Aug. 31, 1937. F. K. LOW 2,091,551

SIGNALING SYSTEM

Filed June 22, 1935

FIG. 1

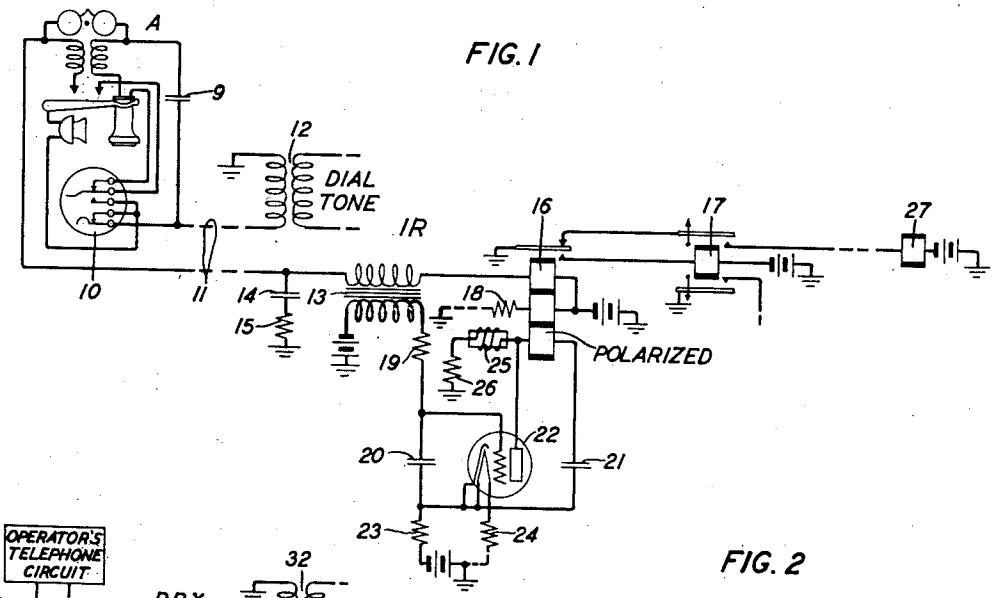


FIG. 2

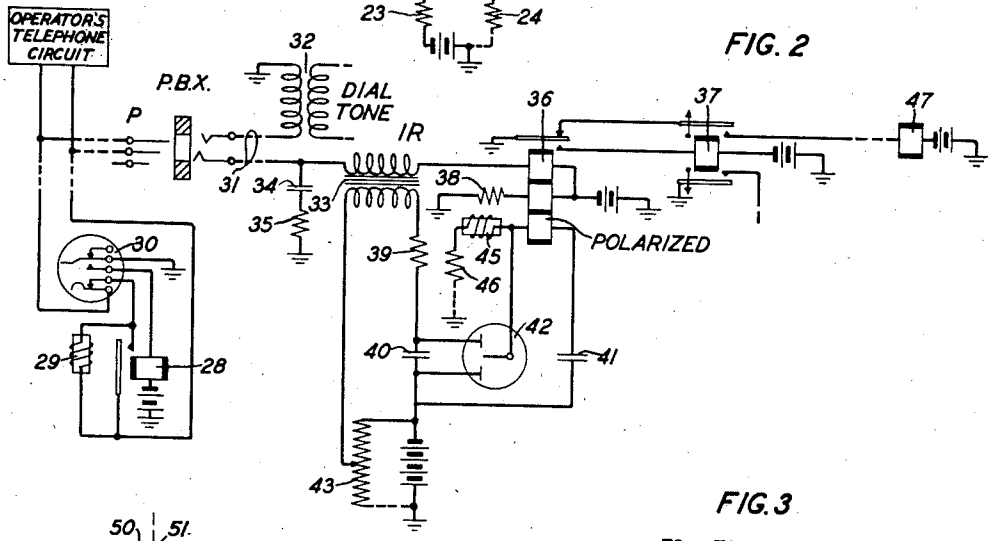
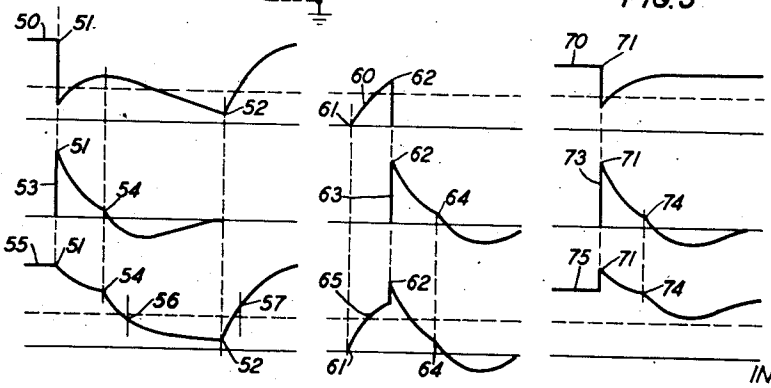


FIG. 3



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Patented Aug. 31, 1937

2,091,551

UNITED STATES PATENT OFFICE

2,091,551

SIGNALING SYSTEM

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Application June 22, 1935, Serial No. 27,940

9 Claims. (Cl. 179—16)

This invention relates to signaling systems and particularly to signaling systems comprising an electrical signaling circuit.

The object of the invention is to provide a more sensitive signal receiving means and to insure the accurate response of such a means to incoming signals.

This invention is a signal receiving means comprising an impulse relay, a transformer and a three-element ionic tube, primary windings of the impulse relay and transformer being connected in series with a line to respond to the opening and closing of the line by the operation of a signal sender. The secondary winding of the transformer is connected to the grid element of the tube so that the opening of the signaling circuit effects the breakdown of the tube and the temporary energization of the secondary winding of the relay by the discharge of a condenser in a direction to hold the relay operated for a short interval. Upon the condenser being sufficiently discharged, it is effective to deenergize the tube and the charging of the condenser through the secondary winding of the relay is thereupon effective to aid the release of the signal receiving relay.

A better and more complete understanding of the invention may be obtained by considering the specific embodiments of the invention shown in the drawing which forms a part of this specification. The invention is not, however, limited in its application to these specific arrangements and is, in general, applicable to any signaling system in which selective signals are created by the opening and closing of a signaling circuit.

Referring to Figs. 1 and 2 of the drawing, IR represents impulse receiving means in an automatic telephone office for operative connection to any one of a plurality of subscribers' lines. In Fig. 1 the line 11 connects the individual subscriber's station A to the central office and in Fig. 2 the line 31 is used as an outgoing one-way trunk from a private branch exchange, P. B. X., to the central office. Fig. 3 of the drawing shows a set of graphs which facilitate the description of the arrangements shown in Figs. 1 and 2.

The apparatus at station A includes a dial 10, and the apparatus at the private branch exchange includes an operator's dial 30, or other equivalent impulse sender, each for use in transmitting dial impulses. The central office includes automatic switching equipment (not shown) for establishing a connection between a calling line and an idle impulse receiving means IR. The impulse receiving means IR may be used to directly control in succession each of a train of selective switches to complete a desired connection or may be used to operate a register which thereafter controls the various switches through which a desired connection is established. Reference may be had to chapter III of the second edition of "Automatic Telephony" by Smith and Campbell for a description of an automatic telephone system comprising switches of the well-known Strowger type controlled by the dial impulses when dialed. Reference may be had to Patent No. 1,395,977, granted to F. A. Stearn et al., November 1, 1921 for a description of a system comprising switches of the power-driven panel type which are revertively controlled by a register-controller, set in accordance with trains of impulses created by the operation of the dial at any calling subscriber's station to which the register-controller is connected.

The impulse receiving means IR, shown in Fig. 1, of the drawing, comprises a transformer 13, a polarized impulse relay 16, a slow-to-release relay 17, condensers 20 and 21, a three-element gas-filled tube 22, and a register or selector 27. The polarized relay 16 has three windings, the upper winding for connection in series with a calling line, the middle winding for biasing the contacts in the position shown in the drawing, and the lower winding for insuring the response of relay 16 to each impulse of a series received by the upper winding. The tube 22 is filled to a low pressure with a gas, such as neon, argon or helium. Although shown as having a cathode which is heated indirectly, the tube may be one in which the cathode is directly heated. For a complete description of hot-cathode three-element gas-filled tubes, reference may be had to an article entitled "Hot-cathode thyratrons" by A. W. Hull, published in General Electric Review, volume 32, pages 213 to 223, inclusive.

The resistor 19 and condenser 20 form a filter for preventing dial tone or disturbances other than those legitimately created by the dial from affecting the control and operation of tube 22. The condenser 14 and resistor 15 form a surge filter which aids in the suppression of such disturbances. With the receiver removed from the receiver hook at station A to originate a call and the line 11 connected to the impulse receiving means IR, the ringing condenser 9 is bridged across the conductors of line 11 in parallel with the transmitter; and the condenser 9 is, therefore, partially charged. As soon as the dial is moved off-normal, the transmitter and condenser are short-circuited so that the con-

denser is discharged. While the dial is restoring to normal, the condenser is charged each time the dialing loop is opened and discharged each time the loop is closed. Each time the dialing loop is opened at the dial contacts the current drops abruptly, the condenser charging current being built up slowly due to the high impedance of the ringer which is in series with the condenser. The result is that the current through the upper winding of impulse relay 16 drops sharply, then rises due to the condenser charging current, and then again decreases; and relay 16 may, unless otherwise prevented, release, reoperate falsely and again release. Such a condenser charging current will herein be referred to as "subset surge". If the line 11 is connected to a private branch exchange as is the line 31 in Fig. 2, the moving of the operator's dial 30 out of normal position causes the operation of relay 28, thereby short-circuiting the retard coil 29 which is bridged across the conductors of the line 31 upon insertion of the plug P in the jack to which the line is connected. When the dial reaches normal, after transmitting a series of impulses, the retard coil 29 is again inserted in the dialing loop and, unless otherwise prevented, the impulse relay may release. Such a drop in the current, due to the insertion of the retard coil in the dialing loop, will hereinafter be referred to as a "P. B. X. surge". While the filter unit 14—15 might be large enough to entirely prevent false operation of the impulse relay due to subset surges, such a filter would also have a tendency to cause bell-tapping at the subscriber's station. The filter 14—15 is, therefore, one which is only partially effective in eliminating false operation due to subset and P. B. X. surges; and the transformer 13 and ionic tube 22 are provided, in combination with the lower winding of relay 16, to completely eliminate such false operation in the manner hereinafter described.

The lower winding of relay 16 is normally connected in a circuit from battery through resistor 23, condenser 21, lower winding of relay 16, retard coil 25 and resistor 26 to ground. Condenser 21 is, therefore, normally charged; and, since the anode of tube 22 is permanently connected to the junction point between coil 25 and the lower winding of relay 16, there is normally a difference in potential across the cathode and anode equal to the battery voltage. Although the grid of tube 22 is normally at the same potential as the cathode, the tube does not energize since the filament circuit is not closed. Condenser 20 is normally not charged. Upon extension of a calling line 11 to the impulse receiving means IR, ground potential is connected to the impulse receiving means to complete a circuit through resistors 23 and 24 for heating the filament and cathode of tube 22 and to complete a circuit through resistor 18 for energizing the middle winding of relay 16 so as to bias the contacts of this relay. With the filament circuit closed, there is a drop in potential in resistor 23, so that the potential of the cathode is increased, making the grid sufficiently negative with respect to the cathode to prevent energization of the tube. The drop in potential in resistor 23 also causes condenser 20 to be slightly charged. The drop in potential in resistor 24 is high so that condenser 21 is only slightly discharged and the potential difference across the cathode and anode only slightly decreased. The electromotive force induced in the secondary winding of transformer 13, upon closure of the impulse circuit through the upper winding of relay 16, merely serves to decrease the potential of the grid; that is, the negative bias of the grid with respect to the cathode is increased so that the tube remains deenergized.

With relay 16 operated, a circuit is closed for operating the slow-to-release relay 17. No further action occurs until the subscriber at station A operates the dial 10 to secure connection with any other desired station. The opening of the impulse circuit to transmit the first impulse of a series causes the deenergization of the upper winding of relay 16 and induces an electromotive force in the secondary winding of transformer 13 which renders the grid element of tube 22 positive with respect to the cathode, thereby causing the ionization of the gas, and energization of the tube. The potential of the anode of tube 22 is thus decreased by the amount of the potential drop in coil 25 and resistor 26 so as to be only a few volts higher than the cathode; and the condenser 21 discharges through the lower winding of relay 16. The combined impedance of coil 25 and resistor 26 being high in comparison with the impedance of the lower winding of relay 16, the cathode-anode current through the relay winding is larger than that through coil 25; and the energization of the lower winding of relay 16, due to the discharge of condenser 21, is in the operating direction so as to temporarily hold relay 16 operated. As soon as condenser 21 is discharged, the path through the condenser and lower winding of relay 16 begins to act as a shunt across the cathode-anode of the tube, and condenser 21 again begins to charge. The impedance of the condenser and relay winding being low as compared with the cathode-anode impedance, the tube is thereby deenergized, such use of a condenser shunt for extinguishing an ionic tube being well-known in the art. After the tube is extinguished, condenser 21 continues to charge, the charging current being effective to energize the lower winding of relay 16 in a direction to aid the release of relay 16. The charging of condenser 21 proceeds at a rate which is determined by the impedances of the retard coil and resistor 26. The release of relay 16 closes the circuit for operating the register or selector 27. When the impulse circuit is closed at the end of the first impulse, the upper winding of relay 16 is again energized; and the condenser charging current through its lower winding having ceased, relay 16 reoperates, thereby opening the register operating circuit. The electromotive force induced in the secondary winding of transformer 19, due to the closing of the impulse circuit, has no effect on tube 22; and relay 16 remains operated until the impulse circuit is opened to transmit the next succeeding impulse of the series. Thereupon the above described cycle of operation is repeated, the energization of the lower winding of relay 16 by the condenser discharge current being effective to hold relay 16 operated, in case the closed period between succeeding dial impulses is too short. Being slow in releasing, relay 17 remains operated during dialing.

To more fully appreciate the effect of the lower winding of relay 16, reference may be had to the graphs shown in Fig. 3. The curves 50, 53 and 55 represent, respectively, the magnetic flux resulting from the energization of the upper winding, the lower winding, and both windings com-

bined of relay 16 when the upper winding is connected in series with a line of such a character as to impose a severe release condition, for instance, a line of low resistance and having a maximum capacity connected across its conductors for ringing purposes. The curves 60, 63 and 65 represent, respectively, the magnetic flux resulting from the energization of these windings separately and together when the upper winding is connected in series with a line of such a character as to impose a severe operate condition, for instance, one in which the line is of high resistance and lower capacity and in which there is a minimum closure of the impulse circuit between succeeding dial impulses of a series. The curves 70, 73 and 75 represent, respectively, the magnetic flux resulting from the energization of these windings separately and together when the line is used as a P. B. X. trunk and a retard coil is bridged across its conductors as a holding bridge. Points directly above or below each other in each set of curves represent simultaneously existing conditions and are given the same reference character. The dotted horizontal lines running through curves 50, 60 and 70 and through curves 55, 65 and 75 represent the level of flux required to just balance out the flux of the biasing, middle, winding of relay 16. The resultant flux of the upper and lower windings must be greater than this level to operate or hold relay 16 and less than this value to cause release of relay 16.

The opening of the impulse circuit through the upper winding of relay 16 occurs at point 51 of curves 50, 53 and 55, the flux due to the upper winding taking a substantially vertical drop at this time. The flux due to the upper winding alone, after being reduced sufficiently to permit release of relay 16, again increases while the line and the subset condensers are being charged, the increase in flux being sufficient to cause a false reoperation of relay 16 if not otherwise prevented. Coincidental with the substantially vertical drop in flux due to the upper winding, is a substantially vertical building up of flux due to the condenser discharge current in the lower winding as shown by curve 53; this flux starts to decrease as the discharge current becomes smaller and at point 54 begins to decrease at a faster rate due to the deionization of the tube and the recharging of the condenser, the flux being reversed as indicated by the portion of the curve below the horizontal axis. The resultant flux is shown by curve 55 to decrease at a moderate rate upon the opening of the impulse circuit but not enough to permit relay 16 to release before the subset surge has ceased, and to decrease more rapidly after the tube 22 is deenergized and condenser 21 is being recharged. Relay 16 begins to release at point 56. Point 52 represents the time at which the flux in the upper winding begins to build up due to the reclosing of the impulse circuit at the end of the dial impulse, relay 16 starting to reoperate at point 57. These curves clearly show that the flux produced by the lower winding of relay 16 is not only effective to prevent the false release and reoperation of relay 16, due to a subset surge, but is also effective to bring about the legitimate release of relay 16 earlier than would otherwise be the case thereby increasing the interval during which the register operating circuit is closed at the back contact of relay 16. Such a result is particularly desirable when the line over which the impulses are being received is one having a large bridged capacity and when the dial contact openings are of relatively short duration.

Referring to curves 60, 63 and 65, point 61 represents the time at which the flux in the upper winding of relay 16 begins to build up due to the closing of the impulse circuit at the end of an impulse, and point 62 represents the time at which this flux decreases vertically due to the opening of the impulse circuit to transmit the next succeeding impulse of the series; the time the impulse circuit is closed is so short that the next impulse would fail to be registered, except for the building up of the flux due to the energization of the lower winding by the discharge of condenser 21 as represented by curve 63. The resultant flux, as shown by curve 65, shows that relay 16 is held operated by the energization of its lower winding, after the opening of the impulse circuit. At point 64, the condenser 21 starts to recharge, the flux being further decreased and then reversed as indicated by the portion of curves 63 and 65 below the horizontal axis.

Referring to curves 70, 73 and 75, the point 71 indicates the time at which the holding bridge is connected over the private branch exchange trunk. The flux due to the upper winding of relay 16 drops sufficiently, as shown in curve 70, to permit the impulse relay to release; but the condenser discharge current in the lower winding builds up a flux as shown in curve 73. Curve 75 shows the resultant flux which is effective to prevent the release of the impulse relay.

The impulse receiving means IR, shown in Fig. 2 of the drawing, comprises the filter 34, 35, transformer 33, three-element cold-cathode gas-filled tube 42, filter 39—40, resistor 43, polarized impulse relay 36, slow-to-release relay 37, and register or selector 47. The arrangement is substantially the same as that shown in Fig. 1 except that a cold-cathode tube is used instead of a hot-cathode tube. For a description of a cold-cathode tube suitable for use in this arrangement, reference may be had to Patent No. 1,784,869 granted to F. Gray, December 16, 1930. The operation of the arrangement of Fig. 2 is the same as that above described.

What is claimed is:

1. In a signaling system, a line, a signal sender, a signal receiving relay, a transformer, a signaling circuit including said line and sender and primary windings of said relay and transformer, an ionic tube, and means including said tube and secondary windings of said relay and transformer effective in response to the opening of said circuit for holding said relay operated for a short interval of time.

2. In a signaling system, a line, a signal sender, a signal receiving relay, a transformer, a signaling circuit including said line and sender and primary windings of said relay and transformer, an ionic tube, and means including said tube and secondary windings of said relay and transformer, said means being operatively non-responsive to the closing of said circuit and operatively responsive to the opening of said circuit for holding said relay operated for a short interval of time.

3. In a signaling system, a line, a signal sender, a signal receiving relay, a transformer, a signaling circuit including said line and sender and primary windings of said relay and transformer, an ionic tube, and means including said tube and secondary windings of said relay and transformer effective in response to the opening of said circuit for aiding the release of said relay.

4. In a signaling system, a line, a signal sender,

a signal receiving relay, a transformer, a signaling circuit including said line and sender and primary windings of said relay and transformer, an ionic tube, means including said tube and secondary windings of said relay and transformer effective in response to the opening of said circuit for holding said relay operated for a short interval of time and for thereupon aiding the release of said relay.

5. In a signaling system, a line, a signal sender, a relay, a transformer, a three-element ionic tube, a first circuit including a first winding of said relay and one winding of said transformer and said line and said signal sender all in series, a register operatively controlled by said relay in response to impulses created in said first circuit by the operation of said sender, a second circuit including a second winding of said relay, the current in said second circuit being effective to energize said second winding in electromagnetic opposition to the energization of said first winding by the current in said first circuit, means comprising another winding of said transformer for varying the potential of the control element of said tube to cause energization of the tube upon the opening of said first circuit, and means comprising a capacitor, an inductor and a third winding of said relay connected to the anode of said tube, said last-mentioned means being effective upon energization of the tube to hold said relay operated for a short interval of time, to deenergize the tube, and to aid the release of said relay all in the order recited.

6. In a signaling system, a line, a retard coil at one end of said line, an impulse dial having impulse contacts connected in series with said coil and line, means effective while said dial is offnormal for short-circuiting said coil, a transformer and an impulse relay at the other end of said line, a circuit including said coil, impulse contacts, line, a primary winding of said transformer, and a primary winding of said relay for operating said relay, an ionic tube, and means including said tube and secondary windings of said transformer and relay for preventing the release of said relay upon opening of the short circuit around said coil when said dial reaches normal.

7. In a signaling system, a line, a signal sender, a signal receiving relay, a transformer, a signaling circuit including said line and sender and windings of said relay and transformer, and a three-element ionic tube, the control element of said tube being connected in series with another winding of said transformer and the anode of said tube being connected in series with another winding of said relay.

8. In a signaling system, a line, an impulse sender connected to said line, an impulse receiving relay having a winding connected to said line for response to each impulse created by the operation of said sender, an impulse register, a circuit for operating said register closed by said relay at the beginning of each impulse and opened by said relay at the end of each impulse, and means comprising a transformer and a three element ionic tube for delaying the response of said relay at the beginning of an impulse and for aiding the response of said relay at the end of an impulse.

9. In a signaling system according to claim 8, a retard coil normally connected in series with the impulse contacts of said sender, and relay means effective during the creation of a series of impulses for short-circuiting said coil, said transformer and ionic tube being effective upon opening of said short circuit to prevent the response of said impulse receiving relay.

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