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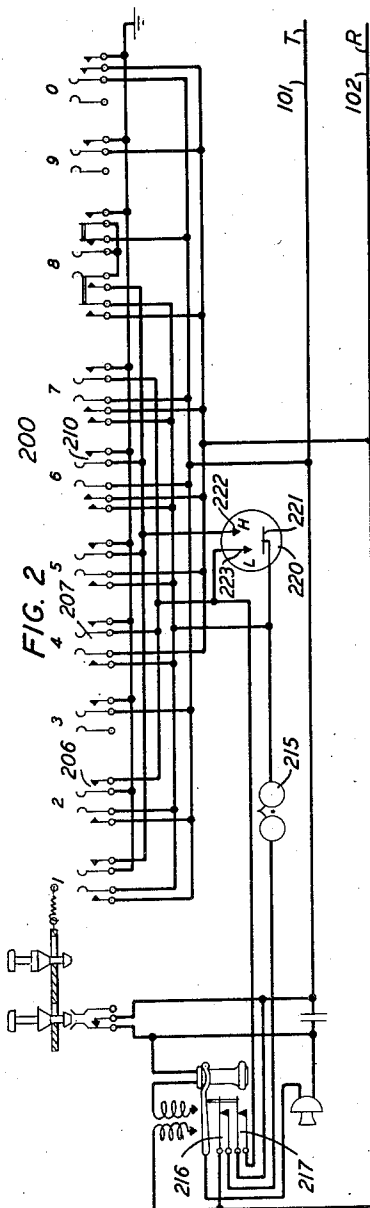
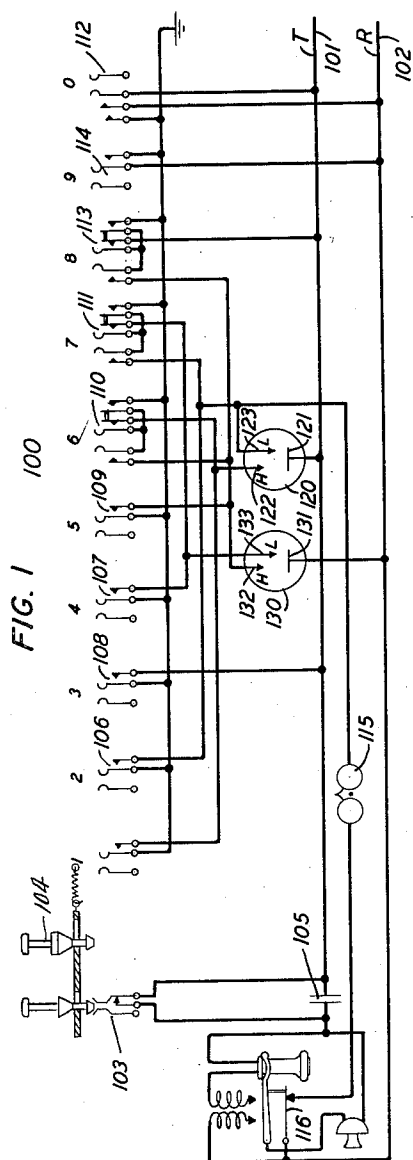
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2,060,184

TELEPHONE SYSTEM

Filed Nov. 21, 1935

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

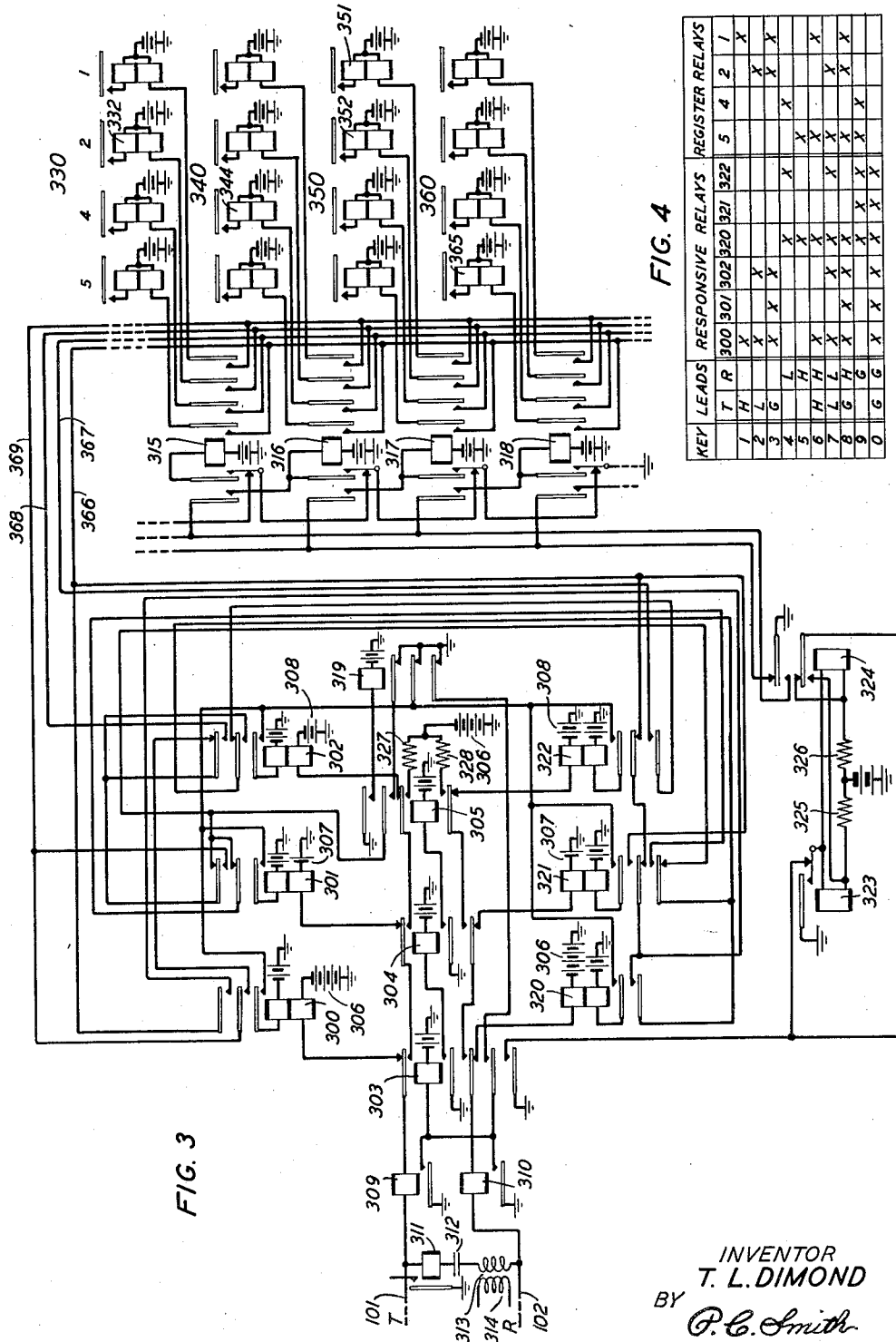


FIG. 4

KEY	LEADS		RESPONSIVE RELAYS								REGISTER RELAYS			
	T	R	300	301	302	320	321	322	5	4	2	1		
1	H		X									X		
2	L		X		X						X	X		
3	G		X	X							X			
4		L					X							
5		H					X		X					
6	H		X			X			X			X		
7	L		X		X			X	X					
8	G		X	X		X			X		X	X		
9		G						X	X					
0	C		V	V	V	X		X	X	X				

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UNITED STATES PATENT OFFICE

2,060,184

TELEPHONE SYSTEM

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20 Claims. (Cl. 179—90)

This invention relates to telephone systems and more particularly to key pulsing equipment for enabling a subscriber to control the establishment of connections to other subscribers' lines over selector switches. In its broader aspect the invention relates to the application of key pulsing to signaling systems. It is the object of the invention to enable the selective control of registering equipment over a control circuit extending from a transmitting station to a receiving station in a simple, economical manner without necessitating the provision of any source of operating current at the transmitting station or reliance upon marginal current operation.

In all automatic telephone systems as now constituted and in wide use, subscribers' substations are equipped with the well known dial for enabling subscribers to either directly control the setting of selector switches, or to control the setting of selector switches through the intermediary of a central office register sender. Although most subscribers do not object to the manipulation of the dial for transmitting series of impulses in accordance with the digits of the directory numbers of desired lines, there are some who believe that the effort required on their part to establish connections should be made as slight and simple as possible.

Key-sets have been provided at operators' positions, replacing dials, to enable operators to more speedily set up connections since the keys of a key-set corresponding to the digits of a line designation can be depressed at much greater speed than the usual dial can be manipulated. The problem of equipping operators' positions with key-sets is not as difficult as the equipping of subscribers' substations with the same type of equipment because operators' positions are located at the central office where sources of operating current are readily available. At subscribers' premises, however, there is no local source of current except the usual commercial power supply and it is undesirable to rely upon commercial power at subscribers' premises for the operation of telephone apparatus.

In accordance with the present invention this difficulty is obviated by the provision of key pulsing equipment at the subscribers' premises which requires no source of power supply at the subscriber's substation, the necessary operating current being supplied over the subscriber's line from a central office source of current. This is accomplished by utilizing one or more ionic tubes at the substation in conjunction with the keys of a ten-button key-set. Ionic tubes have the character-

istic that they do not pass any current until a potential greater than their inherent breakdown potential is applied to them. The tubes employed are of the three-element type each having a single cathode and two anodes, one of the anodes being positioned at a greater distance from the cathode than the other anode. Thus, two cathode-anode paths of different length are provided, the shorter of which will pass current when a potential of one value is applied across the cathode and anode thereof, and the longer of which will pass current when potential of a greater value is applied across the cathode and other anode thereof.

The keys of the key-set are arranged to connect to either the tip or ring conductor of the subscriber's line or to both, either a direct ground or a high or low potential breakdown path to ground through one or more of the ionic tubes. Central office equipment is provided which detects the different combinations by applying to each side of the line every time a key is depressed, three different potentials in succession. The highest potential is sufficient to cause current to flow even through the high potential breakdown path of a tube. The intermediate potential is just sufficient to cause current to flow through the low potential breakdown path of a tube, while the lowest potential will cause current to flow only if a direct ground has been applied at the substation. A relay in series with each source of potential determines whether current flows and the combination of relays operated at the end of each complete test determines the digits keyed.

The inventive concept may be carried out by the use of a single ionic tube, the cathode of which may be connected to either the tip or ring conductor of the line circuit dependent upon the key operated, or by the use of two tubes the cathodes of which are respectively connected to the tip and ring conductors. In either case all operating current is supplied over the line conductors from the central office. In addition, one of the tubes may be employed as a condenser in the circuit of the substation ringer or bell. The tubes could also be provided with one anode and two cathodes and function with the operating circuits in substantially the same manner.

For a clearer conception of the invention and the manner in which it functions reference may be made to the following description taken in connection with the attached drawings in which:

Fig. 1 shows one embodiment of a substation circuit equipped with a key-set;

Fig. 2 shows a second embodiment of a substation circuit;

Fig. 3 shows such portions of a central office sender as are necessary for an understanding of the invention; and

Fig. 4 is a chart showing the various combinations of responsive and registering relays which are operated in response to the keying of different digits.

The circuit of Fig. 3 should be placed to the right of either Fig. 1 or Fig. 2. The relay registers and transfer relays shown at the right of Fig. 3 are of the general type disclosed, for example, in Patent No. 1,862,549 granted June 14, 1932 to R. Raymond and W. J. Scully. The sender may be associated with the calling subscriber's line of Fig. 1 or Fig. 2 in any well-known manner, for example, as disclosed in the patent above referred to, in response to the initiation of a call by the subscriber.

It will first be assumed that the subscriber whose substation apparatus is disclosed in Fig. 1 desires to establish a connection with another subscriber's line and therefore removes his receiver from the switch-hook preparatory to dialing. A connection is thereupon established with the sender of Fig. 3. Two impulsing circuits are effective as follows: From the negative terminal of the grounded source of the high potential 306, lower operating winding of impulse responsive relay 300, upper back contact of sequence relay 303, winding of relay 309, tip impulsing conductor 101 to the cathode 121 of tube 120; from the negative terminal of the grounded source of high potential 306, upper operating winding of impulse responsive relay 320, lower back contact of relay 303, winding of relay 310, ring impulsing conductor 102 to the cathode 131 of tube 130. At the substation the conductor 101 is looped to conductor 102 through the normal contacts of start key 103, through the substation receiver and switch-hook contacts. No relays of the sender operate over this loop, however, since the source of potential 306 is connected to both the tip and ring conductors.

At the sender a bridge is established from the tip conductor 101 through the alternating current holding relay 311, condenser 312, the secondary winding of tone coil 313 to the ring conductor 102 over which dialing tone from the tone source 314 is inductively transmitted to the calling subscriber's substation as a signal that he may commence the keying of the desired subscriber's number. Relay 311 also operates and serves to hold the sender until the subscriber either restores his receiver to the switch-hook or until the sender has completed its function and has been dismissed from the connection in the usual manner. Upon hearing the dial tone the calling subscriber first depresses the start key 103 which locks under the control of key 104 thereby removing the shunt from condenser 105. With the condenser 105 now connected into the loop between conductors 101 and 102 at the substation alternating current induced from the tone coil may flow over the calling line holding relay 311 operated but the tip and ring conductors are effectively isolated from each other with respect to the conduction of direct current.

Before proceeding with the description of the operation of the circuit incident to the operation of keys of the key-set 100, it is to be noted that each of the tubes 120 and 130 is of the three-element cold cathode type, tube 120 having a single cathode 121, an anode 123 having a low break-

down potential with respect to cathode 121 and an anode 122 having a high breakdown potential with respect to cathode 121. Similarly tube 130 has a single cathode 131, an anode 133 having a low breakdown potential with respect to cathode 131 and an anode 132 having a high breakdown potential with respect to cathode 131. The keys of the key-set are non-locking and are so arranged that whenever a key is depressed it will connect direct ground to the tip conductor 101 or to the ring conductor 102 or to both, or connect ground to one or the other of the anodes of either or both of the tubes 120 and 130. At the sender negative potential is applied successively to the cathode 121 of tube 120 over tip conductor 101 and to the cathode 131 of tube 130 over the ring conductor 102 by the sequential operation of relays 303, 304 and 305 as will be later described, from a source of high potential 306, a source of low potential 307, and a source of intermediate potential 308.

It will now be assumed that the subscriber desires to obtain a connection with a subscriber's line, the directory number of which is CHelsea 3-567OW and after receiving the dial tone proceeds to depress the keys of key-set 100 to cause the registration of this number on the registers of the sender, four of which are disclosed at 330, 340, 350 and 360. The remaining registers of the sender have been omitted to simplify the disclosure. The subscriber first depresses key 106 corresponding to the code letter C thereby connecting ground to the low potential anode 123 of tube 120. With high negative potential present on the cathode 121 of tube 120, the tube ionizes permitting current to flow from the source 306 through the lower winding of relay 300 thence as traced through the winding of relay 309 to the cathode 121, thence through the tube to the anode 123, over the right contacts of key 106 to ground, operating relay 300 which locks from battery over its upper winding and inner upper front contact to ground at the middle back contact of relay 319. Since ground is not applied to either anode of tube 130 or to ring conductor 102 by the depression of key 106 relay 320 does not operate.

Relay 309 also operates establishing an obvious circuit for sequence relay 303 which operates locking over its next to lower front contact to ground at the lower contact of relay 319 and at its inner lower front contact establishing the operating circuit of sequence relay 304. Relay 304 upon operating establishes at its inner lower front contact the operating circuit of sequence relay 305 which in turn upon operating establishes at its upper front contact the operating circuit of relay 319. Thus the sequence relays 303, 304, 305 and 319 operate in rapid succession in response to the momentary depression of key 106 to successively switch the operating windings of responsive relays 300, 301, 302, 320, 321 and 322 to and from the tip and ring impulsing conductors 101 and 102 in the manner to be described.

At its lower front contact relay 303 establishes a circuit from ground through the normal contacts and winding of relay 323, resistance 325 to battery and also establishes a circuit from ground over the normal contacts of relay 323, winding of relay 324, resistance 326 to battery. Relay 323 operates, locking to ground over its alternate contacts but relay 324 does not operate as its winding is shunted by ground applied from the lower front contact of relay 303, over

the inner upper back contact of relay 324, so long as relay 303 remains operated. At its upper and next to lower back contacts relay 303 disconnects the high potential source 306 and operating windings of relays 300 and 320 from the impulsing conductors 101 and 102 thereby causing the deionization of tube 120. At its upper front contact relay 303 immediately connects the tip conductor 101 over the upper back contact of relay 304 through the operating winding of responsive relay 301 to the negative terminal of the low potential source 307 and at its next to inner lower front contact connects the ring conductor 102 over the lower back contact of relay 304 through the operating winding of responsive relay 321 to the negative terminal of the low potential source 307.

With key 106 depressed ground is still applied to the anode 123 of tube 120 but this tube will not reionize since the potential applied to the cathode 121 is not now high enough. No operating path is therefore completed for responsive relay 301 during the interval immediately preceding the operation of sequence relay 304. No operating path for relay 321 is completed during this interval as no ground has been applied to impulsing conductor 102 or to either anode of tube 130 through the operation of key 106.

As soon as relay 304 operates the impulsing conductors 101 and 102 are disconnected at its back contacts from the operating windings of responsive relays 301 and 321, conductor 101 is connected over the upper front contacts of relays 303 and 304 and upper back contact of relay 305 through the operating winding of responsive relay 302 to the negative terminal of the source 308 of the intermediate potential and conductor 102 is connected over the next to inner lower front contact of relay 303, the lower front contact of relay 304 and the lower back contact of relay 305 through the operating winding of responsive relay 322 to the negative terminal of the source 308 of intermediate potential.

With key 106 depressed ground is still applied to the anode 123 of tube 120 and since now the potential from the source 308 connected to its cathode 121 over conductor 101 is high enough the tube reionizes and completes the circuit of relay 302 over the path previously traced to its cathode, thence to the anode 123 and over the right contacts of key 106 to ground. Relay 302 operates during the interval immediately preceding the operation of sequence relay 305 and locks over its upper winding and inner upper front contact to ground at the intermediate back contact of relay 319. No operating path for responsive relay 322 is completed at this time since no ground has been applied to conductor 102 or to either anode of tube 130 by the operation of key 106.

As soon as relay 305 operates, at its back contacts, disconnects conductors 101 and 102 from the operating windings of responsive relays 302 and 322 thereby causing the deionization of tube 120. Conductor 101 is now connected over front contacts of relays 303, 304 and 305 through resistance 327 and conductor 102 is connected over front contacts of relays 303, 304 and 305 through resistance 328 to the negative terminal of the high potential source 306. Should the key 106 be still depressed, the tube 120 will again ionize thereby holding relay 309 operated to maintain relay 303 and relays 304 and 305 operated after relay 319 operates and opens the locking circuit of relay 303, until the key 106

is finally released. This insures that no further tests will be made by the responsive relays until the operated key 106 is released.

In response to the operation of key 106 for the code letter C responsive relays 300 and 302 have operated and locked. During the interval following the operation of relay 305 and before the operation of relay 319 a circuit is closed from ground at the inner back contact of relay 319, the middle upper front contact of relay 305, the outer back contact of relay 301, the upper front contact of relay 302, conductor 368, the next to outer right front contact of transfer relay 315, assumed to have been operated upon the seizure of the sender, lower winding of register relay 332 to battery. Relay 332 operates and locks in any well-known manner over its upper winding and upper front contact. No circuits are effective for the other relays of register 330.

As soon as relay 319 operates the locking circuits of all operated responsive relays, in this case relays 300 and 302, are opened and these relays release, the operating ground for operating register relays is removed and the locking circuit of relay 303 is opened. If the key 106 has been released and relay 309 is not operated, relays 303, 304, 305 and 319 now release in succession. Relay 303 upon releasing removes the shunting ground from the winding of relay 324 which now operates in a circuit from ground over the alternate contacts of relay 323, winding of relay 324, resistance 326 to battery, establishing an operating circuit for transfer relay 316. This circuit may be traced from ground over the upper front contact of relay 324, outer left front contact of transfer relay 315, winding of transfer relay 316 to battery. Relay 316 operates locking over its inner left alternate contacts and the inner left normal contacts of succeeding transfer relays 317, 318, etc. to ground, and opening at its left normal contacts the locking circuit for transfer relay 315 which extends over the inner left alternate contacts of relay 315 and through the winding of relay 315 to battery. Transfer relay 315 upon releasing disconnects the conductors 366 to 369, inclusive, from the operating windings of the relays of register 330 and transfer relay 316 upon operating connects these conductors to the operating windings of the relays of register 340. The first code digit C has now been registered through the sole operation of register relay 332 and the circuits are prepared for registering the next code letter.

The subscriber now proceeds to depress key 107 to cause the registration of the second code letter H, resulting in the connection of ground to the low potential anode 133 of tube 130. With sequence relay 303 released the negative terminal of the high potential source 306 is now connected through the operating winding of responsive relay 320 thence as traced over conductor 102 to the cathode 131 of tube 130 causing the tube to ionize and operate relay 320 which locks over its lower winding and inner lower front contact to ground at the middle back contact of relay 319. Relay 310 also operates in turn causing the sequential operation of relays 303, 304, 305 and 319 and the locking of relay 303 under the control of relay 319. Relay 303 upon operating applies ground from its lower front contact over the inner upper front contact of relay 324 to a point between the winding of relay 323 and resistance 325 thereby shunting down relay 323 which at its transfer contacts transfers the operating ground of relay 324 to

the lower front contact of relay 303. Relay 324 is now maintained operated under the control of relay 303.

Following the operation of relay 303 and prior to the operation of relay 304 the operating winding of relay 320 is disconnected from conductor 102 thereby causing the deionization of tube 130 and the low potential source 307 is connected through the operating winding of relay 321 over the lower back contact of relay 304 and the next to inner lower front contact of relay 303 to conductor 102. This potential is not, however, high enough to cause the reionization of tube 130 and relay 321 does not therefore operate. Following the operation of relay 304 and prior to the operation of relay 305, the operating winding of relay 321 is disconnected from conductor 102 and the intermediate potential source 308 is connected through the operating winding of relay 322 over the lower back contact of relay 305 and the front contacts of relays 304 and 303 to conductor 102. This potential is high enough to cause the ionization of tube 130 and relay 322 therefore operates over the ionization path through the tube which is completed from conductor 102 over the cathode 131 and anode 133 of the tube, the right contacts of key 107 to ground. Relay 322 upon operating locks over its lower winding and inner lower front contact to ground at the middle back contact of relay 319. Since no ground was applied through the operation of key 107 to conductor 101 or to either anode of tube 120, tube 120 does not ionize and none of the responsive relays 300, 301 and 302 operate.

Following the operation of relay 305 and prior to the operation of relay 319 with responsive relays 320 and 322 both operated a circuit is established from ground at the upper back contact of relay 319, middle upper front contact of relay 305, lower back contact of relay 321, inner back contact of relay 302, lower front contact of relay 322, conductor 367 next to inner front contact of transfer relay 316, lower winding of relay 344 of register 340 to battery. Relay 344 operates and locks over its upper winding. No operating circuits for the other relays of register 340 are effective.

Upon the operation of relay 319 the operating circuit of register relay 344 is opened and the locking circuits of responsive relays 320 and 322 are opened releasing the latter relays. If the key 107 has not yet been released relay 310 is operated in a circuit extending from the source of high potential 306, through resistance 323, over the front contacts of relays 305, 304, 303, winding of relay 310, conductor 102, through the tube 130 which is ionized by the potential from source 306, to ground over the contacts of key 107. Relay 310 holds relay 303 operated after its holding circuit is opened by the operation of relay 319, thus insuring that no further tests will be made by the responsive relays until the operated key 107 is released. With relay 319 operated, when key 107 is released, relay 310 releases and relays 303, 304, 305 and 319 release in turn.

When relay 303 releases it opens the holding circuit of relay 324 which now releases and establishes a circuit from ground over its upper back contact, the outer left front contact of transfer relay 316 to battery through the winding of transfer relay 317. Relay 317 operates and locks over its left alternate contacts and the left normal contacts of succeeding transfer relays 318, etc. to ground and by opening its left

normal contacts opens the locking circuit of transfer relay 316 which now releases. The release of transfer relay 316 disconnects conductors 366 to 369, inclusive, from the operating windings of the relays of register 340 and the operation of transfer relay 317 connects these conductors to the operating windings of the relays of the next register 350. The second code letter H has now been registered through the sole operation of register relay 344 and the circuits are prepared for registering the third code digit.

The subscriber now proceeds to depress key 108 to cause the registration of the code digit 3 resulting in the connection of direct ground to the tip conductor 101. With sequence relay 303 released a circuit is completed from ground on conductor 101, through the winding of relay 309 and the operating winding of responsive relay 300 causing relay 300 to operate and lock and causing the sequential operation of relays 303, 304, 305 and 319 and the locking of relay 303 under the control of relay 319 in the manner previously described. With relays 323 and 324 now both released, the operation of relay 303 causes the operation and locking of relay 323 and the preparation of an operating circuit for relay 324 as previously described.

Following the operation of relay 303 and prior to the operation of relay 304, the operating winding of relay 300 is disconnected from conductor 101 and the low potential source 307 is connected through the operating winding of relay 301 over the upper back contact of relay 304 and the upper front contact of relay 303 to conductor 101. Since the key 108 has applied direct ground to conductor 101 relay 301 now operates and locks over its upper winding and inner upper front contact to ground at the middle back contact of relay 319. Following the operation of relay 304 and prior to the operation of relay 305 the operating winding of relay 301 is disconnected from conductor 101 and the intermediate potential source 308 is connected through the operating winding of relay 302 over the upper back contact of relay 305 and the upper front contacts of relays 304 and 303 to grounded conductor 101 resulting in the operation and locking of relay 302. Since no ground was applied through the operation of key 108 to conductor 102 or to either anode of tube 130, none of the responsive relays 320, 321 and 322 operate.

Following the operation of relay 305 and prior to the operation of relay 319 with responsive relays 300, 301 and 302 all operated, a circuit is established from ground at the upper back contact of relay 319, middle upper front contact of relay 305, lower back contact of relay 321, middle front contact of relay 302, thence in parallel over the upper front contact of relay 301 to conductor 369 thence over the outer right front contact of transfer relay 317 to battery through the lower winding of register relay 351 and over the upper front contact of relay 302, conductor 368, next to outer right front contact of transfer relay 317 to battery through the lower winding of register relay 352. Register relays 351 and 352 operate and lock over their upper windings. No operating circuits for the other relays of register 350 are effective.

Upon the operation of relay 319 the operating circuits of register relays 351 and 352 are opened and the locking circuits of responsive relays 300, 301 and 302 are opened releasing the latter relays. If the key 108 has been released relays 303, 304, 305 and 319 release in turn.

When relay 303 releases it removes the shunting ground from the winding of relay 324 which now operates and establishes a circuit from ground at its upper front contact over the outer left front contact of transfer relay 317 to battery through the winding of transfer relay 318. Relay 318 operates and locks over its left alternate contacts and the left normal contacts of succeeding transfer relays (not shown) and by opening its left normal contacts opens the locking circuit of transfer relay 317 which now releases. The release of relay 317 disconnects conductors 366 to 369, inclusive, from the operating windings of the relays of register 350 and the operation of relay 318 connects these conductors to the operating windings of the relays of the next register 360. The third code digit 3 has now been registered through the operation of register relays 351 and 352 and the circuits are prepared for registering the thousands digit.

The subscriber now proceeds to depress key 109 to cause the registration of the thousands digit 5 resulting in the connection of ground to the high potential anode 132 of tube 130. With sequence relay 303 released the negative terminal of the high potential source 306 is now connected through the operating winding of relay 320 thence as traced over conductor 102 to the cathode 131 of tube 130 causing the tube to ionize and operate relay 320, which locks to ground at the middle back contact of relay 319. Relay 310 also operates in turn causing the sequential operation of relays 303, 304, 305 and 319 and the locking of relay 303 under the control of relay 319. Relay 303 upon operating applies ground from its lower front contact, the inner upper front contact of relay 324 to a point between the winding of relay 323 and resistance 325 thereby shunting down relay 323 which at its transfer contacts transfers the operating ground of relay 324 to the lower front contact of relay 303. Relay 324 now is held operated under the control of relay 303.

Following the operation of relay 303 and prior to the operation of relay 304 the operating winding of relay 320 is disconnected from conductor 102 thereby causing the deionization of tube 130 and the low potential source 307 is connected through the operating winding of relay 321 over the lower back contact of relay 304 and the next to inner lower front contact of relay 303 to conductor 102. This potential is not, however, high enough to cause the reionization of tube 130 and relay 321 does not therefore operate. Following the operation of relay 304 and prior to the operation of relay 305, the operating winding of relay 321 is disconnected from conductor 102 and the intermediate potential source 308 is connected through the operating winding of relay 322 over the lower back contact of relay 305 and front contacts of relays 304 and 303 to conductor 102. This potential is not high enough to cause the reionization of tube 130 and relay 322 does not therefore operate. Since no ground was applied through the operation of key 109 to conductor 101 or to either anode of tube 120, tube 120 does not ionize and none of the responsive relays 300, 301 and 302 operate.

Following the operation of relay 305 and prior to the operation of relay 319, with responsive relay 320 operated a circuit is established from ground at the upper back contact of relay 319, middle upper front contact of relay 305, lower back contact of relay 321, lower front contact of relay 320, inner back contacts of relays 321 and 322,

conductor 366, inner right front contact of transfer relay 318 to battery through the lower winding of relay 365 of register 360. Relay 365 operates and locks over its upper winding. No operating circuits for the other relays of register 360 are effective.

Upon the operation of relay 319 the operating circuit of relay 365 is opened and the locking circuit of responsive relay 320 is opened releasing relay 320. If key 109 has been released relays 303, 304, 305 and 319 release in turn. When relay 303 releases it opens the holding circuit of relay 324 which now releases and establishes a circuit from ground over its upper back contact, the outer left front contact of transfer relay 318 to battery through the winding of the succeeding transfer relay (not shown). This transfer relay operates opening the locking circuit of transfer relay 318 which now releases. The release of relay 318 disconnects conductors 366 to 369, inclusive, from the operating windings of relays of register 360 and the operation of the next succeeding transfer relay connects these conductors to the operating windings of the next or hundreds register. The thousands digit 5 has now been registered through the operation of relay 365 and the circuits are prepared for registering the hundreds digit.

The subscriber now proceeds to depress key 110 to cause the registration of the hundreds digit 6 resulting in the connection of ground over its outer right and left contacts to the high potential anode 132 of tube 131 and the connection of ground over its right contacts to the high potential anode 122 of tube 121. In this connection it is to be noted that the outer right contacts of keys 110, 111 and 113 make, after the other contacts of these keys have made. With sequence relay 303 released the negative terminal of the high potential source 306 is now connected through the operating windings of responsive relays 300 and 320 thence as traced over conductors 101 and 102 to the cathodes 121 and 131 of tubes 120 and 130 causing the tubes to both ionize and operate relays 300 and 320. These relays upon operating both lock to ground at the middle back contact of relay 319. Relays 309 and 310 also operate in turn causing the sequential operation of relays 303, 304, 305 and 319 and the locking of relay 303 under the control of relay 319. With relays 323 and 324 now both released, the operation of relay 303 causes the operation and locking of relay 323 and the preparation of an operating circuit for relay 324 in the manner previously described.

Following the operation of relay 303 and prior to the operation of relay 304, the operating windings of relays 300 and 320 are disconnected from conductors 101 and 102 thereby causing the deionization of tubes 120 and 130 and the low potential source 307 is connected through the operating windings of relays 301 and 321 to conductors 101 and 102. This potential is not, however, high enough to cause the reionization of the tubes and therefore relays 301 and 321 do not operate. Following the operation of relay 304 and prior to the operation of relay 305 the operating windings of relays 301 and 321 are disconnected from conductors 101 and 102 and the intermediate potential source 308 is connected through the operating windings of relays 302 and 322 to conductors 101 and 102. This potential is not, however, high enough to cause the reionization of the tubes and relays 302 and 322 do not operate.

Following the operation of relay 305 and prior to the operation of relay 319 with responsive relays 300 and 320 operated a circuit is established from ground at the upper back contact of relay 319, middle upper front contact of relay 305, upper back contact of relay 301, upper back contact of relay 302, middle front contact of relay 300 to conductor 369 and a branch of this circuit extends over the lower back contact of relay 321, lower front contact of relay 320 and inner back contacts of relays 321 and 322 to conductor 366 resulting in the operation and locking of the Nos. 1 and 5 relays of the hundreds register. No operating circuits for the other relays of this register are effective.

Upon the operation of relay 319 the operating circuits of the hundreds register relays are opened and the locking circuits of responsive relays 300 and 320 are opened releasing the latter relays. If key 110 has been released relays 303, 304, 305 and 319 release in turn. When relay 303 releases it removes the shunting ground from the winding of relay 324 which now operates and establishes a circuit from ground at its upper front contact for operating the next transfer relay which upon operating releases the preceding transfer relay. The conductors 366 to 369, inclusive, are now disconnected from the operating windings of the hundreds register relays and are connected to the operating windings of the tens register relays. The hundreds digit 6 has now been registered and the circuits are prepared for registering the tens digit.

The subscriber now proceeds to depress key 111 to cause the registration of the tens digit 7 resulting in the connection of ground to the low potential anodes 123 and 133 of tubes 120 and 130. With sequence relay 303 released the negative terminal of the high potential source 306 is now connected through the operating windings of responsive relays 300 and 320 thence as traced over conductors 101 and 102 to the cathodes 121 and 131 of tubes 120 and 130 causing these tubes to ionize and operate relays 300 and 320. These relays upon operating lock to ground at the middle back contact of relay 319. Relays 309 and 310 also operate in turn causing the sequential operation of relays 303, 304, 305, and 319 and the locking of relay 303 under the control of relay 319. Relay 303 upon operating applies ground from its lower front contact over the inner upper front contact of relay 324 to the point between the winding of relay 323 and resistance 325 thereby shunting down relay 323 which, at its transfer contacts, transfers the operating ground of relay 324 to the lower front contact of relay 303. Relay 324 is now maintained operated under the control of relay 303.

Following the operation of relay 303 and prior to the operation of relay 304, the operating windings of relays 300 and 320 are disconnected from conductors 101 and 102 thereby causing the deionization of tubes 120 and 130 and the low potential source 307 is connected through the operating windings of relays 301 and 321 to conductors 101 and 102. This potential is not, however, high enough to cause the reionization of the tubes and relays 301 and 321 do not, therefore, operate. Following the operation of relay 304 and prior to the operation of relay 305 the operating windings of relays 301 and 321 are disconnected from conductors 101 and 102 and the intermediate potential source 308 is connected through the operating windings of relays 302 and 322 to conductors 101 and 102. This potential is high enough to

cause the reionization of the tubes and the consequent operation of relays 302 and 322 which then lock under the control of relay 319.

Following the operation of relay 305 and prior to the operation of relay 319 with responsive relays 300, 302, 320 and 322 operated a circuit is established from ground at the upper back contact of relay 319, middle upper front contact of relay 305, upper back contact of relay 301, upper front contact of relay 302 to conductor 368 and in a branch of this circuit over the lower back contact of relay 321, the lower front contact of relay 320 and upper front contact of relay 300 to conductor 369, resulting in the operation and locking of the Nos. 2 and 5 relays of the tens register. No operating circuits for other relays of the register are effective.

Upon the operation of relay 319 the operating circuits of the relays of the tens register are opened and the locking circuits of responsive relays 300, 302, 320 and 322 are opened releasing the latter relays. If key 111 has been released, relays 303, 304, 305 and 319 release in turn. When relay 303 releases it opens the holding circuit of relay 324 which now releases and establishes a circuit from ground over its upper back contact for operating the next transfer relay, which upon operating releases the preceding transfer relay. The conductors 366 and 369, inclusive, are now disconnected from the operating windings of the tens register relays and are connected to the operating windings of the units register relays. The tens digit 7 has now been registered and the circuits are prepared for registering the units digit.

The subscriber now proceeds to depress key 112 to cause the registration of the units digit 0 resulting in the connection of direct ground to both conductors 101 and 102. With sequence relay 303 released, both responsive relays 300 and 320 now operate and lock and relays 309 and 310 also operate causing the sequential operation of relays 303, 304, 305 and 319 and the locking of relay 303 under the control of relay 319. With relays 323 and 324 now both released, the operation of relay 303 causes the operation and locking of relay 323 and the preparation of an operating circuit for relay 324 in the manner previously described. Upon the operation of relay 303 the operating windings of responsive relays 300 and 320 are disconnected from grounded conductors 101 and 102 and the operating windings of relays 301 and 321 are connected thereto resulting in the operation and locking of the latter relays. When relay 304 operates the operating windings of relays 301 and 321 are disconnected from grounded conductors 101 and 102 and the operating windings of relays 302 and 322 are connected thereto resulting in the operation and locking of the latter relays. With all of the responsive relays 300, 301, 302, 320, 321 and 322 operated, when relay 305 operates with relay 319 still unoperated no circuit is effective over the back contact of relay 319 and the upper middle front contact of relay 305 over any of the conductors 366 to 369, inclusive, and therefore no relays of the units register are operated and the units digit 0 is registered.

When relay 319 operates the locking circuits of the responsive relays are opened and these relays release. If the key 112 has been released, relays 303, 304, 305 and 319 release in turn. When relay 303 releases it opens the shunt around the winding of relay 324 which now operates and at its upper front contact establishes a circuit for operating the next transfer relay

which, in turn, releases the preceding transfer relay. The conductors 366 to 369, inclusive, are thereby disconnected from the relays of the units register and connected to the relays of the stations register. The circuits are now in condition to register the stations letter.

The subscriber now proceeds to depress key 114 to cause the registration of the stations letter W, which has an equivalent of the digit 9, resulting in the connection of direct ground to conductor 102. With sequence relay 303 released responsive relay 320 operates and locks and relay 310 also operates causing the sequential operation of relays 303, 304, 305 and 319 and the locking of relay 303 under the control of relay 319. Relay 303 upon operating shunts down relay 323 in the manner previously described, relay 324 being now maintained operated so long as relay 303 is operated.

Upon the operation of relay 303 the operating winding of relay 320 is disconnected from grounded conductor 102 and the operating winding of relay 321 is connected thereto resulting in the operation and locking of relay 321. When relay 304 operates, the operating winding of relay 321 is disconnected from grounded conductor 102 and the operating winding of relay 322 is connected thereto resulting in the operation and locking of relay 322. Since the operation of key 114 has applied no ground to conductor 101 or to the anodes of tube 120, none of the relays 300, 301 and 302 is operated. With relays 320, 321 and 322 operated when relay 305 operates with relay 319 still unoperated, a circuit is established from ground over the upper back contact of relay 319, middle upper front contact of relay 305, inner back contact of relay 301, lower front contact of relay 321, lower front contact of relay 320, middle front contact of relay 321, to conductor 366 and in a branch of this circuit extending over the inner back contact of relay 301, lower front contact of relay 321, inner back contact of relay 302, lower front contact of relay 322 to conductor 367 resulting in the operation of the Nos. 4 and 5 relays of the stations register.

When relay 319 operates, the operating circuits of the stations register relays are opened and the operated responsive relays 320, 321 and 322 are released. If the key 114 has been released relays 303, 304, 305 and 319 release in turn, relay 303 causing the release of relay 324. The subscriber having keyed the entire number now momentarily depresses key 104 thereby releasing key 103.

The entire line number has now been registered and the sender proceeds in the usual manner to control the setting of selector switches to establish the desired connection in accordance with the setting of its registers. In the foregoing description the functioning of the circuits in response to the keying of all digits except 1 and 8 has been described in detail. By reference to the chart of Fig. 4 it is believed that the manner in which the circuits function when either the digit 1 or the digit 8 is keyed will be apparent without a detailed description thereof.

On an incoming call when the subscriber's line is seized and ringing current is applied thereto, the ringing current path extends from conductor 101 across the cathode 121 and anode 123 of tube 120, which now functions as a ringing condenser, through the substation ringer 115, normal switch-hook contacts 116 to conductor 102.

The modified substation circuit of Fig. 2 func-

tions with Fig. 3 in much the same manner as previously described in connection with Fig. 1, the essential difference being that by a modification of the contacts of the key-set 200 only one tube 220 is required, the key contacts serving to transfer the cathode 221 of tube 220 into connection with either or both of the impulsing conductors 101 and 102 as may be necessary.

For example, when key 206 for the digit 2 is depressed, the closure of its left contacts connects the tip conductor 101 to the cathode 221 of the tube and the closure of its right contacts connects ground to the low potential anode 223 of the tube. If the key 207 were depressed for the digit 4 the closure of its left contacts connects the ring conductor 102 to the cathode 221 of the tube and the closure of its right contacts connects ground to the low potential anode 223 of the tube. If the key 210 were depressed for the digit 6, the closure of its left contacts connects both conductors 101 and 102 to the cathode 221 of the tube and the closure of its right contacts connects ground to the high potential anode 222 of the tube. By reference to the chart of Fig. 4 it will be apparent that the operation of the keys of Fig. 2 for the tens digit will satisfy the conditions necessary for causing the sender to function correctly.

In referring to the chart the designation H under the heading T indicates that ground is applied to the high potential anode of the tube whose cathode is connected to the tip conductor 101 and the designation H under the heading R indicates that ground is applied to the high potential anode of the tube whose cathode is connected to the ring conductor 102. The designation L under the heading T indicates that ground is applied to the low potential anode of the tube whose cathode is connected to the tip conductor 101 and the designation L under the heading R indicates that ground is applied to the low potential anode of the tube whose cathode is connected to the ring conductor 102. The designation G under either heading T or R indicates the direct grounding of the tip or ring conductor. The crosses in the columns headed by the designations of the responsive relays and register relays indicates the operated condition of those relays for each of the several digits.

When the circuit of Fig. 2 is used the tube 220 functions as a ringing condenser on incoming calls, the ringing circuit extending from conductor 101, lower normal switch-hook contacts 217, anode 223 and cathode 221 of tube 220, ringer 215, switch-hook contacts 216 to conductor 102.

What is claimed is:

1. In a signaling system, a transmitting station, a receiving station, a control circuit extending between said stations, a key-set and a gaseous discharge device at said transmitting station, a plurality of relays at said receiving station respectively associable with said control circuit through sources of different potential, and means including the keys of said key-set and said device for selectively operating said relays.

2. In a signaling system, a transmitting station, a receiving station, a control circuit extending between said stations, a key-set and a gaseous discharge device at said transmitting station, a plurality of relays at said receiving station, a source of different potential associated with each of said relays, means for successively associating said relays with said control circuit, and means including the keys of said key-set and said device

for selectively completing operating paths for said relays over said control circuit.

3. In a signaling system, a transmitting station, a receiving station, a two-conductor control circuit extending between said stations, a key-set and a gaseous discharge device at said transmitting station, a plurality of pairs of relays at said receiving station, a source of different potential associated with each pair of said relays, means for successively associating said pairs of relays with the respective conductors of said control circuit, and means including the keys of said key-set and said device for selectively completing operating paths for said relays over said control circuit.

4. In a signaling system, a transmitting station, a receiving station, a two-conductor control circuit extending between said stations, a key-set and a gaseous discharge device at said transmitting station, a plurality of pairs of relays at said receiving station, a source of different potential associated with each pair of said relays, means for successively associating said pairs of relays with the respective conductors of said control circuit, and means including the keys of said key-set and said device for selectively completing operating paths for said relays over said control circuit either directly through said keys, or through said keys and said discharge device.

5. In a signaling system, a transmitting station, a receiving station, a control circuit extending between said stations, a key-set and a plurality of gaseous discharge devices at said transmitting station, a plurality of relays at said receiving station associable with said control circuit through sources of different potential, and means including the keys of said key-set and said devices for selectively operating said relays.

6. In a signaling system, a transmitting station, a receiving station, a control circuit extending between said stations, a key-set and a plurality of gaseous discharge devices at said transmitting station, a plurality of relays at said receiving station, a source of different potential associated with each of said relays, means for successively associating said relays with said control circuit, and means including the keys of said key-set and said devices for selectively completing operating paths for said relays over said control circuit.

7. In a signaling system, a transmitting station, a receiving station, a two-conductor control circuit extending between said stations, a key-set and two gaseous discharge devices at said transmitting station, said devices being associated respectively with the two conductors of said control circuit, a plurality of pairs of relays at said receiving station, a source of different potential associated with each pair of relays, means for successively associating said pairs of relays with the respective conductors of said control circuit, and means including the keys of said key-set and said devices for selectively completing operating paths for said relays over one or both of the conductors of said control circuit.

8. In a signaling system, a transmitting station, a receiving station, a two-conductor control circuit extending between said stations, a key-set and two gaseous discharge devices at said transmitting station, said devices being associated respectively with the two conductors of said control circuit, a plurality of pairs of relays at said receiving station, a source of different potential associated with each pair of relays, means

for successively associating said pairs of relays with the respective conductors of said control circuit, and means including the keys of said key-set and said devices for selectively completing operating paths for said relays either directly through said keys or through said keys and said discharge devices over one or both of the conductors of said control circuit.

9. In a signaling system, a transmitting station, a receiving station, a control circuit extending between said stations, a key-set and a gaseous discharge device at said transmitting station, said device having a cathode and two anodes, a plurality of relays at said receiving station, a source of different potential associated with each of said relays, means for successively associating said relays with said control circuit, and means controlled by the keys of said key-set for selectively completing operating paths for said relays either directly through said keys or through said keys, the cathode and one anode of said device, or through said keys, the cathode and other anode of said device.

10. In a signaling system, a transmitting station, a receiving station, a two-conductor control circuit extending between said stations, a key-set and a gaseous discharge device at said transmitting station, said device having a cathode and two anodes, a plurality of pairs of relays at said receiving station, a source of different potential associated with each pair of said relays, means for successively associating said pairs of relays with the respective conductors of said control circuit, and means controlled by the keys of said key-set for selectively completing operating paths for said relays either directly through said keys, or through said keys, the cathode and one anode of said device, or through said keys, the cathode and other anode of said device.

11. In a signaling system, a transmitting station, a receiving station, a two-conductor control circuit extending between said stations, a key-set and two gaseous discharge devices at said transmitting station, each of said devices having a cathode and two anodes, the cathode of one device being connected to one of said control conductors and the cathode of the other device being connected to the other of said control conductors, a plurality of pairs of relays at said receiving station, a source of different potential associated with each pair of relays, means for successively associating said pairs of relays with the respective conductors of said control circuit, and means controlled by the keys of said key-set for selectively completing operating paths for said relays over one or both of said conductors either directly through said keys, or the cathode and either anode of one of said devices through said keys, or the cathode and either anode of the other of said devices through said keys.

12. In a signaling system, a transmitting station, a receiving station, a two-conductor control circuit extending between said stations, a key-set and two gaseous discharge devices at said transmitting station, each of said devices having a cathode and two anodes, the cathode of one device being connected to one of said control conductors and the cathode of the other device being connected to the other of said control conductors, a plurality of pairs of relays at said receiving station, a source of different potential associated with each pair of relays, means for successively associating said pairs of relays with the respective conductors of said control circuit, and means controlled by the keys of said key-set for connect-

ing ground to one conductor of said control circuit either directly or over the cathode and either anode of one of said devices, for connecting ground to the other conductor of said control circuit either directly or over the cathode and either anode of the other of said devices, or for connecting ground to both conductors directly or over said devices to electrically operate said relays.

13. In a telephone system, a substation, a central station, a control circuit extending between said stations, a key-set and a gaseous discharge device at said substation, a plurality of relays at said central station, a source of different potential associated with each of said relays, means for successively associating said relays with said control circuit, digit registers operable by said relays, and means including the keys of said key-set and said device for selectively completing operating paths for said relays over said control circuit to control the registration of the digits of line designations.

14. In a telephone system, a substation, a central station, a two-conductor control circuit extending between said stations, a key-set and a gaseous discharge device at said substation, a plurality of pairs of relays at said central station, a source of different potential associated with each pair of said relays, means for successively associating said pairs of relays with the respective conductors of said control circuit, digit registers operable by said relays, and means including the keys of said key-set and said device for selectively completing operating paths for said relays over said control circuit to control the registration of the digits of line designations.

15. In a telephone system, a substation, a central station, a control circuit extending between said stations, a key-set, a gaseous discharge device and a ringer at said substation, a plurality of relays at said central station, a source of different potential associated with each of said relays, means for successively associating said relays with said control circuit, digit registers operable by said relays, means including the keys of said key-set and said device for selectively completing operating paths for said relays over said control circuit to control the registration of digits of line designations, and a ringing current path through said ringer and said device whereby said device functions as a ringer condenser.

16. In a signaling system, a transmitting station, a receiving station, a two-conductor control circuit extending between said stations, a key-set and a gaseous discharge device at said transmitting station, a plurality of pairs of relays at said receiving station, a source of different potential associated with each pair of said relays, means for successively associating said pairs of relays with the respective conductors of said control circuit, means including the keys of said key-set and said device for selectively completing operating paths for said relays over said control circuit, and means operative following each association of all of said relays with said control circuit for preventing the reassociation of said relays with said control circuit until after any operated key of said key-set has been released.

17. In a signaling system, a transmitting station, a receiving station, a two-conductor control circuit extending between said stations, a key-set

and two gaseous discharge devices at said transmitting station, a plurality of pairs of relays at said receiving station, a source of different potential associated with each pair of said relays, means for successively associating said pairs of relays with the respective conductors of said control circuit, means including the keys of said key-set and said devices for selectively completing operating paths for said relays over said control circuit, and means operative following each association of all of said relays with said control circuit for preventing the reassociation of said relays with said control circuit until after any operated key of said key-set has been released.

18. In a signaling system, a transmitting station, a receiving station, a two-conductor control circuit extending between said stations, a key-set and a gaseous discharge device at said transmitting station, a plurality of pairs of responsive relays at said receiving station, a source of different potential associated with each pair of relays, sequence relays operable in response to the depression of any key of said key-set for successively associating said pairs of relays with the respective conductors of said control circuit, means including the keys of said key-set and said device for selectively completing operating paths for said responsive relays over said control circuit, and means operative following the operation of said sequence relays for locking said sequence relays operated to prevent the reassociation of said responsive relays with said control circuit until the operated key has been released.

19. In a signaling system, a transmitting station, a receiving station, a two-conductor control circuit extending between said stations, a key-set and two gaseous discharge devices at said transmitting station, a plurality of pairs of responsive relays at said receiving station, a source of different potential associated with each pair of relays, sequence relays operable in response to the depression of any key of said key-set for successively associating said pairs of relays with the respective conductors of said control circuit, means including the keys of said key-set and said devices for selectively completing operating paths for said responsive relays over said control circuit, and means operative following the operation of said sequence relays for locking said sequence relays operated to prevent the reassociation of said responsive relays with said control circuit until after the operated key has been released.

20. In a signaling system, a transmitting station, a receiving station, a two-conductor control circuit extending between said stations, a key-set and a gaseous discharge device at said transmitting station, said device having a cathode and two anodes, a plurality of pairs of relays at said receiving station, a source of different potential associated with each pair of relays, means for successively associating said pairs of relays with the respective conductors of said control circuit, and means controlled by the keys of said key-set for connecting ground to either or both of said conductors or for connecting the cathode of said device to either or both of said conductors and either anode of said device to ground to selectively complete operating paths for said relays.