

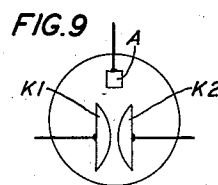
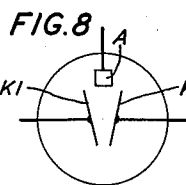
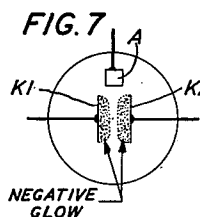
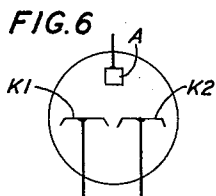
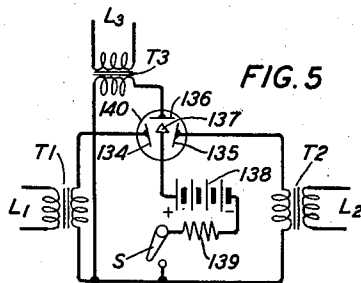
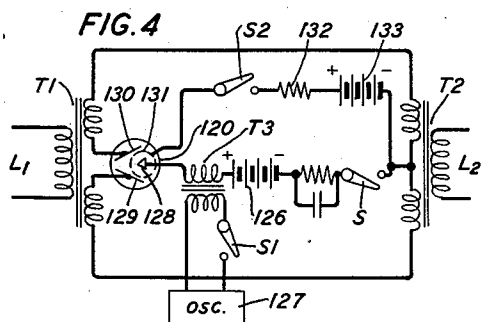
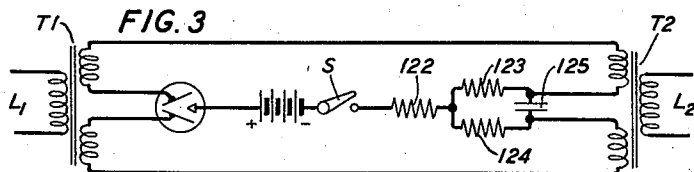
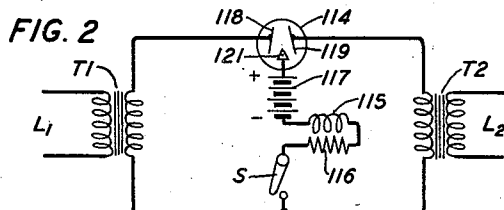
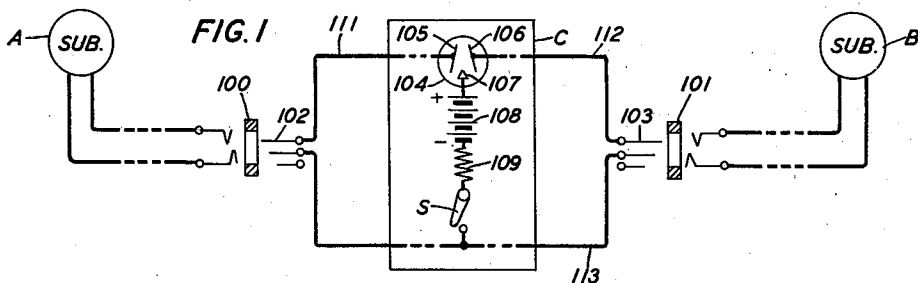
Sept. 8, 1942.

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2,294,910

SIGNALING AND COMMUNICATION SYSTEM

Filed March 26, 1941



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2,294,910

SIGNALING AND COMMUNICATION
SYSTEM

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Application March 26, 1941, Serial No. 385,231

12 Claims. (Cl. 179—51)

This invention relates to signaling systems and communication systems and particularly to those in which electronic devices are used for controlling the transmission circuits.

An object of the invention is to provide an improved gaseous conduction relay for making and breaking connections among a plurality of electric circuits.

Another object is to simplify maintenance of electric circuits by reducing the amount of electromagnetic relays to a minimum without sacrificing any of the operating features and substituting therefor improved gaseous conduction relays.

It is well known that electric circuits may be operatively controlled through flow of current in an associated circuit by interposing therebetween a cold cathode tube, which will act as a trigger device. The tube in general comprises a cathode, a control anode, and a main anode, and when placed in an electric circuit, connections are made through the anode circuit of the tube. It is also known that when the anode potential is maintained at a value intermediate between the main gap breakdown and sustaining voltages, the passage of a small amount of current in the control gap will produce ionization sufficient to initiate conduction in the main gap. It is this property of the tube which enables it to be used as a relay in electric circuits when utilized for control or signaling purposes. However, as far as applicant knows, the cold cathode tube because of its inherent noise and energy loss has not been satisfactorily used as a relay in the talking path of communication circuits.

In accordance with this invention, a novel electronic discharge device having divided cathode elements and an anode, is utilized as a relay for making and breaking connections in an electric circuit. Heretofore, mechanical relay contacts with their inherent maintenance problems have been employed to a large extent in the talking path of communication circuits because of low impedance after contact closure. It is now advantageous by the use of applicant's gas conduction relay to include the divided cathode elements in series with the talking path of a transmission circuit and to shunt the anode across the transmission circuit. While the cathode elements will introduce an open circuit condition during the gas conduction relay's normally inoperative state, breakdown of the gap between the anode and cathode elements will produce a low impedance to alternating current from one cathode element to another, and consequently

permit alternating current to flow therethrough since the cathodes are in series with the circuit. During the operated state of the relay the circuit condition presented is thus analogous to closure of mechanical relay contacts.

A feature therefore of this invention resides in an electronic discharge device having divided cathode elements, which are placed in series with an electric circuit, and an anode, which in conjunction with a source of energy and switch means is shunted across the circuit.

Another feature resides in an electronic discharge device having a plurality of cathode elements angularly spaced with each other and an anode symmetrically disposed with respect to the cathode elements.

A clearer understanding of the invention may be obtained from a consideration of the following detailed description read in connection with the accompanying drawing in which:

Fig. 1 illustrates one embodiment of the invention employing an electronic discharge device in a telephone operator's cord circuit with the divided cathode elements connected in series and the anode circuit shunted across the talking circuit;

Fig. 2 illustrates a simple embodiment of the invention;

Fig. 3 illustrates a more balanced arrangement of the circuit shown in Fig. 2;

Fig. 4 illustrates another embodiment of the invention with added controls;

Fig. 5 illustrates another embodiment of the invention in which several circuits are connected in parallel through the cathode elements of the device;

Fig. 6 shows the present type of cold cathode tube with the surfaces of the cathode elements parallel and in the same plane;

Fig. 7 shows an improved arrangement of cathode elements in a cold cathode tube;

Fig. 8 shows a tube with slanting cathode elements as embodied in this invention; and

Fig. 9 shows a tube with curved cathode elements as embodied in this invention.

Electronic discharge devices exemplified as relays herein are of the type that are filled with an inert gas of a composition usually inserted in such devices and when ionized at a certain potential become conducting; but once rendered conductive maintain their conductivity until the potential is removed therefrom or is reduced below the sustaining value.

Referring to Fig. 1, two substations A and B of a telephone system are disclosed with appear-

ances at jacks 100 and 101, respectively, before a telephone operator's cord circuit C for manual interconnection. By the insertion of cord circuit plugs 102 and 103 into jacks 100 and 101, respectively, a circuit is prepared for interconnecting the substations A and B. In the operator's cord circuit C is introduced a gaseous conduction relay 104 having divided cathode elements 105 and 106 connected in series with tip conductors 111 and 112, respectively, and an anode 107 in series with a battery 108, current limiting resistance 109, and switch S connected to the ring conductor 113 of the circuit. While switch S is in an open position, no current can flow between the anode 107 and cathode elements 105 and 106 and therefore the path between the cathode elements 105 and 106 presents an open circuit to the tip conductors 111 and 112. After switch S is closed, a battery potential of sufficient magnitude to break down the gap between anode 107 and cathode elements 105 and 106 will cause current to flow in a circuit from the positive pole of battery 108, through anode 107, and thence normally in an evenly divided stream through parallel paths, one path through cathode element 105, tip conductor 111, plug 102, jack 100, over loop of substation A and back through jack 100, plug 102, ring conductor 113, switch S, and limiting resistance 109 to negative pole of battery 108; and the other path through cathode element 106, tip conductor 112, plug 103, jack 101, over loop of substation B and back through jack 101, plug 103, ring conductor 113, switch S, and resistance 109 to negative pole of battery 108.

The current that flows across the gap from anode 107 normally divides equally between the cathode elements 105 and 106, but a small potential applied in either direction in series with the line causes more current to flow to the one cathode than to the other. The added potential generates a direct current through the gap between the cathodes, adding its own value to the current of one cathode and subtracting an equal amount from that of the other cathode. For example, with a small potential (not shown) superimposed on conductor 111 at element 105, current flowing from anode 107 to cathode element 105 would be slightly less than that flowing to element 106, although the total current flowing through anode 107 would still be the same. A division of current is merely effected. The two cathode elements, therefore, form a path of low impedance to alternating current between the two conductors 111 and 112 of the cord circuit C, as long as current flows in the anode circuit. This path is of considerably lower impedance and lower energy loss than that between the anode and cathodes, at least for currents of low frequency. It can be traced from the left cathode element 105 through conductor 111, plug 102, jack 100, over loop of substation A and back through jack 100, plug 102, ring conductor 113, plug 103, jack 101, over loop of substation B and back through jack 101, plug 103, over tip conductor 112, and then through cathode element 106 to cathode element 105. It will be noted that this path through the cathode elements does not include the battery 108, resistance 109, or switch S, which factors contribute toward reducing the impedance and energy loss in the talking circuit. After the cord circuit has performed its function, the operator opens switch S and relay 104 deionizing, opens the circuit.

In Fig. 2, transmission lines L1 and L2 are

shown connected through a gas conduction relay 114 by means of transformers T1 and T2. A choke coil 115 is inserted between limiting resistance 116 and battery 117 to keep alternating current out of the anode circuit. The operation of relay 114 is similar to that described in Fig. 1 wherein the cathode elements 118 and 119 cause an open circuit to exist between lines L1 and L2 while relay 114 is in its normal inoperative condition. When switch S is closed, ionization of relay 114 takes place in a circuit from positive pole of battery 117, through anode 121, and thence in equal parallel paths, one path through cathode element 118 and transformer T1, and the other path through cathode element 119 and transformer T2, both paths then converging through closed switch S, resistance 116, and choke coil 115 to negative pole of battery 117. Following ionization and subsequent conductivity of relay 114, alternating current (not shown) entering, say at line L1, will be conducted through the cathode elements 118 and 119 of relay 114 to line L2 in an obvious circuit.

Another property of the gas conduction relay 114 makes it useful as a current limiter. Let it be assumed that a signal current is being transmitted from line L1 to line L2. If the signal current should exceed the total current in the anode circuit at any time, then one cathode element 118 or 119 would lose all of its current with the result that the lines would be disconnected while this condition lasted. This action takes place during both the positive and negative alternating current cycles.

A more balanced arrangement is shown in Fig. 3, wherein the transformers T1 and T2 are provided with split windings for connection to the gaseous conduction relay circuit. In addition to the limiting resistance 122, there is a smaller resistance 123 and 124 in each branch of the circuit for maintaining the two normal currents more nearly equal. These balancing resistances may be by-passed by a condenser 125 so as not to absorb power from the signal. A choke coil is not included herein since there is less tendency for alternating current to flow in the anode circuit. The operation of this arrangement is similar to that described in Fig. 2.

Fig. 4 shows another embodiment in which several control features have been added. In this arrangement the battery 126 is of insufficient voltage to initiate ionization of gas conduction relay 120 and therefore to effect ionization a source of alternating current is added. The alternating current energy is supplied by an oscillator 127 through a transformer T3 and switch S1 and when superimposed upon the direct current energy supplied by battery 126 causes a discharge to take place between anode 128 and cathode elements 129 and 130 in a manner already described. If the frequency of the impressed voltage is high enough, it will not interfere with the signal or talking current passing through the cathode elements 129 and 130.

A further control is obtained by means of a trigger electrode 131 of the usual type inserted in the relay 120 and connected through a switch S2 and high resistance 132 to the positive pole of a battery 133. The voltages of batteries 126 and 133 are then so adjusted that a connection is made from line L1 to line L2 only when all three switches, S, S1, and S2 are closed. The circuit is thus subject to a triple control.

In a similar manner applicant's gas conduction relay can be utilized to connect several cir-

cuits in parallel by means of its cathode elements. This is illustrated in Fig. 5 where three transmission lines are so connected. The relay 140 has three cathode elements 134, 135 and 136, and one common anode 137 controlled by a switch S. Upon closure of switch S, relay 140 is ionized in a circuit from the positive pole of battery 138 through anode 137, then in three parallel paths through cathode element 134 and transformer T1, cathode element 135 and transformer T2, and cathode element 136 and transformer T3, respectively, all converging through switch S and limiting resistance 139 to the negative pole of battery 138. Current can thereby flow from any one line L1, L2 or L3, to each of the other two lines; opening switch S deionizes the relay and disconnects all of the lines. By thus providing a plurality of cathode elements, applicant has discovered a novel means for connecting a plurality of circuits in parallel.

The structure and operation of the gas conduction relay used in the above-mentioned circuits will now be described in greater detail. In general, the device comprises an anode of any suitable metal, cathode elements of extended area so treated as to have low striking voltage and low sustaining voltage, and a filling of one or more noble gases, such as neon, argon, or helium at a pressure of a few millimeters to a few centimeters of mercury.

A "cold cathode," in a discharge tube, is a cathode that is operated near room temperature, that is, it is not heated so as to emit electrons thermionically. In a glow discharge at low gas pressure and with a cold cathode the current flows between a small area on the anode and a larger area on the cathode. The part of the cathode to which the current flows is covered with a glow of appreciable thickness called the "negative glow." The glow is caused by ionization in the gas, and neither the gas nor the cathode is incandescent. If the negative glow does not cover the whole cathode, the current density in the glow is constant, and the glow spreads over the cathode in proportion to the current flowing, without much change in voltage drop. Only when the negative glow covers the whole cathode, does the current density and potential drop increase. If attention is fixed on one of the cathodes, the current flowing out of it may vary considerably with relatively small variations of voltage drop, so long as the glow is able to expand or contract over the surface of this cathode. Variation of current with relatively small variation of voltage characterizes the property of low impedance. The path from one cathode to the other may be considered as two regions in series, each of low electrical impedance. Therefore, in applicant's device the gas pressure and cathode area are so proportioned that the normal current covers about one-half of each cathode, so that all of the current may be diverted to one or the other cathode element without much change in potential between them. There then exists a path of low impedance between the cathodes for alternating current of not greater amplitude than the steady current to the anode.

In Fig. 6 is shown a well-known type of cold cathode tube wherein the cathodes K1 and K2 are parallel and in the same plane while the anode A may be in a different plane. A better arrangement, as shown in Fig. 7, is to have the cathodes K1 and K2 in planes separated by about twice the thickness of the negative glow. Fur-

thermore, the current density increases considerably, for the same pressure and voltage, if the separation is just right. This phenomenon is known as the "hollow cathode effect" and results in a lower impedance.

The critical separation varies inversely with the pressure. To make the operation less dependent upon pressure, the cathode planes are given a variable separation. This is done as shown in Fig. 8, by slanting the cathode planes K1 and K2 or, as shown in Fig. 9, by curving the cathode planes K1 and K2. In this manner, a considerable part of the space between the cathodes will offer the right conditions for high current density and low impedance.

When the cathode-anode path of a gas discharge device is used in a talking circuit, it is found that the device introduces considerable noise in the circuit. This noise is associated with fluctuations in the conditions at the anode that give rise to current variations. In applicant's device a considerable improvement is achieved in the reduction of noise. This improvement may be explained by saying that in his device the anode gap is eliminated from the circuit; or in saying that the noisy anode current divides equally between the two cathodes, cancelling one another in the talking circuit.

The gas conduction relays and their circuits described herein therefore offer the advantage of eliminating noisy or faulty mechanical contacts from the signal path and replacing them by easily controlled low impedance gas discharge connections involving no high voltage path in the signal circuit. In addition, these arrangements find useful application in the switching and control of speech and signaling channels.

While this invention has been shown and described as embodying certain features merely for the purposes of illustration, it will be understood that it can be used in many other and widely varied fields without departing from the spirit of the invention and scope of the appended claims.

What is claimed is:

1. In combination, a communication circuit, a gas-conduction relay for opening and closing said circuit, said relay comprising a plurality of cathode elements, an anode, said cathode elements being connected in series with said communication circuit, a circuit containing said anode connected in bridged relationship to said communication circuit, and means included in said bridged circuit for rendering said relay conductive and non-conductive.

2. In combination, a transmission line, an electronic discharge device for opening and closing said line, said device comprising a plurality of cathode elements angularly spaced, an anode symmetrically disposed with respect to said cathode elements, said cathode elements being connected in series with said transmission line, a circuit including said anode bridged across said transmission line, and a source of energy included in said bridged circuit for applying potential to said anode to render said device conductive.

3. A transmission system comprising in combination with subscribers' lines and an operator's cord circuit, a gas-conduction relay for connecting and disconnecting said lines, said relay comprising a plurality of split cathodes angularly spaced, an anode symmetrically disposed with respect to said cathodes, said cathodes connected in series with one leg of said cord circuit, a circuit containing said anode connected to the other leg

of said cord circuit, a source of potential, a resistor, and a key included in said anode circuit for ionizing and deionizing said relay.

4. In combination, a transmission line, a gas-conduction relay for opening and closing said line, said relay comprising a plurality of divided cathode elements, a main anode, a control anode, said cathode elements being connected in series with said transmission line, a circuit containing said anodes connected in bridged relationship to said transmission line, and means included in said bridged circuit for rendering said relay conductive and non-conductive.

5. In combination, a transmission line, a gas-conduction relay for opening and closing said line, said relay comprising a plurality of angularly spaced cathodes, an anode symmetrically disposed with respect to said cathodes, said cathodes being connected in series with said transmission line, a circuit containing said anode shunted across said line, a source of direct potential included in said shunt circuit, said potential being insufficient to ionize said relay, and a source of alternating current energy superimposed upon said potential to render the relay conductive.

6. In combination, a transmission line, a gas-conduction relay for opening and closing said line, said relay comprising a plurality of split cathode elements angularly spaced, a main anode symmetrically disposed with respect to said elements, a control anode, said elements being connected in series with said transmission line, a circuit containing said anodes bridged across said transmission line, a source of direct potential included in series with each of the anodes, and a source of alternating potential superimposed upon the direct potential of the main anode, all of said potentials cooperating to render the relay conductive.

7. In combination, a transmission line, a gas-conduction relay for opening and closing said line, said relay comprising a plurality of cathodes angularly spaced, a main anode symmetrically placed with respect to said cathodes, a control anode, said cathodes being connected in series with said transmission line, a circuit bridged across said transmission line, said bridged circuit containing said anodes in parallel, a source of direct potential and switch means included in series with each of the anodes, switch means and a source of alternating potential superimposed upon the direct potential of the main anode, in which all potentials cooperate to render the relay conductive at the closure of all switch means, and in which said relay is rendered non-conductive at the discontinuance of the main anode direct potential.

8. In combination, a plurality of transmission lines, a gas-conduction relay for opening and closing said lines, said relay comprising a plurality of cathodes angularly spaced, an anode, said cathodes being connected in series with each of said lines, a circuit containing said anode bridged across one of said lines, and a source of energy included in said anode circuit for ren-

dering said device conductive in order to connect said lines in parallel.

9. In combination, a transmission line, an electron discharge device for opening and closing said line, said device comprising an envelope having a gaseous atmosphere therein, an anode, a plurality of planular cathode elements symmetrically disposed with respect to said anode, the gas pressure within said envelope and area of said elements being so proportioned that when said device is ionized the normal current covers about one-half of each cathode element, said cathodes being connected in series with said transmission line, a circuit containing said anode connected in bridged relationship to said line, and a source of energy included in said bridged circuit for applying potential to said anode to render said device conductive.

10. In combination, a transmission line, an electron discharge device for opening and closing said line, said device comprising a sealed envelope having a gaseous atmosphere therein, an anode, a plurality of divided planular cathodes symmetrically disposed with respect to said anode, said cathodes being angularly spaced with each other to obtain the hollow cathode effect, said cathodes being connected in series with said transmission line, a circuit containing said anode bridged across said line, and a source of energy included in said bridged circuit for applying potential to said anode to render said device conductive.

11. In combination, a transmission line, a gas-conduction relay for limiting the current in said line, said relay comprising a plurality of cathode elements, an anode, said cathode elements being connected in series with said transmission line, a circuit containing said anode bridged across said line, means included in said anode circuit for ionizing said relay and causing current to flow therein, said ionization rendering said relay conductive for the flow of signal current from one cathode element to another, and said relay being rendered non-conductive when said signal current exceeds said current in the anode circuit.

12. In combination, a transmission line, a gas-conduction relay for the transmission of signal current, said relay comprising a plurality of divided cathode elements, an anode, said elements being connected in series with said transmission line, a circuit containing said anode bridged across said line, means included in said anode circuit for ionizing said relay by flow of current from the anode to the cathode elements, said current dividing equally between the cathode elements, said ionization providing a low impedance for passage of signal current from one cathode element to another, and said signal current decreasing said current in one cathode and increasing said current in the other cathode element while the total current in said anode circuit remains substantially constant.

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