

June 30, 1942.

P. B. MURPHY

2,288,251

AUTOMATIC TOLL SWITCHING TELEPHONE SYSTEM

Filed Dec. 31, 1940

10 Sheets-Sheet 1

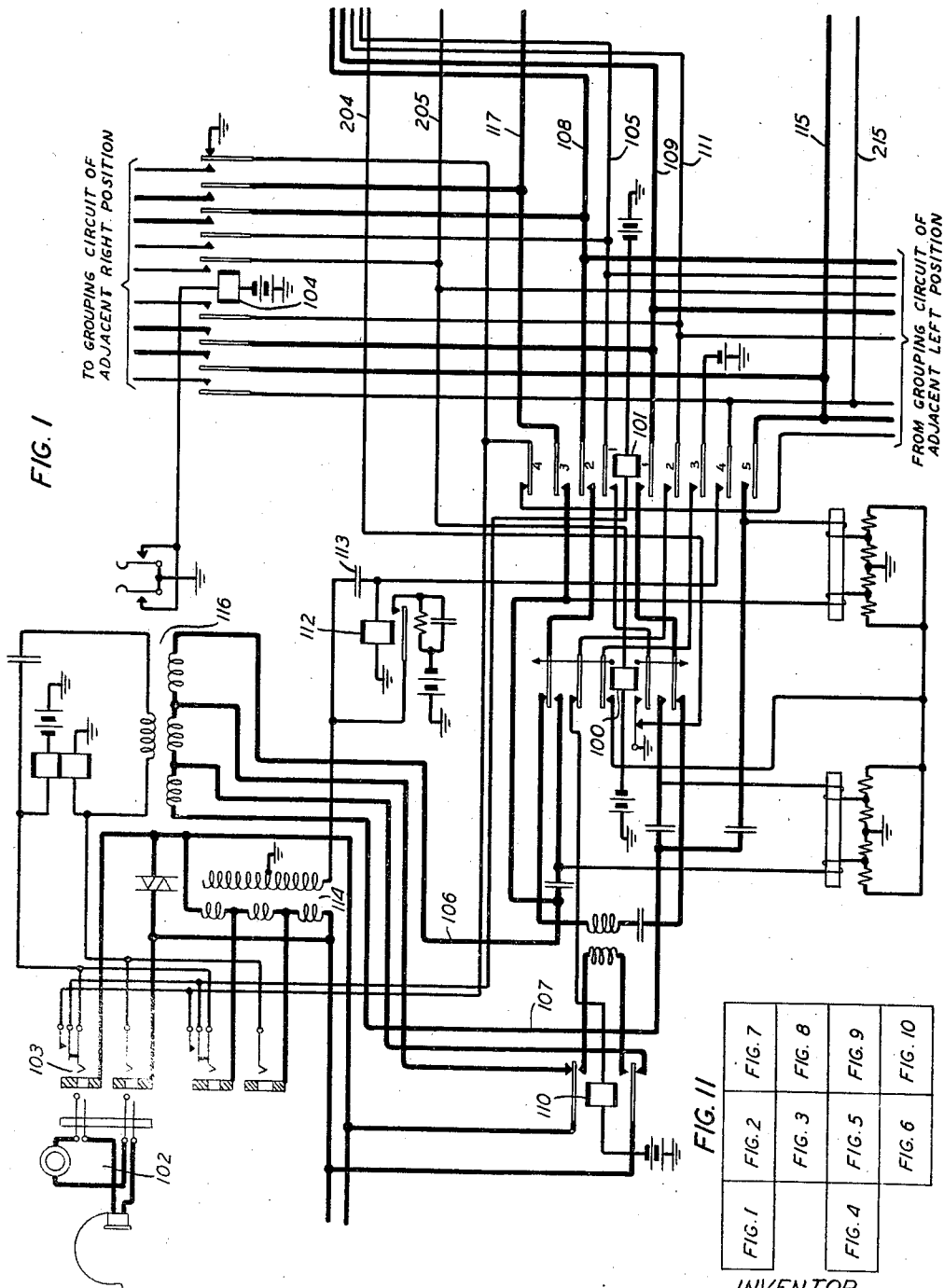


FIG. 1

FIG. 11

FIG. 1	FIG. 2	FIG. 7
	FIG. 3	FIG. 8
FIG. 4	FIG. 5	FIG. 9
	FIG. 6	FIG. 10

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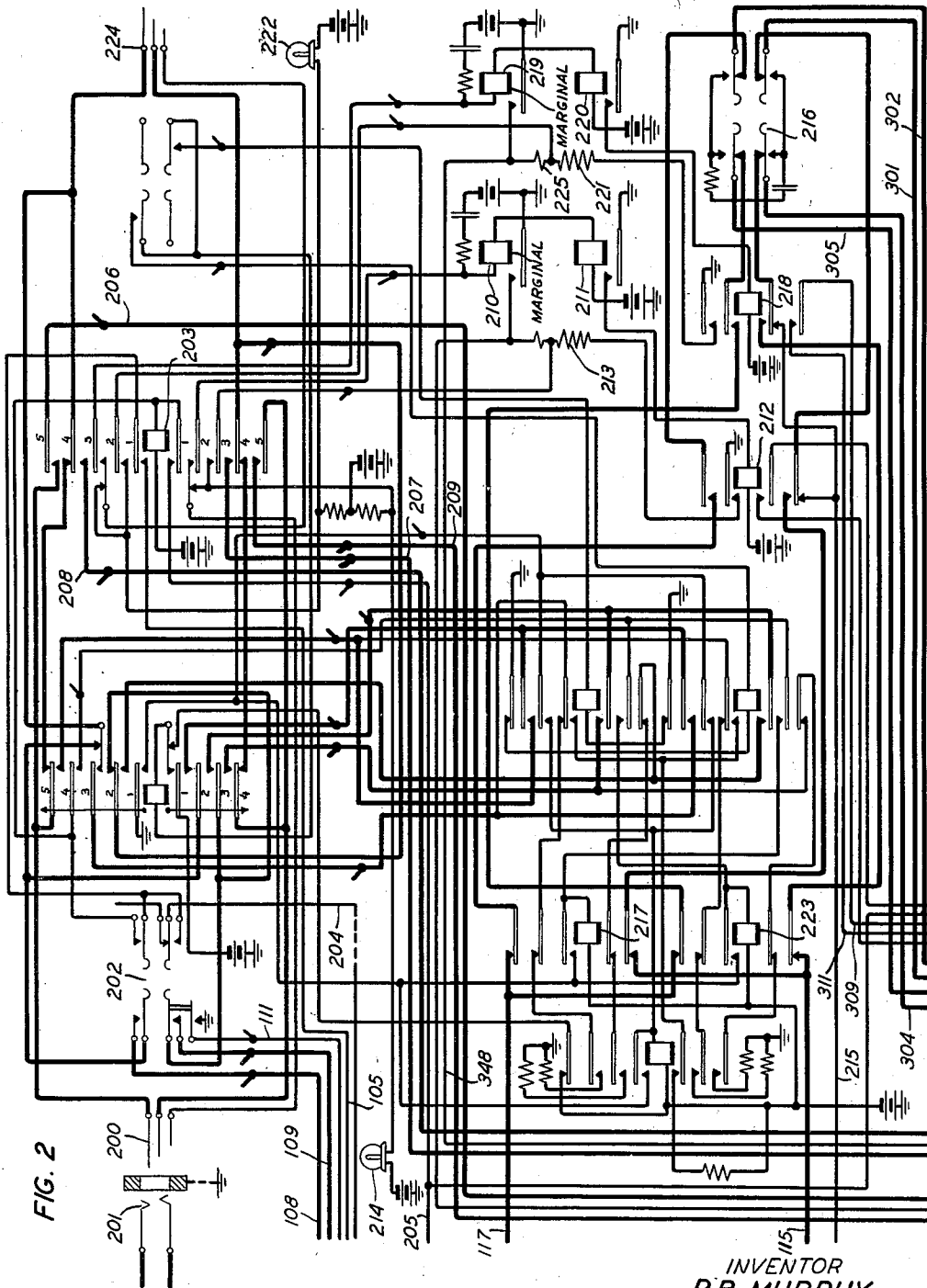
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10 Sheets-Sheet 2



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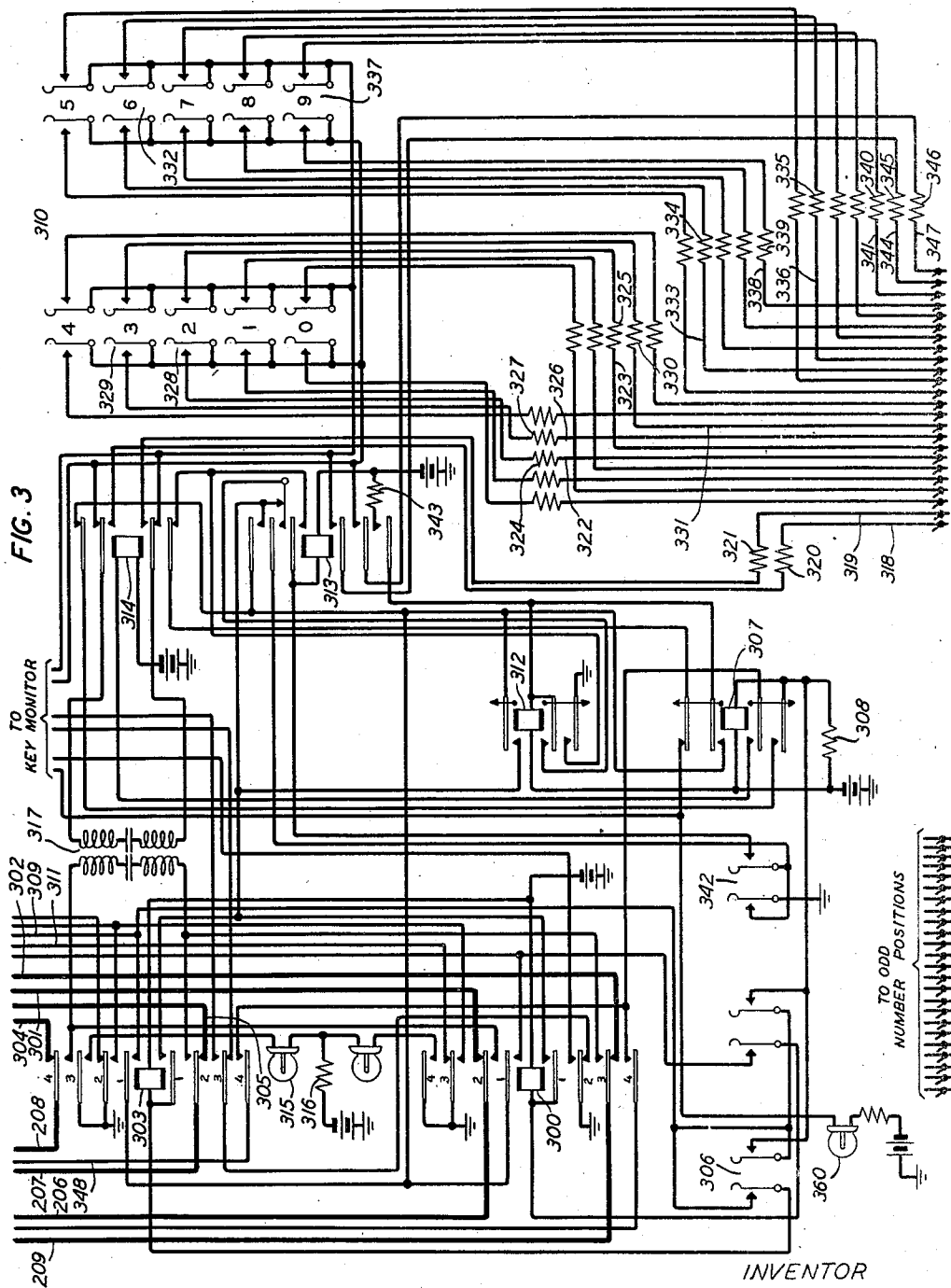
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10 Sheets-Sheet 3



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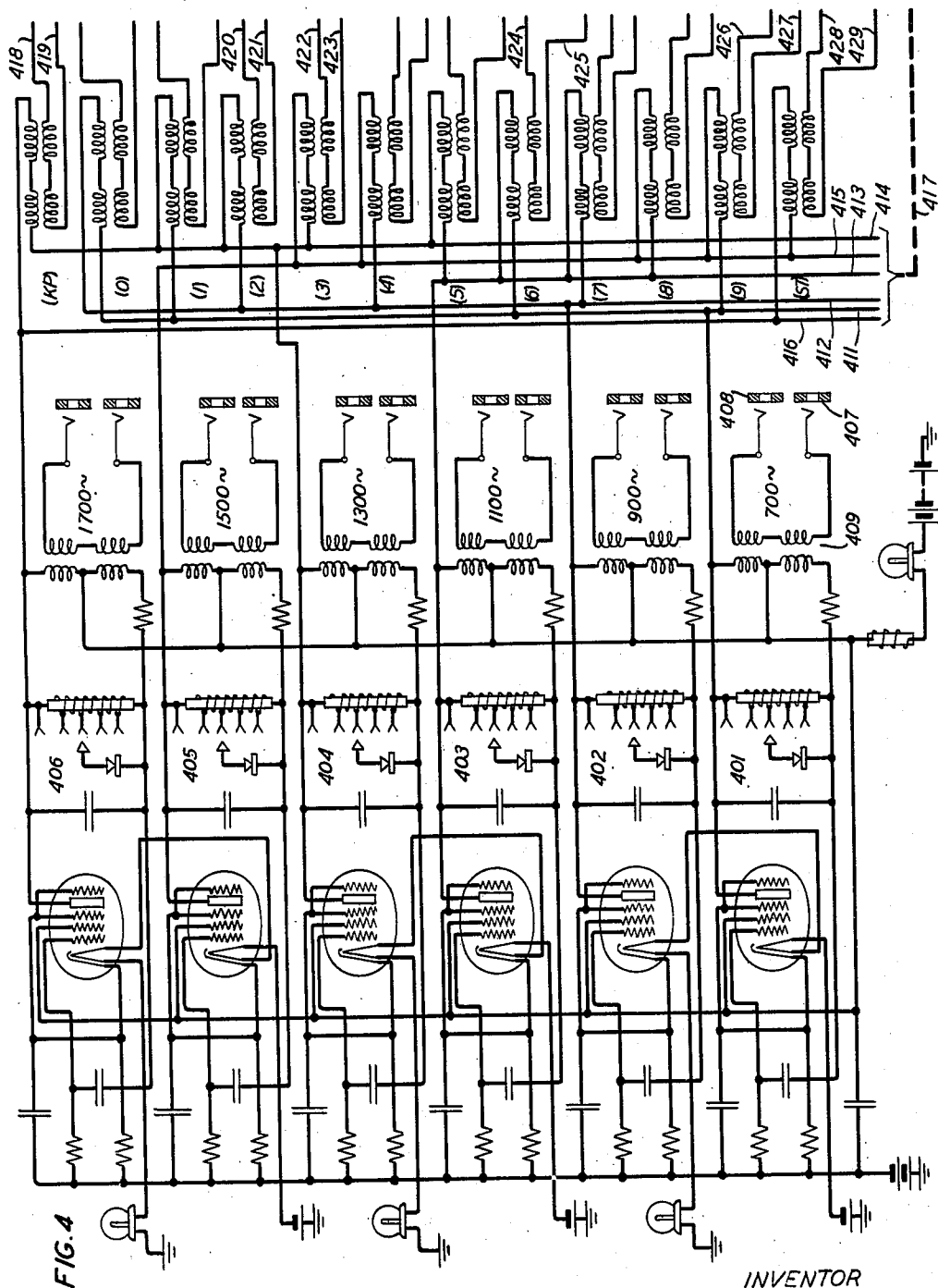
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10 Sheets-Sheet 5

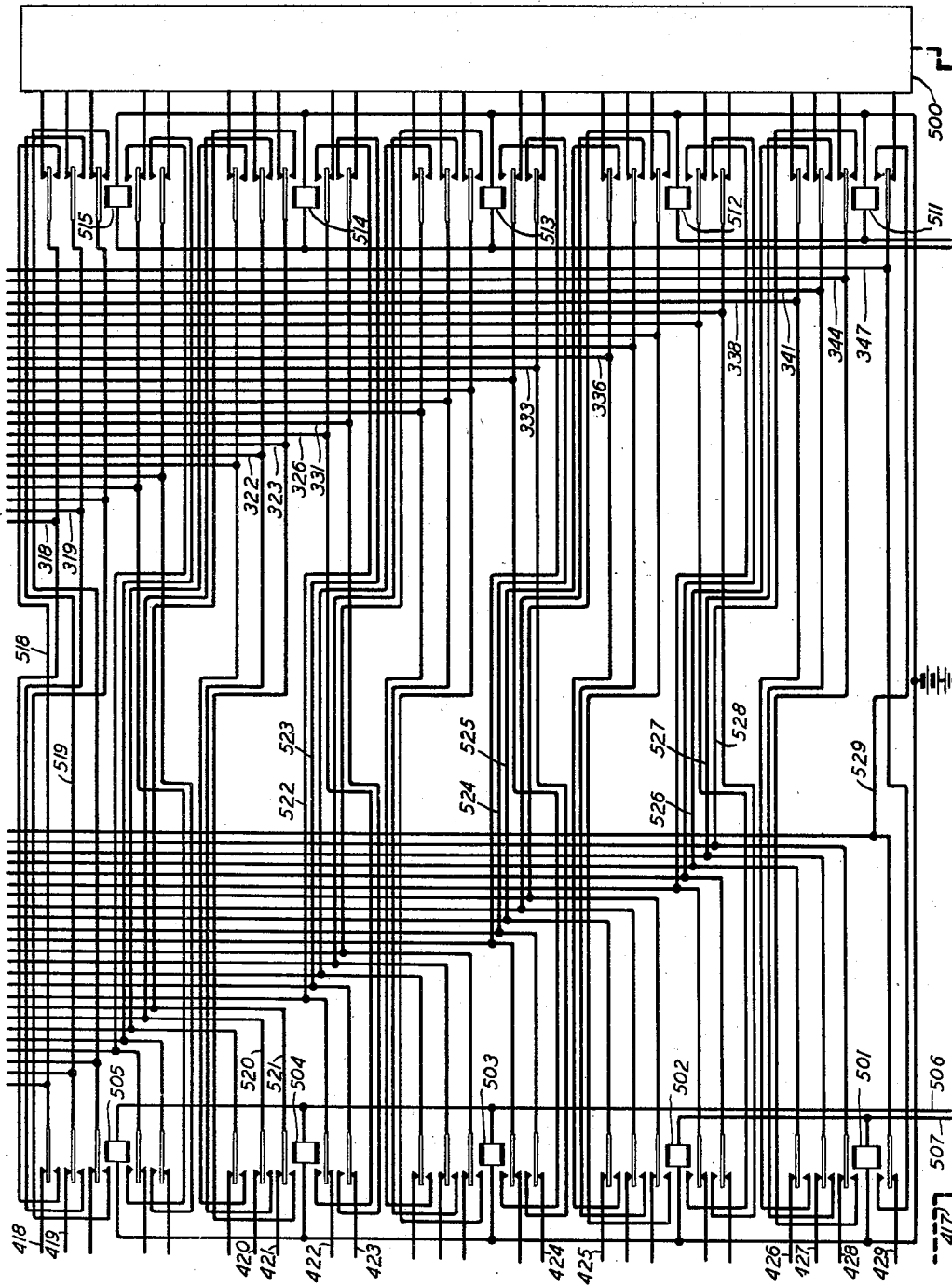


FIG. 5

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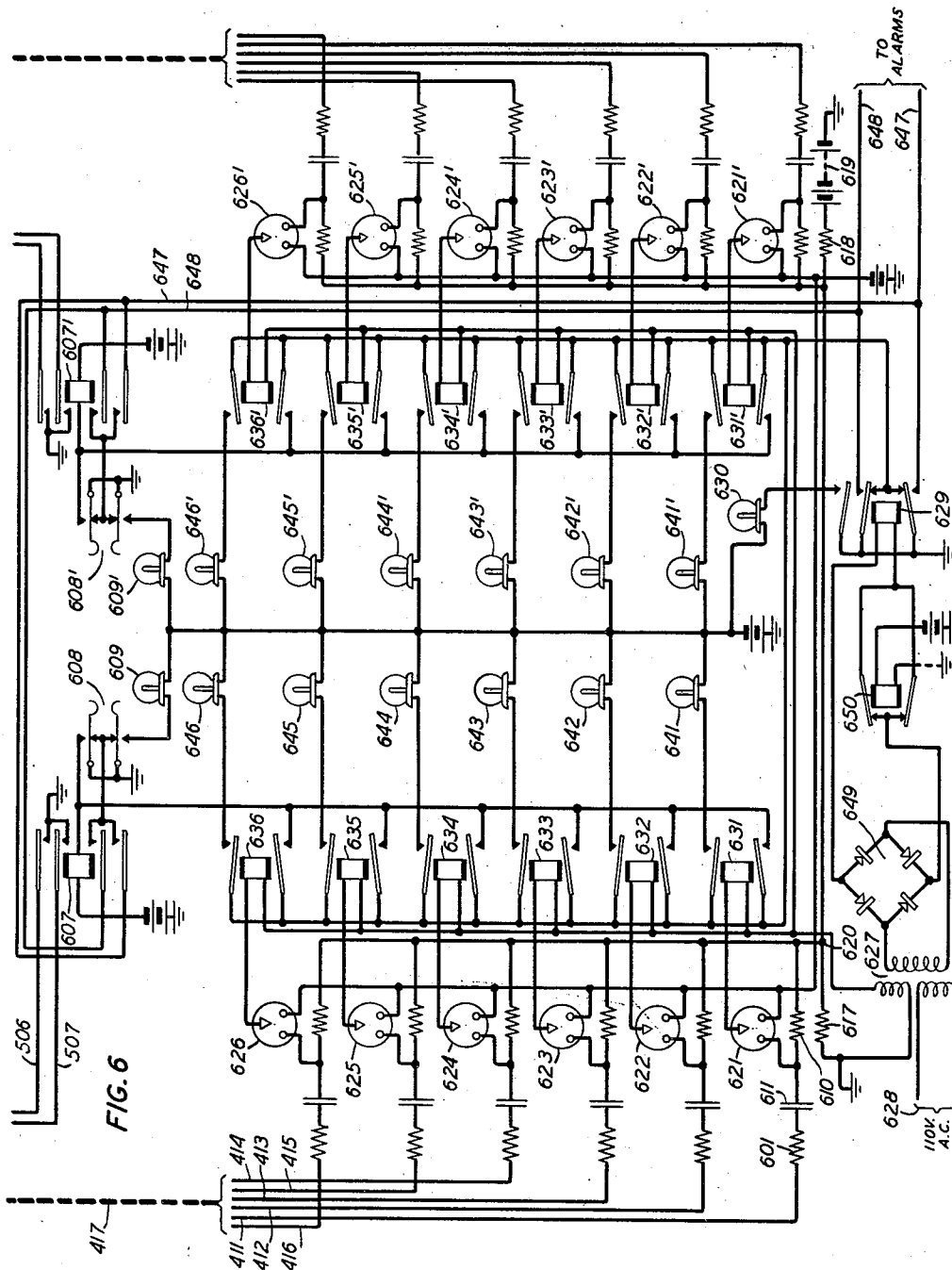
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AUTOMATIC TOLL SWITCHING TELEPHONE SYSTEM

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10 Sheets-Sheet 7

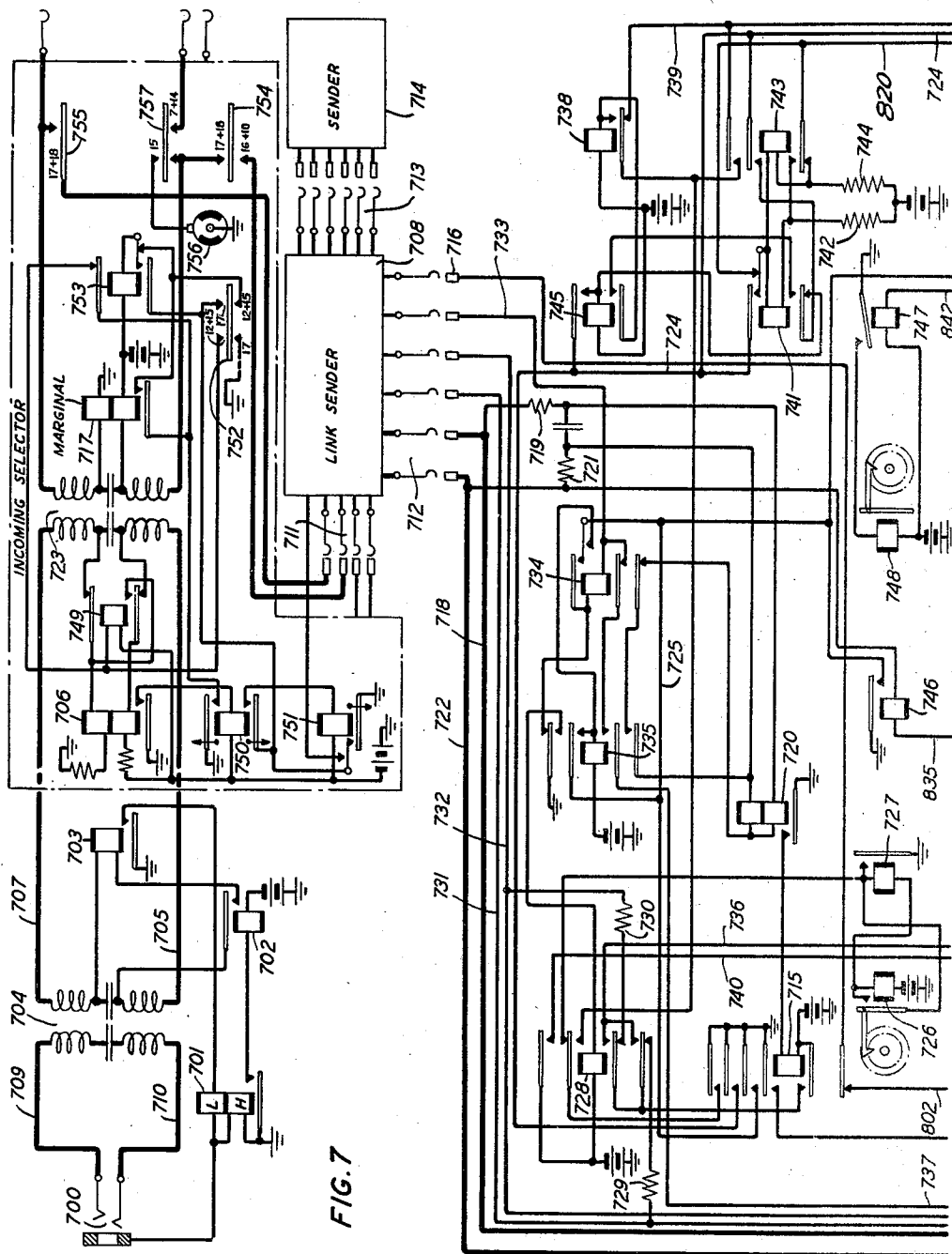


FIG. 7

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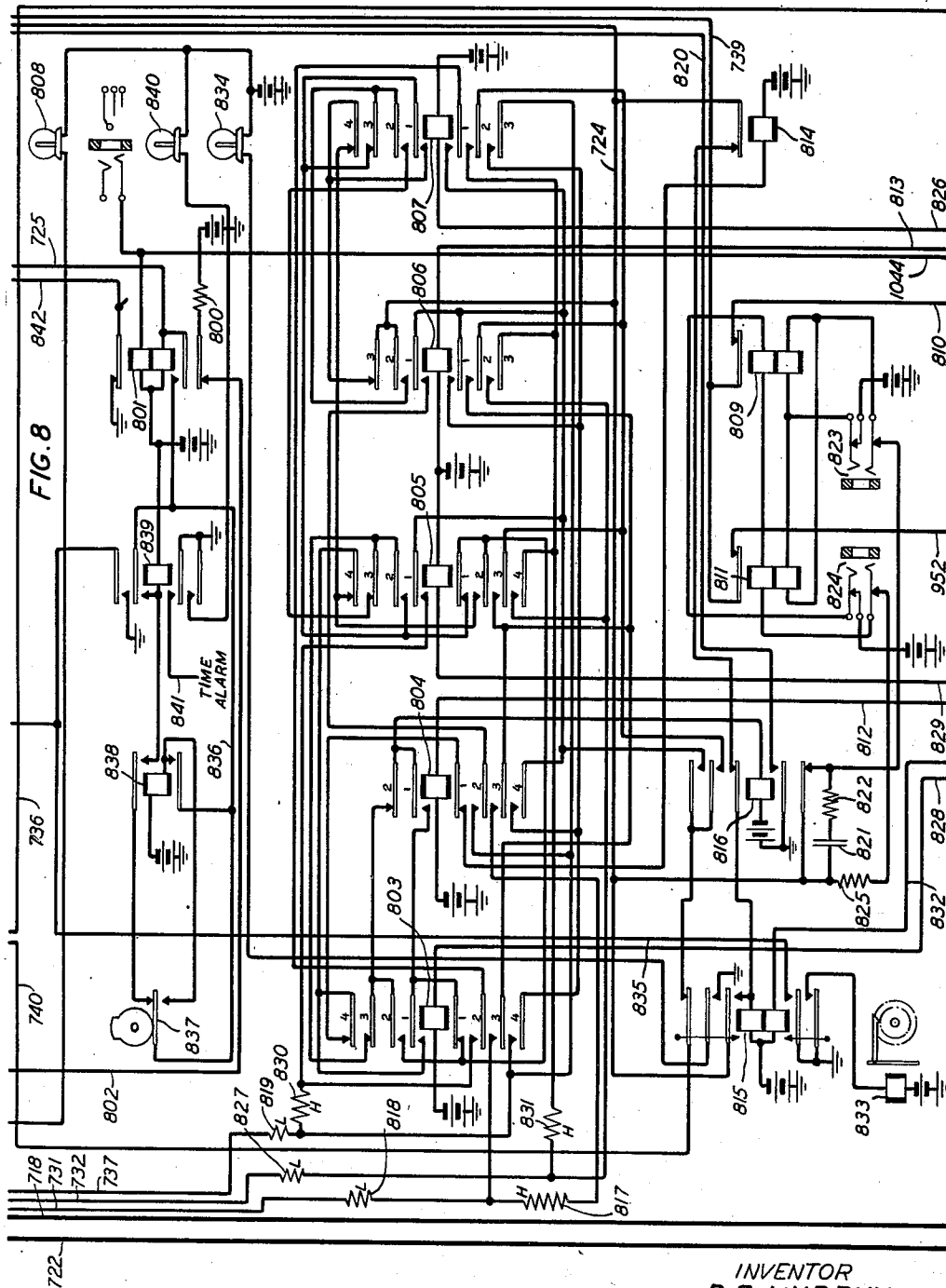
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AUTOMATIC TOLL SWITCHING TELEPHONE SYSTEM

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10 Sheets-Sheet 8



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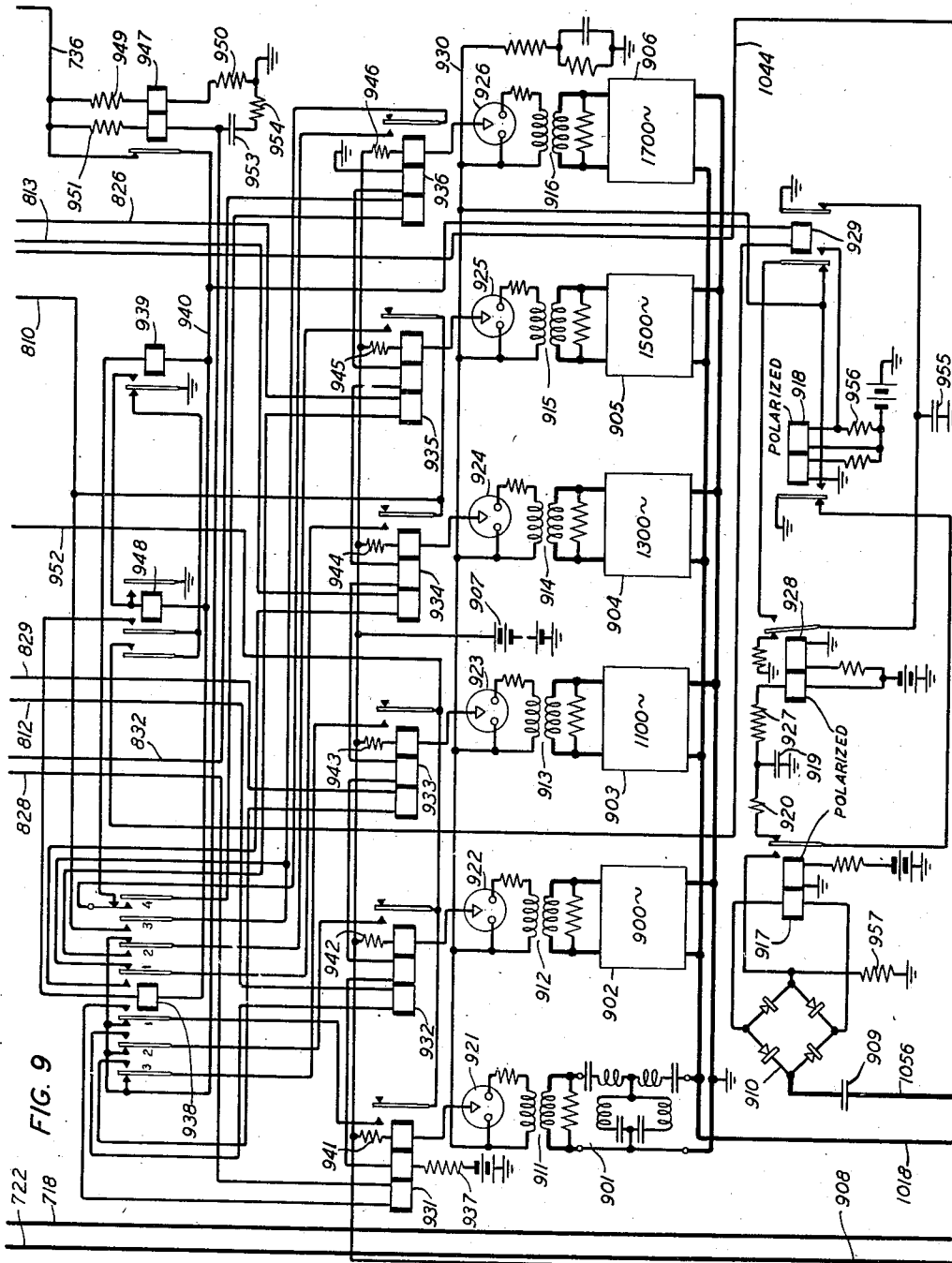
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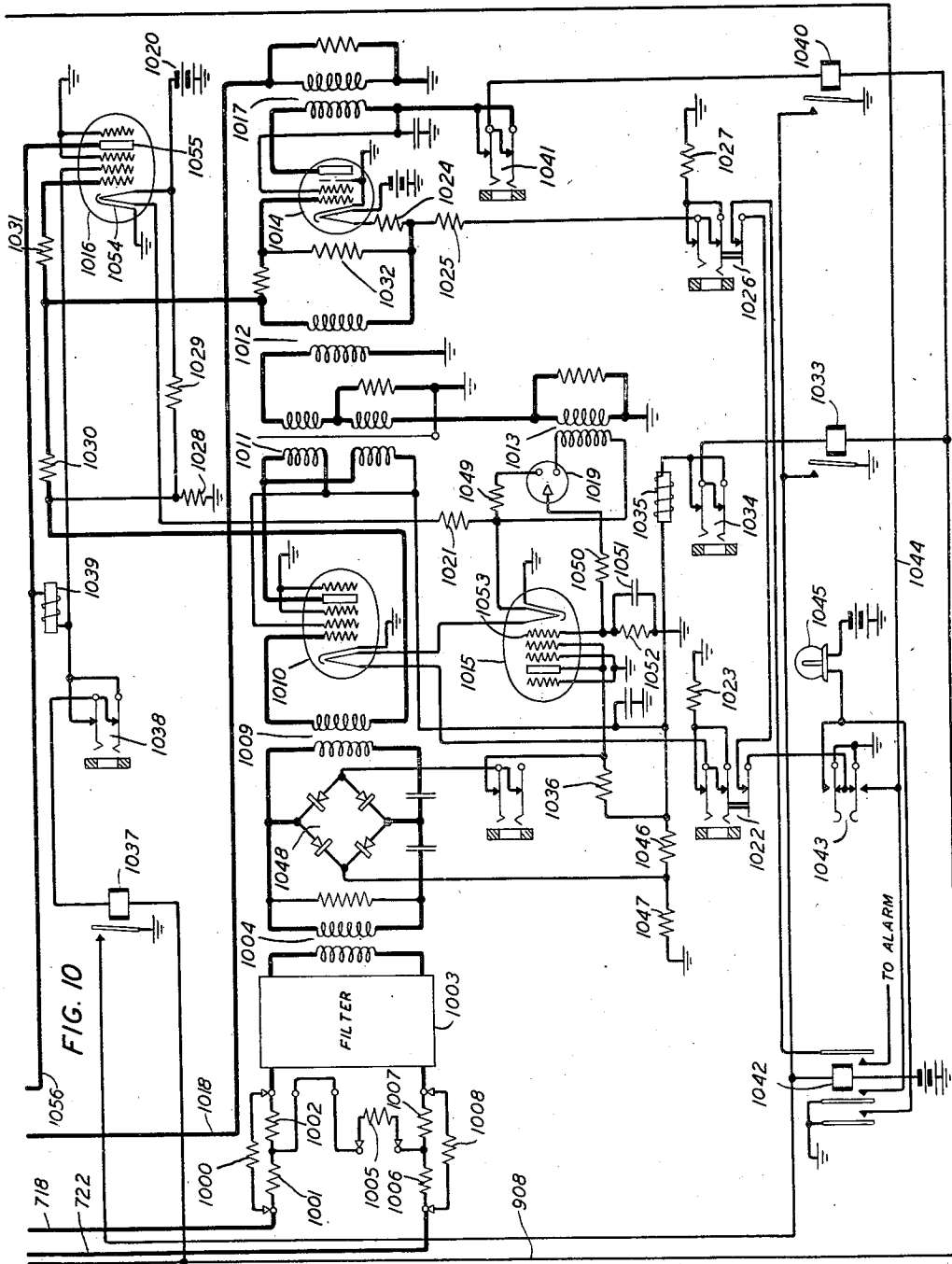
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AUTOMATIC TOLL SWITCHING TELEPHONE SYSTEM

Filed Dec. 31, 1940

10 Sheets-Sheet 10



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UNITED STATES PATENT OFFICE

2,288,251

AUTOMATIC TOLL SWITCHING TELEPHONE SYSTEM

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Application December 31, 1940, Serial No. 372,560

16 Claims. (Cl. 179—27)

This invention relates to telephone exchange systems and, more particularly, to systems in which connections are established between subscribers' lines terminating in different offices over toll trunks by dial switching mechanism under the control of a toll operator.

In the establishment of connections to offices of a dial switching area for which toll rates should be assessed for service, it is customary for a calling subscriber in such an office who desires a connection with another subscriber at a remote point to dial a number whereby a connection is first obtained with a toll operator who then proceeds to set up the desired connection and to supervise the assessment of the required toll charge.

Several methods of establishing such toll connections have heretofore been proposed for use in connection with dial switching systems. In accordance with one of these methods, disclosed by way of example in Patent No. 1,780,906, granted November 11, 1930, to W. W. Carpenter and R. E. Hersey, a toll connection incoming from a distant toll point is answered by the toll operator who then terminates the call by plugging directly into an idle trunk extending to the dial switching office in which the desired subscriber's line terminates which trunk is then automatically associated over a link circuit with an idle register sender, and by then keying the directory number of the desired line on a key-set associated with her position cord circuits to control the registration of the line number in the seized idle sender. The registration is controlled by the key-set through the transmission of marginal and reverse current impulses over the talking conductors of the cord circuit and trunk, through the link circuit to the responsive equipment in the sender. The sender after having registered the line designation then proceeds to control the setting of dial switching apparatus in accordance therewith to extend the connection from the trunk to the desired line.

In some cases it is desirable to include in an exchange area offices which are located on the fringe of such area and to control the extension of toll connections to lines terminating in such offices from toll operators' positions located in the main exchange area. Under these conditions the trunks extending from the toll operator's position to the fringe offices might be of considerable length and since the register sender equipment would be located in the terminating office, the transmission of key-pulsing impulses over such a long trunk for setting the digit registers of a selected register sender by the method disclosed in the Carpenter et al patent hereinbefore referred to might prove to be unreliable due to the losses incident to the transmission of direct current impulses over long cable

paths and to the fact that certain digit codes involve the transmission of impulses of different voltages requiring the response of sensitive and marginal responsive relays in the sender.

It is therefore an object of the present invention to provide apparatus whereby a toll operator may transmit impulses from her key-set over a long trunk to control the registration of a desired line number in the sender of a terminating office in an efficient and reliable manner.

It is a further object of the invention to enable key pulsing to be accomplished by the transmission and reception of codes of impulses comprising combinations of a plurality of frequencies.

The present invention has been illustrated as applicable to a system in which the terminating dial office to which a toll connection may be established is equipped with a call distributing B operator's position, link circuit and sender equipment for terminating incoming calls from toll or manual offices, of the type disclosed in Patent 2,020,458, granted November 12, 1935, to J. F. Dahl. The toll completing trunks incoming from the toll operator's position in the main exchange area terminate in the terminating office in incoming selector switches and are connectable over link circuits of the terminating office with a key impulse receiving circuit and with a register sender.

The toll operator's position circuit is provided with a ten-button key-set common to the cord circuits of her position which becomes associated with a cord circuit when she takes it for use and equipment is provided common to all of the operators' positions for generating a plurality of different alternating current frequencies, for combining such frequencies in different combinations of two frequencies each and applying them to the keys of the key-set, to the contacts of a key-pulsing signaling relay and to the contacts of a start relay also provided at each operator's position. As illustrated, the six frequencies employed are generated by vacuum tube oscillators of the type disclosed in the application of L. A. Meacham, Serial No. 372,557, filed December 31, 1940, but such frequencies might be generated by other well-known types of generators. The frequency generating equipment is provided in duplicate and automatic alarm and transfer equipment is provided for transferring the connections between the operators' positions from one generating equipment to the other in the event any frequency generator fails.

The key-pulsing receiving equipment at the terminating office is, as previously stated, associated with a calling incoming trunk and with a call distributing terminating sender by a link circuit in the same manner as the call distributing B operator's position and key-set circuit of the terminating office are associated. The conductors

over which the alternating current key-pulsing signals are incoming to the receiving equipment are connected through transformers and amplifying tubes of the pentode type to six receiving channels each of which channels includes a filter circuit, a space discharge responsive device and a signal responsive relay, the different channels being responsive respectively to signals of the frequencies generated by the six frequency generators associated with the operators' position circuits. The receiving circuit is also provided with translating equipment which is effective in response to the selective operation of the signal responsive relays of the receiving channels in response to keyed digits, to make such translations of the incoming signals as are necessary to set the digit registers of the terminating sender at the time associated with the receiving equipment to register the keyed digits. The receiving equipment is also provided with a volume limiter, circuits for enabling the space discharge devices of the receiving channels and circuits for permitting the transmission of signals by the signal responsive relays of the receiving channels to the translating equipment only after a key-pulsing signal has been received and if no signal within the voice frequency range is present upon the termination of the key-pulsing signal thereby eliminating the possibility of false registrations which might result due to the presence of conversational current on the signaling circuit prior to key pulsing.

In general the system disclosed operates as follows: In response to an incoming toll call which is to be terminated in the dial switching office disclosed, the operator plugs into an idle trunk extending to such office whereupon a start circuit is closed which causes the trunk finder of an idle link circuit to hunt for the trunk, which causes the position finder of the link circuit to hunt for and select an idle key-pulsing receiving circuit and which causes the sender finder of the link circuit to hunt for an idle sender. The operator then operates a key-pulsing key at her key-set circuit and as soon as a signal is received from the terminating office that a sender has been selected a relay is operated to transmit a preliminary key-pulsing signal comprising two of the frequencies generated by the frequency generating oscillators. A predetermined interval following the receipt of this key-pulsing signal the enabler circuit functions to render the space discharge devices operable to receive the signal frequencies whereupon if only the two frequencies transmitted for the signal are received and therefore only the corresponding responsive relays are operated, relays in the receiving circuit are operated to establish operating circuits for translating relays controllable by the responsive relays in response to subsequently keyed digits. If, however, frequencies within the voice frequency range should be present in addition to the signaling frequencies, the receiving circuit becomes blocked until such extraneous frequencies disappear.

Following the transmission of the key-pulsing signal the operator depresses keys of her key-set to transmit signals in accordance with the digits of the wanted line number, the enabling circuit responding as before to render the space discharge devices responsive a predetermined interval following the reception of each signal but at this time disabling the space discharge devices after a further interval following the reception of each signal. The responsive relays selectively operated in response to the transmission of each digit

signal are effective to selectively operate the translator relays to set the registers of the sender in the same manner as though the digits had been keyed on a key-set of the call distributing B operator's position. Following the completion of keying the operator depresses a start key at her position which is effective to transmit a distinctive start signal to the receiving circuit for signaling the sender that all digits have been keyed and that therefore the sender may proceed to set up the connection in accordance with the digital information registered therein.

The invention having been considered in a general manner, reference may now be had for a clearer understanding thereof to the following detailed description thereof taken in connection with the accompanying drawings in which:

Figs. 1 and 2 taken together disclose in the upper portion of Fig. 2 one of the cord circuits of an operator's position, in the lower portion of Fig. 2 the position circuit common to all cord circuits of the position and in Fig. 1 the grouping and operator's telephone circuit;

Fig. 3 shows the key-set circuit of the operator's position of Fig. 2;

Figs. 4, 5 and 6 taken together show the signaling frequency generators, switching and alarm circuits common to a plurality of operators' positions, Fig. 4 disclosing the vacuum tube oscillators for generating six signaling frequencies and the transformers by means of which these frequencies are grouped in the proper combinations for signaling purposes; Fig. 5 showing switching circuits for connecting the oscillators of Fig. 4 and a second set of oscillators indicated by the box at the right of Fig. 5 to the key-set circuits such as disclosed in Fig. 3 of operators' positions; and Fig. 6 showing alarm equipment and equipment operable to control the switching circuits of Fig. 5 upon failure of any oscillator tube;

Fig. 7 shows a trunk outgoing from the toll operator's position and incoming at a distant terminating office in an incoming selector switch indicated by the box in the upper right-hand corner thereof, a link circuit represented by the box so labeled, a sender represented by the box so labeled and a portion of the apparatus of a key impulse translator circuit;

Fig. 8 shows the remaining portion of the translator circuit;

Figs. 9 and 10 taken together disclose the key impulsing receiving circuit, Fig. 9 showing the tuned frequency channels each comprising a filter circuit, a gas-filled tube and a signal responsive relay, blocking and switching relays and a portion of the channel enabling circuit, and Fig. 10 showing the amplifier tubes, the volume limiter and the remaining portion of the enabling circuit; and

Fig. 11 is a chart showing how the several sheets of the drawings should be assembled to disclose the complete invention.

As previously stated, the incoming selector, the trunk and sender represented by the boxes in Fig. 7 may be of the types disclosed in Patent No. 2,020,458 to J. F. Dahl hereinbefore referred to and the final selectors employed in completing connections to desired lines in the terminating office may be of the well-known panel type.

It will be assumed that a toll call is incoming to the operator's position of Figs. 1 and 2 and that the operator answers the call on the toll lines by plugging the plug 200 of a cord circuit of her position into the toll line jack 201. She then depresses her cord key 202 to the right or

talking position. A circuit is thereupon established for relay 203 extending from battery, through the winding of relay 203, the alternate contacts of key 202, conductor 204 to ground at the inner lower normal contacts of relay 100 of the operator's telephone circuit. Relay 203 upon operating closes a circuit for relay 100 extending as traced from ground on conductor 204 over the alternate contacts of key 202, the No. 1 lower front contacts of relay 203, conductor 205 to battery through the winding of relay 100. Relay 100 thereupon operates removing ground from conductor 204 to prevent another cord circuit relay, such as relay 203, from operating. With relay 101 operated, since the operator's telephone set 102 will have been plugged into the position jack to establish the circuit thereof extending from battery through its winding, the upper contacts of jack 103 to ground at the outer right back contact of relay 104, relay 100 closes a holding circuit for cord circuit relay 203 which may be traced from ground over its inner lower alternate contacts, the No. 1 upper front contacts of relay 101, conductor 105, the No. 1 upper front contacts of relay 203, the upper alternate contacts of key 202 to battery through the winding of relay 203. Thereby relay 203 individual to the cord circuit and relay 100, common to all cord circuits of the position, are held operated. Relay 203 splits the cord circuit and associates conductors 206 to 209 with the cord circuit.

The operation of relay 100 connects the tip and ring conductors 106 and 107 of the operator's headset circuit over its outer front contacts and the No. 2 upper and No. 1 lower front contacts of relay 101 to conductors 108 and 109 extending to the left or monitoring contacts of the key 202 and at its inner upper back contact disconnects the winding of relay 110 from conductor 111. If at this time the key 202 of another cord circuit of the operator's position is operated to the left or monitoring position the operator will be able to talk or listen on both cord circuits but will be able to split, transfer or key pulse on only the cord circuit the talking key of which has been operated to the right or talking position.

Upon the operation of relay 203 a circuit is also established from high resistance ground on the sleeve of jack 201 over the sleeve of plug 200, the No. 2 lower contacts of relay 203 to battery through the windings of relays 210 and 211. Relay 211 upon operating closes an obvious circuit for relay 212 but relay 210 being marginal does not operate at this time. At its inner upper front contact relay 212 connects ground through high resistance 213 and over the No. 3 lower contacts of relay 203 to the rear cord supervisory lamp 214 to warm the lamp without lighting it thereby improving its flashing characteristic. At its lower back contact relay 212 disconnects the tip of the answering plug 200 from the busy test conductor 215 which is connected over the No. 4 lower front contact of relay 101 through the winding of relay 112 to ground and through condenser 113 to ground through the primary winding of transformer 114 and thence inductively to the operator's headset 102. At its outer front contacts relay 212 also establishes a talking circuit which may be traced from the tip of the plug 200 over the No. 5 upper contacts of relay 203, conductor 206, the No. 2 upper back contact of relay 300, conductor 301, the lower right normal contacts of splitting key 216, the lower front contact of relay 212, the lower back contact of relay 217, conductor 115, the lower No. 5 con-

tacts of relay 101, conductor 107, through the lower windings of repeating coil 116, inductively coupled to the operator's headset transmitter, and over the back contacts of relay 110 to the operator's headset receiver, thence returning over conductor 108, the No. 3 upper contacts of relay 101, conductor 117, the upper back contact of relay 217, the upper front contact of relay 212, the upper right normal contacts of splitting key 216, conductor 302, the No. 3 lower back contact of relay 300, conductor 209, the No. 5 lower contacts of relay 203 to the ring of plug 200. The operator is now enabled to receive instructions over the toll trunk for the further extension of the connection.

Having received instructions and it having been assumed that a connection is desired with a subscriber's line which terminates in a dial switching office accessible over a group of trunks of which one is disclosed in Fig. 7, the operator proceeds to test such trunks by touching the tip of plug 224 to the sleeves of the trunk jacks. A circuit is thereupon established from the tip of plug 224 over the No. 4 upper contacts of relay 203, conductors 208, the No. 4 upper back contact of relay 303, conductor 304, the lower left normal contacts of splitting key 216, the lower back contact of relay 218, conductor 215, thence as previously traced to ground through the winding of relay 112 and through the primary winding of transformer 114. It will be assumed that the trunk terminating in jack 700 tests idle and that the operator on receiving no busy click in her headset inserts the plug 224 into jack 700. A circuit is thereupon established from ground through the high and low resistance windings of sleeve relay 701 in series over the sleeves of jack 700 and plug 224, the No. 3 upper alternate contacts of relay 203 to battery through the windings of relays 219 and 220. Sleeve relay 701 operates in this circuit establishing an obvious circuit for relay 702 which operates establishing a direct current loop circuit over the two-conductor trunk extending to the terminating office. This loop circuit may be traced from battery at the terminating office through the lower winding of relay 706, the lower back contact of relay 749, the lower left winding of repeating coil 723, over interoffice trunk conductor 705, the lower right winding of repeating coil 704, the contacts of relay 702, the winding of relay 703, the upper right winding of coil 704, trunk conductor 707, the upper left winding of repeating coil 723, the upper back contact of relay 749 and through the upper winding of relay 706 to ground. Relays 703 and 706 both operate, relay 706 closing an obvious circuit for relay 750, and relay 703 connecting direct ground through the upper or low resistance winding of relay 701 to the previously traced sleeve circuit thereby operating both relay 219 and relay 220 at the operator's position circuit.

Relay 750 upon operating establishes an operating circuit for relay 749 extending from battery through the winding thereof, over the back contact of relay 753 to ground over the upper contacts of relay 750 whereupon relay 749 operates to open the previously traced loop circuit through the windings of relays 703 and 706. Relay 706 does not release, however, being held operated in a local circuit through both of its windings and over the front contact of relay 749. Relay 703, however, releases again removing low resistance ground from the trunk sleeve circuit thereby releasing marginal sleeve relay

219. Relay 219, therefore, operates only momentarily and without effect at this time.

Relay 220 upon operating establishes an obvious circuit for relay 218 which at its upper front contact connects ground through high resistance 221, over the No. 2 upper contacts of relay 203 to the circuit of calling supervisory lamp 222 for warming such lamp without lighting it to improve its flashing characteristic and establishes a talking circuit from the tip conductor 709 of the outgoing trunk over the tips of jack 700 and plug 224, the No. 4 upper front contact of relay 203, conductor 208, the No. 4 upper back contact of relay 303, conductor 304, the lower left contacts of splitting key 216, the inner lower front contact of relay 218, the lower back contact of relay 223, conductor 115, thence as traced to the operator's telephone circuit and returning over conductor 117, the upper back contact of relay 223, the inner upper front contact of relay 218, the upper left normal contacts of key 216, conductor 305, the No. 2 lower back contact of relay 303, conductor 207, the No. 4 lower front contact of relay 203, over the rings of plug 224 and jack 700 to the ring conductors 710 of the outgoing trunk. At its lower back contact relay 218 opens the busy test circuit previously traced.

Relay 750 upon operating also closes a circuit extending from battery through the winding of relay 751, thence over the lower contacts of relay 750 to ground over the normal or position 17 contacts of sequence switch cam 752 whereupon relay 751 operates, locks in a circuit from battery through its winding, over the lower contacts of relay 750, to ground over its own lower contacts and connects ground to the start circuit for starting a preselected idle link circuit, such as is represented by the box 708, and which is fully disclosed in the patent to J. F. Dahl hereinbefore referred to, whereupon the trunk finder 711 of the link circuit is started in search of the calling trunk. As soon as the trunk is found the link circuit sequence switch is advanced thereby causing the advance of the sequence switch of the incoming selector into position 18 and the selector 712 of the link circuit is started in search of an idle key-pulsing receiving circuit. An idle receiving circuit is identified by battery connected through resistance 800 over the lower back contact of relay 801, conductor 802, the lower back contact of relay 715 to a test terminal 716 appearing in the bank of the selector 712. When the selector 712 finds the first idle receiving circuit, assumed to be the circuit disclosed in Figs. 7 to 10, inclusive, a test relay in the link circuit operates to arrest the hunting movement of the selector and to advance the sequence switch of the link circuit. A circuit is thereupon established from battery through the lower winding of supervisory relay 717 in the trunk circuit, through the lower right winding of repeating coil 723, over the contacts of sequence switch cam 754, over the ring talking conductor extending through the link circuit, ring conductor 718 of the receiving circuit, resistance 719, both windings of relay 720, resistance 721, tip conductor 722 of the receiving circuit, tip talking conductor extending through the link circuit, the contact of cam 755, upper right winding of repeating coil 723 to ground through the upper winding of relay 717. Due to the inclusion of the upper high resistance winding of relay 720 in the circuit thus traced, marginal supervisory relay 717 does not operate but relay 720

operates and closes an obvious circuit for relay 715 which also operates.

Relay 715 upon operating opens at its lower back contact the connection from battery through resistance 890 over the test terminal set 716, thereby releasing the test relay in the link circuit to advance the sequence switch of the link circuit into the position for starting the sender selector 713 to hunt for an idle sender. Relay 715 also closes an obvious circuit for the busy lamp 808; connects ground to the off-normal conductor 724; establishes a circuit extending over conductor 725 through the lower winding of make-busy relay 801; establishes a circuit for the peg-count register 726 which may be traced from battery through its winding and the winding of relay 727, inner upper back contact of relay 728 to ground at the upper front contact of relay 715 whereupon the register is operated and locked in its operated condition over its armature contact and the front contact of relay 727; and connects battery over its lower front contact, the lower back contacts of relay 728 and through the resistances 729 and 730 to conductors 731 and 732 extending through the link circuit 708 toward the sender 714.

When the sender has been seized by the link circuit, battery thus connected to conductors 731 and 732 causes the sender to connect battery through an 840 ohm resistance to a conductor extending therefrom through the link circuit to conductor 733, thence through the winding of relay 734 to ground at the back contact of relay 735. Relay 734 thereupon operates locking over its upper front contact to ground on conductor 725 and closing a circuit from ground on conductor 725 over its next to upper front contact through the winding of relay 735 to battery which relay thereupon operates, locks to ground on conductor 725 over its inner upper front contacts and closes an obvious circuit for relay 728 which also operates. Relay 728 upon operating opens the circuit of the peg-count register 726; disconnects battery from conductors 731 and 732 and connects battery over the lower front contact of relay 715 and its own lower front contacts to conductor 736 extending to the impulse receiving circuit of Figs. 9 and 10. With battery disconnected from conductors 731 and 732, the sender responds to disconnect battery from conductor 733 whereupon relay 734 releases, closes a shunt around the high resistance winding of relay 720 extending from the left terminal thereof over the lower back contact of relay 734 and the lower front contact of relay 735 to the right terminal thereof and at its inner lower back contact connects conductor 733 over the inner lower front contact of relay 735 to conductor 737. Conductors 731, 732 and 733 are now extended from the sender 714 to the contacts of the translation relays 803 to 807, inclusive.

Following the short-circuiting of the upper winding of relay 720, the current flowing through the windings of marginal relay 717 of the trunk is increased to such an extent that relay 717 operates to close the circuit of relay 753 which may be traced from battery through its winding and normal contacts, over the contacts of relay 717 to ground over the upper contacts of relay 750. Relay 753 locks over its alternate contacts to ground at the lower contacts of relay 751 and opens the circuit of relay 749 which releases to restore the loop circuit through the winding of relay 703. Relay 703 now operates to reconnect low resistance ground to the sleeve of the trunk

through the upper low resistance winding of sleeve relay 701. In response to the increased current now flowing over the sleeve circuit previously traced through the windings of relays 219 and 220, marginal relay 219 now operates to connect ground over its contacts through low resistance 225, the No. 2 upper contacts of relay 203, to the supervisory lamp 222 whereupon such lamp lights as a signal to the operator that a sender has become associated with the extended connection.

Since the call is an inward call, the operator may depress the front cord key-pulsing key 306 as soon as she has plugged up the cord whereupon a circuit is established from ground over the No. 3 upper back contact of relay 300, conductor 311, lower front contact of relay 219, conductor 309, over the right contacts of key 306, thence in parallel through the winding of relay 307 and the non-inductive resistance 308 to battery and a circuit is also established from battery through the winding of relay 303, left contacts of key 306, conductor 309, lower contacts of relay 218, conductor 311, to ground at the No. 3 upper back contact of relay 300. Relays 307 and 303 both operate, relay 307 upon operating extending its operating ground over its lower contacts, the upper back contact of relay 314 and the upper front contacts of relay 307, to battery through the winding of relay 312. Relay 312 thereupon operates and locks itself from ground on conductor 309 over the No. 1 upper contacts of relay 303, over its own upper contacts, the normal contacts of relay 313 and through its own inner lower front contact and winding to battery and extends this locking circuit from its upper contacts through the No. 1 lower contacts and winding of relay 303 to battery. Relay 303 upon operating closes the circuit of lamp 315 in a circuit through resistance 316 and over the No. 3 upper contacts of relay 303 and at its No. 4 lower contacts prepares the circuit for relay 314. Relay 307 is now held operated under the control of relay 314 over a circuit extending from battery through its winding and outer lower contacts, over the upper back contact of relay 314 and the No. 1 upper contacts of relay 303 to ground on conductor 309.

Before proceeding with the operations incident to keying the wanted line number, the manner in which the signaling frequencies are generated and made available to the key-set circuits will first be described. For each call the operator causes the transmission of a key-pulsing signal, may cause the transmission of a start signal and may transmit signals in accordance with any one of the digit values 1 to 0, inclusive.

These twelve possible signals comprise different combinations of two frequencies each from a total of six available frequencies. For generating these six frequencies two groups of vacuum tube oscillators are provided, one group comprising six oscillator circuits 401 to 406, inclusive, for generating alternating current frequencies of 700, 900, 1100, 1300, 1500 and 1700 cycles, respectively, being disclosed in Fig. 4, and the other group, comprising six similar oscillator circuits, being represented by the box 500 in the right portion of Fig. 5. These oscillators are of the type fully disclosed in the application of L. A. Meacham, Serial No. 372,557, filed December 31, 1940.

The alternating current output circuits of the oscillators 401 to 406, inclusive, are connected to conductors 411 to 416, respectively, of cable 417

which conductors are connected through resistances and condensers to the control electrodes of gas-filled tubes 621 to 626, respectively, of the alarm and control circuit of Fig. 6. For example, conductor 411 is connected through resistance 601 and condenser 611 to the control electrode of tube 621. These conductors are also multiplied as required to the terminals of the primary windings of transformers KP, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and ST disclosed in the right portion of Fig. 4 whereby each primary winding is bridged across the output circuits of two of the oscillator circuits. For example the primary winding of transformer KP is connected at one terminal to conductor 416 and to the output circuit of the 1700 cycle oscillator circuit 406 and at its other terminal to conductor 414 and to the output circuit of the 1300 cycle oscillator circuit 404. The primary windings of other transformers are connected in accordance with the following table:

Table I

Frequency	Code signals										
	0	1	2	3	4	5	6	7	8	9	KP ST
1,700				x	x				x	x	x
1,500				x		x					x
1,300		x	x			x					x
1,100						x	x	x			
900	x		x		x						
700	x	x				x			x		

The secondaries of these transformers are connected over the normal contacts of switching relays 501 to 505, inclusive, to pairs of conductors extending in multiple to the key-set keys; to contacts of the key-pulsing relays such as 314 and to the contacts of the start relays such as 313 of all odd numbered operator's positions. Similarly the secondaries of the transformers of the oscillator circuits represented by the box 500 are connected over the normal contacts of switching relays 511 to 515, inclusive, to pairs of conductors extending in multiple to the key-set keys, to contacts of the key-pulsing relays and to the contacts of the start relays of all even numbered operator's positions such as the position illustrated. Thus normally the oscillators of Fig. 4 supply codes of signaling frequencies to one half of the operator's positions and the oscillators represented by the box 500 supply codes of signaling frequencies to the other half of the operator's positions. If switching relays 501 to 505, inclusive, are operated the secondaries of the transformers of Fig. 4 are disconnected at the back contacts of such relays from the pairs of conductors multiplied to the odd numbered operator's positions and such pairs of conductor's are connected over the front contacts of such relays to the corresponding pairs of conductors extending to the even numbered positions whereby all positions are supplied with signaling frequencies from the oscillator circuits represented by the box 500. On the other hand if switching relays 511 to 515, inclusive, are operated, the secondaries of the transformers of the oscillator circuits represented by the box 500 are disconnected at the back contacts of such relays from the pairs of conductors multiplied to the even numbered operators' positions and such pairs of conductors are connected over the front contacts of such relays to the corresponding pairs of conductors extending to odd numbered positions whereby all positions are supplied

plied with signaling frequencies from the oscillator circuits of Fig. 4.

Normally the gas-filled tubes 621 to 626, inclusive, are maintained in a conducting condition by the presence of signaling potential applied to their control electrodes over the conductors 411 to 416, inclusive, in addition to the potential applied thereto from the potential divider extending from ground through resistance 617, resistance 618 and the positively poled battery 619 to ground. The associated relays 631 to 636, inclusive, are thus maintained operated. For example, relay 631 is maintained operated in a circuit from the positive potential junction 620 on the potential divider through resistance 610 across the cathode path through tube 631, through the winding of relay 631 to ground through the upper left winding of transformer 627. Should the oscillator circuit 401 fail, the output potential applied therefrom over conductor 411 to the control electrode of the tube 621 would cease thereby lowering the potential on the control electrode to such an extent that upon the next negative half wave of the alternating current source 628, the negative potential applied to the control electrode therefrom will so oppose the potential applied to the control electrode from the source 619 as to cause the tube to become extinguished thereby releasing the associated relay 631. Relays 632 to 636, inclusive, become released in a similar manner upon the failure of the associated oscillator circuits 402 to 406, inclusive.

The release of any one of the relays 631 to 636, inclusive, establishes a circuit from ground over the front contacts of relay 629, the lower back contact of the released relay, for example, relay 631, to battery through the winding of relay 607 whereupon relay 607 operates in turn operating the switching relays 501 to 505, inclusive, over conductors 506 and 507, thereby removing the group of oscillator circuits disclosed in Fig. 4 from service. At the same time, the release of any one of the relays 631 to 636, inclusive, establishes a circuit from ground over the front contacts of relay 629, the upper back contact of the released relay, for example relay 631 to battery through the associated lamp, for example lamp 641, to indicate to the maintenance man which of the oscillator circuits has failed. Relay 607 upon operating also connects ground over the normal contacts of key 608 and its own lower front contacts to conductors 647 and 648 extending to visual and audible alarm devices.

The maintenance man noting the operation of the alarm devices then operates key 608 to stop the operation of such devices, to close a holding circuit for operated relay 607 and to light guard lamp 609. Noting the lighted one of the lamps 641 to 646, inclusive, for example lamp 641, the maintenance man is thus apprized of the particular oscillator circuit which has failed. He may then take steps to rectify the trouble and may then listen to the output of the oscillator circuit to determine if the trouble has been corrected by plugging a headset receiver into the testing jacks associated with such oscillator circuit. The testing jacks for the oscillator circuit 401 are disclosed at 407 and 408 and are associated with the output circuit of the oscillator circuit by the transformer 409. After the trouble has been fully corrected the gas-filled tube associated therewith will again function to operate the associated relay thereby extinguishing the

associated lamp and opening the initial operating circuit of relay 607. The maintenance man may then release key 608 to release relays 607 and 501 to 505, inclusive, thereby restoring the oscillator circuits of Fig. 4 to service. Upon the release of key 608 the guard lamp 609 becomes extinguished.

Tubes 621' to 626', inclusive, relays 631' to 636', inclusive, lamps 641' to 646', inclusive, relay 607', key 608' and lamp 609' function in a similar manner with respect to the oscillator circuits represented by the box 500 and with respect to the switching relays 511 to 515, inclusive.

In order that the maintenance man may be informed of any failure of the commercial source 628 of alternating current which is provided for extinguishing tubes 621 to 626, inclusive, and 621' to 626', inclusive, upon the failure of their associated oscillator circuits, the source is inductively connected through another secondary winding of the transformer 627 and the rectifier bridge 649 over the front contacts of relay 650 with the winding of relay 629 whereby relay 629 is maintained operated. Should the source of power fail relay 629 will release thereby removing ground from the contacts of relays 631 to 636, inclusive, and 631' to 636', inclusive, to prevent their release from operating either relay 607 or relay 607' and from lighting associated lamps 641 to 646, inclusive, and 641' to 646', inclusive; to close the alarm circuits 647 and 648 and to close the circuit of guard lamp 630.

In view of the fact that the oscillator circuits which normally supply even numbered operator's positions including the position fully disclosed in Figs. 2 and 3, have not been disclosed in detail, it will be assumed in order to clarify the following description of the operation of the circuits that the switching relays 511 to 515, inclusive, have been operated and that the oscillator circuits of Fig. 4 are therefore supplying all of the operator's positions.

It will be recalled that the operator has through the depression of key-pulsing key 306 caused the operation of relays 303, 307 and 312. As soon as a sender has become connected to the link circuit and such connection has been signaled by the operation of sleeve relay 219, a circuit is established from ground over its contacts, conductor 348, the No. 4 lower contacts of relay 303, the inner lower contacts of relay 307 to battery through the winding of relay 314. Relay 314 operates opening the locking circuit of relay 307 at its upper back contact and establishing a circuit from the right terminal of the secondary winding of transformer KP, over conductor 418, the upper back contact of relay 505, conductor 518, the upper front contact of relay 515, conductor 318, resistance 320, the upper front contact of relay 314, through the right windings of repeating coil 317, the lower front contact of relay 314, resistance 321, conductor 319, the middle upper front contact of relay 515, conductor 519, the middle upper back contact of relay 505 and conductor 419 to the left terminal of the secondary winding of transformer KP. By reference to the preceding table, it will be noted that output circuits from the oscillator circuits 404 and 406, having frequencies of 1300 and 1700 cycles, are impressed upon the primary winding of transformer KP and thus current of these frequencies is impressed upon the right windings of repeating coil 317 over the circuit just traced,

With relay 303 operated, the current impressed upon the right windings of repeating coil 317 is transmitted to the trunk of Fig. 7 over a circuit which may be traced from the upper terminal of the left windings of repeating coil 317, over the No. 4 upper front contact of relay 303, conductor 208, the No. 4 upper front contact of relay 203, tips of plug 224 and jack 709, tip trunk conductor 709 through the primary windings of repeating coil 704, returning over trunk conductor 710, rings of jack 709 and plug 224, the No. 4 lower front contact of relay 203, conductor 207, the No. 2 lower front contact of relay 303 to the lower terminal of the secondary winding of repeating coil 317. The current is further inductively transmitted over conductors 705 and 706 of the interoffice trunk through the secondary winding of repeating coil 704 and the primary winding of repeating coil 723 and is inductively transmitted to the key-pulsing receiving circuit over a path extending from the upper terminal of the secondary winding of repeating coil 723, over the tip talking conductor extending through the link circuit 708, tip conductor 718 through the padding resistances 1006, 1001 and 1002, filter circuit 1003 bridged by the padding resistance 1005, through the primary winding of transformer 1004, returning through the filter circuit 1003, through padding resistances 1006, 1007 and 1008, over ring conductor 722 and the ring talking conductor extending through the link circuit 708 to the lower terminal of the secondary winding of repeating coil 723.

By the transformer 1004 the signaling current is impressed through the windings of transformer 1009 upon the input circuit of the primary amplifier tube 1010, the output of which is impressed upon the primary windings of transformer 1011. The secondary windings of transformer 1011 are coupled to the primary winding of transformer 1012 and to the primary winding of transformer 1013 whereby the signaling current is further impressed upon the input circuit of the secondary amplifier tube 1014, upon the input circuit of the volume control tube 1015 and upon the input circuit of the amplifier tube 1016. The output of the secondary amplifier tube 1014 is further applied through the transformer 1017 and over conductor 1018, thence in parallel through the tuned filters 901 to 906, inclusive, and the associated transformers 911 to 916, inclusive, upon the input circuits of the associated gas-filled tubes 921 to 926, inclusive. The filter circuits 901 to 906, inclusive, are so tuned as to pass frequencies of 700, 900, 1100, 1300 and 1700 cycles respectively. The tubes 921 to 926, inclusive, are of the cold cathode gas-filled type and are normally so conditioned as to be non-conducting. The amplifier tubes 1010, 1014 and 1015 and the volume control tube 1015 are vacuum tubes of the pentode type and the tube 1019 interposed between the secondary of transformer 1013 and the input circuit of the volume control tube 1015 is of the cold cathode gas-filled type.

Heater current is supplied to the filaments of tubes 1010, 1015 and 1016, in series, from the source 1020 through the filament of 1016, resistance 1021, the filaments of tubes 1015 and 1010 over normal contacts of test jack 1022 to ground through resistance 1023 and heater current is supplied to the filament of the tube 1014 from battery through such filament, through resistances 1024 and 1025 over the normal contacts of test jack 1025 and through resistance 1027 to

ground. The control grid of the primary amplifier tube 1010 is negatively biased from battery 1029 through the secondary winding of transformer 1009 from a point between resistances 1028 and 1029 of the potential divider including battery 1029. Negative bias is applied to the control grid of tube 1015 from this potential divider through resistances 1030 and 1031 and negative bias is applied to the control grid of the secondary amplifier tube 1014 from the battery supplying the filament circuit thereof through resistances 1024 and 1032. Anode potential is supplied to tube 1010 from the 130 volt source 907 of positive potential over conductor 908, through the winding of alarm relay 1033, normal contacts of test jack 1034, impedance coil 1035 and through the primary windings of transformer 1011 and to the anode of tube 1015 in a branch of such circuit extending through resistance 1036. Anode potential is applied from the source 907 over conductor 908 through the winding of alarm relay 1037, normal contacts of test jack 1038 and impedance coil 1039 to the anode of tube 1016 and anode potential is applied from conductor 908 through the winding of alarm relay 1040 over the normal contacts of test jack 1041 and the primary winding of transformer 1017 to the anode of tube 1014.

The tubes 1010, 1014, 1015 and 1016 should normally conduct sufficient space current across the cathode-anode paths therethrough to maintain alarm relays 1033, 1037 and 1040 operated. However, should one of the tubes fail and its associated anode-alarm relay become released the circuit for relay 1042 is thereby closed and relay 1042 upon operating establishes an alarm circuit extending from ground at the normal contacts of key 1043, normal contacts of test jacks 1022 and 1026 and the right contacts of relay 1042, establishes the circuit for guard lamp 1045 and establishes a circuit from ground over its inner left contacts and conductor 1044 to battery through the upper winding of make-busy relay 801, whereupon relay 801 operates to render the receiving circuit busy to all link circuits. Noting the alarm the maintenance man operates key 1043 to open the alarm circuit, to connect ground to hold make-busy relay 801 operated and to close another circuit of guard lamp 1045 which remains lighted until the trouble condition has been removed, relay 1042 has been released and the key 1043 restored to normal.

It having been assumed that a key-pulsing signal comprising current of the two frequencies 1300 and 1700 cycles has been transmitted, the amplifier tube 1010 amplifies such signaling current and impresses it upon the input circuits of amplifier tubes 1014 and 1015 and across the control gap of the gas-filled tube 1019. The tube 1019 together with pentode tube 1015, resistances 1036, 1046 and 1047 and varistor 1048 constitute a volume limiter of the type fully disclosed in Patent No. 2,208,752, granted July 23, 1940, to S. Doba, Jr. The varistor 1048 is in the form of a copper-oxide bridge having two vertices connected across the transmission line between the transformers 1004 and 1009. The tubes 1015 and 1019 together with a resistance bridge three arms of which comprise the resistances 1036, 1046 and 1047 and the fourth arm of which includes the cathode-anode path through the tube 1015, control the varistor 1048. The source of potential 907 is connected across two vertices of the resistance bridge and the other two vertices are connected to the free vertices of the varistor 1048.

Under normal operating conditions with no energy peaks on the transmission line above a predetermined level, the resistance bridge is balanced so that no current is supplied therefrom to the varistor 1048. Should a peak of energy 5 above the predetermined level occur, the potential applied across the cathodes of the tube 1019 from the secondary winding of transformer 1013 will cause this tube to ignite and to establish an operating circuit extending from the source of potential 1020, thence as traced through resistance 1021, resistance 1049 across the cathode-anode path of tube 1019 through resistance 1050 and delay condenser 1051, shunted by resistance 1052 to ground. The condenser 1051 charges in this circuit and when fully charged, the potential 15 applied to the control grid 1053 decreases the flow of space current through said tube thereby unbalancing the resistance bridge and effecting current flow from battery 907 through the varistor 1048. The impedance of the varistor is thus lowered to produce a shunting action on the transmission line.

The signaling current applied to the amplifier tube 1016 causes a flow of alternating current therethrough over the circuit extending from ground across the cathode-anode path through the tube between the cathode 1054 and the anode 1055 over conductor 1056, through condenser 909, the varistor 910 and resistance 957 to ground. This current is rectified by the varistor and applied through the left or operating winding of polarized relay 917. Normally the current applied through the right or biasing winding of relay 917 holds the armature of such relay against its back contact. When, however, current flows in its left winding due to an incoming signal, it overcomes the effect of the right winding to operate the relay armature into engagement with its front contact at which time resistance 957 becomes shunted by direct ground applied over the back contact of polarized relay 918 to increase the current flowing in the left winding of relay 917 to insure that such relay will continue to hold its armature against its front contact so long as the signal continues even though the signal strength should diminish. Relay 917 also opens the discharge path of condenser 919 through resistance 920 and over the back contact of relay 917 to ground at the back contact of relay 918 and opens the circuit extending from ground over the back contact of relay 918, the back contact of relay 917 through resistances 920 and 927 and the left winding of polarized relay 928 to battery.

Prior to the opening of the circuit through the left winding of relay 928, this winding has been so energized as to hold the armature of relay 928 against its front contact. Following the disengagement of the armature of relay 917 from its back contact and the opening of the discharge path through condenser 919, current continues to flow through the left winding of relay 928, resistance 927 and condenser 919 to charge such condenser and until the charging current ceases to flow, the armature of relay 928 is still held against its front contact by the energization of its left winding. When charging current ceases to flow through its left winding, the right or biasing winding of relay 928 becomes effective to move its armature into engagement with its back contact to connect ground from the right back contact of relay 929, back contact of relay 928, left back contact of relay 929 and conductor 930 to the cathodes of all gas-filled tubes 921 to

925, inclusive, whereby such tubes are rendered responsive to incoming signaling current. It will be noted that the interval required to charge the condenser 919 following the movement of the armature of relay 917 in response to the incoming signal has introduced a delay to permit any transient frequencies which may occur in adjacent filters upon the initial closure of the signaling circuit to disappear before the tubes are rendered responsive or are enabled.

With the tubes 921 to 926, inclusive, enabled, the signaling current as further amplified by the secondary amplifier tube 1014 is impressed upon the paralleled filters 901 to 906, inclusive, and since the first signal received is a key-pulsing signal, comprising current of the two frequencies 1300 and 1700 cycles, such current is passed through the filters 904 and 906 and impressed through the transformers 914 and 916 across the cathodes of tubes 924 and 926 causing such tubes to become conducting. Current now flows in a circuit from ground on conductor 930, over the cathode-anode path through tube 924, right winding of responsive relay 934, through resistance 944 to the source of potential 907 and in a second circuit from ground on conductor 930, over the cathode-anode path through tube 926, right winding of responsive relay 936, through resistance 946 to the source of potential 907. The responsive relays are normally biased to hold their armatures in engagement with their back contacts by their middle or biasing windings which are connected in a series circuit from battery through resistance 937 and through such windings to ground. When, however, the right windings of relays 934 and 936 become energized as previously described in response to the key-pulsing signal, these windings overcome the biasing windings thereby moving the armatures of such relays into engagement with their front contacts.

With relays 934 and 936 thus operated, a circuit is established from ground over the upper front contact of relay 715, the inner upper front contact of relay 728, the back contact of relay 738, conductor 739, the back contact of relay 809, conductor 810, the front contact of relay 934, the No. 1 right back contact of relay 938, the front contact of relay 936, the No. 4 right normal contacts of relay 938, the winding of relay 939, conductor 940, the back contact of relay 947 to battery previously connected to conductor 736 through the operation of relays 715 and 728. Relay 939 thereupon operates, closing a circuit for relay 948 from battery on conductor 940 through its winding and the front contact of relay 939, whereupon relay 948 operates and locks to ground over its right front contact and under the control of relay 947. Upon the termination of the key-pulsing signal, relays 934 and 936 release, in turn releasing relay 939, whereupon with relay 948 operated, a circuit is established from ground over the back contact of relay 939, the inner left front contact of relay 948 and the winding of relay 938 to battery on conductor 940 and a second circuit is established from ground on the back contact of relay 939, the outer left front contact of relay 948, through the winding of relay 929 to battery on conductor 940. Relay 938 upon operating connects the front contact of each of the relays 931 to 936, inclusive, to the left terminal of the left winding thereof, respectively, the other terminal of each of such windings of relays 931 to 935, inclusive, being connected to battery through the windings of translator relays 803 to 807, respectively, and the other ter-

minal of the left winding of relay 936 being connected to battery through the lower winding of relay 815. Relay 929 upon operating removes ground at its right back contact from conductor 930 to disable the tubes 921 to 926, inclusive, and at its left front contact prepares a circuit to include an additional timing interval controlled by relay 918. Upon the termination of the key-pulsing signal relays 917 and 919 release to their normal conditions as illustrated.

Normally when battery is connected to conductor 736 upon the seizure of the receiving circuit, the right winding of relay 947 is energized in a circuit extending from conductor 736 through resistance 949 and resistance 950 to ground thereby holding its armature against its back contact. Since during the initiation of a call and before code impulses are transmitted, the transmission circuit may be briefly exposed to conversation, there may be present current of the frequencies 700, 900, 1100 and 1500 cycles during the time that the key-pulsing signal is being transmitted and before relays 930 and 929 have become operated whereby one or more of the responsive relays 931, 932, 933 and 935 may also be operated. Under this condition, a circuit is established from battery on conductor 736 through resistance 951, the left winding of relay 947 over one or more of the back contacts of relay 938 and the front contacts of one or more of relays 931, 932 and 933, conductor 952 and the back contact of relay 811 to ground on conductor 739 or over the front contact of relay 935, conductor 810 and over the back contact of relay 809 to ground on conductor 739. Relay 947 will thereupon operate in about 5 milliseconds to disconnect battery from conductor 940 to arrest the operation of relays 938, 939, 948 and 929 or to release them depending upon their condition at the time relay 947 operates. As soon, however, as the extraneous frequencies disappear and only the key-pulsing code frequencies remain, any operated responsive relays such as 931, 932, 933 or 935 will release, thereby removing the shunting ground from condenser 953 whereupon condenser 953 will charge in a circuit from battery on conductor 736 through resistance 951, the left winding of relay 947, condenser 953 and resistance 954 to ground. Since it requires condenser 953 about 50 milliseconds to charge, relay 947 does not release until this interval has expired. Following its release relays 939, 948, 938 and 929 function as previously described thereby conditioning the receiving circuit to receive code digit impulses. This feature thus serves as a guard to prevent a false registration due to voice currents incident to conversation.

Following the operation of relay 314, it will be recalled that the holding circuit for relay 307 was opened whereby as soon as key 306 was released, relay 307 released after an interval, in turn releasing relay 314 to discontinue the key-pulsing signal. With relays 307 and 314 both released a circuit was established from ground over the lower contacts of relay 312, the lower back contact of relay 314 and the upper back contact of relay 307 to battery through lamp 360 which lighted as a signal to the operator that she could proceed with the keying of the desired line number on the key-set 310. It will be assumed that the number of the desired line is 2369 and that the operator therefore first momentarily operates the digit key 323 of her key-set. Current of the two frequencies 900 and 1300 cycles, as indicated by the preceding table, is thereupon impressed from the primary wind-

ing of transformer 2 upon the circuit which may be traced from the right terminal of the secondary winding of such transformer over conductor 420, the middle upper back contact of switching relay 504, conductor 520, middle upper front contact of switching relay 514, conductor 322, resistance 324, the left contacts of the depressed key 328, over the inner upper back contact of relay 314 through the right windings of repeating coil 317, over the inner lower back contact of relay 314, the right contacts of key 328, resistance 325, conductor 323, the inner upper front contact of relay 514, conductor 521, the inner upper back contact of relay 504, and conductor 421 to the left terminal of the secondary winding of transformer 2. In the manner previously described, this signaling current is transmitted to the receiving circuit and is impressed upon the input circuit of tube 1016 associated with the enabling circuit and is passed through the filters 902 and 904 tuned to the signaling frequencies of 900 and 1300 cycles, respectively, and impressed upon the input circuits of tube 922 and 924.

In response to the impression of the signaling current on the input circuit of tube 1016, relay 917 at once operates its armature to its front contact and after a delay interval, relay 928 operates its armature into engagement with its back contact, whereupon with relay 929 operated, a charging circuit is established for condenser 955 extending from battery through resistance 956 and the right winding of polarized relay 918 in parallel, left front contact of relay 928, back contact of relay 928 through condenser 955 to ground. The charging current through the right winding of relay 918 is of sufficient strength to quickly overcome the current flowing through the left or biasing winding of such relay, whereupon it moves its armature from its back contact into engagement with its front contact thereby connecting enabling ground to conductor 930 and thus to the cathodes of tubes 921 to 926, inclusive, to render such tubes responsive to the incoming signaling current. Tubes 922 and 924 now respond to operate their associated responsive relays 932 and 934. As soon as condenser 955 becomes fully charged, current will cease to flow in the right winding of relay 918 and its left winding will then again become effective to move the armature into engagement with its back contact thereby removing ground from conductor 930 to disable tubes 921 to 926, inclusive, thus the tubes are not enabled until after a predetermined interval following the receipt of the incoming signal to prevent their false operation by transient frequencies which may be present due to the establishment of the signaling circuit and are disabled after a further predetermined interval in the order of 5 milliseconds or before the end of the signal to prevent false operation by transient frequencies which may be present at the time the signaling circuit is opened.

Responsive relay 932 upon operating establishes a locking circuit for itself from battery through the winding of translator relay 804 over conductor 812, the left winding of relay 932, the No. 2 left front contact of relay 938, the front contact of relay 932 to ground on conductor 952 and relay 934 upon operating establishes a locking circuit for itself from battery through the winding of translator relay 805 over conductor 813, through the left winding of relay 934, the No. 1 right front contact of relay 938, the front

contact of relay 934 to ground on conductor 810. Translator relays 804 and 806 operate in these locking circuits.

Following the seizure of the receiving circuit and the connection of ground to conductor 724 by the energization of relay 715 and until translator relays are operated in response to the first keyed digit, relay 814 is held operated in a circuit from battery through its winding, the No. 1 lower back contact of relay 804, the No. 4 upper back contact of relay 803, the No. 4 upper back contact of relay 805, the No. 4 upper back contact of relay 807 and the No. 3 upper back contact of relay 806 to ground on conductor 724 thereby holding open the circuit for relay 815. The circuit of relay 815 may be traced from battery through the upper winding of relay 815, and the upper back contact of relay 816 and the back contact of relay 814 to ground on conductor 724.

As soon, however, as translator relays 804 and 806 operate in response to the keying of the first digit, assumed to be the digit 2, relay 814 releases but relay 816 immediately operates if but two of the translator relays have operated, in a circuit which may be traced from battery through its winding, the No. 1 upper front contact of relay 804, the No. 1 lower back contact of relay 803, the No. 1 lower back contact of relay 805, the No. 3 upper back contact of relay 807, and the No. 2 upper front contact of relay 806 to ground on conductor 724. Since relay 815 is slow to operate, it does not have sufficient time to become operated between the release of relay 814 and the subsequent operation of relay 816. If, however, more than two of the translator relays should operate, then relay 816 would fail to operate and relay 815 would then operate and lock over its inner upper contact to ground on conductor 724 for a purpose to be later described. With translator relays 804 and 806 both operated and relay 816 operated, battery is connected over the upper front contact of relay 728, conductor 749, upper back contact of relay 815, inner upper front contact of relay 816, the No. 2 lower front contact of relay 806, the No. 3 lower front contact of relay 804, through high resistance 817 and low resistance 818 in series, thence over conductor 731 to the sender and over the upper front contact of relay 816, the No. 1 upper front contact of relay 806, and the No. 2 lower front contact of relay 804 through low resistance 819 and conductor 737 to the sender. Relays in the sender respond to register the thousands digit 2 therein.

Relay 816 upon operating also establishes a circuit from ground over its lower front contact, conductor 820 and through the upper normal contacts and winding of counting relay 741 to battery through resistance 742 whereupon relay 741 operates and locks over its upper alternate contacts to ground on conductor 724 and prepares a circuit from ground over such contacts through the winding of counting relay 743 and resistance 744 to battery but relay 743 does not operate at this time since its winding is shunted over its lower back contact so long as ground remains connected to conductor 820.

Prior to the operation of relay 816, the lower windings of polarized relays 809 and 811 are energized in a circuit extending from battery over the upper normal contacts of jack 823 through the lower windings of such relays in parallel, thence over the lower normal contacts of jack 823 and the lower back contact of relay 816 to ground on conductor 724 and the upper

windings of such relays are energized in a circuit extending from battery over the upper normal contacts of jack 824 through such upper windings in series over the lower normal contacts of jack 824 and through resistance 825 to ground on conductor 724 whereby such relays are energized in such a manner as to hold their armatures against their back contacts. When, however, relay 816 operates as previously described and opens its back contact, the circuit just traced through the lower windings of relays 809 and 811 is opened and a charging circuit for condenser 821 is closed through such windings from battery as traced over the lower normal contacts of jack 823, thence through resistance 822 and condenser 821 to ground on conductor 724 whereby the charging current maintains the lower windings of relays 809 and 811 energized until condenser 821 becomes fully charged. When the charging current ceases to flow through the lower windings of these relays, the upper windings thereof become effective to move the armatures thereof to open their back contacts whereupon ground is removed from conductors 810 and 952 and responsive relays 932 and 934 and translator relays 804 and 806 release in turn releasing relay 816. The delay interval introduced by the charging time of condenser 821 thus insures that the translator relays 804 and 806 shall remain operated for a sufficient interval to cause register relays in the sender to be operated and locked. When relay 816 releases, a discharge circuit is established over its lower back contact whereby condenser 821 becomes discharged and relays 809 and 811 again cause their armatures to engage with their back contacts. Relay 816 also disconnects ground from conductor 820 whereupon counting relay 743 operates. Thus at the completion of the registration of the first or thousands digit, both counting relays 741 and 743 are operated and with all of the translator relays 803 to 807, inclusive, released, relay 814 is again operated over the circuit previously traced.

The operator will next momentarily depress the digit key 329 to register the digit 3 whereupon current of the two frequencies 1300 and 1500 cycles, as indicated in the preceding table, will be impressed from the primary winding of transformer 3 upon the circuit which may be traced from the right terminal of the secondary winding of such transformer over conductor 422, the inner lower back contact of switching relay 504, conductor 522, the inner lower front contact of switching relay 514, conductor 326, resistance 327, the left contacts of key 329, the inner upper back contact of relay 314, the right windings of repeating coil 317, the inner lower back contact of relay 314, the right contacts of key 329, resistance 330, conductor 331, the lower front contact of relay 514, conductor 523, the lower back contact of relay 504 and conductor 423 to the left terminal of the secondary winding of transformer 3. In the manner previously described the signaling current is transmitted to the receiving circuit and causes the functioning of the enabler circuit thereat and is impressed through the filters 904 and 905 upon the input circuits of tubes 924 and 925 which upon being enabled by the enabler circuit cause the operation of the associated responsive relays 934 and 935. Relay 934 upon operating closes a locking circuit for itself extending from battery through the winding of translator relay 806 over conductor 813, the left winding of relay 934, the No. 1 right front contact of relay 938, the front contact of relay

934, conductor 810 over the back contact of relay 809 to ground on conductor 724 and relay 935 in operating closes a locking circuit for itself extending from battery through the winding of translator relay 807 over conductor 826, through the left winding of relay 935, the No. 2 right front contact of relay 938, the front contact of relay 935, to ground on conductor 810. Translator relays 806 and 807 operate in these locking circuits.

Upon the operation of these translator relays, relay 814 releases and if only the two translator relays 806 and 807 have operated, relay 816 again operates in a circuit which may be traced from battery through its winding, the No. 2 upper back contacts of relay 804, the No. 3 upper back contact of relay 803, the No. 3 upper back contact of relay 805, the No. 2 upper front contact of relay 807 and the No. 2 upper front contact of relay 806 to ground on conductor 724. Since relay 816 will operate immediately following the release of relay 814, slow-to-operate relay 815 will not have sufficient time to operate. Relay 816 upon operating connects battery from conductor 740 over the upper back contact of relay 815, over its own upper front contact, the No. 1 lower contact of relay 806, the No. 3 lower contact of relay 807, through low resistance 819 and over conductor 737 to the sender and connects battery over its inner upper front contact, the No. 2 lower contact of relay 807, the No. 3 lower contact of relay 806 through low resistance 827 and over conductor 732 to the sender. Relays in the sender are thereupon operated to register the second, or hundreds, digit 3. Relay 816 also connects ground to conductor 820 which becomes connected over the lower front contact of counting relay 743 to a point between the winding of counting relay 741 and resistance 742 thereby shunting down relay 741. Relay 741 upon releasing recloses its upper normal contacts thereby establishing a holding circuit for relay 743 to ground on conductor 820 so long as relay 816 remains operated and establishes a circuit for counting relay 745 extending from battery through the winding of relay 745, over the lower back contact of relay 741 and the inner upper front contact of relay 743 to ground on conductor 724. Relay 745 thereupon operates and locks over its upper front contact to ground on conductor 724 and at its lower front contact prepares an operating circuit for counting relay 738. The operation of relay 745 is indicative of the fact that two digits have been received and registered.

Relay 816 also causes the delayed operation of polarized relays 809 and 811 in the manner previously described to open the locking circuits over which the operated responsive relays 934 and 935 and the translator relays 806 and 807 have been maintained operated following the release of the operated key 329 of the keyset and the termination of the code digit signal. Such relays therefore release in turn releasing relay 816, reoperating relay 814 and restoring relays 809 and 811 to their normal condition. Relay 816 upon releasing removes ground from conductor 820 whereupon counting relay 743 releases.

The operator will next momentarily depress the digit key 332 to register the tens digit 6 whereupon current of the two frequencies 700 and 1100 cycles, as indicated in the preceding table, is impressed from the primary winding of transformer 6 upon the circuit which may be traced from the right terminal of the secondary

winding of such transformer over conductor 424, the lower back contact of switching relay 503, conductor 524, the lower front contact of switching relay 513, conductor 333, through resistance 334, over the left contacts of operated key 332, the inner upper back contact of relay 314, the right windings of repeating coil 317, the inner lower back contact of relay 314, the right contacts of key 332, through resistance 335, conductor 336, the upper front contact of switching relay 512, conductor 525, the upper back contact of switching relay 502 and conductor 425 to the left terminal of the secondary winding of transformer 6. In the manner previously described the signaling current is transmitted to the receiving circuit and causes the functioning of the enabler circuit and is impressed through the filters 901 and 903 upon the input circuits of tubes 921 and 923 which upon being enabled by the enabler circuit cause the operation of the associated responsive relays 931 and 933. Relay 931 upon operating closes a locking circuit for itself extending from battery through the winding of translator relay 803 over conductor 828 through the left winding of relay 931, the No. 1 left front contact of relay 938, the front contact of relay 931, conductor 952 and over the normal contact of relay 811 to ground on conductor 739 and relay 933 upon operating closes a locking circuit for itself extending from battery through the winding of translator relay 805 over conductor 829 through the left winding of relay 933, the No. 3 left front contact of relay 938, the front contact of relay 933 to ground on conductor 952. Translator relays 803 and 805 operate in these locking circuits.

Upon the operation of these translator relays, relay 814 releases and if only the two translator relays 803 and 805 have operated, relay 816 again operates in a circuit which may be traced from battery through its winding, the No. 2 upper back contact of relay 804, the No. 2 upper front contact of relay 803, the No. 2 lower front contact of relay 805, the No. 4 upper back contact of relay 807 and the No. 3 upper back contact of relay 806 to ground on conductor 724. Since relay 816 will operate immediately following the release of relay 814, slow-to-operate relay 815 will not have sufficient time to operate. Relay 816 upon operating connects battery from conductor 740 over the upper back contact of relay 815, over its own upper front contact, the No. 1 upper front contact of relay 805, through high resistance 830 and low resistance 819 and over conductor 737 to the sender and over its inner upper front contact, the No. 3 lower contact of relay 805, the No. 3 lower front contact of relay 803, through low resistance 818 and over conductor 731 to the sender. Relays in the sender are thereupon operated to register the third, or tens, digit 6. Relay 816 also connects ground to conductor 820 which again causes counting relay 741 to operate and lock as before described to prepare the operating circuit for counting relay 743. Relay 816 also causes the delayed operation of polarized relays 809 and 811 in the manner previously described to open the locking circuits over which the operated responsive relays 931 and 933 and the translator relays 803 and 805 have been maintained operated following the release of the depressed key 332 of the key-set and the termination of the code digit signal. These relays thereupon release in turn releasing relay 816, reoperating relay 814 and restoring relays 809 and 811 to their normal condition. Relay 816 upon releasing and removing

ground from conductor 820, permits counting relay 743 to operate in the locking circuit of counting relay 741. With counting relays 741, 743 and 745 all operated, a circuit is established for counting relay 738 which may be traced from battery through its winding over the lower front contacts of relays 745 and 741 and over the inner upper front contact of relay 743 to ground on conductor 724. Relay 738 upon operating locks over its front contact, the inner upper front contact of relay 728 and the upper front contact of relay 715 to ground. The operation of relay 738 is indicative of the fact that three digits have been received and registered.

The operator will next momentarily depress the digit key 337 to register the units digit 9 whereupon current of the two frequencies 700 and 1500 cycles, as indicated in the preceding table, is impressed from the primary winding of transformer 9 upon the circuit which may be traced from the right terminal of the secondary winding of such transformer, over conductor 426, the upper back contact of switching relay 501, conductor 523, the upper front contact of switching relay 511, conductor 338, resistance 339, the left contacts of key 337, the inner upper back contact of relay 314, the right windings of repeating coil 317, the inner lower back contact of relay 314, the right contacts of key 337, resistance 340, conductor 341, the middle upper front contact of relay 511, conductor 527, the middle upper back contact of relay 501 and conductor 427 to the left terminal of the secondary winding of transformer 9. In the manner previously described the signaling current is transmitted to the receiving circuit and causes the functioning of the enabling circuit and is impressed through the filters 901 and 905 upon the input circuits of tubes 921 and 925 which upon being enabled by the enabler circuit cause the operation of the associated responsive relays 931 and 935. Relay 931 upon operating closes a locking circuit for itself extending from battery through the winding of translator relay 803 over conductor 823 through the left winding of relay 931, the No. 1 left front contact of relay 938, the front contact of relay 931, conductor 952 and over the normal contact of relay 811 to ground on conductor 739 and relay 935 upon operating closes a locking circuit for itself extending from battery through the winding of translator relay 807 over conductor 825 through the left winding of relay 935, over the No. 2 right front contact of relay 938, the front contact of relay 935, conductor 810 and over the normal contact of relay 809 to ground on conductor 739. Translator relays 803 and 807 operate in these locking circuits.

Upon the operation of these translator relays relay 814 releases and if only the two translator relays 803 and 807 have operated, relay 816 again operates in a circuit which may be traced from

battery through its winding, the No. 2 upper back contact of relay 804, the No. 2 upper front contact of relay 803, the No. 1 lower back contact of relay 805, No. 1 upper front contact of relay 807 and the No. 3 upper back contact of relay 806 to ground on conductor 724. Since relay 816 will operate immediately following the release of relay 814, slow-to-operate relay 815 will not have sufficient time to operate. Relay 816 upon operating connects battery from conductor 740 over the upper back contact of relay 815, over its own upper front contact, the No. 1 lower front contact of relay 807, the No. 2 lower front contact of relay 803, through high resistance 830 and low resistance 819 to conductor 737 extending to the sender and over its next-to-upper front contact, the No. 2 lower front contact of relay 807, through high resistance 831 and low resistance 827 to conductor 732 extending to the sender. Relays in the sender are thereupon operated to register the fourth, or units, digit 9. Relay 816 also connects ground to conductor 820 and with counting relay 743 operated causes ground to become connected over the lower front contact of relay 743 to a point between resistance 742 and the winding of relay 741, whereupon the winding of relay 741 becomes shunted and such relay releases. Following the release of relay 741, relay 743 is maintained operated in a circuit from battery through resistance 744, through its winding and over the upper normal contacts of relay 741 to ground on conductor 820 so long as relay 816 remains operated. Relay 816 also causes the delayed operation of polarized relays 809 and 811 in the manner previously described to open the locking circuits over which the operated responsive relays 931 and 935 and the translator relays 803 and 807 have been maintained operated following the release of the depressed key 337 and the termination of the code digit signal. These relays thereupon release in turn releasing relay 816, reoperating relay 814 and restoring relays 809 and 811 to their normal condition. Relay 816 upon releasing also removes ground from conductor 820 whereupon counting relay 743 releases. With counting relay 738 operated and counting relay 743 released ground is removed from conductor 739 so that with relays 809 and 811 restored to their normal condition ground is not connected to conductors 810 and 952 and the subsequent operation of responsive relays 931 to 936, inclusive, is without effect.

In the foregoing discussion the operation of the translator relays 803 to 807, inclusive, and the manner in which either high or low resistance battery is connected to the register control conductors 731, 732 and 737 have been described in connection with signals having the digit values 2, 3, 6 and 9. By reference to the following table the manner in which the translator relays control other digit registrations may be ascertained:

Table II

Digit	Responsive relays operated	Translator relays operated	Battery condition on control conductors—		
			731	732	737
0.....	931, 932	803, 804	Open.....	Open.....	Low resistance.
1.....	931, 934	803, 806	Low resistance.	do.....	Do.
2.....	932, 934	804, 806	High resistance.	do.....	Do.
3.....	934, 935	806, 807	Open.....	Low resistance.	Do.
4.....	932, 935	804, 807	do.....	High resistance.	Do.
5.....	933, 934	805, 806	do.....	Open.....	High resistance.
6.....	931, 933	803, 805	Low resistance.	do.....	Do.
7.....	932, 933	804, 805	High resistance.	do.....	Do.
8.....	933, 935	805, 807	Open.....	Low resistance.	Do.
9.....	931, 935	801, 807	do.....	High resistance.	Do.

If during the reception and translation of the code digit signals, relay 814 had failed to operate indicating that some one or more of the translator relays 803 to 807, inclusive, had failed to release or relay 816 had failed to operate indicating either that only one translator relay or more than two of the translator relays had operated in response to a digit signal, then relay 815 would have operated over its upper winding. Also had the responsive relay 936 been erroneously operated by a premature operation of the start key at the operator's key-set circuit, then a circuit would have been established from battery through the lower winding of relay 815, over conductor 832 through the left winding of relay 936, the No. 4 right alternate contacts of relay 938, the front contact of relay 936, the No. 3 right front contact of relay 938, conductor 810 and thence over the normal contact of relay 809 to ground on conductor 739. Relay 815 upon operating locks over its inner upper front contact to ground on conductor 724; at its back contact opens the connection from battery on conductor 740 to the upper contacts of relay 816 to prevent the connection of battery to any of the leads 731, 732 and 737 extending to the sender; establishes the circuit of peg-count register 833 over its lower front contact to register a false translation condition; closes a circuit from ground over its upper front contact to battery through lamp 834 to indicate to the maintenance man a false translation condition and establishes a reorder signaling circuit from ground over its inner lower front contact, conductor 835, through the winding of relay 746 thence over the tip conductor 722 to the link circuit where a relay responds, in the same manner as though a "B" completing operator had keyed a reorder signal, to cause the advance of the sequence switch of the incoming selector to position 15, in which position relay 717 is intermittently operated over a circuit extending from ground through interrupter 756, contacts of cam 757 to battery through the lower winding of relay 717. Relay 717 controls the intermittent operation of relay 749 in a circuit extending over contacts of cam 752 thereby causing the intermittent operation of relay 703 to intermittently increase and reduce the resistance of the sleeve circuit extending as previously traced through the windings of relays 219 and 220 in the operator's position circuit. Marginal relay 219 now releases and reoperates intermittently thereby flashing the cord lamp 222 as a signal to the operator that she should pull down the cord circuit plug 224 from the trunk jack and reestablish the desired connection. Relay 746 upon operating connects holding ground to conductor 725 thereby holding make-busy relay 801 operated until the link circuit has been advanced to release the receiving circuit.

It will be recalled that make-busy relay 801 operated following the seizure of the receiving circuit by the link circuit and upon operating disconnected battery through resistance 800 for making the receiving circuit busy to all other link circuits. At its lower front contact relay 801 also connected ground on conductor 725 over conductor 836 to the armature contact of interrupter 837 thereby closing the circuit of relay 838 as soon as such interrupter closes its lower contact. Relay 838 upon operating locked over its lower contact to ground on conductor 836 and over its upper contact prepared a circuit for operating relay 839 which became completed as soon as interrupter 837 thereafter closed its up-

per contact. Thus following the operation of make-busy relay 801 a time interval is measured before relay 839 is operated to allow sufficient time for the receiving and translating functions of the receiving circuit to be completed. If relay 839 operates it causes the operation of relay 746 to perform the function previously described, lights the time alarm lamp 840 and connects ground to the time alarm lead 841.

Should all receiving circuits be busy at any time and consequently the make-busy relays 801 thereof all be operated, the circuits controlled thereby over conductors such as 842 for relay 747 will be opened whereupon relay 747 will release to establish the circuit of register 748 to register an all-circuits-busy condition.

After the sender has received the complete registration the link circuit sequence switch is advanced by the sender to a position to release the receiving circuit and the sender then proceeds in the usual manner to control the switching mechanism to complete the connection in accordance with the digit registrations which have been set up therein, whereupon the connection between the link circuit and the sender and between the link circuit and the trunk become released.

At the operator's key-set circuit following the keying of the last, or units, digit on the key-set 310, the operator momentarily depresses the start key 342 thereby closing an obvious circuit over the alternate contacts of such key for start relay 313 which operates and locks over its inner upper front contact to ground at the lower front contact of relay 312 and at its upper transfer contacts transfers the holding circuit for relay 312 from ground at the No. 3 upper back contact of relay 300 to ground over the left contacts of key 342 so that relay 312 is now maintained operated under the control of key 342. Relay 313 also establishes a new holding circuit for relay 303 extending from battery through the winding of such relay, the No. 1 lower contacts thereof, the upper contacts of relay 313, the No. 1 upper contacts of relay 303, conductor 309, the lower contacts of relay 218 and conductor 311 to ground at the No. 3 upper back contact of relay 300. At its lower front contact relay 313 connects non-inductive resistance 343 in parallel with the winding of relay 312 to render it slow to release and at its other lower front contacts establishes a signaling circuit from the right terminal of the secondary winding of transformer ST over conductor 428, the inner upper back contact of switching relay 501, conductor 528, the inner upper front contact of switching relay 511, conductor 344, through resistance 345, the inner lower front contact of relay 313, the inner lower back contact of relay 314, through the right windings of repeating coil 317, the inner upper back contact of relay 314, the middle lower front contact of relay 313, resistance 346, conductor 347, over the lower front contact of relay 511, conductor 529, the lower back contact of relay 501 and conductor 429 to the left terminal of the secondary winding of transformer ST. Since the primary winding of this transformer is supplied with current of the two frequencies 1500 and 1700 cycles, a signal of such frequencies is transmitted. It is to be noted, however, that in the specific circuits illustrated this signal is ineffective but is required when senders are provided in which line designations having different numbers of digits may be registered in order to inform such send-

ers when no further digit signals are to be expected.

As soon as the operator releases the key 342, relay 313 releases followed after an interval by the release of relays 312 and 303. The operator's key-set circuit is now restored to its normal condition. Since the present invention does not involve the supervisory features of the cord circuit and of the position circuit no detailed description thereof will be given herein. The release of the established connection proceeds in the usual manner following the termination of the conversation upon the withdrawal of the cord circuit plugs 200 and 224 from the trunk jacks 201 and 700.

What is claimed is:

1. In a telephone system, a plurality of operators' positions divided into two groups, a key-set circuit at each operator's position, two groups of signaling current sources one of which is normally connected with the key-set circuits of one of said groups of positions and the other of which is normally connected with the key-set circuits of the other of said groups of positions, and switching means for removing either one of said groups of sources from service and for connecting the other of said groups of sources to the key-set circuits of both groups of positions.

2. In a telephone system, a plurality of operators' positions divided into two groups, a key-set circuit at each operator's position, two groups of signaling current sources one of which is normally connected with the key-set circuits of one of said groups of positions and the other of which is normally connected with the key-set circuits of the other of said groups of positions, two groups of switching relays for removing either one of said groups of sources from service and for connecting the other of said groups of sources to the key-set circuits of both groups of positions, keys for controlling the operation of said groups of switching relays and lamps for indicating which of said groups of sources has been removed from service.

3. In a telephone system, a plurality of operators' positions divided into two groups, a key-set circuit at each operator's position, two groups of signaling current sources one of which is normally connected with the key-set circuits of one of said groups of positions and the other of which is normally connected with the key-set circuits of the other of said groups of positions, two groups of switching relays for removing either one of said groups of sources from service and for connecting the other of said groups of sources to the key-set circuits of both groups of positions, and means automatically effective upon the failure of any one of said sources to operate one group of said switching relays to remove from service the entire group in which said source is included.

4. In a telephone system, a plurality of operators' positions divided into two groups, a key-set circuit at each operator's position, two groups of signaling current sources one of which is normally connected with the key-set circuits of one of said groups of positions and the other of which is normally connected with the key-set circuits of the other of said groups of positions, two groups of switching relays for removing either one of said groups of sources from service and for connecting the other of said groups of sources to the key-set circuits of both groups of positions, means automatically effective upon the failure of any one of said sources to operate one of

said groups of switching relays to remove from service the entire group in which said source is included, means to give an alarm that such failure has occurred and means to indicate which of said sources has failed.

5. In a telephone system, a plurality of operators' positions divided into two groups, a key-set circuit at each operator's position, two groups of signaling current sources one of which is normally connected with the key-set circuits of one of said groups of positions and the other of which is normally connected with the key-set circuits of the other of said groups of positions, two groups of switching relays for removing either one of said groups of sources from service and for connecting the other of said groups of sources to the key-set circuits of both groups of positions, a signal lamp individual to each of said sources, alarm circuits, means automatically effective upon the failure of any one of said sources to operate the signal lamp individual thereto, to close said alarm circuits and to operate one of said groups of switching relays to remove from service the entire group in which said source is included, a guard lamp, a key operable to open said alarm circuits, to hold said switching relays operated and to light said guard lamp until such time as said individual lamp signal becomes extinguished to indicate that the defective source has again been rendered operative.

6. In a telephone system, a plurality of operators' positions divided into two groups, a key-set circuit at each operator's position, two groups of signaling current supply circuits one of which is normally connected with the key-set circuits of one of said groups of positions and the other of which is normally connected with the key-set circuits of the other of said groups of positions, two groups of switching relays for disconnecting either one of said groups of circuits and for connecting the other of said groups of circuits to the key-set circuits of both groups of positions, two similar groups of vacuum tube oscillators for generating currents of different frequencies, the output circuits of each group of tubes being selectively associated with a corresponding group of said supply circuits, corresponding groups of gaseous discharge devices, said devices being associated respectively with the output circuits of said oscillator tubes, an anode relay in the output circuit of each device and normally maintained operative thereby when the associated oscillator tube is in an operative condition, and means operative upon the release of any relay indicating the failure of the associated oscillator tube to operate a group of said switching relays to disconnect the group of supply circuits extending from the group of tubes including the tube which has failed.

7. In a telephone system, a plurality of operators' positions divided into two groups, a key-set circuit at each operator's position, two groups of signaling current supply circuits one of which is normally connected with the key-set circuits of one of said groups of positions and the other of which is normally connected with the key-set circuits of the other of said groups of positions, two groups of switching relays for disconnecting either one of said groups of circuits and for connecting the other of said groups of circuits to the key-set circuits of both groups of positions, two similar groups of vacuum tube oscillators for generating currents of different frequencies, the output circuits of each group of tubes being selectively associated in different combinations

of two to each supply circuit of the corresponding group of supply circuits, groups of gaseous discharge devices corresponding to said groups of tubes, each of said devices being connected to the output circuit of one of said tubes and having an anode relay in its output circuit normally maintained operative thereby when the associated oscillator tube is in an operative condition, a lamp associated with each anode relay and a relay common to the anode relays of each group of devices for controlling said groups of switching relays respectively whereby upon the failure of any tube and the anode relay of the corresponding discharge device releases to close the circuit of the associated lamp and of said common relay thereby operating the group of switching relays to disconnect the group of supply circuits extending from the group of tubes including the tube which has failed.

8. In a telephone system, a first office having a key-set circuit comprising a key-pulsing key and a plurality of digit keys and a signaling current supply circuit for supplying signaling currents, each of a plurality of different frequencies, to said key-set circuit, a second office, means for establishing a connection between said offices, and means at said second office for completing connections incoming thereto from said first office including a key-pulsing receiving circuit comprising a plurality of receiving channels each tuned to be responsive to a different frequency component of incoming signals, an electronic device in each of said channels having an anode relay in the output circuit thereof, a register controlling circuit controlled by each of said relays and a relay jointly controlled by a predetermined number of said anode relays in response to a preliminary key-pulsing signal transmitted by the operation of said key-pulsing key to render said register controlling circuits effective upon the reception of subsequent signals.

9. In a telephone system, a first office having a key-set circuit comprising a key-pulsing key and a plurality of digit keys and a signaling current supply circuit for supplying signaling currents, each of a plurality of different frequencies, to said key-set circuit, a second office, means at said second office for completing connections incoming thereto from said first office including a key-pulsing receiving circuit comprising a plurality of receiving channels each tuned to be responsive to a different frequency component of incoming signals, an electronic device in each of said channels having an anode relay in the output circuit thereof, a register controlling circuit controlled by each of said relays, a first relay controlled jointly by predetermined ones of said anode relays in response to a preliminary key-pulsing signal transmitted by the operation of said key-pulsing key to render said register controlling circuits effective upon the reception of subsequent signals, and a further relay operable through the operation of others of said anode relays, if other signaling frequencies are received together with the frequencies of the key-pulsing signal, to prevent the operation of said first relay or to release it if it has operated to render the register controlling circuits ineffective.

10. In a telephone system, a first office having a key-set circuit comprising a key-pulsing key and a plurality of digit keys and a signaling current supply circuit for supplying signaling currents, each of a plurality of frequencies, to said key-set circuit, a second office, means for establishing a connection between said offices and

means at said second office for completing connections incoming thereto from said first office including a key-pulsing receiving circuit comprising a plurality of receiving channels each tuned to be responsive to a different frequency component of incoming signals, an electronic device in each of said channels having an anode relay in the output circuit thereof, register controlling circuits controlled respectively by said anode relays, a first relay controlled jointly by predetermined ones of said anode relays in response to a preliminary key-pulsing signal transmitted by the operation of said key-pulsing key, a second relay operable in response to said first relay to extend said register controlling circuits over its front contacts, and a third relay operable over the back contacts of said second relay in response to the operation of others of said anode relays, if other frequencies are received together with the frequencies of the key-pulsing signal, to prevent the operation of the first and second relays or to release them if operated to render said register controlling circuits ineffective.

11. In a telephone system, a first office having a key-set circuit and a signaling current supply circuit for supplying signaling currents, each of a plurality of different frequencies, to said key-set circuit, a second office, means for establishing a connection between said offices, and means at said second office for completing connections incoming thereto from said first office including a key-pulsing receiving circuit comprising a plurality of receiving channels each tuned to be responsive to a different frequency component of incoming signals, an electronic device in each of said channels having an anode relay in the output circuit thereof, a plurality of translator relays corresponding in number to said anode relays, and an operating circuit for each of said translator relays closed upon the operation of the corresponding anode relay over the contacts and through a locking winding of said anode relay.

12. In a telephone system, a first office having a key-set circuit and a signaling current supply circuit for supplying signaling currents, each of a plurality of different frequencies, to said key-set circuit, a second office, means for establishing a connection between said offices, and means at said second office for completing connections incoming thereto from said first office including a key-pulsing receiving circuit comprising a plurality of receiving channels each tuned to be responsive to a different frequency component of incoming signals, an electronic device in each of said channels, an anode relay associated with each of said devices having a polarizing winding, an operating winding and a locking winding, an operating circuit for each of said anode relays including its operating winding and the cathode-anode path through the associated electronic device and an operating circuit for each of said translator relays closed upon the operation of the corresponding anode relay over the contacts and through the locking winding of said anode relay.

13. In a telephone system, a first office having a key-set circuit comprising a key-pulsing key and a plurality of digit keys and a signaling current supply circuit for supplying currents, each of a plurality of different frequencies, to said key-set circuit, a second office, means for establishing a connection between said offices, and means at said second office for completing connections incoming thereto from said first office including a key-pulsing receiving circuit comprising a plurality of receiving channels each

tuned to be responsive to a different frequency component of incoming signals, an electronic device in each of said channels, an enabling channel responsive to all incoming signals, means controlled by said enabling channel for rendering said electronic devices responsive a predetermined interval following the receipt of any signal, means operative upon the response of certain only of said channels to a preliminary key-pulsing signal for disabling said electronic devices, and means controlled by said enabling channel in response to each subsequent incoming signal for disabling said electronic devices a predetermined interval after they have been rendered responsive.

14. In a telephone system, a first office having a key-set circuit comprising a key-pulsing key and a plurality of digit keys and a signaling current supply circuit for supplying currents, each of a plurality of different frequencies, to said key-set circuit, a second office, means for establishing a connection between said offices, and means at said second office for completing connections incoming thereto from said first office including a key-pulsing receiving circuit comprising a plurality of receiving channels each tuned to be responsive to a different frequency component of incoming signals, an electronic device in each of said channels having an anode relay in the output circuit thereof, an enabling channel responsive to all incoming signals, means controlled by said enabling channel for rendering said electronic devices responsive a predetermined interval following the receipt of any signal, a relay operable in response to the operation of a predetermined plurality of said anode relays upon the receipt of a preliminary key-pulsing signal for disabling said electronic devices, and means controlled by said enabling channel in response to each incoming signal received subsequent to the operation of said latter relay for disabling said electronic devices a predetermined interval after they have been rendered responsive.

15. In a telephone system, a first office having a key-set circuit comprising a key-pulsing key and a plurality of digit keys and a signaling current supply circuit for supplying currents, each of a plurality of different frequencies, to said key-set circuit, a second office, means for establishing a connection between said offices, and

means at said second office including a key-pulsing receiving circuit comprising a plurality of receiving channels each tuned to be responsive to a different frequency component of incoming signals, an electronic device in each of said channels having an anode relay in the output circuit thereof, an enabling channel responsive to all incoming signals, timing relays associated with said enabling channel and operable to render said electronic devices responsive a predetermined interval following the receipt of any signal, a relay operable in response to the operation of a predetermined plurality of said anode relays upon the receipt of a preliminary key-pulsing signal for disabling said electronic devices, and a further timing relay responsive following the operation of said other timing relays on all incoming signals received subsequent to the operation of said latter relay for measuring a predetermined interval during which said electronic devices are maintained responsive.

16. In a telephone system, a first office having a key-set circuit comprising a key-pulsing key and a plurality of digit keys and a signaling current supply circuit for supplying currents, each of a plurality of different frequencies, to said key-set circuit, a second office, means for establishing a connection between said offices, and means at said second office including a key-pulsing receiving circuit comprising a plurality of receiving channels each tuned to be responsive to a different frequency component of incoming signals, a gas-filled tube in each of said channels having an anode relay in the cathode-anode circuit thereof, an enabling channel responsive to all incoming signals, timing relays associated with said enabling channel and operable to connect enabling ground to the control electrodes of said tubes a predetermined interval following the receipt of any signal, a relay operable in response to the operation of a predetermined plurality of said anode relays upon the receipt of a preliminary key-pulsing signal for disconnecting said enabling ground, and a further timing relay responsive following the operation of said other timing relays on all incoming signals received subsequent to the operation of said latter relay for measuring a predetermined interval during which said enabling ground remains connected to the control electrode of said tubes.

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