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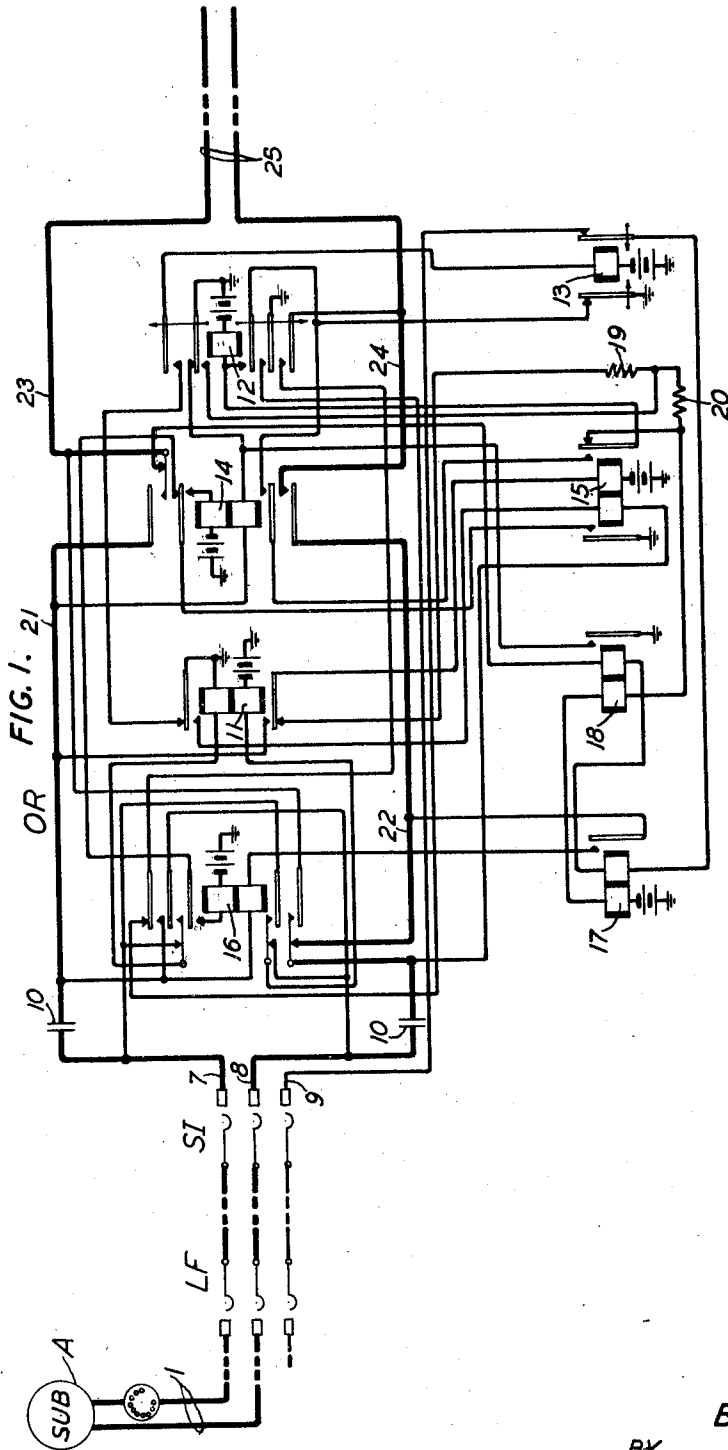
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1,836,582

TELEPHONE EXCHANGE SYSTEM

Filed Jan. 27, 1931

2 Sheets-Sheet 1



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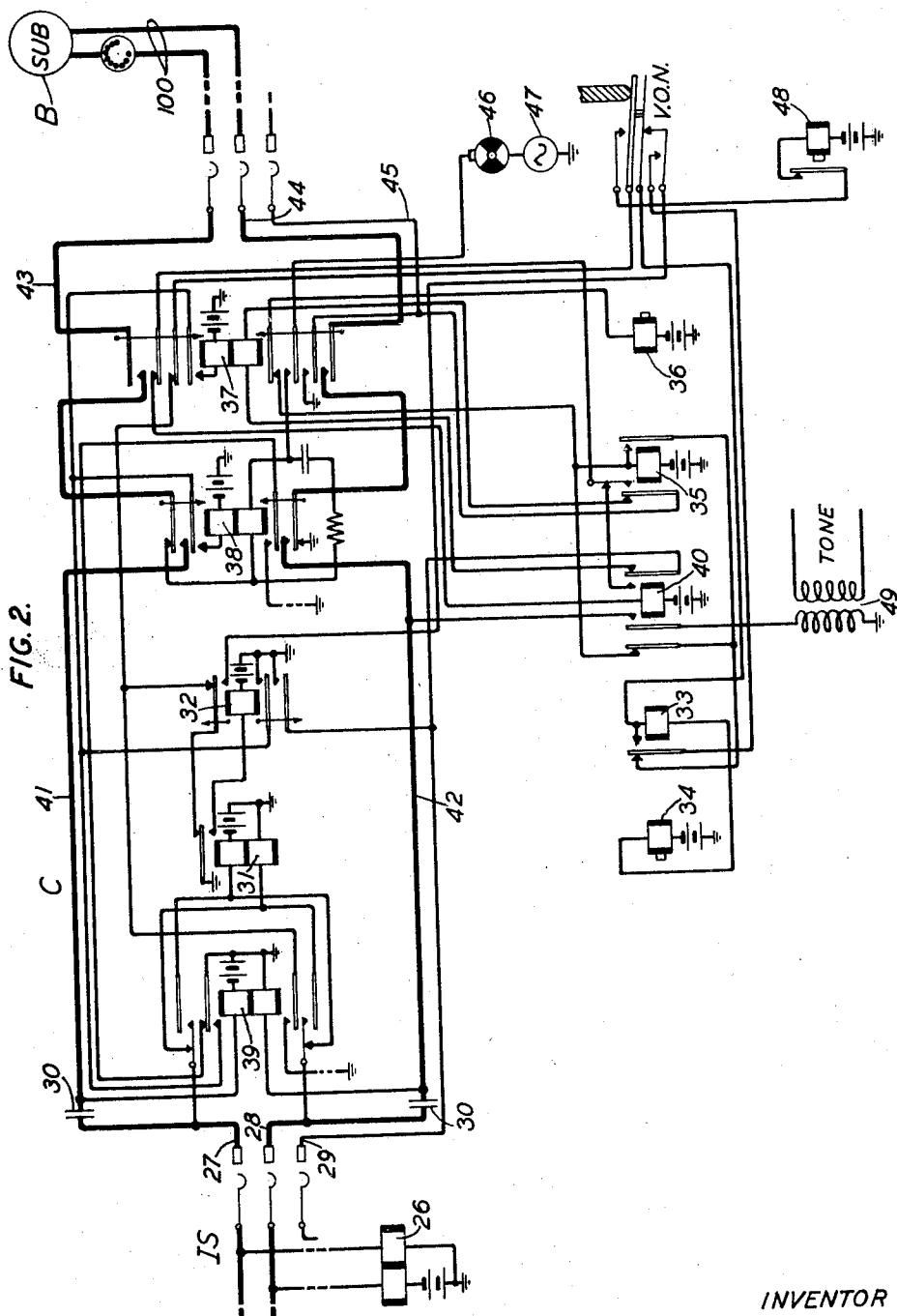
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TELEPHONE EXCHANGE SYSTEM

Application filed January 27, 1931. Serial No. 511,489.

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

5 The object of the invention is to increase the length of trunks over which impulses may be satisfactorily transmitted and over which satisfactory supervision may be obtained.

Heretofore repeater circuits have usually
10 been arranged so that impulses are repeated over an outgoing trunk by interrupting a bridge connected across the outgoing conductors, battery and ground being supplied through the windings of the line relay of the
15 succeeding selector to which the trunk is connected. Supervision over this outgoing trunk has been obtained by connecting the windings of a polarized supervisory relay in series with the conductors of the outgoing
20 trunk. Other repeater circuits have been arranged to repeat impulses by interrupting separate grounded circuits over each side of the outgoing trunk, the supervisory signals being transmitted over one side of the trunk
25 only.

According to this invention a repeater circuit arranged for transmitting impulses over both sides of the outgoing trunk in separate grounded circuits is also arranged to receive
30 supervisory signals over both sides of the outgoing trunk in separate grounded circuits. Battery and ground are connected to the two sides of the trunk through the windings of the supervisory relay and upon the reversal of the current over each side of the trunk in
35 consequence of the answer of the called subscriber the windings of the supervisory relay are also reversed, with respect to the trunk conductor, so as to maintain the operated
40 condition of the relay until the connection is released by the calling subscriber.

The features of this invention will be better understood by considering its application
45 to the telephone system illustrated in the drawings. The invention is not limited in its use to this particular system but may be applied in any communication or signaling system in which it is necessary to transmit im-
50 pulses over long distances.

Referring to the drawings:—

Fig. 1 shows a calling subscriber's station A, a line-finder switch LF, a first selector switch S1, and an outgoing repeater circuit
55 OR;

Fig. 2 shows an incoming selector IS, a connector C, and a called subscriber's station B.

In the system shown in the drawings, calls from subscribers in one office to subscribers in another office are completed over interoffice
60 trunks, the outgoing end of each interoffice trunk being arranged to repeat dial impulses to switches at the distant office. Each subscriber's station is equipped with a dial for use in controlling the automatic switches by
65 which the connection is established. The line-finder, selector and connector switches are of the well known Strowger type. Upon the origination of a call at the subscriber's station A, the calling line is extended by line-
70 finder switch LF to the first selector switch S1. For a detailed description of the operation of the line-finder switch LF, reference may be had to Patent 1,711,682, issued May 7,
75 1929, to H. Hovland. When the number of the called station is dialed by the calling subscriber, the selector switch S1 is selectively operated by the first train of impulses to select a group of trunks outgoing to the called
80 office and is then automatically operated to seize an idle trunk in the selected group. The outgoing end of the trunk is arranged to repeat the succeeding trains of impulses over the outgoing conductors to selectively operate the incoming selector switch IS and the
85 connector switch C in the distant office. For a complete description of the operation of the selector and connector switches, reference may be had to pages 53 to 65, inclusive, of the second edition of "Automatic Telephony" by
90 Smith and Campbell.

The operation of this system will now be described in detail, insofar as such a description tends to explain the features of
95 this invention. Assume that the subscriber at station A originates a call to the subscriber at station C, that the line-finder LF has extended the calling line 1 to the first selector S1, that the selector S1 has been selectively operated under the control of
100

the impulses created by the dialing of the first digit of the called number to select a group of trunks, and that the selector has seized the terminals to which the outgoing repeater circuit OR is connected. When the selector S1 extends the connection from the calling line 1 through its brushes to the outgoing repeater OR, a circuit is closed for operating the line relay 11; this circuit may be traced from battery through the lower winding of relay 11, the inner lower back contact of relay 16, conductor 8, the middle brushes of selector S1 and line-finder LF, over the calling line 1, through the upper brushes of line-finder LF and selector S1, conductor 7, the inner upper back contact of relay 16, and through the upper winding of relay 11 to ground. Relay 11 closes a circuit for operating relay 15 which is traced from battery through the right hand winding of relay 15, the lower front contact of relay 11, conductor 21, the lower winding of relay 14, and through the upper back contact of relay 12 to ground. Relay 14 is sufficiently energized by the current through its lower winding to operate its inner upper armature; and, with relay 15 operated, the operation of relay 14 is completed by the energization of its upper winding in a circuit closed by its inner upper front contact and the left hand front contact of relay 15. When completely operated, relay 14 connects the windings of relay 15 over conductors 23 and 24 to the outgoing trunk 25, thereby causing the operation of the line relay 26 of the incoming selector IS, each winding of relay 15 being energized in series with one of the windings of relay 26 in separate grounded circuits over the two conductors of trunk 25. One of these circuits is traced from battery through the right hand winding of relay 15, the lower front contact of relay 11, conductor 21, the outer upper front contact of relay 14, conductor 23, over the tip conductor of trunk 25, and through the right hand winding of relay 26 to ground; the other circuit is traced from ground through the upper front contact of relay 11, the left hand winding of relay 15, the outer lower back contact of relay 16, conductor 22, the outer lower front contact of relay 14, conductor 24, over the ring conductor of trunk 25, through the left hand winding of relay 26 to battery. When thus connected the current flows in opposite directions over the conductors of trunk 25, so that the energization of relays 15 and 26 is not effected by any difference in the ground potential between the two ends of trunk 25, a decrease in the current through one winding of each of these relays being compensated by an increase in the current through the other winding. Relay 15 closes a circuit from battery through the winding of relay 12, the right hand front

contact of relay 15, the inner lower front contact of relay 14 and through the left hand back contact of relay 13 to ground, thereby causing the operation of relay 12. Relay 12 locks through its inner lower front contact to the same ground at relay 13. Relay 12 opens the circuit through the lower winding of relay 14 but relay 14 does not release since it is held operated by its upper winding, under the control of relay 15. Relay 12 closes a circuit from battery through the left hand windings of relays 17 and 18, resistance 20, and through the inner upper front contact of relay 12 to ground; the polarizing windings of relays 17 and 18 are energized in this circuit but neither of these relays operates at this time.

When the subscriber at station A dials the first digit of the called number, relay 11 releases and reoperates in response to each impulse created by the operation of the dial. The release of relay 11 opens the circuits over the tip and ring conductors of trunk 25 to cause the release of relay 26; but relay 15 is held operated in a circuit from battery through its right hand winding, the lower contact of relay 11, resistance 19, and through the inner upper front contact of relay 12 to ground. Relay 11 also closes a circuit from ground through its upper back contact, the outer upper front contact of relay 12, and through the winding of relay 13 to battery. Relay 13 is a slow-to-operate relay and the circuit through its winding is not closed for a sufficient length of time, upon the release of relay 11 in response to impulses during dialing, to cause its operation and relay 12 remains locked to the ground at the left hand back contact of relay 13. When relay 11 reoperates, the circuits through the windings of relays 15 and 26 are again closed to cause the reoperation of relay 26. All of the impulses created by the dialing of each digit of the called number are in this manner transmitted over trunk 25 to selectively operate the selector and connector switches used in establishing the desired connection.

The first series of impulses are thus transmitted to line relay 26, and the brushes of the incoming selector IS are advanced to select a corresponding group of trunks. The selector IS then automatically hunts for an idle trunk in the selected group; and we will assume that the connection is extended over the selected trunk to the connector switch C in the usual manner. The windings of relay 15 in the outgoing repeater are thus connected through the brushes of selector IS, conductors 27 and 28, and through the outer back contacts of relay 39 to the windings of the line relay 31 of connector C.

If relay 15 releases during the interval in which the conductors of trunk 25 are being transferred from the windings of relay 26

of selector IS to the windings of relay 31 of connector C, relay 14 will also release. With relays 14 and 15 both released, a circuit is closed from battery through the upper winding of relay 31, the outer lower back contact of relay 39, conductor 28, the middle brush of selector IS, the ring conductor of trunk 25, conductor 24, the outer lower front contact of relay 12, the outer upper back contact of relay 16, the right hand back contact of relay 13, the right hand windings of relays 17 and 18, the outer upper back contact of relay 14, conductor 23, the tip conductor of trunk 25, the tip brush of selector IS, conductor 27, the outer upper back contact of relay 39, and through the lower winding of relay 31 to ground. Relays 31 and 18 operate, the current flowing through the right hand winding of relay 18 being in such a direction as to aid the polarizing winding; but relay 17 does not operate since the current through its right hand winding is in the opposite direction to that which would aid its polarizing winding. Relay 18 thereupon closes a circuit from ground through its front contact, the lower winding of relay 14, the lower front contact of relay 11, and through the right hand winding of relay 15 to battery. Relays 14 and 15 are, in this manner, reoperated; and with relay 14 operated, relays 15 and 31 are held operated in separate grounded circuits over the conductors of trunk 25 in the same manner that relays 15 and 26 were operated.

The aforementioned operation of relay 31 causes the operation of relay 32 which thereupon connects a holding ground through its outer lower front contact to the sleeve conductor 29 to prevent the release of the incoming selector switch IS in the usual manner. The release of relay 31, in response to the first impulse received, closes a circuit from ground at its back contact, through the upper front contact of relay 32, the normally closed contact of the vertical off-normal springs VON, winding of relay 33, and through the winding of magnet 34 to battery. Relay 33 and magnet 34 operate, the operation of magnet 34 being effective to step the shaft and brushes of the connector switch C up to the first level of the associated terminal bank. When relay 31 reoperates, magnet 34 releases; each release and reoperation of relay 31, in response to the impulses corresponding to the next to the last digit of the called number, causes the operation and release of magnet 34 to step the brushes of switch C up to the desired level. Relay 33 is a slow-to-release relay and it remains operated until all of the impulses in the train have been received. Relay 32 is also a slow-to-release relay and it remains operated during the receipt of impulses. As soon as the shaft of the connector switch is moved out of its normal position, the VON springs are ac-

tuated; and the circuit for operating magnet 34 and for holding relay 33 is now traced from the ground at the upper back contact of relay 31, through the upper front contact of relay 32, the lower front contact of the VON springs, the front contact and winding of relay 33, and through the winding of magnet 34 to battery. The release of relay 33, after all of the impulses in the train have been received, transfers the impulsing circuit from the vertical magnet 34 to the rotary magnet 36 in preparation for the next train of impulses to be received by relay 31.

When the impulses corresponding to the last digit of the called number are repeated over trunk 25 to relay 31, the first release of relay 31 causes the operation of the rotary magnet 36 and relay 35 in a circuit which is traced from ground at the back contact of relay 31, the upper front contact of relay 32, the lower front contact of the VON springs, the back contact of relay 33, the left hand back contact of relay 40, through the winding of relay 35 in parallel with the inner lower back contact of relay 37 and the winding of rotary magnet 36, to battery. With relay 35 operated, the circuit for relay 35 and magnet 36 is closed through the right hand front contact of relay 35; so that the subsequent operation of relay 40 will be ineffective to open this circuit. The operation of magnet 36 rotates the brushes of the connector switch one step, into engagement with the first set of terminals in the selected level. When relay 31 reoperates, magnet 36 releases. The release and reoperation of relay 31 in response to each impulse of the last digit is, in this manner, effective to advance the brushes of the connector switch step-by-step until they reach the terminals to which the line of the called station is connected. Relay 35 is a slow-to-release relay so that this relay remains operated until all of the impulses in the train have been received. With relay 35 operated, the winding of relay 40 is connected through the outer upper back contact of relay 37, the left hand front contact of relay 35, and over conductor 45 to the sleeve (test) brush of the connector switch. If the called line is busy, the sleeve terminal is connected to ground, and relay 40 operates to transmit a busy tone to station A by connecting the secondary winding of tone transformer 49, through the left hand front contact of relay 40, through condenser 30 and conductor 28, to the ring conductor of trunk 25.

If the called line is idle, relay 40 does not operate and when relay 35 releases the sleeve brush of switch C is connected over conductor 45 through the left hand back contact of relay 35, the lower winding of relay 37, the right hand back contact of relay 40, to ground at the outer lower front contact of relay 32. The lower winding of relay 37 is thus sufficiently energized, in series with the cut-off

relay (not shown) of the called line 100, in the usual manner, to close its inner upper front contact and thereby close a circuit from battery through its upper winding and inner upper front contact, to ground at the inner lower front contact of relay 32. Relay 37 is thus completely operated to close the ringing circuit which is traced from the ringing generator 47, through the ringing interrupter 46, the inner lower front contact of relay 37, the lower winding of relay 38, the outer upper back contact of relay 38, the outer upper front contact of relay 37, over conductor 43 to one side of the line 100, back over the other side of the line to conductor 44, through the outer lower front contact of relay 37, to ground at the outer lower back contact of relay 38. When the called subscriber answers, relay 38 is sufficiently energized by the current through its lower winding to close the inner upper front contact and thereby close a circuit from battery through its upper winding and inner upper front contact to the ground at the inner lower front contact of relay 32. Relay 38 is thus completely operated to connect battery and ground through the upper and lower windings of relay 39, over conductors 41 and 42, through the outer front contacts of relays 38 and 37, over conductors 43 and 44 and the conductors of line 100, to the called subscriber's station B. Relay 39 operates and remains operated until the called subscriber replaces the receiver upon the receiver hook. The talking circuit is traced from conductors 41 and 42 through the talking condensers 30, over conductors 27 and 28, through the incoming selector IS, over trunk 25, over conductors 23 and 24, the outer front contacts of relay 14, over conductor 21 and conductor 22 in series with the outer lower back contact of relay 16, through talking condensers 10, over conductors 7 and 8, through the selector switch S1 and line-finder switch LF, to the calling line 1.

With relay 39 operated, the connections between the windings of relay 31 and conductors 27 and 28 are reversed so that relays 31 and 15 both release. The release of relay 15 causes the release of relay 14; and the release of relay 14 connects the right hand windings of relays 17 and 18 across the conductors of trunk 25 to cause the reoperation of relay 31 with its windings in series and thus prevent the release of the connector switch C. The current flowing in this circuit is in such direction as to cause the operation of relay 17 but not to cause the operation of relay 18. Relay 17 causes the reoperation of relay 15 by closing a circuit from battery through the right hand winding of relay 15, the lower front contact of relay 11, the lower winding of relay 16, the front contact of relay 17, conductor 22, the outer lower back contact of relay 16, the left hand winding of relay 15, and through the upper front

contact of relay 11 to ground. Relay 16 is also operated in this circuit and relay 16 locks through its upper winding and inner upper front contact, through the inner upper back contact of relay 14, to ground at the left hand front contact of relay 15. Relay 16 disconnects the windings of relays 17 and 18 and the lower winding of relay 16 from conductors 23 and 24 and reconnects the winding of relay 15 to conductors 23 and 24 in such manner that the windings of relays 15 and 31 are again energized in separate grounded circuits over the conductors of trunk 25. The operation of relay 16 is also effective to reverse the connections between conductors 7 and 8 and the windings of relay 11 and thus reverse the current over the calling line to indicate that the call has been answered.

When relay 11 releases in consequence of the receiver being replaced upon the receiver hook at station A, relay 13 operates thereby opening the locking circuit for the slow-to-release relay 12. The release of relay 11 also opens the two circuits through the windings of relay 15 and relay 31. When relay 15 releases, relay 16 releases; and, since relay 13 has operated, the windings of relay 17, 18 and 16 cannot be reconnected across trunk 25 to hold relay 31. When relay 12 releases, it disconnects the holding ground at its middle lower armature from sleeve conductor 9 thereby causing the selector switch S1 and line-finder switch LF to be restored to normal in the usual manner. The release of relay 12 also causes the release of relay 13 so that the outgoing repeater circuit OR is now ready for use on another call.

When relay 31 of connector switch C releases, relay 32 also releases thereby disconnecting the holding ground from sleeve conductor 29. The incoming selector switch IS is thus caused to restore to normal in the usual manner. Relays 37 and 38 are held operated by their upper windings to the ground at the inner upper front contact of relay 39 until the receiver is also replaced at station B. When relay 39 releases, relays 37 and 38 release; and the release magnet 48 is operated in a circuit from battery through its winding, the upper front contact of the VON springs, the inner upper back contact of relay 37, the back contact of relay 32 to ground at the back contact of relay 31. The operation of magnet 48 causes the shaft and brushes of switch C to be restored to normal. When the shaft reaches its normal position the VON springs are restored to their normal position and magnet 48 releases. The connector switch C is now ready for use in another connection.

What is claimed is:

1. In combination, a first relay, a pair of conductors, a second relay, a circuit including one winding of each of said relays and

one of said conductors, a circuit including another winding of each of said relays and the other of said conductors, means for interchanging the windings of said second relay with respect to said conductors, and means for interchanging the windings of said first relay with respect to said conductors.

2. In combination, a first relay, a pair of conductors, a second relay, a circuit including one winding of each of said relays and one of said conductors, a circuit including another winding of each of said relays and the other of said conductors, means for interchanging the windings of said second relay with respect to said conductors, and means effective in consequence of said interchange of the windings of said second relay for interchanging the windings of said first relay with respect to said conductors.

3. In a telephone system, an impulse receiving relay for responding to incoming impulses, an outgoing trunk, another relay, a source of battery and ground potential, a circuit from said battery through a primary winding of said other relay over one conductor of said outgoing trunk, a circuit from said ground potential through a secondary winding of said other relay over the other conductor of said outgoing trunk, contacts of said impulse receiving relay for interrupting said circuits to transmit outgoing impulses corresponding to incoming impulses, means for holding said other relay operated during the transmission of impulses, and means effective in consequence of the release of said other relay for reversing the connections from said primary and secondary windings with respect to the conductors of said outgoing trunk.

4. In combination, a first relay having a primary winding connected to battery and a secondary winding connected to ground, a pair of conductors, a second relay having a primary winding connected to ground and a secondary winding connected to battery, a circuit including the primary windings of said first and second relays and one of said conductors, a circuit including the secondary windings of said first and second relays and the other of said conductors, means for interchanging the windings of said second relay with respect to said conductors, and means for interchanging the windings of said first relay with respect to said conductors.

5. In combination, a first relay having a primary winding connected to battery and a secondary winding connected to ground, a pair of conductors, a second relay having a primary winding connected to ground and a secondary winding connected to battery, a circuit including the primary windings of said first and second relays and one of said conductors, a circuit including the secondary windings of said first and second relays and the other of said conductors, means for inter-

changing the windings of said second relay with respect to said conductors, and means effective in consequence of said interchange of the windings of said second relay for interchanging the windings of said first relay with respect to said conductors.

6. In combination, a circuit, an impulse receiving relay for receiving impulses over said circuit, another relay, a second impulse receiving relay, a second circuit including one winding of said other relay and one winding of said second impulse receiving relay, a third circuit including another winding of said other relay and another winding of said second impulse receiving relay, means for opening and closing each of said second and third circuits in response to each impulse received by said impulse receiving relay, means for interchanging the windings of said second impulse receiving relay with respect to the windings of said other relay, and means for interchanging the windings of said other relay with respect to the windings of said second impulse receiving relay.

7. In combination, a circuit, an impulse receiving relay for receiving impulses over said circuit, another relay, a second impulse receiving relay, a second circuit including one winding of said other relay and one winding of said second impulse receiving relay, a third circuit including another winding of said other relay and another winding of said second impulse receiving relay, means for opening and closing each of said second and third circuits in response to each impulse received by said impulse receiving relay, means for interchanging the windings of said second impulse receiving relay with respect to the windings of said other relay, and means effective in consequence of said interchange of the windings of said second impulse receiving relay for interchanging the windings of said other relay with respect to the windings of said second impulse receiving relay.

8. In combination, a circuit, an impulse receiving relay for receiving impulses over said circuit, another relay having a primary winding connected to battery and a secondary winding connected to ground, a second impulse receiving relay having a primary winding connected to ground and a secondary winding connected to battery, a second circuit including the primary winding of said other relay and the primary winding of said second impulse receiving relay, a third circuit including the secondary winding of said other relay and the secondary winding of said second impulse receiving relay, means for opening and closing each of said second and third circuits in response to each impulse received by said impulse receiving relay, means for interchanging the windings of said second impulse receiving relay with respect to the windings of said other relay, and means for interchanging the windings of said other

relay with respect to the windings of said second impulse receiving relay.

9. In combination, a circuit, an impulse receiving relay for receiving impulses over said circuit, another relay having a primary winding connected to battery and a secondary winding connected to ground, a second impulse received relay having a primary winding connected to ground and a secondary winding connected to battery, a second circuit including the primary winding of said other relay and the primary winding of said second impulse receiving relay, a third circuit including the secondary winding of said other relay and the secondary winding of said second impulse receiving relay, means for opening and closing each of said second and third circuits in response to each impulse received by said impulse receiving relay, means for interchanging the windings of said second impulse receiving relay with respect to the windings of said other relay, and means effective in consequence of said interchange of the windings of said second impulse receiving relay for interchanging the windings of said other relay with respect to the windings of said second impulse receiving relay.

10. In an impulse repeater, incoming conductors, an impulse receiving relay for responding to impulses incoming over said conductors, outgoing conductors, another relay, a circuit including a winding of said other relay and one of said outgoing conductors, a circuit including another winding of said other relay and another of said outgoing conductors, means responsive to the initial operation of said impulse receiving relay for closing said circuits, means for opening and closing said circuits in response to each impulse received over said incoming conductors, means for preventing the release of said other relay during each of said openings of said circuits, means effective in consequence of the release of said other relay for bridging said outgoing conductors, and means for opening said bridge and connecting the windings of said other relay to said outgoing conductors in such a manner that the windings are interchanged with respect to said outgoing conductors.

11. In an impulse repeater, an impulse receiving relay for responding to incoming impulses, outgoing conductors, another relay, a circuit including a winding of said other relay and one of said outgoing conductors, a circuit including another winding of said other relay and another of said outgoing conductors, means for opening and closing both of said circuits in response to each impulse received by said impulse receiving relay, means for holding said other relay operated during each of said openings of said circuits, two polarized relays, means responsive to the release of said other relay for bridging the windings of said polarized

relays across said outgoing conductors, means effective in consequence of the operation of one of said polarized relays for opening said bridge and for again closing said circuits, and means effective in consequence of the operation of the other of said polarized relays for opening said bridge and for connecting the windings of said other relay to said outgoing conductors in such a manner that the windings are interchanged with respect to said outgoing conductors.

12. In an impulse repeater, incoming conductors, an impulse receiving relay for responding to impulses incoming over said conductors, outgoing conductors, another relay, a circuit including a winding of said other relay and one of said outgoing conductors, a circuit including another winding of said other relay and another of said outgoing conductors, means for opening and closing both of said circuits in response to each impulse received by said impulse receiving relay, means for holding said other relay operated during each of said openings of said circuits, two polarized relays, means responsive to the release of said other relay for bridging the windings of said polarized relays across said outgoing conductors, means effective in consequence of the operation of one of said polarized relays for opening said bridge and for again closing said circuits, and means effective in consequence of the operation of the other of said polarized relays for opening said bridge and for connecting the windings of said other relay to said outgoing conductors in such a manner that the windings are interchanged with respect to said outgoing conductors and for interchanging the windings of said impulse receiving relay with respect to said incoming conductors.

13. In an impulse repeater, incoming conductors, an impulse receiving relay for responding to impulses incoming over said conductors, outgoing conductors, another relay, a circuit including a winding of said other relay and one of said outgoing conductors, a circuit including another winding of said other relay and another of said outgoing conductors, means responsive to the initial operation of said impulse receiving relay for closing said circuits, means for opening and closing said circuits in response to each impulse received over said incoming conductors, means for preventing the release of said other relay during each of said openings of said circuits, polarized relays, means responsive to the release of said other relay for bridging the windings of said polarized relays across said outgoing conductors, means effective in consequence of the operation of one of said polarized relays for opening said bridge and for again closing said circuits, and means effective in consequence of the operation of another of said polarized

relays for opening said bridge and for connecting the windings of said other relay to said outgoing conductors in such a manner that the windings are interchanged with respect to said outgoing conductors and for
5 interchanging the windings of said impulse receiving relay with respect to said incoming conductors.

In witness whereof, I hereunto subscribe
10 my name, this 22d day of January, 1931.

BERT G. DUNHAM.

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