

May 19, 1936.

O. MYERS

2,041,084

TELEPHONE SYSTEM

Filed Dec. 29, 1934

4 Sheets-Sheet 1

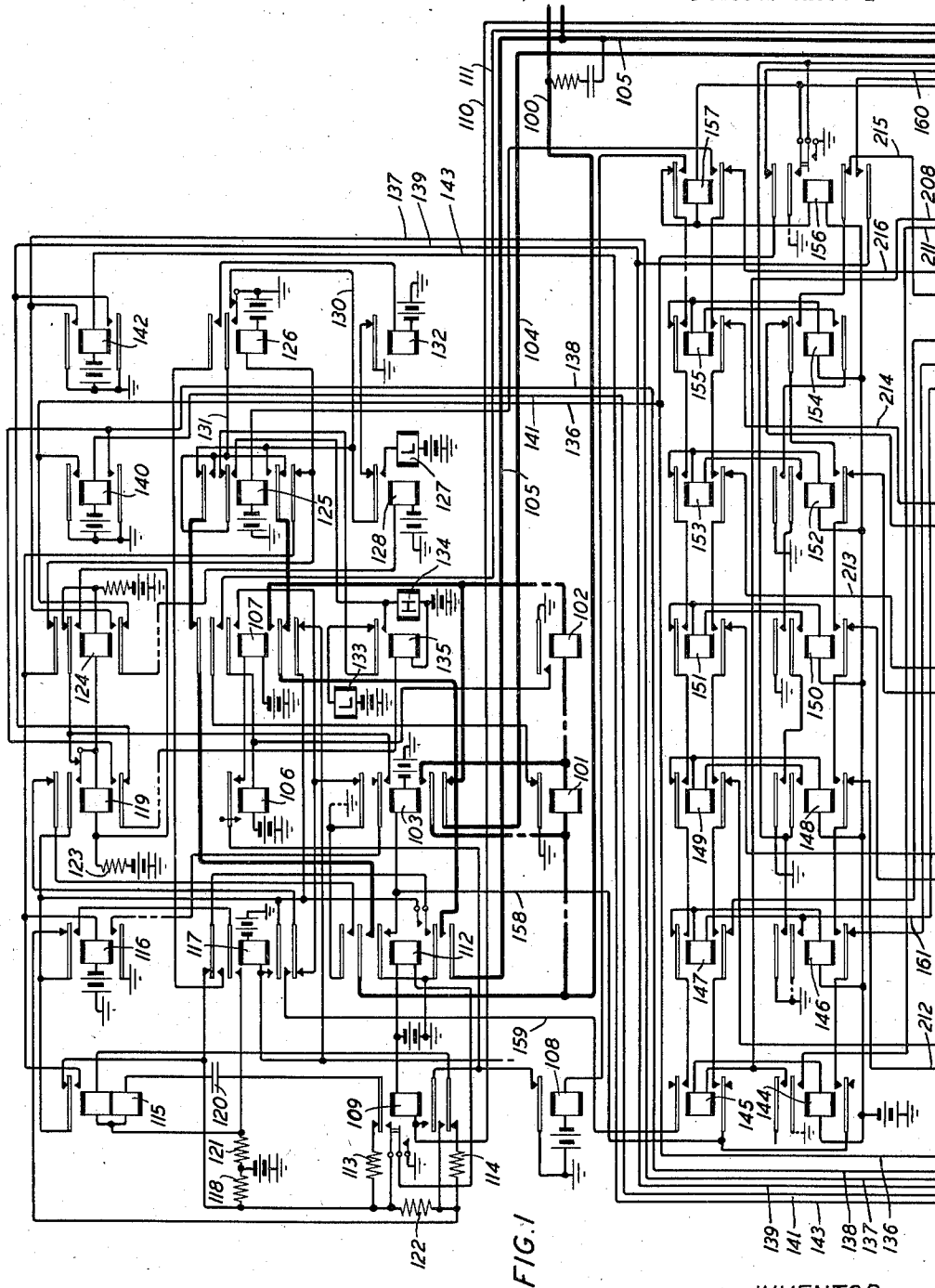


FIG. 1

INVENTOR
O. MYERS

BY

P. C. Smith

ATTORNEY

May 19, 1936.

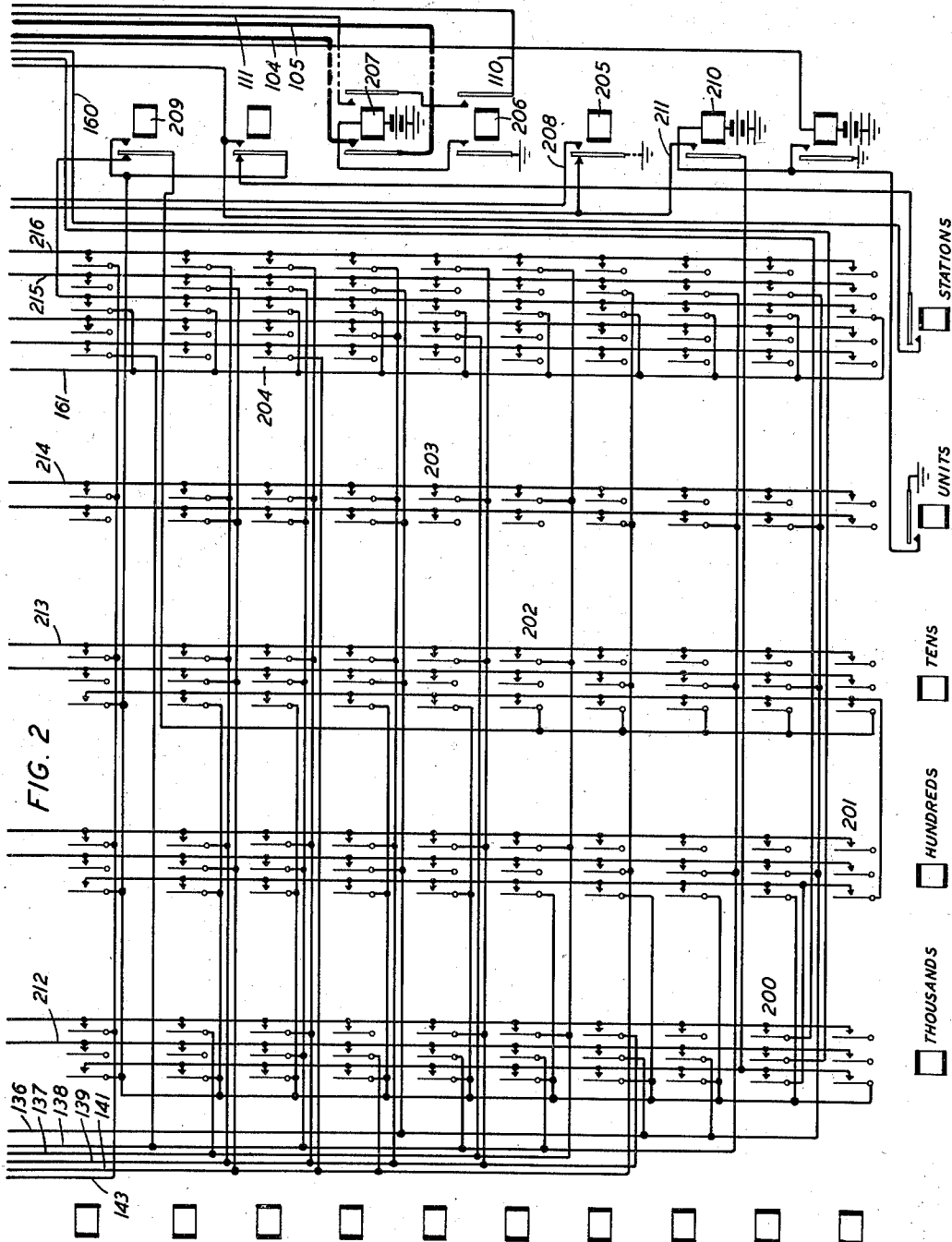
O. MYERS

2,041,084

TELEPHONE SYSTEM

Filed Dec. 29, 1934

4 Sheets-Sheet 2



INVENTOR
O. MYERS

BY

P. C. Smith

ATTORNEY

May 19, 1936.

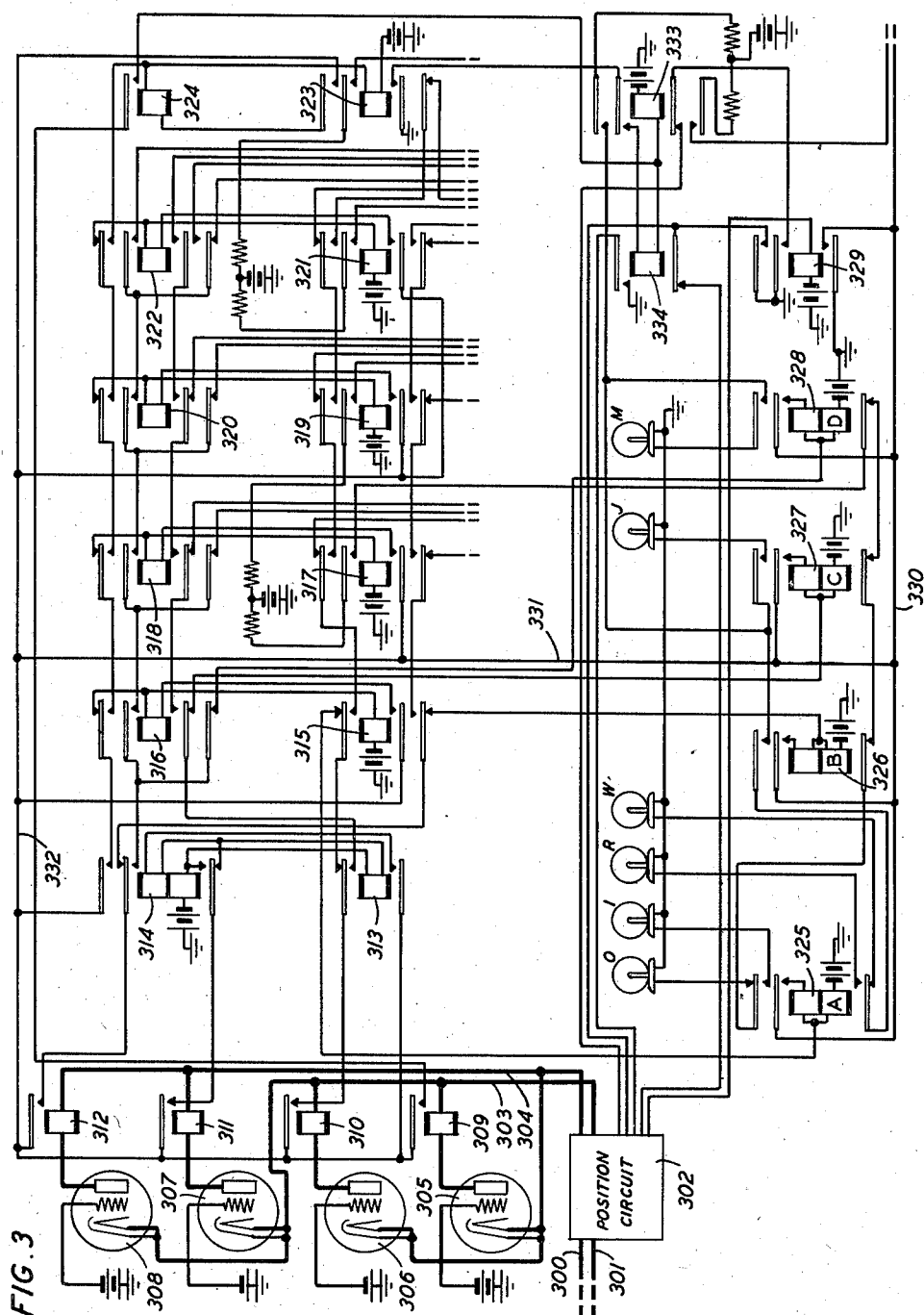
O. MYERS

2,041,084

TELEPHONE SYSTEM

Filed Dec. 29, 1934

4 Sheets-Sheet 3



INVENTOR
O. MYERS
BY
P. C. Smith
ATTORNEY

May 19, 1936.

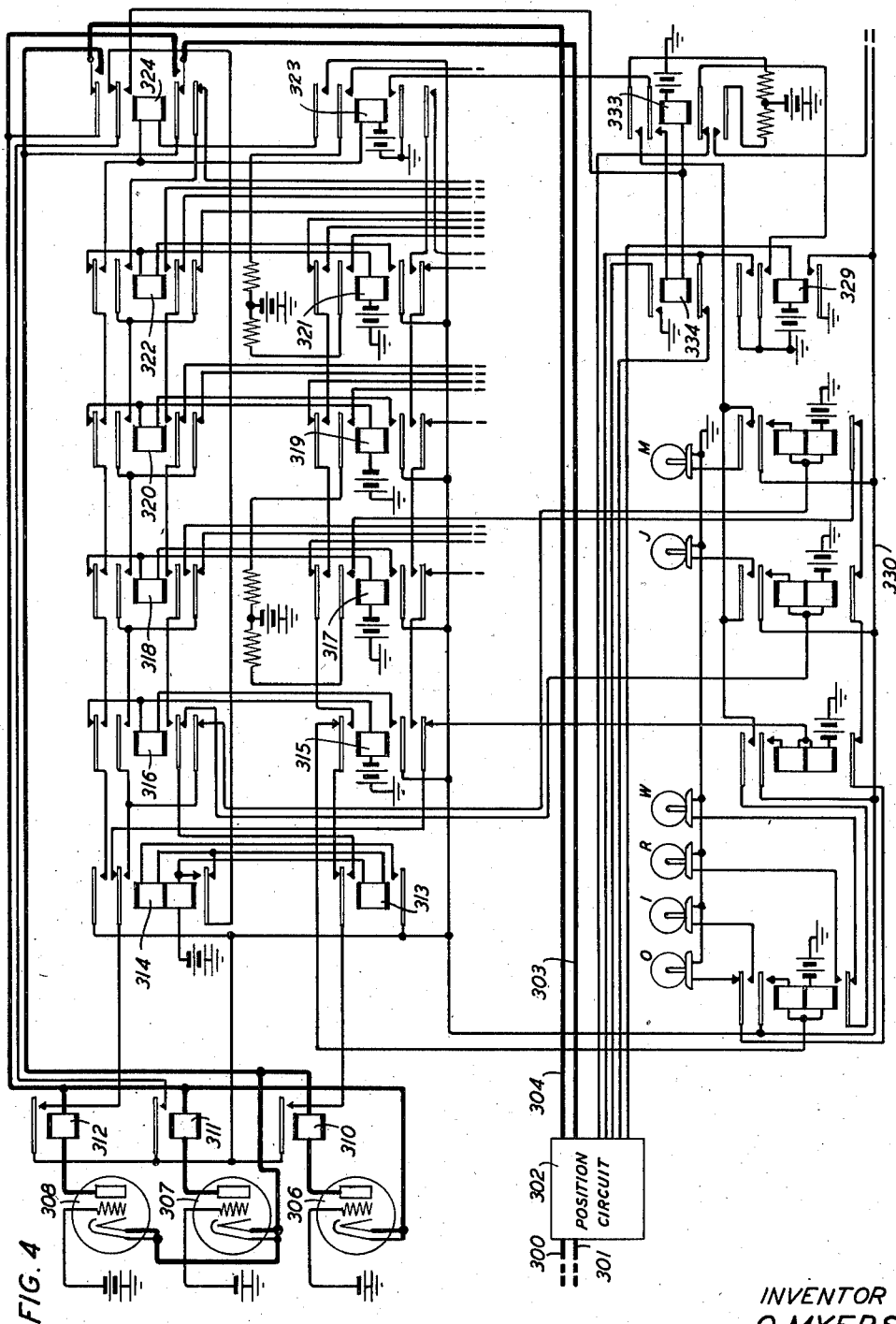
O. MYERS

2,041,084

TELEPHONE SYSTEM

Filed Dec. 29, 1934

4 Sheets-Sheet 4



INVENTOR
O. MYERS
BY
P. C. Smith
ATTORNEY

UNITED STATES PATENT OFFICE

2,041,084

TELEPHONE SYSTEM

Oscar Myers, Brooklyn, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application December 29, 1934, Serial No. 759,666

9 Claims. (Cl. 179—90)

This invention relates to a telephone exchange system and more particularly to circuits for enabling the registration of the digits of a called line number in the registering mechanism of a manual office or at a tandem office by means of series of code impulses transmitted from the sender of an originating office.

Heretofore circuits of this character as disclosed, for example, in Patent No. 1,968,420 granted July 31, 1934 to A. C. Powell, have employed three impulse responsive relays connected in a bridge across the conductors of the cable loop extending from the sender of the originating office to the digit registering equipment of the terminating manual office. Two of these relays are polarized, one responsive to impulses of negative polarity only and the other responsive to impulses of positive polarity only. The third relay is responsive to impulses of either polarity, but is so margined as to respond only to impulses of increased current strength. The three relays cooperate to sequentially select relay registers and to control the selective operation of the relays of each register. The registers after they have assumed their settings are then instrumental in selectively lighting lamps on a display board to display the number of the subscriber's line terminating in the manual office which the calling subscriber has dialed and caused to be transferred to the manual office by series of code impulses transmitted by the sender of the originating office.

Accurate response to the series of code impulses transmitted over the control conductors is dependent to a great degree on the design and adjustment of the three impulse responsive relays associated with the control circuit and this is particularly true of the marginal relay which is dependent upon the restriction of the resistance of the control circuit within certain definite limits. It is therefore the object of the present invention to increase the accuracy of the registration of wanted line numbers in the display equipment of an operator's position, or the registration of line numbers in the registering equipment of a tandem sender in response to series of code impulses transmitted thereto from an originating office; to make possible the transmission of impulses over longer control circuit loops; to eliminate the effect of leakage and capacity of the conductors of the control circuit; to enable response to impulses of shorter duration and to eliminate the use of polarized and marginal impulse responsive relays.

In accordance with the present invention, use

is made of gaseous conductor tubes as impulse responsive relays. The gaseous conductor tube employed 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. As disclosed, each tube is of the hot cathode type having a filament heated by either direct or alternating current and a cathode heated conductively from the filament. Obviously, a hot cathode type of tube in which the filament, heated by direct current, serves as the cathode or a cold cathode type of tube might be employed. Each tube functions as an ionic relay to establish an operating circuit for an impulse responsive relay included in the cathode-anode circuit thereof. The relay associated with each tube may be of simple, efficient design since it is not required to be selective to current margins or reversal of potential over the control circuit extending from the sender of the originating office.

For the purpose of illustration, the invention has been disclosed in connection with the registering equipment of a manual office essentially similar to that disclosed in the patent to Powell previously referred to.

In order to simplify the disclosure, only one of the digit registers and associated display lamps has been illustrated and the operator's position equipment, by means of which an incoming call is answered and completed to a wanted line as indicated by the number displayed, has been omitted and designated by a rectangle labeled "position circuit". For transmitting code impulses to the registering equipment of the manual office only so much of the sender of an originating office has been disclosed as is necessary for an understanding of the invention. This sender may, for example, be of the type disclosed in the application of R. Raymond, Serial No. 27,340, filed June 19, 1935, modified to function with the ionic impulse responsive apparatus of the present invention.

The application of ionic tubes to the registering equipment of a manual office has been illustrated by two modifications. In one modification four gaseous conductor tubes are associated with the tip and ring conductors of the control circuit incoming from the sender of the originating office. Two of these tubes have their anodes

connected through the windings of associated impulse responsive relays to the ring conductor and their cathodes connected to the tip conductor. The grids of these two tubes may be negatively biased with different potentials to provide definite breakdown potentials for the tubes, or the tubes may be selected for inherent breakdown potential and operate without grids. One of these tubes breaks down when a low potential negative impulse is applied to the tip conductor and ground is applied to the ring conductor and thus operates the impulse responsive relay over its cathode-anode circuit and both tubes break down when a high potential negative impulse is applied to the tip conductor and ground is applied to the ring conductor and thus operate the two impulse responsive relays associated with their cathode-anode circuits. The other two tubes have their anodes connected through the windings of associated impulse responsive relays to the tip conductor and their cathodes connected to the ring conductor. The grids of these tubes may be negatively biased to different potentials to provide definite breakdown potentials for these tubes, or the tubes may be selected for inherent breakdown potential and operate without grids. One of these latter tubes breaks down when a low potential positive impulse is applied to the ring conductor and ground is applied to the tip conductor and thus operates the associated impulse responsive relay over its cathode-anode circuit and both of these tubes break down when a high potential positive impulse is applied to the ring conductor and ground is applied to the tip conductor and thus operate the two impulse responsive relays associated with their cathode-anode circuits. All relays release upon the deionization of the tubes following the removal of battery potential on the cathodes or ground from the anodes and since each relay is in series with a tube it releases in an open circuit. The polarized and marginal effects are obtained from the tubes and therefore all relays are alike and non-polarized. A gain in the length of impulse necessary results from the use of more sensitive tubes as ionic relays and the avoidance of release against the leak and capacity of the control circuit. The impulse responsive relays function in the usual manner to control the sequential setting of the lamp display registers of the positional equipment.

In the second modification of the invention but three gaseous conductor tubes are employed, two of which function in the same manner as the corresponding tubes of the first modification in response to the application of either low or high negative potential impulses to the tip conductor and ground to the ring conductor. The third tube breaks down when a low potential negative impulse is applied to the ring conductor and ground is applied to the tip conductor. When it is necessary to register a final heavy positive impulse following the registration of all digits, the register circuit reverses the connection of the cathodes and anodes of the tubes to the tip and ring conductors of the control circuit so that both of the two first tubes break down when the final heavy positive impulse is transmitted by the connection of heavy negative potential to the ring conductor and ground to the tip conductor. The three responsive relays associated with the tubes function to control the sequential setting of the lamp display registers and to record the receipt of a final heavy positive impulse in the same manner as the corresponding impulse responsive

relays of the Powell patent hereinbefore referred to.

For a more complete understanding of the invention reference may be had to the following detailed description taken in connection with the attached drawings in which:

Figs. 1 and 2 show such portions of a central office sender as are necessary to an understanding of the invention; Fig. 1 showing relay equipment for generating and transmitting code impulses for setting up line designations on indicating equipment in a manual office and transfer relays for successively associating the impulsing equipment with the digit register of Fig. 2, and Fig. 2 showing a register of the cross-bar type upon which the numerical and stations digits of telephone designations may be registered.

Fig. 3 shows a portion of the call indicating equipment of a manual office, and

Fig. 4 shows a modified form of the call indicating equipment.

For a complete disclosure of the invention, Fig. 2 should be placed beneath Fig. 1, and either Fig. 3 or Fig. 4 should be placed to the right of Fig. 1.

Since the invention relates more particularly to the use of gas-filled tubes as responsive relays for receiving call indicator code impulses and for controlling the registration and indication of the digits of line designations in accordance therewith, only so much of a sender for generating and transmitting the code impulses in accordance with digits registered in the sender has been disclosed as is considered necessary to an understanding of the invention. For this purpose a portion of the cross-bar register and code impulse generating and transmitting equipment of a typical sender has been disclosed. For a complete disclosure of a sender of this type reference may be had to the application of R. Raymond hereinbefore referred to. In this connection it may be noted that the impulsing equipment has been slightly modified to generate impulses of a character to which the gas-filled tubes are particularly responsive.

The call indicator equipment of Fig. 3 is substantially identical to the similar equipment disclosed in Patent 1,968,420, granted to A. C. Powell hereinbefore referred to with the exception that the two polarized relays and the marginal relay which respond to code impulses transmitted thereto from a sender, have been replaced by four gas-filled tubes and anode relays.

The call indicator equipment of Fig. 4 is identical to the similar equipment disclosed in Fig. 3 with the exception that the four tubes and associated anode relays which respond to code impulses transmitted thereto have been replaced by three gas-filled tubes and associated relays.

In both Figs. 3 and 4, the operator's position equipment has been indicated by small rectangles in order to simplify the drawings. It is to be understood that the trunk incoming from the sender terminates at the operator's position in a plug by means of which the operator may complete a call incoming over the trunk to a desired subscriber's line whose number is indicated on her indicating equipment and that the position equipment comprises the usual assignment key and relays by means of which the operator may cause the association of her indicating equipment with the incoming trunk and signal the sender to transfer thereto the line designation registered in the sender.

It is believed that the invention will be best understood if the operation thereof is described in

connection with a typical call. It will therefore be assumed that a calling subscriber has dialed the line designation MA3-10457 and that this line designation has been registered on the register of the sender, a portion of this register being illustrated in Fig. 2. Since this invention is not concerned with the registration of the office code MA3 and the manner in which the sender controls the setting of selector switches to extend a connection to this office, in the case assumed in the manual office of Fig. 3, the portion of the register upon which the office code designation is registered, the selector controlling apparatus of the sender and the selector switches have been omitted and only that portion of the sender register upon which the numerical digits and the station's letter are registered has been illustrated. Under the assumption that the numerical designation registered was 10457, the cross-point contact sets 200, 201, 202, 203 and 204 have been operated to register the ten thousands digit 1, the thousands digit 0, the hundreds digit 4, the tens digit 5 and the units digit 7 in a manner fully set forth in the Raymond application hereinbefore referred to.

In the establishment of the connection to the wanted manual office of Fig. 3, after the selector switches (not shown) have been set by the sender to select idle trunk 300 and 301 extending thereto, with the class relays 205, 206 and 207 operated for a call of this class, a trunk test circuit is established to test the selected trunk to determine if the trunk is in condition to be used for the connection. This circuit may be traced in part from the tip conductor 300 of the trunk back to the sender thence over conductor 100, winding of overflow relay 101, winding of trunk test relay 102, lower back contact of relay 103, conductor 104, left contact of class relay 207, conductor 105 to the ring trunk conductor 301. If the trunk is in proper condition to complete the connection, relay 102 operates, but overflow relay 101 does not. Relay 102 closes an obvious circuit for relay 106 which causes the operation of relay 107 in a circuit extending from battery, winding of relay 107, contact of relay 106, back contact of relay 108 to ground. With relay 107 operated, relay 106 is now locked in a circuit extending over the inner upper front contact of relay 107, upper back contact of relay 103, to ground and a circuit is established from battery, winding of relay 109, conductor 110, right contacts of class relays 206 and 207, conductor 111, middle upper front contact of relay 107 to ground at the back contact of relay 101. Relay 109 upon operating locks over its inner lower front contact, to ground at the back contact of relay 108. At its inner upper front contact it establishes an obvious operating circuit for relay 112 and at its upper and lower contacts removes resistances 113 and 114 from the circuits of pulsing relay 115 preparing it to operate at a fast rate.

Relay 112 upon operating causes the operation of relay 103 which opens the locking circuit of relays 106 and 107, but these relays remain operated under the control of relay 102. Relay 103 at its lower back contact, opens the fundamental circuit above traced, but when relay 112 operated, a substitute circuit was closed over conductor 300, conductor 100, lower front contact of relay 103, winding of relay 102, lower front contact of relay 107, lower front contact of relay 112, conductor 105, to conductor 301, thus holding relay 102 operated under the control of the manual operator until the operator assigns the trunk.

Relay 103 also closes a shunt around the winding of overflow relay 101 over its lower front contact. To prevent the release of relay 107 and the start of pulsing before the proper conditions have been established, a holding circuit is provided for relay 106 over the inner upper front contact of relay 107, the lower back contact of relay 117, the upper back contact of relay 119, upper front contact of relay 112 to ground, relay 106 holding relay 107 operated over the previously traced locking circuit.

Relay 115 is a non-biased, condenser-timed, polarized relay which closes its front contact when energized in one direction, closes its back contact when energized in the other direction and leaves either contact closed when not energized. When current is first passed through its upper winding in either direction, its force is neutralized by an opposing current over the lower winding caused by the discharge of the timing condenser 120 and its recharge in the opposite sense. When the condenser has been discharged and recharged, current ceases to flow in the lower winding and the upper winding causes the armature to move over from one contact to the other. The alternate back and forth movement of the armature can be retarded as desired by selecting the proper capacity and resistances. Both ends of both windings are normally connected to battery, the left ends in common through resistance 121. The right end of the upper winding is connected over the lower front contact of relay 109, resistance 122 and resistance 118 to battery, while the right end of the lower winding is connected through condenser 120, the upper front contact of relay 109, resistance 118 to battery. By shunting one or the other battery connection with ground, current is caused to flow through the upper winding in one direction or the other and in the lower winding always in the opposing direction. With relays 115 and 116 normal, resistance 122 is shunted over the back contacts thereof and with either relay operated, this resistance is introduced in series with the upper winding of relay 115 to delay the closure of its back contact and thus equalize alternate pulses.

When relay 112 operated, it connected ground over its inner lower front contact to the armature of relay 115 and to the upper armature of relay 116 thereby connecting ground over the back contacts of these armatures in shunt of battery through resistance 118. Therefore relay 115 closes its front contact extending ground to the winding of relay 116. Since relay 117 is not operated at this time, the operation of relay 116 is ineffective to release relay 115 and relays 115 and 116 remain operated ready to start pulsing. Since relay 103 is operated, the circuit closed at the lower contact of relay 116, extends from ground at that contact over the upper front contact of relay 103, inner upper normal contacts and winding of relay 119, resistance 123, to battery. The circuit also extends to the winding of relay 124 but this relay is shunted over its inner upper back contact so that relay 119 operates alone, locking over its alternate contacts to ground over the inner lower contacts of relay 112. With relay 115 operated and either relay 124 or relay 125 non-operated, a circuit is closed from ground over the front contact of relay 115, outer upper back contact of relay 124, or lower back contact of relay 125, winding of relay 126 to battery.

When the operator at the manual office assigns

the trunk 300 and 301, battery and ground are removed at the position circuit 302 in the usual manner and conductors 300 and 301 are connected to conductors 304 and 303, respectively. Relay 329 is also operated from the position circuit 302 at this time. Relay 102 now releases in turn releasing relays 106 and 107. With relay 112 operated and relay 107 released, the fundamental tip conductor 304 is extended over conductors 300 and 100, middle upper front contact of relay 112, upper back contact of relay 107, upper back contact of relay 125, to conductor 130. The fundamental ring conductor extends from conductor 303 over conductors 301 and 105, lower front contact of relay 112, inner lower back contact of relay 107, inner lower back contact of relay 125 to conductor 131. The release of relay 107 also closes a circuit from ground at the inner lower contact of relay 112, lower back contact of relay 107, winding of relay 117 to battery. Relay 117 operates and locks over its inner lower front contact to ground at the contacts of relay 112, at its upper back contact removes the shunt from battery through resistance 118, and connects the upper front contact of relay 116 over its inner upper front contact in shunt of battery through resistance 121 thereby starting relays 115 and 119 to pulsing. Relay 115 opens its front contact releasing relay 116 which opens the shunt around the winding of relay 124 and that relay operates. When relay 116 next closes its lower contact, it connects ground over the inner upper front contact of relay 124 to resistance 123 in shunt of the winding of relay 119. Relay 119 releases, but relay 124 is held operated over the inner make-before-break contacts of relay 119, first to the locking ground of relay 119 and then to ground at the contact of relay 116. When relay 116 releases, relay 124 also releases. Relays 119 and 124 repeat this cycle of operations under the control of relay 116 until the designation has been completely transmitted. Each complete cycle generates four impulses to transmit one digit as follows:

Pulse	Relay 116	Relay 119	Relay 124
1.....	Operated..	Operated..	Released..
2.....	Released..	Operated..	Operated..
3.....	Operated..	Released..	Operated..
4.....	Released..	Released..	Released..

Relay 126 operates in parallel with relay 116 being operated for the odd pulses and released for the even pulses. At each operation relay 126 closes a circuit from battery through the winding of relay 132, upper contact of relay 126, upper front contact of relay 117, to ground at the middle lower contact of relay 112. Relay 126 serves to alternately connect ground to conductor 131 thence over the fundamental ring for the odd pulses and to conductor 130 thence over the fundamental tip for the even pulses. On the first or odd pulse with relay 126 operated, the fundamental ring conductor is connected to ground over the front contact of relay 126 and either the low inductance coil 133 or the high inductance coil 134 is energized in a circuit extending from ground at the make contacts of relay 126, and either the low inductance coil 133 or the high inductance coil 134 is energized in a circuit extending from ground at the make contacts of relay 126, inner upper back contact of relay 125 to the armature of relay 135, thence through the coil 133 or the coil 134 dependent upon the con-

dition of relay 135, thus completely saturating the core of the energized coil. At the same time the fundamental tip conductor is either momentarily connected to ground over the back contact of relay 128 and the back contact of relay 132, or to the winding of the previously charged inductance coil 127, dependent on whether relay 128 has or has not been operated from the dial register to denote either a blank or light positive pulse.

On the second or even pulse with relay 126 unoperated, ground is connected over the normal contacts of relay 126 to the fundamental tip conductor and the winding of the previously charged low inductance coil 133 or the winding of the charged high inductance coil 134, is connected to the fundamental ring conductor dependent on whether relay 135 has or has not been operated from the dial register to denote a heavy or light negative impulse.

On the third or odd pulse with relay 126 operated, the fundamental ring conductor is again connected to ground over the front contact of relay 126 and either the low inductance 133 or the high inductance coil 134 is again energized dependent upon the condition of relay 135. At the same time the fundamental tip conductor is either momentarily connected to ground over the back contact of relay 128 and the back contact of relay 132 or to the winding of inductance coil 127 dependent upon whether relay 128 has not or has been reoperated from the dial register to denote either a blank or light positive pulse.

On the fourth or even pulse with relay 126 unoperated ground is connected over the normal contacts of relay 126 to the fundamental tip conductor and the winding of the previously charged low inductance coil 133 or the winding of the charged high inductance coil 134 is connected to the fundamental ring conductor dependent upon whether relay 135 has or has not been operated from the dial register to denote a heavy or light negative pulse.

In general relay 128 is operated in a circuit extending from battery through its winding to the lower armature of relay 124. With this relay released either before pulsing or in the fourth pulse period, the circuit extends over conductor 136 to contacts in the No. 1 and No. 6 levels of the dial register to operate relay 128 in readiness to send out a positive pulse in the first pulse period as called for by the code for digits 1 and 6. With relay 124 operated in the second pulse period, the circuit extends over conductor 137 to contacts in the No. 4 level of the dial register to operate relay 128 in readiness to send out a positive pulse in the third pulse period. Similarly the circuit of relay 135 extends to the lower armature of relay 119. Relay 119, being operated in the first pulse period, the circuit of relay 135 is extended over conductor 138 to contacts in the No. 2 and No. 7 levels to prepare for sending a heavy negative pulse in the second pulse period. When relay 119 releases in the third pulse period, the circuit of relay 135 extends over conductor 139 to contacts in the No. 5, No. 6, No. 7, and No. 8 levels.

To save contacts on the dial register, when a heavy negative pulse follows a positive pulse directly as in the codes for the digits 3, 8, and 9, relay 140 is operated over conductor 141 and contacts of the No. 3 and No. 8 levels of the dial register and relay 142 is operated over conductor 143 and contacts of the No. 9 level to supply additional circuits for operating relays 128 and 135. Conductors 136 to 139 and 141 also extend to contacts in levels other than those mentioned above.

These contacts occur in the thousands and stations verticals which are cross-connected according to different code arrangements as will appear from the following table, in which "n" represents a light negative pulse, "N" a heavy negative pulse, "p" a positive pulse and "—" a blank pulse.

Regular digit	Thousands digit	Stations digit	Code
0	0	0	—n—n
1	2	1	pn—n
2	4	W (9)	—N—n
3	6	R (7)	pN—n
4	8	J (5)	—npn
5	1	M (6)	—n—N
6	3		pn—N
7	5		—N—N
8	7		pN—N
9	9		—npN

front contact of relay 144 to ground in any suitable manner. Since a five digit numerical designation 10457 has been registered, when the fifth digit was registered a circuit was closed from battery through the windings of transfer relays 146 and 147, conductor 161, middle contacts of the No. 7 contact set 204 in the stations vertical, back contact of relay 209, cross-point contact of the No. 4 contact set 202 in the tens vertical, cross-point contact of the No. 0 contact set 201 in the hundreds vertical, cross-point contact of the No. 1 contact set 200 in the thousands vertical, front contact of relay 210, which operated when the fourth numerical digit was registered, conductor 211 to ground over the inner upper front contact of transfer relay 144. Relays 146 and 147 lock over the inner upper front contact of relay 146 to ground.

Since transfer relays 144 to 147, inclusive, are operated and the ten thousands digit 1 has been registered on the thousands vertical, ground over the inner upper front contact of relay 112 and conductor 158 is extended over the lower front contacts of transfer relays 144 and 146 and the lower back contact of transfer relay 148 to one set of contacts in the thousands vertical and over the lower front contacts of transfer relays 145 and 147 and the lower back contact of transfer relay 149 to another set of contacts of the thousands vertical for controlling the operation of relays 128, 135, 140 and 142.

With the cross-point contact set 200 operated, to register the ten thousands digit 1, a circuit is effective just prior to the first pulse period at which time relay 124 is released for operating relay 128. This circuit extends from battery, winding of relay 128, lower back contact of relay 124, conductor 136, upper back contact of relay 156, conductor 160, middle contact of cross-point 200, conductor 212, lower back contact of relay 148, lower front contacts of relays 146 and 144, conductor 158, thence as traced to ground. Therefore when relay 126 operates during the first pulse period, the ring conductor 303 is grounded and a surge of low negative potential is applied from inductance coil 127, over the front contact of relay 128 and thence as traced to the tip conductor 304, coil 127 having charged as previously described prior to the first impulse period. Tube 306 will now ionize since the low negative potential applied to its cathode over conductor 304 will overcome the low negative bias on its grid and its anode is supplied with positive or ground potential over conductor 303. Tube 305 having a heavier negative bias will not ionize and tubes 307 and 308 will not ionize since negative potential is applied to their anodes over conductor 304 and positive potential is applied to their cathodes over conductor 303.

With tube 306 ionized, relay 310 is operated in the cathode-anode circuit thereof extending from the negative terminal of battery, coil 127, front contact of relay 128, upper back contact of relay 125, thence as traced to conductor 304, cathode and anode of tube 306, winding of relay 310, conductor 393, thence as traced to the inner lower back contact of relay 125, conductor 131 to ground at the alternate contacts of relay 126. Relay 310 upon operating closes a circuit from ground at the lower front contact of relay 329, conductors 330, 331 and 332, contacts of relay 310, upper back contact of relay 313, upper back contact of transfer relay 315, lower winding of register relay 325 to battery. Relay 325 operates and locks in a circuit from battery through both of its windings

At the manual office of Fig. 3, the tip and ring conductors 304 and 303 are associated with four gas-filled tubes, each having a cathode heated by a filament, a control electrode or grid and an anode. The ring conductor 303 is connected to the anodes of tubes 305 and 306 through anode relays 309 and 310, respectively, and to the cathodes of tubes 307 and 308, and the tip conductor 304 is connected to the cathodes of tubes 305 and 306 and to the anodes of tubes 307 and 308 through anode relays 311 and 312, respectively. The grid of each tube is biased negatively by the connection thereof to the negative terminal of a biasing battery, the grids of tubes 306 and 307 being biased to a lower negative potential than the grids of tubes 305 and 308. Tube 307 is thus biased so as to ionize when low negative potential is applied to its cathode over the ring conductor 303 and ground potential is applied to its anode over the tip conductor 304 and thus responds to a light negative code impulse. Tube 308 having a higher negative bias will ionize at the same time as tube 307 when high negative potential is applied to its cathode over the ring conductor 303 and ground potential is applied to its anode over the tip conductor 304 and thus responds to a heavy negative code impulse. Tube 306 is so biased as to ionize when low negative potential is applied to its cathode over tip conductor 304 and ground potential is applied to its anode over ring conductor 303 and thus responds to a light positive code impulse while tube 305 having a higher bias ionizes at the same time as tube 306 when high negative potential is applied to its cathode over tip conductor 304 and ground potential is applied to its anode over ring conductor 303 and thus responds to a heavy positive code impulse. None of the tubes will ionize when ground potential is applied to both conductors 303 and 304 as on blank pulses.

Relay 311 controls the operation and release of relays 313 and 314 in cycles which in turn control the transfer relays 315 to 324 inclusive for associating the groups of digit register relays with the contacts of relays 309, 310 and 312. Only one group of relays 325 to 328, constituting the station's register, has been disclosed, other groups of register relays being connected to contacts of the transfer relays in the manner disclosed in Patent 1,968,420 granted to A. C. Powell hereinbefore referred to.

It was previously assumed that class relay 205 was operated and therefore a circuit is established from ground over its contacts, conductor 208, windings of transfer relays 145 and 144 in series, to battery, these relays locking over the upper

and its inner upper front contacts to ground on conductor 330.

Since during the first pulse period there is no circuit effective for relay 135 over cross-point 200 when relay 119 operates, relay 126 upon releasing during the second pulse period removes ground potential from the ring conductor 303, thus causing the deionization of tube 306 and the release of relay 310. With relay 126 released it connects ground to the fundamental tip conductor 304 and with relay 135 unoperated, a surge of low negative potential is applied from inductance coil 133 to the fundamental ring conductor 303, this coil having been charged as previously described during the first pulse period. Tube 307 will now ionize since the low negative potential applied to its cathode over conductor 303 will overcome the low negative bias on its grid and its anode is supplied with ground or positive potential over the tip conductor 304. Tube 308 having a heavier negative bias will not ionize and tubes 305 and 306 will not ionize since negative potential is applied to their anodes over conductor 303 and positive potential is applied to their cathodes over conductor 304.

With tube 307 ionized, relay 311 is operated in the cathode-anode circuit thereof extending from the negative terminal battery, coil 133, back contact of relay 135, inner upper and inner lower back contacts of relay 125, thence as traced to conductor 303, cathode and anode of tube 307, winding of relay 311, conductor 304, thence as traced to the upper back contact of relay 125, conductor 130 to ground at the normal contacts of relay 126. Relay 311 upon operating closes a circuit from ground on conductor 332, contact of relay 311, lower back contact of relay 314, winding of relay 313, lower winding of relay 314 to battery. Relay 313 operates but the lower winding of relay 314 being marginal, relay 314 does not operate. Relay 313 upon operating closes a short circuit around the upper winding of relay 314, extending from conductor 332, lower contact of relay 313, upper winding of relay 314, lower back contact of relay 314, contact of relay 311 to conductor 332.

During the second pulse period no circuit is effective over cross-point 200 for relay 128 and thus during the third pulse period when relay 126 operates, both the tip and ring conductors 304 and 303 are grounded, resulting in a blank pulse. None of the tubes will ionize in response to this blank pulse and since ground potential is now supplied to the cathode of tube 307 in place of negative potential tube 307 deionizes releasing relay 311. Upon the release of relay 311 the shunt around the upper winding of relay 314 is removed and relay 314 now operates in series with relay 313 in a circuit extending from battery, lower winding of relay 314, winding of relay 313, upper winding of relay 314, lower contact of relay 313 to ground on conductor 332. Relay 314 upon operating closes a circuit from ground on conductor 332 upper front contact of relay 314, upper back contact of transfer relay 316, winding of transfer relay 315 to battery. Relay 315 operates and locks in a circuit from battery through its winding and the winding of relay 316, inner lower front contact of relay 315 to ground on conductor 332, but relay 316 being shunted so long as relay 314 remains operated, does not operate in this locking circuit.

At the sender with relay 135 unoperated and relay 126 operated, the low inductance coil 133 is recharged in a circuit extending from bat-

tery, winding of coil 133, back contact of relay 135, inner upper back contact of relay 125, conductor 131 to ground at the alternate contacts of relay 126. With relay 119 released during the third pulse period, ground is connected over the upper front contact of relay 112, upper back contact of relay 119, lower front contact of relay 117, conductor 159, upper front contacts of transfer relays 145 and 147, upper back contact of transfer relay 149, winding of transfer relay 148 to battery. Relay 148 operates, locking in a circuit extending from battery through its winding and the winding of relay 149, inner upper front contact of relay 148 to ground at the upper contact of relay 146. Relay 149 does not operate in this locking circuit since its winding is shunted so long as relay 119 remains released and connects ground to conductor 159. Relay 148 upon operating disconnects conductor 158 from a thousands vertical of the dial register and connects it over the lower contacts of relays 144, 146 and 148 and the lower back contact of relay 150 to a hundreds vertical of the dial register, preparing the circuits which control the first and second pulse periods of the next or thousands digit.

Since no circuit is effective over cross-point 200 for relay 135, during the third pulse period when relay 119 is released, when therefore relay 126 releases during the fourth pulse period, ground potential is connected to the fundamental tip conductor 304 and with relay 135 unoperated, a surge of low potential is applied from induction coil 133, to the fundamental ring conductor 303, coil 133 having been placed in a charged condition as previously described during the third pulse period. Tube 307 will now ionize, tubes 305, 306, and 308 remaining deionized. Relay 311 now operates in the cathode-anode circuit of tube 307, previously traced, and connects ground from conductor 332 over its contacts to the lower front contact of relay 314 holding relay 314 and shunting down relay 313. The impulses transmitted during the first four impulse periods have therefore resulted in the operation and locking of one relay 325 of the station's register.

At the end of the fourth pulse period relay 119 is reoperated thus permitting transfer relay 149 to operate in the locking circuit of relay 148 and transfer the connection of conductor 158 from a thousands vertical of the dial register to a hundreds vertical over the lower front contacts of relays 145, 147 and 149 and the lower back contact of relay 151 preparing the circuits which control the third and fourth pulse periods of the next or thousands digit.

Since the thousands digit registered was zero and the cross-point contacts 201 are operated, there are no circuits effective for relays 128, 135, 140 and 142 during the next four pulse periods and only two light negative impulses are transmitted characteristic of the digit zero. During the first of these pulse periods, relay 126 operates and removes ground potential from conductor 304 and the anode of tube 307 thus deionizing this tube and releasing relay 311. Relay 311 upon releasing opens the locking circuit of relay 314 which also releases removing the shunt from transfer relay 316 which now operates. With both relays 315 and 316 now operated the circuit from the contacts of relays 310 and 312 are transferred from relays of the station's register to relays of the thousands register (not shown).

During the second pulse period with relay 126 released, tube 307 reionizes in the same manner as previously described causing the operation of

relays 311 and 313. When relay 126 reoperates during the third pulse period tube 307 deionizes and releases relay 311 thus permitting relay 314 to operate in series with relay 313. The operation of relay 314 closes a circuit from ground on conductor 332 over its upper front contact, the upper front contact of relay 316, the upper back contact of relay 318 to battery through the winding of relay 317. Relay 317 operates and locks in series with the winding of relay 318 and its own inner lower front contact to ground on conductor 332, but relay 318 being shunted over the contacts of relay 314 does not operate at this time. When relay 126 releases during the fourth pulse period tube 307 reionizes and operates relay 311 which shunts down relay 313 and holds relay 314 operated. Since neither tube 306 nor 308 has been ionized during these four pulse periods and relays 310 and 312 have not operated, no relays of the thousands register (not shown) are operated.

At the sender during the third of these pulse periods with relay 119 released, ground is connected to conductor 159, thence over the upper front contacts of relays 145, 147 and 149, the upper back contact of relay 151, winding of relay 150 to battery. Relay 150 operates and locks in a circuit through the winding of relay 151, the inner upper contacts of relay 150 and the upper contact of relay 148 to ground and disconnects conductor 158 from a hundreds vertical of the dial register and connects it over the lower front contacts of relays 144, 146, 148 and 150 and the lower back contact of relay 152 to a tens vertical of the dial register. The circuits are now prepared which control the first and second pulse period of the next or hundreds digit. At the end of the fourth pulse period relay 119 reoperates thus permitting relay 151 to operate in the locking circuit of relay 150. Relay 151 upon operating disconnects conductor 158 from a hundreds vertical of the dial register and connects it over the lower front contacts of relays 145, 147, 149 and 151 and the lower back contact of relay 153 to a tens vertical of the dial register. The circuits are now prepared which control the third and fourth pulse periods of the next or hundreds digit.

The next digit to be transmitted is the hundreds digit 4 and since no circuit has been made effective over cross-point 202 for relay 128 during the previous fourth pulse period, the operation of relay 126 during the first pulse period first removes ground from the tip conductor 304 to cause the deionization of tube 307 and the consequent release of relays 311 and 314. Relay 314 upon releasing now permits the operation of relay 318 in the locking circuit of relay 317. With both relays 317 and 318 now operated, the circuits from the contacts of relays 310 and 312 are transferred from relays of the thousands register to relays of the hundreds register (not shown). Relay 126 upon operating also connects ground to both the tip and ring fundamental conductors resulting in a blank impulse to which none of the tubes responds. During the first pulse period there is no circuit effective over cross-point 202 for relay 135 when relay 119 operates and therefore, during the second pulse period when relay 126 releases, ground is connected to the tip conductor 304 and a surge of low negative potential is applied from inductance coil 133 to the ring conductor 303 resulting in the ionization of tube 307 and the operation of relays 311 and 313.

During the second pulse period with relay 124

operated a circuit is established from ground on conductor 158, thence as traced to the lower front contact of relay 151, lower back contact of relay 153, conductor 213, cross-point 202, conductor 137, lower front contact of relay 124, thence through the winding of relay 128 to battery. Thus, when relay 126 operates during the third pulse period ground is first removed from the tip fundamental conductor 304 thus deionizing tube 307 and releasing relay 311 which then permits the operation of relay 314. Relay 314 upon operating closes a circuit from ground on conductor 332 over its upper front contact, thence as traced to the upper front contact of relay 318, the upper back contact of relay 320 to battery through the winding of relay 319. Relay 319 locks in a circuit through the winding of relay 320 and the inner lower front contact of relay 319 to ground on conductor 332, but relay 320 being shunted does not operate at this time. By the operation of relay 126 ground is also applied to the ring fundamental conductor 303 and a surge of low negative potential is applied from the low inductance coil 127 to the fundamental tip conductor 304. This results in the ionization of tube 306 and the operation of relay 310. With relays 310 and 313 both operated a circuit is established from ground on conductor 332, contacts of relay 310, upper front contact of relay 313, inner lower front contacts of relays 316 and 318, inner lower back contact of relay 320 to the C relay of the hundreds register (not shown).

During the third impulse period relay 119 releases and connects ground over conductor 159, thence over the upper front contacts of relays 145, 147, 149 and 151, the upper back contact of relay 153 to battery through the winding of relay 152. Relay 152 operates and locks in a circuit through its winding and the winding of relay 153, the inner upper front contact of relay 152 to ground at the upper front contact of relay 150 and disconnects conductor 158 from a tens vertical of the dial register and connects it over the lower front contacts of relays 144, 146, 148, 150 and 152 and the upper back contact of relay 154 to a units vertical thus preparing circuits which control the first and second pulse periods of the next or tens digit. Since there is no circuit effective over the cross-point 202 with relay 119 released, relay 135 is not operated. When, therefore, relay 126 releases during the fourth pulse period it first disconnects ground from the ring fundamental conductor 303 thus deionizing tube 307 and releasing relay 310 and then connects ground to the tip conductor 304 and applies a surge of low negative potential from inductance coil 133 to the ring conductor. Tube 307 now ionizes operating relay 311 which shunts down relay 313 and holds relay 314 operated. The impulses thus transmitted for the hundreds digit 4 have resulted in the operation of only the C relay of the hundreds register.

At the end of the fourth pulse period relay 119 reoperates thus permitting relay 153 to operate in the locking circuit of relay 152. Relay 153 upon operating disconnects conductor 158 from a tens vertical of the dial register and connects it over the circuit traced to the lower front contact of relay 151, the lower front contact of relay 153 and the lower back contact of relay 155 to a tens vertical of the dial register. The circuits are now prepared which control the third and fourth pulse periods of the next or tens digit.

The tens digit recorded was 5 and thus the contacts at cross-point 203 are operated. Since there is no circuit effective over these cross-point contacts when relay 124 releases during the previous fourth pulse period, relay 128 is not operated and when, therefore, relay 126 operates during the first pulse period it first removes ground from the tip fundamental conductor 304 to deionize tube 307 causing the release of relays 311 and 314. The release of relay 314 permits the operation of relay 320 in the locking circuit of relay 319. Relay 126 then connects ground to both the tip and ring fundamental conductors. No tubes, therefore, become ionized.

During the first pulse period when relay 119 operates there is no effective circuit for relay 135 over the cross-point 203 and therefore when relay 126 releases during the second pulse period ground is applied to the tip fundamental conductor 304 and a surge of low negative potential is applied to the ring conductor 303 resulting in the ionization of tube 307 and the operation of relays 311 and 313. During the second pulse period there is no effective circuit over cross-point 203 for relay 128 and thus when relay 126 operates during the third pulse period, ground is first removed from the tip fundamental conductor 304 thus deionizing tube 307 and releasing relay 311 thereby permitting the operation of relay 314. Relay 314 upon operating closes a circuit from ground on conductor 332 over its upper front contact and the upper front contacts of relays 316, 318 and 320, the upper back contact of relay 322 to battery through the winding of relay 321. Relay 321 operates and locks in series with the winding of relay 322 to ground over its inner lower front contact, but relay 322 being shunted does not operate at this time. Relay 126 then connects ground to both the tip conductor 304 and the ring conductor 303 resulting in a blank pulse. No tube will therefore ionize.

During the third pulse period relay 119 releases and connects ground over conductor 159, thence as traced to the upper front contact of relay 151, upper front contact of relay 153, upper back contact of relay 155 to battery through relay 154. Relay 154 operates and locks in a circuit through the winding of relay 155, the lower contact of relay 154 to ground at the upper contact of relay 153 and disconnects conductor 158 from a units vertical of the dial register and connects it over the circuit previously traced to the lower front contact of relay 152, thence over the upper front contact of relay 154 and the lower back contact of relay 156 to a station's vertical of the dial register. The circuits are now prepared which control the first and second pulse periods of the last or units digit. Upon releasing, relay 119 also establishes a circuit for relay 135 extending from ground on conductor 158, thence as traced to the lower front contact of relay 151, lower front contact of relay 153, the lower back contact of relay 155, conductor 214, cross-point 203, conductor 139, lower back contact of relay 119 to battery through the winding of relay 135. When relay 126 releases during the fourth pulse period it connects ground to the fundamental tip conductor 304 and applies a surge of high negative potential from the inductance coil 134, front contact of relay 135, thence as traced to the fundamental ring conductor 303. Both tubes 307 and 308 therefore ionize operating relays 311 and 312. Relays 311 shunts down relay 313 and holds relay 314 operated and relay 312 closes a circuit con-

nected from ground on conductor 332 over its contact, the inner upper front contact of relay 314, the inner upper front contacts of relays 316, 318 and 320, lower back contact of relay 322 to the D relay of the tens register (not shown). At the end of the fourth pulse period relay 119 reoperates thus permitting relay 155 to operate in the locking circuit of relay 154. Relay 155 upon operating disconnects conductor 158 from a units vertical of the dial register and connects it over the circuit previously traced to the lower front contact of relay 155, the lower back contact of relay 157 to a stations vertical of the dial register. The circuits are now prepared which control the third and fourth pulse periods of the last or units digit.

The units digit recorded was 7 and thus the contacts at cross-point 204 are operated. Since there is no circuit effective over these cross-point contacts when relay 124 releases during the previous fourth pulse period, relay 128 is not operated. When therefore, relay 126 operates during the first pulse period, it first removes ground from the tip fundamental conductor 304 to deionize tubes 307 and 308 causing the release of relays 311, 312 and 314, the release of relay 314 permitting relay 322 to operate in the locking circuit of relay 321. Relay 126 then connects ground to both the tip and ring fundamental conductors. No tubes, therefore, become ionized.

During the first pulse period when relay 119 operates, a circuit is established from ground on conductor 158, thence as traced to the lower front contact of relay 152, upper front contact of relay 154, lower back contact of relay 156, conductor 215, contacts of cross-point 204, conductor 138, front contact of relay 119, winding of relay 135 to battery. When relay 126 releases during the second pulse period with relay 135 operated, ground is applied to the tip fundamental conductor 304 and a surge of high negative potential is applied to the ring conductor 303 from inductance coil 134 resulting in the ionization of both tubes 307 and 308 and the operation of relays 311, 312 and 313. Relay 312 upon operating closes a circuit from ground on conductor 332 over its contacts, the upper back contact of relay 314, the lower front contacts of relays 315, 317, 319 and 321 to the B relay of the units register (not shown). During the second pulse period there is no effective circuit over cross-point 204 for relay 128 and thus when relay 126 operates during the third pulse period, ground is first removed from the tip fundamental conductor 304 thus deionizing tubes 307 and 308 and releasing relays 311 and 312. Relay 311 upon releasing permits the operation of relay 314 which closes a circuit from ground on conductor 332 over its upper front contact, thence as traced to the upper front contact of relay 320, upper front contact of relay 322, winding of relay 323 to battery. Relay 323 operates and locks in series with the winding of relay 324 and its own upper front contact to ground on conductor 332, but relay 324 being shunted does not operate at this time. Relay 126 then connects ground to both the tip conductor 304 and the ring conductor 303 resulting in a blank pulse. No tube will, therefore, ionize.

During the third impulse period, relay 119 releases and connects ground over conductor 159, thence as traced to the upper front contact of relay 153, upper front contact of relay 155, upper back contact of relay 157, winding of relay 156 to battery. Relay 156 operates and locks in a circuit through the winding of relay 157, the upper front

contact of relay 156 to ground and disconnects conductor 158 from a station's vertical. Upon releasing, relay 119 also establishes a circuit for relay 135 extending from ground on conductor 158, thence as traced to the lower front contact of relay 153, lower front contact of relay 155, lower back contact of relay 157, conductor 216, contacts of cross-point 204, conductor 139, lower back contact of relay 119 to battery through the winding of relay 135. When relay 126 releases during the fourth pulse period, it connects ground to the fundamental tip conductor 304 and applies a surge of high negative potential from the inductance coil 134, front contact of relay 135, thence as traced to the fundamental ring conductor 303. Both tubes 307 and 308 therefore ionize operating relays 311 and 312. Relay 311 shunts down relay 313 and holds relay 314 operated and relay 312 closes a circuit from ground on conductor 332 over its contact, the inner upper front contact of relay 314, thence as traced to the inner upper front contact of relay 320, inner upper front contact of relay 322 to the D relay of the units register (not shown).

At the end of the fourth pulse period relay 119 reoperates thus permitting relay 157 to operate in the locking circuit of relay 156. Relay 157 upon operating disconnects conductor 158 from a station's vertical of the digit register and connects it over a lower front contact of relay 157 to the winding of relay 125 which now operates. During the first pulse period when relay 126 operates, ground is first removed from the tip conductor 304 thus deionizing tubes 307 and 308 and releasing relays 311, 312 and 314. Relay 314 upon releasing permits relay 324 to operate in the locking circuit of relay 323. Relay 126 then closes a charging circuit for the high inductance coil 134 extending from battery, winding of coil 134, inner upper front contact of relay 125 to ground at the alternate contacts of relay 126. Ground from the front contact of relay 126 is also applied over the upper front contact of relay 125 to the tip fundamental conductor 304 and to the ring fundamental conductor 303 from the back contact of relay 132, back contact of relay 128 over the inner lower front contact of relay 125, thence as traced.

During the second pulse period when relay 126 releases ground is connected to the ring fundamental conductor 303 from the normal contacts of relay 126 and over the lower front contact of relay 125 and ground being removed from the tip fundamental conductor by the operation of relay 126, a surge of high negative potential is applied from the charged high inductance coil 134 over the inner upper and outer upper front contacts of relay 125 to the tip conductor 304 thus transmitting a heavy positive impulse. With high negative potential applied to the cathodes of tubes 305 and 306 over conductor 304, both tubes ionize operating relays 309 and 310. Relay 310 is without function at this time, but relay 309 upon operating closes a circuit from ground on conductor 332, contacts of relay 309, contacts of relay 324, winding of relay 333 to battery. Relay 333 operates and locks in series with relay 334, front contacts of relay 333 to ground at the inner lower front contact of relay 323. With relay 125 operated, relay 124 which is operated during the second and third pulse periods holds open the circuit of relay 126.

When relay 119 releases at the beginning of the third pulse period it connects ground to conductor 159 and thence as traced to the upper front

contact of relay 157 to battery through the winding of relay 108. Relay 108 initiates a series of operations for releasing the sender and opens the locking circuit of relay 109 which in turn releases relay 112. Relay 112 opens the fundamental circuit, releases relays 117 and 103, removes ground from the pulsing relays 115 and 116, releases relay 125 and opens the holding circuit for relays 119 and 124 thereby restoring the pulsing circuit to normal. The transfer relays of Fig. 1 are released in the restoration of the sender. Upon the opening of the fundamental circuit, tubes 305 and 306 deionize, releasing relays 309 and 310, relay 309 upon releasing permitting relay 334 to operate in the locking circuit of relay 333.

Since the manner in which the indicator lamps at the manual office are lighted in accordance with the operated condition of the digit registers to indicate the called number 10457 and the manner in which the operator proceeds to complete the call incoming over trunk 300, 301 do not concern the present invention, reference may be had to Patent No. 1,968,420 hereinbefore referred to for a detailed description thereof.

Fig. 4 shows a modified form of the call indicator equipment at the manual office which is in most respects similar to that shown in Fig. 3 except that three tubes and associated anode relays rather than four tubes and associated relays are employed. Tube 305 and the associated anode relay 309 of Fig. 3 are employed only to respond to a heavy positive impulse which is transmitted from the sender following the transmission of the codes of impulses corresponding to the digits of the line designations. In Fig. 4 all apparatus which is similar to that of Fig. 3 has been designated by corresponding reference numerals and the functions performed by tube 305 and relay 309 of Fig. 3 are performed by tube 307 and relay 314 through the reversal of the connections of the tip and ring conductors 304 and 303 to the cathode and anode of tube 307 through the operation of the last transfer relay 324.

During the reception of the code impulses for all of the digits of a line designation, relays 323 and 324 are unoperated and therefore the tip conductor 304 extends over the upper normal contacts of relay 324 to the cathode of tube 306 and to the anodes of tubes 307 and 308 and the ring conductor 303 extends over the inner lower normal contacts of relay 324 to the cathodes of tubes 307 and 308 and to the anode of tube 306. The circuits controlled by anode relays 310 and 312 are the same as disclosed in Fig. 3 and the control exercised by these relays is therefore the same as previously described. The circuit controlled by relay 311 is, however, extended over the inner upper back contacts of relay 324 to the lower armature of relay 314, but until relay 324 is operated, relay 311 functions in the manner previously described. It will be recalled that during the reception of the code impulses for the last or units digit of the line designation all of the transfer relays 315 to 323, inclusive, were operated, that relay 314 was also operated and that during the first pulse of the transmission of the final heavy positive impulse code, relay 314 released permitting relay 324 to operate in the locking circuit of relay 323. With relay 324 operated, the connection of the tip and ring conductors 304 and 303 to the cathodes and anodes of tubes 306, 307 and 308 is reversed and the front contact of anode relay 311 is disconnected from the lower armature of relay 314 and con-

connected to the winding of relay 333. When, therefore, the sender impulser connects ground to the ring conductor 303 and applies a surge of high negative potential to the tip conductor during the second impulse period, the anodes of tubes 307 and 308 now having positive or ground potential applied thereto over conductor 303 and the cathodes thereof having high negative potential applied thereto over conductor 304, both tubes 307 and 308 ionize and operate their anode relays 311 and 312. With relay 314 released and relay 323 operated, the operation of anode relay 312 is without function but the operation of anode relay 311 causes the operation of relay 333 over a circuit extending from ground on conductor 330, front contact of relay 311, inner upper front contact of relay 324, winding of relay 333 to battery. From this point the circuits of Fig. 4 function in the same manner as those of Fig. 3.

From the foregoing it will be apparent that through the use of gas-filled tubes which are very sensitive to marginal and reversed polarity conditions, the call indicator equipment may be very accurately controlled over long cable loops and that the marginal and polarized responsive relays heretofore employed for impulse response may be replaced by simple relays whose adjustment may be easily made and maintained. Although gas-filled tubes of the hot cathode type have been disclosed, it will be obvious to those skilled in the art that gas-filled tubes of the cold cathode type might be employed. It is also to be understood that while a sender having a relay type impulser and a cross-bar type register has been disclosed, any well-known type of sender having an impulser for transmitting call indicator code impulses might be used with equal facility.

What is claimed is:

1. In a signaling system a two-conductor control circuit, a first gaseous conductor tube having its cathode connected to one conductor of said circuit and its anode connected to the other conductor, a second tube having its anode connected to said one conductor and its cathode connected to said other conductor, a relay in the cathode-anode circuit of each tube, and means for selectively operating said relays by applying negative potential to said one conductor and ground to said other conductor or vice versa.
2. In a signaling system a two-conductor control circuit, a first gaseous conductor tube having its cathode connected to one conductor of said circuit and its anode connected to the other conductor, a first relay in the cathode-anode circuit of said tube, a second gaseous conductor tube having its anode connected to said one conductor and its cathode connected to said other conductor, a second relay in the cathode-anode circuit of said second tube, means for operating said first relay by the connection of negative potential to said one conductor and ground to said other conductor, and means for operating said second relay by reversing the connection of negative potential and ground to said conductors.
3. In a telephone system an impulse sending device, a registering device, a control circuit extending from said sending device to said registering device, a plurality of ionic relays in said registering device associated with said control circuit, and means controlled by said sending device for transmitting impulses differing in potential and polarity over said control circuit, one of said relays being responsive only to impulses

of heavy potential of one polarity, a second of said relays being responsive to impulses of either light or heavy potential of said one polarity, a third of said relays being responsive only to impulses of heavy potential of reverse polarity, and a fourth of said relays being responsive to impulses of either light or heavy potential of reverse polarity.

4. In a telephone system an impulse sending device, a registering device, a control circuit extending from said sending device to said registering device, a plurality of gaseous conductor tubes in said registering device associated with said control circuit, means controlled by said sending device for transmitting impulses differing in potential and polarity over said control circuit, one of said tubes being responsive only to impulses of heavy potential of one polarity, a second of said tubes being responsive to impulses of either light or heavy potential, a third of said tubes being responsive only to impulses of heavy potential of reverse polarity, and a fourth of said tubes being responsive to impulses of either light or heavy potential of reverse polarity, and registers operable by said tubes.

5. In a telephone system an impulse sending device, a registering device, a two-conductor control circuit extending from said sending device to said registering device, a plurality of ionic relays, certain of said ionic relays having their cathodes connected to one of said conductors and their anodes connected to the other of said conductors, and others of said ionic relays having their anodes connected to said one of said conductors and their cathodes connected to said other of said conductors, and means controlled by said sending device for transmitting impulses over said control circuit by applying negative potential to said one conductor and ground to said other conductor or vice versa.

6. In a telephone system an impulse sending device, a registering device, a two-conductor control circuit extending from said sending device to said registering device, a plurality of gaseous conductor tubes in said registering device, certain of said tubes having their cathodes connected to one of said conductors and their anodes connected to the other of said conductors, and others of said tubes having their anodes connected to said one of said conductors and their cathodes connected to said other of said conductors, a relay in the cathode-anode circuit of each tube, registers selectively operable by said relays, and means controlled by said sending device for transmitting impulses over said control circuit for selectively operating said relays by applying negative potential to said one conductor and ground to said other conductor or vice versa.

7. In a telephone system an impulse sending device, a registering device, a two-conductor control circuit extending from said sending device to said registering device, a plurality of gaseous conductor tubes in said registering device, certain of said tubes having their cathodes connected to one of said conductors and their anodes connected to the other of said conductors and said certain tubes each having a different breakdown potential, and others of said tubes having their anodes connected to said one of said conductors and their cathodes connected to said other of said conductors and said other tubes each having a different breakdown potential, a relay in the cathode-anode circuit of each tube, registers selectively operable by said relays, and means controlled by said sending device for selec-

tively operating said relays by applying light or heavy negative potential to said one conductor and ground to said other conductor or vice versa.

8. In a telephone system an impulse sending device, a registering device, a two-conductor control circuit extending from said sending device to said registering device, three gaseous conductor tubes in said registering device, two of said tubes having their cathodes connected to one of said conductors and their anodes connected to the other of said conductors and each having a different breakdown potential whereby one tube will break down when light negative potential is applied over said one conductor to the cathode thereof and ground is applied over the other of said conductors to the anode thereof and whereby both tubes will break down when said negative potential is of increased value, said third tube having its anode connected to said one of said conductors and its cathode connected to said other of said conductors and having a breakdown potential such that when negative potential is applied to the cathode thereof and ground is applied to the anode thereof said tube breaks down, a relay in the cathode-anode circuit of each tube, registers selectively operable by said relays, and means controlled by said sending device for selectively operating said relays by applying either light or heavy negative potential to said one of said conductors and ground to said other of said conductors or vice versa.

9. In a telephone system an impulse sending device, a registering device, a two-conductor control circuit extending from said sending device

to said registering device, three gaseous conductor tubes in said registering device, two of said tubes having their cathodes connected to one of said conductors and their anodes connected to the other of said conductors and each having a definite breakdown potential whereby one tube will break down when light negative potential is applied over said one conductor to the cathode thereof and ground is applied over the other of said conductors to the anode thereof and whereby both tubes will break down when said negative potential is of increased value, said third tube having its anode connected to said one of said conductors and its cathode connected to said other of said conductors and having a breakdown potential such that when negative potential is applied to the cathode thereof and ground is applied to the anode thereof said tube breaks down, a relay in the cathode-anode circuit of each tube, registers selectively operable by said relays, means in said register circuit for reversing the connection of said control conductors to said tubes whereby said first two tubes become responsive to the connection of negative potential of increased value to the cathodes thereof over said other of said conductors and ground to the anodes thereof over said one of said conductors, and means controlled by said sending device for selectively operating said relays by applying either light or heavy negative potential to said one of said conductors and ground to said other of said conductors or vice versa.

OSCAR MYERS.