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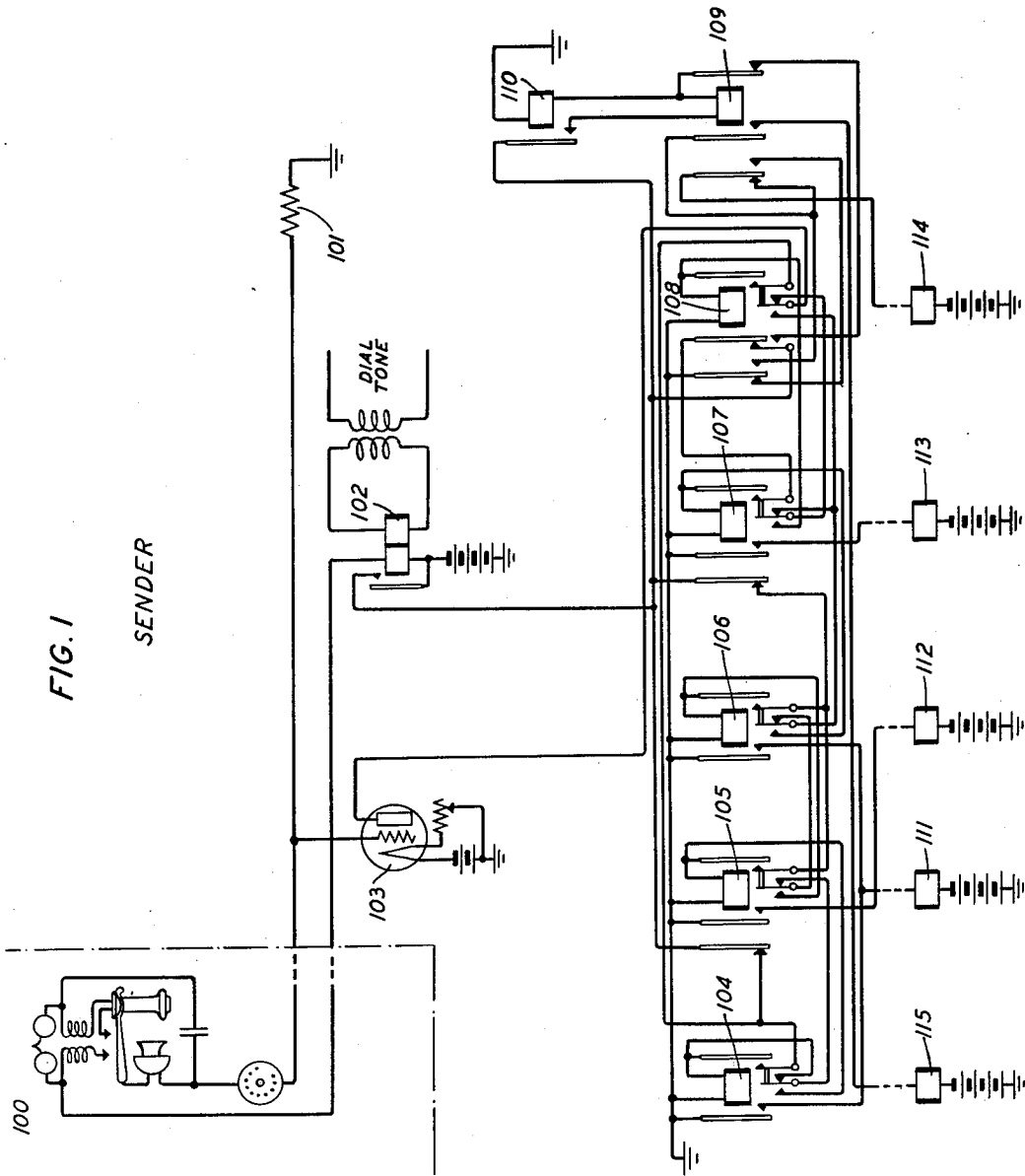
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1,963,769

TELEPHONE SYSTEM

Filed Nov. 11, 1933

2 Sheets-Sheet 1



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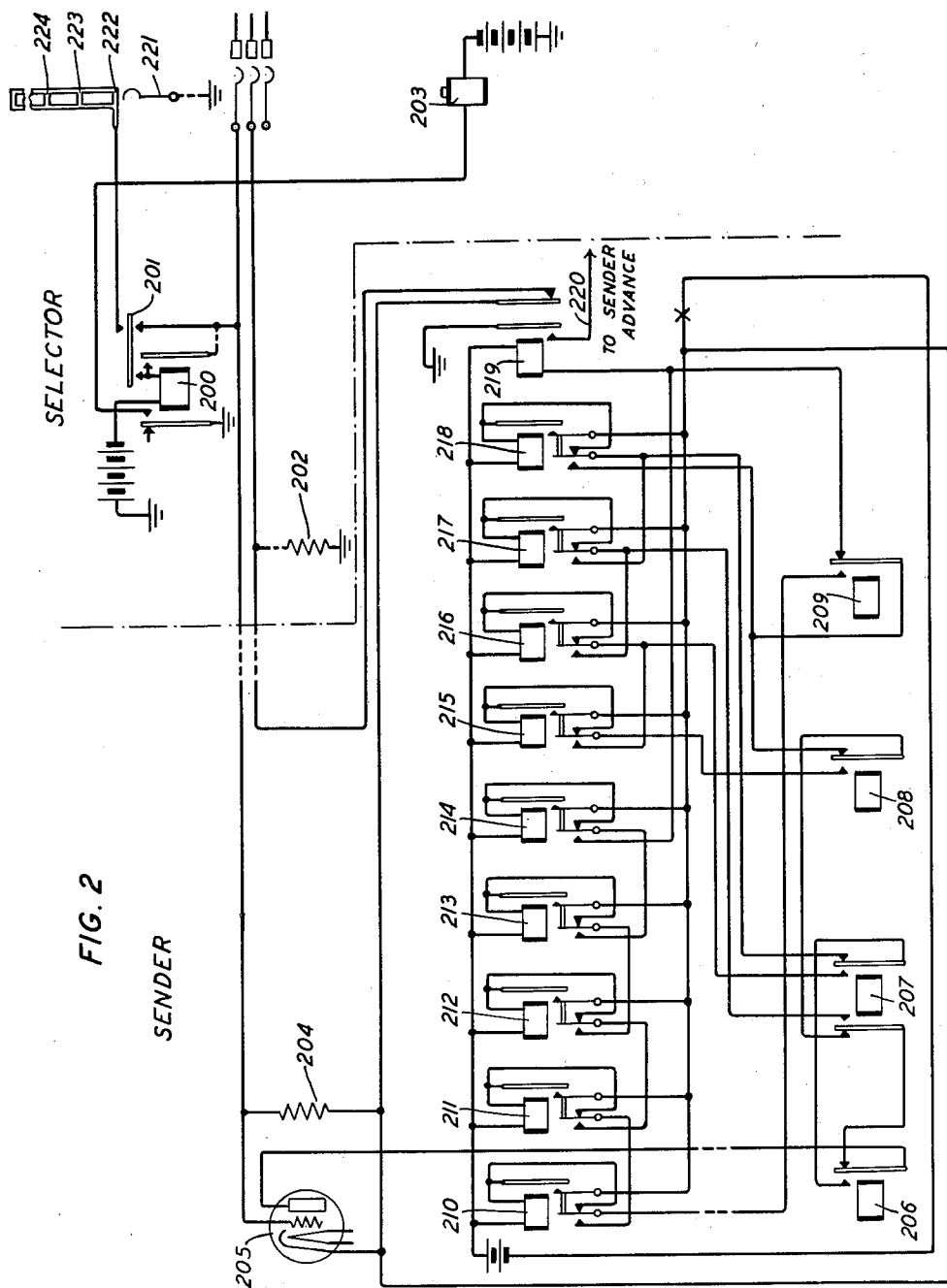
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TELEPHONE SYSTEM

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This invention relates to telephone systems and more particularly to the utilization in the impulse recording circuits thereof of gaseous conductor or discharge tubes as impulse responsive relays.

5 In a machine switching telephone system of the type employing a common sender which registers series of impulses dialed by a subscriber in accordance with the directory number of a desired line and which controls the setting of selector switches in accordance with such registration, the impulse circuit extending from a calling line substation to the sender heretofore has included an impulse dial at the substation and an impulse responsive relay in the sender, the impulse
10 relay in response to the impulses of each digit series dialled controlling the successive operation of the relays of a train of impulse recording relays. The group of impulse recording relays is instrumental in response to successive trains of
15 dialed impulses to successively set registers of the sender.

20 If the sender is employed in a telephone system of the type employing power driven selector switches, for example of the panel type, the setting of the switches is controlled in accordance with the setting of the sender registers by impulses transmitted
25 reverberately to the sender by the switches during their selective movements. The control circuit known as the fundamental circuit has heretofore comprised a control relay in the selector at the time associated with the sender and an impulse responsive or stepping relay in the sender. When
30 the control circuit is established preparatory to setting the switch, both relays operate by battery and ground usually applied at the switch to the two conductors respectively of the fundamental circuit. The operation of the control relay at the switch starts the movement of the brush shaft of the switch and the impulse relay
35 at the sender prepares the sender for controlling the amount of selective movement of the brush shaft of the switch. The switch is provided with a commutator, which, as the brush shaft advances, intermittently connects ground to one of the conductors of the control circuit thereby intermittently shunting the impulse relay of the sender. The intermittent operation of the impulse relay controls the successive operation of relays of a train of counting relays, the end relay of the train
40 when operated opening the control circuit to arrest further movement of the brush shaft of the switch. The number of the counting relays operated by the impulse relay to control the amount of selective movement of the switch is deter-

mined by the setting of the register of the sender at the time rendered effective.

The present invention provides for the replacement of the usual impulse relays of the dialing circuit and the replacement of the usual impulse responsive or stepping relay of the control or fundamental circuit by gaseous conductor or discharge tubes. The gaseous conductor tube utilized is a tube filled with a low pressure gaseous content which for purposes of illustration might be neon, argon, helium, mercury vapor or combinations of gases of this group. The tube has a certain characteristic, namely, that the gaseous content will become ionized and thus conducting on one potential determined by the electrode design, the nature of the gaseous content and its pressure, but once rendered conducting will maintain this condition of conductivity on a much lower potential.

The invention has as one of its objects the utilization of a gaseous conductor tube as an impulse responsive relay whereby more accurate and faster impulse control may be realized both over long dialing loops and over long fundamental circuit loops.

A further object of the invention is the simplification of the impulse recording and counting relay train whereby a saving in initial cost of relays and in the maintenance cost thereof is attained.

A further object of the invention is in the provision of a quick acting relay in a dialing loop at the sender to perform impulse changeover functions to replace the usual slow to release type relays.

The present invention has been illustrated schematically by only so much of a subscriber's dialing loop, sender circuit and a selector switch circuit as are necessary to a complete understanding of the invention. A typical sender circuit to which the invention is applicable is disclosed in detail in Patent No. 1,862,549, granted June 14, 1932 to R. Raymond et al. A typical selector switch circuit is disclosed in detail in Patent No. 1,395,977, granted to F. A. Stearn et al on November 1, 1921.

In the application of the invention for recording impulses dialed by a subscriber, the dialing loop when established from the subscriber's substation to the sender extends from the grounded positive terminal of the central station battery through a resistance over the dialing loop to the negative terminal of the central station battery through the winding of the relay which

serves to control changeover at the sender following the termination of each series of impulses dialed by the subscriber. The control electrode or grid of a gaseous discharge tube is branched from the conductor of the dialing loop which is connected to the positive terminal of the battery whereby the grid of the tube is negatively biased over the dialing loop when the loop is closed at the substation. The anode of the tube is connected through the winding of the first of a train of impulse recording relays to the positive terminal of the central station battery. When the dial is operated off-normal and returns to normal, it, in the usual manner, opens the dialing loop one or more times dependent upon the setting of the dial. On the first opening of the loop by the dial contacts the negative bias on the grid of the tube is removed and the grid of the tube is then made positive due to its connection through the resistance to the positive terminal of the battery and the tube immediately ionizes and becomes conducting thus operating the impulse recording relay connected to its anode. The impulse recording relay upon operating, first locks under control of the pulse changeover relay, then momentarily disconnects the anode of the tube from the positive terminal of the battery to deionize the tube and then connects the anode through the next relay of the train of recording relays to the positive terminal of the battery. In response to succeeding openings of the dialing loop the tube responds in a similar manner to successively operate recording relays, the number of recording relays operated depending upon the digit dialed. The dial may be so constructed that its pulsing contact will produce such short openings of the dialing loop that the changeover relay will not release on such openings but will release only on the last opening of the loop which may be made longer. When the dialing loop is thus opened on the opening of the dialing loop for the last impulse of a digit series, the changeover relay releases in turn releasing the operated impulse recording relays in readiness for recording the next impulse series dialed. In the meantime the record set up by the impulse recording relays is transferred in the usual manner to the first digit register of the sender. Since the tube will ionize on a very short opening of the dialing loop, the changeover relay need not be made slow to release as heretofore, thus eliminating the use of the slow to release relays employed in connection with impulse recording circuits. Further, since the tube responds quickly to changes of potential only and not to current built up as in the case of an impulse responsive relay, impulsing may be accurately accomplished over either short or long dialing loops and at much greater speed. With only light current flowing over the dialing loop the sparking at the dial contacts during dialing is reduced to such an extent that interference with radio reception would be greatly minimized or substantially eliminated. Further, the use of the tube as an impulse responsive device permits the employment of a train of recording relays having one half as many relays as heretofore employed.

In the application of the invention to the reverte control of a selector switch, the fundamental or control circuit is established in the well-known manner between the sender and the selector switch to be controlled, the control relay of the switch operating and locking to the fundamental circuit and closing the circuit of

the updrive magnet of the switch. At the sender a resistance is placed in bridge of the fundamental circuit and in bridge of the grid and cathode elements of the gaseous discharge tube. The grid of the tube is then negatively biased due to the drop of potential across the resistance, thus preventing the ionization of the tube. The anode of the tube is connected through contacts of the relays of a particular register then effective for controlling the selection movement of the switch through the winding of one of a train of counting relays to the positive terminal of the central station battery.

As the brush shaft of the selector switch advances under the control of the updrive magnet, ground is connected to the tip conductor of the fundamental circuit and the control electrode is thereby made positive thus causing the tube to ionize and become conducting. The particular counting relay connected in the anode circuit of the tube now operates locking itself operated, opening the anode circuit momentarily to deionize the tube and reestablishing the anode circuit through the winding of the next succeeding counting relay. Since at the time the next succeeding counting relay is connected in the anode circuit, the tube has become deionized, such succeeding counting relay does not operate until the tube reionizes when the commutator again connects ground to the tip conductor of the fundamental circuit. Thus as the commutator intermittently connects ground to the tip conductor of the fundamental circuit, the tube causes successive counting relays to operate until the end relay operates to open the fundamental circuit and to prepare the sender for the next selection control.

Since the tube ionizes very rapidly when its grid is made sufficiently positive, a very short application of ground to the tip conductor of the fundamental circuit by the switch commutator is effective to cause the tube to ionize and become conducting and therefore the speed at which the switch shaft may be advanced may be materially increased over the speed hitherto possible. Further in view of the fact that the tube responds to successive closures of the switch commutator as contrasted with the present fundamental circuit employing an impulse responsive relay which controls the counting relays in response to successive closures and openings of the switch commutator, it is possible to use a train of counting relays having less than one half as many relays as heretofore employed and relays of a simpler and more reliable type.

A clearer understanding of the invention may be obtained from a consideration of the following detailed description read in connection with the accompanying drawings in which:

Fig. 1 shows the subscriber's dialing loop and that portion of the sender circuit involved in the recording of a digit dialed by a subscriber.

Fig. 2 shows such portions of the sender and a selector circuit as are involved in the control of the selector circuit by the sender circuit.

Registration of a dialed digit

Referring to Fig. 1, when a subscriber at substation 100 initiates a call and is connected through to the sender circuit in the usual manner, the dialing loop is established from the positive grounded terminal of the central station battery, through resistance 101, over the subscriber's loop and through the contacts of the subscriber's dial, to the negative terminal of the central station bat-

tery through the left hand winding of the pulse changeover relay 102 operating this relay. Relay 102 operating, provides battery for locking the impulse recording relays operated, the circuits for which are described in detail hereinafter. The dial at substation 100 is so constructed that all openings of the dialing loop except the last, for each digit dialed, are of such short duration that pulse changeover relay 102 remains operated. Upon the final opening of the dialing loop for each digit, however, changeover relay 102 releases.

The control electrode or grid of the gaseous discharge tube 103 is branched from the conductor of the dialing loop which is connected to the positive grounded terminal of the battery through resistance 101. The grid of tube 103 is therefore negatively biased as it is connected through the closed dialing loop to the negative terminal of the battery through the left hand winding of the pulse changeover relay 102. The anode of tube 103 is connected over the right back contacts of impulse recording relays 108, 107, 106, 105 and 104 respectively, through the winding of impulse recording relay 104 to the positive grounded terminal of battery.

On the closure of the dialing loop, dial tone is transmitted to the calling subscriber through the windings of relay 102. It will be assumed that the subscriber dials the letter C as the first letter of the exchange code, which has the numerical equivalent of the digit 2. When the dial returns to normal upon its release, it, in the usual manner, opens the dialing loop two times.

On the first opening of the dialing loop by the dial contacts the negative bias on the grid of tube 103 is removed due to the opening of the circuit from the grid of tube 103 to negative battery through the left hand winding of relay 102. The bias on the grid of tube 103 then becomes positive due to its connection to the positive grounded terminal of the battery through resistance 101. With the positive bias on its grid tube 103 immediately ionizes and becomes conducting. With tube 103 in the conducting condition, impulse recording relay 104 operates from negative battery, cathode and anode of tube 103, right back contacts of relay 108, 107, 106, 105 and 104 respectively, to positive grounded battery through the winding of relay 104. As the outer right front contact of relay 104 closes before the right back contact of relay opens, relay 104 locks from ground through its winding and outer right front contact, left back contact of relay 105, to battery over the front contact of relay 102. As relay 104 operates it opens the circuit from positive grounded battery, winding and right back contact of relay 104, right back contacts of relays 105, 106, 107 and 108 respectively, to the anode of tube 103. The removal of positive grounded battery from the anode of tube 103 causes the tube to deionize. Relay 104 operating, also closes a circuit from positive grounded battery, through the winding of impulse recording relay 105, inner right front contact of relay 104, right back contacts of relays 105, 106, 107 and 108 respectively, to the anode of tube 103. Relay 104 operating also closes a circuit from ground over its left front contact to battery through the winding of register relay 111 operating this relay.

On the second opening of the dialing loop by the dial contacts the negative bias on the grid of tube 103 is again removed by the opening of the circuit from negative battery through the left winding of relay 102 to the grid of tube 103. The bias on the grid of tube 103 becomes positive from

its connection to the positive grounded terminal of the battery through resistance 101 and tube 103 immediately ionizes and becomes conducting. Impulse recording relay 105 operates from negative battery through the cathode and anode of the now conducting tube 103, over the right back contacts of relays 108, 107, 106 and 105 respectively, inner right front contact of relay 104, through the winding of relay 105 to the positive grounded battery terminal. As the outer right front contact of relay 105 closes before the right back contact of the relay opens, relay 105 locks from ground through its winding and outer right front contact, left back contact of relay 107 to battery over the front contact of relay 102. As relay 105 operates it opens the circuit from positive grounded battery, winding of relay 105, inner right front contact of relay 104, right back contacts of relays 105, 106, 107 and 108 respectively, to the anode of tube 103 causing the tube to deionize. Relay 105 operating, also closes a circuit from the positive grounded battery terminal, through the winding of relay 106, over the inner right front contact of relay 105, right back contacts of relays 106, 107 and 108 respectively, to the anode of the tube 103. Relay 105 operating, also closes a circuit from ground over its left front contact to battery through the winding of register relay 112 operating this relay, and, in addition, opens the circuit from ground through the winding of relay 104, outer right front contact of relay 104, left back contact of relay 105, to battery over the front contact of relay 102, releasing relay 104. Relay 104 releasing, opens the circuit from ground on its left front contact to battery through the winding of register relay 111, releasing this relay.

As the dial at substation 100 is so constructed that a longer opening of the dialing loop is produced for the last impulse of the series of pulses for each digit, changeover relay 102 releases during the second impulse which is the last of the assumed dialed digit 2. Relay 102 releasing, opens the holding circuit for any operated impulse recording relays, in this case relay 105, preparatory to recording the impulses of the second digit to be dialed. Changeover relay 102 releasing, also may cause the transfer of the circuits over the left front contacts of impulse recording relays 104, 105, 106, 107, 108 and 109 from the first digit register relays 111, 112, 113, 114, and 115 to the second digit register relays (not shown) in the usual manner.

For succeeding digits dialed, changeover relay 102, tube 103, impulse recording relays 104, 105, 106, 107, 108, 109 and 110, and the succeeding digit register relays function in a manner similar to that hereinbefore described for the first dialed digit, the number of impulse recording and register relays operating depending upon the number of impulses of the digit dialed.

To further illustrate the functioning of the impulse recording relay chain, it will be assumed that the subscriber dials the digit 0 which causes the dial, on its return to normal, to open the dialing loop ten times. Changeover relay 102 in this case remains operated until the tenth and last dialing loop opening at which time it releases.

For the first two openings of the dialing loop, changeover relay 102, tube 103, impulse recording relays 104 and 105 and register relays 111 and 112 function as hereinbefore described in detail, changeover relay 102, however, remaining operated during the second opening of the dialing loop. At this point therefore, changeover relay

102 is operated, impulse recording relay 104 and register relay 111 are released, impulse recording relay 105 and register relay 112 are operated and positive grounded battery is connected through the winding of impulse recording relay 106, inner right front contact of relay 105, right back contacts of relays 106, 107 and 108, respectively, to the anode of tube 103.

On the third opening of the dialing loop the grid of tube 103 becomes positive, in the manner hereinbefore described in detail, and tube 103 ionizes and becomes conducting, operating relay 106 from negative battery, cathode and anode of tube 103, right back contacts of relays 108, 107 and 106, respectively, inner right front contact of relay 105, to positive grounded battery through the winding of relay 106. Relay 106 operating, connects ground over its left front contact to battery through the winding of register relay 111 operating this relay. As the outer right front contact of relay 106 closes before the right back contact opens, relay 106 immediately locks from positive grounded battery, outer right front contact of relay 106, left back contact of relay 107 to negative battery over the front contact of relay 102. As relay 106 operates it opens the circuit from positive grounded battery through its winding, inner right front contact of relay 105, right back contacts of relays 106, 107 and 108 respectively, to the anode of tube 103 causing the tube to deionize. Relay 106 operating, also connects positive grounded battery, through the winding of relay 107, inner right front contact of relay 106, right back contacts of relays 107 and 108 respectively, to the anode of tube 103. At the end of the third dialing loop opening therefore, impulse recording relays 105 and 106 and register relays 111 and 112 are operated.

On the fourth dial impulse tube 103 ionizes and becomes conducting, in the manner hereinbefore described, and relay 107 operates from negative battery, cathode and anode of tube 103, right back contacts of relays 108 and 107 respectively, inner right front contact of relay 106, through the winding of relay 107 to positive ground. As the outer right front contact of relay 107 closes before its right back contact opens, relay 107 immediately locks from ground through its winding, outer right front contact of relay 107, inner left back contact of relay 108, to negative battery over the front contact of relay 102. Relay 107 operating, connects ground over its left front contact to battery through the winding of register relay 113 operating this relay, and also opens the circuit from battery over the front contact of relay 102, left back contact of relay 107, outer right front contacts and windings of relays 106 and 105 to ground, releasing relays 106 and 105. Relays 106 and 105 releasing, open the circuits from ground over their left front contacts to battery through the windings of register relays 111 and 112 respectively, releasing these relays. Relay 107 operating, also opens the circuit from positive grounded battery through its winding, inner right front contact of relay 106, right back contact of relay 107, right back contact of relay 108, to the anode of tube 103 causing the tube to deionize. Relay 107 operating, in addition, connects positive grounded battery through the winding of relay 108, inner right front contact of relay 107, right back contact of relay 108, to the anode of tube 103.

On the fifth opening of the dialing loop tube 103 ionizes and becomes conducting, as hereinbefore described, operating relay 108 from posi-

tive grounded battery, winding of relay 108, inner right front contact of relay 107, right back contact of relay 108, to negative battery through the anode and cathode of tube 103. As the outer right front contact of relay 108 closes before the right back contact opens, relay 108 immediately locks from ground through its winding and outer right front contact, left back contact of relay 105, to battery over the front contact of relay 102. Relay 108 operating, connects ground over its outer left front contact, left back contact of relay 109, to battery through the winding of register relay 114 operating relay 114. Relay 108 operating, also opens the circuit from battery over the front contact of relay 102, inner left back contact of relay 108, outer right front contact and winding of relay 107 to ground, releasing relay 107. Relay 107 releasing, opens the circuit from ground over its left front contact to battery through the winding of register relay 113 releasing relay 113. Relay 108 operating, also removes positive ground through its winding, inner right front contact of relay 107, right back contact of relay 108 to the anode of tube 103 causing the tube to deionize. The operation of relay 108 also connects positive grounded battery through the winding of relay 104, right back contacts of relays 104, 105 and 106 respectively, inner right front contact of relay 108 to the anode of tube 103. Lastly, the operation of relay 108 connects battery over the front contact of relay 102, inner left front contact of relay 108, right back contact of relay 109, to ground through the winding of relay 110 operating relay 110. Relay 110 operating connects battery over the front contact of relay 102, front contact of relay 110 to the winding of relay 109. As battery is also connected to the other side of the winding of relay 109, over the back contact of relay 109, inner left front contact of relay 108, and front contact of relay 102, relay 109 does not operate at this time.

On the sixth dial pulse tube 103 ionizes and becomes conducting, as hereinbefore described, and relay 104 operates from positive grounded battery through its winding, right back contacts of relays 104, 105 and 106 respectively, inner right front contact of relay 108, anode and cathode of tube 103 to negative battery. As the outer right front contact of relay 104 closes before the right back contact opens, relay 104 immediately locks from ground through its winding, outer right front contact to battery over the front contact of relay 102. Relay 104 operating removes the positive grounded battery through its winding, right back contacts of relays 104, 105 and 106 respectively, inner right front contact of relay 108, from the anode of tube 103 causing the tube to deionize. Relay 104 operating, also connects positive grounded battery, through the winding of relay 105, inner right front contact of relay 104, right back contacts of relays 105 and 106, inner right front contact of relay 108 to the anode of tube 103. In addition, the operation of relay 104 connects ground over its left front contact to battery through the winding of register relay 111, operating relay 111. At the end of the sixth dial opening therefore, register relays 111 and 114 are operated.

On the seventh opening of the dialing loop tube 103 again ionizes and becomes conducting, operating relay 105 from positive grounded battery through its winding, inner right front contact of relay 104, right back contacts of relays 105 and 106, inner right front contact of relay 108 to the anode of tube 103.

108, anode and cathode of tube 103 to negative battery. The immediate closure of its outer right front contact locks relay 105 operated from ground through its winding, outer right front contact of relay 105, left back contact of relay 107 to battery over the front contact of relay 102. Relay 105 operating, connects ground over its left front contact to battery through the winding of register relay 112 operating relay 112. Relay 105 operating, also opens the circuit from positive grounded battery through its winding, inner right front contact of relay 104, right back contacts of relays 105 and 106, inner right front contact of relay 108, to the anode of tube 103 causing the tube to deionize. The operation of relay 105 also opens the circuit from battery over the front contact of relay 102, left back contact of relay 105, outer right front contacts of relays 104 and 108, windings of relays 104 and 108 to ground, releasing relays 104 and 108. Relay 104 releasing, opens the ground over its left front contact to the winding of register relay 111, releasing that relay. Relay 108 releasing, opens the circuit from battery over the front contact of relay 102, inner left front contact of relay 108, right back contact of relay 109 to the windings of relays 109 and 110. Relay 109 now operates in series with relay 110 from ground through the winding of relay 110, winding of relay 109, front contact of relay 110 to battery over the front contact of relay 102. Relay 109 operating, closes the circuit from battery through the winding of register relay 114, outer left front contact of relay 109, outer left back contact of relay 108 to ground, thereby maintaining an operating circuit for register relay 114. The operation of relay 105 also connects positive grounded battery, through the winding of relay 106, inner right front contact of relay 105, right back contacts of relays 106, 107 and 108 respectively, to the anode of tube 103.

On the eighth dial impulse tube 103 again ionizes and becomes conducting and relay 106 operates from positive ground through its winding, inner right front contact of relay 105, right back contacts of relays 106, 107 and 108 respectively, anode and cathode of tube 103 to negative battery. The immediate closure of its outer right front contact locks relay 106 from ground through its winding and outer right front contact, left back contact of relay 107 to battery over the front contact of relay 102. Relay 106 operating, connects ground over its left front contact to battery through the winding of register relay 111 operating that relay. Relay 106 operating, also connects positive grounded battery, through the winding of relay 107, inner right front contact of relay 106, right back contacts of relays 107 and 108, to the anode of tube 103. For the eighth impulse of the dial, therefore, register relay 111 is operated and register relays 112 and 114, which were also operated at the seventh impulse, remain operated.

On the ninth opening of the dialing loop the grid of tube 103 again becomes positive and the tube ionizes and becomes conducting operating relay 107 from positive grounded battery through its winding, inner right front contact of relay 106, right back contacts of relays 107 and 108 to negative battery over the anode circuit of tube 103. Relay 107 immediately locks operated over its outer right front contact, inner left back contact of relay 108 to battery over the front contact of relay 102. Relay 107 operating, opens the circuit from battery over the front contact of relay 102,

left back contact of relay 107, outer right front contacts and windings of relays 106 and 105 to ground, releasing relays 106 and 105. Relay 106 releasing opens the circuit from ground over its left front contact through the winding of register relay 111, releasing relay 111. Relay 105 releasing, opens the circuit from ground over its left front contact through the winding of register relay 112, releasing that relay. Relay 107 operating, also connects ground over its left front contact to battery through the winding of register relay 113 operating relay 113. In addition, the operation of relay 107 connects positive grounded battery through the winding of relay 108, inner right front contact of relay 107, right back contact of relay 108 to the anode of tube 103. For the ninth dial impulse therefore, register relay 113 operates and relay 114, previously operated, remains so.

On the tenth and last opening of the dialing loop, the ionization of tube 103 operates relay 108 from positive grounded battery through its winding, inner right front contact of relay 107, right back contact of relay 108 to negative battery over the anode of tube 103. Relay 108 immediately locks operated over its outer right front contact, left back contact of relay 105, to battery over the front contact of relay 102. Relay 108 operating, releases register relay 114 by opening the circuit over its outer left back contact, outer left front contact of relay 109, through the winding of relay 114. Relay 108 operating, also opens the circuit from battery over the front contact of relay 102, inner left back contact of relay 108, to ground through the outer right front contact and winding of relay 107, releasing relay 107. Relay 107 releasing, opens the circuit from ground over its left front contact, through the winding of register relay 113, releasing relay 113. Relay 108 operating, also opens the circuit from positive grounded battery, winding of relay 108, inner right front contact of relay 107, right back contact of relay 108 to the anode of tube 103 causing the tube to deionize. Finally, the operation of relay 108 connects ground over its outer left front contact, inner left front contact of relay 109, to battery through the winding of register relay 115, operating that relay. Therefore, for ten impulses of the dial only register relay 115 is operated.

As the dial is constructed to give a longer opening on the last pulse, changeover relay 102 releases on the tenth and last opening of the dialing loop. Relay 102 releasing, opens the circuit from battery over its front contact which releases relay 108. The release of relay 102 may also transfer the circuits from the left front contacts of the impulse recording relays from the register relays of the digit just recorded to the register relays for the succeeding digit.

As gaseous discharge tube 103 ionizes on very short dial contact openings, being dependent only upon changes in grid potential and not on current built up, accurate dialing may be accomplished at greater dial speeds and over longer dialing loops than heretofore attainable. Relay 102 does not require a heavy current flow over the dialing loop to operate it and consequently the opening of the dial contacts during the return of the dial does not disrupt as heavy a current as heretofore and sparking at the dial contacts is minimized to such an extent that there is little or no interference with the operation of an adjacent radio receiver. Also, since the dialing loop openings may be of very short duration, due to the quick response of the tube, pulse changeover be-

tween digits may be accomplished by the use of the single relay 102, instead of by the use of relays of the slow to release type formerly required for this purpose. In addition, as tube 103 controls the impulse recording relays in response to successive dialing loop openings, in contrast with the present dial impulse recording circuit which employs an impulse responsive relay controlling the impulse recording relays in response to successive openings and closures of the dialing loop, the recording relay chain is simplified, only one half as many relays being employed as heretofore.

Revertive control of a selector

Referring to Fig. 2, when the fundamental or control circuit is established in the usual manner, between the sender and the selector circuit to be controlled, selector control relay 200 operates from the negative terminal of battery through its winding, over the lower contacts of sequence switch cam 201, over the tip conductor of the fundamental circuit, through resistance 204, back contact of counting relay 219 over the ring of the fundamental circuit, to positive ground through resistance 202. Relay 200 operating, locks over its right front contact to ground through resistance 202 over the fundamental circuit, and closes the circuit from ground over its left front contact to negative battery through the winding of the selector updrive magnet 203.

Resistance 204 is placed in bridge of the grid and cathode elements of gaseous discharge tube 205 and in bridge of the fundamental circuit. Due to the potential drop across resistance 204, a negative bias is maintained on the grid of tube 205, preventing ionization of the tube when the fundamental circuit is established. The cathode of tube 205 is connected to the negative battery terminal.

Assuming that register relay 207 has been previously operated under control of dial impulses in the usual manner, the anode of tube 205 is connected over the back contact of register relay 206, left front contact of register relay 207, back contact of counting relay 217, through the winding of relay 217 to the positive terminal of battery.

Upon energizing, selector updrive magnet 203 causes the selector brush shaft to be moved upward and advance selector brush 221 along the selector commutator. When brush 221 contacts commutator segment 222, positive grounded battery is connected over brush 221, segment 222, right contacts of sequence switch cam 201, to the tip of the fundamental circuit, one side of resistance 204 and the grid of tube 205. With positive grounded battery on resistance 204 and the grid of tube 205, the negative bias on the grid of tube 205 is removed causing tube 205 to immediately ionize and become conducting. With tube 205 in the conducting condition, counting relay 217 operates from negative battery through the cathode and anode of tube 205, over the back contact of register relay 206, left front contact of register relay 207, back contact and winding of relay 217 to positive battery.

As the outer front contact of relay 217 closes before the back contact of the relay opens, relay 217 operating immediately locks over its outer right front contact to negative battery. As relay 217 operates, it opens the circuit from positive battery, through its winding and back contact, over the left front contact of relay 207, back contact of relay 206, to the anode of tube 205, causing the tube to deionize. After removing the

positive battery from the anode of tube 205 by the opening of its back contact, relay 217 again connects positive battery to the tube anode through the winding and back contact of counting relay 218, inner front contact of relay 217, left front contact of relay 207 and back contact of relay 206.

As the advancing selector brush 221 contacts the next commutator segment, positive grounded battery is connected over brush 221, segment 223, right contacts of sequence switch 201, the tip of the fundamental circuit, to the grid of tube 205, and to one side of resistance 204. This removes the negative bias on the grid of tube 205 and the tube ionizes and becomes conducting. With tube 205 in the conducting condition, counting relay 218 operates from positive battery through its winding and back contact, inner front contact of relay 217, left front contact of relay 207, back contact of relay 206, to negative battery through the anode and cathode of tube 205.

As the outer front contact of relay 218 closes before the back contact of the relay opens, relay 218 operating immediately locks over its outer front contact to negative battery. As relay 218 operates, it opens the circuit from positive battery through its winding and back contact, inner front contact of relay 217, left front contact of relay 207, back contact of relay 206, to the anode of tube 205, causing the tube to deionize. Relay 218 operating then connects positive battery through the winding of the last counting relay 219, over the back contact of register relay 209, inner front contacts of relays 218 and 217 respectively, left front contact of relay 207, back contact of relay 206, to the anode of tube 205.

When the advancing selector brush 221 reaches commutator segment 224, positive grounded battery is again connected to the fundamental tip, resistance 204 and the grid of tube 205 over brush 221, segment 224 and right contacts of switch cam 201. This removes the negative bias on the grid of tube 205 and the tube ionizes and becomes conducting. Counting relay 219 operates from positive battery, winding of relay 219, back contact of register relay 209, inner front contacts of relays 218 and 217 respectively, left front contact of relay 207, back contact of relay 206, to negative battery through the anode and cathode of tube 205. Relay 219 operating, opens the fundamental circuit over its back contact which removes the ground through resistance 202, resistance 204, lower contacts of sequence switch cam 201, from the right front contact and winding of selector control relay 200.

As selector brush 221 advances past conducting commutator segment 224 it opens the circuit from ground over brush 221, segment 224, upper and lower contacts of sequence switch cam 201, to the front contact and winding of selector control relay 200 and the tip of the fundamental circuit, releasing relay 200. Relay 200 releasing, opens the circuit from ground over its left front contact to negative battery through the winding of selector updrive magnet 203 causing magnet 203 to de-energize and arrest the upward movement of the selector brush shaft and brush 221, as the sender counting relays have now been satisfied by the revertive ground pulses from the commutator of the particular selector under control of the sender at this time.

The operation of counting relay 219 also connects ground over its front contact to lead 220 to cause the sender to advance out of the control

position of the selection just completed. The advance of the sender circuit opens the negative battery from the cathode of tube 205, and from the windings of the counting relays which are being held operated, allowing these relays to release preparatory to their control of the next selection.

In the foregoing description of the operation of Fig. 2 it was assumed that the setting of the register relays, as controlled in the usual manner by the dial impulses, was such that register relay 207 was operated and register relays 206, 208 and 209 were unoperated. Therefore, as hereinbefore described, three reverte ground impulses from the selector sufficed to satisfy the sender counting relay chain, operating relays 217, 218 and 219 in that order.

With other combinations of operated and unoperated register relays, as set up under control of various dial impulses, the circuit illustrated in Fig. 2 functions in a manner similar to that hereinbefore set forth, except that the number of reverte ground impulses required to satisfy the sender counting relay chain depends upon the register relay combination previously set up for that particular selection, as this setting determines which counting relay winding is first connected in the anode circuit of tube 205.

With no register relays operated, counting relay 219 is connected in the anode circuit of tube 205 and one reverte ground impulse from the selector under control, satisfies the sender, operating relay 219. With register relay 206 operated and relays 207, 208 and 209 unoperated, relay 218 is first connected in the anode circuit of tube 205. Two reverte impulses satisfy the sender, operating relays 218 and 219 in that order. With only register relay 207 operated, three reverte impulses are required (as hereinbefore described in detail). Register relays 206 and 207 operated, require four reverte impulses, operating relays 216, 217, 218 and 219 in that order. With register relay 208 only, operated, five reverte pulses are required to operate relays 215, 216, 217, 218 and 219 in that order. With only register relay 209 operated, six impulses are required and operate relays 210, 211, 212, 213, 214 and 219 in the order named. The combination of operated register relays 206 and 209 require seven reverte impulses, operating relays 218, 210, 211, 212, 213, 214 and 219 in that order. Operated register relays 207 and 209 require eight impulses and relays 217, 218, 210, 211, 212, 213, 214 and 219 operate in the order named. With register relays 206, 207 and 209 operated, nine impulses are required and counting relays 216, 217, 218, 210, 211, 212, 213, 214 and 219 operate in that order. Register relays 208 and 209 operated, require ten reverte ground impulses from the selector, operating the full counting relay chain in the following order:—215, 216, 217, 218, 210, 211, 212, 213, 214 and 219.

Since gaseous discharge tube 205 ionizes very rapidly, and since the ionization is dependent upon grid potential change only, instead of upon current built up over the fundamental circuit, selector circuits may be controlled over greater fundamental circuit loops than hitherto possible. Furthermore, since only a very short application of ground from the selector commutator is sufficient to ionize the tube, the selector brush shaft may be advanced at materially increased speed. In addition, since tube 205 controls the counting relays in response to successive closures of the switch commutator as contrasted with the pres-

ent fundamental circuit which employs an impulse responsive relay controlling the counting relays in response successive closures and openings of the switch commutator, a simplified train of counting relays is used, having less than one half as many relays as heretofore employed.

What is claimed is:

1. In a signaling system, an impulsing device, an impulse responsive device, a control circuit extending from said impulsing device to said responsive device, a gaseous discharge tube at said responsive device associated with said circuit, the grid of said tube being negatively biased below the ionization potential of said tube when said circuit is closed, an impulse counting circuit extending from a source of positive potential to the anode of said tube, means controlled by said impulsing device for intermittently rendering the grid of said tube sufficiently positive to cause said tube to intermittently ionize and produce impulses in said impulse counting circuit, and means in said impulse counting circuit responsive to each impulse to momentarily open said impulse counting circuit to deionize said tube.

2. In a signaling system, an impulsing device, an impulse responsive device, a control circuit extending from said impulsing device to said responsive device, a gaseous discharge tube at said responsive device associated with said circuit, the grid of said tube being negatively biased below the ionization potential of said tube when said circuit is closed, a train of counting relays, an impulse circuit extending from a source of positive potential through the winding of one of said relays to the anode of said tube, and means controlled by said impulsing device for intermittently rendering the grid of said tube sufficiently positive to cause said tube to intermittently ionize, said tube upon its first ionization operating said one of said counting relays to first lock itself operated, to then momentarily disconnect said source of potential from the anode of said tube and to then connect said source of potential to the anode through the winding of the next succeeding counting relay, succeeding ionizations of said tube causing the similar functioning of successive counting relays.

3. In a telephone system, a selector switch, a sender, a control circuit extending from said switch to said sender, a control relay at said switch in said control circuit, a gaseous discharge tube at said sender associated with said control circuit, the grid of said tube being negatively biased below the ionization potential of said tube when said circuit is closed, an impulse counting circuit including the cathode-anode circuit of said tube, means controlled by said control relay for advancing said switch in a selective movement, and means controlled in said selective movement for intermittently changing the potential on the grid of said tube sufficiently to cause said tube to intermittently ionize and produce impulses in said impulse counting circuit.

4. In a telephone system, a selector switch, a sender, a control circuit extending from said switch to said sender, a control relay at said switch in said control circuit, a gaseous discharge tube at said sender associated with said control circuit, the grid of said tube being negatively biased below the ionization potential of said tube when said circuit is closed, an impulse counting circuit extending from a positive source of potential to the anode of said tube, means controlled by said control relay for advancing said switch in a selective movement, means controlled in said

selective movement for intermittently rendering the grid of said tube sufficiently positive to cause said tube to intermittently ionize and produce impulses in said impulse counting circuit, and means in said impulse counting circuit responsive to each impulse to momentarily open said impulse counting circuit to deionize said tube.

5. In a telephone system, a selector switch, a sender, a control circuit extending from said switch in said control circuit, a gaseous discharge tube at said sender associated with said control circuit, the grid of said tube being negatively biased below the ionization potential of said tube when said circuit is closed, a train of counting relays, means for establishing an impulse circuit from a source of positive potential through the windings of one of said relays to the anode of said tube, means controlled by said control relay for advancing said switch in a selective movement and means controlled in said selective movement for intermittently rendering the grid of said tube sufficiently positive to cause said tube to intermittently ionize, said tube upon its first ionization operating said one of said counting relays to first lock itself operated, to then momentarily disconnect said source of potential from the anode of said tube and to then connect said source of potential to the anode through the winding of the next succeeding counting relay, succeeding ionizations of said tube causing the similar functioning of successive counting relays.

6. In a telephone system, a selector switch having a control relay and a commutator, a sender for controlling the setting of said switch comprising registering means, impulse counting means and a gaseous discharge tube, a control circuit extending from said sender to said switch, said control circuit having one of its conductors connected to the grid of said tube and through the winding of said control relay to grounded battery, having the other of its conductors connected to the cathode of said tube and to ground and having its two conductors bridged at said sender by a resistance, an impulse counting circuit extending from the anode of said tube under the control of said registering means to said impulse counting means, and means controlled by said control relay to advance said switch in a setting movement whereby said commutator intermittently grounds the grid of said tube thereby causing said tube to ionize and upon each ionization to close said impulse counting circuit.

7. In a telephone system, a selector switch having a control relay and a commutator, a sender for controlling the setting of said switch comprising registering means, impulse counting means and a gaseous discharge tube, a control circuit looped through said sender and having one conductor thereof connected through the winding of said control relay to grounded battery and the other conductor thereof connected to ground, circuit means for associating the grid of said tube with said control circuit whereby when said control circuit it initially closed said grid is negatively biased below the ionization potential of said tube, an impulse counting circuit including the cathode-anode circuit of said tube and extending under the control of said registering means through said impulse counting means, and means controlled by said control relay to advance said switch in a setting movement whereby said commutator intermittently changes the potential of the grid of said tube thereby causing said tube

to ionize and upon each ionization to close said impulse counting circuit.

8. In a telephone system, a dial having impulsing contacts, arranged to produce short impulse openings in a control circuit for each impulse of a dialed series with the exception of the last impulse which is lengthened, a sender comprising a source of current, a quick acting pulse changeover relay, a train of impulse recording relays and a gaseous discharge tube, a control circuit looped from the sender through the contacts of said dial, and having one conductor thereof connected to the grid of said tube and to the positive terminal of said source and having the other conductor thereof connected through the operating winding of said pulse changeover relay to the negative terminal of said source, said pulse changeover relay operating over said control circuit and releasing only in response to the last and lengthened impulse of a dialed series, and an impulsing circuit extending from the anode of said tube to said train of recording relays, said gaseous discharge tube being responsive to said dial to successively operate said recording relays.

9. In a telephone system, a dial having impulse contacts arranged to produce short impulse openings in the control circuit for each impulse of a dialed series with the exception of the last impulse which is lengthened, a sender comprising a source of current, a quick acting pulse changeover relay, a train of impulse recording relays and a gaseous discharge tube, a control circuit looped from said sender through the contacts of said dial and having one conductor thereof connected to the grid of said tube and to the positive terminal of said source and having the other conductor thereof connected through the operating winding of said pulse changeover relay to the negative terminal of said source, said pulse changeover relay operating over said control circuit and releasing only in response to the last and lengthened impulse of a dialed series and an impulsing circuit extending from the positive terminal of said source through the winding of the first of said train of recording relays to the anode of said tube, each opening of said control circuit by the contacts of said dial causing said tube to ionize, said tube upon its first ionization operating said first recording relay to first lock itself under control of said pulse changeover relay, to then deionize the tube and to then connect the anode of the tube to the winding of the next succeeding recording relay of said train, whereby successive ionizations of said tube cause the similar functioning of successive recording relays to record the number of impulses in the series dialed.

10. In a signaling system, an impulsing device, an impulse responsive device, a control circuit extending from said impulsing device to said responsive device, a gaseous discharge tube at said responsive device associated with said circuit, the grid of said tube being negatively biased below the ionization potential of said tube when said circuit is closed, an impulse counting circuit extending from a source of positive potential to the anode of said tube, means controlled by said impulsing device for intermittently changing the potential of the grid of said tube sufficiently to cause said tube to intermittently ionize and produce impulses in said impulse counting circuit, and means in said impulse counting circuit responsive to each impulse to cause the deionization of said tube.

11. In a signaling system, an impulsing device,

an impulse responsive device, a control circuit extending from said impulsing device to said responsive device, a gaseous discharge tube at said responsive device associated with said circuit, the
5 grid of said tube being negatively biased below the ionization potential of said tube when said circuit is closed, a train of counting relays, an impulse circuit extending from a source of positive potential through the winding of one of said
10 relays to the anode of said tube, and means controlled by said impulsing device for intermittently changing the potential of the grid of said tube sufficiently to cause said tube to intermittently ionize, said tube upon its first ionization operating
15 said one of said counting relays to lock itself operated, to cause the deionization of said tube and to then connect said source of potential to the anode through the winding of the next succeeding counting relay, succeeding ionizations of
20 said tube causing the similar functioning of successive counting relays.

12. In a telephone system, a selector switch, a sender, a control circuit extending from said switch to said sender, a control relay at said
25 switch in said control circuit, a gaseous discharge tube at said sender associated with said control circuit, the grid of said tube being negatively biased below the ionization potential of said tube when said circuit is closed, an impulse counting
30 circuit extending from a positive source of potential to the anode of said tube, means controlled by said control relay for advancing said switch

in a selective movement for intermittently changing the potential of the grid of said tube sufficiently to cause said tube to intermittently ionize and to produce impulses in said impulse counting
80 circuit, and means in said impulse counting circuit responsive to each impulse to cause the deionization of said tube.

13. In a telephone system, a selector switch, a sender, a control circuit extending from said switch to said sender, a control relay at said
85 switch in said control circuit, a gaseous discharge tube at said sender associated with said control circuit, the grid of said tube being negatively biased below the ionization potential of said tube when said circuit is closed, a train of counting
90 relays, means for establishing an impulse circuit from a source of positive potential through the winding of one of said relays to the anode of said tube, means controlled by said control relay for advancing said switch in a selective movement,
95 and means controlled in said selective movement for intermittently changing the potential of the grid of said tube sufficiently to cause said tube to intermittently ionize, said tube upon its first
100 ionization operating said one of said counting relays to lock itself operated, to cause the deionization of said tube and to then connect said source of potential to the anode through the winding of the next succeeding counting relay, succeeding
105 ionizations of said tube causing the similar functioning of successive counting relays.

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