Feb. 1, 1938. R. E. RESSLER 2,106,810

SIGNALING SYSTEM

Filed Dec. 11, 1935 2 Sheets-Sheet 1

FIG. 1

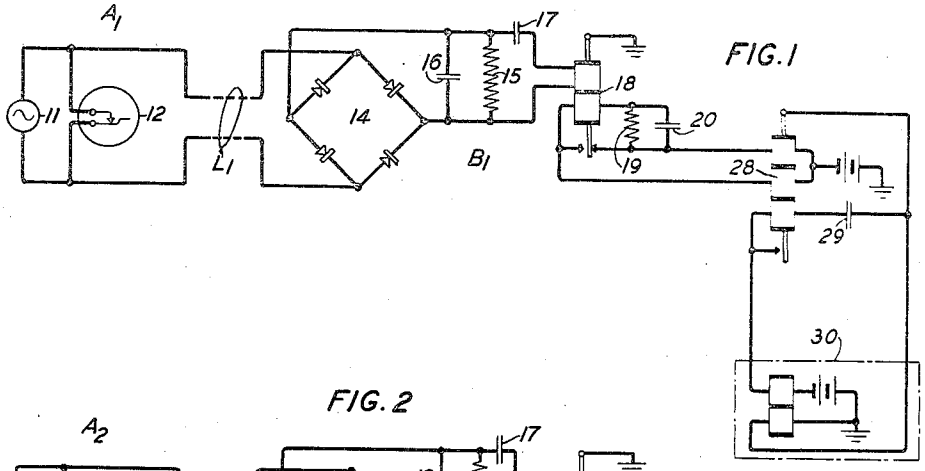


FIG. 2

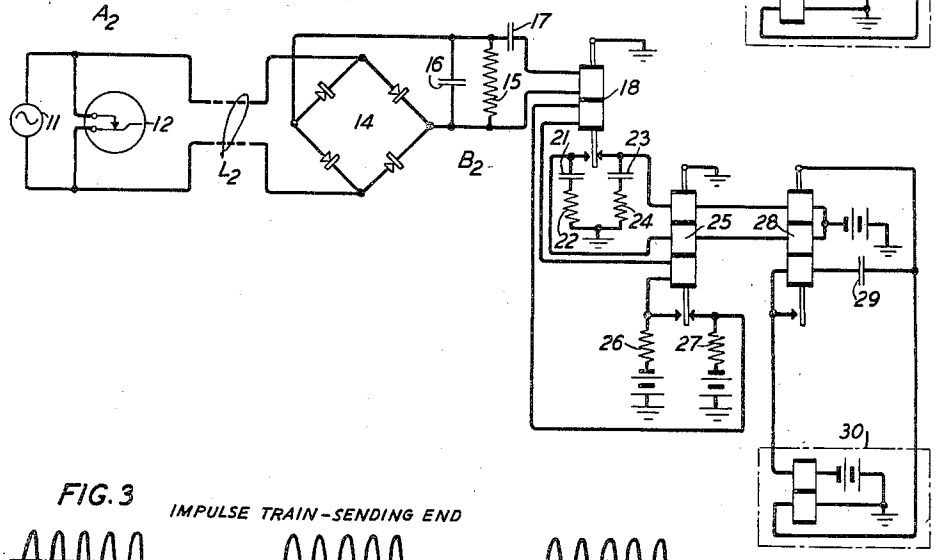


FIG. 3 IMPULSE TRAIN-SENDING END

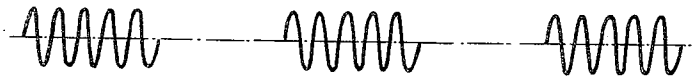


FIG. 4 IMPULSE TRAIN-RECEIVING END

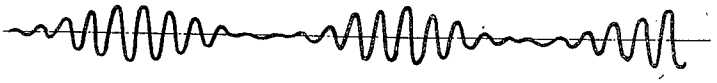


FIG. 5

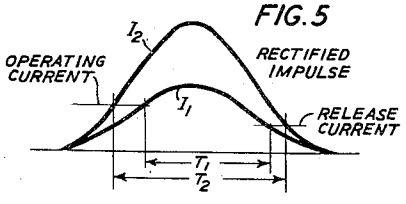
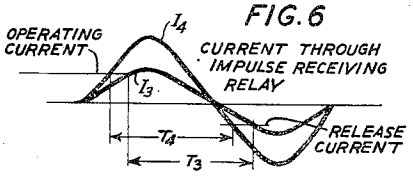


FIG. 6



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Feb. 1, 1938. R. E. RESSLER 2,106,810

SIGNALING SYSTEM

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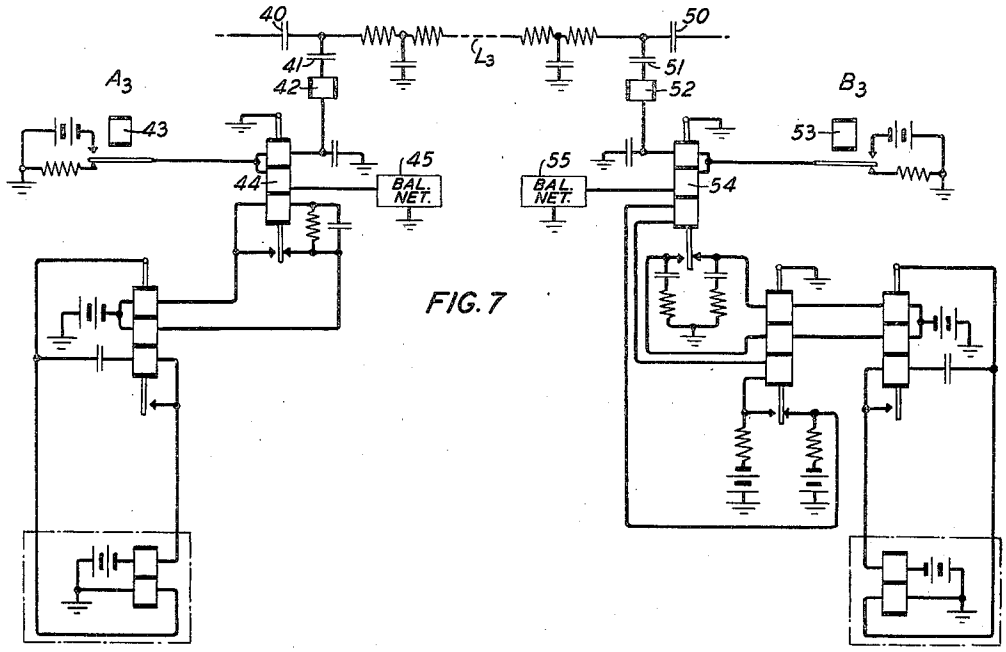


FIG. 7

FIG. 8

CURRENT IN WINDINGS OF RECEIVING RELAY AT SENDING END OF DIRECT CURRENT TRANSMITTING CIRCUIT.

FIG. 10

CURRENT IN WINDINGS OF RECEIVING RELAY AT SENDING END OF ELECTRO-STATIC TRANSMITTING CIRCUIT.

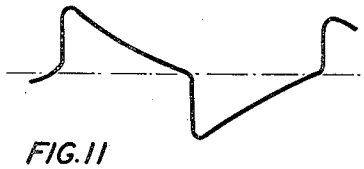


FIG. 9

CURRENT IN WINDING OF RECEIVING RELAY AT RECEIVING END OF DIRECT CURRENT TRANSMITTING CIRCUIT-AT TWO ENERGY LEVELS.

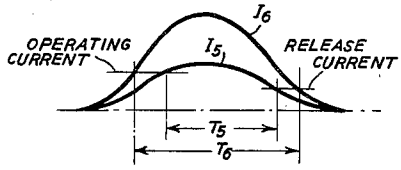
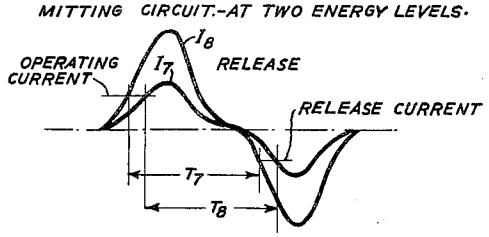


FIG. 11

CURRENT IN WINDING OF RECEIVING RELAY AT RECEIVING END OF ELECTRO-STATIC TRANSMITTING CIRCUIT.-AT TWO ENERGY LEVELS.



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UNITED STATES PATENT OFFICE

2,106,810

SIGNALING SYSTEM

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Application December 11, 1935, Serial No. 53,948

8 Claims. (Cl. 178—59)

This invention relates to signaling systems and particularly to systems in which switching mechanism is selectively operated under control of impulses received over a signal line from a distant point.

The object of the invention is to improve the operation of impulse receiving and repeating means in response to signal impulses received at varying transmission levels and to provide an impulse receiving and repeating means which is accurate and positive in operation when subjected to line transients or mechanical disturbances.

This invention is a new and improved impulse receiving and repeating circuit arrangement comprising a polarized impulse receiving relay and a polarized impulse repeating relay. The polarized impulse receiving relay has an operating winding and a holding winding, the energization of the operating winding in series with a condenser, first in one direction and then in the other in response to each incoming impulse, being effective to move the armature from the normal one of its operated positions to the other when the condenser is charged and back to normal when the condenser is discharged. With the armature of the impulse repeating relay in the normal one of its positions, the holding winding is energized in one direction in series with one of two operating windings of the impulse repeating relay; and, with the armature of the impulse receiving relay in the other of its operated positions, the holding winding is energized in the opposite direction in series with the other of the operating windings of the impulse repeating relay. The holding winding of the impulse receiving relay is thereby energized whenever the armature is in either of its operated positions, to hold the armature in whichever position it happens to be; and the operating windings of the impulse repeating relay are energized to position and hold the armature of the impulse repeating relay in the normal one of its operated positions when the armature of the impulse receiving relay is in its normal position and to position and hold the armature of the impulse repeating relay in the other of its operated positions when the armature of the impulse receiving relay is in the other of its operated positions.

A feature of the invention is the connection of a condenser in parallel with a resistor and in series with the holding winding of the impulse receiving relay across the two contacts with which the armature engages in its two operated positions, so that the condenser is charged first in one direction and then in the other according to the position in which the armature of the impulse receiving relay is resting, the charging current being effective when the armature engages either of its contacts to energize the holding winding to reduce contact chatter. Upon movement of the armature of the impulse receiving relay away from either of its two operated positions, due to the energization of its operating winding, a circuit comprising the condenser and resistor in series with the holding winding of the impulse receiving relay and both operating windings of the impulse repeating relay becomes effective to aid the movement of the armature to the other of its operated positions.

Another feature of the invention is the provision of an auxiliary polarized relay for controlling the holding winding of the impulse receiving relay to maintain the bias of the impulse receiving relay for a short interval after its armature has moved away from either of its operated positions and thus prevent false operation of the impulse receiving relay in case the armature starts to move due to a transient line disturbance or due to a mechanical disturbance.

A better and more complete understanding of the invention may be obtained by considering the specific embodiments of the invention shown in the drawings which form a part of this specification. The application of the invention is, however, not limited to these specific arrangements and is, in general applicable to any signaling system in which selective signals comprise impulses of current.

Referring to the drawings,

Fig. 1 represents a signaling system comprising two interconnected stations, the station A_1 being represented by signal transmitting apparatus and the station B_1 by signal responsive apparatus;

Fig. 2 represents a similar signaling system comprising stations A_2 and B_2, the signal responsive apparatus at station B_2 being a modification of that at station B_1 in Fig. 1;

Fig. 3 is a curve showing a train of three current impulses at the transmitting end of the line in either of Figs. 1 and 2;

Fig. 4 is a curve showing a train of three current impulses at the receiving end of the line in either of Figs. 1 and 2;

Fig. 5 is a set of two curves showing the envelopes of one rectified current impulse of Fig. 4 at two different energy levels;

Fig. 6 is a set of two curves showing the current, corresponding to the rectified impulses of

Fig. 5, through the line winding of the impulse receiving relay of Figs. 1 and 2;

Fig. 7 represents a composite signaling circuit arrangement modified for the electrostatic transmission of signal impulses in either direction over line L_3 between stations A_3 and B_3;

Fig. 8 is a curve representing the current for one cycle of an impulse train at the transmitting end of line L_3 of Fig. 7 when arranged for the transmission of direct current signal impulses;

Fig. 9 is a curve representing the current for one cycle of an impulse train at two different energy levels at the receiving end of line L_3 of Fig. 7 when arranged for the transmission of direct current signal impulses;

Fig. 10 is a curve representing the current for one cycle of an impulse train at the transmitting end of line L_3 of Fig. 7 when arranged as shown for the electrostatic transmission of signal impulses; and

Fig. 11 is a curve representing the current, at two different energy levels, corresponding to one signal impulse, electrostatically transmitted and received over line L_3, through the line winding of the impulse receiving relay of Fig. 7.

The signal transmitting means at stations A_1 and A_2 comprises a source of alternating current 11 and a signal sender 12 of the dial type, the impulse contacts of the dial being bridged, in parallel with the source of current 11, across the line. The curve in Fig. 3 represents the current for a train of three dial impulses at the transmitting end of line L_1 or L_2 and the curve in Fig. 4 represents the current for this train of impulses at the receiving end of the line. Since the signaling current source is an alternating current source, a full wave rectifier unit 14 comprising rectifiers of the copper-oxide type is provided at stations B_1 and B_2 to rectify each impulse of alternating current transmitted by the operation of the associated dial 12. The curves I_1 and I_2 in Fig. 5 represent the rectified current for two impulses at different energy levels; horizontal lines indicate the current required for operating and releasing the impulse relay if connected directly to the output side of the rectifier and the variation in the resulting operating periods T_1 and T_2 due to the difference in the energy level. The rectified current has three parallel paths, one through resistance 15, another to charge condenser 16, and the third to charge condenser 17 in series with and energize the upper winding of a polarized impulse relay 18. Condenser 16 bypasses the alternating components of the rectified current and condenser 17 blocks the direct current which is by-passed through resistor 15. These three elements together constitute a network, the transmission efficiency of which is substantially proportional to frequency, from zero up to the signal frequency or the highest harmonic of the signaling frequency which it is desired to receive. With this network between the detector or rectifier 14 and the relay 18, alternately positive and negative current impulses, proportional to the rate of rise or fall of direct current voltage across resistor 15 and corresponding to the envelope of the received signal impulse, are transmitted through the upper winding of relay 18. The curves I_3 and I_4 in Fig. 6 represent the current through the upper winding of relay 18 for two impulses at different energy levels; horizontal lines indicate the current required for the operation and for the release of relay 18, the periods T_3 and T_4 during which relay 18 is operated by the two impulses being substantially independent of the energy level. The current through the upper winding of relay 18 builds up in one direction to charge condenser 17 while the amplitude of an incoming signal is increasing. As the condenser becomes charged, the current begins to decrease and, when the amplitude of the incoming signal begins to decrease, the condenser begins to discharge, the current through the upper winding of relay 18 being reversed. The capacity of condenser 17 and conductance of resistor 15 should be such that at the maximum desired impulse speed, condenser 17 will be fully charged before the rectified current begins to decrease and be fully discharged before the rectified current again begins to increase. This prevents a transient condition involving a direct current component in the relay winding at the beginning of a train of impulses and tends to produce positive and negative impulses of equal amplitude and similar wave form. The resistance in the discharge path of condenser 17 should be high enough to prevent any oscillations tending to occur between condenser 17 and the inductance of the winding of relay 18. Since relay 18 is biased by its lower winding, as hereinafter described, to hold its armature in either position, the operation of relay 18 occurs when the condenser charging current overcomes the holding current through the lower winding of relay 18; and the release of relay 18 occurs when the condenser discharging current overcomes the holding current through the lower winding of relay 18. A comparison of the curves in Figs. 5 and 6 clearly shows the superiority of the impulse receiving circuit of Figs. 1 and 2 with respect to maintaining the required open and closed periods for each impulse cycle independent of variation in the energy level of the incoming signal impulses. The maximum allowable rate of variation in signal level and line attenuation is, of course, limited by the non-operate current adjustment of relay 18.

Since the contacts of relay 18 are used to control the holding and biasing circuits through its lower winding, relay 18 does not directly repeat the received impulses to a register or selector. In Fig. 1 the holding and biasing circuits include windings of an impulse repeating relay 28 which in turn controls the operation of a register or selector 30. Relay 28 is a polarized relay and with the armature of relay 18 in normal position as shown in the drawings, one circuit is closed from battery through the uppermost winding of relay 28, and through the right contact and armature of relay 18 to ground; and another circuit is closed from battery through the middle winding of relay 28, lower winding of relay 18, resistor 19, and through the right contact and armature of relay 18 to ground. The current through the lower winding of relay 18 is effective to hold the armature of this relay against its right contact, the current through the uppermost winding of relay 28 being enough stronger than the electromagnetically opposing current through its middle winding to hold the armature of relay 28 in normal position with its contacts open. The condenser 20, connected in parallel with resistor 19, is normally charged to a potential equal to the drop across resistor 19. As soon as the upper winding of relay 18 is sufficiently energized by rectified impulse current in series with condenser 17 to overcome the holding current through the lower winding of relay 18, the armature of relay 18 breaks its right contact, whereupon condenser 20 discharges through the lower winding of relay

18 to hasten the travel of the armature over to the left contact. Upon engagement of the armature of relay 18 with its left contact, the middle winding of relay 28 is connected directly to ground, the resistor 19 and lower winding of relay 18 now being in series with the uppermost winding of relay 28. The discharge of condenser 20 is followed upon engagement of the armature of relay 18 with its left contact by the charging of condenser 20 in the opposite direction, the charging current tending to hold the armature against the left contact without chatter. When the condenser is fully charged, the current through the uppermost winding of relay 28 and lower winding of relay 18 is sufficient to hold the armature of relay 18 in its operated position; and the current in the middle winding of relay 28 is enough stronger than the electromagnetically opposing current in its uppermost winding to operate the armature and hold the contacts of relay 28 closed. With relay 28 operated, a circuit is closed from battery through the upper winding of the magnet of the register or selector magnet 30, the contact and armature of relay 28, and through the lower winding of the selector or register magnet to ground. The lowermost winding of relay 28 and condenser 29 protect the contacts of relay 28 from discharge of the inductance of the selector or register magnet; and the discharge of condenser 29 through this winding, upon closure of the contacts of relay 28, tends to hold the armature of relay 28 against its front contact so as to prevent chatter.

In Fig. 2 the holding and biasing circuits for the impulse relay 18 include windings of a bias control relay 25 in addition to windings of the impulse repeating relay 28. With the armature of relay 18 in normal position against its right contact, there is a circuit for holding the armatures of relays 25 and 28 in normal position; this circuit is traced from battery through the uppermost winding of relay 28, uppermost winding of relay 25, right contact and armature of relay 18 to ground. At the same time the armature of relay 18 is held against its right contact by current in a circuit from battery through resistor 26, lowermost winding of relay 25, lower winding of relay 18, through the right contact and armature of relay 25 to ground. When the upper winding of relay 18 is sufficiently energized by rectified current through condenser 17 to cause the armature of this relay to move away from its right contact, condenser 23 begins to charge in series with resistor 24 and the uppermost windings of relays 25 and 28, this charging current being momentarily effective to hold the armature of relay 28 in normal position and to aid the lowermost winding of relay 25 in maintaining the normal position of its armature so that the circuit through resistor 26 and the lower winding of relay 18 is not immediately opened. As soon as the armature of relay 18 engages its left contact, the middle windings of relays 25 and 28 are energized to cause the operation of their armatures. The operation of relay 25 opens the holding and biasing circuit through resistor 26 and closes a circuit for holding the armatures of relays 18 and 25 against their left contacts, this circuit being traced from battery through resistor 27, lower winding of relay 18, lowermost winding and left contact of relay 25, to ground. Relay 28 closes the circuit for operating the register or selector 30. When the current through the uppermost winding of relay 18 is reversed, due to the discharge of condenser 17, and the armature moves away from its left contact, condenser 21 begins to charge through resistor 22 and the middle windings of relays 25 and 28, this charging current being momentarily effective to hold the armature of relay 28 in operated position and to aid the lowermost winding of relay 25 in maintaining its armature in operated position so that the holding and biasing circuit through resistor 27 and the lower winding of relay 18 is not immediately opened. When the armature of relay 18 reengages its right contact, the uppermost windings of relays 25 and 28 are reenergized to move their armatures to normal, thereby opening the selector magnet circuit, opening the circuit through resistor 27 and again closing the circuit through resistor 26 and the lowermost winding of relay 18 so as to hold the armature of relay 18 against its right contact. By this arrangement the bias of relay 18 is not immediately changed upon the opening of either of its contacts thereby preventing false operation in case of contact chatter due to mechanical vibration.

The line L_3 of Fig. 7 may be a grounded telephone line composited for telegraph service or may be one of the conductors of a two-wire line equipped for composite telephone and telegraph service. The line L_3 is connected to the telephone apparatus, which is not shown, by condenser 40 at station A_3 and by condenser 50 at station B_3. For the transmission of signal impulses, the line L_3 is connected at station A_3 through condenser 41, choke coil 42, the uppermost winding of signal receiving relay 44, through the contacts of sending relay 43 to a source of signaling current; and at station B_3 through condenser 51, choke coil 52, the uppermost winding of signal receiving relay 54, through the contacts of sending relay 53 to a source of signaling current. The signaling apparatus is arranged for full polar duplex operation, the receiving relays 44 and 54 being polarized with their middle windings connected to line balancing networks 45 and 55, each of which may include a blocking condenser similar to condensers 41 and 51. The uppermost and middle windings of each of the receiving relays are connected so as to neutralize each other when the station at which the relay is located is the sending station. The lowermost, biasing and holding, winding of relay 44 is connected by its contacts in series with the one or the other of the operating windings of an impulse repeating relay in like manner to that in which the corresponding winding of relay 18 is connected in Fig. 1. The lowermost, biasing and holding, winding of relay 54 is connected in series with a winding and the one or the other of the contacts of a biasing control relay in like manner to that in which the corresponding winding of relay 18 is connected in Fig. 2.

With the usual direct current signal circuit, that is with condensers 41 and 51 omitted so that direct current signal impulses are transmitted through choke coils 42 and 52 and over line L_3, the current in the windings of the impulse receiving relay (44 or 54) at the sending station would be as shown in the curve of Fig. 8 and the current in the operating winding of the impulse receiving relay at the receiving station would be as shown in the curves of Fig. 9, I_5 representing the current at one energy level and I_6 the current at a higher energy level. The intersection of the current curves I_5 and I_6 with the short horizontal lines representing the operating and release current levels define time intervals T_5 and

T_6 during which the impulse receiving relay is operated. It is apparent from these curves of Fig. 9 that a variation in energy level of direct current signal impulses causes a substantial variation in the portion of an impulse cycle during which the impulse receiving relay is operated. However, with the signal impulses electrostatically transmitted through condensers 41 and 51, the current in the windings of the impulse receiving relay (44 or 54) at the sending station would be as shown in the curve of Fig. 10 and the current in the operating winding of the impulse receiving relay at the receiving station would be as shown in the curves of Fig. 11, I_7 representing this current at one energy level and I_8 at a higher energy level. The intersection of the curves I_7 and I_8 with the short horizontal lines representing the operating and release current levels define time intervals T_7 and T_8 during which the impulse receiving relay is operated. It is apparent from these curves of Fig. 11 that the portion of an impulse cycle during which the impulse receiving relay is operated is substantially independent of a variation in the energy level at which the signal impulses are transmitted.

What is claimed is:

1. In combination in a signaling system, a polarized impulse receiving relay having an operating winding and a holding winding, a polarized impulse repeating relay having two operating windings, a circuit including the armature of said impulse receiving relay in one of its two operated positions for energizing said holding winding in a direction to maintain the position of its armature, a circuit including the armature of said impulse receiving relay in said one of its positions for energizing one of the operating windings of said impulse repeating relay to position and hold the armature of said impulse repeating relay in one of its two operated positions, a circuit including the armature of said impulse receiving relay in the other of its two operated positions for energizing said holding winding in a direction to maintain the position of its armature, and a circuit including the armature of said impulse receiving relay in said other of its two operated positions for energizing the other of the operating windings of said impulse repeating relay to position and hold the armature of said impulse repeating relay in the other of its two operated positions.

2. In a signaling system, a line, an impulse sender for transmitting impulses over said line, a polarized impulse receiving relay having an operating winding and a holding winding, a condenser, said operating winding and condenser being connected in series with each other and with said line, a resistor and another condenser each connected in series with said line and in parallel with said condenser and operating winding, said relay being energized by its operating winding in response to each impulse transmitted over said line to move its armature from a normal one of its two operated positions to the other position and to move its armature back to normal position, circuits including the armature of said impulse receiving relay in either of its operated positions for energizing the holding winding in a direction to maintain the position of the armature, an impulse repeating relay having two operating windings, a circuit including the armature of said impulse receiving relay in one of its operated positions for energizing one of the operating windings of said impulse repeating relay to position and hold the armature of said impulse repeating relay in one of its two operated positions, and a circuit including the armature of said impulse receiving relay in the other of its operated positions for energizing the other of the operating windings of the impulse repeating relay to position and hold the armature of the impulse repeating relay in the other of its operated positions.

3. In a signaling system and combination according to claim 1, a condenser connected in parallel with a resistor and in series with said holding winding across the contacts which the armature of the impulse receiving relay engages in its two operated positions, the discharge of said condenser upon movement of the armature of the impulse receiving relay away from either of its contacts being effective to accelerate the movement.

4. In a signaling system and combination according to claim 1, a condenser connected in parallel with a resistor and in series with the holding winding across the contacts which the armature of the impulse receiving relay engages in its two operated positions, and circuits comprising said condenser and resistor in parallel connected in series with the holding winding of said impulse receiving relay and each of the operating windings of said impulse repeating relay, each of said last mentioned circuits being alternately rendered effective upon movement of the armature of said impulse receiving relay away from the one or the other of its operated positions to aid the movement.

5. In combination in a signaling system, a polarized impulse receiving relay having an operating winding and a holding winding, a polarized impulse repeating relay having two operating windings, a polarized control relay having two operating windings and a holding winding, a circuit including the armature of said impulse receiving relay in the normal one of its two operated positions for energizing one of the operating windings of each of the other two relays to position and hold the armature of each of said other two relays in the normal one of its two operated positions, a circuit including the armature of said impulse receiving relay in the other of its two operated positions for energizing the other one of the operating windings of each of the other two relays to position and hold the armature of each of said other two relays in the other of its two operated positions, a circuit including the armature of said control relay in the normal one of its two operated positions for energizing the holding windings of said impulse receiving and control relays in a direction to maintain the position of the armature of each of these relays, and a circuit including the armature of said control relay in the other of its two operated positions for energizing the holding windings of said impulse receiving and control relays in a direction to maintain the position of the armature of each of these relays.

6. In a signaling system and combination according to claim 5, a condenser and a resistor connected in series with one of the operating windings of each of said other two relays, and a condenser and a resistor connected in series with the other of the operating windings of each of said other two relays.

7. In a signaling system and combination according to claim 5, a condenser and resistor connected in series with one of the contacts of said impulse receiving relay, and a condenser and re-

sistor connected in series with the other of the contacts of said impulse receiving relay, the charging of the one or the other of said condensers upon movement of the armature of said receiving relay away from either of its contacts being effective to continue the energization of the then energized operating windings of said other two relays.

8. In a signaling system and combination according to claim 5, a condenser and resistor connected in series with one of the operating windings of each of said other two relays, and a condenser and resistor connected in series with the other of the operating windings of each of said other two relays, the charging of said condensers being effective to reduce the effect of chatter of the contacts of said impulse receiving relay.

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