June 2, 1936. P. C. SMITH 2,042,869

CODE CALLING SYSTEM

Filed Jan. 23, 1935 2 Sheets-Sheet 1

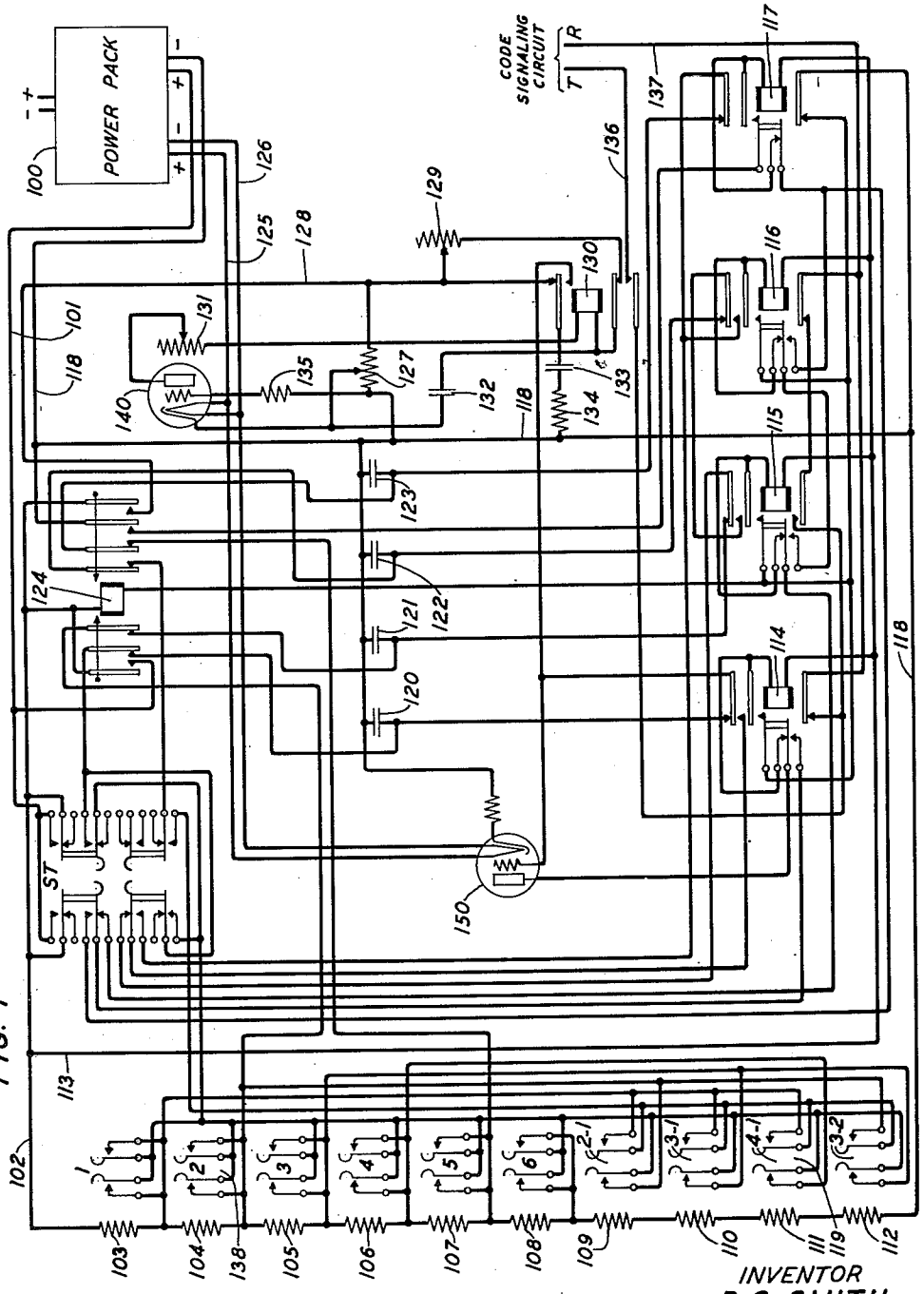

FIG. 1

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CODE CALLING SYSTEM

Filed Jan. 23, 1935 2 Sheets-Sheet 2

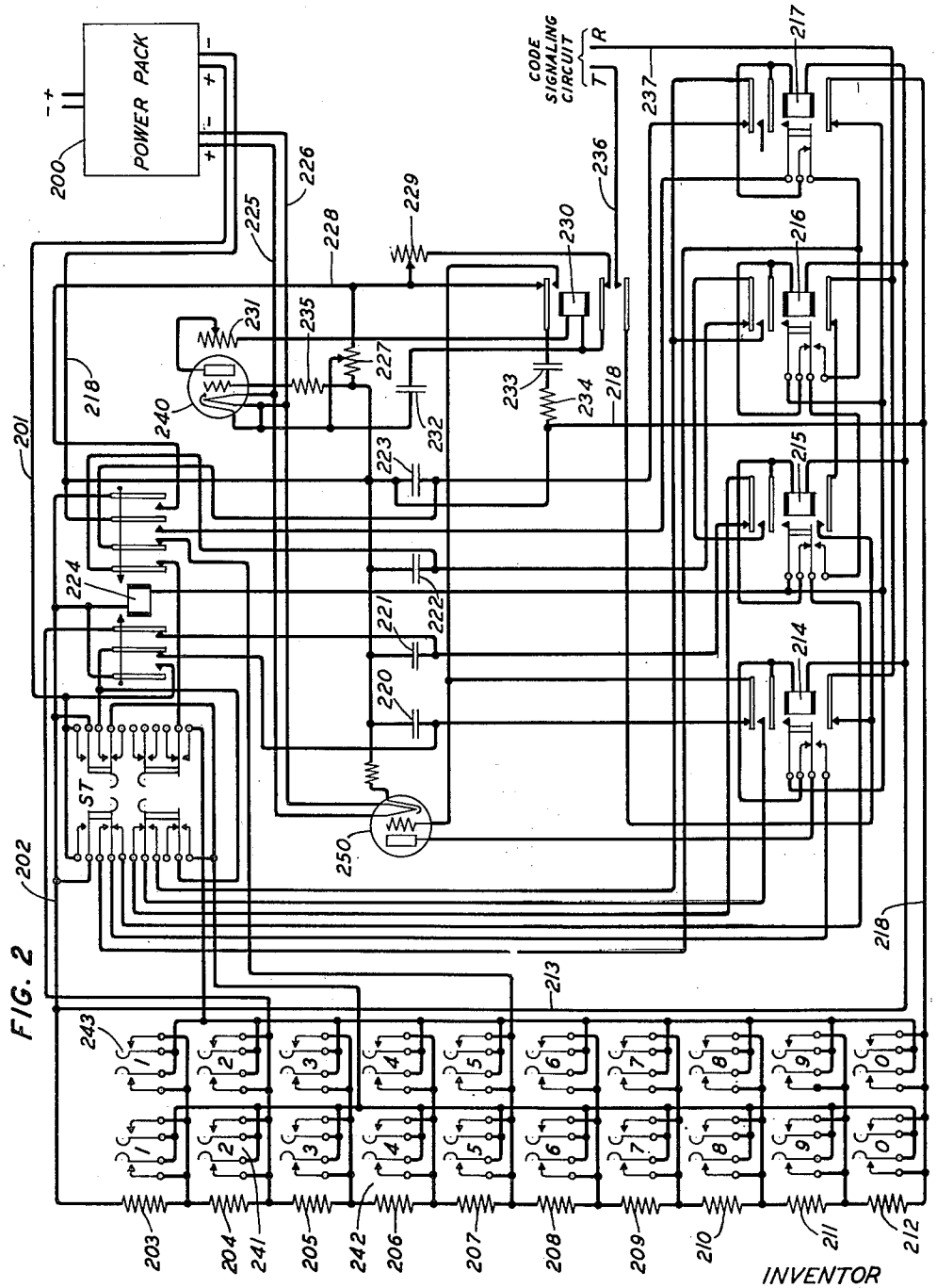

FIG. 2

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CODE CALLING SYSTEM

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Application January 23, 1935, Serial No. 2,980

13 Claims. (Cl. 177—380)

This invention relates to a signaling system and more particularly to code signaling arrangements whereby certain persons may be reached when they are absent from their offices on business in other departments of a store, factory or other business establishment.

The object of the invention, generally stated, is the provision of new and improved circuit arrangements whereby code signals may be transmitted efficiently and with less apparatus than has been heretofore necessary.

The code signaling system in accordance with the present invention is adapted for use in conjunction with a private branch exchange system and particularly with a system installed in business establishments, such as stores and factories. When the operator receives a call for a particular official, such as a superintendent or foreman, and upon establishing the usual telephone connection to his substation receives no response, she may, if the call is urgent, signal the desired person over a code signaling circuit. The code signaling circuit extends through the establishment and has connected thereto, at strategic points, signal bells or other announcing means. When the operator connects with the signaling circuit she causes signals to be transmitted thereover in accordance with a predetermined code thereby operating all of the signal bells associated with the signaling circuit in accordance with the transmitted code. The desired official, if he is in any department of the establishment where one of the signal bells is located, hearing his particular code rung will then return to his own substation or to the nearest telephone substation to answer the incoming call.

The present invention relates particularly to a sending circuit by means of which an operator may transmit any one of a plurality of predetermined codes of signals over the signaling circuit. According to one modification of the invention, the sender comprises a bank of locking keys comprising as many keys as there are codes which may be sent, certain of the keys being arranged for controlling the transmission of single digit codes while others are arranged for controlling the transmission of two-digit codes. Associated with the keys is a start key and a group of condensers serving as registers. When any key is operated followed by the operation of the start key, initial charges are placed on the register condensers, the charges on one or more of the condensers being commensurate with the digital value of the code digit or digits for which the particular key is wired. Charges are also placed on the remaining condensers commensurate with the length of digit spacing and code spacing intervals which are to be introduced between the transmission of successive series of impulses to the signaling circuit.

For generating impulses for transmission over the signaling circuit, an impulsing relay is provided which may be operated by any suitable interrupting means operating at a predetermined rate. This interrupting means may be of any well-known type although for the purposes of illustration an interrupter circuit employing a gas-filled tube of the type disclosed in Patent No. 1,979,054 granted October 30, 1934 to W. H. Scheer has been shown. The impulsing relay in addition to transmitting impulses over the signaling circuit also controls an impulse counting arrangement for counting the number of impulses in each series transmitted and for counting impulses for determining the spacing intervals. The impulse counting arrangement comprises a gas-filled tube which may be of the three-element type filled with an inert gas such as neon, argon, helium, mercury vapor or combinations of gases of this class and which breaks down or ionizes when the potential on its control or grid element is raised sufficiently above a critical value, a secondary condenser and a train of anode or stop relays. This counting arrangement functions with the impulsing relay and register condensers in much the same manner as disclosed in Patent No. 2,002,219, granted May 21, 1935 to T. L. Dimond, except that the anode relays also serve as a steering switch for associating the register condensers successively with the tube during the sending of codes of impulses.

The start key has three positions, a normal or non-operate position, a left start position for starting the sender for transmitting any single digit code of impulses and a right start position for starting the sender for transmitting any two-digit code of impulses.

In general, the sender functions in the following manner: If it be assumed that the key for the two-digit code 4—1 is operated and the start key is then operated to the right, an initial charge is placed on the first register condenser of a value which is the complement of the value of the first digit 4 of the code, that is, six increments of charge are placed thereon, an initial charge is placed on the second register condenser which is the complement of the digital value of the digit spacing interval, an initial charge is placed on the third register condenser which is the complement of the second digit 1 of the code, that is,

nine increments of charge are placed thereon, and an initial charge is placed on the fourth register condenser which is the complement of the digital value of the code spacing interval. A slow-to-operate relay then operates to isolate the condensers from their charging circuits and to then start the interrupter to cause the periodic operation and release of the impulsing relay and the charging and discharging of a secondary condenser.

The grid of the tube of the counting circuit is at this time connected with the first registering condenser over back contacts of the first of the train of anode relays. The anode of the tube is connected through the winding of the first anode relay to a source of positive potential and the cathode of the tube is connected to a source of negative potential. The grid of the tube is then raised to the potential of the first registering condenser. The secondary condenser is associated with contacts of the impulsing relay so that it becomes charged to a definite potential each time that the impulsing relay releases and becomes connected into a discharging circuit each time that the impulsing relay operates. Upon the first operation of the impulsing relay to transmit the first impulse over the signaling circuit, the charged secondary condenser discharges into the first registering condenser thus raising its potential by a predetermined increment and consequently raising the potential on the grid of the tube by the same increment. Upon the subsequent releases and operations of the impulsing relay this cycle of operations is repeated to add further increments of potential to the associated register condenser until such condenser has received four increments or has a total of ten increments of potential, at which time the potential on the grid of the tube will have been raised to such an extent that the tube will flash and operate the first anode relay. The impulsing relay will thus have transmitted a series of four impulses to the signaling circuit.

The first anode relay upon operating first opens the signaling circuit to prevent the transmission of further impulses as the impulse relay continues operating, opens the anode circuit of the tube thus causing the tube to deionize, then locks itself operated under the control of the last anode relay of the train, connects the winding of the second anode relay to the anode of the tube and transfers the circuit of the grid of the tube from the first to the second registering condenser. The sender is now conditioned for measuring off a delay interval prior to the transmission of the second digit series of the code.

With the grid of the tube now connected to the second registering condenser the grid is raised to the potential of this second condenser and in the previously described manner the potential of the second condenser is raised by increments and consequently the potential of the grid of the tube is raised by the continued operation of the impulsing relay until the condenser has been charged to ten increments of potential at which time the potential on the grid of the tube will have been raised to such an extent that the tube will flash and operate the second anode relay. A digit spacing interval has thus been measured off, the length of which has been determined by the amount of the initial potential on the second registering condenser. Since, however, the signaling circuit was opened by the operation of the first anode relay, the impulse relay has not been instrumental in transmitting further impulses over the signaling circuit.

The second anode relay upon operating functions to deionize the tube, to lock itself operated under the control of the last anode relay of the train, to prepare a new anode circuit from the anode of the tube through the winding of the third anode relay, to reestablish the signaling circuit and to transfer the connection of the grid of the tube from the second to the third registering condenser. The sender is now conditioned for transmitting a series of impulses in accordance with the second digit of the keyed code, which series of impulses is transmitted and counted in the same manner as the first series.

It having been assumed that the third condenser had an initial charge of nine increments, the potential on the grid of the tube will be raised to such a potential as to cause the tube to flash after one impulse has been transmitted and one increment of potential has been added to the third condenser. When the tube flashes the third anode relay operates and functions to deionize the tube, lock itself operated under the control of the last anode relay of the train, to prepare a new anode circuit from the anode to the winding of the last anode relay, to open the signaling circuit and to transfer the connection of the grid of the tube from the third to the fourth registering condenser. The sender is now conditioned for measuring off a delay interval prior to the repetition of the first digit of the code.

The counting circuit now functions in the manner previously described to count off a delay interval as determined by the initial charge on the fourth registering condenser but the signaling circuit being open through the operation of the third anode relay, no impulses are transmitted over the signaling circuit. When the impulse relay has caused the addition of sufficient increments of potential to the fourth condenser to raise its total potential to ten increments, the tube flashes and operates the last anode relay which deionizes the tube, momentarily locks, and unlocks the other anode relays. With the first anode relay released the grid of the tube is again connected to the first condenser, the anode is connected through the winding of the first anode relay and the signaling circuit is reestablished. If the start key is still operated the circuits function in the same manner to repeat the transmission of the code impulses so long as the start key remains operated.

The sender functions in much the same manner to transmit a single digit code except that with the start key operated to the left the first anode relay upon operating to terminate the transmission of the first or single digit series transfers the grid of the tube from the first to the fourth condenser and transfers the anode circuit of the tube to the winding of the last anode relay whereby the functions performed by the second and third anode relays are omitted and a code spacing delay is measured immediately following the transmission of the single digit series.

A second modification of the invention is disclosed which functions in a similar manner, the chief difference residing in the fact that two rows of keys are provided, the keys of one row being operated for any one of ten single digit codes and the keys in each row being operated for any of a plurality of two-digit codes thus enabling a large number of codes to be employed.

For a more complete understanding of the invention reference may be had to the following de-

tailed description taken in connection with the drawings:

Fig. 1 shows one embodiment of the invention comprising a single row of digit keys and impulse transmitting mechanism; and

Fig. 2 shows a second embodiment of the invention comprising two rows of digit keys and impulse transmitting mechanism.

The keys of the key-set of Fig. 1 are of the locking type, any depressed key remaining in its operated position until another key is operated. Ten keys are disclosed six of which control the transmission of the six single digit codes 1 to 6, inclusive, and four of which control the transmission of two-digit codes 2—1, 3—1, 4—1 and 3—2. Other keys obviously might be added to control the transmission of further single and two-digit codes.

The keys of the key-set of Fig. 2 are also of the locking type, any operated key of either vertical row remaining in its operated position until another key of the same row is operated. Ten keys are provided in each row, any key of the left-hand row being operated alone for any one of ten single digit codes and a key in each row being operated for any desired two-digit code. The start key ST of each figure is of the three-position type, its mid-position being a non-operate position, its left position being an operate position for starting the circuit for transmitting any single digit code of impulses and its right position being an operate position for starting the circuit for transmitting any two-digit code of impulses.

The rectangles indicated by the numerals 100 and 200 of Figs. 1 and 2 represent power-packs of any well-known type capable of taking alternating current from a power outlet and transforming it into direct current of the proper voltages and polarity for supplying operating current to the apparatus of the sender. The tubes 140 and 150 of Fig. 1 and the tubes 240 and 250 of Fig. 2 are of the hot cathode, gas-filled type each having a cathode heated conductively from a filament, a control electrode or grid, and an anode.

In each figure the code signaling circuit to which code impulses are applied has been only indicated, it being understood that this circuit would be extended throughout the office, store or factory which the impulse sender serves, and supplied at strategic points with the usual bells or signaling devices. The impulses are transmitted to the code signaling circuit of Fig. 1 by impulse relay 130 under the control of the gaseous tube interrupter including tube 140 and similarly, impulses are transmitted to the code signaling circuit of Fig. 2 by impulse relay 230 under the control of the gaseous conductor tube interrupter including tube 240. These interrupter circuits are of the type disclosed in the patent to Scheer hereinbefore referred to. It will, of course, be obvious that any other well-known type of interrupter could be used with equal facility.

The invention will first be described in connection with Fig. 1, it being assumed that the operator desires to call a person whose code call number is 4—1. For this purpose the operator first depresses the code key 119 which is allocated to the code 4—1 and then throws the start key ST to the right. With the start key operated the positive bus-bar 101, extending from the power-pack 100, is connected over the upper right contact of key ST and conductor 102 to the upper terminal of the voltage divider comprising the serially connected resistances 103 to 112, inclusive, and over conductor 113 through the winding of the first anode relay 114 and the inner upper normal contacts thereof to the anode of tube 150 thus applying positive anode potential to the anode of this tube. The lower terminal of the voltage divider and the upper terminals of condensers 120, 121, 122 and 123 are connected to the negative bus-bar 118 extending from the power-pack 100.

With the key 119 operated, the lower terminal of condenser 120 is connected over the outer left back contact of relay 124, inner upper right alternate contact of key ST, left contacts of key 119 to a point on the voltage divider between resistances 106 and 107 whereby condenser 120 is charged to a potential equal to the drop of potential across the six resistances 107 to 112, inclusive, or is charged with six increments of potential. The lower terminal of condenser 121 is connected over the inner left back contact of relay 124 to a point on the voltage divider between resistances 104 and 105 whereby condenser 121 is charged to a potential equal to the drop of potential across the eight resistances 105 to 112, inclusive, or is charged with eight increments of potential. The lower terminal of condenser 122 is connected over the inner right back contact of relay 124, the lower right alternate contacts of start key ST, the right contacts of key 119 to a point on the voltage divider between resistances 103 and 104 whereby condenser 122 is charged to a potential equal to the drop of potential across the nine resistances 104 to 112, inclusive, or is charged with nine increments of potential. The lower terminal of condenser 123 is connected over the outer right back contact of relay 124 to a point on the voltage divider between resistances 107 and 108 whereby condenser 123 is charged to a potential equal to the drop of potential across the five resistances 108 to 112, inclusive, or is charged with five increments of potential. Thus, condensers 120 and 122 assume charges commensurate with the complements of the digital values of the digits 4 and 1. Condenser 121 assumes a charge commensurate with the complement of the digital value of the digit spacing interval which is, in the case assumed, equal to the period required to produce two impulses and condenser 123 assumes a charge commensurate with the complement of the digital value of a code spacing interval which, in the case assumed, is equal to the period required to produce five impulses. It will, of course, be obvious that the digit spacing and code spacing intervals may be made of any required value by varying the initial charges of condensers 121 and 123 through the connection of their upper terminals to different points on the voltage divider comprising resistances 103 to 112, inclusive.

The operation of start key ST also establishes a circuit for relay 124 extending from the positive bus-bar 101, over the upper right contacts of key ST, winding of relay 124, lower back contact of relay 117 to the negative bus-bar 118, relay 124 locking over its left front contact to the positive bus-bar 101 independent of start key ST and remaining operated over this locking circuit until pulsing is completed for a single transmission of the keyed digit code. Relay 124 being slow to operate does not operate immediately when the key ST is operated thus allowing a sufficient interval for condensers 120 to 123, inclusive, to become charged. When it finally operates, it opens at its back contacts, the initial charging circuits for these condensers and at its outer right contacts connects positive potential from the positive

bus-bar 101 over the upper right contacts to key ST to conductor 128 for starting the gaseous tube interrupter.

The application of positive potential to conductor 128 charges condenser 133 in a circuit extending from conductor 128, upper back contact of pulsing relay 130, condenser 133, resistance 134 to the negative bus-bar 118; applies positive potential to the anode of tube 140 over the adjustable resistance 129, the lower back contact and winding of relay 130 and adjustable resistance 131; and charges condenser 132 in a circuit extending from conductor 128, resistance 129, lower back contact of relay 130, condenser 132, voltage divider 127 to the negative bus-bar 118. The voltage divider 127 is bridged between conductor 128 and the negative bus-bar 118 and is so adjusted that the potential between the anode and cathode of tube 140 is less than that required to ionize the gaseous content of the tube. The cathode of tube 140 is heated conductively from the filament which is connected by conductors 125 and 126 to the filament current supply of power-pack 100. The control electrode or grid of the tube is connected to the negative bus-bar 118 through resistance 135.

When condenser 132 becomes charged to a potential equal to the ionization potential of tube 140, tube 140 ionizes and becomes conducting causing condenser 132 to discharge in a circuit through the winding of relay 130, adjustable resistance 131 to the negative bus-bar 118 through the anode and cathode of tube 140, thereby operating relay 130. Relay 130 upon operating opens the charging circuit for condenser 132 at its lower back contact and remains operated until the potential across the plates of condenser 132 falls sufficiently below the ionization potential of tube 140 to cause the tube to be deionized and become non-conducting. With tube 140 deionized the discharge circuit of condenser 132 is opened and relay 130 releases. When relay 130 releases the previously traced charging circuit for condenser 132 is again closed. When relay 130 operated it also connected the condenser 133 into a discharge path and closed one point in the tip conductor 136 of the outgoing code signaling circuit for a purpose to be later described. Upon the release of relay 130 the charging circuits of condensers 132 and 133 are again established and the tip conductor 136 of the signaling circuit is opened.

The above cycle of operations, namely charging condensers 132 and 133, ionizing tube 140, discharging condensers 132 and 133, deionizing tube 140, and operating and releasing relay 130 continues as long as positive potential is applied to conductor 128 through the operation of relay 124. The periodic operation and release of relay 130 causes the periodic opening and closing of the signaling circuit to produce impulses thereover. The periodicity of the impulses so generated may be controlled by varying the capacitance of condenser 132 and the charging and discharging rate thereof. The discharge rate of condenser 132 is controlled by adjustable resistance 131 and, since relay 130 operates in the discharge circuit of condenser 132, the adjustment of resistance 131 determines the time interval during which relay 130 is maintained operated and the interval during which the signaling circuit is maintained closed. The charging rate of condenser 132 is controlled by adjustable resistance 129 and since relay 130 does not operate until the charge on condenser 132 is sufficient to cause tube 140 to ionize, the adjustment of resistance 129 determines the time interval during which relay 130 remains released and therefore the intervals between successive impulses transmitted over the signaling circuit.

Upon the first operation of pulsing relay 130 following the depression of start key ST, the signaling circuit is closed from the tip conductor 136 over the lower front contact of relay 130, the lower back contact of anode relay 114 to the ring conductor 137 thereby causing the transmission of one impulse over the signaling circuit. At the same time condenser 133 is connected into a discharge circuit extending over the upper front contact of relay 130, the upper back contact of anode relay 114, through condenser 120, negative bus-bar 118, resistance 134 and condenser 133. Condenser 133 thereupon discharges into condenser 120 adding an increment of charge to the six increments of initial charge previously applied to condenser 120. On its next release relay 130 causes the recharging of condenser 133 and the opening of the signaling circuit thus terminating the first impulse.

Upon the subsequent energizations of relay 130 additional closures of the signaling circuit result in the transmission of further impulses and further increments of charge are added to condenser 120 by the discharge of condenser 133 thereinto until condenser 120 becomes fully charged, at which time four impulses will have been transmitted to the signaling circuit. The potential on the grid of tube 150 will now be rendered sufficiently positive by the application of potential thereto from the lower terminal of condenser 120 over the upper back contact of anode relay 114, to cause tube 150 to ionize since its cathode is supplied with negative potential from the bus-bar 118, its anode is supplied with positive potential over the circuit previously traced and its cathode is heated conductively by the filament which is connected to the filament supply conductors 125 and 126. Condenser 120 discharges in a path from its upper terminal over the cathode and grid of tube 150, upper back contact of relay 114 to the lower terminal of the condenser.

When tube 150 ionizes current flows in its cathode-anode circuit from the negative bus-bar 118, cathode and anode of the tube, inner upper normal contacts and winding of anode relay 114, conductor 113, thence as traced to the positive bus-bar 101. Relay 114 operates in this circuit first locking in a circuit from conductor 113 through its winding and middle upper front contact, lower back contact of relay 117 to the negative bus-bar 118, then opening the cathode-anode circuit of tube 150 at its inner upper back contact thereby deionizing tube 150 and finally connecting the anode of tube 150 over its inner upper front contact, the inner upper left normal contacts of key ST, the inner upper normal contacts and winding of anode relay 115 to conductor 113 and thence to the positive bus-bar 101. At its upper back contact relay 114 disconnects the grid of tube 150 and the discharge circuit of condenser 133 from the lower terminal of condenser 120 and connects the grid of tube 150 and the discharge circuit of condenser 133 over the upper front contact of relay 114, the inner lower left normal contacts of key ST, the upper back contact of anode relay 115 to the lower terminal of condenser 121. Tube 150 is now prepared for response to the counting of the digit spacing interval as determined by the initial charged condition of condenser 121. Relay 114 also opens

the signaling circuit at its lower back contact thereby preventing the transmission of further impulses over the signaling circuit through the continued operation of impulsing relay 130 during the counting of the digit spacing interval. Thus, the operation of relay 130 in conjunction with tube 150 has resulted in the transmission of four impulses over the signaling circuit.

As relay 130 continues to operate and release under the control of tube 140, condenser 133 is periodically charged and discharged, but no impulses are transmitted over the signaling circuit since this circuit is open at the lower back contact of relay 114. The discharge circuit of condenser 133 now extends over the upper front contact of relay 130, thence as traced to the lower terminal of condenser 121 and from the upper terminal of condenser 121, over bus-bar 118, resistance 134 to condenser 133. Upon each discharge of condenser 133 into condenser 121 an increment of charge is added to condenser 121 until when two increments have been added, condenser 121, which as will be recalled was initially charged with eight increments of charge, will become fully charged. The potential on the grid of tube 150 will now be sufficiently positive to permit tube 150 to ionize and operate anode relay 115 in its cathode-anode circuit. Condenser 121 discharges through tube 150.

Relay 115 upon operating first locks in a circuit extending from conductor 113 through its winding and upper middle front contact, back contact of relay 117 to negative bus-bar 118, then opens the cathode-anode circuit of tube 150 at its inner upper back contact thereby deionizing tube 150, and finally connects the anode of tube 150 over the inner upper front contact of relay 114, inner upper left normal contacts of key ST, inner upper front contact of relay 115, inner upper back contact and winding of anode relay 116, conductor 113 and thence to the positive bus-bar 101. At its upper back contact relay 115 disconnects the grid of tube 150 and the discharge circuit of condenser 133 from the lower terminal of condenser 121 and connects the grid of tube 150 and the discharge circuit of condenser 133 over the upper front contact of relay 114, the inner lower left normal contacts of key ST, the upper front contact of relay 115, the upper back contact of relay 116, to the lower terminal of condenser 122. Tube 150 is now prepared for response to the counting of the second digit of the code as determined by the initial charged condition of condenser 122. Relay 115 also recloses the signaling circuit at its lower front contact thereby permitting the transmission of further impulses over the signaling circuit through the continued operation of impulsing relay 130.

As relay 130 continues to operate and release under the control of tube 140 it, upon each operation, closes the signaling circuit which now extends from conductor 136, lower front contact of relay 130, lower front contact of relay 115, lower back contact of relay 116 to conductor 137 and, at its upper contact, causes the periodic charging and discharging of condenser 133. The discharge circuit of condenser 133 may now be traced over the upper front contact of relay 130, the upper front contact of relay 114, thence as traced to the upper front contact of relay 115, upper back contact of relay 116, through condenser 122, negative bus-bar 118, resistance 134 to condenser 133. Upon the first discharge of condenser 133 into condenser 122 an increment of charge is added to the nine increments of charge which, it will be recalled, were initially placed in condenser 122 thus fully charging this condenser. The potential on the grid of tube 150 will now be sufficiently positive to permit tube 150 to ionize and operate anode relay 116 in its cathode-anode circuit previously traced. Condenser 122 now discharges through tube 150.

Relay 116 upon operating first locks in a circuit extending from conductor 113 through its winding and upper middle front contact, lower back contact of relay 117 to negative bus-bar 118, then opens the cathode-anode circuit of tube 150 at its inner upper back contact thereby deionizing tube 150, and finally connects the anode of tube 150 over the circuit previously traced to the inner upper front contact of relay 115, the inner upper front contact of relay 116, the inner upper normal contacts and winding of anode relay 117, conductor 113 and thence to the positive bus-bar 101. At its upper back contact relay 116 disconnects the grid of tube 150 and the discharge circuit of condenser 133 from the lower terminal of condenser 122 and connects the grid of tube 150 and the discharge circuit of condenser 133 over the upper front contact of relay 114, thence as traced to the upper front contact of relay 115, the upper front contact of relay 116, the upper back contact of relay 117 to the lower terminal of condenser 123. Tube 150 is now prepared for response to the counting of the code spacing interval as determined by the initial charged condition of condenser 123. Relay 116 also opens the signaling circuit at its lower back contact thereby preventing the transmission of further impulses over the signaling circuit through the continued operation of impulsing relay 130 during the counting of the code spacing interval. Thus, the operation of relay 130 in conjunction with tube 150 has resulted in the transmission of a single impulse over the signaling circuit.

As relay 130 continues to operate and release under the control of tube 140 it causes the periodic charging and discharging of condenser 133, but does not transmit impulses over the signaling circuit since this circuit is open at the lower back contacts of relays 114 and 116. The discharge circuit of condenser 133 may now be traced over the upper front contact of relay 130, the upper front contact of relay 114, thence as traced to the upper front contact of relay 116, upper back contact of relay 117, through condenser 123, negative bus-bar 118, resistance 134 to condenser 133. Upon each discharge of condenser 133 into condenser 123 an increment of charge is added to the five increments of charge which, it will be recalled, were initially placed in condenser 123. When five such increments have been added the potential on the grid of tube 150 will be sufficiently positive to permit tube 150 to ionize and operate anode relay 117 in its cathode-anode circuit, previously traced. Condenser 123 discharges through tube 150.

Relay 117 upon operating first locks in a circuit extending from conductor 113 through its winding and inner upper front contact, the inner right front contact of relay 124 to the negative bus-bar 118 and then opens the cathode-anode circuit of tube 150 at its inner upper back contact thereby deionizing tube 150. At its lower back contact relay 117 opens the locking circuits of anode relays 114, 115 and 116 which then release, and opens the circuit of relay 124. Relay 124 releases opening the locking circuit of relay 117 which then also releases and opens the start cir-

cuit of interrupter tube 140. If the start key ST is still operated condensers 120, 121, 122 and 123 will be immediately recharged with initial charges as determined by the operated key 119 and relay 124 will thereafter operate to start the sender to repeat the cycle of operations previously described. Thus, so long as the key 119 and start key ST remain operated, the code signal 4—1 will be repeatedly transmitted, the digits 4 and 1 being spaced by a short spacing interval and successive repetitions of the code 4—1 being spaced by a longer code spacing interval. When the operator desires to terminate the transmission of the code call, she will restore key ST to its normal or middle position thus opening the initial operating circuit of relay 124. As soon as pulsing is completed for the transmission of the code 4—1 and relay 117 operates, relays 114, 115 and 116 will release and the locking circuit of relay 124 will be opened. Relay 124 will release in turn causing the release of relay 117 and the stopping of the gaseous tube interrupter.

It will now be assumed that the operator desires to transmit the single digit code 2 and therefore first operates the key 138 followed by the operation of start key ST to the left. With key 138 operated, the lower terminal of condenser 120 is connected over the outer left back contact of relay 124, lower alternate left contacts of key ST, contacts of key 138 to a point on the voltage-divider between resistances 104 and 105 whereby condenser 120 is charged to a potential equal to the drop of potential across the eight resistances 105 to 112, inclusive, or is charged with eight increments of potential. Condenser 121 is charged over the circuit previously traced with eight increments of potential and condenser 123 is charged over the circuit previously traced with five increments of potential. There is no charging circuit for condenser 122 with the start key ST operated to the left, and therefore this condenser remains uncharged. Thus, condenser 120 assumes a charge commensurate with the complement of the digit value of digit 2 and condenser 123 assumes a charge commensurate with the complement of the digital value of a code spacing interval which, in the case assumed, is equal to the period required to produce five impulses. The charging of condenser 121 is without effect.

The operation of start key ST causes the operation and locking of relay 124 and the starting of the gaseous tube interrupter in the manner previously described. Upon the first operation of pulsing relay 130 following the depression of the start key ST, the signaling circuit is closed as previously described over the lower back contact of anode relay 114 thereby causing the transmission of one impulse over the signaling circuit. At the same time condenser 133 is connected into a discharge circuit extending over the upper front contact of relay 130, the upper back contact of anode relay 114, through condenser 120, negative bus-bar 118, resistance 134 and condenser 133. Condenser 133 thereupon discharges into condenser 120 adding an increment of charge to the eight increments of initial charge previously applied to condenser 120. On its next release relay 130 causes the recharging of condenser 133 and the opening of the signaling circuit. Upon the next energization of relay 130 a second impulse is transmitted over the signaling circuit and a second increment of charge is added to condenser 120 by the discharge of condenser 133 therethrough. Condenser 120 is now fully charged and the potential of tube 150 has now been rendered sufficiently positive, by the application of potential thereto from the lower terminal of condenser 120 over the upper back contact of relay 114 to cause tube 150 to ionize.

When tube 150 ionizes current flows in its cathode-anode circuit from the negative bus-bar 118, cathode and anode of the tube, inner upper normal contacts and winding of anode relay 114, conductor 113, upper left alternate contacts of key ST to the positive bus-bar 101. Condenser 120 discharges through tube 150. Relay 114 operates in this circuit first locking in a circuit from conductor 113 through its winding and middle upper front contact, lower back contact of relay 117 to the negative bus-bar 118, then opening the cathode-anode circuit of tube 150 at its inner upper back contact thereby deionizing tube 150, and finally connecting the anode of tube 150 over the inner upper front contact of relay 114, the inner upper alternate contacts of key ST, the inner upper normal contacts and winding of anode relay 117 to conductor 113 and thence to the positive bus-bar 101. At its upper back contact relay 114 disconnects the grid of tube 150 and the discharge circuit of condenser 133 from the lower terminal of condenser 120 and connects the grid of tube 150 and the discharge circuit of condenser 133 over the upper front contact of relay 114, the inner lower left alternate contacts of key ST and the upper back contact of anode relay 117 to the lower terminal of condenser 123. Tube 150 is now prepared for response to the counting of the code spacing interval as determined by the initial charged condition of condenser 123. Relay 114 also opens the signaling circuit at its lower back contact thereby preventing the transmission of further impulses over the signaling circuit through the continued operation of impulsing relay 130 during the counting of the code spacing interval. Thus, through the operation of relay 130 in conjunction with tube 150 two impulses have been transmitted to the signaling circuit.

As relay 130 continues to operate and release under the control of tube 140 it causes the periodic charging and discharging of condenser 133, but does not transmit impulses over the signaling circuit since the signaling circuit is open at the lower back contact of relay 114. The discharge circuit of condenser 133 may be traced over the upper front contact of relay 130, the upper front contact of relay 114, the inner lower left alternate contacts of key ST, the upper back contact of relay 117, through condenser 123, negative bus-bar 118, resistance 134 to condenser 133. Upon each discharge of condenser 133 into condenser 123 an increment of charge is added to the five increments of charge initially in condenser 123. When five such increments have been added, the potential on the grid of tube 150 will be sufficiently positive to permit tube 150 to ionize and operate anode relay 117 in its cathode-anode circuit. Condenser 123 discharges through tube 150.

Relay 117 upon operating functions in the manner previously described to release relays 114, 115, 116 and 124 and to deionize tube 150. Relay 124 upon releasing causes the recharging of condensers 120 and 123 if key 138 and start key ST are still operated and the release of relay 117. Relay 117 upon releasing recloses the operating circuit of relay 124 and the circuits then function in the manner previously described to cause the retransmission of impulses

for the code digit 2, this digit being retransmitted repeatedly with an interpolated code spacing interval so long as key 138 remains operated and the start key is operated to the left.

From the foregoing description it is believed that it will be apparent how other single and two-digit codes of impulses are transmitted.

In Fig. 2 the invention has been illustrated in connection with two rows of digit keys, each row comprising ten keys numbered 1 to 0 inclusive, whereby a much greater number of calling codes may be registered and transmitted. Theoretically by the use of two rows of digit keys it would be possible to transmit 100 different codes of impulses although from a practical standpoint certain codes which might be confused with others or which would require the transmission of too large a number of impulses would not be used. All apparatus and circuits of Fig. 2 which are identical to and function in the same manner as similar apparatus and circuits of Fig. 1 have been designated by reference characters having the same tens and units digits, but with the hundreds digits two.

To transmit any single digit code the appropriate key in the left row of keys is depressed followed by the operation of the start key ST to the left. For example, if key 241 is operated to cause the transmission of the code digit 2, the operation of key ST closes an initial charging circuit for condenser 220 extending from the lower terminal of this condenser, over the outer left back contact of relay 224, lower left alternate contacts of key ST, contacts of key 241 to a point on the voltage divider between resistances 204 and 205 thus charging condenser 220 with eight increments of potential. Condensers 221 and 223 will also become initially charged as previously described, but condenser 222 will not be charged as no charging circuit therefor is closed. The operation of key ST also causes the delayed operation of relay 224 which opens the initial charging circuits of the condensers and starts the transmission of impulses in the manner previously described. Thus, a code of two impulses is repeatedly transmitted, each code being separated by a code spacing interval.

To transmit any two-digit code the appropriate keys in the two rows of keys are depressed followed by the operation of the start key ST to the right. For example, if keys 242 and 243 are operated to cause the transmission of code 4—1, the operation of key ST closes an initial charging circuit for condenser 220 extending from the lower terminal of this condenser over the outer left back contact of relay 224, inner upper right alternate contacts of key ST, contacts of key 242 to a point on the voltage divider between resistances 206 and 207 thus charging condenser 220 with six increments of potential. An initial charging circuit for condenser 222 is also closed extending from the lower terminal of this condenser over the inner right back contact of relay 224, lower right alternate contacts of key ST, contacts of key 243 to a point on the voltage divider between resistances 203 and 204 thus charging condenser 222 with nine increments of potential. Initial charging circuits are also effective for condensers 221 and 223 thus charging these condensers to degrees commensurate with the digital values of the desired digit and code spacing intervals. The operation of key ST also causes the delayed operation of relay 224 which opens the initial charging circuits of the condensers and starts the transmission of impulses in the manner previously described.

Although the invention has been disclosed in both of its modifications as especially adapted to a code signaling system, it will be obvious that the invention is of much broader scope and could, with slight alterations as would be obvious to those skilled in the art, be applied to the transmission of impulses for setting selector switches for the establishment of telephone or other communication or signaling channels.

What is claimed is:

1. In a code calling system, a sender comprising a plurality of code keys, a start key, an impulsing relay for transmitting series of impulses over a signaling circuit, a group of condensers, means controlled by the operation of one of said code keys and said start key for charging certain of said condensers to a degree commensurate with the numerical value of the digit or digits of a desired code number, means for charging others of said condensers to degrees commensurate with the numerical values of digit spacing and code spacing intervals respectively, and means successively controlled by said condensers for determining the number of impulses in each series transmitted by said relay and the spacing of successive series of impulses.

2. In a code calling system, a sender comprising a plurality of code keys, a start key, an impulsing relay for transmitting series of impulses over a signaling circuit, a group of condensers, means controlled by the operation of a code key and said start key for charging one of said condensers to a degree commensurate with the numerical value of said operated code key, means for charging another of said condensers to a degree commensurate with the numerical value of a code spacing interval, and means successively controlled by said condensers for determining the number of impulses in each series transmitted by said relay and the spacing of successive code series.

3. In a code calling system, a sender comprising a plurality of code keys, a start key, an impulsing relay for transmitting series of impulses over a signaling circuit, a group of condensers, means controlled by the operation of a code key and said start key for charging the first and third of said condensers, respectively, to degrees commensurate with the numerical values of the two digits of a code number, means for charging the second and fourth of said condensers, respectively, to degrees commensurate with the numerical values of digit spacing and code spacing intervals, and means successively controlled by said condensers for determining the number of impulses in each series of a code transmitted by said relay, the spacing of the impulse series of a code and the spacing of codes of impulse series.

4. In a code signaling system, a sender comprising a plurality of code keys, a start key, an impulsing relay for transmitting series of impulses over a signaling circuit, a group of condensers, means controlled by the joint operation of two of said code keys and said start key for charging two of said condensers to degrees commensurate with the numerical values of said operated code keys, respectively, means for charging others of said condensers to degrees commensurate with the numerical values of digit spacing and code spacing intervals, respectively, and means successively controlled by said condensers for determining the number of impulses

in each series transmitted by said relay and the spacing of successive series of impulses.

5. In a code calling system, a sender comprising a plurality of code keys, a start key having two operated positions, an impulsing relay for transmitting series of impulses over a signaling circuit, a group of condensers, means controlled by the operation of one of said code keys and the operation of said start key to one of its positions for charging one of said condensers to a degree commensurate with the numerical value of said operated code key and controlled by the operation of another of said code keys and the operation of said start key to its other operated position for charging two of said condensers to degrees commensurate with the numerical values of two digits of a code number, respectively, means for charging others of said condensers to degrees commensurate with the numerical values of digit spacing and code spacing intervals, respectively, and means successively controlled by said condensers for determining the number of impulses in each series transmitted by said relay and the spacing of successive series of impulses.

6. In a code calling system a sender comprising a plurality of code keys, a start key having two operated positions, an impulsing relay for transmitting series of impulses over a signaling circuit, a group of condensers, means controlled by the operation of one of said code keys and the operation of said start key to one of its positions for charging one of said condensers to a degree commensurate with the numerical value of said operated code key, and controlled by the operation of another of said code keys and the operation of said start key to its other operated position for charging two of said condensers to degrees commensurate with the numerical values of two digits of the code number respectively, means for charging others of said condensers to degrees commensurate with the numerical values of digit spacing and code spacing intervals respectively, means successively controlled by said condensers for determining the number of impulses in each series transmitted by said relay and the spacing of successive series of impulses, and means controlled in accordance with the operated position of said start key for determining whether a single series of impulses followed by a code spacing interval or a code of two series of impulses with an intervening digit spacing interval and a following code spacing interval will be transmitted.

7. In a code signaling system, a sender comprising a plurality of code keys, a start key, an impulsing relay for transmitting impulses over a signaling circuit, a group of primary condensers, means controlled by one of said keys and said start key for applying an initial charge to one of said primary condensers commensurate with the numerical value of said operated code key, means for applying an initial charge to another of said primary condensers commensurate with the numerical value of a code spacing interval, and means controlled by said condensers for determining the number of impulses in each series transmitted by said relay and the spacing of successive series of impulses comprising a gas-filled tube, a secondary condenser, means controlled by said relay for periodically charging said secondary condenser and connecting it into a discharge path, and sequence relays operable in succession in response to successive ionizations of said tube for successively connecting said primary condensers across the discharge path of said secondary condenser and across the terminals of said tube, whereby said tube is caused to ionize and operate one of said sequence relays each time that successive primary condensers acquire the breakdown potential of said tube.

8. In a code calling system, a sender comprising a plurality of code keys, a start key, an impulsing relay for transmitting series of impulses over a signaling circuit, a group of primary condensers, means controlled by the operation of one of said code keys and said start key for charging certain of said condensers to degrees commensurate with the numerical values of the digits of a desired code number, means for charging others of said condensers to degrees commensurate with the numerical values of digit spacing and code spacing intervals respectively, means controlled by said condensers for determining the number of impulses in each series transmitted by said relay and the spacing of successive series of impulses comprising a gas-filled tube, a secondary condenser, means controlled by said relay for periodically charging said secondary condenser and connecting it into a discharge path, and sequence relays operable in succession in response to successive ionizations of said tube for successively connecting said primary condensers across the discharge path of said secondary condenser and across the terminals of said tube, whereby said tube is caused to ionize and operate one of said sequence relays each time that successive primary condensers acquire the breakdown potential of said tube.

9. In a code calling system, a sender comprising a plurality of code keys, a start key, an impulsing relay for transmitting series of impulses over a signaling circuit, a group of primary condensers, means controlled by the joint operation of two of said code keys and said start key for charging two of said condensers to degrees commensurate with the numerical values of said operated code keys respectively, means for charging others of said condensers to degrees commensurate with the numerical values of digit spacing and code spacing intervals respectively, and means controlled by said condensers for determining the number of impulses in each series transmitted by said relay and the spacing of successive series of impulses comprising a gas-filled tube, a secondary condenser, means controlled by said relay for periodically charging said secondary condenser and connecting it into a discharge path, and sequence relays operable in succession in response to successive ionizations of said tube for successively connecting said primary condensers across the discharge path of said secondary condenser and across the terminals of said tube, whereby said tube is caused to ionize and operate one of said sequence relays each time that successive primary condensers acquire the breakdown potential of said tube.

10. In a code signaling system, a sender comprising a gas-filled tube having a cathode, a grid and an anode, a first and a second condenser, a source of current, a plurality of code keys, a start key, means controlled by an operated code key and said start key for applying from said source an initial charge to said first condenser commensurate with the numerical value of said operated code key, means for applying an initial charge to said second condenser commensurate with the numerical value of a code spacing interval, a first and a second anode relay, an operating circuit controlled over the cathode-

anode circuit through said tube and transferable by the operation of said first relay to said second relay, a locking circuit for said first relay controlled by said second relay, a signaling circuit extending over the normal contacts of said first relay, a condenser discharge path across the grid and cathode of said tube transferable from the first to the second condenser by the operation of said first relay, a third condenser, and an impulsing relay periodically operable to transmit impulses over said signaling circuit and to repeatedly charge said third condenser from said source and to discharge it into said path until said first condenser has accumulated a potential equal to the breakdown potential of said tube, said first anode relay operable upon the first breakdown of said tube to lock under the control of said second anode relay, to open said signaling circuit, to restore said tube and to transfer said path across said tube from said first to said second condenser, said second anode relay operating when said second condenser has accumulated a potential from the continued intermittent discharge of said third condenser equal to the breakdown potential of said tube and said tube again breaks down, to restore said tube and to release said first anode relay whereby said path across said tube is transferred from said second condenser to said first condenser and said signaling circuit is again closed, said circuit functioning in this cycle until said start key is restored.

11. In a code signaling system, a sender comprising a gas-filled tube having a cathode, a grid and an anode, four primary condensers, a source of current, a plurality of code keys, a start key, means controlled by an operated code key and said start key for applying from said source initial charges to the first and third of said condensers commensurate with the numerical values of two digits of a code number, means for applying initial charges to the second and fourth of said condensers, respectively, commensurate with the numerical values of digit spacing and code spacing intervals, four anode relays, an operating circuit controlled over the cathode-anode circuit through said tube and extended to successive ones of said relays through their operation, locking circuits for the first of said relays controlled by the last of said relays, a signaling circuit controlled over contacts of said relays, a condenser discharge path across the grid and cathode of said tube transferable through the operation of successive ones of said relays to successive ones of said condensers, a secondary condenser, and an impulsing relay periodically operable to transmit impulses over said signaling circuit and to repeatedly charge said secondary condenser from said source and to discharge it into said path until said first condenser has accumulated a potential equal to the breakdown potential of said tube, said first anode relay operable upon the first breakdown of said tube to lock under the control of the last anode relay, to open said signaling circuit, to restore said tube and to transfer said path from said first to said second primary condensers, said second anode relay operable when said second primary condenser has accumulated a charge equal to the breakdown potential of said tube to lock under the control of the last anode relay, to close said signaling circuit, to restore said tube and to transfer said path from said second to said third primary condensers, said third anode relay operable when said third primary condenser has accumulated a charge equal to the breakdown potential of said tube to lock under the control of said last anode relay, to open said signaling circuit, to restore said tube and to transfer said path from said third to said fourth primary condenser and said last anode relay operable when said fourth primary condenser has accumulated a charge equal to the breakdown potential of said tube to release all of said anode relays whereby said path across said tube is transferred from said fourth to said first primary condenser and said signaling circuit is again closed, said circuit functioning in this cycle until said start key is restored.

12. In a signaling system, a sender comprising a gas-filled tube having a cathode, a grid and an anode, a group of primary condensers, a source of current, a key-set, means controlled by said key-set for applying initial charges to said condensers from said source commensurate with the digits of a number, an impulsing relay, a signaling circuit, sequence relays for successively connecting said condensers in a path across said tube and for controlling the continuity of said signaling circuit, a secondary condenser and means for periodically operating said impulsing relay to transmit impulses over said circuit and to repeatedly charge said secondary condenser from said source and to discharge it into said path until each primary condenser has successively accumulated a potential equal to the breakdown potential of said tube, said sequence relays operating successively in response to successive breakdowns of said tube over the cathode-anode circuit thereof.

13. In a code signaling system, a sender comprising a gas-filled tube having a cathode, a grid and an anode, a group of primary condensers, a source of current, a plurality of code keys, a start key, means controlled by an operated code key and said start key for applying initial charges from said source to certain of said condensers commensurate with the code value of said operated code key, means for applying initial charges to other of said condensers commensurate with the numerical values of digit and code spacing intervals, an impulsing relay, a signaling circuit, sequence relays for successively connecting said condensers in a path across said tube and for controlling the continuity of said signaling circuit, a secondary condenser and means for periodically operating said impulsing relay to transmit impulses over said circuit and to repeatedly charge said secondary condenser from said source and to discharge it into said path until each primary condenser has successively accumulated a potential equal to the breakdown potential of said tube, said sequence relays operating successively in response to successive breakdowns of said tube over the cathode-anode circuit thereof.

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