Jan. 9, 1945. R. B. SHANCK 2,366,838

PULSE REPEATING SYSTEM

Filed July 10, 1943

FIG. 1

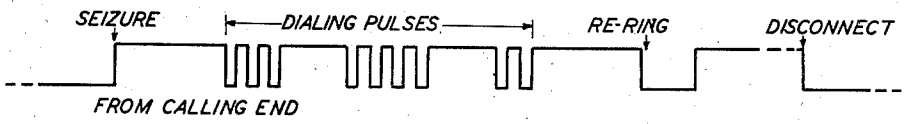


FIG. 2

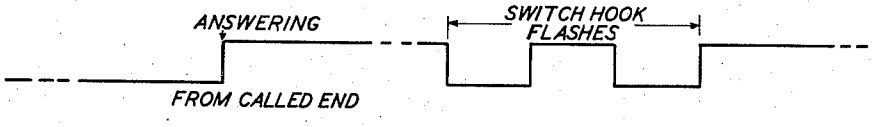


FIG. 3

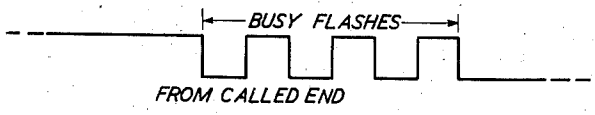
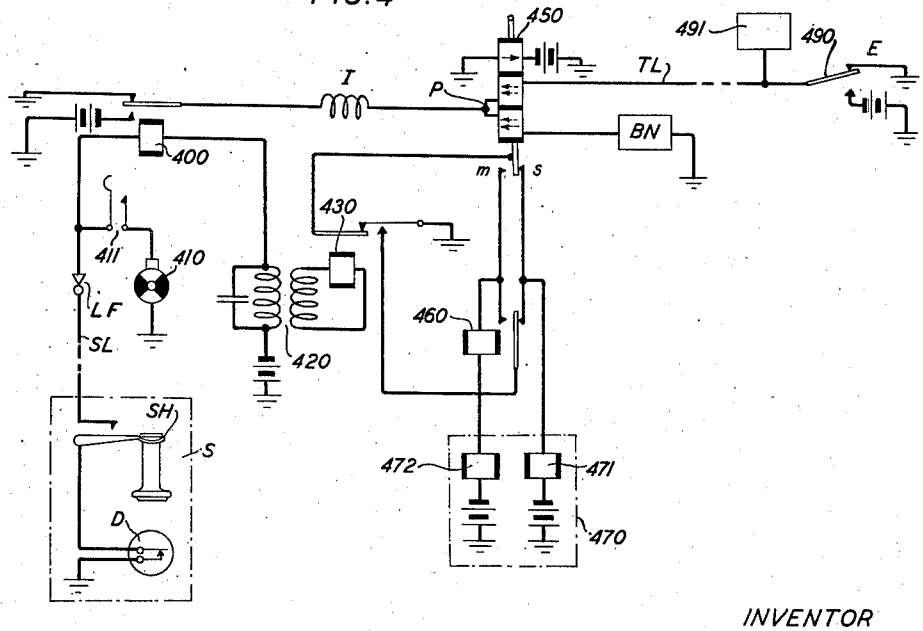


FIG. 4



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PULSE REPEATING SYSTEM

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2 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 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 balance 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 circuits or connected in a bridge between these 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 and 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 provide 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 also 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 of 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 of the receiving relay circuit to effectiveness upon termination of the transmission of outgoing signals.

In accordance with a more specific feature of the invention, the control circuit from the contacts of the receiving relay is rendered immune to operations by the receiving relay during transmission of outgoing pulses and for this purpose by-pass circuits are provided for the receiving relay contacts for temporarily completing the control circuit, irrespectively of fortuitous operations by the receiving relay during transmission of outgoing pulses.

In accordance with another specific feature of the invention, the by-pass is applied across the marking contacts or the spacing contacts of the relay in accordance with 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 impulses 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 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 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 through the primary winding of transformer 420 to battery, the other end of the circuit being connected to ground at the dial D.

The polar 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 the 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.

The secondary winding of transformer 420 is connected through relay 430. The contacts of this relay and the contacts of relay 450 and also the contacts of relay 460 are interconnected to cooperate in the control of a circuit equipment 470 which is part of the exchange equipment and serves to selectively control switches for setting up a connection in response to pulses incoming from a distant exchange to the repeater R. The equipment 470 will have certain portions, represented by a relay 471, responsive to relay 450 in spacing position and other portions, represented by a relay 472, responsive to relay 450 in marking position. Relay 460 will be operated together with relay 472 but not with relay 471.

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 winding of relay 400 and the primary of transformer 420. 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.

The rise of current through transformer 420 induces a short pulse in the secondary winding for temporary operation of relay 430. Relay 430 normally applies ground over its break contact and over the spacing contact of relay 450 to the relay 471. When relay 430 operates it applies ground instead over its make contact and over the break contact of relay 460 to relay 471, thereby excluding the contacts of relay 450 from the control circuit for relay 471. Relay 471 may or may not respond to this change, depending upon traffic requirements. Relays 471 will, however, be independent of any fortuitous operation by relay 450 due to unbalance currents in the duplex circuit caused by the operation of relay 400. After the transition has passed into the line circuit and relay 430 has released, the equipment 470 will again be under control of relay 450.

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 relay 400 releases and relay 430 is again operated by an impulse from the transformer 420, thereby again removing the control of equipment 470 from the relay 450 during the sending of the transition from marking to spacing.

At the end of the first dial pulse relay 400 operates to again apply battery to the bridge circuit, and during each pulse series relay 400 will repeat each marking and spacing transition. During an interval between pulse series relay 400 remains attracted.

Relay 430 may be fast enough in operating in either direction to operate once for each outgoing transition, thereby protecting the equipment 470 against "kick-off" operations by relay 450 during any transition. However, relay 430 may be made sluggish enough in its release operation to remain attracted during a pulse series once it has been operated by the first transition of the series. The relay may, however, at the same time be fast enough in releasing to release during the interval between pulse series and to release after each transition of special supervisory signals of longer duration than the dial pulses.

After the dialing has been completed steady

battery will be applied to the bridge 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 and particularly to relay 472 for the proper reception of the answering signal. Relay 450 also operates relay 460.

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. Relay 400 will momentarily interrupt the battery connection to the line and relay 430 will operate for each transition. Under this condition relay 430 removes the ground from the marking contacts of relay 450 and extends it over its make contact and the make contact of relay 460 to the relay 472, thereby protecting the relay 472 against fortuitous operation of relay 450 during each transition. Any convenient arrangement may be provided for preventing relays 460 and 472 from releasing in response to the operation of relay 430, as by providing make-before-break contacts on relay 430.

In case a busy condition existed at the distant end after all dial pulses were transmitted, a series of pulses 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.

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 station S to the repeater station R. This switch is diagrammatically represented by contacts LF; contacts LF may also represent the line-finder switch for connecting the subscriber's 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 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. This will cause relays 400 and 430 to operate in unison with the busy pulses and establish locking circuits for relays 471 and 472, 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 back 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.

From the description presented above, it will be understood that the purpose of relays 430 and 460 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 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.

In the protecting equipment shown in the drawing the contacts of the receiving relay are disabled during the sending of pulses, thereby permitting the relay 450 to "kick-off" without disturbing effect upon the equipment 470. Thus, an appreciable leeway is afforded in the balancing of this circuit, thereby permitting the use of universal networks for approximate balancing over wide ranges and also in special cases obviating the need of continual readjustment of the network.

By switching the protecting circuit in accordance with the position of the receiving relay it is insured that fortuitous operations by this relay from either of its positions will have no disturbing effect.

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 duplex 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 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 relay means connected to be responsive to incoming line currents for the con-

ditioning of said auxiliary circuit means for the proper prevention of said control under both of said steady state conditions, said auxiliary circuit means comprising locking circuit means connected to said contacts for locking said receiving circuit in marking or spacing condition in accordance with said conditioning, and relay means responsive to outgoing signal pulses and having normal contacts for completing said receiving circuit during either of said steady state conditions and having alternate contacts for completing said locking circuit means during the outgoing signals.

2. A duplex 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 relay 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 locking circuit means connected to said contacts for locking said receiving circuit in marking or spacing condition in accordance with said conditioning and pulse relay means responsive to each outgoing transition and having normal contacts for completing said receiving circuit during either of said steady state conditions and having alternate contacts for momentarily completing said locking circuit means during each outgoing transition, said switching relay means being connected to said receiving relay means contacts and to contacts of said pulse relay means for operation to either position.

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