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R. B. SHANCK

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PULSE REPEATING SYSTEM

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FIG. 1

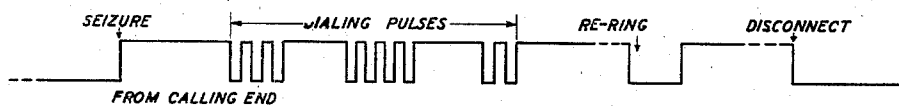


FIG. 2

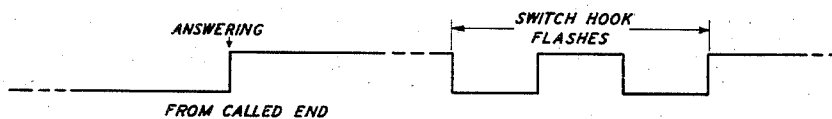


FIG. 3

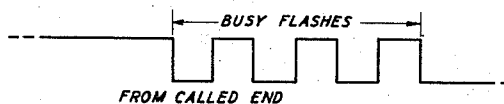
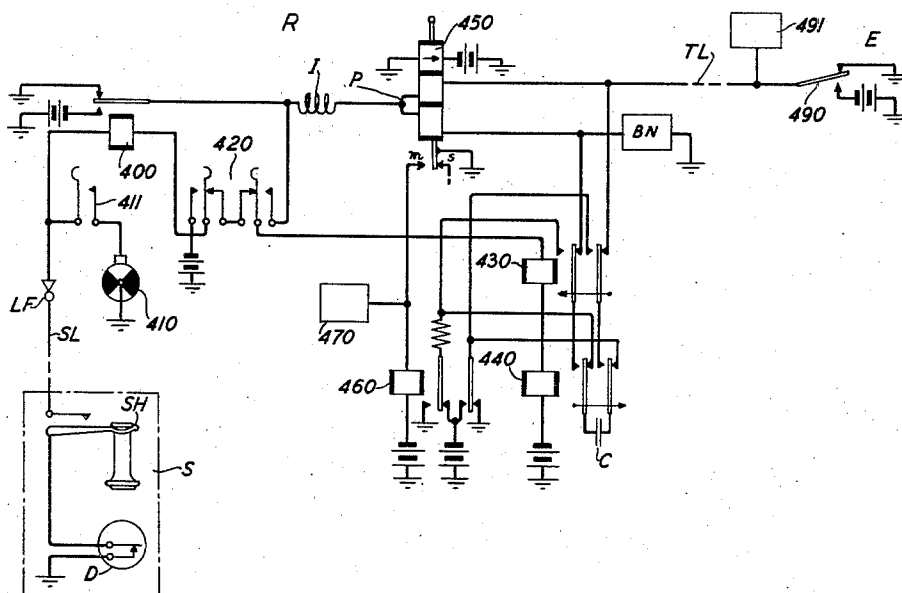


FIG. 4



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PULSE REPEATING SYSTEM

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10 Claims. (Cl. 179-84)

The invention relates to pulse repeating systems and more particularly to systems of this type operating on a duplex basis.

It is an object of the invention to provide a pulse repeating system with a simplified duplex balance and capable of efficient operation under conditions of line variations and interference.

It is a more specific object of the invention to provide a system of this type which with standardized equipment is adapted for repeating selecting and supervising pulses for telephone switching systems over lines of greatly differing characteristics and lengths.

The selective and supervisory operations of automatic telephone switching systems are frequently performed over extensive line circuits, such as toll lines, the lengths of which differ greatly and which are subject to well-known disturbances and interferences. The selecting pulses, usually termed the dial pulses, are usually transmitted from one telephone exchange to another over half-duplex pulse repeating circuits, which hitherto have been carefully balanced to operate satisfactorily under the changing operating conditions in the line circuit. The reason for duplexing the pulse circuit is mainly to be found in the fact that the traffic requirements include the transmission in both directions over the line circuit of supervisory signals or pulses. The operations are complicated by the requirement that, in the series of operations involved in the setting up of a connection, the line circuit is placed under two different conditions, which may be termed the idle and the busy conditions.

The pulse repeating system is adapted to receive dialing pulses from a calling station, which may be a remote telephone subscriber's station or a local operator's dialing circuit, and to repeat the pulses over an outgoing line circuit to a distant telephone exchange, equipped for automatic switching in response to the dial pulses for the selection of another exchange or another subscriber's station.

The repeating circuit includes a pole changing relay for applying two different transmitting potentials to the line circuit corresponding to the two conditions of the pulses, namely, marking and spacing or current and no current. The pulses from the pole changing relay are impressed upon a duplex circuit including the line circuit in one branch and a balancing circuit in the other branch.

A polar receiving relay is included in the duplex circuit for reception of signals incoming over the line circuit, this relay being unaffected by outgoing signals when the impedance bal-

ance is perfect. For this purpose the polar relay may be connected in any well-known manner, as by having its operating windings directly included in the two balanced branches or connected in a bridge between the balanced circuits, in accordance with well-known practices in telegraph repeating systems. The system is also equipped for the transmission of busy signals comprising a series of pulses of a predetermined frequency, usually about 80 cycles per minute, which are impressed upon the duplex circuit by operation of the pole changer.

As is well known it has hitherto been necessary to establish a fair balance between the line circuit and the balancing network in duplex systems of either type referred to above, in order to prevent the receiving relay from responding to the outgoing pulses. When signals are impressed on an unbalanced system unbalance currents arise which may operate the receiving relay. Thus in the differential duplex circuit the currents in the two operating windings will be unequal or unbalanced and the stronger current may operate the relay. In the bridge duplex circuit the potentials applied to the relay winding are unequal and an equalizing or unbalance current will flow through the windings and may operate the relay.

In accordance with a feature of the invention, the balancing network is simplified and is standardized to supply a fair balance for a large variety of line circuits so that it may be manufactured at comparatively low cost. In accordance with the invention the system is furthermore arranged so that it will be unnecessary to adjust the balancing network to compensate for sporadic variations in the line circuits during ordinary operating conditions including temperature and leakage changes. This simplification of the balancing network is further effective in reducing the large amount of designing work involved in the provision of a large variety of differently dimensioned balancing networks for the corresponding varieties of line circuits to satisfy the present day severe demands for accuracy.

For the purposes just outlined the invention provides an arrangement for preventing false operations, which would be due to improper responses by the receiving relay during the transmission of outgoing pulses resulting from unbalance conditions. By this provision a given design of balancing network may be based on certain average or predominant line conditions among the large variety of conditions met with in the plant. Such a network may thus pro-

vide an accurate balance for a large number of lines with average characteristics; it would, however, be less accurate in the balancing of line circuits having more diverging characteristics, without, however, establishing a circuit condition which would result in false operations due to unbalance conditions caused by line variations or interference.

When the pulse repeating system is idle, the pole changing or sending relay will apply an idle condition to the toll line, which may be assumed to be a spacing or no current condition, the other end of the line circuit being assumed to apply a similar condition to the line. In response to the seizure of the repeater station by a calling station or an operator, the pole changer applies a busy or marking condition to the toll line. After the transmission of dialing pulses, the distant station also applies a marking or answering condition to the line circuit which consequently will operate the polar receiving relay at the repeating station.

After this condition has been reached, further pulses may be transmitted in either direction over the line circuit. For example, a rering pulse may be transmitted by the sending station in the form of a pulse which will cause the distant exchange to rering the called line; busy flashes may be transmitted back to the calling line; and switchhook flashes may be transmitted in either direction.

The polar receiving relay at the repeater station will respond to incoming pulses from the line circuit and will respond to the answering condition imposed upon the line circuit from the distant end by operating to marking position. Thus, the receiving relay is arranged to control circuit equipment which, in a well-known manner, may be arranged to respond in proper sequence to the traffic signals, such as "answering" and "busy," from the called line. It may furthermore be arranged to function in response to dial pulses from the distant station, when the call is in the opposite direction, for control of the selecting operation of telephone switches at the exchange with which the repeater is immediately associated.

It will, therefore, be seen that in a sense the repeater operates under full-duplex conditions, inasmuch as it will operate with either of two polarities applied to either or both ends of the line circuit. However, though the repeater is required to operate in both directions, it will operate only in one direction at a time, so that for any particular line condition the repeater will be operating on a half-duplex basis.

This particular condition permits the introduction of a feature of the invention which basically resides in rendering the receiving relay ineffective during the transmission of outgoing signals and restoring the receiving relay circuit to effectiveness upon termination of the retransmission of outgoing signals.

In accordance with a more specific feature of the invention the receiving relay has its sensitivity materially reduced during the transmission of outgoing pulses and for this purpose a circuit, which may include capacitance means, is connected to form a by-path for the operating windings of the receiving relay only during the sending conditions. By this provision any unbalance current from the line and balancing circuits, due to the outgoing pulses, will be diverted from the windings of the receiving relay to pass over the capacitance shunt, thereby preventing "kick-off."

In view of the application of different line potentials under different operating conditions the act of connecting a capacitance shunt circuit across the relay windings may under certain circumstances cause "kick-off." Therefore, in accordance with another specific feature of the invention, provision is made for charging the capacitance shunt in alternate directions, while it is disconnected from the line circuit, to produce a properly directed discharge current and prevent "kick-off" when the capacitance is connected to the line circuit during the sending of pulses.

In accordance with a more specific feature of the invention, the direction of charging current is controlled by the position of the receiving relay at any time, as determined by the line potential applied at the distant end.

The invention will now be described more in detail as to its organization and operation and as applied to a specific embodiment. In the description reference will be made to the attached drawing in which:

Figs. 1, 2 and 3 are diagrammatic representations of different typical pulses that may be transmitted in either direction over the line circuit; and

Fig. 4 is a circuit diagram of a repeater circuit, representing a specific application of the invention and including the features of the invention.

Referring to the drawing, it will be assumed that a subscriber's station is connected to a telephone exchange and desires to make a call to a distant subscriber's station at another telephone exchange. The two exchanges are connected together over toll lines.

In accordance with established traffic conditions in the telephone plant, the subscriber first removes his receiver from the hook, thereby establishing a calling condition. Thereafter the subscriber operates his calling dial which transmits the usual groups of dialing pulses. The distant exchange then applies an answering condition to the line circuit and rings the called subscriber, who answers by lifting his receiver off the hook, thereby establishing a busy condition. If the called subscriber should be busy, a continuous series of busy pulses will be transmitted back to the calling station at the rate of 80 pulses per minute. Other busy conditions, as for local trunks or distant trunks, are indicated by similar pulses of different frequencies. Upon the distant subscriber disconnecting prematurely, a rering pulse may be transmitted from the calling end of the line circuit. Subscribers' switchhook flashes may be transmitted at any time in either direction.

The diagram in Fig. 1 shows the signaling current in the line circuit at the time of a call. Thus, when the line circuit is seized, the line current increases from a no current or spacing condition to a steady marking current condition. Thereafter the marking current is interrupted by the dialing pulses, whereupon the line current remains steady. In the case of a subsequent rering the line current is momentarily interrupted.

Fig. 2 refers to the conditions at the called end of the toll line, which normally is applying a spacing condition to the line circuit. Upon answering, the called exchange transmits a steady line current which may subsequently be interrupted by switchhook flashes.

Fig. 3 shows conditions at the called exchange when a busy condition exists, in which case the

steady marking condition is interrupted by spacing conditions.

Referring now particularly to Fig. 4, the circuit is that of a repeater station R connected over a toll line circuit TL to a distant exchange station represented at E. The repeater station may be assumed to be located at an exchange to which a plurality of subscribers are connected, one of which is shown at S.

The subscriber station S may be a conventional station with a switchhook SH and dial D. The station is connected over a subscriber's line SL to the repeater station. However, for the purposes of the invention the line circuit SL may be connected to a toll operator's circuit instead of to a subscriber's station, in which case the switchhook may be replaced by a key and the dial by an operator's pulse sending device.

The repeater station R comprises the pole changer or sending relay 400 connected in the line circuit SL to receive pulses and having contacts for alternately applying ground and battery to the line circuit TL in sending the pulses outgoing from the exchange. A source of busy signal 410 may be connected through busy key 411 or any automatic means for applying the busy signal to the line circuit SL for operation of relay 400. The pulse circuit SL through relay 400 extends over a key 420 and through relays 430 and 440 to battery, the other end of the circuit being connected to ground at the dial D.

The polar receiving relay 450 has a biasing winding normally holding the relay in its spacing position and two operating windings cooperating to operate the relay to marking. The contacts of relay 400 are connected through an inductance I, through the upper operating winding of relay 450 to the toll line TL and through the lower operating winding to the balancing network BN. Thus, the operation of relay 400 in sending outgoing pulses will not ordinarily affect relay 450, since proportionate currents pass through the two windings in opposing relation in accordance with the balance between the line circuit TL and the network BN.

The distant exchange E may include a suitable responsive switch control circuit 491. The station E may also include a repeater circuit similar to the circuit R with a receiving relay similar to relay 450 and with transmitting contacts 490 similar to those of relay 400.

When the circuit is in the condition shown in the drawing, ground is applied to both ends of the line TL and to the balancing network BN so that no current will be flowing. When relay 400 operates, battery is connected to the bridge point P and current flows through one winding over the line circuit to ground at E and through the other winding through the balancing network to ground. The windings being opposed under this condition, relay 450 would not respond provided the balance is good. With relay 400 applying ground to the duplex circuit and contacts 490 at the distant end of the line operated to apply battery, the incoming line current will pass through the upper operating winding to ground at relay 400 and in a direction to overcome the biasing winding and operate relay 450 to marking. If now relay 400 be operated to also apply battery to the duplex circuit, practically no current will flow in the line and through the upper operating winding; the battery at relay 400 will, however, send current through the lower operating winding on relay 450 in a direction to keep

relay 450 operated to marking. Thus in receiving incoming, marking, and spacing pulses, the two operating windings of relay 450 will be in cooperative relation to operate the relay to marking or spacing, respectively.

Although the receiving relay 450 is shown in the drawing and is described herein as being connected in a differential duplex circuit, it should be understood that in accordance with the invention, this relay may be connected in a duplex bridge circuit with similar advantages.

Relay 450 in marking condition applies ground to relay 460 and at the same time to a circuit equipment 470 which is part of the exchange equipment and serves in part to selectively control switches for setting up a connection in response to pulses incoming from a distant exchange to the repeater R.

A condenser C is normally connected over contacts of relays 440 and 460 to battery and ground and thus will be normally charged in a predetermined direction. When relay 450 operates to marking, thereby operating relay 460, the ground and battery connections are reversed to the condenser, thereby reversing the charge on the condenser. Thus, the condenser is charged in a direction depending on the position of relay 450.

Relay 430 is slow to attract and relay 440 is slow to release. These two relays serve to connect condenser C to the duplex circuit and to disconnect it therefrom under control of the dial pulses. With the condenser C connected to the duplex circuit, it will provide a shunt path for the operating windings of relay 450 with respect to currents incoming over the line TL to the network BN.

The operation of the circuit will now be described. It will be assumed that the circuit is in rest condition, as shown in the drawing.

When the subscriber removes the receiver from the hook SH, ground is extended over the subscriber's line SL, through the windings of relays 400, 430 and 440 and relays 400 and 440 quickly operate; relay 430 being slow to operate will operate shortly after. Relay 400 applies battery to the duplex circuit and over the line to the distant exchange E for operation of the switch control circuit 491.

Relay 440 disconnected condenser C from the charging battery and connected it temporarily over the contacts of relay 430 to the duplex circuit with its battery side connected to the network BN and its grounded side to the line TL. The discharge current from condenser C through the windings of relay 450, at the moment it is connected to the duplex circuit, will thus be in a direction to aid the biasing winding and will tend to hold the relay in spacing. Shortly thereafter the condenser C will be disconnected from the line circuit by the delayed operation of relay 430 and connected for recharging to the battery at the contacts of relay 460.

The subscriber now operates the dial, the contacts of which produce spacing pulses, as shown in Fig. 1, by short interruptions of the ground connection to the line SL. In response to the first interruption by the dial, relays 400 and 430 release; relay 440, being slow in releasing, remains unaffected during each short interruption. Relay 430 again connects the condenser to the line circuit with the same polarity, thereby holding relay 450 to spacing. When the armature of relay 400 reaches the grounded contact, the currents

in the line and the network will be reduced to zero without affecting relay 450.

At the end of the first dial pulse relay 400 operates to apply battery to the duplex circuit; relay 430 remains retracted; and relay 440 remains attracted. During each pulse series relay 400 will repeat each marking and spacing transition, relay 430 will remain released and relay 440 will remain attracted, thereby keeping condenser C connected to the duplex circuit. During an interval between pulse series relay 400 remains attracted, relay 440 also remains attracted and relay 430 may or may not be attracted depending upon the duration of the interval. During the succeeding series of pulses these operations are repeated.

Thereafter steady battery will be applied to the duplex circuit by relay 400 in marking condition and relays 430 and 440 will remain attracted, thereby disconnecting condenser C from the duplex circuit, and causing it to be recharged.

When the answering condition is established at the distant end of the line TL, as by the contacts 490 operating to battery, relay 450 will operate to marking, thereby applying ground to the circuit equipment 470 for the proper reception of the answering signal. Relay 450 also operates relay 460 to reverse the battery connection to condenser C which will be charged in the opposite direction over the contacts of relays 430 and 440.

The desired connection may now be assumed to have been established and the called subscriber will be rung from the ringing equipment at the exchange E. When the called subscriber answers, the conversation may be carried on over a talking circuit, not shown in the drawing, but which would be closely associated with the toll line TL, as by being included in the same cable quad or by some composite arrangement.

It will now be assumed that some special circumstance arises, as for example, that the distant subscriber hangs up prematurely, necessitating the sending of further pulses from the calling end, for example, a rering pulse, as indicated in Fig. 1. The relay 400 would momentarily interrupt the battery connection to the line. Relay 430 would quickly release and relay 440 would remain attracted. Thus, during the sending of the grounded pulse over the line circuit the condenser C will be bridged across the windings of relay 450 with a reversed polarity, and the discharge current through the operating windings of relay 450 will hold the relay to marking. The condenser furthermore provides a by-path for unbalance currents as already described. At the end of the pulse, relays 400, 430 and 440 would all remain attracted, thereby disconnecting the condenser from the line circuit and recharging it.

In the case a busy condition existed at the distant end after all dial pulses were transmitted, a series of pulses, shown in Fig. 3, would be transmitted by the contacts 490 over the line TL, through the windings of relay 450 and network BN to ground, causing relay 450 to operate in unison with the busy pulses and apply corresponding busy pulses to the circuit 470 for suitable response. The consequent operation of relay 460 will cause the condenser to be charged in opposite directions but will ultimately leave the condenser charged in the direction which corresponds to the final position of relay 450.

In the case of a call incoming to repeater station R, relay 450 would be operated to marking in response to the application of battery at the distant exchange E to the line. Subsequent inter-

ruptions, as by dial pulses, would cause relay 450 to oscillate and apply corresponding pulses to the circuit 470 for selective operation of switches. In response to this selective operation a switch may ultimately connect the subscriber's station S to the repeater station R. This switch is diagrammatically represented by contacts LF; contacts LF may also represent a line finder switch for connecting the subscriber station to the repeater in response to a call by the subscriber. With the subscriber connected in this manner, switchhook flashes may be transmitted back to the station E in the manner already described.

In case the subscriber S is busy, the connection at switch LF will remain open and the circuit 470 may be arranged to automatically operate the key 411 for application of busy signal from interrupter 410. Relay 400 will operate in unison with the busy pulses and relays 430 and 440 will produce corresponding holding impulses for relay 450 and establish the by-path for the windings of relay 450, as already described.

On observing the busy signal, the distant calling station at E will hang up and thus will send a disconnect signal by applying steady ground over contacts 490, through the windings of relay 450, thereby operating the relay to spacing. The circuit 470 responding to this operation may be arranged to automatically disconnect the interrupter 410 by means of contacts 411, whereupon the whole system will be restored to idle condition.

The relays 430 and 440 may, by means of the key 420, be connected directly to the apex P of the duplex circuit. In operated position the key 420 completes the subscriber's line SL through relay 400 directly to battery. Under this condition relays 430 and 440 will not be operated directly by the subscriber's dial D but will be operated in response to the corresponding operations by relay 400. The operations of the entire system will be the same as already described with the difference that those of relays 430 and 440 will be slightly delayed with respect to the operations of relay 400 as compared with conditions described above.

It should be understood that the key 420 may be omitted and the circuit connected permanently in either of the two manners provided by the key.

The inductance I is inserted between the contacts of relay 400 and the apex P for the purpose of shaping the outgoing pulses in any desired manner.

The purpose of connecting condenser C across the duplex circuit is attained during transmission of outgoing pulses. Thus, in accordance with the invention and as already explained above, the balancing network is of simple construction and is designed so that networks of this kind may be used universally with toll lines of different lengths and different characteristics. It is, of course, within the scope of the invention that a few standardized types of network may be provided, each type to be used with lines having characteristics within comparatively narrow limits and the different types of network supplementing one another to satisfy the requirements of all types of lines. Thus, any one network will be connected to a particular line circuit and may establish only on approximate balance, and the unbalance may be so pronounced that the receiving relay ordinarily would "kick-off" during transmission of outgoing pulses.

It is furthermore well known that long line cir-

cuits as used in toll service, are subject to sporadic variations in their characteristics which are beyond control. Where a very close balance is necessary, it has been the practice to continuously observe the line conditions and correspondingly vary the balance by the network.

With the by-path condenser C connected across the operating windings of the receiving relay during sending of pulses, appreciable leeway is afforded in the balancing of the circuit, thereby permitting the use of universal networks for approximate balancing over wide ranges and also in special cases obviating the need for continual readjustment of the network. Thus, during sending of pulses any unbalance currents that would tend to flow in or out of the line circuit or the network due to unbalance conditions would find a low impedance path through the condenser C and thus would avoid the higher impedance path through the two operating windings in series of relay 450.

By always charging the by-path condenser in a direction corresponding to the position of the receiving relay, it is insured that this relay will not be operated when the by-path is closed.

It should be understood that the invention may readily be adapted for application to a telegraph repeating system with similar advantages, where sending takes place against two different signaling conditions imposed by the remote station.

What is claimed is:

1. A two-way signaling system comprising an approximately balanced line circuit normally maintained alternately in marking and spacing steady state conditions, receiving relay means at one end of said line circuit having contacts for control of a receiving circuit in response to incoming marking and spacing signal pulses superimposed on said steady state conditions, auxiliary circuit means including relay means connected to be responsive to outgoing marking and spacing signal pulses to prevent said control by said contacts in response to unbalance currents due to said outgoing pulses, and switching means connected to be responsive to incoming line currents for the conditioning of said auxiliary circuit means for the proper prevention of said control under both of said steady state conditions.

2. A duplex signaling system comprising a line circuit normally maintained alternately in marking and spacing steady state conditions, a balancing circuit, a receiving circuit, receiving relay means connected to said line and balancing circuits and having contacts for control of said receiving circuit in accordance with marking and spacing pulses of signals incoming over said line circuit and superimposed on said steady state conditions, sending contact means connected for passing outgoing signals into said line and balancing circuits, auxiliary circuit means connected to be responsive to marking and spacing pulses of the outgoing signals to prevent said control by said relay means contacts in response to unbalance currents between said line and balancing circuits produced by operation of said sending contact means, and switching means connected to be responsive to incoming line currents for the conditioning of said auxiliary circuit means for the proper prevention of said control under both of said steady state conditions.

3. A two-way signaling system in accordance with claim 1 in which said auxiliary circuit means further includes a shunt path for the winding

circuit of said receiving relay means including capacitance means, and said switching means comprises circuit means for preconditioning said capacitance means for connection into said shunt path without production of false impulses under either of said alternative steady state conditions of said line circuit.

4. A two-way signaling system in accordance with claim 1 in which said auxiliary circuit means further includes a desensitizing circuit for said receiving relay means, slow-acting relay means for connecting said desensitizing circuit to said receiving relay means in response to outgoing marking pulses of predetermined length, and other slow-acting relay means for disconnecting said desensitizing circuit from said receiving relay means in response to an outgoing marking pulse longer than said predetermined length.

5. A two-way signaling system comprising a line circuit normally maintained alternately at steady marking and spacing potential applied at the distant end, a signal repeating circuit connected to the other end of said line circuit and comprising a balancing circuit for approximate impedance balance against said line circuit, receiving relay means connected in duplex relation to said line and balancing circuits and having control contacts, sending contact means connected for passing outgoing signals into said line and balancing circuits, a receiving circuit connected for control by said control contacts, auxiliary circuit means responsive to outgoing signals for preventing false operation of said receiving relay means in response to unbalance currents between said line and balancing circuits during transmission of outgoing signals, and switching means connected for preconditioning of said auxiliary circuit means in accordance with said alternate marking and spacing conditions to prevent false operation of said receiving relay means by said auxiliary circuit means.

6. A signaling system in accordance with claim 5 in which said auxiliary circuit means includes a capacitance circuit and timed relay means responsive to outgoing signal transitions for connecting said capacitance circuit between said line and balancing circuits for by-passing unbalanced currents due to said transitions.

7. A signaling system in accordance with claim 5 in which said auxiliary circuit means includes a capacitance shunt for said receiving relay means and timed relay means responsive to outgoing signal transitions for completing said shunt during sending, and said switching means includes a current source and is responsive to said receiving relay means for precharging said capacitance means from said source alternately in opposite directions in accordance with said steady marking and spacing potentials.

8. In a balanced duplex signaling circuit, a receiving relay, a capacitance shunt path for said relay, circuit means responsive to outgoing pulses for connecting said shunt to said relay for by-passing unbalance currents during sending and including a charging circuit for said capacitance shunt path to precondition said path for connection to said relay without operating said relay.

9. In a balanced duplex signaling circuit adapted for sending against alternate line conditions of marking and spacing potentials, a receiving relay responsive to said conditions and having operating windings, a normally open capacitance shunt path for said relay, a charging circuit for said capacitance shunt path, timed circuit means responsive to outgoing signal pulses for connect-

ing said shunt path across the operating windings of said relay for by-passing unbalance currents due to outgoing pulses and for disconnecting said shunt path in the absence of outgoing signal pulses and connecting it to said charging circuit for precharging, and switching means responsive to said receiving relay means to reverse the direction of precharging for locking of said receiving relay means in its prevailing position by the discharge current when said shunt path is connected across said windings.

10. A two-way signaling circuit for transmission in both directions one at a time which comprises a line having a near end, a balancing circuit, receiving relay means connected to said near end of the line and to said balancing circuit and having control contacts for control of a receiving circuit in response to incoming line cur-

rents, sending contact means connected for passing outgoing signal pulses into said line and said balancing circuit, auxiliary circuit means including relay means connected to be responsive to outgoing signal pulses for preventing said control by said control contact means in response to unbalance currents due to said outgoing pulses, reversing contact means connected to a remote point on said line for normally applying alternately marking and spacing steady state conditions to said line, and switching means connected to be responsive to incoming line currents for conditioning of said auxiliary circuit means for the effective prevention of said control by said control contacts under both of said steady state conditions.

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