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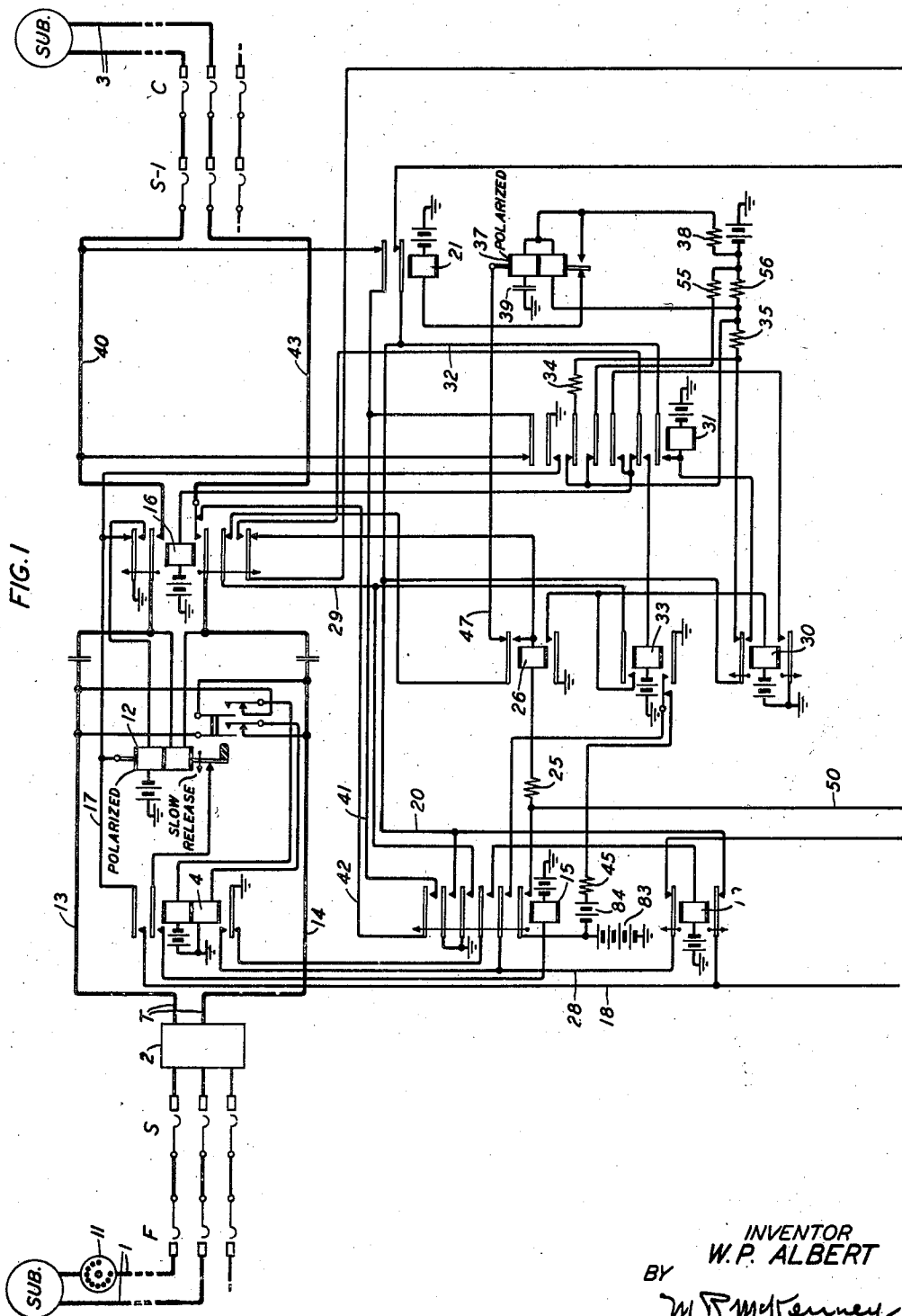
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2,248,212

TELEPHONE SYSTEM

Filed Nov. 15, 1939

3 Sheets-Sheet 1



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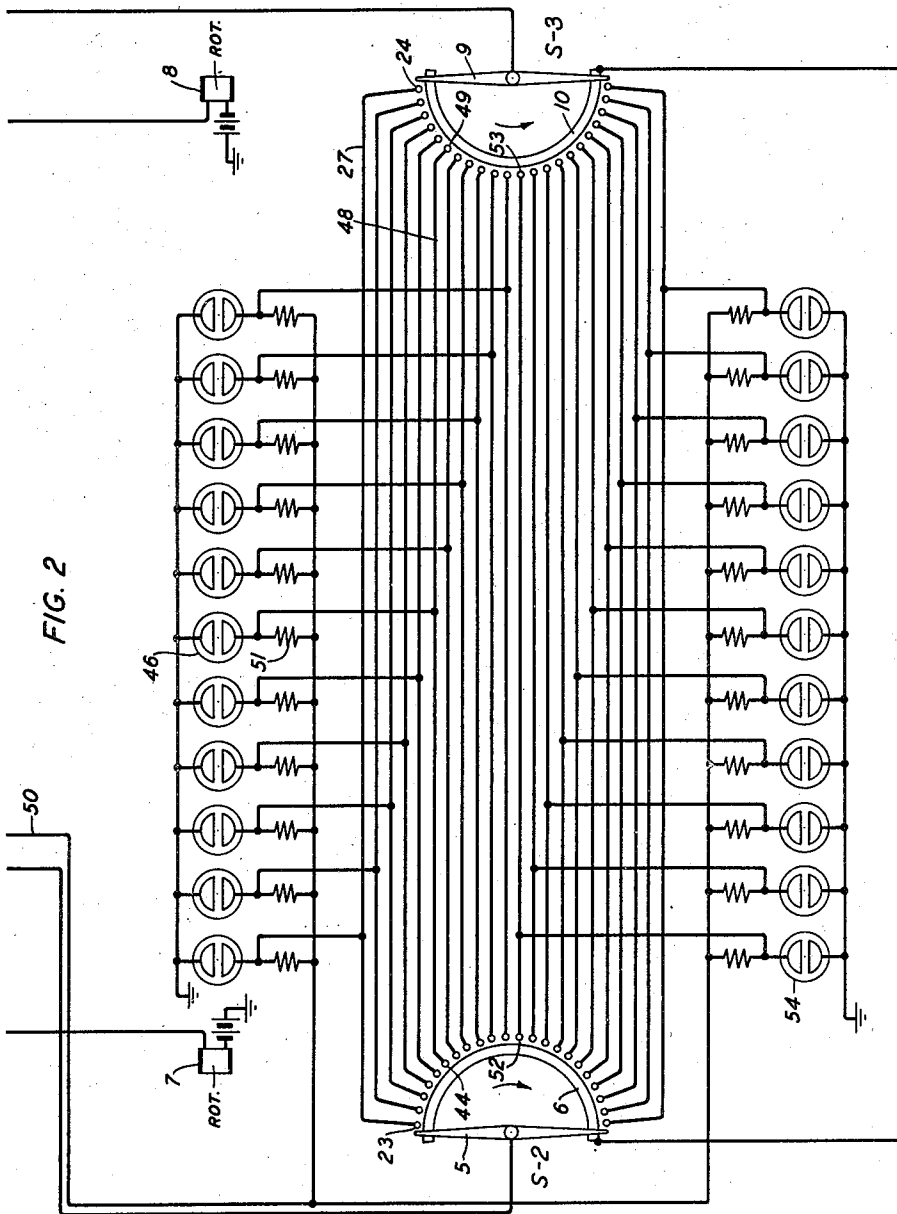
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3 Sheets-Sheet 2



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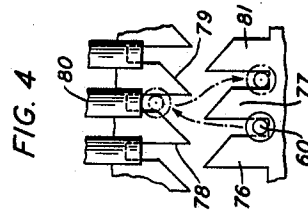
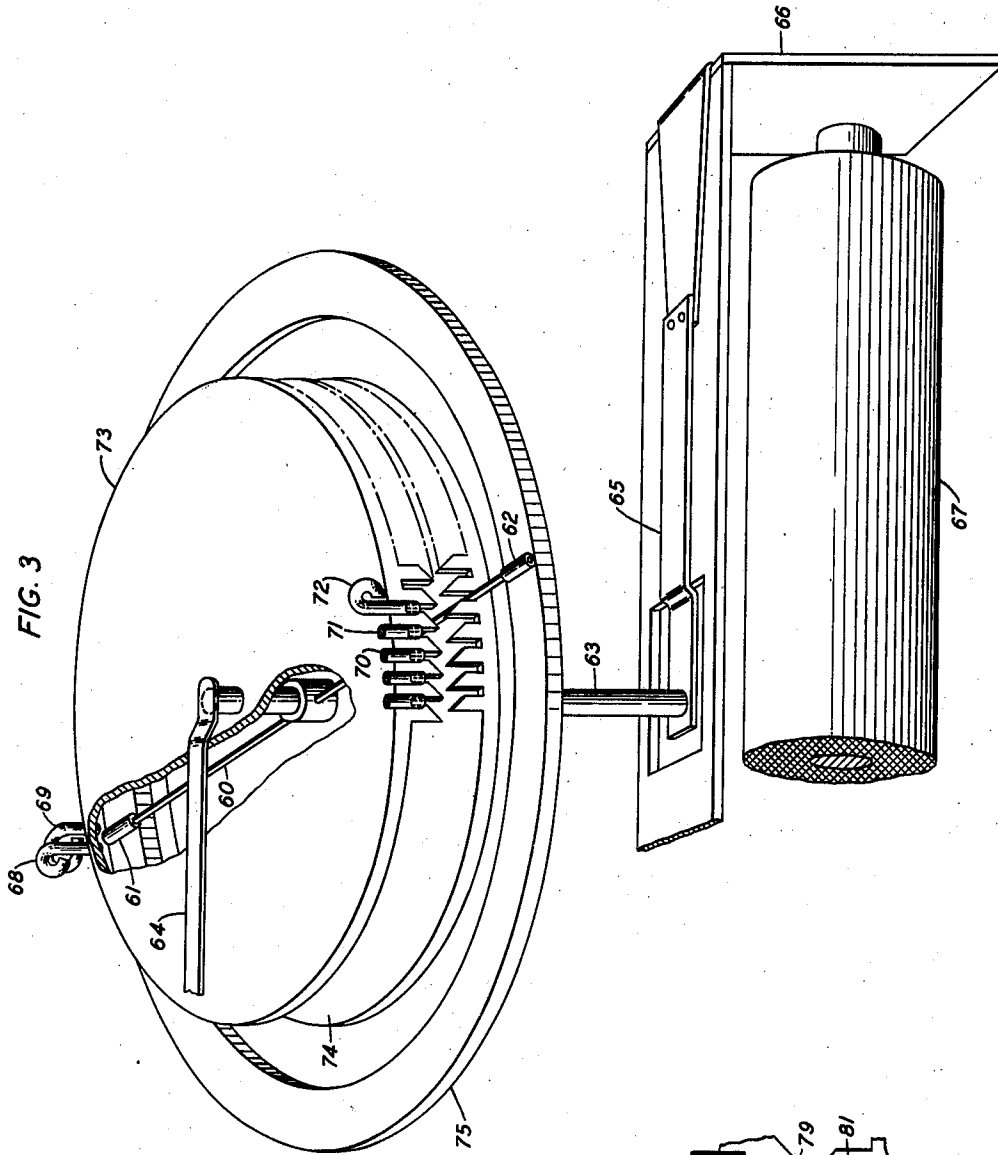
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TELEPHONE SYSTEM

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3 Sheets-Sheet 3



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2,248,212

TELEPHONE SYSTEM

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12 Claims. (Cl. 179—16)

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

The objects of the invention are to simplify the structure and the operation of impulse repeaters; to improve the registration and counting of the impulses; to enable the immediate seizure of a repeater following its previous use without danger of false operation; and otherwise to improve these devices.

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 with necessary corrections for distortion. 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. Since the register switch may advance at a faster rate than the counting switch, it is necessary to provide some means to maintain the stopping position of the register switch in a marked condition after said switch has moved away from that position.

Also it is desirable in a repeater of this kind that the register switch be capable of starting from any position of rest in response to an incoming series of impulses, and that the counting switch commence its counting operation in the position corresponding to the starting position of the register switch. This requirement is, of course, fulfilled if both switches are left standing in corresponding positions after each use of the repeater. However, it is possible under some conditions for these switches to stop in positions that do not correspond, particularly if the call is abandoned during the transmission of an impulse series. In such a case it is necessary to provide special means for bringing the counting switch back into phase with the register switch before the repeater is available for the next use. Should the trunk including the repeater be unguarded during this interval of adjustment, a seizure of the trunk for a new call might result in mutilation of an impulse series. On the other hand, if the trunk is guarded artificially during the time the counting switch is advanced into phase with the register switch, the usefulness of the trunk is considerably impaired.

According to a feature of the present invention advantages are secured over these prior arrangements by a repeater in which the positions of

the register switch are marked primarily by means including the movable contacts of the switch standing in these positions, and in which the marking is performed by a secondary means, such as discharge tubes, as soon as the register switch leaves any one of its marked positions before the counting switch has reached such position. This provision makes it unnecessary to use the tube marking means as long as the counting switch is able to reach each significant position of the register switch before the latter moves out of that position.

A further feature of the invention is a repeater of the kind above described provided with means whereby the same terminal series of the register and counting switches that are used for registering and counting the incoming and outgoing impulses are also utilized to maintain these switches in their proper phase relation. This arrangement dispenses with additional terminal banks for these switches and simplifies accordingly the equipment needed for the repeater. The single terminal rows of the register and counting switches have their corresponding terminals multiplied, and a series of discharge tubes are connected to these multiples for the purpose of marking the starting and stopping positions of the register switch. The counting switch, which is set in operation in response to the incoming impulse series, hunts for the marked positions and controls the transmission of a number of outgoing impulses corresponding to the number of steps taken by the register switch.

Another feature of the invention is an arrangement in which the counting switch, if out of phase with the register switch when the repeater is seized, is advanced at a relatively high rate of speed until it reaches the starting position of the register switch. During this preliminary movement of the counting switch no outgoing impulses are transmitted. Having reached the starting position of the register switch, the counting switch pauses and then, if the register switch had advanced, proceeds at a slower rate until it reaches the marked stopping position of the register switch, and during this second advance the counting switch controls the sending of impulses over the outgoing line. It is possible, therefore, that the counting switch will not overtake the register switch, that is, that the synchronism of these switches will not be restored until the incoming impulses have been received and registered by the register switch. With this arrangement it is possible to re seize the repeater without delay, whether the switches are in phase

or out of phase, and without any danger of mutilating a series of incoming impulses.

These and other features of the invention will be described in detail in the following specification; also they will be each set forth in the appended claims.

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

Figs. 3 and 4 disclose the structure of the stepping switches used in the impulse repeater.

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 I 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, if needed, and through the connector switch C to called subscribers' lines, such as the line 3.

The incoming impulse repeater includes an impulse receiving relay 4 which responds to impulses transmitted from the calling subscriber's dial. The repeater also includes a register switch S-2 and a counting switch S-3, each of which comprises a single row of stationary terminals, a stationary contact segment and a movable contact. These switches have no normal position, the movable contact being capable of starting from any position and advancing to any stopping position. The movable contact, such as the contact 5 of switch S-2, engages the stationary segment 6 at a point intermediate to consecutive stationary terminals of the switch. The stepping magnet 7 when energized disengages the movable contact 5 from the segment 6 and moves it into engagement with the next stationary terminal. The following deenergization of the magnet 7 causes the movable contact 5 to step out of engagement with the stationary terminal and into engagement with the segment 6. This action continues for each energization and deenergization of the magnet 7. In a similar manner the magnet 8 of the switch S-3 causes the advance of the movable contact 9 over the row of stationary terminals and the engagement of the contact 9 with the stationary segment 10 in each resting position of the movable contact 9.

The individual terminal in each position of the switch S-2 is multiplied to the corresponding terminal of switch S-3, and the multiple is connected to one electrode of a two-element gas-filled discharge tube. Twenty-two of these gas-filled tubes are illustrated, one for each of the twenty-two positions of the switches. These tubes mark the terminal positions of the switches, the designation being obtained by firing the tube connected to the position on which the register switch S-2 pauses between digits and to which it is desired to advance the counting switch S-3.

The feature, disclosed herein, of utilizing discharge tubes for marking the switch positions to determine the number of impulses to be sent is claimed in the patent to Cesareo and Rippere, No. 2,236,499 of April 1, 1941.

While the invention is disclosed in an incoming impulse repeater, it is equally applicable to outgoing repeaters. Moreover, these repeaters may be used in various types of systems and are not limited to the particular system illustrated herein.

Before proceeding with a discussion of the repeater circuits a description will be given of Figs. 3 and 4 of the drawings, which illustrate a structure suitable for the switches S-2 and S-3. The single movable contact 60 of the switch, which corresponds to the contact 5 of switch S-2 and the contact 9 of the switch S-3, consists of a wire having enlarged conducting tips 61 and 62 attached to its ends. The contact wire 60 is secured to a shaft 63 which is normally held by the spring 64 in its downward position against the operating lever 65 attached to the armature 66 of the electromagnet 67. The stationary terminals, such as the terminals 68, 69, 70, 71 and 72 are arranged in a circular row around the shaft 63 and are insulated from each other and from the movable contact 60. There may be as many of these terminals as is desired. For example, there may be forty-four stationary terminals arranged in a complete circle around shaft 63. Half of the forty-four terminals may be used, as illustrated in Fig. 2 of the drawings, or the full row of terminals may be used by connecting diametrically opposite terminals together to give parallel contacts for the associated circuit closures.

The rotary stepping motion of the movable contact 60 is caused by series of teeth which present camming surfaces to the contact wire 60. There are two opposing rows of these cam-shaped teeth. The upper row of teeth is formed integrally with the disc 73 which is secured to the frame of the structure in such a way that the successive stationary terminals 70, 71, 72, etc., align with the spaces between the successive teeth of the disc. The lower row of teeth, similarly formed integral with the disc 74, is positioned in offset relation with respect to the corresponding teeth of the upper row. This relation is best seen in the detail of Fig. 4. The switch also includes a conducting ring or segment 75 so disposed that the conducting tips 61 and 62 rest on the surface thereof when the stepping shaft 63 is in its normal or lowermost position.

Normally, when the magnet 67 is deenergized and the shaft 63 is in its lower position, the movable contact 60 lies between adjacent teeth in the lower row and is in electrical engagement with the conducting segment 75. Assume, for example, that the contact wire 60 is at this time resting between the two adjacent teeth 76 and 77. When the magnet 67 is energized, its armature 66, acting through the lever 65, moves the shaft 63 and contact 60 upwardly against the tension of the restoring spring 64. In its upward movement the contact wire 60 engages the slanting surface of the tooth 78 in the upper row, causing the wire 60 to rotate until it passes into the slot formed by the tooth 78 and the adjacent tooth 79. The continued upward movement of the wire 60, after having entered the slot, causes it to come to rest in engagement with the stationary terminal 80 and, of course, into engagement with the corresponding terminal which lies diametrically opposite the terminal 80. When the magnet 67 is subsequently deenergized, the restoring spring 64 moves the shaft 63 and the contact wire 60 downwardly, whereupon the contact wire 60 engages the slant-

ing surface of the tooth 77 in the lower row and rotates until it enters the slot formed by the tooth 77 and the next tooth 81, coming finally to rest with the rollers 61 and 62 in engagement with the conducting segment 75. With each succeeding energization and deenergization of the magnet and movable contact 60 advances in a step-by-step manner around the circular row of stationary terminals.

Referring now to Figs. 1 and 2, a detailed description will be given of the operation of the system. For this purpose it will be assumed that the subscriber of line 1 in an originating telephone office wishes to converse with the subscriber of line 3 in a distant or terminating telephone office. The calling subscriber initiates the call in the usual manner and operates the selector switch S by means of his dial 11 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 at the distant office. The operating circuit of relay 4 may be traced from battery through the upper winding of the relay, normal contacts of relay 12, trunk conductor 13 thence over the loop and returning over trunk conductor 14 through normal contacts of relay 12 and the lower winding of relay 4 to ground.

When relay 4 operates, it closes a circuit for the slow-release relay 15 traceable from battery through the winding of the latter relay, closed contacts of relay 4, normal contacts of relay 12 to ground at the back contact of relay 16. Relay 4 also closes parallel circuits for the immediate energization of magnets 7 and 8 and for relay 37. The circuits for magnets 7 and 8 may be traced from ground through the back contact of relay 16, conductor 17, closed contact of relay 4, conductor 18 thence in parallel through the winding of magnet 7 and through the back contact of slow-release relay 19, conductor 20, normal contact of relay 21 through the winding of magnet 8 to battery. Magnet 7 disengages the movable contact 5 from the segment 6 and advances it into engagement with the next individual terminal which is assumed to be the zero position terminal 23. It will also be assumed at this time that the switch S-3 was left in phase with switch S-2 following the preceding use of the repeater. Therefore, the energization of magnet 8 moves the contact 9 out of engagement with segment 10 and into engagement with the zero position terminal 24. As soon as relay 15 operates an instant later, a substitute energizing circuit is closed for magnet 8. This circuit may be traced through normal contacts of relay 21 and over the conductor 20 to ground at the front contact of relay 15. The circuit for relay 37 may be traced from conductor 20, normal contacts of relay 30, thence in parallel through resistances 34 and 35, through the lower or operating winding of polarized relay 37, resistance 38 to battery. This circuit causes relay 37 to move its armature away from its left contact before relay 15 operates and connects ground to the armature of relay 37, thus insuring against false operation of the pulse relay 21.

Since the switches S-2 and S-3 are in phase, a circuit is traceable from the positive pole of 110-volt battery 83, contacts of relay 15 resistance 25, winding of relay 26, back contacts

of relay 16, contact 9, terminal 24, multiple wire 27, terminal 23, contact 5, back contacts of slow-release relay 19, conductor 28 to ground at the front contact of relay 4. Relay 26 operates in this circuit and locks in a circuit through its front contact and armature through a back contact of relay 16, conductor 29 to ground at the front contact of relay 15. Relay 26 closes an obvious operating circuit for slow-release relay 30. Relay 30 operates relay 31 in a circuit from battery through the winding of the latter relay, front contacts of relay 30 to the grounded conductor 20. Relay 31 locks in a circuit from battery through its winding and front contact, conductor 32 to the grounded conductor 20. A circuit is now closed for slow-release relay 16. This circuit may be traced from battery through the winding of the relay, front contacts of relay 31 to ground at the front contacts of relay 30. With relays 31 and 16 operated, and since the switches S-2 and S-3 are in phase, an operating circuit is closed for relay 33. This circuit may be traced from battery through the winding of relay 33, front contacts of relays 31 and 16 thence through the contacts of switch S-3 and S-2 to the grounded conductor 28. Relay 33 disconnects the 140-volt battery 83 and 84 from conductor 28 to prevent the firing of a tube when the switch S-2 starts to advance. Relay 33 also locks to ground at its own front contact independent of the ground supplied to the conductor 28 at the front contact of relay 4. Relay 33 also closes a holding circuit for relay 30 traceable from battery through the winding of the latter relay, front contacts of relay 33 to ground at the contacts of relay 15. This circuit holds the relay 30 independently of relay 26, which now releases because its operating and locking windings are both opened by the energized relay 16. When relay 16 operates it opens the original energizing circuit of magnet 7, but the magnet is maintained energized in a circuit traceable over conductor 17 through the front contacts of relay 31 to ground.

When relay 15 first operates, it closes a supplemental circuit by way of ground over its front contact, conductor 20, normal contacts of relay 30 thence in parallel through resistance 34 and resistance 35 through the lower or operating winding of relay 37, resistance 38 to battery. As above noted, current flowing in this direction through the operating winding of relay 37 holds the armature of the relay away from its left contact and right contact in order to place the relay in condition for pulsing before ground potential is connected to the armature thereof as will be explained below. The connection of ground potential through the operating winding of relay 37 to the junction point of the two windings causes the condenser 39 to discharge partially through the biasing winding aiding in movement of the armature to the right contact. This condenser was previously charged in a circuit from battery through resistance 38 through the upper or biasing winding of relay 37 to the condenser to ground.

Also at the time relay 15 first operates, the outgoing pulsing circuit to the switch S-1 is closed to prepare the switch S-1 for receiving the repeated series of impulses. The outgoing pulsing circuit may be traced from conductor 40 through the back contacts of relays 21 and 31 in parallel, conductor 41, front contacts of relay 15, conductor 42, normal contacts of relay 16 to conductor 43. When relay 31 subsequently operates,

as above described, one of the parallel branches of the pulsing circuit is opened, the circuit remaining closed, however, at the normal contacts of pulsing relay 21. When, still later, relay 16 operates, the pulsing circuit is opened temporarily, but the impulse relay associated with the selector S—1 is maintained in its energized condition over a circuit which is closed prior to the opening of the pulsing circuit. This holding circuit is traceable from conductor 40 through the front contacts of relay 16, winding of polarized supervisory relay 12, front contacts of relay 16 to conductor 43, the front contacts of relay 16 being adjusted to close prior to the opening of its normal contact. Relay 12, however, does not operate at this time since current flows in the wrong direction.

When the incoming series of impulses commences, relay 4 releases in response to the first impulse and opens the energizing circuit of magnet 7 and at its back contacts closes an obvious operating circuit for slow-release relay 19. Relay 19 opens the circuit leading to the movable contact of switch S—2 and also opens the holding circuit of the magnet 7. Magnet 7 deenergizes and steps contact 5 forward to an intermediate position and the subsequent energizing of magnet 7 will step contact 5 to the No. 1 position terminal. For each succeeding impulse in the series, relay 4 responds, and the magnet 7 is energized and deenergized to advance the contact 5 from one terminal to the next. Assuming that the first series comprises five impulses, the contact 5 is stepped into engagement with the fifth position terminal 44, the magnet 7 being held energized following the termination of the series over the circuit above traced through the front contact of the impulse relay 4. After the impulse series is terminated and relay 4 maintains its armatures attracted for an interval, slow-release relay 19 releases and closes the tube-firing circuit, which may or may not result subsequently in the firing of the particular tube selected by the contact 5, depending, as will be explained herein-after, upon the rapidity with which the subscriber transmits the succeeding series of impulses. The tube-firing circuit may be traced from the positive terminal of 140-volt battery 83, resistance 45, normal contacts of relay 33, relay 33 having released as will be described presently, closed contacts of relay 15, conductor 28, closed contacts of relay 19, contact 5, terminal 44, electrodes of discharge tube 46 to ground. The tube 46 does not discharge at this time because it is shunted by the ground connection from conductor 28 to the front contact of relay 4, which is now energized during the interval between digits. Resistance 45 is relatively high to prevent excessive current flow in the shunt circuit.

When switch S—2 takes its first step in response to the first impulse of the incoming series, the counting switch S—3 is set in motion after a time interval to follow switch S—2, counting the outgoing impulses until it reaches the stopping position marked by the switch S—2. The stopping position for switch S—3 is marked by the presence of switch S—2 in that position until the latter is in the act of advancing on the second series of impulses. At that time it marks the stopping terminal by firing the tube on which the pause between digits was made but only if switch S—3 has not yet reached the terminal. When relay 19 opens its top contacts before switch S—2 takes its first step, disengaging the terminal 23, it opens the circuit above traced which has been

holding the relay 33 energized and by the same contact opens the firing circuit of the tubes before relay 33 releases. Relay 33 releases and opens the holding circuit of slow-release relay 30. Relay 30 releases after an interval and opens the circuit of slow-release relay 16, which releases after a further interval. When relay 16 releases, the outgoing series of impulses is commenced, and the movement of switch S—3 begins. The releasing time of relays 30 and 16 introduces an interval between the start of switch S—2 and the start of switch S—3 to insure that the latter does not overtake the former switch during the impulse series.

When relay 30 releases, as noted, the grounded conductor 20 is extended through the back contacts of relay 30, resistance 35 through the operating winding of relay 37, resistance 38 to battery. The armature of the relay 37 again is moved to or is maintained against its right contact by the flow of current through the operating winding in this direction, and it will be noted that the parallel resistance 34 is now excluded from the energizing circuit. A moment later, when relay 16 releases, the grounded conductor 29 is extended through the back contacts of relay 16, back contacts of relay 26, conductor 47, armature and right contact of relay 37 through the biasing winding of relay 37 to the condenser 39. Also the application of ground potential to the junction point of the relay windings causes a reversal of current in the operating winding, tending to operate the armature to the left contact. The circuit for the flow of current in the reverse direction may be traced from battery, resistance 56, through the lower winding of relay 37, to ground at the junction point. The operating winding, however, is opposed by the flow of current through the biasing winding while the condenser 39 is being discharged. It will be noted that the condenser is normally in a charged or partially charged condition by means of a circuit through resistance 38 and the upper winding of relay 37. When the condenser approaches a condition of discharge, the operating winding of relay 37 moves the armature to the left contact, and the impulse relay 21 is operated to open the outgoing circuit for the transmission of the first outgoing impulse. The relay 16 having released as above described, the outgoing impulse circuit at this time extends through the closed contacts of relay 16 and the closed contacts of relays 15 and 21. Relay 21 in operating also deenergized the magnet 8 to step the contact 9 off the terminal 24 and to a position intermediate the terminal 24 and the next position terminal. When the armature of relay 37 leaves its right contact, current reversal in the operating winding tends to move the armature back to its right contact. However, the operating winding is opposed at this time by charging current flowing through the biasing winding to condenser 39. The charging of the condenser measures the open period of the outgoing impulse, and, when the condenser has reached a state of charge, the operating winding of the relay overcomes the biasing winding, and the armature is attracted to its right contact. Relay 21 now releases and recloses the impulse circuit to terminate the first impulse. Relay 21 also energizes magnet 8, and contact 9 is stepped into engagement with the next individual terminal. This impulsing and stepping operation continues until the movable contact 9 reaches

the position marked by the switch S—2 at the termination of the first impulse series.

The position to which the switch S—2 advances at the end of the first impulse series may be marked in either one of two ways. So long as the contact 5 remains standing on the terminal 44, to which it advances in response to the impulse series, this position is marked by the presence of a ground potential on the multiple wire 48 and on the corresponding terminal 49 in the switch S—3. If, therefore, the subscriber is somewhat slow in transmitting the next digit to cause the second advance of switch S—2, switch S—3 will reach terminal 49 while switch S—2 is still standing on terminal 44, and the switch S—3 recognizes this stopping position by the presence of a direct ground potential on the terminal 49. On the other hand, if the subscriber is fast with the manipulation of his dial for the second digit, the contact 5 will step away from the terminal 44 before the switch S—3 arrives on the terminal 49. In this case the circuits are so arranged that the corresponding tube 46 is fired over the contact 5 of which S—2 just before the switch leaves terminal 44, and the tube remains in a discharged condition to provide the ground potential to mark the terminal 49, which the switch S—3 will recognize when it subsequently arrives in that position. The operating conditions for both slow and fast dialing will now be explained.

Assume first that the subscriber is slow in manipulating his dial for the second digit. In this case the switch S—3 will, as explained, reach the terminal 49 while switch S—2 is still standing on terminal 44. A circuit is now closed for the detecting relay 26, traceable from the positive pole of 110-volt battery 83, contacts of relay 15, resistance 25, relay 26, back contact of relay 16, contact 9, terminal 49, conductor 48, terminal 44, contact 5, back contact of relay 19 to the grounded conductor 28. Relay 26 operates in this circuit and locks through its armature and contact and a back contact of relay 16 to the grounded conductor 29. Relay 26 in operating removes ground from conductor 47 to stop the pulsing operation by relays 37 and 21. It will be noted that the armature of relay 37 is left in engagement with its right contact at this time. Relay 26 also operates relay 30, which in turn reoperates relay 16. Since switches S—2 and S—3 are now in phase, the previously traced circuit is closed for reoperating relay 33, this circuit extending through the contacts 9 and 5 to ground over conductor 28. Relay 16 releases relay 26, but relay 30 holds through the closed contact of relay 33 to the grounded conductor 29. When relay 33 operates, it prevents the firing of the tube when switch S—2 is about to leave terminal 44 on the next series of pulses. The repeater has now reached a stable condition, the first series having been received and retransmitted, and the repeater remains in this condition until the commencement of the next series of impulses.

Assume next that the subscriber is fast in the manipulation of his dial for the second series of impulses, namely, that the first impulse is received before the switch S—3 reaches terminal 49. When the front contacts of relay 4 are opened in response to the first impulse of the second series, the ground shunt is removed, and tube 46 discharges over the circuit previously traced by way of contact 5 and terminal 44. Having discharged, the tube 46 is held in an ion-

ized condition by a circuit traceable from the positive pole of 110-volt battery 83, contact of relay 15, conductor 50 through the high resistance element 51 and the tube 46 to ground.

Also the opening of the front contacts of relay 4 deenergizes the magnet 7 to step the contact 5 off the terminal 44. When the relay 4 closes its back contacts in response to the first impulse, relay 19 reoperates and opens the tube discharge circuit. It will be noted that the firing of the tube to mark the stopping position of the switch S—2 at the end of the impulse series is delayed until the switch is about to take its first step in response to the succeeding impulse series. This arrangement economizes in the use of the tubes since it gives the switch S—3 an opportunity to overtake the switch S—2, thus making it unnecessary to fire the tube, and furthermore, since it reduces to a minimum the interval during which the high firing voltage is applied to the tube when discharge is necessary. For each succeeding impulse in the second series the relay 4 and magnet 7 release and reoperate, and the contact 5 advances from one position to the next. Assuming that the second series comprises six impulses, the contact 5 comes to rest on terminal 52.

Returning now to the operation of switch S—3, it will be recalled that this switch commences to step soon after the beginning of the first series of incoming impulses. The switch continues to step, and outgoing impulses are transmitted as described until the contact 9 reaches terminal 49. Under the present assumption the switch S—2 has already left the corresponding terminal 44, but the tube 46 is in a discharged condition marking this position. When, therefore, contact 9 engages terminal 49, a circuit is closed for the test relay 26. This circuit may be traced from battery 83, contact of relay 15, resistance 25, relay 26, back contact of relay 16, contact 9 and terminal 49 of switch S—3, multiple conductor 48 through the discharged tube 46 to ground. This circuit including relay 26 is in parallel with a circuit through high resistance 51 to tube 46, but sufficient current flows in this circuit to operate the test relay 26. The operation of relay 26 terminates the pulsing as above described and stops the stepping movement of the switch S—3. Relay 26 also closes a locking circuit from the positive pole of battery 83 through the contact of relay 15, resistance 25, winding and front contact of relay 26, back contact of relay 16 to ground on conductor 29. Relay 26 also closes a circuit for quenching the tube 46 traceable from the grounded conductor 29 through the back contact of relay 16, locking contact of relay 26, back contact of relay 16, contact 9, terminal 49, conductor 48 to one electrode of the tube 46, the other electrode also being connected to ground. Relay 26 causes the successive operation of relays 30 and 16 as hereinbefore described, and relay 16, in turn, causes the release of relay 26.

Relay 26, having released following the completion of the counting operation of the switch S—3 for the first digit, and relay 33 failing to operate at this time since the switch S—2 has already moved away from terminal 44, relays 30 and 16 commence their timed release to measure the pause before the switch S—3 resumes its operation to count the second impulse series, which is now being registered by the advancing switch S—2. When the relay 16 finally releases, the outgoing impulses are started, and switch

S—3 steps from terminal 49 over succeeding terminals until it reaches terminal 53 which position will have already been marked by the stopping of switch S—3 on its terminal 52. If the calling subscriber has not yet begun dialing for the third digit, contact 5 is still in engagement with terminal 52, and the circuit therebefore traced is again closed for operating the test relay 26 to terminate the outgoing impulses and to stop switch S—3. On the other hand if the calling subscriber has commenced the dialing of the third digit, the tube 54 will be in a discharged condition, marking the stopping position of the switch S—2 at the end of the second digit, and the test relay 26 operates over a circuit including the discharged tube 54.

In this manner the successive series of incoming impulses are registered by the switch S—2, which steps in synchronism with the calling subscriber's dial; and the counting switch S—3 follows the switch S—2 to control the transmission of corresponding outgoing series of impulses.

When the last series of incoming impulses has been received, and the sending of the corresponding series of outgoing impulses has been completed, the switches S—2 and S—3 come to rest in the same position. When, therefore, relay 16 operates, following the operation of the test relay 26, the circuit previously traced is closed for reoperating relay 33. Although relay 16 in operating causes the release of relay 26, relay 30 is held energized and in turn holds relay 16 energized by reason of the fact that relay 33 is now operated. The holding circuit for relay 30 may be traced through the closed contacts of relay 33 to the grounded conductor 29. Relay 16 extends the talking conductors 40 and 43 through to the lower winding of the electropolarized supervisory relay 12, the upper or biasing winding of which is energized over an obvious circuit closed at the front contact of relay 16.

When the subscriber of the called line 3 answers, the direction of current is reversed, and relay 12 operates. Relay 12 reverses the connection of the windings of relay 4 to reverse the direction of current flowing back over the trunk T, the reversal serving in the well-known manner to operate supervisory devices in the originating office. Relay 12 releases relay 15, which in turn causes the release of relays 31, 33 and 30 and the release of magnets 7 and 8. Magnets 7 and 8 on deenergizing advance the contacts 5 and 9, respectively, into engagement with the conducting segments 6 and 10. Relay 31 opens the circuit of relay 16, but the latter relay, being slow to release, is held in an energizing circuit which is closed when relay 31 closes its back contacts. This circuit may be traced from battery through the winding of relay 16, back contacts of relay 31, front contacts of relay 16, contact 9, segment 10, segment 6, contact 5, contacts of relay 19, conductor 28 to ground at the front contact of relay 4. The repeater remains in this condition during the conversational period.

When the calling subscriber replaces his receiver on the switchhook at the end of conversation, the trunk circuit T is opened, and relay 4 releases. Relay 4 releases relay 16, which opens the outgoing trunk to cause the release of the switches S—1 and C.

Although the switches S—2 and S—3 are normally left in phase, standing in the same position, following each use of the repeater, it is

possible for these switches to stop in different positions, particularly if a call is abandoned during the transmission of impulses. In such a case the switch S—3 would stop an indefinite number of positions back of the switch S—2. On the next seizure of the repeater for a new call the switch S—3 is brought into phase with the switch S—2, that is, to the starting position of S—2, before any outgoing impulses are transmitted. To conserve time, this preliminary adjustment of switch S—3 is performed at a higher rate of speed.

Assume, for example, that when the repeater is seized the switch S—2 is standing before its terminal 44 and that switch S—3 is as shown standing before its terminal 24. Seizure of the repeater results in the energization of relay 4, relay 15, and magnets 7 and 8. Magnet 7 advances the contact 5 into engagement with terminal 44, and magnet 8 advances the contact 9 into engagement with terminal 24. Since contacts 5 and 9 are in different positions, relay 26 does not operate; consequently, relays 30, 31, 16 and 33 remain deenergized. Therefore, the pulsing relays 37 and 21 are rendered effective immediately to step the switch S—3. The pulsing speed of the relay 37 is increased by the inclusion of parallel resistances 34 and 55. The circuit for energizing the operating winding of relay 37 in the direction to attract the armature to the right contact now extends from grounded conductor 20, through the back contact of relay 30 thence in parallel through resistances 35 and 34 and the operating winding of relay 37, resistance 38 to the negative pole of battery. The parallel resistance 34 increases the current flowing and consequently the speed of operation of the armature to its right contact. Similarly the circuit through the operating winding for the flow of current in the opposite direction now extends over the grounded conductor 47, armature and right contact of relay 37 through the operating winding of relay 37 thence in parallel over resistances 56 and 55 to the negative pole of battery. The parallel resistance 55 increases the flow of current to hasten the operation of the armature to the left contact. Relay 21 operates in response to each operation of relay 37 and steps the switch S—3 until the contact 9 reaches the position 49 corresponding to the starting position of the switch S—2.

In the meantime the switch S—2 may be advancing in response to the incoming series of impulses. On the first impulse relay 4 releases and removes ground from conductor 28, thus removing the shunt around the tube 46. This tube now ionizes in a circuit from the positive pole of battery 84, resistance 45, normal contacts of relay 33, front contacts of relay 15, conductor 28, normal contacts of relay 19, contact 5, terminal 44 through the tube 46 to ground. Tube 46 thus marks the starting position of the switch S—2 in order that the counting switch S—3 may be brought into phase with the starting terminal of switch S—2 before outgoing impulses are commenced. During the preliminary stepping movement of the switch S—3 under the control of relay 21 no outgoing impulses are transmitted since the contacts of relay 21 are rendered ineffective by the short circuit closed at the normal contacts of relay 31. When switch S—3 reaches the starting position of the register switch S—2, namely, the position of terminal 49, the test relay 26 operates in the manner above described either through the ionized tube 46

or to grounded lead 28. Relay 26 stops the stepping action of the switch S—3 and causes the operation of relays 30, 31 and 16. If switch S—2 is still on terminal 44, relay 33 operates in a circuit from battery through its winding, front contacts of relays 31 and 16, contact 9, terminal 49 through terminal 44, contact 5 to ground on lead 28. If, however, switch S—2 has already left terminal 44, relay 26 closes the previously traced circuit for quenching the fired tube, and relay 33 remains deenergized. Since relay 33 does not operate, relay 30 releases, followed by the release of relay 16. The pulsing relays 31 and 21 now become effective to advance the switch S—3 at its lower speed to count the number of outgoing impulses registered by the switch S—2. Relay 37 operates at its lower pulse speed because relay 31 is now energized, and the parallel resistances 34 and 55 are excluded from the operating circuits of the relay itself. Also the pulsing relay 21 is now effective to transmit outgoing impulses since relay 31 is operated, and the short circuit is removed from the pulsing contacts of relay 21.

It is possible, although quite unlikely, due to brief time interval, that the relay 16 may operate, following the receipt of a given series of impulses, just as relay 4 releases in response to the first impulse of the succeeding series but before relay 33 has time to operate. In such a case the release of relay 4 removes ground from conductor 28 and allows the tube corresponding to the position taken by contact 5 to fire before relay 19 operates. Relay 16 having operated, however, the circuit over which a fired tube is normally quenched is not closed at this time through the locking contact of relay 26. After an instant relay 19 operates and opens the ionizing circuit of the tube, whereupon the tube is quenched immediately by means of a circuit traceable from the negative pole of battery through the winding of relay 33, front contacts of relays 31 and 16, contact 9 to the electrodes of the ionized tube. The voltage applied to the tube over this circuit is opposite in polarity to the firing and sustaining voltages, and is insufficient to deionize the tube. Hence the ionized tube marking the stopping position of the switch S—2 is properly quenched before the switch S—3 resumes its counting operation for the next outgoing impulse series.

What is claimed is:

1. The combination in an impulse repeater comprising a register switch having a movable contact and a series of position terminals for registering successive series of incoming impulses, means responsive to a first impulse series for advancing said movable contact from any position to a succeeding stopping position and responsive to further series of impulses for advancing it successively to succeeding stopping positions, a primary means and a secondary means for applying a marking condition to each of said stopping positions, a counting switch having a movable contact and a series of position terminals corresponding respectively to the positions of said register switch, circuit means for detecting a marking condition when applied by either said primary or secondary means and for stopping said counting switch, and means for preventing said secondary means from applying the marking condition if the marking condition applied by said primary means has been detected.

2. The combination in an impulse repeater comprising a register switch having a movable

contact and a series of position terminals for registering successive series of incoming impulses, means responsive to a first impulse series for advancing said movable contact from any position to a succeeding stopping position and responsive to further series of impulses for advancing it successively to succeeding stopping positions, a counting switch having a movable contact and a series of position terminals corresponding respectively to the positions of said register switch, dual means of marking the starting and subsequent stopping positions of said register switch, means for operating said counting switch, a test circuit associated with said counting switch for detecting a position marked by either of said dual means, and means controlled by said test circuit for stopping said counting switch in the marked position.

3. The combination in an impulse repeater comprising a register switch having a movable contact and a series of position terminals for registering successive series of incoming impulses, means responsive to a first impulse series for advancing said movable contact from any starting position to a succeeding stopping position and responsive to further series of impulses for advancing it successively to succeeding stopping positions, a counting switch having a movable contact and a series of position terminals corresponding respectively to the positions of said register switch, a series of discharge tubes connected respectively to the position terminals of said register and counting switches, means including the movable contact of said register switch and effective when said register switch is standing in a given position for placing a distinctive marking condition on the terminal of said position, means effective before the register switch leaves said given position for operating the corresponding discharge tube to continue the presence of the marking condition on the corresponding positional terminal, means for operating said counting switch, test means associated with the counting switch for detecting a marked position of said register switch, and means controlled by said testing means for stopping the counting switch in the corresponding position.

4. The combination in an impulse repeater comprising a register switch having a movable contact and a series of position terminals for registering successive series of incoming impulses, means responsive to a first impulse series for advancing said movable contact from any starting position to a succeeding stopping position and responsive to further series of impulses for advancing it successively to succeeding stopping positions, a counting switch having a movable contact and a series of position terminals corresponding respectively to the positions of said register switch, a series of discharge tubes connected respectively to the position terminals of said register and counting switches, means including a movable contact of said register switch and effective when the switch is standing in any starting or stopping position for placing a distinctive condition upon the corresponding terminal to mark such starting or stopping position, means effective whenever the register switch moves away from a starting or a stopping position before the counting switch reaches the corresponding position for operating the corresponding discharge tube to maintain the distinctive marking condition on the terminal of such position, means for operating the counting switch, a test circuit including the movable contact of the counting

switch for detecting the marked condition of a starting or a stopping position of said register switch, and means controlled by said test circuit for stopping said counting switch in the position corresponding to said marked position.

5. The combination in an impulse repeater comprising a register switch having a movable contact and a series of position terminals for registering successive series of incoming impulses, means responsive to a first impulse series for advancing said movable contact from any position to a succeeding stopping position and responsive to further series of impulses for advancing it successively to succeeding stopping positions, a counting switch having a movable contact and a series of position terminals corresponding respectively to the positions of said register switch, a series of space-discharge tubes common to said switches and connected respectively to the position terminals thereof, means for sending out a series of impulses for each incoming series, means responsive to said first series and to each succeeding series of incoming impulses for causing the advance of said counting switch to count the outgoing impulses, a circuit including the movable contacts of both switches effective to stop said counting switch in each stopping position of the register switch if the counting switch reaches such stopping position before the register switch resumes its advance, means effective to ionize the tube at each stopping position of said register switch if the register switch advances out of such position before the counting switch reaches the same, and circuit means including the ionized tubes for stopping the counting switch in each stopping position to which an ionized tube is connected.

6. The combination in an impulse repeater comprising a register switch having a movable contact and a series of position terminals for registering successive series of incoming impulses, means responsive to a first impulse series for advancing said movable contact from any starting position to a succeeding stopping position and responsive to further series of impulses for advancing it successively to succeeding stopping positions, a counting switch having a movable contact and a series of position terminals corresponding respectively to the positions of said register switch, a series of discharge tubes connected respectively to the position terminals of said register and counting switches, means including a movable contact of said register switch and effective when the switch is standing in any starting or stopping position for placing a distinctive condition upon the corresponding terminal to mark such starting or stopping position, means effective whenever the register switch moves away from a starting or a stopping position before the counting switch reaches the corresponding position for ionizing the corresponding discharge tube to maintain the distinctive marking condition on the terminal of such position, means for operating the counting switch, a test circuit including the movable contact of the counting switch for detecting the marked condition of a starting or a stopping position of said register switch, means controlled by said test circuit for stopping said counting switch in the position corresponding to said marked position, and means effective when said counting switch reaches a position that is marked by an ionized tube for quenching said tube as soon as the marked position is detected.

7. The combination in a telephone system of

an incoming impulse circuit, an outgoing impulse circuit, a register switch comprising a movable contact and a series of stationary terminals for registering incoming series of impulses, means responsive to an incoming series of impulses for advancing said register switch from any one of said terminals as a starting position over a number of said terminals corresponding to the number of impulses, a counting switch comprising a movable contact and a series of stationary terminals corresponding respectively to the stationary terminals of said register switch, means for marking the terminal to which said register switch is advanced in response to the incoming impulse series and for marking the corresponding terminal of said counting switch, transmitting means for sending impulses over said outgoing circuit, means controlled by said transmitting means for advancing said counting switch from any one of its terminals as a starting position to its marked terminal, means effective when the counting switch reaches its marked terminal for terminating the transmission of impulses over said outgoing circuit, and means controlled over the movable contact and terminals of said counting switch when the starting position thereof differs from the starting position of said register switch for advancing the counting switch to the terminal corresponding to the starting position of said register switch prior to the transmission of impulses over said outgoing circuit.

8. The combination in a telephone system of an incoming impulse circuit, an outgoing impulse circuit, a register switch comprising a movable contact and a series of stationary terminals for registering incoming series of impulses, means responsive to an incoming series of impulses for advancing said register switch from any one of said terminals as a starting position over a number of said terminals corresponding to the number of impulses, a counting switch comprising a movable contact and a series of stationary terminals corresponding respectively to the stationary terminals of said register switch, means for marking the terminal to which said register switch is advanced in response to the incoming impulse series and for marking the corresponding terminal of said counting switch, transmitting means for sending impulses over said outgoing circuit, means controlled by said transmitting means for advancing said counting switch from any one of its terminals as a starting position to its marked terminal, means effective when the counting switch reaches its marked terminal for terminating the transmission of impulses over said outgoing circuit, circuit means controlled by the movable contacts of said register and counting switches for causing the preliminary advance of said counting switch to the position corresponding to the starting position of said register switch, and means for disabling said impulse transmitting means during the preliminary advance of said counting switch.

9. The combination in a telephone system of an incoming impulse circuit, an outgoing impulse circuit, a register switch comprising a movable contact and a series of stationary terminals for registering incoming series of impulses, means responsive to an incoming series of impulses for advancing said register switch from any one of said terminals as a starting position over a number of said terminals corresponding to the number of impulses, a counting switch comprising a movable contact and a series of stationary ter-

minals corresponding respectively to the stationary terminals of said register switch, means for marking the terminal to which said register switch is advanced in response to the incoming impulse series and for marking the corresponding terminal of said counting switch, transmitting means for sending impulses over said outgoing circuit, means controlled by said transmitting means for advancing said counting switch from any one of its terminals as a starting position to its marked terminal, means effective when the counting switch reaches its marked terminal for terminating the transmission of impulses over said outgoing circuit, circuit means controlled by the movable contacts of said register and counting switches for causing the preliminary advance of said counting switch to the position corresponding to the starting position of said register switch, means for disabling said impulse transmitting means during the preliminary advance of said counting switch, and circuit means effective in each stopping position of the counting switch for deionizing the corresponding tube.

10. The combination in a telephone system of an incoming impulse circuit, an outgoing impulse circuit, a register switch comprising a movable contact and a series of stationary terminals for registering incoming series of impulses, means responsive to an incoming series of impulses for advancing said register switch from any one of said terminals as a starting position over a number of said terminals corresponding to the number of impulses, a counting switch comprising a movable contact and a series of stationary terminals corresponding respectively to the stationary terminals of said register switch, means for marking the terminal to which said register switch is advanced in response to the incoming impulse series and for marking the corresponding terminal of said counting switch, transmitting means for sending impulses over said outgoing circuit, means responsive to the closure of the incoming impulse circuit if said counting switch is in some position other than the starting position of said register switch for causing said counting switch to advance at a relatively high speed to the terminal corresponding to said starting position, means for disabling said impulse transmitting means while said counting switch is advancing to the starting position, means for causing said counting switch to advance from said starting position at a relatively low speed to its marked terminal to count the number of impulses transmitted over the outgoing circuit, and means for rendering said transmitting means effective during the movement of said counting switch from the starting position to its marked terminal.

11. The combination in a telephone system of an incoming impulse circuit, an outgoing impulse circuit, a register switch comprising a movable contact and a series of stationary terminals for registering incoming series of impulses, means responsive to an incoming series of impulses for advancing said register switch from any one of said terminals as a starting position over a num-

ber of said terminals corresponding to the number of impulses, a counting switch comprising a movable contact and a series of stationary terminals corresponding respectively to the stationary terminals of said register switch, a series of space-discharge tubes common to said switches and connected respectively to the corresponding stationary terminals thereof, means for discharging the tube connected to the terminal to which the register switch advances in response to the impulse series to mark said terminal and the corresponding terminal in said counting switch, means responsive to the incoming impulse series for advancing the counting switch from any position in which it may be standing to the terminal marked by the operated discharge tube, impulse transmitting means for sending impulses over said outgoing circuit in synchronism with the movement of said counting switch from its terminal corresponding to the starting position of the register switch to its marked terminal, and means for disabling said impulse transmitting means during any preliminary movement of said counting switch necessary to reach said starting position.

12. The combination in a telephone system of an incoming impulse circuit, an outgoing impulse circuit, a register switch comprising a movable contact and a series of stationary terminals for registering incoming series of impulses, means responsive to an incoming series of impulses for advancing said register switch from any one of said terminals as a starting position over a number of said terminals corresponding to the number of impulses, a counting switch comprising a movable contact and a series of stationary terminals corresponding respectively to the stationary terminals of said register switch, a series of space-discharge tubes common to said switches and connected respectively to the corresponding stationary terminals thereof, means for discharging the tube connected to the terminal to which the register switch advances in response to the impulse series to mark said terminal and the corresponding terminal in said counting switch, means effective if the counting switch is standing in some position other than the starting position when the incoming impulse series is received for discharging the tube corresponding to said starting position, impulse transmitting means controlled by said counting switch for sending impulses over said outgoing circuit, means for advancing said counting switch from the position it occupies when the incoming impulses are received first to the starting position marked by the last-mentioned tube and then to the position marked by said first-mentioned tube, means for rendering said impulse transmitting means ineffective to send impulses while said counting switch is moving from its initial position to the position corresponding to the starting position of said register switch and for rendering said transmitting means effective to send impulses during the movement of the counting switch from said starting position to the position marked by the incoming impulse series.

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