Sept. 26, 1939. O. R. MILLER 2,174,006

SIGNALING SYSTEM

Filed Dec. 1, 1938 2 Sheets-Sheet 1

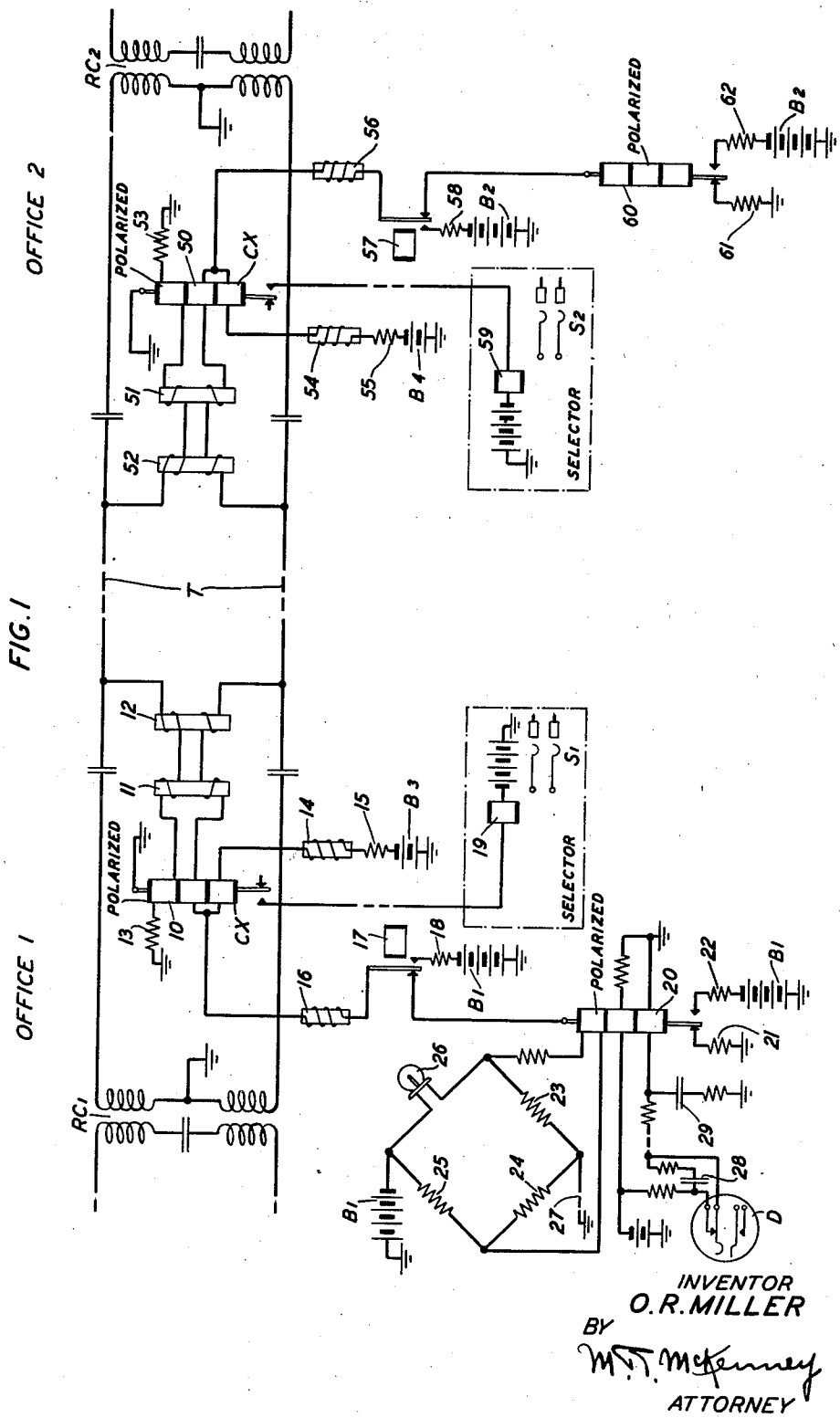

FIG. 1

INVENTOR
O. R. MILLER
BY
M. T. McKenney
ATTORNEY

Sept. 26, 1939. O. R. MILLER 2,174,006

SIGNALING SYSTEM

Filed Dec. 1, 1938 2 Sheets-Sheet 2

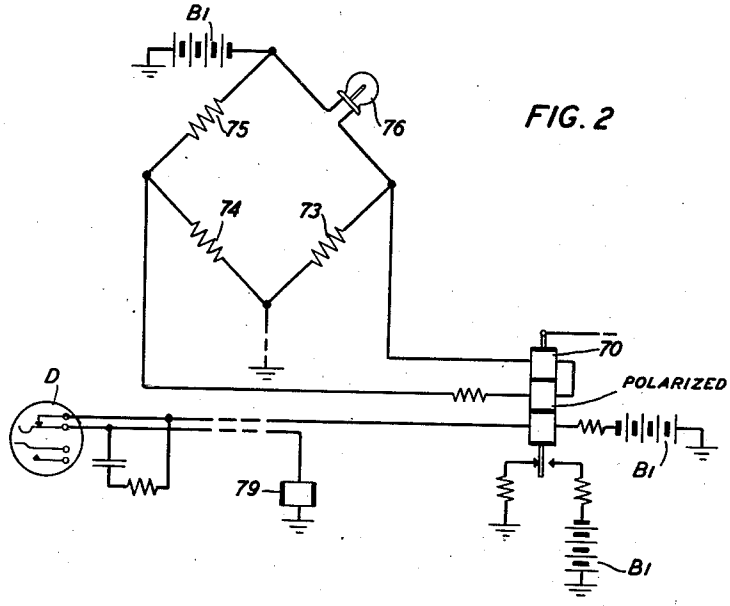

FIG. 2

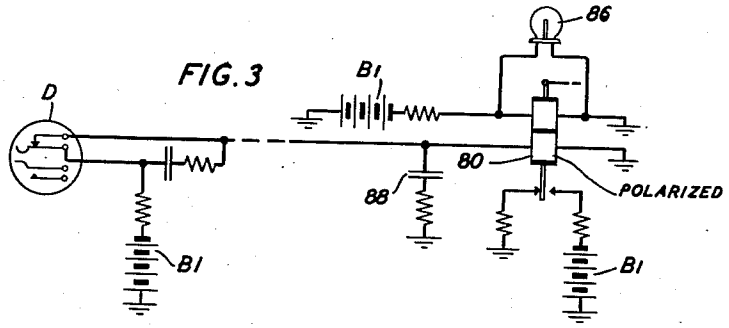

FIG. 3

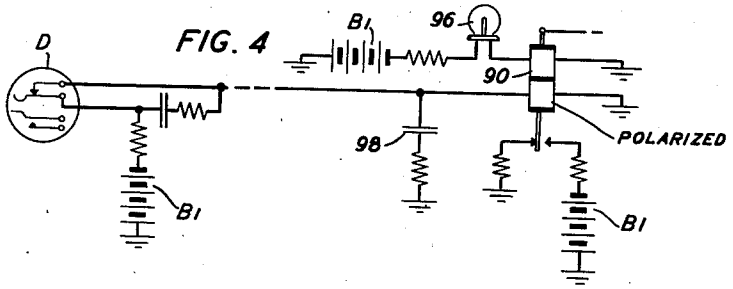

FIG. 4

INVENTOR
O. R. MILLER
BY
M. V. T. McKenney
ATTORNEY

Patented Sept. 26, 1939 2,174,006

UNITED STATES PATENT OFFICE

2,174,006

SIGNALING SYSTEM

Ohmer R. Miller, Morristown, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application December 1, 1938, Serial No. 243,349

14 Claims. (Cl. 179—3)

This invention relates to signaling systems and particularly to systems comprising electromagnetic means for sending and receiving signaling impulses.

It is the object of the invention to provide a circuit arrangement which insures accurate and efficient signaling and minimizes variations in the response of signal receivers.

This invention is a signaling system comprising a signal sending relay for opening and closing a signaling circuit, the sending relay having a biasing winding, the direction and amplitude of the current therethrough being controlled by variations in the voltage of the source of signaling current in the signaling circuit. A feature of the invention is the provision of a resistor connected in circuit with the signaling battery, and a biasing winding of an impulse transmitting relay for controlling the energization of the biasing winding, the resistor having a relatively large variation in resistance with variations in the voltage of the signaling battery as compared with the corresponding variation in the resistance of the biasing winding. According to this feature of the invention the resistor may be connected in parallel or in series with the biasing winding and the resistor may have either a positive or a negative change in resistance with respect to the magnitude of the applied voltage. According to another feature of the invention the signaling battery and the biasing winding of the signal sending relay are connected across the arms of a resistance network to form a Wheatstone bridge, the resistors comprising three of the arms of the bridge having a like change in specific resistance with variations in the voltage of the signaling battery and the resistor comprising the fourth arm of the bridge having a different and relatively large change in specific resistance with variations in the voltage of the signaling battery. According to a further feature, the resistor which controls the energization of a biasing winding of a signal sending relay to compensate for variations in the voltage of the signaling battery comprises a ballast lamp having a high positive temperature coefficient of resistance.

These and other features of the invention will be more readily described and understood by considering the embodiment of the invention in an intertoll dialing system which is schematically shown in part in the drawings which form a part of this specification. The invention is not limited in its application to the specific arrangements herein disclosed but is generally applicable to any electromagnetic signaling system.

Referring to the drawings, Fig. 1 shows a two-way trunk T between two telephone offices in an intertoll dialing system, an impulse device D, signaling transmitting relays 17 and 20, signal receiving relay 10 and a selector S1 all in office 1, and signal transmitting relays 57 and 60, a signal receiving relay 50 and a selector S2 all in office 2. Each of Figs. 2, 3 and 4 shows a signal transmitting relay and circuit arrangement which can be substituted for the relay 20 and circuit arrangement shown in Fig. 1.

For a more complete disclosure of an intertoll dialing system comprising the trunk T and circuit means shown in Fig. 1, reference may be had to the patent applications of R. E. King and O. R. Miller, Ser. Nos. 243,347 and 243,348 filed on even date herewith. The trunk T is composited for two-way signaling over one conductor, the other conductor being used to compensate for differences in ground potential between office 1 and office 2. The talking connection over trunk T includes the repeating coils RC1 and RC2. Relays 20 and 60 are impulse and signal sending relays in outgoing trunk circuits at each end of trunk T; and relays 10 and 50 are impulse and signal receiving relays for controlling the associated selector circuits S1 and S2 and for controlling the various supervisory signals transmitted from the calling to the called office. Relays 17 and 57 are supervisory relays for transmitting supervisory signals from the called to the calling office. The dial D is part of a calling operator's position equipment and is connected through a cord and jack, which are not shown in the drawings, to the signal sending relay 20 of the outgoing trunk circuit in office 1 on a call to office 2. Like means is provided in office 2, but not shown in the drawings, for controlling the operation of the sending relay 60 on a call outgoing from office 2 to office 1. The voltage of the signaling batteries B1 and B2 varies within certain limits, for instance from 40 to 56 volts. The signaling battery may be used in the dialing circuit as shown in Figs. 2, 3 and 4; or a battery having a different voltage may be used for dialing as shown in Fig. 1.

When the trunk T is not in use, the armature of each of relays 20 and 60 is held in the position shown in the drawings by the energization of its middle, biasing winding; and the armatures of relays 10 and 50 are held in the positions shown in the drawings by the energization of their lower windings in series with biasing batteries B3 and B4. With both of sending relays 20 and 60 normal, there is a circuit from ground through re-

sistor 21 and retard coil 16, the middle winding of relay 10, through the lower windings of retard coils 11 and 12, lower conductor of trunk T, lower windings of retard coils 52 and 51, middle winding of relay 50, through retard coil 56 and resistor 61 to ground. Any difference in ground potential between office 1 and office 2 is compensated by a circuit from ground through resistor 13, upper winding of relay 10, upper windings of retard coils 11 and 12, upper conductor of trunk T, upper winding of relay 50, and through resistor 53 to ground.

When the trunk T is seized by a calling operator in office 1, ground is connected to conductor 27 to complete a resistance network for controlling the energization of the upper, biasing winding of relay 20 as hereinafter described; and upon connection of the calling operator's dial D to the outgoing trunk circuit comprising relay 20, the lower, operating winding of relay 20 is energized in series with the impulse contacts of the dial. Since the middle, biasing winding of relay 20 is connected in series with the battery used in the dialing circuit, variations in the energization of the operating winding of relay 20 due to variations in the voltage of the dialing battery, are balanced by the corresponding variations in the energization of the middle winding of relay 20. The energization of the lower, operating winding of relay 20, when the trunk T is seized by the operator in office 1, moves the armature to disconnect the junction between the middle and lower windings of relay 10 from ground and connect this junction through resistor 22 to signaling battery B1. The middle and lower windings of relay 10 are thereby differentially energized and since the current in the one winding is approximately equal to the current in the other winding, relay 10 does not operate. The middle and lower windings of relay 50 are also differentially energized but relay 50 operates because the current in the middle, operating winding is about twice the strength of the current in the lower, biasing winding. Relay 50 closes a circuit for operating the line relay 59 of the associated selector S2. When the calling operator dials the first digit of the called toll office number, relay 20 repeats the dial impulses over the lower conductor of trunk T to relay 50; and relay 50 repeats these impulses to relay 59 of selector S2. When dialing is completed, the dial is disconnected from relay 20 but the lower winding of relay 20 is held energized in a circuit path not shown in the drawings as long as the calling operator's cord is connected to trunk T. When the connection is answered by an operator or a called subscriber, a supervisory relay 57 in office 2 is energized thereby disconnecting the junction between the lower windings of relay 50 from ground and connecting it through resistor 58 to battery B2. The resulting change in the energization of the middle and lower windings of relay 50 is ineffective to cause the release of this relay but causes the energization of the middle and lower windings of relay 10 in office 1 to operate relay 10 and thereby give, in a manner not shown in the drawings, an answering signal to the calling operator. When the calling operator disconnects, the circuit through the lower winding of relay 20 is opened causing the release of relays 20 and 50. When the called operator or subscriber disconnects the release of relay 57 causes the release of relay 10.

Since the signaling battery B1 may vary between rather wide limits, the response of relay 50 to the dial impulses repeated by relay 20 may thereby be varied to such a degree that the selector S2 and other selectors employed in completing a connection will fail to operatively follow the impulses. It is the function of the upper winding of relay 20 to vary the operating characteristics of relay 20 in accordance with variations in the voltage of the signaling battery B1 so that the response of relay 50 to dial impulses will not be sufficiently affected by the variation in the voltage of battery B1 to cause a substantial change in the percentage break of the impulses received by the selector S2 and succeeding switches. To this end the signaling battery B1 and the upper winding of relay 20 are connected across the network comprising resistors 23, 24 and 25 and ballast lamp 26 to form a Wheatstone bridge which is balanced when the voltage of battery B1 is at its median value and in this case there is no current through the upper winding of relay 20. The resistors 23, 24 and 25 are of similar type and their resistance does not vary to any substantial degree within the limits of the voltage of battery B1. The ballast lamp 26 has a filament whose temperature coefficient of resistance is comparatively high, and the resistance of lamp 26 increases substantially when the current increases due to an increase in the voltage of battery B1 and decreases substantially when the current decreases due to a decrease in the voltage of battery B1. Therefore, if the voltage of battery B1 is reduced below its median value, the current through lamp 26 is reduced and the resistance of lamp 26 increases to unbalance the bridge; and the upper winding of relay 20 is energized to aid the operation of relay 20 and thereby compensate for the smaller current through the windings of relay 50. And if the voltage of battery B1 increases to a value higher than the median value, the current through lamp 26 is increased and the resistance of lamp 26 reduced to unbalance the bridge; and the upper winding of relay 20 is energized in the opposite direction to delay the operation of relay 20 and thereby compensate for the larger current through the windings of relay 50.

It is necessary that both the build-up and the decay of the current through the operating winding of relay 20 be long enough in duration to enable the desired compensating effect on the operating and release times of this relay due to the energization of the upper biasing winding. For this reason the operating winding of relay 20 is shunted by a capacitor 29 which causes the current through the operating winding to have the desired amplitude-time characteristics. The capacitor 28 bridged across the contacts of the dial protects these contacts and also aids the capacitor 29 in controlling the build-up and decay of the operating current.

The arrangement shown in Fig. 2 differs from that of Fig. 1 in that the operating winding of the polarized signal transmitting relay 70 is energized in series with the signaling battery instead of a different battery and the upper and middle windings of relay 70 are connected in series across the arms of the bridge comprising resistors 73, 74, 75 and ballast lamp 76. Since the winding of a relay 79 of the outgoing trunk circuit is included in the dialing circuit, the effect of the biasing windings of relay 70 is sufficient to produce the desired degree of compensation for changes in the voltage of signaling battery B1 without connecting a capacitor in parallel

with the operating winding as in the arrangement shown in Fig. 1.

The arrangement shown in Fig. 3 comprises a polarized signal transmitting relay 80, the operating winding of which is connected in series with the dial D and the signaling battery B1, and the biasing winding of which is connected in parallel with a ballast lamp 86 and in series with the signaling battery B1. The capacitor 88 is connected in parallel with the operating winding to enable the desired compensating effect due to the biasing winding. Variations in the resistance of lamp 86, due to variations in the voltage of battery B1, enables the desired variable energization of the biasing winding of relay 80 to compensate for the variations in the current in the signaling circuit controlled by the contacts of relay 80 due to variations in the voltage of the signaling battery B1.

The arrangement shown in Fig. 4 comprises a polarized signal transmitting relay 90 having an operating winding connected in series with the dial contacts and signaling battery B1 and having a biasing winding connected in series with a resistor 96 and the signaling battery B1. The resistor 96 has a negative coefficient of resistance with respect to voltage and thereby varies the biasing current according to the voltage of the signaling battery. A capacitor 98 is connected in parallel with the operating winding of relay 90 to enable the desired compensating effect due to the biasing winding.

The desired variation in the operating characteristics of the impulse sending relay 20, 70, or 80 may, of course, be secured by the provision of a resistor having a negative coefficient of resistance connected in circuit with a compensating winding in place of the ballast lamp 26, 76 or 86 which has a positive coefficient of resistance; and the desired variation in the operating characteristics of impulse sending relay 90 may, of course, be secured by the provision of a resistor having a positive coefficient of resistance connected in circuit with a compensating winding in place of the resistor 96 which has a negative coefficient of resistance. Thus the resistor which is used to vary the energization of a biasing or compensating winding of the impulse transmitting relay may consist of any material which has a relatively high positive or a relatively high negative voltage coefficient of resistance.

What is claimed is:

1. In a signaling system, an impulse transmitting relay, an impulse receiving relay, a signaling battery, a signaling circuit including said battery, contacts of said transmitting relay and a winding of said receiving relay, means comprising a winding of said transmitting relay for operating said relay to transmit signal impulses in said circuit, a compensating winding for said transmitting relay, and means comprising a resistor connected in circuit with said signaling battery and with said compensating winding for varying the energization of said compensating winding to compensate for variations in the current in said signaling circuit due to variations in the voltage of said battery.

2. In a signaling system, a signaling circuit comprising a signaling battery, a relay for opening and closing said signaling circuit, means comprising a winding for operating said relay, and means comprising a compensating winding of said relay and a resistor connected in circuit with said battery for varying the operating and releasing time characteristics of said relay to compensate for variations in the current in said signaling circuit due to variations in the voltage of said signaling battery.

3. In a signaling system, a signaling circuit comprising a signaling battery, a relay for opening and closing said signaling circuit, means comprising a winding for operating said relay, and means comprising a compensating winding of said relay and a ballast lamp connected in circuit with said battery for varying the operating and releasing time characteristics of said relay to compensate for variations in the current in said signaling circuit due to variations in the voltage of said signaling battery.

4. In a signaling system, an impulse transmitting relay, an impulse receiving relay, a signaling battery, a signaling circuit including said battery, contacts of said transmitting relay and a winding of said receiving relay, means comprising a winding of said transmitting relay for operating said relay to transmit signal impulses in said circuit, a compensating winding for said transmitting relay, a capacitor connected in parallel with the operating winding of said relay to control the amplitude-time characteristics of the current through said operating winding, and means comprising a resistor connected in circuit with said signaling battery and with said compensating winding for varying the energization of said compensating winding to compensate for variations in the current in said signaling circuit due to variations in the voltage of said battery.

5. In a signaling system, an impulse transmitting relay, an impulse receiving relay, a signaling battery, a signaling circuit including said battery, contacts of said transmitting relay and a winding of said receiving relay, means comprising a winding of said transmitting relay for operating said relay to transmit signal impulses in said circuit, a compensating winding for said transmitting relay, an inductor connected in series with the operating winding of said relay to control the amplitude-time characteristics of the current through said operating winding, and means comprising a resistor connected in circuit with said signaling battery and with said compensating winding for varying the energization of said compensating winding to compensate for variations in the current in said signaling circuit due to variations in the voltage of said battery.

6. In a signaling system, an impulse transmitting relay, a compensating winding for said relay, an impulse receiving relay, a battery, a circuit including said battery and contacts of said impulse transmitting relay for transmitting signal impulses to said impulse receiving relay, and means automatically effective upon a variation in the voltage of said battery for preventing a variation in the response of said impulse receiving relay, said means comprising a Wheatstone bridge in series with said battery, one of the arms of said bridge being a ballast lamp whose resistance varies with the voltage of said battery, the compensating winding of said impulse transmitting relay being connected across the arms of said bridge.

7. In combination, a signal transmitting relay, a signal receiving relay, a signaling circuit comprising a signaling battery in series with contacts of said transmitting relay and the winding of said signal receiving relay, a signal sender for operating said signal transmitting relay, and means preventing variation in the time charac-

teristics of the response of the signal receiving relay due to variation in the voltage of the signaling battery, said means comprising a compensating winding of said transmitting relay and a network of resistors connected in series with the signaling battery to form a Wheatstone bridge, the resistor constituting one of the arms of the bridge having a resistance which varies with the voltage of the signaling battery, each of the resistors constituting the other arms of the bridge having a substantially constant resistance within the limits of the voltage of the signaling battery.

8. In a signaling system, an impulse transmitting relay, an impulse receiving relay, a signaling battery, a signaling circuit including said battery, contacts of said transmitting relay and a winding of said receiving relay, an impulse device, an impulse battery, an operating winding of said transmitting relay connected in series with said impulse device and said impulse battery, biasing windings for said transmitting relay, a first one of said biasing windings connected in series with said impulse battery to compensate for variations in the voltage of the impulse battery, and a Wheatstone bridge in series with said signaling battery, said bridge comprising three resistors having a small and like temperature coefficient of resistance, a resistor having a relatively large temperature coefficient of resistance and the second biasing winding of the transmitting relay connected across the junction between two of said three resistors and the junction between the other two resistors, the energization of said second biasing winding being effective to vary the time characteristics of the transmitting relay inversely as the voltage of the signaling battery and thereby compensate for variations in the voltage of the signaling battery.

9. In a signaling system, an impulse transmitting relay, an impulse receiving relay, a signaling battery, a signaling circuit including said battery, contacts of said transmitting relay and a winding of said receiving relay, an impulse device, an impulse battery, an operating winding of said transmitting relay connected in series with said impulse device and said impulse battery, a biasing winding for said transmitting relay, and a Wheatstone bridge in series with said signaling battery, said bridge comprising three resistors having a small and like temperature coefficient of resistance, a resistor having a relatively large temperature coefficient of resistance and said biasing winding of the transmitting relay connected across the junction between two of said three resistors and the junction between the other two resistors, the energization of said biasing winding being effective to vary the time characteristics of the transmitting relay inversely as the voltage of the signaling battery and thereby compensate for variations in the voltage of the signaling battery.

10. In a telephone system, a first office, a second office, a trunk between said offices, an outgoing trunk circuit including a polarized impulse transmitting relay in the first office, an impulse receiving relay and a selector controlled by said impulse receiving relay in said second office, an impulse device for operating said transmitting relay, an impulse circuit controlled by contacts of said transmitting relay, said circuit including a grounded signaling battery in said first office, a conductor of said trunk and a winding of said receiving relay, and a Wheatstone bridge in series with said signaling battery, said bridge comprising a biasing winding of said transmitting relay, a ballast lamp, and three resistors, the resistance of each of said three resistors being substantially constant within the limits of the voltage of said signaling battery, said biasing winding being connected across the junction between said lamp and one of said three resistors and the junction between the other two resistors, said bridge being balanced when the voltage of said signaling battery is at its median value, an increase or decrease in the voltage of said signaling battery from said median value being effective to cause a decrease or increase in the resistance of said lamp to unbalance the bridge and energize said biasing winding in such a direction as to vary the time characteristics of the impulses transmitted to said impulse receiving relay and thereby compensate for the variation in the voltage of said signaling battery.

11. In a signaling system, an impulse transmitting relay, an impulse receiving relay, a signaling battery, a signaling circuit including said battery, contacts of said transmitting relay and a winding of said receiving relay, an impulse device, an operating winding of said transmitting relay connected in series with said impulse device and said battery, a biasing winding for said transmitting relay, and a Wheatstone bridge in series with said battery, said bridge comprising three resistors having a small and like temperature coefficient of resistance, a resistor having a relatively large temperature coefficient of resistance and said biasing winding of the transmitting relay connected across the junction between two of said three resistors and the junction between the other two resistors, the energization of said biasing winding being effective to vary the time characteristics of the transmitting relay inversely as the voltage of the signaling battery and thereby compensate for variations in the voltage of the signaling battery.

12. In a signaling system, an impulse transmitting relay, an impulse receiving relay, a signaling battery, a signaling circuit including said battery, contacts of said transmitting relay and a winding of said receiving relay, an impulse device, an operating winding of said transmitting relay connected in series with said impulse device and said battery, a biasing winding for said transmitting relay, means comprising an inductor in series with the operating winding of said transmitting relay for controlling the amplitude-time characteristics of the circuit through said operating winding, and a Wheatstone bridge in series with said battery, said bridge comprising three resistors having a small and like temperature coefficient of resistance, a resistor having a relatively large temperature coefficient of resistance and said biasing winding of the transmitting relay connected across the junction between two of said three resistors and the junction between the other two resistors, the energization of said biasing winding being effective to vary the time characteristics of the transmitting relay inversely as the voltage of the signaling battery and thereby compensate for variation of the current in the signaling circuit due to variations in the voltage of the signaling battery.

13. In a signaling system, an impulse transmitting relay, an impulse receiving relay, a signaling battery, a signaling circuit including said battery and contacts of said transmitting relay and a winding of said receiving relay, an impulse

device, an operating winding of said transmitting relay connected in series with said impulse device, a compensating winding for said transmitting relay connected in series with said battery, and a resistor connected in parallel with said compensating winding, said resistor comprising a conductor whose resistance varies substantially with the voltage impressed thereon.

14. In a signaling system, an impulse transmitting relay, an impulse receiving relay, a signaling battery, a signaling circuit including said battery and contacts of said transmitting relay and a winding of said receiving relay, an impulse device, an operating winding of said transmitting relay connected in series with said impulse device, a compensating winding for said transmitting relay connected in series with said battery, and a resistor connected in series with said compensating winding, said resistor comprising a conductor whose resistance varies substantially with the voltage impressed thereon.

OHMER R. MILLER.