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SIGNALING SYSTEM

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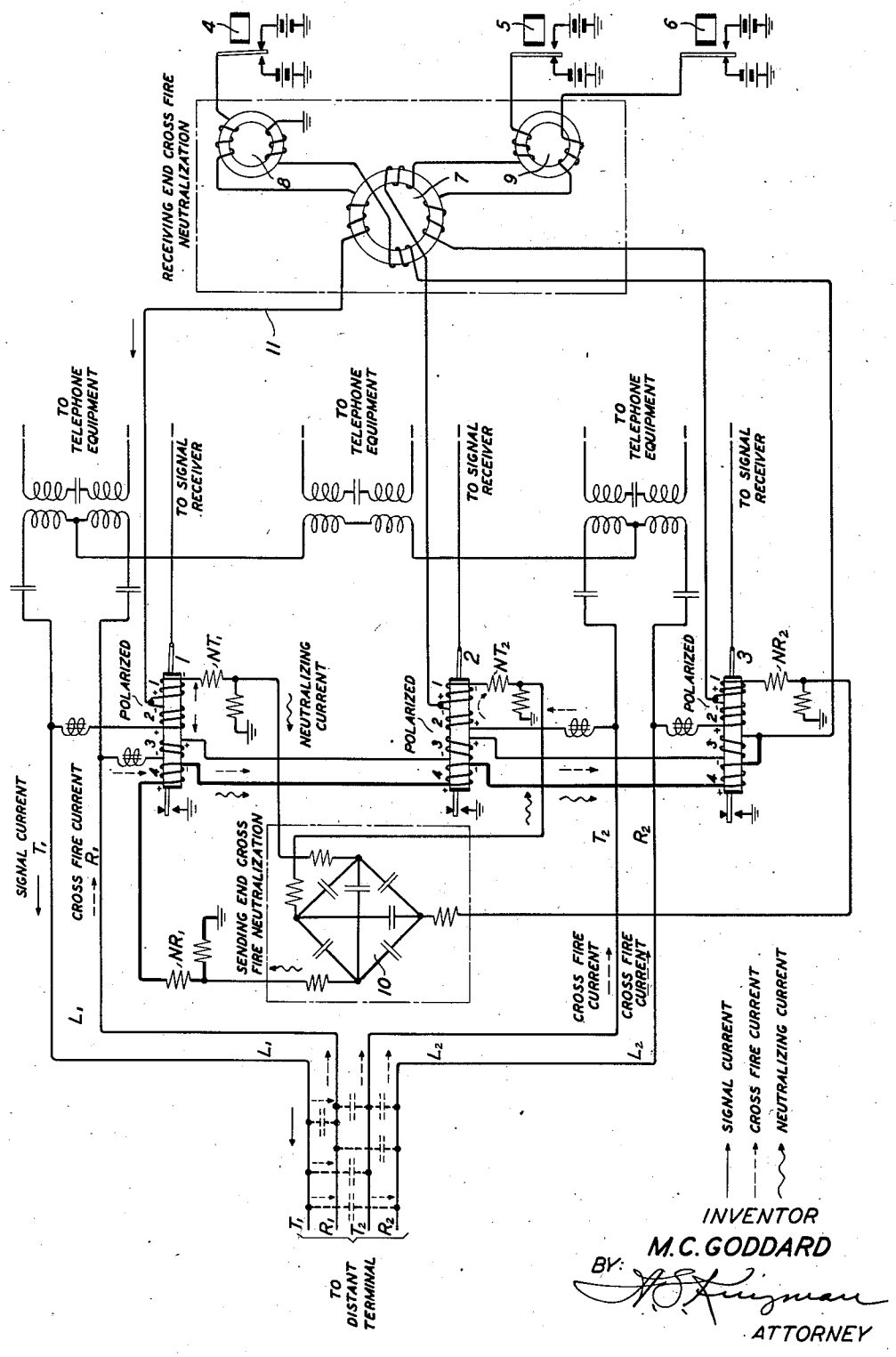

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SIGNALING SYSTEM

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This invention relates to duplex signaling systems and more particularly to systems of the character disclosed in United States Patent 1,287,831 to H. M. Bascom in which three independent direct current duplex telegraph or signal channels and a ground potential compensating channel are superimposed on a four-wire phantom telephone group.

An object of the invention is to substantially reduce, at each end of such phantom groups the effect of crossfire between the four wires of such groups on the terminal relays caused by inductance and capacity between the wires, and by leakage, which crossfire effect is due largely to the proximity of the four wires to each other on a pole line or in a cable.

Another object is to reduce interference with operation of all the terminal relay caused by transformer action between a line winding of one of the relays through which signals are being transmitted and the compensating winding of the same relay.

A further object is to reduce interference with the operation of the terminal relay equipment due to longitudinal current induced in the line wires from adjacent alternating current power circuits.

In duplex signaling systems of the prior art, such as the Bascom patent above mentioned, multiwound signaling relays for each of the three signaling channels are provided, one for each terminal of the system, each relay having one winding connected in series with its respective signaling channel, a second winding connected to a grounded balancing network having equivalent characteristics of that of the signaling channel with which it is associated, and a third winding connected in a series circuit between ground at each terminal and including the fourth or compensating conductor and all the other third windings of the signal relays at the two terminals. which arrangement therefore provides three balancing networks at each terminal, i. e., one for each of the three signaling channels but it will be noted that the fourth or compensating conductor unlike the other three signaling conductors has no such balancing network.

In United States Patent 1,560,540 to Samuel I. Cory, issued November 10, 1925, a system is disclosed for neutralizing the effect of crossfire both at the receiving end and also at the sending end of two grounded telegraph circuits in which sending end crossfire is neutralized by connecting a condenser between the artificial lines of the two duplex channels and receiving end crossfire is neutralized by inductively coupling such channels together in such a manner that crossfire disturbance between the two telegraph conductors is neutralized by a simultaneous disturbance in an opposing direction due to the inductive coupling.

Obviously neutralization of crossfire, as shown in the Cory patent, can be applied to four-wire groups of conductors wherein each wire is used for a duplex signaling circuit and consequently balanced at each terminal by an equivalent artificial line network.. To obtain neutralization of receiving end crossfire all four signaling wires can be inductively coupled, each with the other three, at each terminal by means of a multiwound transformer having one winding in series with each wire and sending end crossfire can be similarly neutralized by interconnecting the four balancing networks or artificial lines at each terminal by a six condenser network, four of the condensers being connected to form a square. the other two connected in the diagonals thereof and the four corners of the square connected to the four networks. Such an arrangement for neutralizing crossfire in a four-channel telegraph system is known and has been previously used. However, in the case of systems where there is a difference in ground potential between the two terminals of the duplex system, it is sometimes desirable to compensate for this difference by employing one of the four line wires of the group, as disclosed and claimed in the before-mentioned Bascom patent and it will be obvious that sending end crossfire neutralization in such a system, as previously described, by connecting the artificial lines at each terminal together by means of a condenser will not reduce the disturbing effect at the transmitting end caused by crossfire between any one of the three signaling wires and the ground compensating wire which wire includes a winding on each of the signaling channel relays.

A feature of the present invention therefore resides in balancing the compensating wire by means of a fourth artificial line at each terminal in a manner corresponding to that of the signal wires which requires the addition of a fourth winding on each of the three signal relays at each terminal which fourth windings are all connected in series between the fourth artificial line and ground.

With such an arrangement, condensers can then be connected between the four artificial lines, in accordance with present telegraph prac-

tice, to neutralize the "sending end crossfire" disturbance between the three signaling wires and also between any one of the signaling wires and the compensating wire.

Also receiving end crossfire between any of the signaling wires and the compensating wires can be neutralized by inductively coupling the signaling wires and the compensating wire by means of a transformer whereby crossfire from one of the signal wires incoming at the receiving end over the compensating wire which flows through the compensating windings is opposed by an induced neutralizing current, due to the signal current, which flows in an opposite direction in the fourth windings to the crossfire current flowing in the third or compensating windings.

The invention will be understood from the following description and accompanying drawing which shows one end of two physical two-wire lines extending between distant terminals, only one being shown, and arranged to provide three direct current duplex signaling channels and a channel for equalizing or compensating for differences in earth potential at the two terminals, to which system is added means in accordance with the invention for neutralizing the effect of crossfire between the four channels on the terminal relay equipment with particular reference to neutralizing the effect of what is known as "sending end crossfire" appearing in the compensating channel due to current in any of the three signal channels.

Referring to the drawing L_1 and L_2 represent two two-wire physical lines terminating in telephone equipment, not shown, as for example in jacks as shown in the before-mentioned Bascom Patent 1,287,831.

For purposes of signaling between the two terminals of the lines three duplex channels are provided comprising line conductors T_1 of line L_1 and conductors T_2 and R_2 of line L_2 with which channels are associated respective multiwound polar relays such as **1**, **2** and **3** at the terminal shown, and corresponding identical relays, not shown, at the distant terminal, each of which control auxiliary pulse or signal receiving relays, also not shown.

Windings Nos. 1 and 2 of each polar relay are the usual balancing and line windings respectively and the No. 3 winding on each relay is the ground compensating windings all of which windings (No. 3) are connected in the usual manner in series between the line conductor R_1 and ground at each terminal in such a manner that any difference in ground potential at the two terminals, which potential tends to effect the operation of the polar relays, will be neutralized by current in an opposing direction in the No. 3 or compensating winding of these relays as clearly described in the Bascom patent.

The method of normal operation of the system, thus far referred to, as regards transmission of signals over the duplex channels T_1, T_2, and R_2, and the compensation for differences in ground potential is well known and fully described in the Bascom patent and also in a more recent Patent 2,133,832 to G. A. Pullis which patent in addition to describing means for providing compensation for differences in earth potential at each terminal also describes additional means for providing for differences in potential between the two normally equal potential signal batteries at the two terminals.

Crossfire neutralization

With further reference to the drawing, each armature of the three conventional pole-changing transmitting relays **4**, **5** and **6** is connected to the junction of the No. 1 and No. 2 windings of the respective polar relay in series with respective windings of a four-winding transformer **7** and the connection to ground for the earth potential compensating circuit includes the additional or fourth winding of this transformer whereby "receiving end crossfire" between the signaling conductors and the compensating conductor is inductively neutralized as described in the Cory Patent No. 1,560,540. In addition to transformer **7** which includes all three transmitting branches of the system and the ground connection for the earth potential compensating channel, the two conductors of each pair, i. e., T_1 and R_1 and T_2 and R_2 are also independently coupled to each other by means of two winding transformers **8** and **9** for the reason that the crossfire between the two conductors of each pair may be greater than that between the conductors of different pairs, and therefore require closer coupling.

In addition to the inductive coupling for "receiving end crossfire" just described, means for neutralizing "sending end crossfire" between the signaling channels T_1, T_2 and R_2 and the compensating channel R_1 is provided by means of condensers **10** in the manner described for two telegraph circuits in the Cory Patent 1,560,540 which requires a line balancing network for each channel. As previous systems of the Bascom and Pullis type, previously referred to, which require one of the four line conductors for earth potential compensation and which have no line balancing network, the first requirement to condition such a system for sending end crossfire is to provide such a balancing network for the compensating channel R_1 in order that the condenser arrangement **10** can be interconnected in balanced relation between all four channels. This requirement is accomplished by the addition to each polar relay of a fourth or No. 4 winding to balance the third or No. 3 compensating winding and in connection the No. 4 winding in series between ground and a fourth network NR_1 corresponding to the other three networks NT_1, NT_2 and NR_2 and simulating the line impedance of the compensating conductor R_1. With this arrangement a condenser network **10** can be interconnected between the four balancing networks to neutralize sending end crossfire.

The operation of this arrangement for neutralizing crossfire at the sending end will be understood from the following. Assume that signals are being transmitted over the first signal channel T_1 by operation of the sending relay **4**. Operation of this relay removes negative potential from the relay armature and substitutes a positive potential therefor which consequently causes a current to flow from right to left, as indicated by the solid arrow, in conductor **11**, line winding 2 of relay **1** and line conductor T_1, to negative battery and ground at the distant terminal. Operation of relay **4** also reverses the current previously flowing in the No. 1 balancing winding of relay **1** to a direction which tends to operate the relay but this effect is neutralized by the flow of current in winding 2 and hence the relay remains inert on its back contact.

Due to capacity and mutual inductance between the line wires this sudden potential increase applied to line conductor T_1 will tend to cause an

impulse of crossfire current in conductors R_1, T_2 and R_2 in a direction indicated by the dotted arrows. Now assuming for example such a crossfire current flowing in line conductor T_2, due to signal current in T_1, then this current will flow through windings 2 and 1 of relay **2** and balancing network NT_2 to ground in a direction tending to operate relay **2**, but due to the fact that the balancing network NT_1 is connected to network NT_2 by means of the condenser network **10**, a neutralizing current indicated by a wavy arrow will flow from the network NT_1 through the condenser network to network NT_2 which opposes crossfire current in line conductor T_2 which otherwise would tend to falsely operate relay **2**.

Similarly, crossfire current in the compensating conductor R_1 due to signal current in conductor T_1, for example, which flows to ground through the serially connected No. 3 windings of all three relays **1**, **2** and **3** is neutralized by neutralizing current flowing from network NT_1 through the condenser network **10** to the network NR_1 and thence to ground through the serially connected No. 4 windings of all three relays which is in an opposing direction to the interfering current in the No. 3 winding.

It will therefore be noted from the foregoing that sending end crossfire neutralization between all four conductors of the systems arranged for earth potential neutralization in accordance with the Bascom patent is effected by providing a fourth winding on each polar signaling relay which windings are serially connected between ground and a balancing network simulating the characteristics of the compensating line conductor.

The foregoing arrangement for neutralizing crossfire disturbance is also effective to neutralize signal distortion caused by longitudinal currents in the line wires due to induction from nearby alternating current power circuits.

What is claimed is:

1. In a duplex signaling system providing three independent duplex signaling channels and a ground potential compensating channel over four conductors, a multiwound polar relay at each end of and associated with each signaling channel, each relay having one winding in the respective signaling channel, a balancing winding therefor connected to a grounded impedance network simulating the characteristics of the respective channel, and a third winding in series with said compensating channel and ground, and means at each end of said channels for neutralizing the effect of sending end crossfire between any of said signaling channels and said compensating channel comprising a fourth winding on each relay serially connected between ground and a grounded impedance network simulating the characteristics of said compensating conductor and a condenser network interconnecting all four of said impedance networks.

2. In a duplex signaling system providing three independent duplex signaling channels and a ground potential compensating channel over four conductors, a multiwound polar relay at each end of and associated with each signaling channel, each relay having one winding in the respective signaling channel, a balancing winding therefor connected to a grounded impedance network simulating the characteristics of the respective channels, and a third winding in series with said compensating channel and ground, and means at each end of said channels for neutralizing the effect of crossfire at both the sending and receiving ends of the system between any of said signaling channels and said compensating channel comprising a fourth winding on each relay, a grounded impedance network simulating the characteristics of said compensating conductor, said fourth windings being serially connected in a circuit including said compensating conductor impedance network and said third windings, a condenser network interconnecting all four of said impedance networks, and an inductive coupling between the sending branches of the three signaling channels and the compensating channel.

3. In a multichannel duplex signaling system employing one conductor of a group of line wires for earth potential compensation and connected to ground at each terminal in series with a third or compensating winding on each of the duplex signal relays at each terminal, and means at each terminal for neutralizing crossfire between the various channels and the compensating conductor to reduce distortion in the operation of the signal relays, said means including an inductive coupling between the sending branches of the signaling channels and the compensating channel, an artificial line simulating the impedance of the compensating line wire, a fourth winding on each duplex relay serially connected between said compensating channel and said artificial line, and a condenser network interconnecting the artificial lines of all of said line wires.

4. In a duplex composite signaling system for groups of four conductors to provide three separate signal channels and a compensating channel, each signaling channel employing a multiwound relay at each of its terminals having one winding in the respective signaling channel, a balancing winding in opposition thereto, and a compensating winding, all of said compensating windings being in series with said compensating channel, and means for neutralizing crossfire between all four conductors, said means including a forth winding on each of said relays.

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