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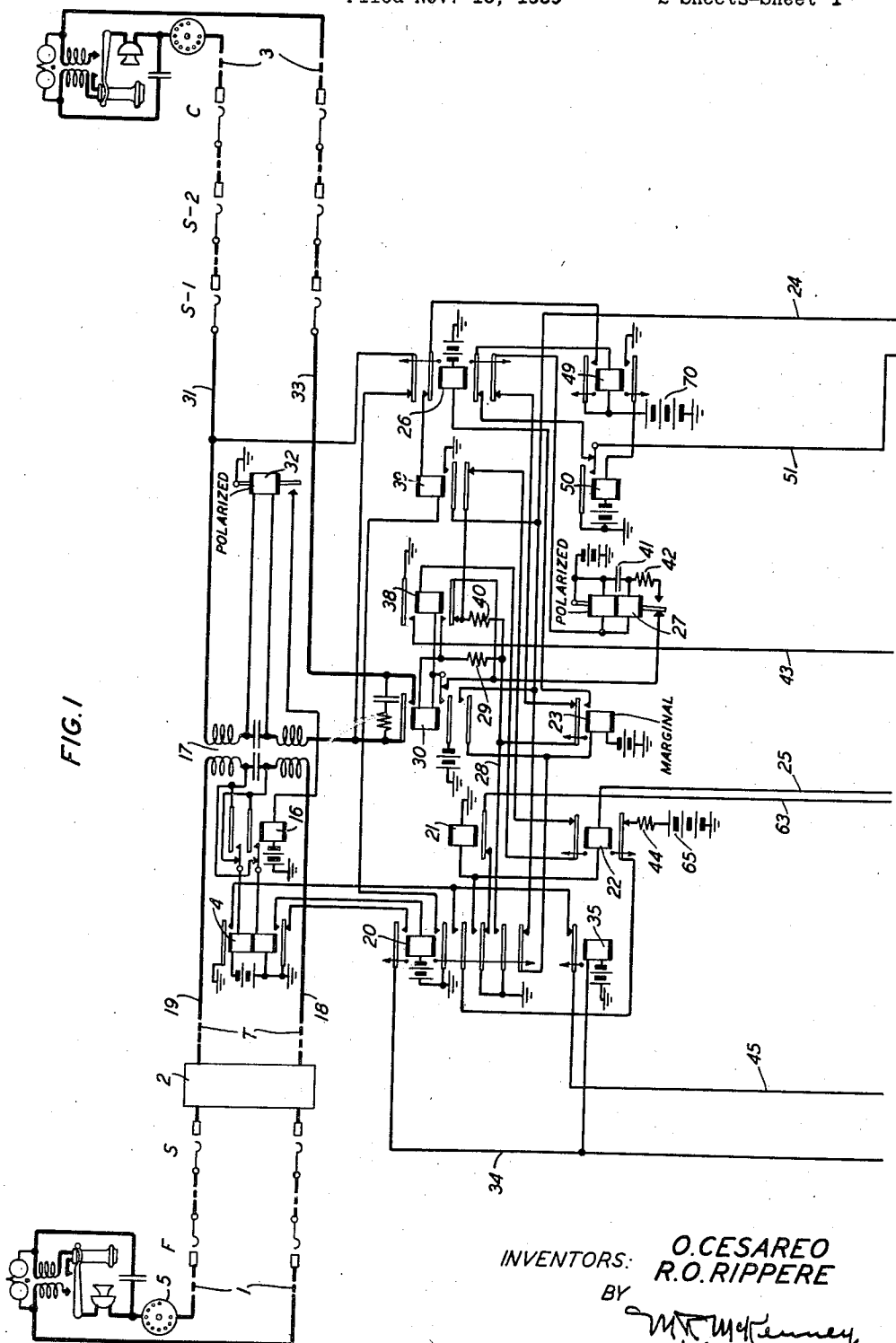
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TELEPHONE SYSTEM

Filed Nov. 15, 1939

2 Sheets-Sheet 1



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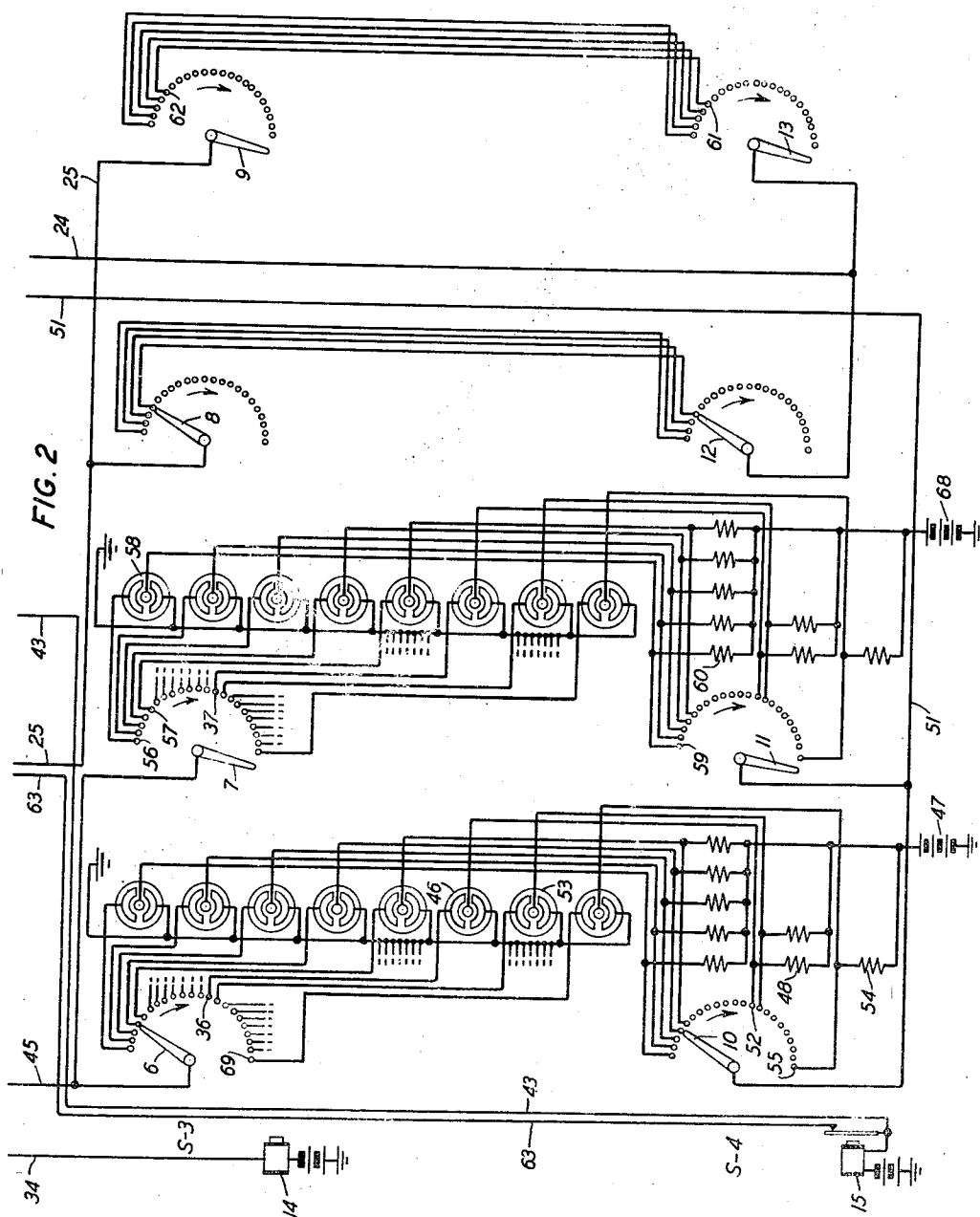
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TELEPHONE SYSTEM

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6 Claims. (Cl. 179—16)

This invention relates to the transmission of impulses and particularly to impulse repeaters used in telephone systems.

The object of the invention is to obtain a greater degree of reliability in the operation of impulse repeaters.

For some purposes it is desirable to use an impulse repeater in which each series of impulses is momentarily stored or registered and is then retransmitted. Usually the incoming series of impulses is registered on a stepping switch which advances and marks a terminal corresponding to the number of impulses, and the number of outgoing impulses is counted by a counting switch which steps over its terminals until it reaches the position marked by the register switch.

According to the present invention the positions to which the registering switch is advanced in response to the successive incoming series of impulses are marked by space-discharge tubes to measure the extent of the corresponding movements of the counting switch in determining the transmission of the outgoing impulse series. One advantage secured by the use of these tubes is that the register switch, having operated the proper tube to mark a position, is free to resume its forward movement at once in response to the next series of impulses. As the counting switch reaches the marked position its movement is arrested by the presence of the operated tube, and the tube is automatically restored to its normal condition. Another advantage in the use of tubes for marking the positions selected by the register switch is that the marking is positive and remains effective until it is encountered subsequently by the counting switch. That the marking, once established, should remain permanently effective until detected by the counting switch is important in the operation of repeaters of this kind, since the counting switch in its movement to control the outgoing impulses may lag considerably behind the register switch, which continues to advance in response to the incoming impulse series.

In the drawings accompanying the detailed specification Figs. 1 and 2 illustrate diagrammatically an automatic telephone system and disclose in detail one embodiment of an impulse repeater incorporating the features of this invention.

The repeater is shown at the incoming end of a trunk T interconnecting an originating automatic office with a terminating automatic office. The originating office includes a line-finder switch

F and a selector S by means of which the calling line 1 is extended over the trunk T to the terminating office. The outgoing end of the trunk T may also be provided with an impulse repeater or with the usual trunk control circuit 2.

The incoming impulse repeater in the terminating office is interposed between the incoming conductors of the trunk T and the first selector switch S—1. The selector switch S—1 has access through succeeding selectors, such as selector S—2, and through connector switch C to called subscribers' lines, such as the line 3. The finder switch F, the selectors S, S—1 and S—2, and the connector switch C may be of any well-known type, such as those generally employed in step-by-step systems.

The incoming impulse repeater includes an impulse receiving relay 4, which responds to the impulses transmitted from the calling subscriber's dial 5. The repeater also includes a register switch S—3 and a counting switch S—4. These switches may be of the well-known step-by-step type in which the brushes have no normal position. Each switch is provided with four brushes and associated arcuate terminal banks and with a stepping magnet. The banks and brushes of each switch are arranged in pairs, the brushes of each pair being positioned on the driving shaft 180 degrees apart so that one brush enters its bank of associated terminals as soon as the other brush of the pair leaves the last terminal of its bank. There are two such pairs in each of the switches; brushes 6 and 7 and brushes 8 and 9, respectively, being paired in the switch S—3, and brushes 10 and 11 and brushes 12 and 13, respectively, being paired in the switch S—4. The stepping magnets 14 and 15 serve respectively to step the brushes of the switches S—3 and S—4, these magnets being arranged to advance the brushes upon deenergization of their coils.

The positions assumed by the brushes 6 and 7 of the register switch S—3 are marked by space-discharge tubes. An individual tube is provided for each terminal position of the brushes 6 and 7. These tubes, which may be of any suitable construction, such as the well-known three-element gas-filled type, have their control electrodes connected to the respective terminals in the switch banks. The anodes of the tubes are connected to the corresponding positional terminals in the banks associated with brushes 10 and 11 of the counting switch S—4. Also the anodes are connected to the sustaining battery through suitable resistance elements. The cathode elements of

the tubes are connected to the grounded pole of battery.

The switch S—3 responds to the incoming series of impulses from the calling office and steps its brushes over a number of terminals corresponding to the number of impulses in the series. The positions assumed by the register switch following the successive series of impulses are marked by firing the tubes connected to the corresponding terminals of the switch. The counting switch S—4, which steps its brushes in unison with transmission of the outgoing impulses, follows the register switch S—3 until it reaches the position marked by the discharged tube. Thereupon the counting switch comes to rest and terminates the transmission of the outgoing impulse series. Depending upon the speed with which the calling party manipulates his dial for each succeeding digit, the counting switch S—4 may or may not reach the marked position before the register switch S—3 moves away from that position in response to the next succeeding series of incoming impulses. Each tube that is fired to mark a terminal position is automatically quenched as soon as the marked position has been reached by the counting switch.

A detailed description will now be given of the operation of the system. For this purpose it will be assumed that the subscriber of line 1 in the originating office wishes to converse with the subscriber of line 3 in the terminating office. It will also be assumed that the directory number of the called line 3 is "9913" and that the register and counting switches S—3 and S—4 of the repeater are standing in position 3 as indicated by their brushes.

The calling subscriber initiates the call in the usual manner and operates the selector switch S by means of his dial 5 to seize an idle outgoing trunk T extending to the desired called office. The trunk control circuit 2 applies the usual guarding potential to the test terminal in the selector S and closes the conductors of trunk T to operate the impulse relay 4 of the incoming repeater. The operating circuit of relay 4 may be traced from battery through the upper winding of the relay, normal contacts of reversing relay 16, lower left winding of repeating coil 17, trunk conductor 18, thence over the loop and returning over trunk conductor 19 through the upper left winding of coil 17 and the normal contacts of relay 16 and the lower winding of relay 4 to ground.

Relay 4 closes an obvious operating circuit for slow-release relay 20. Relay 20 closes a short circuit around the winding of relay 21. Relay 21 and slow-release relay 22 are normally in an energized condition when the switches S—3 and S—4 are standing in the same position. The energizing circuit for these relays may be traced from battery through the winding of slow-release relay 23, normally closed contacts of 20, conductor 24, brush 12, brush 8, conductor 25 through the windings of relays 22 and 21 to ground. Relay 23, however, is marginal and does not operate in series with the resistance of relay 21. The operation of relay 20, therefore, as above noted, closes a short circuit around the winding of relay 21, whereupon relay 21 releases. Relay 20 also opens the circuit above traced for relays 23 and 22.

Relay 20 in operating also closes a circuit from ground over conductor 28 through resistance 29, winding and normal contacts of relay 30 to battery at the left contacts of the pulsing relay 27. Relay 30 operates and locks directly to battery through its lower front contact. Relay 30 at its

upper contact closes the pulsing loop extending to the succeeding switch S—1. This pulsing circuit may be traced from conductor 31 to the upper right winding of repeating coil 17, winding of polarized supervisory relay 32, lower right winding of coil 17, upper contacts of relay 30 to conductor 33. The closure of this circuit prepares the switch S—1 for receiving the next series of impulses. Relay 30 also closes a circuit from battery through the winding of relay 23, contact of relay 30, thence over conductor 24, brushes 12 and 8, conductor 25, winding of relay 22 to ground at relay 20. Relay 23 operates and relay 22 holds in this circuit, relay 21 remaining deenergized. Relay 23 closes an operating circuit of slow-release relay 26 traceable from battery through the winding of the latter relay, front contact of relay 23 to ground at the front contact of relay 20. Relay 26 opens the circuit leading to the windings of the pulse-generating relay 27 to prevent this relay from producing impulses.

When the calling subscriber manipulates his dial to transmit the series of impulses representing the first digit of the called number, namely the digit "9," the impulse relay 4 releases and reoperates in response to each of these impulses. On the first release of relay 4 a circuit is closed from ground through the lower armature and back contact of said relay, front contact of relay 20, conductor 34 and thence in parallel through the windings of slow-release relay 35 and magnet 14 to battery. At the end of the first impulse relay 4 reoperates, and magnet 14 deenergizes to step brushes 6, 7, 8 and 9 to the next position. In like manner the switch S—3 advances in response to each succeeding impulse of the series and finally comes to rest at the end of nine steps in position 12. In this position brush 6 engages the terminal 36. Relay 35 energizes in the circuit above noted and, being slow to release, maintains its armature operated throughout the impulse series.

As soon as the register switch S—4 takes its first step in response to the first impulse, the previously traced circuit for relays 23 and 22 is opened, and these relays release after an interval. Relay 22 closes a circuit from battery through the front contacts of relay, winding of relay 38, contacts of relay 22, closed contacts of relay 39, resistance 40 to ground on conductor 28. Relay 38, however, does not operate at this time since direct battery potential is connected to its winding by way of the closed left contact of the pulsing relay 27, normal contacts of relay 38 and the contacts of relays 39 and 22. When relay 23 releases, as above noted, it opens the operating circuit of relay 26 and this latter relay releases after an interval.

Relays 23 and 36 measure an interval between the commencement of the incoming impulse series and the closure of the operating circuit for relay 27 to commence the outgoing impulse series. The purpose of this interval is to enable the selector switches to perform their trunk hunting operations between digit series. The operating circuit for relay 27, which is closed as soon as both relays 23 and 26 have released, may be traced from battery through the upper or operating winding of relay 27, normal contacts of relays 26 and 23 to the grounded conductor 28. The operating winding of relay 27 tends to move the armature from its left to its right contact but is delayed in doing so by the biasing winding of the relay, which is energized by charging current flowing to the condenser 41. As soon, therefore, as the

condenser 41 is charged, current ceases to flow in the biasing winding, and the operate winding of the relay shifts the armature to the right contact. When the relay 27 opens its left contact, relay 38 operates in the circuit above traced. Also, relay 27 in closing its right contact prepares an obvious discharge circuit for condenser 41 through the resistance 42. As the condenser becomes discharged, current increases in the biasing winding (the interval being measured by the resistance 42) in such a direction that the armature is shifted to its left contact. The engagement of the armature with its left contact results in a circuit from battery through the armature and front contact of relay 38 to the winding of relay 30. This circuit causes the shunting of relay 30, which releases and opens the impulsing circuit extending to the selector S—1. Relay 38 remains energized in a circuit from battery through the armature and left contact of relay 27, normal contacts of relay 30, winding of relay 38 through the contacts of relays 22 and 39 and through resistance 40 to the grounded conductor 28. When the impulse relay 27 again attracts its armature to its right contact, the energizing circuit of relay 38 is opened, and this relay releases. The next release of relay 27 to its left contact closes the original energizing circuit of relay 30, and the latter relay operates to reclose the impulse circuit. This cycle of operations continues, and measured impulses are transmitted over the conductors 31 and 33 to operate the selector switch S—1. For each one of these impulses over the outgoing circuit, relay 38 operates and closes an obvious circuit over conductor 43 to operate the stepping magnet 15 of the counting switch S—4. Switch S—4 takes a step with each impulse transmitted and therefore reaches position 12 upon the transmission of the last or ninth impulse for the first digit of the called subscriber's number.

In the meantime the register switch S—3 has already reached position 12 in response to the incoming series of impulses; and, if the calling party is prompt in transmitting the second digit, the register switch will have advanced out of position 12 before the counting switch reaches this position. Assume this to be the case, namely, that the second series of incoming impulses for the second digit "9" commences before the first outgoing series has been completed. Following the completion of the first series of incoming impulses, relay 35 released to close the tube ionizing circuit for marking the twelfth position of the register switch S—3. This circuit may be traced from the positive pole of battery 65, resistance 44, closed contacts of relay 22, this relay being de-energized at this time, front contacts of relay 20, back contacts of relay 35, conductor 45, brush 6, terminal 36 through the ionizing gap of tube 46 to ground. Although this ionizing circuit is closed when relay 35 releases, the tube is not discharged, since a short circuit is closed at the front contacts of impulse relay 4. As soon, however, as the first impulse of the succeeding series is received, relay 4 opens its contact and removes ground potential from the ionizing circuit, whereupon the tube 46 is immediately discharged. Although this discharge circuit extends through the back contact of relay 35, the tube has ample time to ionize its control gap before relay 35 attracts its armature to open the ionizing circuit. The discharge tube 46 is held in an ionized condition over a circuit extending from the positive pole of the anode battery 47, resistance 48, through the anode and cathode of the tube 46 to ground.

When, therefore, the counting switch S—4 reaches position 12 at the end of the first outgoing series of impulses, it finds the position marked by the discharged tube. This marked condition is detected by the operation of relay 49 in a circuit from the positive pole of battery 70 through the winding of the relay, back contacts of relay 26, normal contacts of relay 50, condenser 51, brush 10, terminal 52 through the discharged tube 46 to ground. Relay 49 operating in this circuit closes a circuit from battery through its contacts, normal contacts of relay 26, winding of relay 39 to ground at the front contacts of relay 20. Relay 39 opens the circuit of relay 38 to prevent further stepping of the switch S—4. Subsequent operation of relay 30, as above described, operates relay 23, the circuit extending through the contacts of relay 30 to ground at the contacts of relay 39. Relay 23 renders the pulse generating relay 27 ineffective and also reoperates relay 26. Thus the impulse generating mechanism is disabled at the termination of the outgoing series, relay 27 maintains its armature on its back contact, and relay 30 is operated and locked as above described to hold the outgoing loop closed. When relay 49 operates as above noted, it closes an obvious circuit for relay 50, which opens the circuit of relay 49 and places ground potential on conductor 51. With ground potential on this conductor a shunt circuit is closed through resistance 48 to quench the tube 46. Relay 49 being slow to release releases its armature after an interval and opens the circuits of relays 39 and 50. Relay 39 opens the energizing circuit of relay 23; and, since the original energizing circuit of this relay through the brushes 12 and 8 is still open, the switch S—3 having resumed its operation in response to the second digit, the relay releases after an interval and causes the release of relay 26. The release of these two relays measures the pause between the first and second digits, giving the switch S—1 time to perform its trunk-hunting operation.

With relays 23 and 26 released, the pulsing relay 27 becomes effective, and outgoing impulses are transmitted for the second digit of the called subscriber's number. In the meantime, the register switch S—3 advances nine steps in response to the second series of incoming impulses and comes to rest in position 21, that is, with its brush 6 resting on terminal 69.

The calling subscriber, continuing to dial, next transmits a single impulse representing the third digit of the wanted number, and the register switch takes a single step as explained and comes to rest in its zero position, namely, with brush 7 in engagement with terminal 56. When relay 4 releases in response to this single impulse, the tube ionizing circuit becomes effective, and tube 53 is fired. The energized tube locks in its anode circuit, which extends from battery 47 through resistance 54. When, a moment later, the counting switch S—4 reaches the twenty-first position, relay 49 operates over the circuit previously traced by way of conductor 51, brush 10, thence over terminal 55 through the discharged tube 53 to ground. Relay 49 causes the cessation of the outgoing impulses for the second digit, and relay 50 operates as explained to quench the tube 53.

Finally the calling party transmits a series of three impulses representing the last digit of the number, and the register switch S—3 advances to its fourth position, namely, with the brush 7 engaging terminal 57. On the first impulse of the last series relay 4 removes ground from the

tube-firing circuit, and this circuit becomes effective to ionize the tube 58, which is connected to the zero position terminal 56 associated with brush 7. The tube 58 is held energized by means of a circuit from the positive pole of battery 68, resistance 60 through the anode and cathode of tube 58 to ground.

After the inter-digital pause is measured between the second and third digits of the number, the impulse mechanism becomes effective to transmit a single outgoing impulse to the connector switch C, and the counting switch S—4 takes a single step bringing its brush 11 into engagement with the zero position terminal 59. Relay 49 operates in the circuit above traced over conductor 51 through brush 11 and terminal 59 and thence to ground through the tube 58. Relay 49 terminates the transmission of the third digit and causes the quenching of tube 58.

In the meantime the register switch S—3 advances as above noted in response to the last digit and comes to rest in position 4. Here it remains, since no further impulses are transmitted from the calling line. After the inter-digital pause between the third and last digits of the number, the impulse generating mechanism commences the transmission of the last series of impulses to the connector switch C, and the counting switch S—4 steps in synchronism therewith until it reaches position 4. When the counting switch reaches position 4, it does not encounter a fired tube, since the impulse relay 4 remains operated following the last digit and maintains the tube-firing circuit ineffective. However, the switches S—3 and S—4 are now standing in the same position at the end of the last digit, and the energizing circuit for relays 23 and 22 is closed when relay 30 operates. This circuit is traceable from battery through the winding of relay 23, front contact of relay 30, conductor 24, brush 13, terminal 61, terminal 62, brush 9, conductor 25, winding of relay 22 to ground at the armature and contact of relay 23. Relay 22 opens the circuit of relay 38 to prevent further stepping of the switch S—4, and relay 23 releases relay 26 as above described.

In the foregoing description it was assumed that the calling subscriber commences the dialing for each succeeding digit before the counting switch S—4 reaches the position marked by the register switch S—3 for the preceding digit. In this case the positions taken by the switch S—3 at the end of each succeeding impulse series are marked by firing the tubes, excepting the last digit, and the counting switch S—4 detects these marked positions by operating the detecting relay 49 when it reaches them. Relay 49 serves to disable the impulse generating mechanism and to quench the fired tubes. In the case of the last digit the tube corresponding to the position reached by the register switch S—3 is not fired, since the ionizing circuit is disabled, and the arrival of the counting switch in the final stopping position of switch S—3 is detected by the operation of relay 22, the circuit of which is closed whenever both switches S—3 and S—4 are standing in the same position. Relay 22, in operating, likewise disables the impulse generating mechanism to prevent the transmission of further impulses and to prevent stepping of the counting switch. It is possible, however, that the calling subscriber may delay the transmission of each succeeding digit until the counting switch S—4 has reached the stopping position of the register switch S—3 for the preceding digit.

If so, the stopping positions of switch S—3 are detected in the manner above described for the last digit of a number.

When the connection is completed through to the called line 3 and the called subscriber answers, current is reversed over the conductors 31 and 33 in the well-known manner, and polarized supervisory relay 32 operates. Relay 32 operates relay 16, which in turn reverses the direction of current flowing over the trunk T to the originating office. This current reversal serves in the well-known manner to operate supervisory apparatus in the calling office.

When the subscribers replace their receivers at the end of conversation, relays 4, 32 and 16 release. Relay 4 also causes the release of relay 20, which in turn releases relay 23. Relays 22 and 21 now operate in the circuit hereinbefore traced and remain operated until the repeater is taken for its next use.

Should the repeater be released while the switches S—3 and S—4 are out of synchronism, that is, while these switches are occupying different positions, a circuit is prepared for automatically moving the counting switch S—4 back into synchronism with the switch S—3. This circuit may be traced from battery through the winding and contacts of magnet 15, conductor 63, through the back contacts of relays 21 and 20 to ground. As soon as switch S—4 reaches the position occupied by switch S—3, the previously-traced circuit is closed and relay 21 operates to open the stepping circuit of magnet 15.

While the invention is disclosed in an incoming impulse repeater it is equally applicable to outgoing repeaters. Also, these repeaters may be used in various types of systems and are not limited to the particular system illustrated herein. Furthermore, it will be apparent that various types of discharge tubes may be used for marking the positions in the register and counting switches. For instance, tubes of the well-known two-element type may be employed if desirable.

What is claimed is:

1. In a telephone system, a repeater comprising a register switch for registering a series of incoming impulses, an impulse transmitter for generating and transmitting a series of outgoing impulses, a counting switch for counting a series of outgoing impulses, means controlled by said impulse transmitter for operating said counting switch, a series of discharge tubes for the successive positions of said switches, each tube having its electrodes connected to the corresponding position terminals of both said switches, means effective following the completion of an impulse series to discharge one of said tubes to mark the position to which said register switch was set in response thereto, and means controlled through the discharged tube and a terminal of said counting switch to terminate the series of outgoing impulses when said counting switch is advanced to the position corresponding to the position taken by said register switch.

2. In a telephone system, a repeater comprising a register switch, means responsive to a plurality of successive incoming impulse series for advancing said switch progressively over its terminals in a corresponding number of consecutive movements to register said impulse series, a counting switch for counting the successive series of outgoing impulses corresponding to said incoming series, an impulse mechanism for generating and transmitting said outgoing impulses,

a series of discharge tubes for the successive positions of said switches, each tube having its electrodes connected to the corresponding position terminals of both switches, means effective after each impulse series for discharging a tube to mark the position assumed by said register switch, and means effective when the counting switch reaches each marked position for disabling the impulse generating mechanism and for stopping the advance of said counting switch.

3. In a telephone system, a repeater comprising a register switch, means responsive to a plurality of successive incoming impulse series for advancing said switch progressively over its terminals in a corresponding number of consecutive movements to register said impulse series, a counting switch for counting the successive series of outgoing impulses corresponding to said incoming series, an impulse mechanism for generating and transmitting said outgoing impulses, a series of discharge tubes for the successive positions of said switches, each tube having its electrodes connected to the corresponding position terminals of both switches, means effective after each impulse series for discharging a tube to mark the position assumed by said register switch, means effective when the counting switch reaches each marked position for disabling the impulse generating mechanism and for stopping the advance of said counting switch, and timing means for measuring an inter-digital pause between successive movements of said counting switch.

4. In a telephone system, a repeater comprising a register switch for registering a series of incoming impulses, an impulse transmitter for generating and transmitting a series of outgoing impulses, a counting switch for counting a series of outgoing impulses, means controlled by said impulse transmitter for operating said counting switch, a series of discharge tubes for the successive positions of said switches, each tube having its electrodes connected to the corresponding position terminals of both said switches, means effective following the completion of an impulse series to discharge one of said tubes to mark the position to which said register switch was set in response thereto, means controlled through the discharged tube and a terminal of said counting switch to terminate the series of outgoing impulses when said counting switch is advanced to the position corresponding to the position taken by said register switch, and means

controlled by said counting switch for restoring each discharged tube to normal as soon as the counting switch has reached the position marked by such tube.

5. In a telephone system, a repeater comprising a register switch for registering a series of incoming impulses, an impulse transmitter for generating and transmitting a series of outgoing impulses, a counting switch for counting a series of outgoing impulses, means controlled by said impulse transmitter for operating said counting switch, a plurality of gas-filled tubes having their control elements connected respectively to terminals of said register switch and having their cathodes connected to a source of potential, means operative after the receipt of said incoming impulse series to apply a potential to the control element of one of said tubes to cause said tube to fire to mark the position to which said register switch was set in response thereto, and means controlled over the conducting path through said fired tube and a bank terminal of said counting switch to terminate the series of outgoing impulses when said counting switch is advanced to a terminal position corresponding to the set position of said register switch.

6. In a telephone system, a repeater comprising a register switch for registering a series of incoming impulses, an impulse transmitter for generating and transmitting a series of outgoing impulses, a counting switch for counting a series of outgoing impulses, means controlled by said impulse transmitter for operating said counting switch, a plurality of gas-filled tubes having their control electrodes connected respectively to bank terminals of said register switch, having their anodes connected respectively to corresponding bank terminals of said counting switch and having their cathodes connected to a source of potential, means operative after the termination of said incoming impulse series to apply ground potential to the control electrode of one of said tubes to cause said tube to fire to mark the position to which said register switch was set in response thereto, and means controlled over the cathode-anode circuit of said fired tube to terminate said series of outgoing impulses when said counting switch is advanced to the terminal thereof to which the anode of the fired tube is connected.

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