge of the tube during the ionization period.

This is the characteristic under normal condition when the line is open. On the other hand, when the connection is made at the substation between the conductors of line 2 it will be observed that it is made over a circuit across the points 23 and 24. This closure of the direct current loop at the substation produces, in effect, a substantial change in the reactive impedance of the line. This change causes the control electrode voltage to shift in phase to be nearly or fully in phase with the effective voltage of the main anode 17. Consequently, the ionization of the tube by the positive characteristics of the control electrode will take place at the time when the positive voltage on the main anode 17 is sufficient to cause a discharge between the anode 17 and cathode 16. The tube will therefore discharge at this time as long as the voltage on the anode 17 is sufficient to maintain it. A current will consequently now flow from the source 10 between anode 17 and cathode 16 over the circuit through the winding of relay 15 to ground and cause this relay to operate. This current will therefore comprise a series of direct current beats continued as long as the line circuit is closed to maintain the tube operated, and relay 15 is designed to operate and hold on these current beats.

This phase shifting function has been illustrated in the sine wave diagram of Fig. 2. The wave form 30 illustrates the voltage on the main anode 17. The normal voltage on the control electrode 18 is illustrated by wave form 31 which, being biased by battery 20, has its zero line at 32. This shows that when wave 31 is thus out of phase or lags behind wave 30 for about 170 degrees the tube will not become conducting as the ionization across the control electrode 18 and cathode 16 ceases before the effective voltage on the main anode 17 has risen sufficiently to strike or discharge to the cathode 16. However, when the control electrode voltage is shifted to take the position indicated by wave 33 approximately 25 degrees towards the right the voltage on anode 17 has risen to a value where it will strike, that is, the tube will discharge, and as indicated by wave 34, the con-

trol anode voltage may shift about 135 degrees further towards the right before the tube ceases to strike. Hence, there may be considerable change in the line attenuations without causing any false operations of the start relay.

Although any suitable means may be used for signaling the subscriber at the substation, an alternating current ringer is illustrated. This bell may be designed to respond readily to the ringing current frequency and to be unresponsive to current of the frequency produced by generator 9.

A description will now be made of the function of the line-finder circuits as disclosed in Fig. 3 whereby a connection may be established from the calling line in Fig. 1, when the line circuit has functioned to operate start relay 15 as hereinbefore described, to cause this line finder to operate to seize the calling line and connect it through line terminals 3 and line-finder brushes 40 to a connection beyond. This line finder is of the well-known type which operates in a vertical direction to advance its brushes 40 to the level in the switch in which the calling line is located and to then advance the brushes in a rotary direction to connect them with the terminals of the calling line. The testing for the calling line will be controlled primarily by the cold-cathode tube 41 and associated circuits over the ring terminal and ring brush as will hereinafter be described. When relay 15 operates the effect will be that a start circuit is closed for the operation of relay 42 over a circuit from battery, winding of this relay, the usual eleventh step contacts 43, contacts of relay 44 to ground at the contacts of relay 15. When relay 42 operates it opens a point in the circuit of release magnet 45 and places ground potential on the conductor 46. This prepares a locking circuit for relays 47 and 44 and operates the vertical magnet 48 over a circuit from battery, contacts of interrupter relay 49, winding of magnet 48, the lower outer contacts of the transfer relay 47 to ground at contacts of relay 42 over conductor 46. Magnet 48 in operating closes a circuit for relay 49 at its contacts, whereupon relay 49 operates and opens the circuit from magnet 48. Magnet 48 thereupon deenergizes and opens the circuit for relay 49 whereupon relay 49 deenergizes and again closes the circuit for magnet 48. These actions continue until the circuit for this magnet is opened on the operation of relay 47 which takes place when the magnet has advanced the vertical wiper 50 to the third level of bank contacts 51. In this position the wiper 50 is brought into engagement with the test contact 52. When this occurs a circuit is completed for relays 47 from battery through its winding, wiper 50, contact 52, contacts of relay 15 to ground. Relay 47 in operating closes a locking circuit for itself through its inner lower armature and front contact to ground over conductor 46 at contacts of relay 42. Relay 47 also opens the circuit for the vertical magnet 48 and thereby terminates the vertical movement. Relay 47 now extends the ground connection from relay 42 over conductor 46 to the rotary magnet 53 which operates over a circuit from battery, contacts of relay 49, winding of magnet 53 and contacts of relays 44, 47 and 42 to ground over conductor 46. The rotary magnet in operating closes a circuit for the operation of relay 49 which opens the rotary magnet circuit so that this magnet releases and causes the release of relay 49. These actions are continued until the

brushes 40 are opposite the terminals 3 of the calling line.

It should now be observed that the control electrode 55 of the cold-cathode tube 41 is connected to the ring brush of the line finder through a resistance 56 and over the ring terminal of the calling line, ring conductor, contact of relay 7 to the point 24. As has already been explained, when this line is calling the phase relation between the alternating current voltages as applied by the source 9 to 10 cause tube 11 to operate. Consequently, as resistance 56 is of the same value as resistance 13 and both being connected to the same point 24 in the circuits and as the phase of the alternating current source 57 connected to the main anode 58 of tube 41 is the same as that of the alternating current source 10, it follows that the voltage on control electrode 55 will now cause tube 58 to operate for the same reason as tube 11 operates when the subscriber calls. It should be noted that the operation of tube 41 will only take place when a called line is encountered. In case the brushes encounter idle lines during their travel to the terminals of the called line, it is evident that the phase of the alternating current voltage as applied at points corresponding to point 24 of such lines and the anode voltage of tubes such as 11 are out of phase and such tubes are not operated as hereinbefore explained. Consequently, under these circumstances tube 41 can not operate. It is also evident that when the brushes 40 encounter busy lines, the tube 41 will not operate as the relays corresponding to relay 7 of such busy line would be operated and thus the tubes corresponding to tube 11 would be eliminated from the circuit. Resistances 13 and 56 are so high that the control electrode current of tube 11 does not appreciably alter the phase angle nor does the connection of the control electrode of tube 41 through the ring conductor of a busy line produce any appreciable disturbance. When tube 41 operates the resulting current through the tube over main anode 58 and the cathode 59 flows through the upper winding of relay 44 from battery through the upper winding of relay 44, cathode 59, main anode 58 and source 57 to ground. This current will, of course, comprise a series of direct current beats continued as long as the tube 41 is in operative condition. Relay 44 in operating provides a locking circuit for itself through its lower winding, lower inner armature and front contact, contacts of relay 42 over conductor 46, and opens the circuit for the rotary magnet 53 so that the line finder will therefore remain connected to the calling line terminals. Relay 44 now extends the connection from the calling line, over terminals 3 and brushes 40 through contacts of this relay to a first selector for the establishing of a connection beyond as is well known in the art. Relay 44 also extends the starting wire from relay 15 to the next finder. When ground is encountered over the sleeve conductor from the first selector, relay 60 operates from battery over the upper winding and provides a connection to ground for maintaining the relay 42 operated. After the starting ground is removed by the operation of relay 44, relay 42 is slow in releasing so as to remain operated during the transfer of the connection. This ground connection of the sleeve from the first selector also causes the operation of relay 7 which disconnects, as hereinbefore described, the connection from the calling subscriber to tube 11 which now ceases to operate and releases

relay 15 to open the starter wire and the connection to contact 52. Consequently, tube 41 also ceases to operate and current through the upper winding of relay 44 is discontinued.

The connection established from the calling subscriber over the line finder to the first selector may now be extended through a called subscriber in the usual manner through any well-known automatic telephone system by having the subscriber dial the called subscriber's number. When the connection is released, ground is removed from the sleeve connection and thus causes the release of relays 60 and 42 which in turn causes the release of relays 47 and 44. The release of relay 42 closes a circuit for release magnet 45 from battery through the winding of this magnet and vertical off-normal contacts 61, contacts of relay 42 to ground. Release magnet 45 restores the line finder to normal. It is evident that this relay 60 will not cause the release of the line finder if the starter wire is used for operating another succeeding line finder at the time the circuit for the upper winding of relay 60 is opened as it will be locked from battery through its lower winding through the starter wire ground. This locking circuit will, of course, be open when the starter wire is no longer needed at which time the ground will be disconnected from this wire by the release of relay 15 which takes place when the line finder has found a calling line and the associated cut-off relay 7 is operated.

What is claimed is:

1. In a signaling system, a line comprising a pair of conductors, a signaling device, a three-element cold-cathode tube, means for normally applying voltage on the control electrode for ionizing said tube at intervals and for applying a discharge voltage on the anode at the intervals when the tube is not ionized so that this tube will not normally discharge across the anode and cathode, means for changing the reactance of said line in response to the closing of a connection between said line conductors, and means responsive to said change in reactance for shifting the ionizing period to occur during the intervals when discharge voltage is applied so that the tube will discharge during said period, and means for actuating said signaling device when a discharge takes place between said anode and cathode.

2. In a telephone system, a signaling device, a cold-cathode tube having a control anode, a main anode and a cathode, means for normally applying voltage on the control anode at intervals for ionizing said tube at said intervals, means for normally applying a discharge voltage on the main anode at the intervals when the tube is not ionized thus normally preventing the tube from discharging, means for shifting the intervals of applications of the ionizing voltage so that they occur during the intervals when a discharge voltage is applied to cause the tube to discharge during said intervals and means responsive to said discharge through said tube for actuating said signaling device.

3. In a telephone system, a relay, two line conductors, a cold-cathode tube having a control anode, a main anode and a cathode, a circuit connecting the cathode through the winding of said relay to ground, means for applying voltage to said control anode at intervals for ionizing said tube during said intervals across said control anode and said cathode, means for applying discharge voltage to the main anode at intervals

when the tube is not ionized so that the tube will not discharge, means including the said line conductor in series for shifting the application of the ionizing voltage to occur during the application of the discharge voltage so that the tube will discharge across the main anode and cathode when the discharge voltage is applied and operate the relay in the cathode circuit.

4. In a signaling system, a relay, a central office, a substation, a telephone line connecting said central office and said substation, a cold-cathode tube having a control anode, a main anode and a cathode, means including a source of alternating current, a transformer and a source of direct current associated with said telephone line and the control anode of said tube for establishing an ionizing potential between said control anode and said cathode at intervals, means including a source of alternating current and the main anode of said tube for establishing a voltage on said anode at intervals that causes said tube to discharge between said main anode and said cathode when the tube has been ionized, said two means being so arranged that the intervals of ionization and the intervals of application of the discharge voltage occur normally when the line conductors are opened at the substation and at alternate periods to prevent discharge of the tube, and occur at the same period when the line conductors are closed at the substation to cause discharges of the tube, and a circuit from the cathode through the winding of said relay to ground for energizing said relay each time the tube discharges.

5. In a telephone system, a line, a repeating coil, a relay, a cold-cathode tube having a control anode, a main anode and a cathode, circuit means comprising one section including a source of direct current, a secondary winding of said repeating coil and a resistance connected in series with the control anode and the winding of said relay connected at one end to the cathode and at the other end to ground, another section including one conductor of said line connected to the control anode, a third section including the other conductor of said line and another secondary winding of said repeating coil, in series connected to said first-mentioned secondary winding and said source of direct current, a fourth section including an alternating current source and a primary winding of said repeating coil in series, a fifth section including a source of alternating current having one terminal connected to ground and the opposite terminal connected to the main anode, said circuit means being so adjusted that when the two conductors are not connected together the tube will ionize across the control anode and cathode and a discharge voltage will be applied to the main anode at alternate intervals and thus prevent the tube from discharging and when the line conductors of said line are connected together, at their free ends, the ionization will occur during the application of the discharge voltage and thus cause the tube to discharge across the main anode and cathode and cause current to flow through the relay winding to operate the relay.

6. In a telephone system, a set of line terminals, a line finder having brushes controllable to connect with said line terminals, a line connected to said line terminals, a relay, a cold-cathode tube, a circuit means associated with said line and tube so arranged that when said line is seized voltage is applied to said tube at

certain intervals to cause it to ionize and discharge, means responsive to said discharge for operating said relay, means in said line finder operative in response to the operation of said relay for actuating said line finder to cause its brushes to engage with said line terminals, a cold-cathode tube in said line finder, means for applying a discharge voltage on the anode of said last-mentioned tube at the same interval that the ionizing voltage is applied to the first-mentioned tube, a circuit means operative when said brushes encounter said line terminals and so arranged that the ionizing voltage applied to said first-mentioned tube at intervals is applied over one of said line terminals and a corresponding brush to said second-mentioned tube at said certain intervals which coincide with the intervals when discharge voltage is applied to said second-mentioned tube and therefore cause said second-mentioned tube to discharge, and means responsive to said last-mentioned discharge for causing said line finder to stop its brushes on said line terminals.

7. In a telephone system, a set of terminals, a line finder having brushes connectable to said terminals, a line connected to said terminals, a relay, a three-element cold-cathode tube, means for applying a voltage on the control anode of said tube for ionizing it at intervals, means for normally applying a voltage to the main anode of said tube at intervals intermediate the ionizing period of said tube so that the tube will not normally discharge, means responsive to the seizure of said line for changing the ionizing intervals of said tube to coincide with intervals of application of the discharge voltage so that the tube will discharge during the interval when a discharge voltage is applied, means responsive to said discharge of the tube for operating said relay, means in said line finder operative in response to the operation of said relay for actu-

ating the line finder to engage said terminals, a three-element cold-cathode tube in said line finder, a circuit means operative when a brush of said line finder engages the corresponding terminal of said line for causing the ionizing voltage applied to the first-mentioned tube to be applied to the control anode of the second-mentioned tube to cause it to ionize, means for causing said second tube to discharge when ionized, a relay, means responsive to the discharge of said second-mentioned tube for actuating said last-mentioned relay, and means responsive to the operation of said relay for actuating said line finder to retain its brushes on said terminals.

8. In a telephone system, a set of terminals, a line finder having brushes connectable to said terminals, a line connected to said terminals, a three-element cold cathode tube associated with said line, means associated with said line and tube so arranged that when said line is calling, voltage is applied to said tube at intervals to cause it to ionize and discharge, means for also applying said ionizing voltage to one of the terminals of said line, means responsive to the discharge of said tube for operating said line finder to cause its brushes to engage said line terminals, a three-element cold cathode tube associated with said line finder, means for applying a discharge voltage on the anode of said last-mentioned tube at the same interval as the ionizing voltage is applied to one of said terminals of the line, a circuit means so arranged that the ionizing voltage applied to one of the terminals of the line will be applied to ionize said second tube and cause it to discharge when one of said brushes of the line finder encounters said one terminal, and means responsive to said last-mentioned discharge for stopping said line finder with its brushes on said line terminals.

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