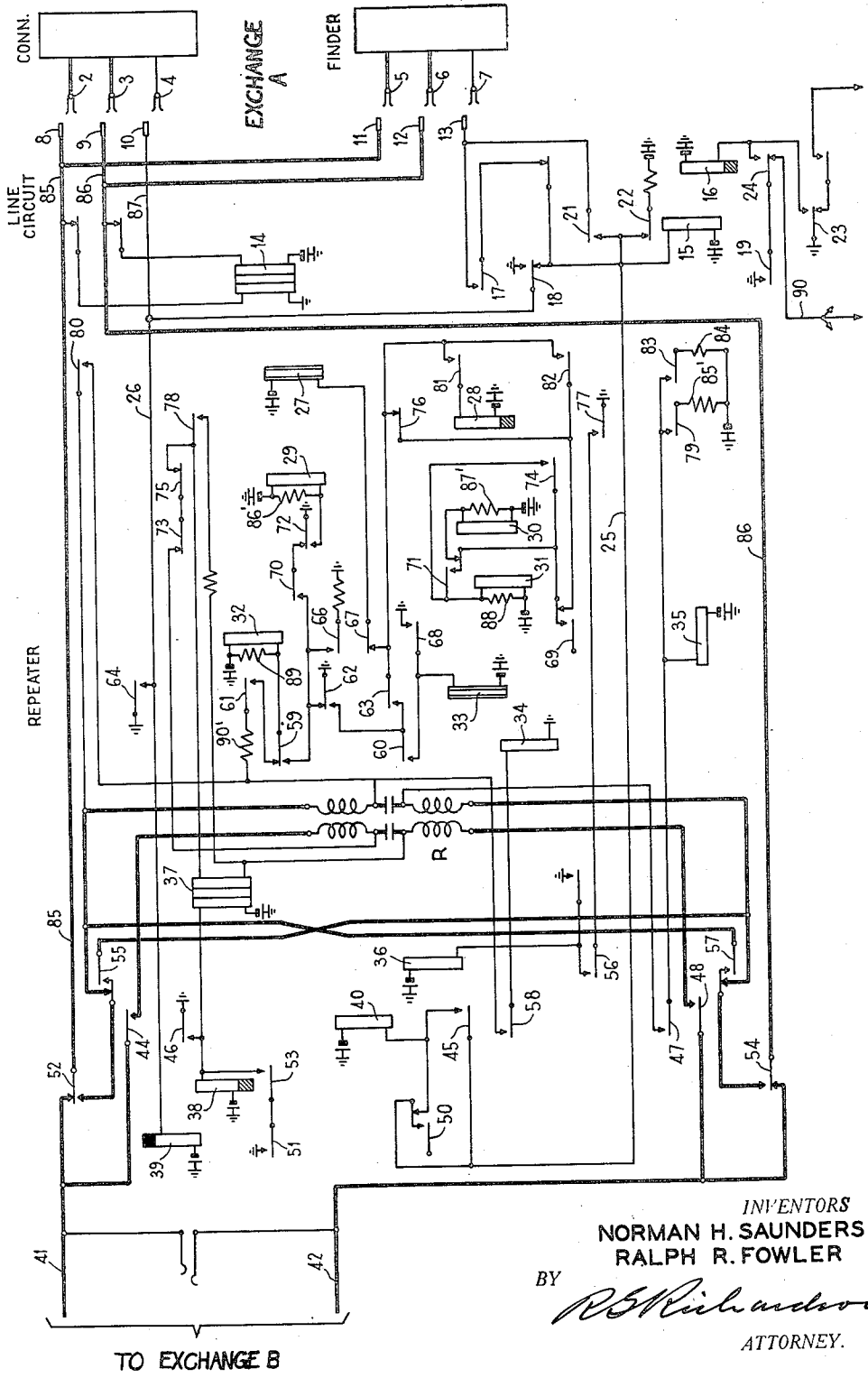
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AUTOMATIC TELEPHONE SYSTEM

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AUTOMATIC TELEPHONE SYSTEM

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The present invention relates in general to automatic telephone systems, and more particularly to such systems as comprise two or more exchanges which are interconnected by trunk lines. The object of the invention, briefly stated, is to provide new and improved trunk circuits for interconnecting two automatic exchanges.

A special feature of the invention is a new and improved repeater. One of these new repeaters may be used at each end of a two way trunk line. The repeater includes a number of improvements among which may be mentioned those having to do with the two way operation of a trunk line and others relating to the automatic transmission of standardized or corrected impulses.

The invention will be described hereinafter with reference to the accompanying drawing, which shows diagrammatically sufficient of the equipment and circuits involved to enable the invention to be explained and understood.

Referring to the drawing, the equipment there illustrated is all located in one exchange, which may be the type shown in the Ostline Patent No. 2,099,429, granted Nov. 16, 1937, or in the Saunders Patent No. 1,999,788, granted April 30, 1935. The exchanges described in these disclosures are small exchanges employing finder connector links for setting up connections. The exchange might also be a relay exchange of the type disclosed in the Ostline Patent No. 2,023,239 granted Dec. 3, 1935, and there are other exchanges to which the invention is applicable.

The drawing shows one end of a trunk line interconnecting two exchanges of the above mentioned character. There may be a number of these trunk lines, all the same as the one shown. The inter-exchange portion of the trunk line shown comprises two conductors 41 and 42. At the end which appears in the drawing the trunk line is provided with a repeater and a line circuit, both of which are so labeled in the drawing, and is multipled in the banks of connector switches and finder switches. The finder and connector branches of the trunk line appear at the right of the drawing, which also indicates one finder and one connector having access to the trunk line. The equipment at the other end of the trunk line may be exactly the same and for convenience it will be assumed that such is the case.

In the following description of the operation, the exchange at which the equipment shown in the drawing is located will be referred to as exchange A, and the exchange at the other end of the trunk line will be referred to as exchange B.

Assuming now that a subscriber in exchange A desires to call a subscriber in exchange B, he will remove his receiver, whereupon his line is picked up by the finder switch of a finder connector link. The calling subscriber then dials the digit or digits assigned to exchange B, with the result that the connector of the link in use will be operated to select the group of trunk lines extending to that exchange, and will then proceed to select an idle trunk line in the group. Assuming that the connector indicated in the drawing is used, and that the trunk line shown is the trunk selected, when the connector wipers 2—4 engage bank contacts 8—10 a ground will be placed on the test wiper 4. A circuit is thus completed by way of 4, 10, 87, and 18 to the cut-off relay 15 in the line circuit. Upon energizing, relay 15 disconnects the line relay 14, and at 23 closes a circuit for relay 16. The operation of the latter relay has no significance at present.

The completion of the circuit of the cut-off relay 15, as above described, also grounds conductors 25 and 26 which extend between the line circuit and the repeater, terminating at the repeater in relays 40 and 39, respectively. Relays 40 and 39 therefore have their circuits closed simultaneously. Relay 39 is arranged to open the circuit of relay 40 at 50, but is slow to energize, and it follows that relay 40 pulls up and locks itself at 45 before relay 39 operates.

On energizing, relay 40 connects the trunk conductors 41 and 42 with the left-hand windings of the repeating coil by way of 44 and 48. Since the two left-hand windings of the repeating coil are connected together by way of the right-hand winding of the electropolarized relay 37 and contacts 75 and 73, the right-hand winding of relay 37 is bridged across the trunk conductors 41 and 42. Responsive to the closure of this bridge, the line relay such as 14 at exchange B operates, starts up a finder in exchange B, and makes the trunk line busy at that exchange. As a result the trunk line is extended through in exchange B to the connector of a finder connector link. These operations will be described more in detail and with reference to the drawing in the course of the explanation of a call originating at exchange B and directed to a subscriber in exchange A.

As a further result of the operation of relay 40, circuits are closed at 46 for the left-hand or polarizing winding of relay 37 and for relay 38. The direction of current flow over the trunk 41—42 is such that relay 37 does not operate. Relay 38 energizes and locks itself by way of 53 and 51 as soon as relay 39 operates. In energized position relay 38 disconnects the conductors 85 and 86 from conductors 41 and 42 of the trunk and connects them through by way of contacts of the reversing relay 36 to the right-hand windings of the repeating coil. Conductor 85 is thus extended by way of 52, contacts controlled

by 55, upper right-hand winding of the repeating coil, and 58 to the line relay 34, while conductor 86 is extended by way of 54, contacts controlled by 57, lower right-hand winding of repeating coil, and 47 to the impedance coil 35.

At the connector switch, the calling subscriber's line is switched through to the wipers 2 and 3, upon seizure of the trunk, the switching through operation taking place a short interval after the bridge cut-off relay 15 is energized over the test wiper 4. Accordingly the line relay 34 of the repeater now energizes over the calling subscriber's loop.

Upon energizing, relay 34 closes a circuit for relay 32 at 59. Relay 32, on energizing, locks itself at 66 so that it can stay up independent of ground at 62, and closes a circuit for the slow acting release relay 33 at 68. On energizing, relay 33 closes another circuit for itself by way of 62 and 60, and grounds conductor 26 at 64. By the latter operation ground is extended back over 26, 87, 16, and 4, to the release trunk conductor in the connector to maintain the connector and finder of the link circuit in operated position after the falling back of the line and release relays of the connector. These relays deenergize following the switching through operation. Ground on conductor 26 also holds up the cut-off relay 15, and relays 38 and 48 of the repeater.

When the calling subscriber dials the next digit of called number, the calling line loop is interrupted a number of times depending on the value of the digit, and as a result the line relay 34 is deenergized a number of times to produce a like number of interruptions in the bridge across trunk conductors 41 and 42, and thus repeat the digit over the trunk line to exchange B. The repeating operation will now be described in detail.

When line relay 34 deenergizes at the beginning of the first interruption it breaks the circuit of relay 32 at 59 and relay 32 falls back. Relay 33 is slow to release and remains operated while relays 34 and 32 are responding to dialling. On falling back relay 32 closes a circuit for the slow acting relay 27 by way of 62, 63, and 67. Relay 27 energizes and stays operated until the digit is completed. In energized position, relay 27 closes a circuit for relay 28 by way of 62, 63, and 81. Relay 28 therefore energizes and stays up until after relay 27 falls back.

The impulses, or interruptions, are repeated by relays 29, 30, and 31, under control of relay 32. When relay 32 falls back it closes a circuit for relay 30 by way of 62, 63, 76, contacts controlled by 69, and contacts controlled by 71. On energizing, relay 30 breaks the bridge across the trunk conductors 41 and 42 at 73, and at 72 closes a circuit for relay 29. Relay 29, on energizing, breaks the bridge at 75 and at 74 closes a circuit for relay 31 in parallel with relay 30. On energizing, relay 31 locks itself at 71, and breaks the circuit of relay 30. Relay 30 falls back, closes a point in the bridge at 73, and breaks the circuit of relay 29 at 72. Relay 29 falls back and closes the bridge at 75, thus ending the first interruption in the bridge across the trunk 41—42.

In the meantime the line relay 34 pulls up again, recloses the circuit of relay 33 at 68, and at 59 recloses the circuit of relay 32. Relay 32, however, cannot energize until the relays 29, 30, and 31 have proceeded with their automatic operation to the point where relay 31 has locked itself and relay 30 has fallen back. At this stage, if the line relay 34 is up, a circuit is completed for relay 32 by way of 72, 76, and 59, and relay 32 reenergizes, breaking the locking circuit of relay 31 at 69. Relay 31 falls back, whereupon conditions are the same as they were before dialling started except that relays 27 and 28 are holding on due to the slow release characteristics of relay 27. If the digit dialled is the digit 1 no further interruptions will occur at the moment, and relay 27 will fall back, followed by the deenergization of relay 28. If the digit dialled is greater than 1, relay 27 will of course be maintained operated by an additional impulse or impulses from relay 32.

The relays respond to the remaining interruptions of the digit the same way. At the beginning of each interruption relays 34 and 32 fall back. The latter relay closes a circuit for relay 30, whereupon relays 30, 29, and 31 pull up successively and relay 31 locks. Following the operation of relay 31, relays 30 and 29 fall back successively. At the end of each interruption relay 34 pulls up again, followed by the energization of relay 32 contingent on relay 30 having restored. It will be seen that the length of the repeated interruptions produced by opening the bridge at 73 and 75 is independent of the length of the interruptions in the circuit of line relay 34, and has a constant value determined by the operating characteristics of relays 29, 30, and 31. A repeated interruption starts with the opening of the bridge at 73 on the energization of relay 30 and it lasts while relay 29 is pulling up, relay 31 is pulling up, relay 30 is falling back, and relay 29 is falling back, the interruption being ended when the bridge is closed at 75 by the deenergization of relay 29.

In view of the foregoing it will be understood that some care is necessary to insure that the relays have the proper operating and release characteristics, and it will be desirable to give some values that have been found to work well in practice. An example that may be cited is a commercial repeater designed to produce repeated interruptions having a constant length or duration of .060 second. With this length of interruption and with a dial speed of 10 impulses, or interruptions, per second, the ratio of the open periods to the closed periods is as 60 to 40. That is, the repeater output during dialling is what is known as a 60 per cent break and a 40 per cent make. Since the open period or break remains constant the ratio of make to break changes with the dial speed, and excessive variations of dial speed are not permissible. The range within which the repeater will work satisfactorily is about 8 to 12 impulses per second.

The desired constant break of .060 second is secured by using the following values: Relays 30 and 31 are each wound to a resistance of 210 ohms, and relay 29 to a resistance of 300 ohms. The non-inductive resistance 88 shunting relay 31 is 2000 ohms, resistance 87' shunting relay 30 is 1000 ohms, and resistance 86' shunting relay 29 is 2000 ohms. While not material to the length of break, it may be stated also that the line relay 34 has a resistance of 200 ohms and relay 32 a resistance of 210 ohms. The latter relay is shunted by a resistance 89 of 2000 ohms. The battery voltage is assumed to be about 46 volts. With the above values standard adjustments may be used which last for a long time,

or indefinitely. It will be understood that the above values are given by way of example and that other sets of values could be used, a change in one relay being compensated for by a change at another.

Some further operations which take place during the repeating of a digit will now be explained. At 80 relay 27 short-circuits the upper right-hand winding of the repeating coil, which improves the operation of relay 34. With the same object, the impedance element 35 is shunted by resistances 84 and 85' at 83 and 79. The impedance element 35 functions to balance the line circuit in a well-known manner during the talking periods and for this reason is of the same impedance value as the impedance value of the line relay 34. The shorting out of an impedance such as 35 to improve the response of the line relay in the other side of the line has been done before, but in this repeater the mere short circuiting of the impedance 35 would not work. If impedance 35 were short circuited in the usual way by relay 27 during dialling, the removal of the short circuit at the end of a digit would suddenly introduce the impedance into the circuit of line relay 34, causing the current to fall momentarily and producing a slight or transient deenergization of the line relay. A very short deenergization such as this, only a small fraction of the length of a standard interruption, does no harm in an ordinary repeater; but in this repeater only a very momentary falling back of relay 34 is sufficient to deenergize relay 32, which initiates a series of operations resulting in the transmission of a standard length impulse. To avoid any possibility of a false deenergization of line relay 34, therefore, relays 27 and 28 are arranged to remove the shunt from impedance 35 in two stages. During the dialling of a digit, impedance 35 is shunted by resistances 84 and 85' which may be 50 and 700 ohms, respectively. When the digit is completed, relay 27 falls back and removes the 50 ohm shunt of resistance 84. An instant later relay 28 falls back and takes off the 700 ohm shunt of resistance 85'. This arrangement has been found to be sufficient to prevent any false deenergization of relay 34 under ordinary conditions. For more severe conditions, it is apparent that another slow acting relay could be added to secure removal of the shunt in three stages instead of two.

Other operations which may be mentioned are the shunting of the right-hand winding of relay 37 at 78 during dialling, and the use of a priming circuit for line relay 34 to assist this relay in energizing quickly during dialling. The object of the first mentioned operation will be obvious. As to the second, it will be noticed that whenever line relay 34 falls back during the dialling it connects itself in series with relay 32 at 59, a resistance 90' being included in the circuit. Resistance 90' may have a value of 3000 ohms and relays 34 and 32 cannot operate in series with this resistance. The current flow established in relay 34, however, primes the relay and enables it to respond more readily when the line circuit is closed after each interruption.

Continuing now with the general explanation, the digits of the called number are repeated in the manner described and result in the completion of the connection to the desired subscriber's line in exchange B. When the called subscriber answers, the connector in use reverses the direction of current flow over the trunk line 41—42 in the usual manner, causing the operation of the electro-polarized relay 37. On operating, relay 37 closes a circuit for reversing relay 36, which reverses the direction of current flow in the calling subscriber's line. At this point it may be mentioned that if the calling party should accidentally operates or move his dial so as to send one or more impulses, which would cause relay 37 to fall back due to being short circuited, the energized position of reversing relay 36 is not disturbed because of the provision of a locking circuit by way of 56 and 77.

When the calling subscriber hangs up his receiver, the release relay 33 falls back following the continued deenergization of relays 34 and 32. Ground is thus removed from the holding circuit at 64, and the link circuit in use by the calling party is restored to normal in the usual manner. When relay 32 in the repeater falls back, relays 27 and 28 of course energize and relays 29, 30, and 31 go through their operations, but the interruption produced thereby in the bridge across the trunk does no harm. Relays 27, 28, and 31 are deenergized by the falling back of relay 33, which opens the circuits of the former relays at 62 and 63. The removal of ground from conductor 26 at 64 by the falling back of relay 33, also lets relays 15 and 40 fall back. The latter relay removes the bridge from conductors 41 and 42 and initiates the release of the equipment in exchange B.

If the release of the connection should take place while current is reversed on trunk line 41—42, no lock up can occur, due to the arrangement involving slow to release relays 39 and 38. When relay 33 falls back, the line relay 14 is promptly connected up by the falling back of relay 15, and if the trunk line were connected through at this time the line relay of the distant connector would hold up in series with the line relay 14, energizing this latter relay also. Such operation is prevented because relay 40 falls back promptly on the falling back of relay 33 and initiates the release at the distant exchange, while the slow acting relays 39 and 38 hold on for an interval and hold the trunk line open at 52 and 54 long enough for the distant connector to release and reverse the direction of current flow back to normal. The holding open of the trunk at 52 and 54 involves also the maintaining of the incoming line conductors connected through to the repeating coil by way of contacts of the reversing relay 36. Since relays 37 and 36 are energized when relay 40 falls back, assuming the release takes place while current on trunk line 41—42 is reversed, and since it takes an instant for relays 37 and 36 to deenergize, contacts 58 and 47 on relay 40 are provided to disconnect line relay 34 and impedance 35 from the repeating coil and prevent any possibility of the false operation of relay 34 in series with relay 14.

In order to complete the explanation, the operation of the repeater and line circuit on a call from exchange B to exchange A will be considered.

When the trunk line is seized at exchange B, the repeater on that end of the trunk places a bridge across the trunk line just as explained in the discussion of the previous call. The bridging of the trunk line results in the operation of the line relay 14 at exchange A. Upon energizing, relay 14 grounds conductors 26 and 87 at 18, the ground on 87 serving to make the trunk line busy in the banks of the connectors. Ground on 26 operates relay 39, which opens the circuit of relay 40 at 50. It will be noted that on a call

coming from exchange B conductor 25 is not grounded immediately, so relay 39 prevents relay 40 from operating. The line relay 14 also connects at 17 the cut-off relay 15 to test contacts such as 13 in the banks of the finders, thus placing a test potential on these contacts, and at 19 closes a finder start circuit including conductor 30. An idle finder is then started up in known manner in search of the trunk line. Assuming the finder in use is the one indicated in the drawing, when the test wiper 7 reaches test contact 13, the finder test relay energizes in series with cut-off relay 15 and stops the finder. Relay 15 locks itself at 21, removes the shunt resistance at 22, and disconnects the line relay 14, which latter relay now falls back. The cut-off relay 15 is held energized by ground from the finder and later from the connector of the link, the circuit including the finder test wiper 7. These circuits are known and are fully explained in the disclosures hereinbefore referred to. It will be noted that as soon as the finder connects with the trunk line the conductor 25 will become grounded but by this time the relay 39 has energized and hence relay 40 cannot pull up.

It will be understood therefore that on an incoming call from exchange B the repeater at exchange A is not used. The trunk conductors 41 and 42 continue through the repeater to the banks of the finders, and after a finder has picked up the trunk line, to the line relay of the associated connector. The connection is completed by operating the connector responsive to the digits repeated over the trunk line by the distant repeater in the manner previously explained.

The invention having been described, that which is believed to be new and for which the protection of Letters Patent is desired will be pointed out in the appended claims.

What is claimed is:

1. In a telephone system, two exchanges, finder and connector switches in each exchange, a two-way trunk line connecting said exchanges, a repeater associated with said trunk line at each end thereof, and two branches of said trunk line at each end, one branch accessible to connector switches to extend an outgoing connection from an exchange via the associated branch repeater and the other branch accessible to finder switches to find the trunk line over which an outgoing connection has been extended from another exchange.

2. In a telephone system, an exchange including finder and connector switches, a trunk line extending to another exchange, a first branch over which said trunk line may be seized by a connector to extend an outgoing connection to the other exchange, a repeater operable to repeat impulses when the trunk line is seized by a connector, a second branch of said trunk line accessible to said finders when an incoming connection is received, line circuit equipment controlled over the trunk line when an incoming call is received from the other exchange to cause a finder to find and seize said second branch, and means in the repeater for discriminating between outgoing and incoming calls to connect the same into the trunk line only on outgoing calls.

3. In a telephone system an exchange comprising finder and connector switches, a two-way trunk line connecting said exchange with another exchange, a repeater, means responsive to the seizure of said trunk line by a connector for inserting said repeater therein to provide a holding circuit for said connector, a line relay energized over said trunk line when the same is seized at the other exchange, means controlled by said line relay for starting a finder switch in search of the trunk line, and means controlled by said line relay for preventing the insertion of said repeater.

4. In a telephone system, an inter-exchange trunk line, a repeater, two conductors normally connected together, a quick-acting relay energized over one conductor and a slow-acting relay energized over the other, said slow relay having means to break the circuit of the quick relay, means for grounding said conductors simultaneously when the trunk line is seized at one end, whereby the quick relay is energized, means whereby said quick relay locks itself and connects the repeater in the trunk line, and means for grounding the conductor associated with the slow relay while the other conductor is free of ground when the trunk line is seized at the other end, whereby the slow acting relay is effective to prevent the operation of the quick relay and the connection of the repeater in the trunk line.

5. In a repeater, a line relay and an impedance coil bridged a cross the incoming line in series with a battery, contacts on the line relay for repeating impulses over the outgoing line, means for shunting the said impedance coil during the operation of said line relay in repeating a series of impulses, and means for removing the shunt at the end of a series in a plurality of stages, whereby the momentary false deenergization of said line relay which might result if the entire shunt were removed at once is effectively prevented.

6. In a telephone system, two exchanges, a two-way trunk line connecting said exchanges, a repeater at one exchange including a repeating coil, a relay in said repeater responsive to the seizure of said trunk line to bridge one side of said repeating coil across the trunk line, a line relay in the other exchange operated by the closure of the bridge, and a busy test circuit completed by the operation of said line relay, whereby upon seizure of the trunk line it is made busy at the other end by the successive operation of only two relays, one in the repeater at the end seized and the other being the line relay at the other end.

7. In a repeater, means responsive to the seizure of the repeater for closing a bridge across the outgoing line, a line relay energized over the incoming line, a series of relays responsive to the deenergization of said line relay, and circuit arrangements whereby said series of relays open said bridge for a predetermined interval which is independent of the length of time said line relay is deenergized.

8. In a repeater, a line relay, a series of three other relays, circuits for automatically and successively energizing said other relays and for successively deenergizing two of said other relays responsive to the momentary deenergization of said line relay, and an impulse bridge held open by contacts on said two relays while the same are energized.

9. In a repeater, a line relay, a plurality of other relays, means responsive to the momentary deenergization of said line relay for automatically energizing a plurality of said other relays in succession and for deenergizing them in the same order, and an impulse repeating bridge including contacts on one of said plurality of relays.

10. In a repeater, a line relay, a second relay initially responsive to said line relay upon seizure

of the repeater, an outgoing trunk line, automatic impulse repeating means for transmitting impulses over said trunk line controlled by said second relay, and circuits effective during the repeating of a digit for making the response of said second relay to said line relay contingent on the operation of said repeating means.

11. In a repeater, a line relay, a second relay energized by said line relay when the same responds to the seizure of the repeater, said second relay deenergizing when said line relay falls back at the beginning of an interruption, repeating means responsive to the deenergization of said second relay for producing an interruption of predetermined duration in the outgoing line, and circuit arrangements for preventing the reenergization of said second relay responsive to the reenergization of the line relay until the operation of said repeating means has reached a definite stage.

12. In a repeater, a line relay, a second relay energized by said line relay when the same responds to the seizure of the repeater, said second relay deenergizing when said line relay falls back at the beginning of an interruption, repeating means responsive to the deenergization of said second relay for producing an interruption of predetermined duration in the outgoing line, circuit arrangements for preventing the reenergization of said second relay responsive to the reenergization of the line relay until the operation of said repeating means has reached a definite stage, and means for preventing said repeating means from fully completing its cycle of operation until said second relay has become reenergized.

13. In a repeater, a line relay, a second relay energized by said line relay upon the seizure of the repeater, a release relay initially energized by said second relay, and a circuit closed by said release relay over which the same is subsequently controlled by said line relay.

14. In combination, a repeater, a trunk line normally extending through said repeater, means responsive to the seizure of the trunk line for opening the trunk line at the repeater, for connecting a line relay bridge across the trunk line on the seized side of the break, and for connecting an impulse repeating bridge across the trunk line beyond the break, means for promptly opening said repeating bridge upon the release of the trunk line by the seizing means, and means for maintaining the open condition of the trunk line at the repeater for a predetermined time after the repeating bridge is opened.

15. In a repeater, a line relay, a plurality of other relays, means responsive to the deenergization of said line relay for automatically and successively energizing said other relays and for deenergizing them in the same order, and an impulse repeating bridge including serially related contacts on two of said other relays.

16. In a repeater, a line relay responsive to digital series of interruptions, means including a pair of auxiliary relays controlled by said line relay for repeating said interruptions, contacts on one of said auxiliary relays for beginning each repeated interruption and contacts on the other auxiliary relay for ending each repeated interruption.

17. In a telephone system, two exchanges, a two-way trunk line extending between said exchanges, a repeater associated with said trunk line at each end thereof, connector switches in each of said exchanges individually operative to select said line to extend a call thereover, finder switches in each of said exchanges individually operative to search for and seize said line when a call is received thereover, and means for selectively rendering the repeater at the exchange receiving the call inoperative.

18. In a telephone system, two exchanges, a two-way trunk line extending between said exchanges, a repeater associated with said trunk line at each end thereof, connector switches in each of said exchanges individually operative to select said line to extend a call thereover, finder switches in each of said exchanges individually operative to search for and seize said line when a call is received thereover, and means controlled by the finder that seizes said line for selectively disconnecting the repeater at the exchange receiving the call from the circuit of said line.

19. In a telephone system, two exchanges, a two-way trunk line extending between said exchanges, a repeater associated with said trunk line at each end thereof, connector switches in each of said exchanges individually operative to select said line to extend a call thereover, finder switches in each of said exchanges individually operative to search for and seize said line when a call is received thereover, means associated with the finder switch operated to seize said line for preventing the connector switches at the same exchange from connecting with the line to extend a call thereover, and means controlled by the operated finder switch for rendering the repeater connected to the trunk line at the exchange receiving the call inoperative.

20. In a repeater, incoming and outgoing lines, a line relay, a battery and a line balancing impedance element, said selector, battery, and impedance all connected in series and bridged across said incoming line, said line relay including means for repeating impulses over said outgoing line, means for shunting said impedance element during the operation of said line relay in repeating a series of impulses, said impedance element so connected that it would cause false operation of said line relay from one of its two positions to the other if said shunting means were removed in its entirety at the same instant, and means for removing said shunting means in a plurality of stages to prevent such false operation.

21. A repeater adapted to interconnect a pair of line circuits to transmit control impulses therebetween comprising, a line relay responsive to impulses received over one of said line circuits, a plurality of relays responsive to operation of said line relay from one of its two positions to the other for repeating said impulses over the other of said line circuits, and control circuits for interconnecting said plurality of relays and said line relay, said plurality of relays being so related to each other and to the interconnecting control circuits that the duration of each repeated impulse is independent of the duration of the corresponding impulse causing operation of said line relay.

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