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TELEPHONE EXCHANGE SYSTEM

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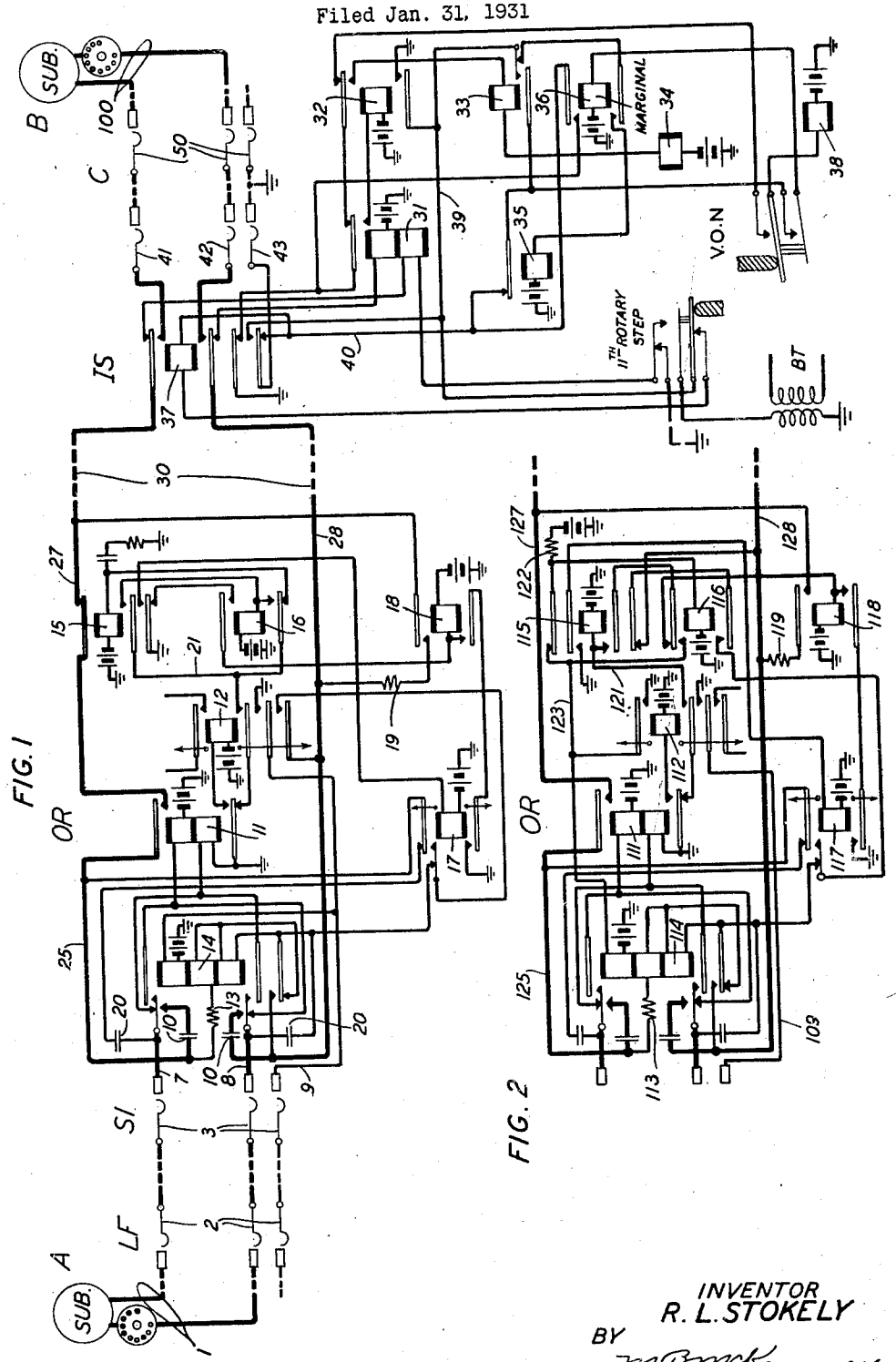

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TELEPHONE EXCHANGE SYSTEM

Application filed January 31, 1931. Serial No. 512,554.

This invention relates to telephone exchange systems and more particularly to repeaters for automatic and semi-automatic systems.

The object of the invention is to minimize the amount of apparatus required for repeating impulses, to insure the proper operation of impulse-controlled switching apparatus, to increase the distance over which impulses may be satisfactorily transmitted, and to minimize cumulative impulse distortion when impulses are successively repeated by several repeaters as in a multi-office area.

Impulses created for controlling the selective operation of automatic switching apparatus may be of such an irregular and distorted character, due to a defective impulse sender or due to varying conditions of resistance, capacity or insulation of the line over which the impulses are being received, that faulty switch operation results. Heretofore, impulse repeaters have been arranged to transform incoming irregular and distorted impulses so that the outgoing impulses will effect the desired switching operation. In Patent 1,589,409, issued June 22, 1926 to O. R. Miller a repeater is disclosed which transforms incoming impulses so that the open periods of outgoing impulses are of constant duration. In my copending application Serial No. 492,629 filed November 1, 1930, a repeater is disclosed which transforms incoming impulses so that the open and closed periods of outgoing impulses vary according to the frequency with which the impulses are being transmitted.

According to the present invention an impulse repeater is arranged to connect a high resistance bridge across the conductors of the outgoing trunk whenever the open periods of the incoming, and corresponding open periods of the outgoing, impulses are so prolonged as to otherwise cause faulty operation of the switching mechanism to which the impulses are being transmitted, the high resistance bridge remaining connected until all of the impulses in the train have been received.

Another feature of this invention is an impulse repeater arranged to transmit outgoing impulses, the open periods of which may be equal to the corresponding open periods of the incoming pulses but never less than a predetermined minimum allowable interval, and to connect a high resistance across the conductors of the outgoing trunk whenever the incoming open periods endure for so long an interval that faulty switch operation would otherwise result from the equal open periods of the corresponding outgoing impulses.

Another feature of the invention is a repeater in which a single relay is employed for operation in response to a reversal of current over the conductors of the outgoing truck in consequence of the answer of a called subscriber, for thereupon reversing the connections from the windings of the incoming impulse relay with respect to the conductors of the incoming trunk, and for maintaining a holding loop through its own windings across the outgoing trunk until the connection is released by the calling subscriber.

The invention will be better understood by considering a telephone system in which the features of the invention have been embodied, such a system being represented schematically in the drawing. The invention is not limited in its application to this particular system, but is adapted for use in any system which requires the transmission of impulses over long distances.

Referring to the drawing;

Fig. 1 represents a calling subscriber's station A and line 1, a line-finder switch LF, a first selector switch S1, an outgoing repeater circuit OR, an interoffice trunk 30, an incoming selector IS in a distant office, a connector C and a called subscriber's station B.

Fig. 2 represents an alternative arrangement of the repeater OR.

The equipment at the subscribers' stations is of the usual type employed in automatic telephone systems, each station being equipped with a dial for use in establishing connections. The line-finder switch LF, first selector switch S1, incoming selector switch IS and connector switch C, are all of the well known two-motion step-by-step type. The line-finder which is represented schematically by the brushes 2, may be similar to that

shown in the Patent 1,711,682, issued May 7, 1929, to H. Hovland, to which patent reference may be had for a complete description of the operation of such a line-finder. The first selector and connector switches are represented schematically by the brushes 3 and 50 respectively; for a complete description of the operation of the first selector S1 and connector C, reference may be had to pages 53 to 67 inclusive of the second edition of "Automatic Telephony" by Smith and Campbell.

The outgoing repeater OR and the incoming selector circuit IS are shown in detail. The repeater OR of Fig. 1 comprises a line relay 11 which responds to incoming impulses, a slow-to-release holding relay 12, a slow-to-release control relay 17, timing relays 15 and 16, a high resistance 19, a control relay 18 for bridging the resistance 19 across the conductors of the outgoing trunk whenever the open period of an outgoing impulse endures for so long an interval as would otherwise cause faulty operation of the switch to which the impulses are being transmitted, and a combined bridge, reversing and cut-through relay 14. Relay 14 has three windings; the upper winding is a polarizing winding which alone is ineffective to operate the relay; the middle winding in series with the resistance 13 constitutes a bridge for connection across the conductors of the outgoing trunk; and the lower winding is arranged for connection in series with the middle winding when the relay is operated to increase the impedance of the bridge and thus improve transmission during conversation. During the establishment of the connection the current through the middle winding is effective to magnetize the relay in the opposite direction to that which results from the energization of the upper or polarizing winding; but when the current over the trunk is reversed in consequence of the answer of the called subscriber, as hereinafter explained, the two windings aid each other and cause the operation of this relay. The repeater OR of Fig. 2 comprises the same elements as that shown in Fig. 1, the reference characters for the relays being the same except that in Fig. 2 they are preceded by the hundreds digit 1. The incoming selector circuit IS comprises a line relay 31, a holding relay 32, a vertical magnet 34, a change-over relay 33, a rotary magnet 35, an interrupter relay 36, a switching relay 37, a release magnet 38, and the multiple brushes 41, 42 and 43 together with a corresponding bank of terminals. The operation of the repeater and incoming selector circuits will be explained in detail in the following description of a call from station A to station B.

When the subscriber at station A removes the receiver from the receiver hook, the line-finder LF operates to extend the line 1 to the first selector S1. When the calling subscriber dials the first digit of the called number, the brushes of selector S1 are advanced to a corresponding group of terminals. The selector then operates in the usual manner to seize an idle set of terminals in the selected group. Assuming that the selected set of terminals are connected to the outgoing repeater OR, line relay 11 is energized in a circuit which may be traced from battery through the upper winding of relay 11, the inner lower back contact of relay 14, conductor 8, the middle brushes of selector S1 and line-finder LF, over the calling line, back through the upper brushes of the line-finder LF and selector S1, conductor 7 of the repeater circuit, the upper back contact of relay 14, and through the lower winding of relay 11 to ground. Relay 11 closes an obvious circuit for operating the slow-to-release holding relay 12. Relay 12 connects a holding ground through its middle lower front contact over conductor 9 through the sleeve brush of selector S1 to the sleeve conductor of the first selector and line-finder switches. Relay 12 also closes an obvious circuit for energizing the upper winding of relay 14 and connects the middle winding of relay 14 in series with resistance 13 across the outgoing conductors of trunk 30 to operate the line relay of the incoming selector IS. The circuit for operating the line relay 31 of selector IS may be traced from battery through the upper winding of relay 31, the inner lower back contact of relay 37, conductor 28, lowermost contact of relay 12, inner back contact of relay 17, lowermost contact and middle winding of relay 14, resistance 13, conductor 25, upper contacts of relays 11 and 15, conductor 27, upper back contact of relay 37, lower winding of relay 31, to ground at the normally closed contacts of the "11th rotary step" springs of the switch IS. Relay 31 operates, but the magnetizing effect of the current through the middle winding of relay 14 is differential with respect to that of the polarizing current through the upper winding, and relay 14 remains unoperated. Relay 31 closes an obvious circuit for operating the slow-to-release holding relay 32 of the incoming selector IS; relay 32 connects ground to conductor 39 and prepares for the operation of the vertical-stepping magnet 34.

No further operation takes place until the calling subscriber dials the next digit of the called subscriber's number, at which time the alternate release and reoperation of line relay 11 of the outgoing repeater OR is effective to repeat the impulses over trunk 30 to line relay 31 of the incoming selector IS. When relay 11 releases in response to the first impulse, it opens the bridge across conductors 27 and 28 to release line relay 31 of selector IS; and it closes a circuit for operating the timing relay 15 which is traced from battery through the winding of relay 15, the

lower back contact of relay 16, conductor 21, inner lower front contact of relay 12, to ground at the back contact of relay 11. With relay 15 operated, the bridge across the conductors of trunk 30 is held open independent of relay 11 for an interval sufficient to insure the release of line relay 31 and the operation of the vertical-stepping magnet 34 as hereinafter described. Relay 15 also closes an obvious circuit for operating relay 17 and also connects the winding of relay 16 to conductor 21. If the open period of the incoming dial impulse is long enough, relay 11 remains in its unoperated position after relay 15 has operated and relay 16 operates over conductor 21 to ground at the back contact of relay 11; if relay 16 operates, it locks through its lower front contact to the same ground. The aforementioned operation of relay 17 is effective to short-circuit resistance 13 and the middle winding of relay 14 and thereby reduce the loop resistance across conductors 27 and 28 to render the outgoing impulse circuit more effective; since relay 17 is slow in releasing it remains operated until all of the impulses of each train of impulses created by the operation of the calling subscriber's dial have been received and repeated over trunk 30. Relay 17 also disconnects the talking condensers 20 from the outgoing impulse circuit to prevent interference with the transmission of impulses. If the open period of the incoming impulse is short, relay 11 may reoperate soon enough to prevent the operation of relay 16, in which case the open period of the corresponding outgoing impulse over trunk 30 is maintained until relay 15 releases to insure proper operation of the switch to which the impulse is being transmitted.

If relay 16 operates, it opens the circuit through the winding of relay 15, and the release of relay 15 closes a circuit for operating relay 18; this circuit is traced from battery through the winding of relay 18, the upper front contact of relay 16, to ground at the lower back contact of relay 15. Relay 18 locks through its lower front contact to ground at the front contact of relay 17 and remains operated until all of the impulses in the train have been received and repeated to the incoming selector over trunk 30. With relay 18 operated, the high resistance 19 is bridged across the conductors 27 and 28 of trunk 30 to aid the reoperation of relay 31 after each impulse and thus insure the proper operation of the incoming selector switch even though the open period of the impulses incoming to relay 31 are of such length as would otherwise cause faulty operation of this switch. Succeeding impulses of the train are repeated by the alternate release and reoperation of relay 11 with the high resistance 19 bridged across the outgoing conductors. When all of the impulses in the train have been received, relay 17 releases thereby causing the release of relay 18 and the opening of the high resistance bridge across the outgoing trunk.

When line relay 31 of selector IS releases in response to the first impulse received over trunk 30 from repeater OR, it closes a circuit from battery through the winding of the vertical-stepping magnet 34, winding of relay 33, upper front contact of relay 32, back contact of relay 31, to ground at the back contact and middle lower armature of relay 37. Magnet 34 and relay 33 both operate in this circuit, the operation of magnet 34 being effective to step the shaft and brushes of switch IS up to the first level of the terminal bank. When relay 31 reoperates, after receipt of the first impulse, magnet 34 releases. Each succeeding release and reoperation of relay 31 causes the operation and release of magnet 34 thereby stepping the brushes 41, 42 and 43 up to the level corresponding to the digit dialed by the calling subscriber. Relay 33 is slow in releasing and remains operated until all of the impulses in the train have been received. Being slow-to-release, the holding relay 32 does not release during the receipt of impulses by relay 31.

As soon as the shaft of switch IS is moved out of its normal position by the operation of magnet 34, the Von springs are actuated thereby closing a circuit for operating relay 36; this circuit is traced from battery through the winding of relay 36, lower contacts of the Von springs, front contact of relay 33, conductor 39, to ground at the lower front contact of relay 32. Relay 36 locks in a circuit from battery through its winding, lower contacts of the Von springs back contact of the rotary-stepping magnet 35, conductor 40, upper front contact of relay 36, to ground at the back contact and middle lower armature of relay 37. When relay 33 releases, after all of the impulses in the train have been received, the rotary-stepping magnet 35 operates in a circuit from battery through its winding, lower front contact of relay 36, back contact of relay 33, to ground on conductor 39. The operation of magnet 35 steps the brushes 41, 42 and 43 into engagement with the first set of terminals in the selected level and opens the circuit through the winding of relay 36; and the release of relay 36 opens the circuit through the winding of magnet 35. With magnet 35 released, the winding of relay 36 is connected through the lower contacts of the Von springs, back contact of magnet 35, over conductor 40, through the outer lower back contact of relay 37 to the sleeve brush 43; and the winding of relay 36 is also connected over conductor 40, through the winding of relay 37 and the lower contacts of the "11th rotary step" springs, to ground on conductor 39.

If the first set of terminals is busy there is a test-busy ground on the sleeve terminal which is effective to short-circuit the winding of relay 37 and cause the reoperation of relay 36; but if this set of terminals is idle, there is no ground on the sleeve terminal and relay 37 operates in the above-traced circuit. Relay 36 is marginal and does not operate in series with the winding of relay 37.

If the first set of terminals is busy, the reoperation of relay 36 again closes the circuit for operating magnet 35 to advance the brushes of switch IS to the next set of terminals. The operation of magnet 35 again releases relay 36 and the release of relay 36 opens the circuit through the winding of magnet 35. The alternate operation and release of relay 36 and magnet 35 continues until an idle set of terminals is reached, at which time relay 37 operates as described in the preceding paragraph.

With relay 37 operated, the incoming conductors of trunk 30 are disconnected from the windings of relay 31, causing the release of this relay, and are connected through the inner front contacts of relay 37 and through brushes 41 and 42 to the line conductors of connector C. When relay 31 releases, relay 32 also releases. Relay 32 is slow in releasing so that the ground at its lower front contact is not disconnected from conductor 39 until the connector C has supplied a holding ground over its sleeve conductor, to the terminal with which brush 43 is in contact. This ground from connector C is effective to hold relay 37 operated and thus prevent the release of the selector IS, the holding circuit being traced from brush 43 through the lowermost front contact of relay 37, conductor 39, the lower contact of the "11th rotary step" springs, winding of relay 37, conductor 40, back contact of magnet 35, lower contacts of the Von springs, through the winding of relay 36 to battery.

Succeeding trains of impulses are repeated over trunk 30 in the same manner to cause the advance of connector switch C in response to the remaining digits of the called subscriber's number and thus extend the connection over the called line 1 to station B in the usual manner. If the called line is idle, ringing current is transmitted over the line 100 to signal the subscriber at station B. Upon the response of the called subscriber, the connector C reverses the current over the talking conductors of the incoming selector IS and trunk 30 in the usual manner. The current through the middle winding of the electro-polarized relay 14 of the outgoing repeater OR is now effective to aid the current through the polarizing winding and thus cause the operation of this relay. When relay 14 operates, it reverses the connections from the windings of line relay 11 with respect to conductors 7 and 8 to indicate that the called subscriber has answered, closes the talking circuit through condensers 10 and 20, and increases the impedance across the conductors 27 and 28 by opening the short circuit around its lower winding so that this winding is included in the bridge across the outgoing trunk.

When the connection is released by the calling subscriber, line relay 11 releases in turn causing the release of the holding relay 12. The release of relay 11 opens the bridge across conductors 27 and 28 thereby releasing the line relay of the connector switch C in the usual manner. When the connector switch C disconnects the holding ground from the sleeve conductor of incoming selector IS, relay 37 releases and the release magnet 38 operates to allow the switch IS to restore to normal. When the shaft and brushes of switch IS reach their normal position, the circuit through the winding of release magnet 38 is opened at the Von springs and this selector is ready for use on another call.

If the repeater is arranged as shown in Fig. 2 relays 111 and 112 operate in the same manner as relays 11 and 12 of the arrangement shown in Fig. 1. Relay 112 connects a holding ground to the sleeve conductor 109 and closes a circuit for energizing the polarizing winding of relay 114. Relay 112 also closes a circuit from battery through the winding of relay 116 in parallel with resistance 122, the upper back contact of relay 115, conductor 123 to ground at relay 112. Relay 116 operates in this circuit thereby closing the bridge across the outgoing trunk; this bridge is traced from conductor 127, upper contact of relay 111, conductor 125, resistance 113, middle winding and lowermost contact of relay 114, inner upper back contact of relay 117, lower front contact of relay 116, and through the lowermost contact of relay 115, to conductor 128. No further operation takes place until relay 111 releases in response to the first impulse received from the calling station, at which time the bridge across conductors 127 and 128 is opened and a circuit is closed for operating relay 115; this circuit is traced from battery through the winding of relay 115, conductor 121, inner lower front contact of relay 112, and through the back contact of relay 111 to ground. Relay 115 locks through its inner lower front contact and the upper front contact of relay 116, over conductor 123 to the ground at relay 112. Relay 115 opens the circuit through the winding of relay 116 and closes an obvious circuit for operating relay 117. With relay 115 operated, the bridge across conductors 127 and 128 cannot be closed by the reoperation of relay 111 until relay 115 releases and relay 116 reoperates, so that the open period of each outgoing impulse endures long enough to insure

the proper operation of the switch to which the impulses are being transmitted. The release of relay 116 closes a circuit from battery through the winding of relay 118, back contact of relay 116 and lower front contact of relay 115 to ground on conductor 121; but if the impulse incoming to relay 111 is of short duration, relay 111 reoperates to release relay 115 and to prevent the operation of relay 118. If the impulse incoming to relay 111 is long, the open period of the corresponding outgoing impulse will also be long, but in this case the release of the switch to which the impulses are being transmitted is prevented by the operation of relay 118 and the closing of high resistance 119 across conductors 127 and 128. If relay 118 operates it locks under control of relay 117. Relay 117 is a slow-to-release relay and remains operated during the receipt of the entire train of impulses. When relay 111 reoperates and relay 115 releases, relay 116 reoperates to again close the bridge across conductors 127 and 128. Relays 117 and 114 function the same as relays 17 and 14 of the repeater shown in Fig. 1. Thus each release and reoperation of relay 111 is effective to repeat the incoming impulse over the outgoing trunk, the minimum length of the open period of each outgoing impulse being controlled by relays 115 and 116; and in case the incoming impulses are too long for satisfactory switch operation the high resistance 119 is bridged across the outgoing trunk to compensate for the length of the open period.

What is claimed is:

1. In combination, an impulse receiving relay for responding to incoming impulses, an outgoing trunk terminating at an automatic switching mechanism, means responsive to the operation of said relay for closing an impulsing circuit over the conductors of said trunk, contacts on said relay for interrupting said circuit, a high resistance, means effective upon the release of said relay enduring for so long a period as would otherwise cause faulty operation of said switching mechanism for connecting said high resistance across the conductors of said trunk, and means for maintaining said connection during the receipt of the remaining impulses in the same impulse train.

2. In combination, a line, a relay for receiving impulses over said line, outgoing conductors, an inductive bridge closed across said conductors in consequence of the operation of said relay, means effective upon the release of said relay in response to each incoming impulse for opening and holding said bridge open for a predetermined interval of time, a resistance, and means for connecting said resistance across said conductors during the receipt of impulses.

3. In combination, a line, a relay for receiving impulses over said line, a circuit closed in consequence of the operation of said relay, means effective in consequence of the release of said relay for opening and holding said circuit open for a predetermined interval of time, a resistance, and means for closing and holding said circuit closed through said resistance in case said relay does not reoperate prior to the expiration of said predetermined interval of time.

4. In combination, a line, a line relay for receiving impulses over said line, a circuit closed in consequence of the operation of said relay, said relay being effective to successively open and close said circuit in response to each of a train of impulses, means for holding said circuit open for a predetermined minimum interval of time, a resistance, and means for closing said circuit through said resistance in case said relay does not reoperate within a predetermined maximum interval of time and for maintaining said closure until all of the impulses in the train have been received.

5. In combination, a line, a relay for receiving impulses over said line, outgoing conductors, an inductance, a resistance, means for bridging said inductance across said conductors in response to the operation of said relay, means effective upon the release of said relay in response to each impulse for opening said bridge, means for holding said inductive bridge open for a predetermined minimum interval of time, and means for bridging said resistance across said conductors in case said inductive bridge is held open beyond a second predetermined minimum interval of time.

6. In combination, a line, a relay for receiving impulses over said line, a trunk, an inductive bridge connected across the conductors of said trunk in consequence of the operation of said relay, a non-inductive resistance, means effective upon the release of said relay in response to each of a train of impulses for opening said inductive bridge, means effective when impulses are being received at any frequency within a certain range of frequencies for holding said bridge open for a predetermined interval, and means effective when impulses are being received at any frequency within a second range of frequencies for bridging said resistance across the conductors of said trunk and for thereafter holding said resistance bridge closed until all of the impulses in the train have been received.

7. In a telephone system, a line divided into two sections, the second section terminating in an automatic switch, a repeater joining the two sections of said line, said repeater comprising a relay for receiving impulses over said first section, an inductive bridge across said second section, a non-inductive bridge across said second section, means responsive to the operation of said relay for

closing said inductive bridge, means effective upon the release of said relay in response to each of a train of impulses for opening said inductive bridge, means for holding said inductive bridge open for a predetermined interval, and means for closing said non-inductive bridge in case said inductive bridge is held open longer than a second predetermined interval.

8. In a telephone system, a line, a trunk, a switch, a repeater for receiving impulses incoming over said line and repeating said impulses over the conductors of said trunk to said switch, said repeater comprising a line relay for receiving impulses, an inductance bridged across said conductors upon the operation of said relay, a resistance, means effective upon the release of said relay in response to each of a train of impulses for opening said bridge and for holding said bridge open for a predetermined interval, and means for connecting said resistance across said conductors to prevent the release of said switch during the transmission of impulses.

9. In a telephone system, a line, a first relay for receiving impulses over said line, a trunk, a second relay for receiving impulses over said trunk, a circuit for operating said second relay closed by the operation of said first relay, means effective upon the release of said first relay in response to an impulse over said line for opening said circuit to release said second relay and for holding said circuit open for a predetermined interval, and a second circuit closed to aid in the reoperation of said second relay in case said first circuit remains open longer than a second predetermined interval.

10. In combination, an impulse receiving relay for responding to incoming impulses, an outgoing trunk terminating at an automatic switching mechanism, means responsive to the operation of said relay for closing an impulse circuit over the conductors of said trunk, contacts on said relay for interrupting said circuit, means effective in response to the release of said relay for holding said circuit open for a predetermined interval of time, a high resistance, and means effective upon the release of said relay enduring for so long a period as would otherwise cause faulty operation of said switching mechanism for connecting said high resistance across the conductors of said trunk.

In witness whereof, I hereunto subscribe my name this 30th day of January, 1931.

RAY L. STOKELY.