Nov. 10, 1936. F. K. LOW 2,060,229

SIGNALING SYSTEM

Filed May 25, 1935

FIG. 1

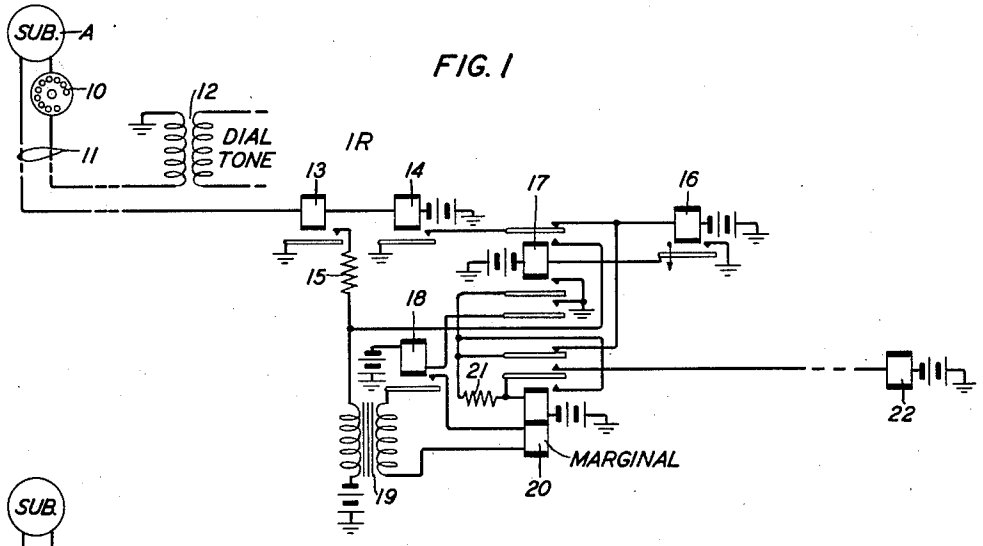


FIG. 2

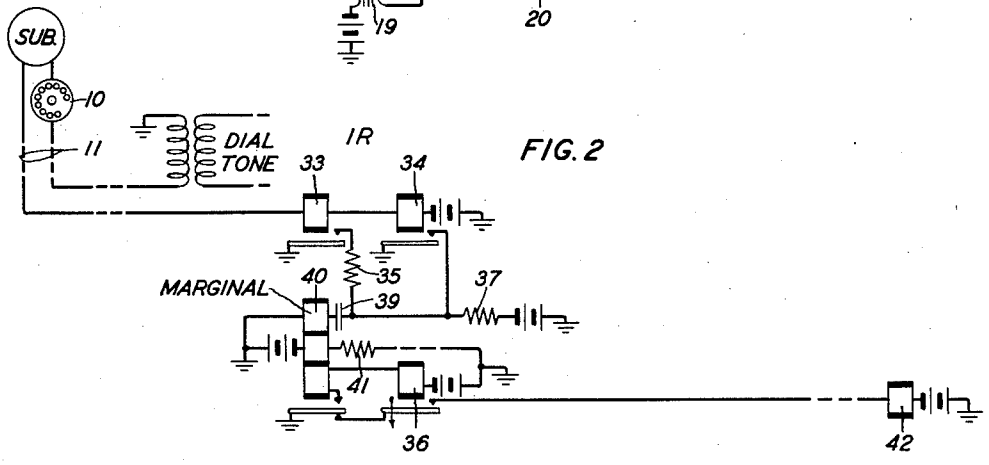
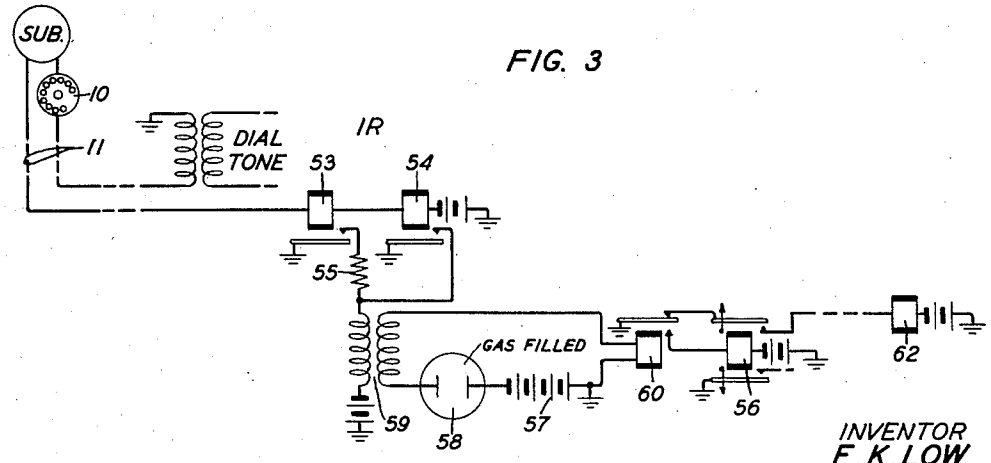


FIG. 3



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SIGNALING SYSTEM

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11 Claims. (Cl. 179—16)

This invention relates to signaling systems and particularly to systems comprising electromagnetic signal receiving means.

The object of the invention is to provide a more sensitive electromagnetic signal receiving means and to insure the accurate response of such a means to incoming signals under wider limits of line resistance, line insulation, and line capacity.

In signaling systems in which selective signals are created and transmitted by the alternate opening and closing of a signaling circuit, it is usual to employ an impulse relay for operation upon the closing of the signaling circuit and release in response to the opening of the signaling circuit. In such a system, the lines over which the signaling circuit is closed vary in length, in insulation resistance and in capacity; and the frequency with which the selective impulses are transmitted varies within certain limits. Since any particular impulse relay is capable of responding only within certain limits with respect to line resistance, line insulation, and line capacity, best results would be obtained by using a less easily operated and more easily released relay with lines of low resistance, high capacity and high leakage and a more easily operated and less easily released relay with lines of high resistance, low capacity, and low leakage. The present invention is a new and improved circuit arrangement in which two impulse receiving relays are provided and in which the response of either of the two relays to impulses is inductively effective to cause the response of an auxiliary impulse relay.

One feature of the invention is a signal receiving means comprising two signal-receiving relays connected in series in a signaling circuit, one of the signal-receiving relays being more easily operated than the other; an auxiliary relay controlled by the signal-receiving relays to repeat signal impulses to operate a register; and a transformer which cooperates with the signal-receiving relays to cause the operation of the auxiliary relay when either one of the signal-receiving relays releases and the release of the auxiliary relay when either one of the signal-receiving relays operates. To aid the desired response of the auxiliary relay, an ionic tube may be connected in series with its winding.

Another feature of the invention is a signal-receiving means comprising two signal-receiving relays, one more easily operated than the other, connected in series in a signaling circuit; an auxiliary relay, controlled by the signal-receiving relays to repeat signal impulses to operate a register; and a condenser which cooperates with the signal-receiving relays to cause the operation of the auxiliary relay in response to the operation of either of the signal-receiving relays and to cause the release of the auxiliary relay in response to the release of either of the signal-receiving relays.

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 each of the three figures of the drawing, A represents a subscriber's station in an automatic telephone system and IR represents impulse receiving means.

The apparatus at station A includes a dial 10 or an equivalent impulse sender, and is connected by line 11 to a central office or exchange in which automatic switching equipment is provided for establishing a connection between the line 11 and an idle impulse receiving means IR in response to the removal of the receiver at station A to originate a call. 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 two impulse receiving relays 13 and 14, a slow-to-release relay 16 and its auxiliary relays 17 and 18, an inductor or transformer 19, an auxiliary impulse relay 20 and a register or selector 22. Upon extension of the line 11 to the impulse receiving means IR, in response to the removal of the receiver at station A

to originate a call, an impulse circuit is completed through the windings of relays 13 and 14 in series, over the conductors of line 11, through the telephone instrument and dial 10 at station A, and through one winding of the dial tone transformer 12. Relay 13 is more easily operated than relay 14 and is capable of operation during impulse transmission when in series with lines of high resistance, low capacity and low leakage. Relay 14 is more easily released than relay 13 and is capable of release during impulse transmission when connected to lines of low resistance, high capacity and high leakage. At least one of relays 13 and 14 is capable of responding, and both of these relays may be capable of responding, to the opening and closing of the impulse circuit under intermediate conditions of line resistance, line capacity and line insulation. The closure of the impulse circuit is maintained for a long enough interval, prior to dialing, to insure the operation of both of relays 13 and 14. The operation of relay 13 closes a circuit through resistor 15 and the primary winding of transformer 19. Operation of relay 14 closes a circuit through the winding of relay 16 and a circuit through resistor 21 and the upper winding of marginal relay 20. Relay 16 operates but the upper winding of relay 20 is not sufficiently energized in series with resistor 21 to cause the operation of relay 20. The operation of relay 16 closes a circuit for operating relay 17. Relay 17 opens the operating circuit for relay 16 and the above mentioned circuit through the upper winding of relay 20 but relay 16 does not release since relay 17 also closes at its lower front contact a circuit for holding relay 16 operated and a circuit for maintaining the energization of the upper winding of relay 20 in series with resistor 21. The operation of relay 17, with relay 14 operated, is effective to short-circuit resistor 15 and cause an increase in the current through the primary winding of transformer 19 and to close a circuit for operating relay 18. The operation of relay 18 connects the secondary winding of transformer 19 in series with the lower winding of relay 20. The current in the primary winding of transformer 19 having reached a substantially steady state prior to the closing of the circuit through its secondary winding, relay 20 does not operate.

No further action occurs until the subscriber at station A operates the dial 10 at which time the impulse circuit is alternately opened and closed to transmit a series of impulses corresponding to the digit dialed. The opening of the impulse circuit at the contacts of dial 10 at the beginning of the first impulse of the series causes the release of relay 14 and may also cause the release of relay 13 before the impulse circuit is again closed at the end of the impulse. The current through the primary winding of transformer 19 is reduced by the release of relay 14 alone and entirely interrupted by the release of both of relays 13 and 14. A transient current is thereby induced in the secondary winding of transformer 19, the resulting energization of the lower winding of relay 20 being effective, in combination with the energization of the upper winding of relay 20, to cause the operation of relay 20. At its inner front contact, relay 20 short-circuits resistor 21, the current through the upper winding of relay 20 being thereby increased so as to be effective to hold relay 20 operated after the current through its lower winding has ceased. In operating, relay 20 opens the circuit through the winding of relay 16 but, being slow in releasing, relay 16 remains operated during the response of relays 13 and 14 to dial impulses. Relay 20 also closes a circuit through its uppermost front contact for operating the register or selector 22. The closing of the impulse circuit at the end of the first dial impulse, causes the reoperation of either or both of relays 13 and 14. If relay 14 alone released upon the opening of the impulse circuit to transmit the first dial impulse, then relay 14 alone is reoperated; if both of relays 13 and 14 released upon the opening of the impulse circuit, then relay 13 reoperates upon the closing of this circuit at the end of the impulse and relay 14 may also reoperate before the impulse circuit is again opened by the dial to transmit the next succeeding impulse of the series. The reoperation of either or both of relays 13 and 14 causes a current or increases the current through the primary winding of transformer 19, the electromotive force thus induced in the secondary winding of transformer 19 causing a transient current which is effective to energize the lower winding of relay 20 in electromagnetic opposition to the energization of the holding winding of relay 20, thereby causing the release of relay 20. In releasing, relay 20 opens the register operating circuit, closes the circuit for reenergizing relay 16, and opens the short circuit around resistor 21, thereby completing a cycle of operations responsive to a dial impulse. The current through the upper winding of relay 20 in series with resistor 21 is sufficient to prevent the reoperation of relay 20 if the transient current, which causes its release, continues for a long enough interval and with sufficient intensity to otherwise cause a reoperation of relay 20. In the same manner, the cooperative action of the impulse relays 13 and 14 and transformer 19 causes the operation and release of the auxiliary impulse relay 20 in response to each succeeding opening and closing of the impulse circuit by the dial, relay 20 being effective to repeat these dial impulses to operate the register or selector.

It is apparent that the interval during which relay 20 is operated in response to one dial impulse of a series and the interval during which relay 20 is released, after response to a dial impulse before it is reoperated in response to the next succeeding impulse of a series, each depends upon which of relays 13 and 14 is the first to cause a change in current through the primary winding of transformer 19. Thus, if relay 13 remains operated during dialing, relay 20 will be operated by the opening of the contacts of relay 14 and be released by the closing of these contacts; if relay 14 remains released during the receipt of dial impulses, relay 20 will be operated by the opening of the contacts of relay 13 and be released by the closing of these contacts; and if both of relays 13 and 14 respond to each opening and closing of the impulse circuit, relay 20 will be operated by the opening of the contacts of relay 14 and be released by the closing of the contacts of relay 13. The auxiliary impulse relay 20 is in this manner controlled jointly by the primary impulse relays 13 and 14 to insure the response of a register or selector to each of a series of impulses received under the widest possible limits of line resistance, line capacity and line leakage.

The impulse receiving means IR, shown in Fig. 2 of the drawing comprises the two impulse relays 33 and 34, a slow-to-release relay 36, a condenser 39, an auxiliary impulse relay 40 and a register or selector 42. Relays 33 and 34 are

similar to relays 13 and 14 of Fig. 1. The auxiliary impulse relay 40 has three windings, the middle winding being energized in series with resistor 41 immediately upon association of the line 11 with the impulse receiving means IR and at least as soon as, if not a little before, the windings of relays 33 and 34 are connected in series with the line 11. The current through the middle winding is insufficient to alone cause the operation of relay 40 or to hold relay 40 operated. The upper winding of relay 40 is connected in series with condenser 39 and resistor 37, the condenser 39 being normally charged. The condenser 39 is partially discharged by the operation of relay 33 and completely discharged by the operation of relay 34, the current through the upper winding of relay 40 being, in either case, effective in combination with the current through the middle winding of relay 40 to cause the operation of relay 40. Relay 40 closes a circuit through the winding of relay 36 in series with the lower winding of relay 40, the current in this circuit being effective to cause the operation of relay 36 and, in combination with the current through the middle winding of relay 40, to hold relay 40 operated after the condenser discharge current through the upper winding of relay 40 has ceased. No further action occurs until the dial is operated. Upon the release of relay 34, in response to the opening of the impulse circuit by the dial to transmit the first impulse of a series, the condenser 39 begins to charge and, if relay 33 also releases, the charge is further increased, the charging current being effective to energize the upper winding of relay 40 in electromagnetic opposition to the energization of the middle and lower windings and thus cause the release of relay 40. The current through the middle winding of relay 40 is effective to prevent the reoperation of relay 40 if the charging current continues for a long enough interval and with sufficient intensity to otherwise cause a reoperation of relay 40. The release of relay 40 closes a circuit through the lower contacts of relay 36 for operating the register or selector 42. Being slow in releasing, relay 36 remains operated during dialing. When the impulse circuit is again closed, at the end of the first impulse, relay 33 reoperates if it released, or relay 34 reoperates if relay 33 did not release, or both of relays 33 and 34 reoperate if they both released at the beginning of the first impulse. In any case the reoperation of either or both of relays 33 and 34 causes a discharge of condenser 39, the transient discharge current being effective to reenergize the upper winding of relay 40. The transient reenergization of the upper winding together with the continued energization of the middle winding of relay 40 is effective to reoperate relay 40 and thus open the operating circuit of the register 42. The reoperation of relay 40 also causes the reenergization of relay 36 and the reenergization of the lower winding of relay 40 so that relay 40 is again held operated, after the transient operating current ceases, by the joint energization of its middle and lower windings. The above described cycle of operations is repeated in response to each opening and closing of the impulse circuit to transmit the succeeding impulses of the series.

The impulse receiving means IR, shown in Fig. 3 of the drawing, comprises the impulse relays 53 and 54, transformer 59, auxiliary impulse relay 60, a two-element gas-filled tube 58, the slow-to-release relay 56 and the register or selector 62. The impulse relays 53 and 54 are similar to relays 13 and 14 of Fig. 1. To avoid the use of a marginal relay for operation and release in response to the transient currents induced in the secondary winding of transformer 59 under the control of impulse relays 53 and 54, the two-element gas-filled tube 58 is connected in series with the secondary winding of transformer 59, the winding of the auxiliary impulse relay 60, and the battery 57. The tube 58 may be of the type disclosed in Patent No. 1,605,001, granted to F. Schroter, November 2, 1926. The electromotive force of the battery 57 is insufficient to cause the breakdown of tube 58 but is sufficient to maintain the energization of the tube if once started. The current induced in the secondary winding of transformer 59 upon the closing of the contacts of either or both of relays 53 and 54 increases the potential across the two electrodes of tube 58 sufficiently to cause energization of the tube and the operation of relay 60. Although the induced electromotive force which caused breakdown of the tube is transient, the tube and relay remain energized until the opening of the contacts of either or both of relays 53 and 54, at the beginning of a dial impulse, causes an induced current in the secondary winding of transformer 59; this current is effective to reduce the potential difference between the electrodes of tube 58 sufficiently to cause the deenergization of the tube and the release of relay 60. At the end of the impulse, the current induced in the secondary winding of transformer 59 due to the closing of the contacts of either or both of relays 53 and 54 effects the reenergization of tube 58 and reoperation of relay 60. The operation and release of relay 60 in response to each impulse of a series closes and opens the register or selector operating circuit.

What is claimed is:

1. In a signaling system, a line, a signal sender, a first relay, a second relay, a third relay, a transformer, a first circuit including said line and sender and windings of said first and second relays, a resistor, a second circuit including one winding of said transformer and said resistor and a normally open contact of said first relay, a third circuit excluding said resistor and including said winding of the transformer and a normally open contact of said second relay, and a fourth circuit including another winding of said transformer and a winding of said third relay.

2. In a signaling system, a line, a signal sender, two signal-receiving relays, one more sensitive than the other, a third relay, a first circuit including said line and sender and windings of said signal-receiving relays, a resistor, a second circuit including a normally open contact of said first relay and said resistor, a third circuit including a normally open contact of said second relay and excluding said resistor, and means including a winding of said third relay for causing the operation of said third relay in response to the release of either of said signal-receiving relays and for causing the release of said third relay in response to the operation of either of said signal-receiving relays.

3. In a signaling system, a line, a signal sender, two signal-receiving relays, one more sensitive than the other, a signaling circuit including said line and sender and windings of said signal-receiving relays, an auxiliary signal relay, and means comprising a condenser and a winding of said auxiliary relay for causing the operation of said auxiliary relay in response to the operation of either of said signal-receiving relays and for

causing the release of said auxiliary relay in response to the release of either of said signal-receiving relays.

4. In a signaling system, a line, a signal sender, two signal-receiving relays, one more sensitive than the other, a signaling circuit including said line and sender and windings of said signal-receiving relays, a transformer, a resistor, a circuit including said resistor and a winding of said transformer, closed by the operation of one of said signal-receiving relays, a circuit excluding said resistor and including said winding of the transformer closed by the operation of the other of the signal-receiving relays, an auxiliary signal relay, a two-element gas-filled tube, and a circuit including the winding of said auxiliary relay and said tube and another winding of said transformer.

5. In a signaling system, a line, two impulse receiving relays, one of said impulse relays being more easily operated and less easily released than the other, a signaling circuit comprising said line in series with the windings of said relays, an impulse sender for opening and closing said circuit to cause the release and reoperation of one or both of said impulse relays, an inductor energized to a certain extent by one of its windings while one of said impulse relays is operated and to a greater extent while the other of said impulse relays is operated, an auxiliary relay having one winding connected in series with another winding of said inductor, any change in the energization of said inductor due to the release of either of said impulse relays being effective to cause the operation of said auxiliary relay, circuit means including a second winding of said auxiliary relay for holding said auxiliary relay operated, any change in the energization of said inductor due to the operation of either of said impulse relays being effective to neutralize the effect of said holding winding and cause the release of said auxiliary relay.

6. In a signaling system, a line, two impulse receiving relays one of which is more easily operated and less easily released than the other, a signaling circuit comprising said line and a winding of each of said relays, an impulse sender at the end of the line remote from said relays for opening and closing said signaling circuit to cause the release and reoperation of one or both of said impulse relays, an inductor energized to a certain extent by its primary winding while one of said impulse relays is operated and to a greater extent while the other of said impulse relays is operated, an auxiliary relay energized by one of its windings upon operation of one of said impulse relays but not sufficiently to cause its operation and momentarily energized by another winding in series with a secondary winding of said inductor upon release of either of said impulse relays, the energization of the auxiliary relay by both windings being effective to cause the operation of said auxiliary relay, and means including said one winding of the auxiliary relay for holding this relay operated without the aid of the other winding, the momentary energization of the auxiliary relay by said other winding upon operation of either of said impulse relays being effective to neutralize its energization by said one winding and thus cause the release of said auxiliary relay.

7. In a signaling system a line, two impulse receiving relays one of which is more easily operated and less easily released than the other, a signaling circuit comprising said line and a winding of each of said relays, an impulse sender at the end of the line remote from said relays for opening and closing said signaling circuit to cause the release and reoperation of one or both of said impulse relays, an auxiliary relay, a circuit including one winding of said auxiliary relay the current in said one winding being insufficient to cause the operation of the auxiliary relay, a capacitor connected in series with another winding of said auxiliary relay, means for charging said capacitor through said other winding of the auxiliary relay to a certain extent when one of said impulse relays is released and to a greater extent when the other of said impulse relays is released, means for discharging said capacitor through said other winding of the auxiliary relay to a certain extent when said other impulse relay is operated and to a greater extent when said one impulse relay is operated, the momentary current in said other winding of the auxiliary relay due to the discharge of said capacitor being effective in combination with the current in said one winding to cause the operation of the auxiliary relay, and a circuit including a third winding of said auxiliary relay closed while said auxiliary relay is operated, the current in said third winding in combination with the current in said one winding being effective to hold said auxiliary relay operated without the aid of current in said other winding, and the momentary current in said other winding due to the charging of said condenser being effective to neutralize the holding effect of the current in said one and said third windings to cause the release of said auxiliary relay.

8. In a signaling system a line, two impulse receiving relays one of which is more easily operated and less easily released than the other, a signaling circuit comprising said line and a winding of each of said relays, an impulse sender at the end of the line remote from said relays for opening and closing said signaling circuit to cause the release and reoperation of one or both of said impulse relays, an inductor energized to a certain extent by its primary winding while one of said impulse relays is operated and to a greater extent while the other of said impulse relays is operated, an auxiliary relay and a two-element ionic tube connected in series with a secondary winding of said inductor, and a battery in series with the winding of said auxiliary relay and ionic tube of sufficient voltage to sustain the energization of the tube but insufficient to energize the tube, the electromotive force induced in the secondary winding of said inductor upon the operation of either of said impulse relays being effective in combination with said battery to energize the tube and cause the operation of said auxiliary relay, and the electromotive force induced in the secondary winding of said inductor upon the release of either of said impulse relays being effective to neutralize the battery and deenergize the tube and release the auxiliary relay.

9. In a signaling system, a line, a signal sender, two signal-receiving relays, one more sensitive than the other, a circuit including said line and sender and windings of said signal-receiving relays, a resistor, a second circuit including a contact of said one relay and said resistor, a third circuit including a contact of said other relay and excluding said resistor, a third relay, and means comprising said second and third circuits for changing the operative con-

dition of said third relay in response to the release of either of said signal-receiving relays and for changing the operative condition of said third relay in response to the operation of either of said signal-receiving relays.

10. In a signaling system, a line, a signal sender, two signal-receiving relays, one more sensitive than the other, a third relay, a circuit including said line and sender and windings of said signal-receiving relays, a resistor, another circuit including a normally open contact of said one relay and said resistor, a third circuit including a normally open contact of said other relay and excluding said resistor, and means including a winding of said third relay for causing the operation of said third relay in response to the operation of either of said signal-receiving relays and for causing the release of said third relay in response to the release of either of said signal-receiving relays.

11. In a signaling system, a line, two impulse receiving relays one of which is more easily operated and less easily released than the other, a signaling circuit comprising said line and a winding of each of said relays, an impulse sender at the end of the line remote from said relays for opening and closing said signaling circuit to cause the release and reoperation of one or both of said impulse relays, an auxiliary relay, a circuit including one winding of said auxiliary relay the current in said one winding being insufficient to cause the operation of the auxiliary relay, a capacitor connected in series with another winding of said auxiliary relay, means for charging said capacitor through said other winding of the auxiliary relay to a certain extent when one of said impulse relays is released and to a greater extent when both of said impulse relays are released, means for discharging said capacitor through said other winding of the auxiliary relay to a certain extent when said other impulse relay is operated and to a greater extent when both of said impulse relays are operated, the momentary current in said other winding of the auxiliary relay due to the discharge of said capacitor being effective in combination with the current in said one winding to cause the operation of the auxiliary relay, and a circuit including a third winding of said auxiliary relay closed while said auxiliary relay is operated, the current in said third winding in combination with the current in said one winding being effective to hold said auxiliary relay operated without the aid of current in said other winding, and the momentary current in said other winding due to the charging of said condenser upon release of either of said impulse relays being effective to neutralize the holding effect of the current in said one and said third windings to cause the release of said auxiliary relay.

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