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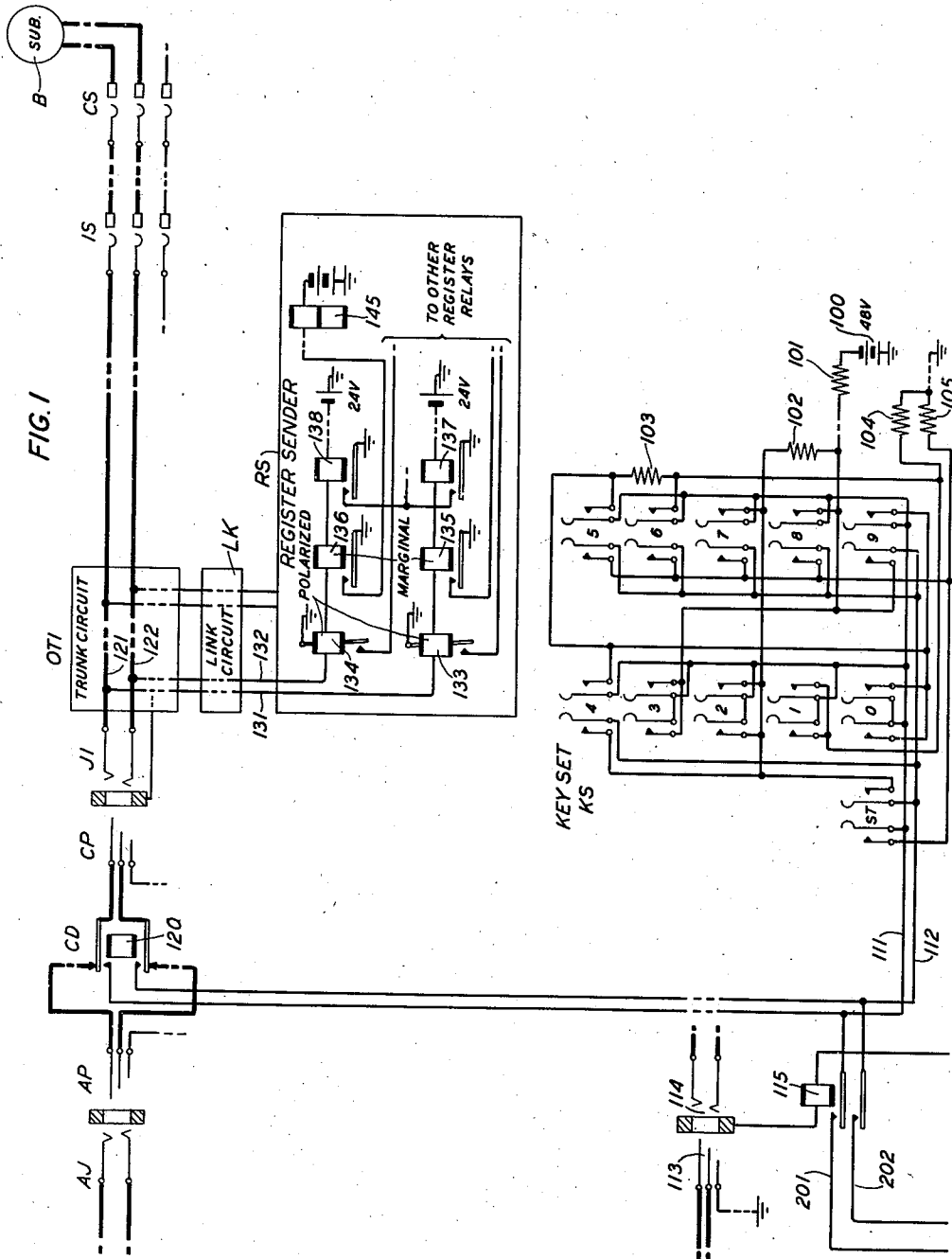
H. E. VAUGHAN

2,352,142

SIGNALING SYSTEM

Filed June 29, 1943

2 Sheets-Sheet 1



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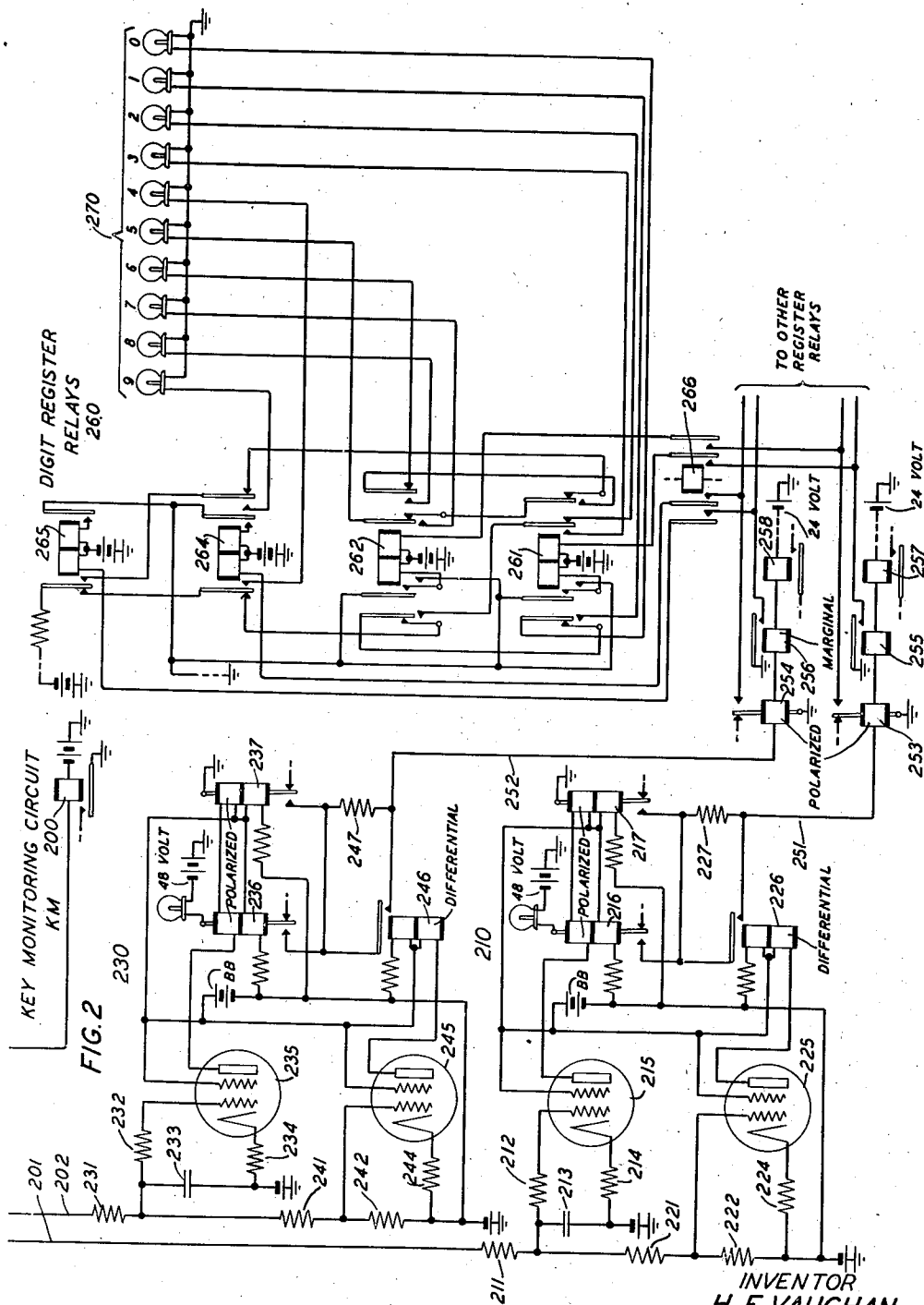
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SIGNALING SYSTEM

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12 Claims. (Cl. 179—175.2)

This invention relates to selective switching systems and particularly to signal repeating and key monitoring in automatic telephone systems.

Objects of the invention are the provision of new and improved signal receiving means in automatic telephone systems and the provision of a key monitoring circuit arrangement which does not interfere with the transmission of key-set signals. Another object is an increase in the length of line over which key-set signals may be satisfactorily transmitted.

One feature of the invention is a key monitoring apparatus comprising means adapted to repeat key-set signal impulses, the arrangement having a high impedance so as not to interfere with the transmission of the signals and establishment of desired connections. Another feature of the invention is a signal receiving circuit arrangement comprising vacuum tubes and relays responsive to polarized and marginal key-set signal impulses transmitted over each of the two conductors of a trunk line.

A clear and complete understanding of these and other features of the invention will be facilitated by a description of a system in which the invention is embodied, one such system being represented schematically in the drawings which form a part of this specification. The invention is not limited in its application to the system shown in the drawings but is generally applicable to any signaling system arranged to transmit polarized and marginal signal impulses.

Referring to the drawings:

Fig. 1 shows an operator's position comprising a cord CD and a key-set KS, an outgoing trunk circuit OTI, link LK, register sender RS, incoming selector switch IS, connector switch CS, and a called subscriber's line and station B; and

Fig. 2 shows a key monitoring circuit KM comprising means for registering and indicating the digits transmitted by the operation of the key-set KS of Fig. 1.

The operator's position comprising the cord CD and key-set KS may be one of a plurality of similarly equipped positions of a dial system A switchboard or of a toll or other manual office. Reference may be had to Patent No. 1,916,760, granted to I. H. Henry, July 4, 1933, for a complete disclosure of an operator's cord, position and key-set circuits. The outgoing trunk circuit OTI, link LK, and register sender RS may also be similar to those shown in detail in the aforementioned Henry patent. The selector and connector switches IS and CS may be of the well-known two-motion step-by-step type. Reference may be

had to the 2nd edition of "Automatic telephony" by Smith and Campbell, pages 53 to 65 for a description of such switches and their operation when used as selectors and connectors.

The key monitoring circuit KM, which is similar to that disclosed in Patent No. 1,753,348, granted to J. B. Newsom, April 8, 1930, comprises two vacuum tube units 210 and 230 which are connected respectively to the tip and ring conductors of the key-set KS in parallel with the register relays of a register sender by a relay 115 which is operated responsive to the insertion of a plug 113 in the monitoring jack 114. The key monitoring circuit KM further comprises sets of digit register relays and lamps for registering and indicating the digits which are being transmitted to the register sender by operation of the key-set KS, only one of these sets of register relays and lamps being shown. The key monitoring circuit KM further comprises relays 253, 255 and 257 which are controlled by vacuum tube unit 210 and relays 254, 256 and 258 which are controlled by vacuum tube unit 230 for operating the sets of register relays. These relays, 253 to 258 inclusive, are similar to relays 133 to 138, inclusive, of the register sender RS. Each of relays 133, 134, 253 and 254 is a polarized relay which is operated only responsive to the connection of 48-volt battery to the associated one of conductors 131, 132, 251 and 252. Each of relays 135, 136, 255 and 256 is a marginal relay which is operated only when ground or 48-volt battery is connected through a low resistance to the associated one of conductors 131, 132, 251 and 252. Each of relays 137, 138, 257 and 258 is a sensitive, non-polarized relay which is operatively energized whenever either ground or 48-volt battery is connected to the associated one of conductors 131, 132, 251 and 252. The unit 210 comprises two, stabilized, negative-feedback, direct-current amplifiers 215 and 225, one for distinguishing between positive and negative signals and the other for distinguishing between the connection of ground or battery to conductor 201 through a low resistance and the connection of ground or battery to conductor 201 through a high resistance. The control grids of tubes 215 and 225 are connected to conductor 201 through a resistor 211 and are shunted by a condenser 213, this arrangement being effective to minimize the effects of transients produced by operation of the keys of key-set KS. The connection between the control grid of tube 225 and conductor 201 includes resistor 221 in series with resistor 211. The repeater unit 210 further comprises two polarized relays 216 and 217 controlled by tube 215

and a relay 226 controlled by tube 225. Each of relays 216 and 217 has two windings, the upper winding being connected in series with the plate of tube 215. The energization of the lower windings of relays 216 and 217 is constant in value and opposes the energization of the upper windings. When the 48-volt battery 100 is connected by the operation of a key of key-set KS to conductor 111, the grid of tube 215 becomes more negative with respect to the cathode and the plate current decreases sufficiently to effect the operation of relay 216; and when ground potential is applied by the operation of a key of key-set KS to conductor 111, the grid of tube 215 becomes more positive with respect to the cathode and the plate current increases sufficiently to effect the operation of relay 217. The resistor 214 connected in series with the cathode provides the desired grid bias and negative feedback and provides compensation for variation in the battery voltage. Relay 226 is a differential relay the lower winding being connected in series with the plate of tube 225. The energization of the upper winding of relay 226 is neutralized by the energization of the lower winding of relay 226 by the normally existing current in the plate circuit of tube 225; but when the plate circuit is either increased or decreased responsive to the operation of a key of key-set KS, relay 226 operates. Relays 216, 217 and 226 are thus controlled by tubes 215 and 225 to repeat to relays 253, 255 and 257 the key-set impulses which are transmitted over conductor 111 to relays 133, 135 and 137 of the register sender.

Transients over conductor 201 are largely due to the inductance of the windings of the impulse receiving relays connected to conductor 111 in the attached register sender. At the instant a key-set key is operated to transmit an impulse over conductor 111, the windings of these relays constitute a very high impedance and there is only a small voltage drop through the resistors at the key-set. Thus the voltage impressed on conductor 201, at the beginning of a key-set impulse over conductor 111, is substantially equal to the full battery voltage. The condenser 213 constitutes a low impedance at the beginning of an impulse and therefore the drop in voltage across resistor 211 is nearly equal to the battery voltage. Condenser 213 absorbs this transient voltage and also absorbs the reverse voltage generated in the windings of the impulse receiving relays connected to conductor 111 when the depressed key-set key is restored to normal. Without resistor 211 and condenser 213, it would be impossible to distinguish between high and low resistance impulses transmitted over conductor 111; and false operations of the key monitoring register relays would also result from the opposite voltage generated in the windings of the impulse receiving relays of the register sender at the end of a key-set impulse.

The repeater unit 230 is similar to the unit 210 and is effective to repeat to relays 254, 256 and 258 the key-set impulses which are transmitted over conductor 112 to relays 134, 136 and 138 of the register sender.

Assume now that the plug 113 has been inserted in monitoring jack 114, operating relays 115 and 200. The operation of relay 115 connects conductors 111 and 112 to conductors 201 and 202 to transmit key-set impulses to the monitoring circuit KM at the same time that these impulses are transmitted to an associated register sender to control the establishment of a desired connection. The connection of the key-set

KS to the key monitoring circuit KM and operation of relay 200 prepares the monitoring circuit for response to key-set impulses, relay 266 being operated to connect the first set of register relays 260 to the contacts of relays 253, 254, 255 and 256 in similar manner to that in which the first set of register relays are connected to the impulse responsive relays in the aforementioned patent to Newsom.

When an operator inserts the calling plug CP of a cord CD in jack J1 of an outgoing trunk circuit OT1, a register sender RS is associated with the trunk circuit in the manner set forth in the aforementioned patent to Henry. Upon operation of a position key, relay 120 is operated and the key-set KS is connected through the tip and ring conductors of plug CP and conductors 121 and 122 of outgoing trunk circuit OT1 to conductors 131 and 132 of the register sender. When a register sender RS is ready to receive key-set impulses, a relay is operated and pilot lamp lighted at the operator's position, to indicate that operation of the key-set may be initiated, and battery and ground are connected to the key-set all as described in detail in the aforementioned Henry patent.

If the first digit key operated, is the key 1, a circuit is closed from ground through low resistance 104, contacts of key 1, conductor 111, tip conductor of plug CP and jack J1, conductors 121 and 131, and windings of relays 133, 135 and 137 to 24-volt battery; whereby relays 135 and 137 are operated but relay 133 is not operated. At the same time, the potential of the grid of tube 215 becomes sufficiently more positive with respect to the cathode to effect the operation of relay 217 and the potential of the grid of tube 225 becomes sufficiently more positive with respect to the cathode to effect the operation of relay 226. With relays 217 and 226 operated, ground is connected to conductor 251 to effect the operation of relays 255 and 257 without operating relay 253. The operation of relay 255 closes a circuit including a front contact of relay 266 for operatively energizing the right winding of relay 261. Relay 261 locks through its left winding and prepares a circuit for energizing the lamp 1 of lamps 270. When the key 1 is released, relays 217 and 226 release, causing the release of relays 255 and 257 but relay 261 remains operated. The operation and release of relay 257 effects the release of relay 266 and the connection of the contacts of relays 253, 254, 255 and 256 to the next set of register relays in the manner set forth in detail in the aforementioned patents to Henry and Newsom.

If the first digit key which is operated is the key 2, a circuit is closed from 48-volt battery 100, through low resistance 101, high resistance 102, contacts of key 2, and conductor 111 for operating relays 133 and 137 in the register sender. At the same time, the potential of the grid of tube 215 becomes sufficiently negative with respect to the cathode to effect the operation of relay 216; but the potential of the grid of tube 225 does not become sufficiently negative with respect to the cathode to effect the operation of relay 226. With relay 216 operated and relay 226 non-operated, 48-volt battery is connected through resistor 227 to conductor 251 to effect the operation of relays 253 and 257 without operating relay 255. The operation of relay 253 closes a circuit for operatively energizing the right winding of relay 262. Relay 262 locks

through its left winding and prepares a circuit for lighting lamp 2 of lamps 270.

If the first digit key which is operated is the key 3, a circuit is closed from 48-volt battery 100 through low resistance 101, and the contacts of key 3 for operating relays 133, 135 and 137 of the register sender; and at the same time the potential of the grids of tubes 215 and 225 is changed sufficiently to effect the operation of relays 216 and 226. With relays 216 and 226 operated, 48-volt battery is connected directly to conductor 251, causing the operation of all of relays 253, 255 and 257. The right windings of both of relays 261 and 262 are thereby operatively energized and these relays lock through their left windings and prepare a circuit for lighting lamp 3.

If the first digit key which is operated is the key 4, a circuit is closed from ground through low resistance 104, high resistance 103, right contact of key 4 and conductor 111 for operating relay 137 in the register sender without operating relays 133 and 135; and a circuit is closed from battery 100 through low resistance 101, high resistance 102, left contact of key 4 and conductor 112 for operating relays 134 and 138 in the register sender without operating relay 136. At the same time, the change in the potential of the grid of tube 215 with respect to the cathode effects the operation of relay 217 but the change in the potential of the grid of tube 225 is ineffective to cause the operation of relay 226; and the change in the potential of the grid of tube 235 with respect to the cathode effects the operation of relay 236, but the change in the potential of the grid of tube 245 with respect to the cathode is ineffective to cause the operation of relay 246. The operation of relay 217 closes a circuit through resistor 227 for operating relay 257 without operating relays 253 and 255 and the operation of relay 236 closes a circuit through resistor 247 for operating relays 254 and 258 without operating relay 256. The operation of relay 254 closes a circuit for operatively energizing the left winding of relay 264. Relay 264 locks through its right winding and prepares a circuit for lighting lamp 4.

If the first digit key which is operated is the key 5, a circuit is closed from ground through low resistance 104, high resistance 103, right contact of key 5, and conductor 111 for operating relay 137 in the register sender without operating relays 133 and 135; and a circuit is closed from ground through low resistance 105, left contact of key 5, and conductor 112 for operating relays 136 and 138 in the register sender without operating relay 134. At the same time, the change in the potential of the grid of tube 215 with respect to the cathode effects the operation of relay 217 but the change in the potential of the grid of tube 225 with respect to the cathode is ineffective to cause the operation of relay 226; and the change in the potential of the grid of tube 235 with respect to the cathode is effective to cause the operation of relay 237 and the change in potential of the grid of tube 245 with respect to the cathode is effective to cause the operation of relay 246. The operation of relay 217 causes the operation of relay 257 without operating relays 253 and 255 and the operation of relays 237 and 246 causes the operation of relays 256 and 258 without operating relay 254. The operation of relay 256 closes a circuit for operatively energizing the left winding of relay 265.

Relay 265 locks through its right winding and prepares a circuit for lighting lamp 5.

If the first digit key which is operated is the key 6, a circuit is closed from ground through low resistance 104, right contact of key 6 and conductor 111 for operating relays 135 and 137 in the register sender without operating relay 133; and a circuit is closed from ground through low resistance 105, left contact of key 6, and conductor 112 for operating relays 136 and 138 in the register sender without operating relay 134. At the same time, the change in potential of the grid of tube 215 with respect to the cathode effects the operation of relay 217; the change in potential of the grid of tube 225 with respect to the cathode effects the operation of relay 226; the change in the potential of the grid of tube 235 with respect to the cathode effects the operation of relay 237; and the change in the potential of the grid of tube 245 with respect to the cathode effects the operation of relay 246. The operation of relays 217 and 226 closes a circuit for operating relays 255 and 257 without operating relay 253; and the operation of relays 237 and 246 closes a circuit for operating relays 256 and 258 without operating relay 254. The operation of relay 255 closes a circuit for operatively energizing the right winding of relay 261; and the operation of relay 256 closes a circuit for operatively energizing the left winding of relay 265. Relays 261 and 265 close locking circuits and prepare a circuit for lighting lamp 6.

If the first digit key which is operated is the key 7, a circuit is closed from battery 100 through low resistance 101, high resistance 102, right contact of key 7 and conductor 111 for operating relays 133 and 137 in the register sender without operating relay 135; and a circuit is closed from ground through low resistance 105, left contact of key 7 and conductor 112 for operating relays 136 and 138 in the register sender without operating relay 134. At the same time, the change in the potential of the grid of tube 215 with respect to the cathode effects the operation of relay 216 but the change in the potential of the grid of tube 225 with respect to the cathode is ineffective to cause the operation of relay 226; and the change in the potential of the grid of tube 235 with respect to the cathode effects the operation of relay 237 while the change in the potential of the grid of tube 245 with respect to the cathode effects the operation of relay 246. The operation of relay 216 closes a circuit for operating relays 253 and 257 without operating relay 255; and the operation of relays 237 and 246 closes a circuit for operating relays 256 and 258 without operating relay 254. The operation of relay 253 closes a circuit for operatively energizing the right winding of relay 262 and the operation of relay 256 closes a circuit for operatively energizing the left winding of relay 265. Relays 262 and 265 lock and prepare a circuit for lighting lamp 7.

If the first digit key which is operated is the key 8, a circuit is closed from battery 100 through low resistance 101, right contact of key 8 and conductor 111 for operating relays 133, 135 and 137 in the register sender and a circuit is closed from ground through low resistance 105, left contact of key 8 and conductor 112 for operating relays 136 and 138 in the register sender without operating relay 134. At the same time, there is a change in the potential of the grid of tube 215 with respect to the cathode which causes the operation of relay 216 and a change in the poten-

tial of the grid of tube 225 with respect to the cathode which causes the operation of relay 226; and there is a change in the potential of the grid of tube 235 with respect to the cathode which causes the operation of relay 237 and a change in the potential of the grid of tube 245 with respect to the cathode which causes the operation of relay 246. The operation of relays 216 and 226 closes a circuit for operating relays 253, 255 and 257; and the operation of relays 237 and 246 causes the operation of relays 256 and 258 without operating relay 254. The operation of relays 253 and 255 closes circuits for operatively energizing the right windings of relays 261 and 262 and the operation of relay 256 closes a circuit for operatively energizing the left winding of relay 265. Relays 261, 262 and 265 lock and prepare a circuit for lighting lamp 8.

If the first digit key which is operated is the key 9, a circuit is closed from ground through low resistance 104, high resistance 103, right contact of key 9 and conductor 111 for operating relay 137 in the register sender without operating relays 133 and 135; and a circuit is closed from battery 100 through low resistance 101, left contact of key 9 and conductor 112 for operating relays 134, 136 and 138 in the register sender. At the same time, the potential of the grid of tube 215 is changed with respect to the cathode to effect the operation of relay 217, but the change in the potential of the grid of tube 225 with respect to the cathode is ineffective to cause the operation of relay 226; and the change in potential of the grid of tube 235 with respect to the cathode effects the operation of relay 236 while the change in potential of the grid of tube 245 with respect to the cathode causes the operation of relay 246. The operation of relay 217 closes a circuit through resistor 227 for operating relay 257 without operating relays 253 and 255; and the operation of relays 236 and 246 closes a circuit for operating relays 254, 256 and 258. The operation of relays 254 and 256 closes circuits for operatively energizing the left windings of relays 264 and 265. Relays 264 and 265 lock and prepare a circuit for lighting lamp 9.

If the first digit key which is operated is the key 0, a circuit is closed from ground through low resistance 104, high resistance 103, contacts of key 0 and conductor 111 for operating relay 137 in the register sender without operating relays 133 and 135. At the same time, the potential of the grid of tube 215 is changed with respect to the cathode to effect the operation of relay 217 but the change in the potential of the grid of tube 225 with respect to the cathode is ineffective to cause the operation of relay 226. The operation of relay 217 closes a circuit through resistor 227 for operating relay 257 without operating relays 253 and 255. Since none of relays 253, 255, 254 and 256 are operated responsive to the depression of key 0, none of register relays 261, 262, 264 and 265 is operated and the normally prepared circuit for lighting lamp 0 is maintained.

Since either or both of relays 257 and 258 are operated responsive to the operation of a digit key corresponding to each digit of a called subscriber's number, the release of relay 266 is effected when the key is released and the contacts of relays 253, 254, 255 and 256 are successively connected to each set of register relays, all in the manner set forth in the aforementioned Henry and Newsom patents. When all digits have been keyed, the key monitoring circuit com-

pletes the circuits for lighting the digit indicating lamps which correspond to the digit keys which were depressed, thereby enabling a monitoring operator to check the number actually keyed with the number requested by a calling operator or subscriber.

The key-set is disconnected after keying is completed and the desired connection is established through switches IS and C under the control of the register sender in the manner set forth in the aforementioned Henry patent.

What is claimed is:

1. In combination, a thermionic valve, signaling means for selectively impressing negative and positive electromotive forces across the grid and cathode of said valve, a polarized relay having two windings, means energizing one of the windings in the anode-cathode circuit of said valve, and means energizing the other winding of said relay, the normal energization of said one winding being effective to neutralize the energization of said other winding, the change in the energization of said one winding responsive to the application of an electromotive force of one polarity across the grid and cathode being ineffective to operate said relay and the change in the energization of said one winding responsive to the application of an electromotive force of opposite polarity across the grid and cathode being effective to operate said relay.

2. In combination, a thermionic valve, signaling means for selectively impressing negative electromotive forces of two different magnitudes and positive electromotive forces of two different magnitudes across the grid and cathode of said valve, a differential relay, means energizing one of the windings of said relay in the anode-cathode circuit of said valve, and means energizing the other winding of said relay, the normal energization of said one winding being effective to neutralize the energization of said other winding, the change in the energization of said one winding responsive to the application of an electromotive force of the lower of said two magnitudes of either polarity being ineffective to operate said relay and the change in the energization of said one winding responsive to the application of an electromotive force of the higher of said two magnitudes of either polarity being effective to operate said relay.

3. In combination, a thermionic valve, signaling means for selectively impressing negative and positive electromotive forces across the grid and cathode of said valve, two polarized relays each having two windings, means energizing one winding of each of said relays in the anode-cathode circuit of said valve, means energizing the other winding of a first one of said relays, and means energizing the other winding of the second of said relays, the normal energization of said one winding of each of said relays being effective to neutralize the energization of said other winding, the change in the energization of said one winding of said first relay responsive to the application of an electromotive force of one polarity across the grid and cathode of said valve being effective to operate said first relay and the change in the energization of said one winding of said second relay responsive to the application of an electromotive force of opposite polarity across the grid and cathode of said valve being effective to operate said second relay.

4. In a signaling system, a conductor, signal receiving means connected to said conductor, and means for selectively transmitting polarized di-

rect current signals over said conductor, said signal receiving means comprising a thermionic valve, a high impedance element connecting the control element of said valve to said conductor, a polarized relay having two windings, means energizing one of the windings, and means energizing the other winding in the anode-cathode circuit of said valve, the normal energization of said other winding being effective to neutralize the energization of said one winding, the change in the energization of said other winding responsive to a direct current signal of one polarity being ineffective to cause the operation of said relay, and the change in the energization of said other winding responsive to a direct current signal of the opposite polarity being effective to cause the operation of said relay.

5. In a signaling system, a conductor, signal receiving means connected to said conductor, and means for selectively transmitting marginal and polarized direct current signals through said conductor, said signal receiving means comprising a thermionic valve, a high impedance element connecting the control element of said valve to said conductor, a marginal differential relay having one winding energized in the anode-cathode circuit of said valve, and means energizing the other winding of said relay, the energization of said other winding being effective to neutralize the normal energization of said one winding, the change in the energization of said one winding responsive to the transmission of a direct current signal of either polarity through said conductor being ineffective to operate said relay in the case of a low amplitude signal current and effective to operate said relay in the case of a high amplitude signal current.

6. In a signaling system, a conductor, signal receiving means connected to said conductor, and means for selectively transmitting polarized direct current signals over said conductor, said signal receiving means comprising a thermionic valve, a high impedance element connecting the control element of said valve to said conductor, two polarized relays each having two windings, means energizing one winding of each of said relays in the anode-cathode circuit of said valve, means energizing the other winding of one of said relays, and means energizing the other winding of the other of said relays, the normal energization of said one winding of each of said relays being effective to neutralize the energization of said other winding, the change in the energization of said one winding of said one relay responsive to a direct current signal of one polarity being effective to operate said one relay and the change in the energization of said one winding of said other relay responsive to a direct current signal of opposite polarity being effective to operate said other relay.

7. In a signaling system, a conductor, signal receiving means connected to said conductor, and means for selectively transmitting marginal and polarized direct current signals through said conductor to said signal receiving means, said signal receiving means comprising a first thermionic valve, a second thermionic valve, a high impedance element connecting the control element of said first valve to said conductor, two polarized relays, each having a biasing winding and an operating winding, means energizing said biasing windings, means energizing said operating windings in the anode-cathode circuit of said first valve to effect the operation of one of said relays responsive to a

direct current signal of one polarity and to effect the operation of the other of said relays responsive to a direct current signal of the opposite polarity, another high impedance element connecting the control element of said second valve to said conductor in series with the first-mentioned high impedance element, a marginal differential relay having one winding energized in the anode-cathode circuit of said second valve, and means energizing the other winding of said differential relay, the energization of said other winding being effective to neutralize the normal energization of said one winding, the change in the energization of said one winding responsive to the transmission of a low amplitude direct current signal of either polarity through said conductor being ineffective to operate said differential relay and the change in the energization of said one winding responsive to the transmission of a high amplitude signal of either polarity through said conductor being effective to operate said differential relay.

8. A signal receiving circuit adapted to respond to polarized and marginal signals, said circuit comprising two vacuum tubes and three relays, means connecting the grid of one of said tubes to a conductor over which said signals are transmitted to impress on said grid substantially the entire voltage derived from transmission of a signal, means connecting the anode of said one tube to windings of a first and a second one of said relays to effect the operation of said first relay responsive to the impression of a positive voltage on said conductor and the operation of said second relay responsive to the impression of a negative voltage on said conductor, means connecting the grid of the other of said tubes to said conductor to impress thereon only a part of the voltage derived from transmission of a signal, and means connecting the anode of said other tube to the winding of the third of said relays to effect the operation of said third relay only in response to the impression of a substantially higher voltage of either polarity to said conductor than that which is effective to operate said first or second relays.

9. In a signaling system, means adapted to repeat polarized and marginal signals, said means comprising two thermionic valves, means connecting the grid of one of said valves to a conductor over which said signals are transmitted to impress on said grid substantially the entire voltage derived from transmission of a signal, two polarized relays, means for biasing said relays, means for energizing a winding of each of said relays in the anode-cathode circuit of said one valve to effect the operation of one of said relays responsive to the transmission of a signal of one polarity and to effect the operation of the other of said relays responsive to the transmission of a signal of the opposite polarity, means connecting the grid of the other of said valves to the conductor over which said signals are transmitted to impress on said grid only a part of the voltage derived from the transmission of a signal, a differential relay having one winding energized in the anode-cathode circuit of said other valve, means energizing another winding of said differential relay to neutralize the normal energization of said one winding, the change in the energization of said one winding of said differential relay responsive to signals of maximum amplitude of either polarity being effective to operate said relay, the change in the energization of

said one winding of said differential relay responsive to signals of less than maximum amplitude of either polarity being ineffective to operate said relay, signal relays, and means controlled by said polarized and differential relays for selectively operating said signal relays.

10. In a signaling system, a source of electromotive force of one polarity, a source of electromotive force of opposite polarity, a line, signal transmitting means connected to said line, and signal receiving means connected to said line, said signal transmitting means comprising digit keys and resistors for selectively completing high resistance and low resistance signaling circuits, one at a time, over each of the conductors of said line, each of said circuits including the one or the other of said sources of electromotive force, a different combination of circuit conditions being established over said conductors responsive to the operation of each of the digit keys, said signal receiving means comprising a first thermionic valve, means connecting the grid of said first valve to one of the conductors of said line to impress on said grid the entire voltage derived from the closure of a signaling circuit over said one conductor, a first polarized relay, a second polarized relay, means energizing one winding of each of said first and second polarized relays in the anode-cathode circuit of said first valve, means energizing another winding of each of said first and second polarized relays, the normal energization of said one winding of each of said first and second polarized relays being effective to neutralize the energization of said other winding, the change in the current in the anode-cathode circuit of said first valve responsive to the closure of a signaling circuit over said one conductor from a source of electromotive force of one polarity being effective to operate said first polarized relay and the change in the current in the anode-cathode circuit of said first valve responsive to the closure of a signaling circuit over said one conductor from a source of electromotive force of the opposite polarity being effective to operate said second polarized relay, a second thermionic valve, means connecting the grid of said second valve to said one of the conductors of said line to impress on said grid only part of the voltage derived from the closure of a signaling circuit over said one conductor, a first differential relay, means energizing one winding of said first differential relay in the anode-cathode circuit of said second valve, means energizing another winding of said first differential relay, the normal energization of said one winding of said first differential relay being effective to neutralize the energization of said other winding, the change in the energization of said one winding of said first differential relay responsive to the closure of a high resistance signaling circuit over said one conductor from either of said sources of electromotive force being ineffective to operate said first differential relay and the change in the energization of said one winding of said first differential relay responsive to the closure of a low resistance signaling circuit over said one conductor from either one of said sources of electromotive force being effective to operate said first differential relay, a third thermionic valve, means connecting the grid of said third valve to the other conductor of said line to impress on said grid the entire voltage derived from closure of a signaling circuit over said other conductor, a third polarized relay, a fourth polarized relay,

means energizing one winding of each of said third and fourth polarized relays in the anode-cathode circuit of said third valve, means energizing another winding of each of said third and fourth polarized relays, the normal energization of said one winding of each of said third and fourth polarized relays being effective to neutralize the energization of said other winding, the change in the current in the anode-cathode circuit of said third valve responsive to the closure of a signaling circuit over said other conductor from a source of electromotive force of one polarity being effective to operate said third polarized relay and the change in the current in the anode-cathode circuit of said third valve responsive to the closure of a signaling circuit over said other conductor from a source of electromotive force of the opposite polarity being effective to operate said fourth polarized relay, a fourth thermionic valve, means connecting the grid of said fourth valve to said other conductor to impress on said grid only a part of the voltage derived from closure of a signaling circuit over said other conductor, a second differential relay, means energizing one winding of said second differential relay in the anode-cathode circuit of said fourth valve, and means energizing another winding of said second differential relay, the normal energization of said one winding of said second differential relay being effective to neutralize the energization of said other winding, the change in the energization of said one winding of said second differential relay responsive to the closure of a high resistance signaling circuit over said other conductor from either of said sources of electromotive force being ineffective to operate said second differential relay and the change in the energization of said one winding of said second differential relay responsive to the closure of a low resistance signaling circuit over said other conductor from either one of said sources of electromotive force being effective to operate said second differential relay.

11. In a signaling system according to claim 10, relays selectively controlled by said first and second polarized relays and said first differential relay, relays selectively controlled by said third and fourth polarized relays and said second differential relay, and means selectively controlled by said relays to indicate the digits corresponding to the operated keys of said signal transmitting means.

12. In a signaling system, a signaling conductor, signal relays connected to said conductor for selective response to marginal and polarized direct current signals, and monitoring means connected to said conductor for response to said signals, said monitoring means comprising two thermionic direct-current amplifiers, relay means selectively controlled by one of said amplifiers for indicating the polarity of a signal transmitted over said conductor, relay means controlled by the other of said amplifiers for response only to signals of maximum amplitude transmitted over said conductor, means comprising a high resistance element operatively connecting the cathode-grid circuits of said amplifiers to said conductor, and a condenser connected to said element in parallel with the cathode-grid circuits of said amplifiers to prevent the operation of said relay means responsive to transient voltages impressed on said conductor.

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