Jan. 9, 1945. R. B. SHANCK 2,366,837

PULSE REPEATING SYSTEM

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FIG. 1

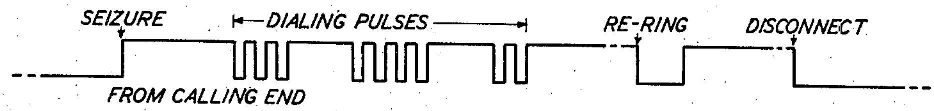

FIG. 2

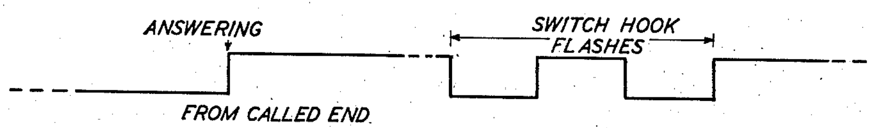

FIG. 3

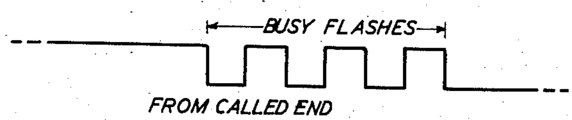

FIG. 4

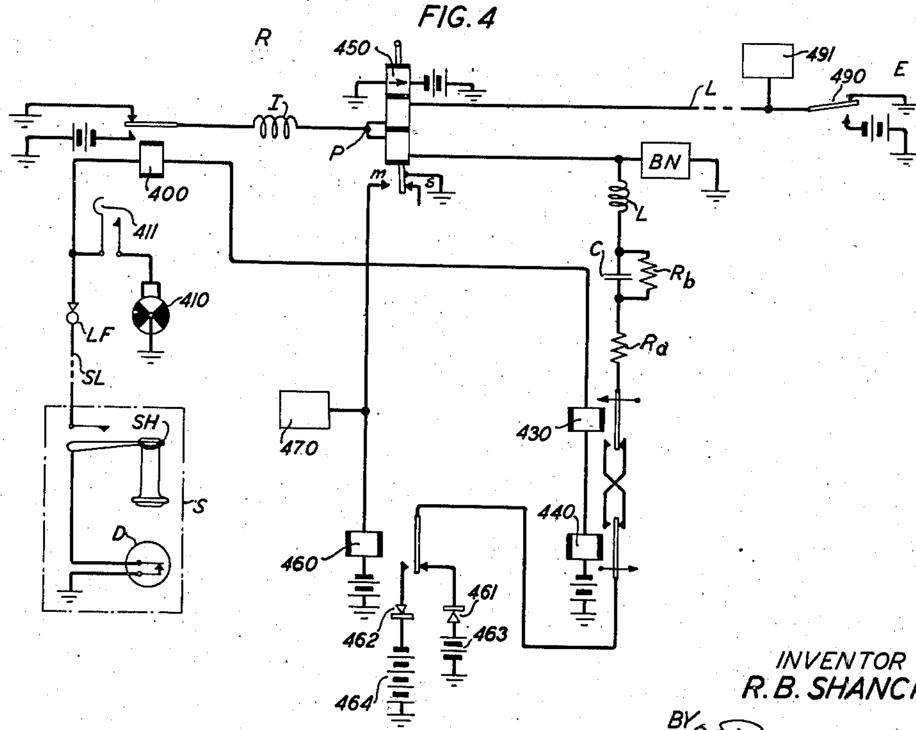

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FIG. 5

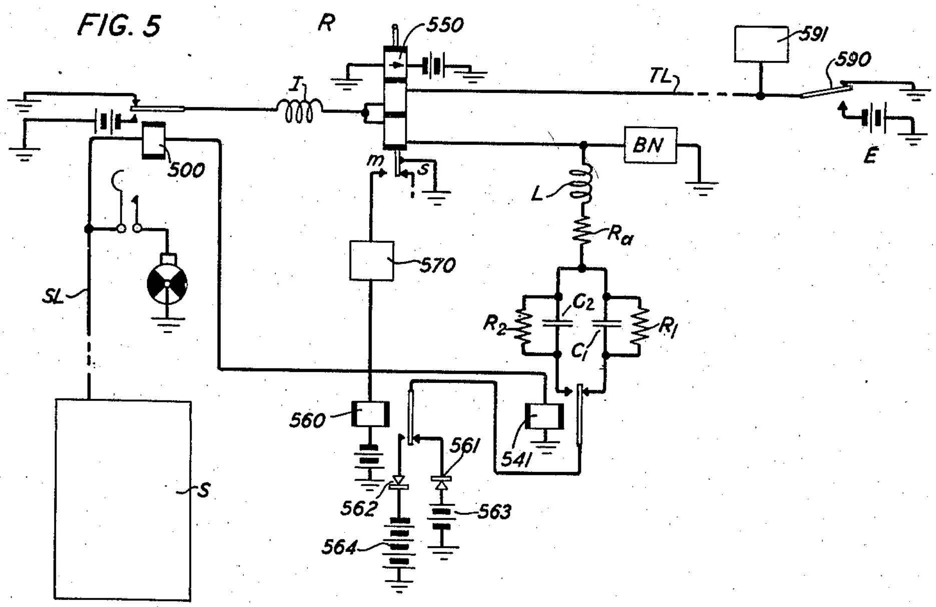
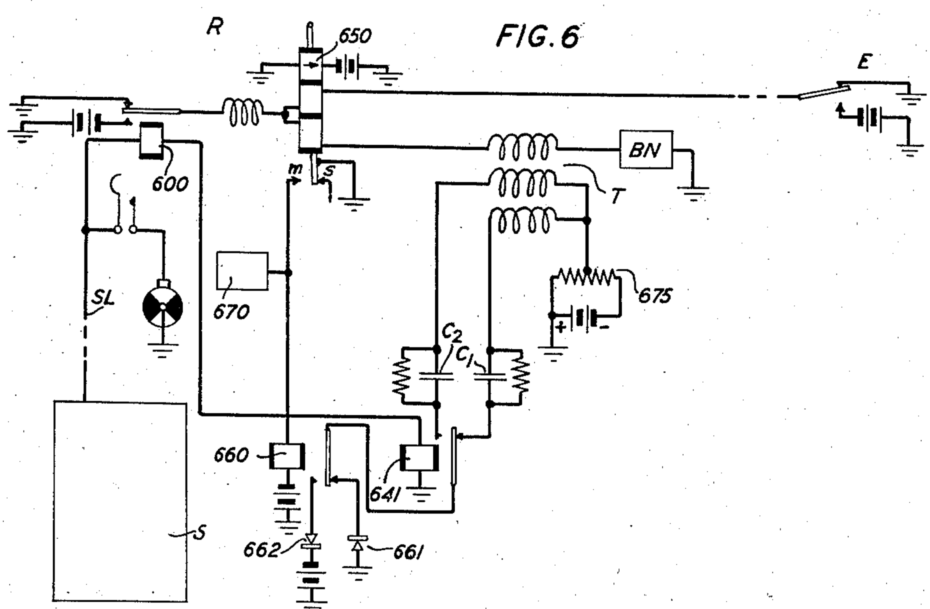


FIG. 6



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PULSE REPEATING SYSTEM

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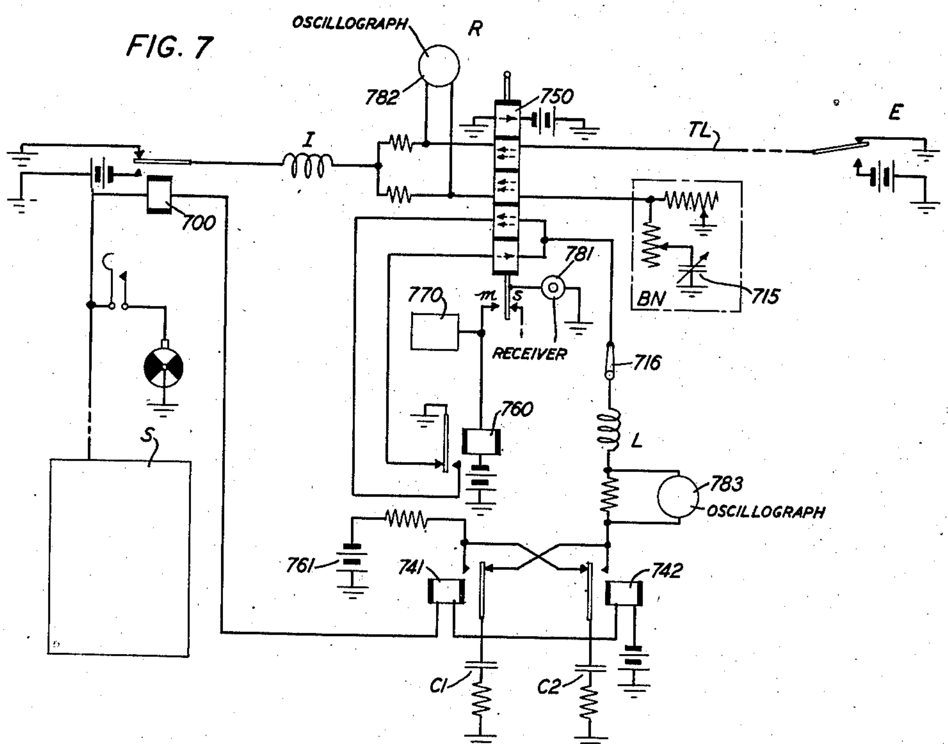
FIG. 7



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2,366,837

UNITED STATES PATENT OFFICE

2,366,837

PULSE REPEATING SYSTEM

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Application July 10, 1943, Serial No. 494,209

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 dialing 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 balance is perfect. For this purpose the polar relay may be connected in any well-known manner as by having its windings directly included in the two balancing branches or connected in a bridge between the balanced circuits in accordance with well-known practice 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 conditions. 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 provide an accurate balance for a large number of lines, but will necessarily be less accurate in the balancing of line circuits having 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 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, holding pulses are caused to flow through the receiving relay during the transmission of outgoing pulses to prevent "kick-off" of the relay, and for this purpose a holding circuit is connected directly or indiricetly to one or more 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 opposed or its effect overcome.

In accordance with another specific feature of the invention, the holding impulse circuit includes capacitance means which may be alternately charged and discharged for producing the desired holding effect once for each outgoing transition.

In accordance with still another specific feature of the invention, the direction of the holding impulses 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 specific embodiments. In the description reference will be made to the attached drawings, 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;

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

Figs. 5, 6 and 7 are similar circuit diagrams of a repeater circuit representing other specific applications of the invention and including different modifications of the arrangement shown in Fig. 4.

Referring to the drawings, 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 impulse 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 the 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 impulses 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 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 L 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 impulses incoming from a distant exchange to the repeater R.

A normally open capacitance circuit, including condenser C, resistance Ra and inductance L is connected to the balancing branch of the duplex circuit. This circuit may be traced as follows: from ground or battery at relay 400, through the lower operating winding of relay 450, inductance L, capacitance C and resistance Rb in multiple, resistance Ra, contacts of relays 430, 440 and 460, through oppositely poled rectifiers 461 and 462 alternately to plus and minus batteries 463 and 464, respectively. The condenser is normally discharged by resistance Rb. The condenser circuit may be completed for charging of the condenser by the operation of either of relays 430 or 440 and the direction of the charge will depend upon the positions of relays 400 and 460. For the proper charging of the condenser under different conditions, battery 463 applies a positive potential with respect to ground of about the same value as the negative battery applied by relay 400. The battery 464 applies a negative potential about twice as high as the negative potential applied by relay 400.

Relay 430 is slow to attract and relay 440 is slow to release. However, these relays are not slow enough to hold over during the impulses; thus, relay 430 is only slightly slower in responding to a transition from spacing to marking than relay 440, and conversely, relay 440 is only slightly slower in releasing than relay 430 in response to a mark-to-space transition. Thus the capacitance circuit will be closed for a short interval in response to each transition, the interval being determined by the amount of delay in the operation of either relay relative to the other. The operation of relay 450 to marking causes relay 460 to operate, thereby reversing the direction of charge on the condenser C in accordance with the line conditions as established by the distant exchange E.

When the condenser circuit is completed in response to a pulse from the subscriber's station, a charging impulse from either of the batteries 463 or 464 through condenser C will pass through the lower winding of relay 450 in the proper direction for temporarily holding relay 450 on the contact against which the armature is resting, the holding current being of sufficient strength in any case to overcome the effect of unbalanced current in the line TL and the balancing network BN at the time of each outgoing transition.

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

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 completes the capacitance circuit through condenser C and a charging impulse will flow as follows: from plus battery 463 through rectifier 461 over break contact of relay 460, make contact of relay 440, break contact of relay 430, through the resistance R*a*, condenser and inductance, through the lower operating winding of relay 450 to minus battery on relay 400. This current will be in a direction to aid the biasing winding of relay 450 in holding the relay against the spacing contact. Shortly thereafter the condenser circuit will be opened by the delayed operation of relay 430, and condenser C discharges through resistance R*b*.

The subscriber now operates the dial, the contacts of which produce spacing impulses, as shown in Fig. 1, by short interruptions of the ground connection to the line SL. On the arrival of the first impulse relays 400 and 430 release and relay 440, being slow in releasing, remains attracted for a short interval during each short interruption by the dial. The capacitance circuit is now closed over the make contact of relay 440 and the break contact of relay 430, thereby again sending a holding pulse through relay 450; under this condition, however, the circuit is terminated at ground on relay 400, thereby somewhat reducing the intensity of the holding impulse which, however, will be of sufficient strength to hold relay 450 in spacing position over any unbalance circuit. When relay 440 releases the capacitance circuit is opened and condenser C discharges.

At the end of the first dial pulse relay 400 operates to again apply battery to the duplex circuit; relay 430 remains temporarily retracted; and relay 440 is quickly attracted. The impulse circuit through condenser C thus is again completed and a charging impulse applied to relay 450; when relay 430 is attracted, the impulse circuit is again opened and condenser C discharges through resistance R*b* in preparation for the next transition. During each pulse series relay 400 will repeat each marking and spacing transition, and relays 430 and 440 will cooperate to send a short holding impulse through relay 450 every time relay 400 reaches either one of its contacts. Thus, with proper delay action of relays 430 and 440, the holding impulse through relay 450 may be of sufficient duration to lock relay 450 in its position while a pulse transition passes through the windings of relay 450, thereby preventing "kick-off" of relay 450 in response to unbalanced currents in the toll line and the network BN through the operating windings of relay 450. The strength of the holding impulse may, of course, be determined by the battery potentials and by adjustment of resistance R*a*. The shaping of the holding impulse relative to the line transitions may be controlled by adjustment of inductance L.

During an interval between pulse series relays 400, 430 and 440 remain attracted, thereby keeping the capacitance circuit open. 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.

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 connections for the capacitance circuit.

The desired connection may now be assumed to have been established and the called subscriber will be rung by 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 drawings, 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 interrupt the battery connection to the line. Relays 430 and 440 would again cooperate to send a charging impulse through relay 450. Due to the changed line condition and the operation of relay 450 to marking, relay 460 now completes the charging circuit from the high negative battery 464, rectifier 462, make contact of relay 460, make contact of relay 440, break contact of relay 430, through the condenser and relay 450 to ground at relay 400. Thus, the charging impulse will pass through the lower winding of relay 450 in a direction to aid the operating windings and of sufficient strength to overcome effect of unbalanced currents, thereby holding relay 450 in marking position during the mark-to-space transition. At the end of the rering pulse relay 400 returns to apply battery to the line circuit; relay 430 quickly releases, and relay 440 remains temporarily attracted, thereby again completing the holding circuit through relay 450 in the same direction to the lock relay in marking.

In the case of a busy condition existing 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 have no effect upon the condenser circuit.

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 interruptions, 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 will 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, 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 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 the condenser circuit connected to the local branch of the duplex circuit is attained during the 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 an 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 circuits, 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.

By the provision of the holding circuit for the receiving relay appreciable leeway is afforded in the balancing of this circuit, thereby permitting the use of universal networks for balancing over wide ranges and also in special cases obviating the need for continual readjustment of the network. Thus, during sending of pulses the effect of any unbalanced currents that would flow in or out of the line circuit or the network due to unbalance conditions would be overpowered by the condenser current and the relay would not be operated.

By reversing the battery potential for the condenser circuit in accordance with the position of the receiving relay it is insured that the holding impulses will always lock the relay in its prevailing position.

Referring now more particularly to the embodiment illustrated in Fig. 5 of the drawings, the system is somewhat similar to that shown in Fig. 4 and corresponding elements are correspondingly numbered in two figures.

In the circuit of Fig. 5 the capacitance circuit includes two condensers C1 and C2, either of which may be connected into the holding circuit by corresponding operations of relay 541. Relay 541 is included in the dial pulse circuit from the subscriber's station so that it will follow the operations of sending relay 500 during dialing as well as during the sending of rering and busy signals.

Under the normal conditions as shown in Fig. 5, the condenser C1 is connected in the circuit from plus battery 563 at the relay 560 to ground at relay 500. Condenser C2 is discharged through resistance R2.

When relay 500 operates to place battery on the duplex circuit, relay 541 will operate to disconnect condenser C1 and replace it by condenser C2 so that a charging impulse will pass through the lower operating winding of relay 550 during the transition time. When relay 500 operates back to spacing, relay 541 is released, thereby connecting condenser C1 into the circuit and causing a similar charging impulse to pass through relay 550. With relays 550 and 560 in the positions shown, the hold impulses will in both cases be in the direction to hold relay 550 in spacing. With battery supplied to the line circuit at the distant end of the line TL, relay 550 will be operated to marking and relay 560 will be energized, thereby reversing the direction of the charging impulses through the condensers C1 and C2 for holding the relay 550 in marking position during the sending of outgoing pulses.

The circuit arrangement shown in Fig. 6 is similar to those shown in Figs. 4 and 5 and is particularly similar to that in Fig. 5 in having two condensers C1 and C2 included in the holding circuit for relay 650. The arrangement differs from that in Fig. 5 mainly in the fact that the capacitance circuit is inductively coupled to the local branch of the duplex circuit.

Thus, a transformer T having two primary windings connected in series with the condensers C1 and C2, respectively, has a secondary winding included in the balancing circuit through the lower operating winding of relay 650.

During the transmission of a space-to-mark transition, relay 641 will operate to complete a circuit from ground potential through rectifier 661 over the break contact of relay 660, make contact of relay 641, condenser C2, through one transformer winding to intermediate potential at potentiometer circuit 675. The resulting charging current will produce an impulse in the secondary winding in the transformer which will pass in the proper direction through relay 650 to hold the relay in spacing position.

During an outgoing mark-to-space transition relay 641 will complete the charging circuit through rectifier 661, condenser C1 and the other primary winding of the transformer, which will produce a holding impulse through relay 650 in the same direction as before.

With battery supplied to the toll line TL from the distant exchange E, relay 650 will operate to marking and relay 660 will be operated to apply negative potential through rectifier 662 to the two condensers alternately, thereby reversing the direction of the charging impulses through the transformer and, in turn, reversing the holding impulse in the secondary winding of the transformer and through the relay 650 to hold the relay in marking position.

It will be noted that with this arrangement a simplification is possible in that only a single battery or other direct current source is necessary for the production of holding impulses under all conditions. This source may furthermore be the common source for the relay operations.

The circuit arrangement shown in Fig. 7 is similar to those described above with the principal modification that the holding circuit for the receiving relay 750 is connected through two separate windings of the relay.

In this arrangement the dialing circuit SL from the subscriber's station extends through relays 700, 741 and 742 which operate in unison in response to dial pulses. By means of the contacts of relays 741 and 742 the condensers C1 and C2 are connected in alternation to battery 761 for charging or to the holding circuit through the two lower windings of relay 750 and to ground at the contacts of relay 760 for discharging.

With the circuit in the condition shown in the drawings condenser C1 is connected over the break contact of relay 741, through the lowermost holding winding of relay 750 and over the break contact of relay 760 to ground; the condenser is originally discharged in this circuit. Condenser C2 is connected over the break contact of relay 742 to battery 761 and is in charged condition.

When the repeater is seized by the subscriber S, relays 700, 741 and 742 are energized. Condenser C1 is disconnected from relay 750 and connected to battery for charging. Condenser C2 is disconnected from battery and is connected to relay 750 for discharging through the lower winding in a direction to aid the biasing winding in holding the relay to spacing, the discharge impulse coinciding with the charge of the line circuit TL and the balancing network BN when the armature of relay 700 reaches the battery contact.

For the sending of a mark-to-space transition relays 700, 741 and 742 release. Condenser C2 is now connected for charging and condenser C1 is connected for discharging through the lowermost winding of relay 750 also in the direction to hold the relay in spacing position.

In answering condition the distant exchange E applies battery to the line circuit, thereby operating relay 750 to marking which, in turn, operates relay 760. Relay 760 disconnects the lowermost winding of relay 750 from the holding circuit and connects the other holding winding into the circuit. The connection through this second holding winding is such that the discharge impulses from the condensers C1 and C2 through the winding will lock the relay in marking position during transmission of both kinds of transitions.

The proper relation between the pulse transitions in the duplex circuit and the holding impulses from the capacitance circuit may be adjusted by adjustment of the inductances I and L in the two circuits. It is, of course, also possible to slightly adjust the timing of relay 700 relatively to relays 741 and 742.

The operation of the type of repeater shown in Fig. 7 has been observed under various circumstances. For this purpose an oscillograph 782 was connected into the duplex circuit for observation of the unbalanced currents in the duplex circuit. Another oscillograph 783 was connected into the capacitance circuit for study of the holding impulses. A telephone receiver 781 was included in the contact circuit of relay 750 for the detection of "kick-off." The balancing network included a capacitance 715 normally adjusted to 4.5 microfarads for good balance. For the observations the capacitance was adjusted over the range between 1.5 and 16.5 microfarads without causing relay 750 to "kick-off." Under the same line conditions but with the holding circuit for relay 750 opened by the switch 716, the range of capacity variation without causing "kick-off" was only about one-third of that observed between the values given above.

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, said auxiliary circuit means comprising an impulse producing circuit connected to a winding circuit for said receiving relay means for holding said receiving relay means in alternate positions in accordance with said alternate steady state conditions.

2. 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, said auxiliary circuit means comprising an impulse producing circuit connected to a winding circuit for said receiving relay means for holding said receiving relay means, and said switching means including relay means having contacts connected for reversing the holding action by said impulse producing circuit in accordance with said alternate steady state conditions.

3. A two-way signaling system comprising an approximately balanced line circuit normally maintained alternately in marking and spacing steady state conditions, receiving relay means 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 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, said auxiliary circuit means comprising a pulse circuit for producing oppositely poled impulses through winding means on said receiving relay means for locking said receiving relay means during the alternating outgoing transitions, and said switching means comprising con-

tact means for reversing the polarity of the locking impulses through said receiving relay means in accordance with said alternate steady state conditions.

4. A two-way signaling system comprising an approximately balanced line circuit normally having marking and spacing steady state conditions alternately applied to the remote end, receiving relay means at the near 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 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 said steady state conditions for conditioning said auxiliary circuit means for the proper prevention of said control under both of said steady state conditions, said auxiliary circuit means comprising an impulse producing circuit connected to a winding on said receiving relay means for locking said receiving relay means during outgoing transitions to marking or to spacing, and said switching means comprising contact means and polarizing means for reversing the polarity of said impulse producing circuit in accordance with said alternate steady state conditions.

5. A two-way signaling system comprising an approximately balanced line circuit normally having marking and spacing steady state conditions alternately applied to the remote end, receiving relay means at the near 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 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 said steady state conditions for the conditioning of said auxiliary circuit means for the proper prevention of said control under both of said steady state conditions, said auxiliary circuit means comprising an impulse producing circuit connected through a winding on said receiving relay means for locking said receiving relay means, and including capacitance means for producing unidirectional impulses for said locking during each outgoing transition, and said auxiliary circuit means further comprising contact means for completing said impulse producing circuit once for each outgoing transition.

6. A two-way signaling system comprising an approximately balanced line circuit normally maintained alternately in marking and spacing steady state conditions from the remote end, receiving relay means 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 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 said steady state conditions for the conditioning of said auxiliary circuit means for the proper prevention of said control under both of said steady state conditions, said auxiliary circuit means comprising an impulse producing circuit connected to a winding circuit for said receiving relay, means for locking said receiving relay means in alternate positions in accordance with said alternate steady state conditions, said auxiliary circuit means further including quick responsive relay means for closing said impulse producing circuit in response to successive transitions, and slow responsive relay means for opening said impulse circuit at an instant between successive transitions.

7. A two-way signaling system comprising an approximately balanced line circuit normally maintained alternately in marking and spacing steady state conditions from the remote end, receiving relay means 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 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 said steady state conditions for conditioning said auxiliary circuit means for the proper prevention of said control under both of said steady state conditions, said auxiliary circuit means comprising an impulse circuit connected to a winding circuit for said receiving relay means for locking said receiving relay means in alternate positions in accordance with said alternate steady state conditions, said impulse circuit including two self-discharging capacitance circuits for producing unidirectional impulses for said locking, and said auxiliary circuit means further including relay means for completing said impulse circuit alternately through said two capacitance circuits during alternate outgoing transitions.

8. A two-way signaling system comprising an approximately balanced line circuit normally maintained alternately in marking and spacing steady state conditions from the remote end, receiving relay means 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 connected to be responsive to outgoing marking and spacing signal pulses to prevent said control by said relay means contacts in response to unbalance currents due to said outgoing pulses, and switching means connected to be responsive to said steady state conditions for conditioning said auxiliary circuit means for the proper prevention of said control under both of said steady state conditions, said auxiliary circuit means comprising an impulse circuit connected to a winding circuit for said receiving relay means for locking said receiving relay means in alternate positions in accordance with said alternate steady state conditions, said impulse circuit including inductance means for producing unidirectional impulses for said locking, and said auxiliary circuit means further including contact means for closing said impulse circuit once for each outgoing transition.

9. A two-way signaling system comprising an approximately balanced line circuit normally maintained alternately in marking and spacing steady state conditions from the remote end, receiving relay means 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 connected to be responsive to outgo-

ing 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 said steady state conditions for conditioning said auxiliary circuit means for the proper prevention of said control under both of said steady state conditions, said auxiliary circuit means comprising an impulse circuit connected to a winding circuit for said receiving relay means for locking said receiving relay means in alternate positions in accordance with said alternate steady state conditions, said impulse circuit including two capacitance circuits and a charging source therefor for producing impulses for said locking, and said auxiliary circuit means further including relay means for alternately charging said condensers and discharging them in said impulse circuit for said locking during each outgoing transition to marking and spacing.

10. A two-way signaling system comprising an approximately balanced line circuit normally maintained alternately in marking and spacing steady state conditions from the remote end, receiving relay means having contacts for control of a receiving circuit in response to incoming marking and spacing signal pulses superimposed on said steady state conditions, auxilitry circuit means connected to be responsive to outgoing marking and spacing signal pulses to prevent said control by said relay means contacts in response to unbalance currents due to said outgoing pulses, and switching means connected to be responsive to said steady state conditions for conditioning said auxiliary circuit means for the proper prevention of said control under both of said steady state conditions, said auxiliary circuit means comprising an impulse circuit connected to a winding circuit for said receiving relay means for locking said receiving relay means in alternate positions in accordance with said alternate steady state conditions, said impulse circuit including two inductance circuits for producing similarly directed impulses for said locking during each outgoing transition to marking and spacing, and said switching means including relay means connected for reversing said impulses for said locking corresponding to said steady state conditions.

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