

May 19, 1936.

O. MYERS

2,041,083

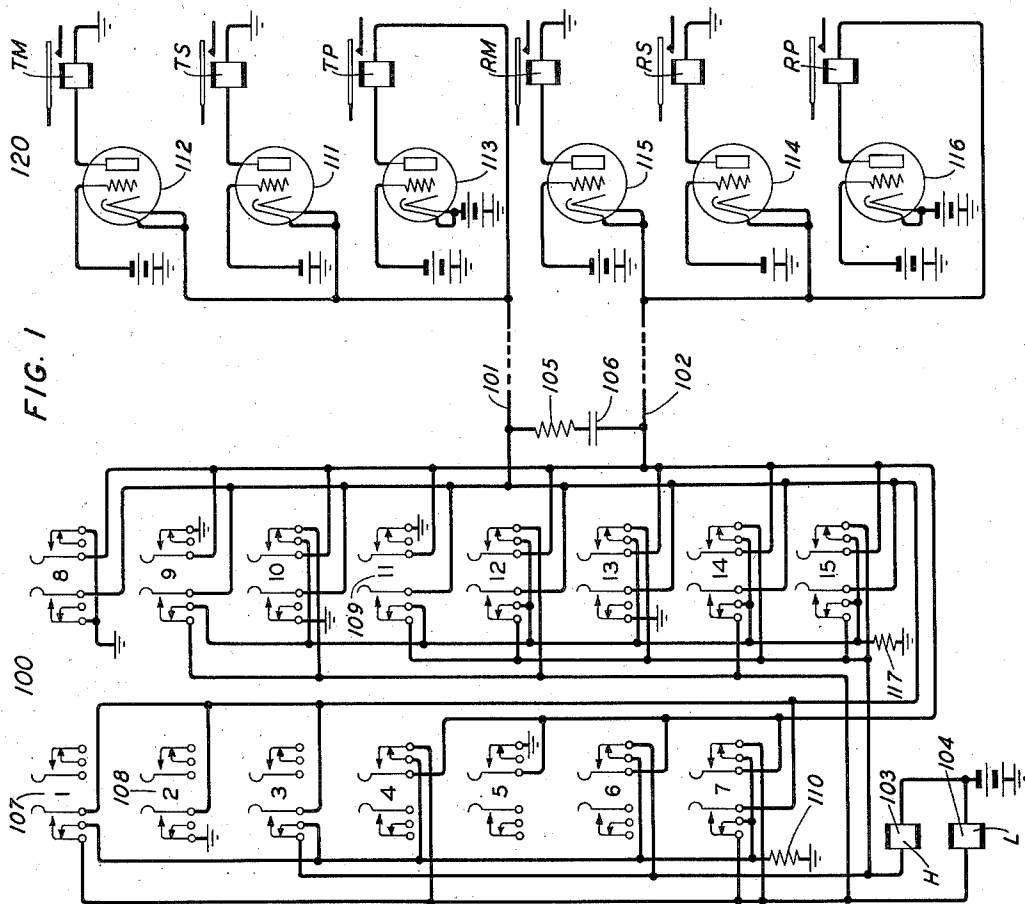
TELEPHONE SYSTEM

Filed Dec. 29, 1934

2 Sheets-Sheet 1

FIG. 2

KEY	LEADS		RESPONSIVE RELAYS									
			T	R	T S	T M	T P	R S	R M	R P		
1	L		X									
2	G				X							
3	H					X						
4		L						X				
5		G							X			
6		H								X		
7	L	L	X					X				
8	G	G				X				X		
9	L	G	X						X			
10	G	L					X				X	
11	H	G	X			X						
12	H	L	X			X		X				
13	G	H					X	X				
14	L	H	X					X	X			
15	H	H	X			X				X	X	



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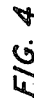
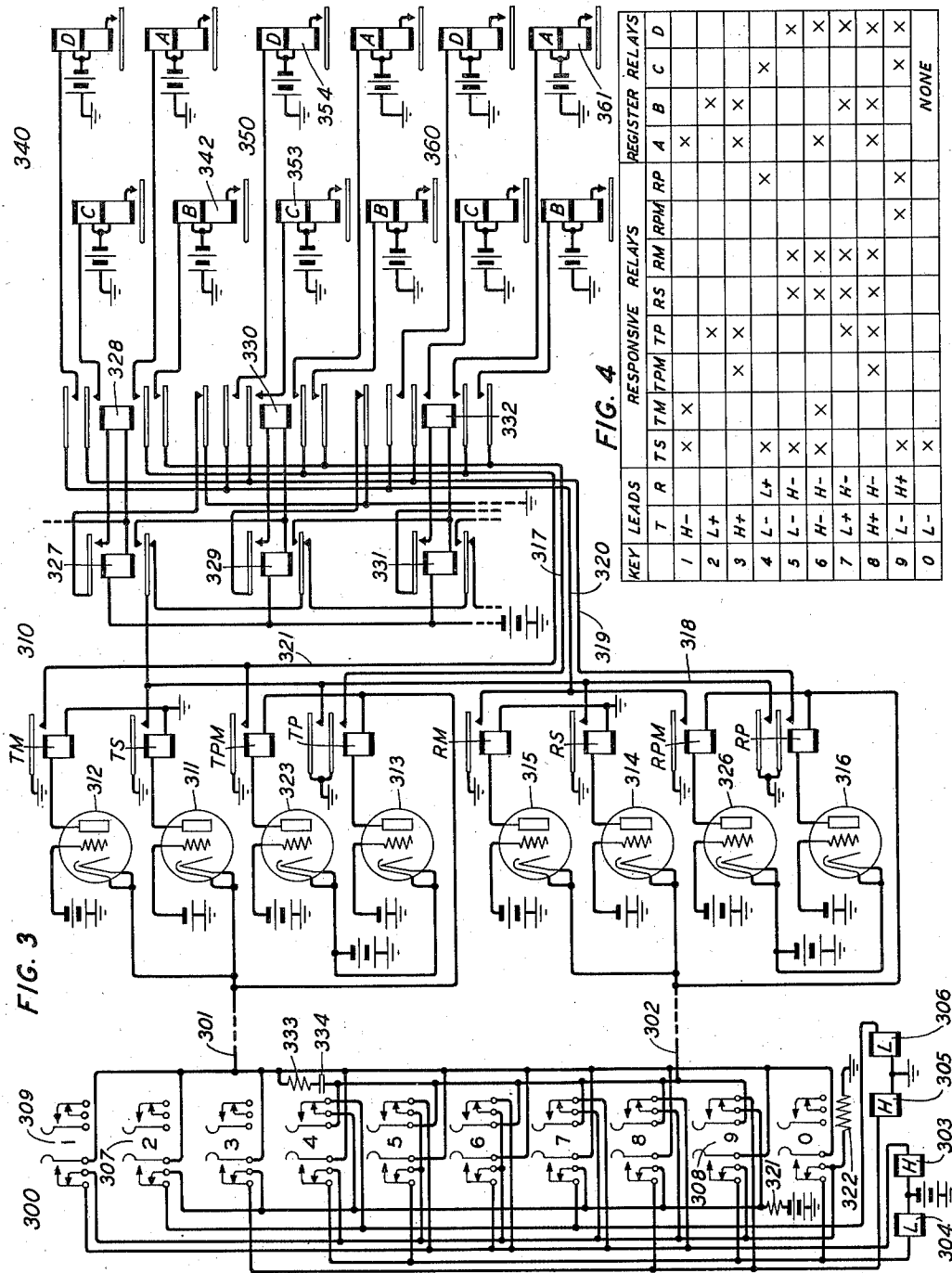
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TELEPHONE SYSTEM

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2 Sheets-Sheet 2

[illegible]

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UNITED STATES PATENT OFFICE

2,041,083

TELEPHONE SYSTEM

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Application December 29, 1934, Serial No. 759,665

11 Claims. (Cl. 179—90)

This invention relates to telephone exchange systems and more particularly to circuits for enabling the registration of digits at a distant point through the operation of digit keys. A circuit of this character is applicable for enabling an operator at a manual or semi-mechanical switchboard position to set up on the registers of a common sender the registration of the digits of a wanted subscriber's directory number whereby the sender may be enabled to proceed in accordance therewith to control selector switches to establish a desired connection.

Heretofore, key pulsing circuits of this general character have been employed as disclosed in Patent 1,780,906, granted November 11, 1930, to W. W. Carpenter and R. E. Hersey to enable a toll operator to complete connections over panel dial switching equipment and as disclosed in Patent No. 1,916,760 granted July 4, 1933, to I. H. Henry to enable an "A" switchboard operator to complete connections over step-by-step type equipment. In these circuits the registers of the sender are set from the operator's key-set through the application in code combinations of current of two strengths and of either negative or positive potential over one or both of the two control conductors extending from the operator's position to the sender. At the sender three impulse responsive relays are connected serially in each control conductor, one being polarized, one being marginal to current of either polarity and a third being sensitive to current of either polarity. For the selective operation of the impulse responsive relays batteries of opposite potential are required at both the operator's key-set and at the sender and the relays require careful adjustment because of the current margins employed for their selective operation.

The present invention has for one of its objects the employment of a key pulsing system whereby a satisfactory marginal operation is obtained without the employment of marginal relays thereby permitting successful operation over longer control circuits. A further object of the invention is to permit selective control through the use of the regular central office battery both at the key-set and at the distant end of the control circuit thereby eliminating the necessity for oppositely poled batteries. A further object is the elimination of polarized impulse responsive relays. A still further object is the provision of impulse responsive apparatus of such a character that correct operation may be assured with very short key closures.

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 its cathode-anode circuit. The impulse responsive 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 potentials over the control circuit extending from the key-set.

For the purposes of illustration two modifications of the invention have been disclosed. In one modification, the invention is shown applicable to the sending and registration of fifteen digit codes over a two-conductor control circuit. To enable this, three gaseous conductor tubes are associated with each conductor of the control circuit. Of each group of three tubes a first one is biased to provide a definite breakdown potential so as to become operative or conducting when potential of a definite amount and polarity is applied at the key-set to the control conductor with which it is associated. The second tube of each group is so biased as to become conducting at the same time as the first one when a higher potential of the same polarity is applied to the associated control conductor and the third tube of the group is so biased and connected to the associated control conductor as to become conducting when ground potential is applied at the key-set to the control conductor. At the key-set, either high or low potential of one polarity may be applied to either or both conductors of the control circuit through the discharge of normally charged inductances or direct ground may be applied to either or both conductors as determined by the operation of a particular digit key.

In the second modification, the invention is shown applicable to the transmission and regis-

tration in a sender of the digits of a subscriber's line designation. The digit codes employed and the arrangement of registers upon which successive digits are registered are similar to those heretofore disclosed in the patent to Carpenter et al. hereinafter referred to. Since in this case the digit codes employed require the transmission of impulses of light and heavy potential of both positive and negative polarity over the two control conductors and means for selective response thereto, four gaseous conductor tubes are associated with each control conductor, one of which is responsive to an impulse of either light or heavy positive potential, a second of which is responsive only to an impulse of heavy positive potential, a third of which is responsive to an impulse of either light or heavy negative potential, and a fourth of which is responsive only to an impulse of heavy negative potential. The keys of the ten-button key-set are selectively associated with the tip and ring conductors of the control circuit and with positively or negatively charged inductances for transmitting the necessary code combinations of impulses to the sender.

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:

Fig. 1 shows one embodiment of the invention comprising a key-set having fifteen code keys connected by a two-conductor control circuit with a receiving apparatus comprising six ionic tubes and associated responsive relays;

Fig. 2 is a chart illustrating the combination of responsive relays which are operated in response to the depression of each code key of Fig. 1;

Fig. 3 shows a further embodiment of the invention as applied to a sender of the key pulsing type; and

Fig. 4 is a chart illustrating the combinations of responsive relays and register relays which are operated in response to the depression of each digit key of Fig. 3.

Referring to Fig. 1, a key-set of fifteen keys is designated by the numeral 100, the inner springs of the keys being connected to one or both of the tip and ring control conductors 101 and 102 and the outer springs being connected to the positive grounded terminal of battery or to the negative terminal of battery through a coil 103 of high inductance or through a coil 104 of low inductance as required to cause the registration of fifteen digit codes. The control conductors 101 and 102 are connected together at the key-set by a bridge comprising the resistance 105 and condenser 106 serving as a padding circuit to lessen the effect of line conditions on the operation of the system.

The control conductors 101 and 102 terminate at their distant ends in a recording circuit designated by the numeral 120. This recording circuit comprises six ionic tubes of the gaseous conductor type and six associated responsive relays. Each tube is filled with a low pressure gaseous content such as neon, argon, helium, mercury vapor or combinations of gases of this group and has a cathode illustrated as heated conductively by a filament, a control electrode or grid and an anode or plate electrode.

Three of the tubes 111, 112 and 113 are associated with the tip control conductor 101 and the remaining three tubes 114, 115 and 116 are associated with the ring control conductor 102. Tubes 111 and 112 have their cathodes con-

nected to the tip conductor 101, their anodes connected to the grounded or positive terminal of battery through the windings of relays TS and TM, respectively, and their grids connected respectively to the negative terminals of biasing batteries of different potentials. The grid of tube 111 is so biased as to cause said tube to become conducting or ionized when negative potential of a definite amount is applied to its cathode over conductor 101, and the grid of tube 112 is so biased as to cause said tube to ionize at the same time as tube 111 when a higher negative potential is applied to its cathode over conductor 101. Tube 113 has its cathode connected to the negative terminal of battery, its grid connected to the negative terminal of biasing battery and its anode connected through the winding of relay TP to the tip conductor 101. The grid of tube 113 is so biased as to cause said tube to ionize when full ground or positive potential is applied to the anode thereof over conductor 101.

Tubes 114 and 115 have their cathodes connected to the ring control conductor 102, their anodes connected to the grounded or positive terminal of battery through the windings of relays RS and RM respectively, and their grids connected to the negative terminals of biasing batteries of different potentials. The grid of tube 114 is so biased as to cause said tube to ionize when negative potential of a definite amount is applied to its cathode over conductor 102 and the grid of tube 115 is so biased as to cause said tube to ionize at the same time as tube 114 when a higher negative potential is applied to its cathode over conductor 102. Tube 116 has its cathode connected to the negative terminal of battery, its grid connected to the negative terminal of biasing battery and its anode connected through the winding of relay RP to the ring conductor 102. The grid of tube 116 is so biased as to cause said tube to ionize when full ground or positive potential is applied to the anode thereof over conductor 102.

Each relay TS, TM, TP, RS, RM and RP operates when the tube with which it is associated ionizes and these relays singly and jointly may be employed to control registering apparatus. Since the registering apparatus is not essential to an understanding of the invention, no disclosure thereof has been made, it being understood that any well-known type may be employed.

It will first be assumed that an operator wishes to cause the registration of the code digit 1. Referring to the chart shown in Fig. 2, it will be noted that for this purpose it is necessary to operate relay TS through the depression of the No. 1 key. With the No. 1 key 107 normal, current flows from ground through resistance 110, over the left normal contacts of key 107 through the low inductance coil 104 to battery thus completely saturating the core of the coil. When key 107 is depressed, its left hand contacts first connect the coil 104 to the tip control conductor 101 and then open the energizing circuit of the coil. The potential stored in the coil 104 is now applied to the cathodes of tubes 111 and 112 and to the anode of tube 113. Since tube 113 requires the connection of positive potential to its anode to cause its ionization, it can not ionize at this time and relay TP is not therefore operated. Tube 111, however, being biased to operate when a surge of low negative potential is applied to its cathode from coil 104 ionizes and operates relay TS over its cathode-anode circuit. This circuit

may be traced from the negative terminal of battery through coil 104, the left alternate contacts of key 107, conductor 101, cathode and anode of tube 111, winding of relay TS to ground.

Relay TS remains operated until the tube de-ionizes upon the release of key 107. Since tube 112 is biased to ionize only when a higher negative potential is applied to its cathode, it does not ionize at this time and relay TM does not therefore operate. Tubes 114, 115 and 116 do not ionize since no potential is applied to the ring control conductor 102 by the depression of key 107 and therefore relays RS and RM and RP do not operate. Thus the depression of key 107 for the code digit 1 is instrumental in operating only relay TS.

Should the operator depress key 108 to cause the registration of the code digit 2 by the operation of relay TP as disclosed in the chart of Fig. 2, then the closure of the left contacts of key 108 connects full ground or positive potential over conductor 101 to the anode of tube 113 and to the cathodes of tubes 111 and 112. Since tubes 111 and 112 require the application of negative potential to their cathodes to cause their ionization, they do not ionize and therefore relays TS and TM do not operate. Tube 113, however, has negative potential applied to its cathode and therefore ionizes when full ground or positive potential is applied to its anode and operates relay TP over its cathode-anode circuit. This circuit may be traced from the negative terminal battery to the cathode, thence to the anode, winding of relay TP, conductor 101, left contacts of key 108, to ground. Tubes 114, 115 and 116 do not ionize since no potential is applied to the ring control conductor 102 by the depression of key 108 and therefore relays RS, RM and RP do not operate. Thus the depression of key 108 for the code digit 2 is instrumental in operating only relay TP.

It will now be assumed that the operator depresses key 109 to cause the registration of the code digit 11 by the operation of relays TS, TM and RP as disclosed in the chart of Fig. 2. With the key 109 normal, current flows from ground through resistance 117 over the left normal contacts of key 109 through the high inductance coil 103 to battery, thus completely saturating the core of this coil. When key 109 is depressed, its left transfer contacts first connect the coil 103 to the tip control conductor 101 and then open the energizing circuit of the coil. The potential stored in the coil 103 is now applied to the cathodes of tubes 111 and 112 and to the anode of tube 113. Since tube 113 requires the connection of positive potential to its anode to cause its ionization, it can not ionize at this time and relay TP is not therefore operated. Tube 112, however, is biased to operate when a surge of high negative potential is applied to its cathode from coil 103 and therefore ionizes and operates relay TM over its cathode-anode circuit. This circuit may be traced from battery through coil 103, the left alternate contacts of key 109, conductor 101, cathode and anode of tube 112, winding of relay TM to ground. The same surge of negative potential from the coil 103 also causes the ionization of tube 111 and the operation of relay TS. Key 109 also at its right contacts connects full ground potential over the ring control conductor 102 to the anode of tube 116 and to the cathodes of tubes 114 and 115. Since tubes 114 and 115 require the connection of negative potential to their cathodes to cause their ioniza-

tion, they do not ionize and relays RS and RM do not operate. Tube 116, however, has negative potential applied to its cathode and therefore ionizes when full ground or positive potential is applied to its anode and operates relay RP over its cathode-anode circuit. This circuit may be traced from the negative terminal of battery to the cathode, thence to the anode, winding of relay RP, conductor 102, right contacts of key 109 to ground. Thus the operation of key 109 for the code digit 11 is instrumental in operating only relays TS, TM and RP, these relays remaining operated by the continued ionization of tubes 111, 112 and 116 until key 109 is released.

By referring to the chart of Fig. 2, it will be obvious how other code digits may be registered by the connection of either the low or high inductance coils or ground in various combinations to one or both of the control conductors 101 and 102 through the depression of the key-set keys. In the chart the second and third columns headed by the letters T and R refer to the tip and ring control leads or conductors 101 and 102, respectively, and the letters beneath them indicate whether the potential condition applied thereover for each of the several digits designated in the first column is L (light negative), H (heavy negative), or G (ground or positive), blanks indicating a no-potential condition. Crosses in the vertical column headed TS, TM, TP, RS, RM and RP indicate the operated condition of these relays for each of the fifteen code digits.

Fig. 3 shows a further embodiment of the invention applicable to a key pulsing sender for enabling the registration of the digits of line designations under the control of an operator. The ten button key-set of an operator's position is designated by the numeral 300, the inner springs of each of the keys being connected to one or both of the tip or ring control conductors 301 and 302 and the outer springs being connected to the positive grounded terminal of battery through the coil 305 of high inductance or the coil 306 of low inductance or to the negative terminal of battery through coil 303 of high inductance or the coil 304 of low inductance, as required to cause the registration of ten digits. The control conductors 301 and 302 are connected together at the key-set by a padding bridge comprising the resistance 333 and condenser 334 for the purpose of lessening the effect of line conditions on the operation of the circuits.

The control conductors terminate at their distant ends in the recording circuit of a sender designated by the numeral 310. This recording circuit comprises eight ionic tubes of the gaseous conductor type and eight associated relays, each tube having a cathode, heated conductively by a filament, a control electrode or grid and an anode. Four of the tubes 311, 312, 313 and 323 are associated with the tip conductor 301 and the four remaining tubes 314, 315, 316 and 326 are associated with the ring conductor 302.

Tubes 311 and 312 have their cathodes connected to the tip conductor 301, their anodes connected to the grounded or positive terminal of battery through the windings of relays TS and TM respectively, and their grids connected to the negative terminals of biasing batteries of different potential. The grid of tube 311 is so biased as to cause said tube to become conducting or to ionize when a surge of negative potential from a low inductance is applied to its cathode over conductor 301 and the grid of tube 312 is so biased as to cause said tube to become conducting at the

same time as tube 311 when a higher negative potential is applied to its cathode over conductor 301.

Tubes 313 and 323 have their cathodes connected to the negative terminal of battery, their grids connected to the negative terminals of biasing batteries of different potentials, and their anodes connected through the windings of relays TP and TPM respectively, to the tip control conductor 301. The grid of tube 313 is so biased as to cause said tube to ionize when ground through a low inductance is applied to its anode over conductor 301 and the grid of tube 323 is so biased as to cause said tube to ionize at the same time as 313 when ground through a higher inductance is applied to its anode over conductor 301.

Tubes 314, 315, 316 and 326 are similar biased and similarly connected to the ring control conductor 302 so that tube 314 will ionize and operate relay RS in response to the connection of negative potential through a low inductance to conductor 302, that tubes 314 and 315 will both ionize and operate relays RS and RM in response to the connection of negative potential through a higher inductance to conductor 302, that tube 316 will ionize and operate relay RP in response to the connection of ground through a low inductance to conductor 302 and that tubes 316 and 326 will both ionize and operate relays RP and RPM in response to the connection of ground through a high inductance to conductor 302.

The eight responsive relays selectively control the operation of groups of register relays, three of such groups of four relays each being indicated by the numerals 340, 350 and 360. As many such groups of register relays may be provided as are necessary to register all of the digits of any line designation. For successively placing the several groups of register relays under the control of the responsive relays, a train of transfer relays serving as a steering switch is provided. Six of such transfer relays 327, 328, 329 and 330, 331 and 332 are disclosed. For a more complete disclosure of a sender having similar registering equipment reference may be had to Patent 1,916,760, granted July 4, 1933, to I. H. Henry.

The chart shown in Fig. 4 illustrates in the second and third columns thereof under the headings T and R, the potential conditions applied to the tip conductor 301 and to the ring conductor 302 by the operation of the key-set keys indicated by the numerals 1 to 0, inclusive of the first column H- (heavy negative), L- (light negative), H+ (heavy positive) and L+ (light positive), the blanks indicating no potential. The crosses in the remaining vertical columns indicate the operated condition of the responsive and register relays whose designations appear at the heads of the respective columns.

It is believed that this embodiment of the invention will be more clearly comprehended if the operation of the circuits in registering one or more typical digits is described in detail. It will, therefore, be assumed that the operator desires to register a line designation, the first three digits of which are 2, 9 and 1 and that the operator first depresses key 307 followed by the depression of keys 308 and 309.

With the No. 2 key 307 normal, current flows from battery, resistance 321, over the left normal contacts of key 307 to ground through the low inductance coil 306, thus completely saturating the core of this coil. When key 307 is depressed, its left transfer contacts first connect the coil 306 to the tip control conductor 301 and then

open the energizing circuit of the coil. The positive potential stored in the coil 306 is now applied to the cathodes of tubes 311 and 312 and to the anodes of tubes 313 and 323. Tubes 311 and 312 require the application of negative potential to their cathodes to cause their ionization and they do not ionize in response to the operation of key 307. Therefore relays TS and TM do not operate. Tube 323 also will not ionize at this time since its grid bias is high and the low positive potential applied to its anode by the low inductance coil 306 is not sufficient to overcome the grid bias. Relay TPM is not therefore operated. Since, however, tube 313 has negative potential applied to its cathode and has a lower grid bias, it will ionize upon the application of low positive potential to its anode and relay TP will operate in the cathode-anode circuit of this tube. This circuit may be traced from the negative terminal of battery, cathode of tube 313, thence to the anode, winding of relay TP, conductor 301, left alternate contacts of key 307 to ground through coil 306. Tubes 314, 315, 316 and 326 do not ionize since no potential is applied to the ring conductor 302 by the operation of key 307 and therefore relays RS, RM, RP and RPM do not operate. Thus the operation of key 307 for the digit 2 is instrumental in operating only responsive relay TP, that relay remaining operated so long as tube 313 is maintained in an ionized condition or until key 307 is released.

It will be further assumed that prior to the operation of relay TP, transfer relays 327 and 328 were operated in a suitable manner and locked in a circuit extending from battery serially through the windings of these relays, the upper contact of relay 327, the upper back contact of transfer relay 330 to ground. With transfer relay 328 operated and with relay TP operated, a circuit is established from ground at the lower contact of relay TP, conductor 317, lower contact of relay 328, upper winding of relay 342 of the first group 340 of register relays to battery. Relay 342 upon operating locks over its lower winding and contacts in any suitable locking circuit. At its upper contact, relay TP also closes a circuit extending from ground thereover, lower front contact of relay 327, winding of transfer relay 329 to battery. Relay 329 operates and locks in a circuit extending from battery through its winding, winding of transfer relay 330, upper contact of relay 329, upper back contact of transfer relay 332 to ground. Relay 330 does not, however, operate in this locking circuit since its winding is short-circuited by ground applied over the lower front contact of relay 327 so long as relay TP remains operated. When, however, the key 307 is released, and tube 313 de-ionizes, relay TP releases and transfer relay 330 operates.

The operation of transfer relay 330 connects the operating windings of the relays of the second register 350 to the contacts of the responsive relays and at its upper back contact opens the locking circuit of transfer relays 327 and 328. These relays now release, relay 328 upon releasing dissociating the operating windings of the relays of the first register 340 from the contacts of the responsive relays and relay 327 preparing an operating circuit for the transfer relays 331 and 332. The circuits are now prepared for the registration of the second digit.

It was previously assumed that the second digit to be registered was 9. With the No. 9 key 308 normal current flows from battery through resistance 321 over the right normal contacts of key 75

308 to ground through the winding of high inductance coil 305 and from ground through resistance 322 over the left normal contacts of key 308 to battery through the winding of low inductance coil 304, thus completely saturating the cores of these coils. When key 308 is depressed, the left transfer contacts thereof first connect the coil 304 to the tip control conductor 301, and then open the energizing circuit of coil 304 and, the right transfer contacts first connect coil 305 to the ring control conductor 302 and then open the energizing circuit of coil 305.

The negative potential stored in coil 304 is now applied to the cathodes of tubes 311 and 312 and to the anodes of tubes 313 and 323. Since tubes 313 and 323 require the application of positive potential to their anodes to cause their ionization, neither of these tubes ionizes and consequently relays TP and TPM do not operate. Tube 312 also will not ionize when low negative potential is applied to its cathode from the low inductance coil 304 since its grid is provided with a high negative bias and therefore relay TM does not operate. Since, however, tube 311 has a low negative bias and has positive potential applied to its anode, it will ionize in response to the surge of low potential from inductance coil 304 and operate relay TS over its cathode-anode circuit. This circuit may be traced from the negative terminal of battery through coil 304, left alternate contacts of key 308, conductor 301, cathode and anode of tube 311 to ground through the winding of relay TS.

The positive potential stored in coil 305 is also applied to the cathodes of tube 314 and 315 and to the anodes of tubes 316 and 326. Since tubes 314 and 315 require the application of negative potential to their cathodes to cause their ionization, neither of these tubes ionizes and consequently relays RS and RM do not operate. Tubes 316 and 326 having negative potential applied to their cathodes, both ionize when a surge of high positive potential is applied over conductor 302 to their anodes and operate relays RP and RPM over their cathode-anode circuits. The circuit of relay RP may be traced from the negative terminal of battery to the cathode of tube 316, thence to the anode of this tube, winding of relay RP, conductor 302, right alternate contacts of key 308 to ground through coil 305, and the circuit of relay RPM may be traced from the negative terminal of battery to the cathode of tube 326, thence to the anode of this tube, winding of relay RPM, conductor 302, right alternate contacts of key 308, to ground through coil 305. Thus in response to the operation of the No. 9 digit key 308, relays TS, RP and RPM are operated, these relays remaining operated as long as tubes 311, 316 and 326 are maintained ionized by the continued depression of the key.

Relays TS and RP upon operating close a circuit extending from ground over their contacts, conductor 318, lower back contact of transfer relay 327, lower front contact of transfer relay 329, winding of transfer relay 331 to battery. Relay 331 operates and locks in a circuit extending from battery through its winding and the winding of transfer relay 332 in series, upper front contact of relay 331, over the back contact of the next transfer relay (not shown) corresponding to relay 332, to ground. Relay 332 being shunted so long as relays TS and RP remain operated, does not operate at this time. Relay RP also closes a circuit extending from ground at its inner contact, over conductor 319, inner upper

front contact of transfer relay 330, upper winding of relay 353 of register 350 to battery. Relay RPM closes a circuit extending from ground at its contacts, over conductor 320, upper front contact of transfer relay 330, to battery through the upper winding of relay 354 of register 350. Register relays 353 and 354 both operate and lock over their lower windings and contacts.

When the key 308 is released, tubes 311, 316 and 326 de-ionize and release relays TS, RP and RPM, relays TS and RP upon releasing removing the shunting ground from the winding of transfer relay 332 which thereupon operates in the locking circuit of transfer relay 331. The operation of transfer relay 332 connects the operating windings of the relays of the third register 350 to the contacts of the responsive relays and at its upper back contact opens the locking circuit of transfer relays 329 and 330. These relays now release, relay 330 upon releasing dissociating the operating windings of the relays of the second register 350 from the contacts of the responsive relays and relay 329 preparing an operating circuit for the pair of transfer relays (not shown) next succeeding the transfer relays 331 and 332. The circuits are now prepared for the registration of the next digit.

It was previously assumed that the third digit to be registered was 1. With the No. 1 key 309 normal, current flows from battery through the winding of high inductance coil 303, left normal contacts of key 309, resistance 322 to ground, thus completely saturating the core of coil 303. When key 309 is depressed, the left transfer contacts thereof first connect coil 303 to the tip control conductor 301 and then open the energizing circuit of coil 303.

The negative potential stored in coil 303 is now applied to the cathodes of tubes 311 and 312 and to the anodes of tubes 313 and 323. Since tubes 313 and 323 require the application of positive potential to their anodes to cause their ionization, neither of these tubes ionizes and consequently relays TP and TPM do not operate. Tubes 311 and 312, however, are normally supplied with positive anode potential and since the surge of potential from the high inductance coil 303 is sufficiently negative to overcome the negative bias of both tubes 311 and 312, these tubes ionize and operate relays TS and TM. Relay TS operates in the cathode-anode circuit of tube 311 extending from the negative terminal of battery, through coil 303, the left contacts of key 309, conductor 301, cathode of tube 311, thence to the anode thereof, winding of relay TS to ground. Relay TM operates in the cathode-anode circuit of tube 312 extending from the negative terminal of battery through coil 303, the left contacts of key 309, conductor 301, cathode of tube 312, thence to the anode thereof, winding of relay TM to ground. Since the depression of key 309 has applied no potential to conductor 302, none of the relays RS, RM, RP and RPM is operated. Thus in response to the depression of key 309 only relays TS and TM are operated, these relays remaining operated as long as tubes 311 and 312 are maintained ionized by the continued depression of the key.

Relay TS upon operating closes a circuit extending from ground over its contact, lower 70 back contacts of transfer relays 327 and 329, the lower front contact of transfer relay 331 through the winding of the next transfer relay (not shown) corresponding to the relay 331, thence to battery. This transfer relay operates 75

and locks through the winding of its companion relay, the companion relay not operating, however, as long as relay TS remains operated. Relay TM upon operating closes a circuit from ground over its contact, conductor 321, the inner lower contacts of transfer relay 332 to battery through the upper winding of relay 361 of the register 360. Relay 361 upon operating locks over its lower winding and contacts.

When the key 309 is released, tubes 311 and 312 de-ionize and release relays TS and TM, relay TS permitting the next transfer relay, corresponding to the transfer relay 332, to operate. The operation of this transfer relay connects the operating windings of the relays of the fourth register (not shown) to the contacts of the responsive relays and opens the locking circuit of transfer relays 331 and 332. Relay 332 upon releasing dissociates the operating windings of the relays of the register 360 from the contacts of the responsive relays and relay 331 upon releasing prepares the operating circuit for a further pair of transfer relays. The circuits are now prepared for the registration of a fourth digit.

Other digits of a line designation may be registered in a similar manner and since the chart shown in Fig. 4 clearly indicates the line potential conditions and operated relay combinations necessary to the registration of digits of all numerical values, it has been considered unnecessary to describe in detail the manner in which such digits are registered.

Although hot cathode type gaseous conductor tubes have been illustrated and described herein, certain tubes having marginal characteristics determined by grid biasing batteries of different voltages, it is to be understood that the invention is not limited to the use of tubes of this particular type. Instead of biasing the tubes by batteries of different potentials to obtain the marginal operation, tubes might be selected which are designed to have different breakdown voltages when the same biasing potential is applied to their grids. Further, tubes of the cold cathode type might be used.

What is claimed is:

1. 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 in said registering device associated with the conductors of said control circuit, and means controlled by said sending device for transmitting impulses of different potential and polarity over either conductor singly or both of the conductors of said control circuit to selectively operate said ionic relays.

2. 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 in said registering device associated with the conductors of said control circuit, means controlled by said sending device for transmitting impulses of different potential and polarity over either conductor singly or both of the conductors of said control circuit to selectively operate said ionic relays and relays operable by said ionic relays.

3. 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 groups of gaseous conductor tubes in said registering

device, one group associated with each conductor of said control circuit respectively and the tubes of each group being arranged to be selectively operable in response to the application of definite potentials to the associated control conductor, means in said sending device for selectively applying operating potential to either conductor singly or both of said conductors and relays controlled by said tubes.

4. In a telephone system, a keyset, a registering device, a two-conductor control circuit extending from said keyset to said device, two groups of gaseous conductor tubes in said device, one group of tubes associated with one conductor of said circuit and the other group of tubes associated with the other conductor of said circuit, the tubes of each group being selectively operable in response to the application of definite potentials to the associated circuit conductor, means controlled by the keys of said keyset for selectively applying operating potential to either conductor singly or both of said conductors and relays controlled by said tubes.

5. In a telephone system, a keyset, a registering device, a two-conductor control circuit extending from said keyset to said device, two groups of gaseous conductor tubes in said device, one group of tubes associated with one conductor of said circuit and the other group of tubes associated with the other conductor of said circuit, the tubes of each group being selectively operable in response to the application of definite potentials to their associated circuit conductor, means controlled by the keys of said keyset for selectively applying surges of potential to either conductor singly or both of said conductors to selectively operate said tubes and relays controlled by said tubes.

6. In a telephone system, a keyset, a registering device, a two-conductor control circuit extending from said keyset to said device, two groups of gaseous conductor tubes in said device, one group of tubes associated with one conductor of said circuit and the other group of tubes associated with the other conductor of said circuit, the tubes of each group being selectively operative in response to the application of definite potentials to their associated circuit conductor, normally charged inductances associated with said keyset, means controlled by the keys in said keyset for selectively establishing discharge paths for said inductances over said conductors for supplying potentials to said tubes, and relays controlled by said tubes.

7. In a telephone system, a keyset, a registering device, a two-conductor control circuit extending from said keyset to said device, two groups of gaseous conductor tubes in said device, one group of tubes associated with one conductor of said circuit and the other group of tubes associated with the other conductor of said circuit, the tubes in each group being selectively operable in response to the application of definite potentials to their associated circuit conductor, normally charged inductances and ground associated with said keyset, means controlled by the keys of said keyset for selectively establishing discharge paths for said inductances over said conductors or for connecting ground thereto for supplying potential to said tubes, and relays controlled by said tubes.

8. In a telephone system, a keyset, a registering device, a two-conductor control circuit extending from said keyset to said device, two

groups of gaseous conductor tubes in said device, one group of tubes associated with one conductor of said circuit and the other group of tubes associated with the other conductor of said circuit, each group of tubes comprising one tube operable by light potential of one polarity, a second tube operable by heavy potential of the same polarity, and a third tube operable by potential of the opposite polarity, means controlled by the keys of said keyset for selectively applying potentials of different potential and polarity to either conductor singly or both of said conductors to selectively operate said tubes, and relays controlled by said tubes.

9. In a telephone system, a keyset, a registering device, a two-conductor control circuit extending from said keyset to said device, two groups of gaseous conductor tubes in said device, one group of tubes associated with one conductor of said circuit and the other group of tubes associated with the other conductor of said circuit, each group of tubes comprising one tube having its cathode connected to the associated circuit conductor, its anode connected to a source of positive potential and its grid so negatively biased that said tube becomes conducting only on the application of a definite negative potential to its cathode, a second tube having its cathode connected to the associated circuit conductor, its anode connected to a source of positive potential and its grid so negatively biased that said tube becomes conducting only on the application of a definite greater negative potential to its cathode, and a third tube having its cathode connected to a source of negative potential, its anode connected to the associated circuit conductor and its grid so negatively biased that said tube becomes conducting only on the application of a definite positive potential to its anode, means controlled by the keys of said keyset for selectively applying potentials of different potential and polarity to either or both of said conductors to selectively operate said tubes, and relays controlled by said tubes.

10. In a telephone system, a keyset, a registering device, a two-conductor control circuit extending from said keyset to said device, two groups of gaseous conductor tubes in said device, one group of tubes associated with one conduc-

tor of said circuit and the other group of tubes associated with the other conductor of said circuit, each group of tubes comprising one tube operable by light potential of one polarity, a second tube operable by heavy potential of the same polarity, a third tube operable by light potential of the opposite polarity, and a fourth tube operable by heavy potential of the opposite polarity, means controlled by the keys of said keyset for selectively applying potentials of different potential and polarity to either or both of said conductors to selectively operate said tubes, and registers controlled by said tubes.

11. In a telephone system, a keyset, a registering device, a two-conductor control circuit extending from said keyset to said device, two groups of gaseous conductor tubes in said device, one group of tubes associated with one conductor of said circuit and the other group of tubes associated with the other conductor of said circuit, each group of tubes comprising one tube having its cathode connected to the associated circuit conductor, its anode connected to a source of positive potential, and its grid so negatively biased that said tube becomes conducting only on the application of a definite negative potential to its cathode, a second tube having its cathode connected to the associated circuit conductor, its anode connected to a source of positive potential and its grid so negatively biased that said tube becomes conducting only on the application of a greater negative potential to its cathode, a third tube having its cathode connected to a source of negative potential, its anode connected to the associated circuit conductor, and its grid so negatively biased that said tube becomes conducting only on the application of a definite positive potential to its anode, and a fourth tube having its cathode connected to a source of negative potential, its anode connected to the associated circuit conductor and its grid so negatively biased that said tube becomes conducting only on the application of a definite greater positive potential to its anode, means controlled by the keys of said keyset for selectively applying potentials of different potential and polarity to either or both of said conductors to selectively operate said tubes and registers controlled by said tubes.

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