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TELEPHONE EXCHANGE SYSTEM

Filed Aug. 28. 1926

2 Sheets-Sheet 1

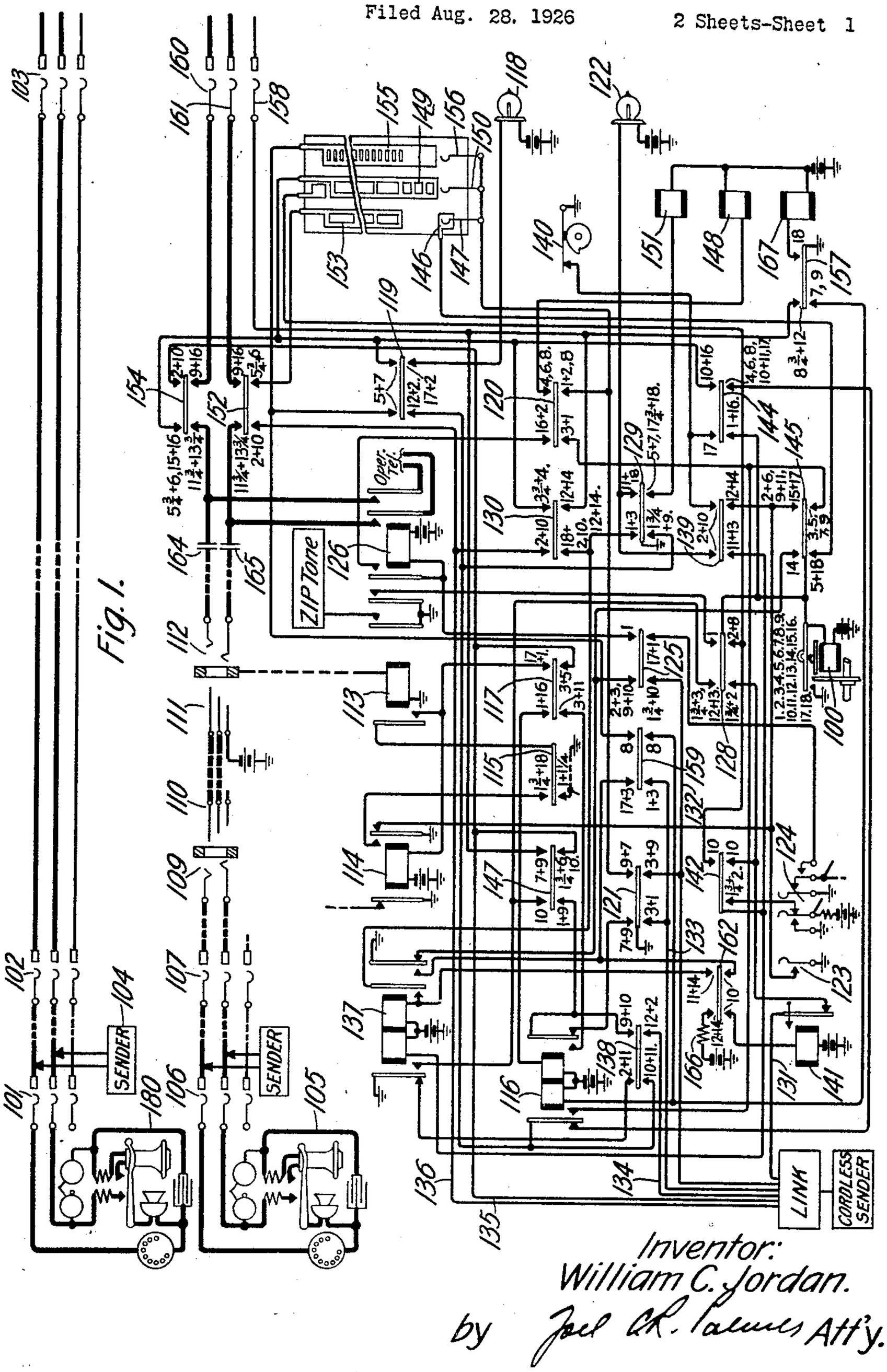

Fig. 1.

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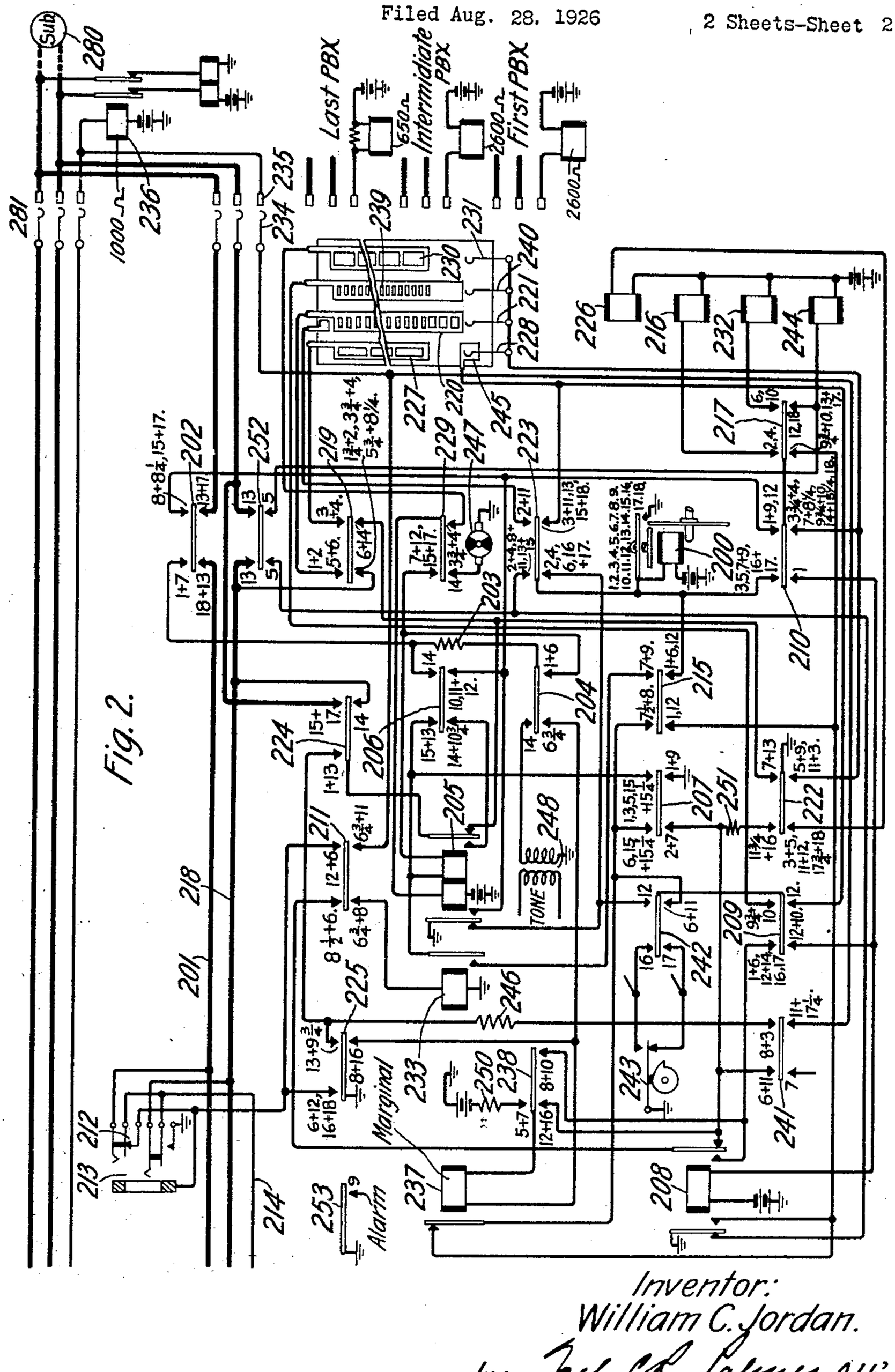

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UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE SYSTEM.

Application filed August 28, 1926. Serial No. 132,087.

This invention relates to automatic telephone exchange systems, and more particularly to improved means for testing called telephone lines prior to completing connections thereto.

Telephone lines appearing before final selectors are customarily identified as of one of two classes, viz, as individual lines and last lines of groups leading to private branch exchanges, or as other P. B. X. lines. This classification is usually indicated by the resistance connected in series with the sleeve terminal of the line in question, the resistance being less for last P. B. X. lines and individual lines, and greater for other P. B. X. lines. Final selectors have heretofore been equipped to apply a simultaneous test to distinguish between these classes of lines, and to determine the busy or idle condition thereof. It has been the practice to identify the sleeve terminals of idle lines with a ground potential and busy lines with battery potential. The testing means operated only in case a busy line was encountered; hence a line whose sleeve terminal was open or grounded accidentally would be treated as an idle line. Where final selectors of the prior art have been used with means to cancel the test, in order that a connection might be completed with a busy line, the release of the selector has been dependent upon the disconnection of the called subscriber.

In accordance with the present invention the sleeve terminals of called lines are connected to battery when idle and to ground when busy and an additional test is provided to distinguish busy lines and those accidentally grounded, the latter condition resulting in the operation of an alarm. According to another aspect of the invention the tests of the called line are applied successively permitting them to be more certain. An additional aspect of the invention contemplates automatic release of a final selector used in establishing a "no test" connection.

The final selector of the present invention is positioned on the called line under control of an external line relay. With the brushes positioned on the terminals of the wanted line, a relay is first connected to the sleeve terminal of the line to test whether it is open or has a low resistance unstandard ground connected thereto. If open, or if such ground is present, this relay fails to operate and the sequence switch is arrested in position to cause the operation of an alarm. If no false ground is present, the relay operates and the line is then tested to see whether it is a busy P. B. X. line. The relay for making this test operates under all other conditions. If the tested line is a busy P. B. X. trunk, or if the line is being tested simultaneously by two final selectors, the selector will be advanced to hunt for an idle P. B. X. trunk, if one exists, in the group. If no idle trunks are present in the group, the selector will stop on the last P. B. X. trunk whether or not it is being simultaneously tested by other final selectors. When the selector comes to rest the line will be tested for busy or idle condition. A busy line will cause the restoration of the selector and the transmission of a busy signal to the calling subscriber.

On a completed call to an idle line, disconnection is under the control of the called station. A connection with a line which tests busy to a service connection, is possible through the aid of a cordless operator's incoming selector, which automatically cancels the tests of the line by prematurely operating one of the test relays. When such a "no test" connection has been made, the incoming selector reoperates this test relay and releases the final selector which has been used for the "no test" call without waiting for the called subscriber to hang up.

The drawings consist of Fig. 1 which shows an incoming selector adapted for extending "no test" connections and Fig. 2 which shows the final selector embodying the present invention.

The operation of a final selector in the course of a service connection will first be described. Assuming that the subscriber at substation 180 desires to converse with the subscriber at station 280, he will remove his receiver from the switchhook whereupon line switch 101 extends the calling line to district selector 102 which operates under the control of sender 104 to select an idle incoming selector, such as selector 103. Selector 103 will then be operated to select

an idle final selector in the desired group, for example, selector 281. Since final selector 281 is in all respects the same as that shown in detail the further extension of the connection will be described in connection with that selector. For a complete showing of the establishment of a connection to an incoming selector, reference is made to U. S. Patent 1,589,402 granted to O. H. Kopp, June 22, 1926 and for the operation of an incoming selector, particularly adapted to function with this final selector, reference may be made to the application of C. H. Berry, Serial No. 132,333, filed Aug. 30, 1926.

When incoming selections have been completed and the brushes brought to rest on the terminals of the final selector, a fundamental circuit is established, including a relay of the incoming selector and the stepping relay of the sender. The operation of the relay in the incoming selector connects battery to tip conductor 201 through a predetermined resistance. This battery serves to complete a fundamental circuit which extends from conductor 201 over the left contacts of cam 202, resistance 203, right contact of cam 204, right winding of relay 205, right contacts of cam 207 to ground. Relay 205 operates in this circuit and locks in a circuit which extends from the right winding of relay 205 over the left contacts of cam 206, right front contact of relay 205, left contact of cam 224, upper right contact of cam 225 to ground. The operation of relay 205 closes a circuit from battery through the winding of relay 208, lower left and upper right contacts of cam 210, left front contact of relay 205 to ground. Relay 208 locks in turn in a circuit through its winding over the left contacts of cam 209, right front contact of relay 208, upper contacts of cam 211, contact 212 of jack 213, to ground applied to sleeve conductor 214 by the incoming selector. This locking circuit remains closed until sequence switch 200 leaves position 6. The operation of relay 208 at this time closes a circuit from battery through the winding of final selector sequence switch magnet 200, lower contacts of cam 215, to ground at the left front contact of relay 208, advancing the sequence switch to position 2.

With sequence switch 200 in position 2, a circuit is closed for high speed-up drive magnet 216 extending from battery through the winding of magnet 216, upper left contact of cam 217, upper right contact 210, left front contact of relay 205 to ground. Under the control of magnet 216 the final selector is driven upward in a brush selecting movement. As brush 221 passes over commutator strip 220, a circuit is intermittently closed from ground over the lower right contact of cam 222, brush 221, commutator strip 220, left contacts of cam 219, to ring conductor 218. This circuit serves to hold the relay of the incoming selector operated and shunt the stepping relay of the sender in the usual manner. When the sender is satisfied, the incoming selector relay releases, removing battery from conductor 218 and relay 205 in turn releases, opening the circuit of magnet 216 and bringing the selector brushes to rest in position to trip the desired set of brushes. With relay 205 released a circuit is closed from battery through the winding of sequence switch magnet 200, lower left contact of cam 223, to ground at the left back contact of relay 205, advancing the sequence switch to position 3.

When the fundamental circuit is again established by the sender, battery is connected to the conductor 201, relay 205 is operated and locked, and the sequence switch 200 advanced to position 4, in a circuit extending over the upper contacts of cam 210 to ground at the left front contact of relay 205. High speed magnet 216 is again operated in the previously traced circuit and while the selector is group hunting, an intermittent circuit is completed to conductor 218 over the lower left and upper right contacts of cam 219, commutator strip 227, brush 228 from ground over the right contacts of cam 210 and the left front contact of relay 205. Trip magnet 226 is operated in positions 3 to 5 of sequence switch 200, in a circuit from battery through its winding to ground at the lower left contact of cam 222, so that when the selector is moved upward under the control of magnet 216 the selected set of brushes is tripped. When the sender is satisfied, battery is removed from conductor 201, relay 205 released, up-drive magnet stopped, and the sequence switch advanced to position 5.

When the fundamental circuit is established for units selection with the final selector sequence switch in position 5, relay 205 is operated as before and locked. The operation of relay 205 advances the sequence switch to position 6. The operation of relay 205 also completes a circuit from battery through the winding of low speed updrive magnet 232, upper right contacts of cams 217 and 210 to ground at the left front contact of relay 205.

In position 6 an intermittent circuit is connected to conductor 218 over the left contacts of cam 219, commutator strip 220, brush 221, lower right contact of cam 222 to ground. When the sender is satisfied, battery is removed from conductor 201, and relay 205 releases stopping the upward movement of the selector and advancing the sequence switch to position 7. Relay 233 operates, if conditions are normal, in position 6¾. The holding circuit of relay 208 is transferred in position 6 to the back con-

tact of relay 237 and left front contact of relay 208 which circuit continues through position 10 or until relay 237 operates.

Sequence switch 200 is now advanced from position 7 to position 9 in a circuit extending from battery through the winding of magnet 200, upper left and lower right contacts of cam 210, lower right contact of cam 222 to ground.

When sequence switch 200 was in positions 6¾ to 8 inclusive, a circuit was closed from ground through winding of relay 233, lower contacts of cam 211 to sleeve brush 234. If the called line is in normal condition, battery will be found to be connected to the sleeve terminal through the cut-off relay of the subscriber's line, or if the line is busy, the cut-off relay will be found to be connected to ground through a resistance. Relay 233 will operate in position 6¾ to 8 unless the sleeve conductor is open or is grounded through a very low resistance such as would occur if the sleeve were accidentally grounded. If either of these last two abnormal conditions exists, relay 233 does not operate, and the circuit for operating relay 205 is left open. When sequence switch 200 reaches position 9 with relay 205 deenergized, no circuit is provided for advancing the sequence switch out of that position and an alarm is operated over cam 253 after an interval. The release of the selector is brought about manually after discovery of such an abnormal condition.

After relay 233 operates, and as soon as sequence switch 200 reaches position 7½, a circuit is closed from battery through the left winding of relay 205, upper contact of cam 229, right winding of relay 205, the front contact of relay 233, upper contacts of cam 215, back contact of relay 237, left front contact of relay 208 to ground. Relay 205 operates in the circuit above traced and locks in a circuit through its two windings, left contacts of cam 206, right front contact of relay 205, left contact of cam 224, upper right contact of cam 225 to ground, until the sequence switch reaches position 9¾.

From the time that relay 205 releases with the sequence switch in position 6 following units selection until the sequence switch leaves position 8¼ ground is connected to conductor 218 over the lower contacts of cam 219, right back contact of relay 205, upper left contact of cam 224, upper right contact of cam 225, or, as soon as position 7 is reached, over the lower contacts of cam 219 and the upper right contact of cam 222.

As the sequence switch passes through position 8+8¼, ground is connected to conductor 201 over the lower right and upper right contacts of cam 202, left contacts of cam 210, and the lower right contact of cam 222. These two grounds serve to advance the incoming selector, to bring the selectors into talking position and release the sender.

With relay 205 operated, a circuit is closed for advancing from position 9 to position 10, extending from battery through the winding of magnet 200, upper contacts of cam 210, left front contact of relay 205 to ground.

While the sequence switch is moved through positions 8½ to 10, a test circuit is closed from sleeve brush 234, lower right and upper left contacts of cam 211, right front contact of relay 208, right contact of cam 238, winding of relay 237, lower contact of cam 225 to ground.

If brush 234 is resting on the terminal of a busy line in a group leading to a private branch exchange, battery will be connected to the terminal through a resistance of 2600 ohms and ground will also be connected thereto through a resistance of 112 ohms. Relay 237 is marginal so that it will not operate through so high a resistance in parallel with the busy ground or in parallel with another P. B. X. test relay. In consequence relay 208 remains operated in the locking circuit previously traced. Relay 205 also remains operated through position 9¾ to ground at cam 225 and through position 10 in a circuit which extends as previously traced to the upper left contact of cam 206, and is completed in this position over the lower right contact of cam 206 to ground at the left front contact of relay 205. With relay 208 operated in position 10 a circuit is again completed from battery through the winding of low speed updrive magnet 232, upper right and lower left contacts of cam 217 to ground at the left front contact of relay 208.

When an idle line is encountered no ground will be connected to the sleeve terminal and the current will be sufficient to operate relay 237. Relay 237 also operates through the lower resistances connected to the sleeve of individual lines and last lines of P. B. X. groups whether busy or not. The resistance used with the last line of a P. B. X. group is made less than for an individual line by the use of a non-inductive shunt around the winding of the cut-off relay so that relay 237 may operate quickly to stop the selector on the last line of the group whether busy or not. The operation of relay 237 opens the holding circuit of relay 208 which in turn opens the circuit of magnet 232 bringing the selector to rest. An additional holding circuit for relay 208 exists at this time from ground at the left front contact of relay 208, lower left contact of cam 217, lower right contact of cam 210, brush 240, commutator strip 239, upper right and lower left contacts of cam 209 to the winding of relay 208 which insures that relay 208 will remain energized until the brush set is prop-

erly centered. The release of relay 208 also closes a circuit from battery through the winding of magnet 200, upper left contact of cam 223, to ground at the left back contact of relay 208, advancing the sequence switch to position 12. As soon as relay 208 releases, ground is connected in position 10 to sleeve brush 234, extending from ground at the left front contact of relay 205, lower contacts of cam 206, right front contact of relay 205, left contact of cam 224, through resistance 246, upper contacts of cam 241, right back contact of relay 208, upper left and lower right contacts of cam 211, to the sleeve brush as a temporary busy condition.

If the line is busy while sequence switch 200 is passing through positions 10 to 10¾, a circuit is closed from battery through the left winding of relay 205, upper contact of cam 229, right winding of relay 205, left contacts of cam 206, right front contact of relay 205, left contact of cam 224, resistance 246, upper contacts of cam 241, right back contact of relay 208, upper left and lower right contacts of cam 211, to the sleeve brush 234. If the line on which the brushes are standing is busy, ground will be connected to the sleeve terminal from the equipment with which it is engaged and relay 205 will be held operated when the sequence switch reaches position 10¾. The only busy line of a P. B. X. group on which the selector can be permitted to come to rest would be the last line which has a sufficiently low resistance to operate relay 237 even though busy. If the line is busy, relay 205 will lock over the upper left and lower right contacts of cam 206 to ground at the left front contact of relay 205 through position 12. The operations following will be described later.

Assuming that the line is idle, as soon as the sequence switch leaves position 10, relay 205 will release and connect ground from the upper right contact of cam 222 over its right back contact, left contact of cam 224 through resistance 246 to sleeve brush 234 over the path previously described.

When the sequence switch reaches position 12, with relay 205 released, relay 208 is operated in a circuit through its winding, lower left contact of cam 209, upper right contact of cam 242, to ground at the left back contact of relay 205. Relay 208 in operating closes a circuit from battery through the winding of sequence switch magnet 200, lower contacts of cam 215, left front contact of relay 208 to ground, advancing the sequence switch to the talking position 13.

As soon as the sequence switch reaches talking position 13, ground is connected over the upper right contact of cam 225, through resistance 246 and the right contacts of cam 241, to the sleeve brush to hold it busy throughout conversation. Relay 208 when operated in position 12, locks over the left contacts of cam 209, right front contact of relay 208, upper contacts of cam 211, contact 212 of jack 213, over the sleeve conductor 214 to the incoming selector.

At the end of conversation, the release of the connection by the calling subscriber restores selectors 102 and 103 and removes ground from conductor 214, permitting relay 208 to release and advancing sequence switch 200 to position 16 in a circuit from battery through the winding of magnet 200, upper left contact of cam 223, to ground at the left back contact of relay 208.

In positions 15 to 15¼ a circuit is closed from battery through the left winding of relay 205, upper contact of cam 229, right winding of relay 205, upper contacts of cam 207, back contact of relay 237, lower left contact of cam 217, lower right contact of cam 210, to ground at the lower right contact of cam 222. Provided the called subscriber has not restored his receiver to the switchhook, relay 205 locks in a circuit extending through its two windings, as previously traced, left contacts of cam 206, right front contact of relay 205, upper right contact of cam 224, over the called subscriber's loop, back to the right contacts of cam 202, left front contact of relay 205 to ground. If the called subscriber still fails to hang up his receiver, interrupter 243 will close its upper contact after an interval, completing a circuit thereover, over the upper left contact of cam 242, and lower left contact of cam 209 through the winding of relay 208 to battery. Relay 208 operates and completes a cicuit through the winding of sequence switch magnet 200, upper left contact of cam 210, lower left contact of cam 217, to ground at the left front contact of relay 208 advancing the sequence switch to position 17, releasing relay 208. After a predetermined interval, interrupter 243 closes its lower contact and extends a circuit thereover from ground over the lower left contact of cam 242 and thence as traced through the winding of relay 208. The operation of relay 208 again advances the sequence switch, this time in position 18.

When the sequence switch leaves position 17, the holding circuit of relay 205 is opened and that relay releases.

If the called subscriber hangs up at the same time as the calling subscriber, the locking circuit above described for relay 205 will be open and that relay will release following position 15¼. Sequence switch 200 is then advanced to position 18 in a circuit over the lower left contact of cam 223 to ground at the left back contact of relay 205.

In position 18 a circuit is closed for down-drive magnet 244, extending over the lower right contacts of cams 217, 210 and 222 to ground. The selector switch is restored to normal under the control of magnet 244, trip

magnet 226 being operated. When it reaches its normal position, a circuit is closed from battery through the winding of sequence switch magnet 200, lower right contact of cam 223, normal commutator segment 245, brush 228 to ground at the lower right contact of cam 222, advancing the sequence switch to normal.

As soon as the incoming selector released relay 208 in position 13 of sequence switch 200, ground was connected to sleeve conductor 214, over the lower contact of cam 225, winding of relay 237, lower left contact of cam 238, right back contact of relay 208, upper contacts of cam 211, contact 212 of jack 213 to conductor 214. This ground serves to mark the final selector busy to any incoming selector. The previously traced circuit likewise functions in connection with a "no test" call which will be described hereinafter. When sequence switch 200 arrived in position 16, ground over the left contact of cam 225 was substituted for ground through the winding of relay 237 to continue the busy condition until the final selector is ready for use again.

If the called line had been busy, relay 205 would operate and lock as previously described and remain operated when the switch reached position 12. With relay 205 operated a circuit is closed in position 12 through the winding of down-drive magnet 244, lower left contact of cam 217, upper right contact of cam 210 to ground at the left front contact of relay 205. The final selector is restored to normal under the control of magnet 244, the trip magnet 226 also being operated at this time. When the final selector reaches normal, a circuit is closed from battery through the winding of relay 208, lower contacts of cam 209, normal commutator segment 245, brush 228 to ground at the lower right contact of cam 222. Relay 208 locks on its front contact to cam 225 and to sleeve conductor 214 until the calling subscriber hangs up. The operation of relay 208 advances sequence switch 200 to position 13 as previously described. With the selector switch normal a circuit is closed from battery through the winding of magnet 200, lower right contact of cam 223, normal segment 245, brush 228 to ground at the lower right contact of cam 222, advancing the sequence switch to position 14.

When the sequence switch leaves position 12, the holding circuit of relay 205 is opened and relay 205 releases. With relay 205 released and sequence switch 200 in position 14, a circuit is closed from ground through interrupter 247, lower left contact of cam 229, left winding of relay 205 to battery causing relay 205 to operate intermittently. On each operation of relay 205 a circuit is closed from ground through the secondary of tone coil 248, upper contact of cam 204, resistance 203, upper right and lower left contacts of cam 206, right front contact of relay 205, lower contact of cam 224, to ring conductor 218 transmitting to the calling subscriber an interrupted tone indicative of the fact that the line is busy. When the calling subscriber restores his receiver in response to this signal, relay 208 releases advancing the sequence switch to position 16 as previously described. Since the selector is normal at this time, a circuit will be closed from battery through the sequence switch magnet 200, lower right contact of cam 223, normal segment 245, brush 228 to ground at the right contact of cam 222, advancing the sequence switch to position 1 and restoring the final selector completely to normal.

The extension of a "no test" call will now be described. A "no test" connection will usually be made when a subscriber's line remains busy to incoming calls over an unusual period of time or when for any reason conditions seem abnormal in connection therewith. It will be assumed, therefore, that a connection has been established between the subscriber at substation 180 and the subscriber at substation 280 extending through line switch 101, district selector 102, incoming selector 103, and final selector 201, under the control of sender 104 as above described. Suppose now that the subscriber at substation 105 attempts a connection with the subscriber at substation 280 and finds the line busy. If this condition continues so that there seems to be some emergency involved in the prolonged busy condition of the line, he may use his line switch 106 and the district selector 107 under control of sender 108 to establish a connection with an operator's position at which selector 107 appears in jack 109. Associated with this jack is a signal (not shown) to which the operator responds by plugging the answering plug of cord 110 into jack 109. The subscriber may then explain his difficulty to the operator and she will then insert the calling plug of her cord 110 in jack 112. This jack is connected with a trunk which is especially adapted for extending "no test" calls and which terminates in an incoming selector at the office in which the wanted subscriber is located. This trunk appears at a cordless operator's position in the incoming office in a pair of lamps and a pair of keys.

The battery connected to the sleeve of the calling plug 111 will complete a circuit over the sleeve of jack 112 through the winding of sleeve relay 113 to ground. Relay 113 operates and completes a circuit from battery through the winding of relay 114, front contact of relay 113, lower contact of cam 115 to ground through an auxiliary alarm circuit (not shown). It also closes

a circuit from battery through the right winding of relay 116, upper contacts of cam 117, front contact of relay 113, to ground over the lower contact of cam 115. Relays 114 and 116 operate, relay 114 closing a holding circuit for itself which will be traced hereinafter. It also opens a circuit for the group busy register and a circuit which is employed in wiping out an abandoned connection. Relay 116 in operating closes a circuit from battery through white lamp 118, lower contacts of cam 119, left front contact of relay 116, lower contacts of cam 120, to ground at the upper right contact of cam 121. The lighting of lamp 118 informs the cordless operator at whose position the incoming selector appears in lamps 118 and 122 and keys 123 and 124 that a call is awaiting attention.

In response to the lighting of lamp 118, the cordless operator will depress key 124, connecting ground over the right contacts of key 124, right contacts of cam 125, winding of relay 126 to battery. Relay 126 operates and locks over its inner left front contact, upper left and lower right contacts of cam 120 to ground at the upper right contact of cam 121. Relay 126 closes a circuit from battery through the winding of sequence switch magnet 100, upper right contact of cam 128, to ground at the middle left contact of relay 126, advancing the sequence switch to position 2. In addition relay 126 connects the cordless operator's telephone circuit to the trunk and starts the zip tone which is associated with the operator's telephone. This tone consists of two short impulses of tone which are transmitted to cord 110 and the A operator's telephone set connected therewith (not shown) informing the A operator that the cordless operator is ready to receive her instructions. The A operator will then inform the cordless operator of the wanted number.

When sequence switch 100 reaches position 1¾ a locking circuit is closed for relay 114 extending over the front contact of relay 113, upper contact of cam 115 to ground at the front contact of relay 114. In position 2, ground is connected to conductor 132 over the left contacts of cam 125 and the right back contact of relay 137; to conductor 136 over the left contacts of cam 130 and the upper left contact of cam 129; and to conductor 134 over the lower right and upper left contacts of cam 138 and the left back contact of relay 137. These grounds serve to cause the link circuit to operate to associate a cordless sender with the trunk. Ground is also removed from conductor 133 to identify the trunk to the link circuit. The operation of a link circuit and sender is disclosed in U. S. Patent 1,345,016 granted to A. E. Lundell et al., June 29. 1920. With the incoming selector sequence switch in position 2 a circuit is also closed from battery through green lamp 122, upper contacts of cam 139, to ground through the contact of interrupter 140, causing lamp 122 to flicker to indicate that a sender is being associated with the trunk.

The cordless operator will then set up on her key board the number she has received from the A operator and the sender will be positioned in accordance therewith. When the link circuit finds the trunk, it connects ground to conductor 133 to mark the trunk as busy to other link circuits. When the last digit of the wanted number has been recorded, ground is connected to conductor 131 and a circuit is completed extending over the back contact of relay 141, lower left contact of cam 128, to the winding of sequence switch magnet 100, advancing the sequence switch to position 3. When the sequence switch leaves position 2, the circuit of white lamp 118 is opened and the lamp extinguished to indicate that the sender has been set.

With the sequence switch in position 3, ground is removed from conductors 134 and 136 and ground is connected to conductor 133 over the lower left contact of cam 121 independent of the link circuit. With sequence switch 100 in position 3 the circuit is ready to start selections. This incoming selector also operates in connection with an external line relay which in this instance is located in the link circuit, as in the disclosure of the above mentioned patent to Lundell, et al. The line relay operates in a fundamental circuit connecting the link and the sender which is similar to the well known fundamental circuit employed in connection with internal line relays and includes the stepping relay of the sender. The line relay of the link operates and locks, and is held by commutator pulses which release the stepping relay of the sender in the usual manner. This line relay operates a relay in the incoming selector circuit as will be described to operate the sequence switch and the drive magnet controlling the selector. It also controls the final selector in a similar manner. It is believed that this brief description of the external line relay in connection with the Lundell et al. patent will be sufficient for the purposes of this disclosure.

When the sender is ready to control incoming brush selection, the line relay in the link operates and connects ground to conductor 135 completing a circuit over the lower right and upper left conductor of cam 117, right winding of relay 116 to battery. Relay 116 operates and closes a circuit from battery through the winding of sequence switch magnet 100, lower right contact of cam 145, left front contact of relay 116, to ground at the lower left contact of cam 129, advancing the sequence switch to position 4.

Relay 116 is held operated in position 4 in a circuit extending from battery through its right winding, left contacts of cam 117, right front contact of relay 116, lower contacts of cam 147 to ground over conductor 135. With relay 116 operated, a circuit is closed from battery through the winding of up-drive magnet 148, upper right and lower left contacts of cam 120, left front contact of relay 116 to ground at the lower left contact of cam 129. As the selector switch moves upward in a brush selecting movement under the control of magnet 148, brush 150 makes contact with the conducting segments of commutator strip 149, thus connecting ground to conductor 136 intermittently. The circuit may be traced from conductor 136 over the upper contacts of cam 130, strip 149, brush 150, upper right contact of cam 121 to ground. As above explained these pulses hold the line relay of the link operated while they release the stepping relay of the sender to operate counting relays in the well known manner. When enough pulses have been received to satisfy the sender, the circuit of the line relay is opened and ground is removed from conductor 135 releasing relay 116. The release of relay 116 opens the circuit of up-drive magnet 148 and brings the selector to rest in position to trip the proper set of brushes. It also closes a circuit from battery through the winding of sequence switch magnet 100, lower contacts of cam 144, left back contact of relay 116, to ground at the lower left contact of cam 129 advancing the sequence switch to position 5. With the sequence switch in position 5 trip magnet 151 is operated over the lower right contact of cam 129.

When the sender is ready for the next selection, relay 116 is again operated and locks to conductor 135. It again closes over its left front contact, the circuit for advancing sequence switch 100, which now moves to position 6. In position 6, the up-drive magnet 148 is operated as before, advancing the incoming selector in its group selecting movement. As the switch moves upward the selected set of brushes is tripped due to the operation of magnet 151. At this time ground is intermittently connected to conductor 136 over the lower contacts of cam 152, commutator strip 153, brush 147, upper right contact of cam 121, to ground. When the sender is satisfied, the holding circuit of relay 116 is opened, but this relay is held operated in a circuit extending from battery through right winding of relay 116, left contacts of cam 117, right front contact of relay 116, lower contacts of cam 147, upper contacts of cam 154, to commutator strip 149 and over the upper contacts of cam 119 to commutator strip 155 and thence over brushes 150 and 156 respectively to ground at the upper right contact of cam 121. These commutator strips serve to insure that the selector brushes are centered on the terminals of the first trunk outgoing to a final selector before the up-drive is stopped. When the brushes are properly centered, relay 116 releases and opens the circuit of magnet 148 bringing the brushes to rest. The release of relay 116 again closes the circuit over its back contact by which sequence switch 100 is advanced, moving the sequence switch to position 7.

When the sequence switch reaches position 7, a circuit is closed from battery through the left winding of relay 116, lower contact of cam 157 to ground. The operation of relay 116, closes the previously traced circuit for sequence switch magnet 100, advancing the sequence switch to position 8.

When the sequence switch leaves position 7, the circuit of trip magnet 151 is opened and that magnet releases. Relay 116 prepares a holding circuit for itself extending from battery through its right winding, left contacts of cam 117, right front contact of relay 116, lower left and upper right contacts of cam 147 to sleeve brush 158. If the outgoing trunk is busy, ground will be connected to the terminal engaged by brush 158 and relay 116 will be held energized in position 8. The circuit of up-drive magnet 148 would then be closed in position 8 over the upper right and lower left contacts of cam 120, left front contact of relay 116, to ground at the lower left contact of cam 129 to cause the selector to hunt for an idle trunk. When an idle outgoing trunk is reached, no ground will be present on the sleeve terminal and relay 116 will release opening the circuit of the up-drive magnet and bringing the incoming selector to rest on the idle trunk as soon as the holding circuit through its left winding, right contacts of cam 159 and commutator strip 155 is opened due to the correct centering of the brush set.

When relay 116 releases it again closes the previously traced circuit for magnet 100, advancing the sequence switch to position 9. As soon as relay 116 releases ground is connected to sleeve brush 158 over the upper right and lower left contacts of cam 147, right back contact of relay 116, from ground at the upper left contact of cam 121. When sequence switch 100 reaches position 8¾, ground is connected to sleeve brush 158 over the upper left contact of cam 157 making the final selector busy to other incoming selectors.

With the sequence switch in position 9 relay 116 is operated on its left winding, in the same circuit as that closed in position 7, and locks in a circuit through its right winding, left contacts of cam 117, right front contact of relay 116, upper contacts

of cam 138, left back contact of relay 137 to ground. In operating relay 116 closes a circuit for sequence switch magnet 100, advancing the sequence switch to position 10. The incoming selector remains in this position while the final selector is being operated.

With sequence switch 100 in position 10, conductor 136 is extended over the lower left and upper right contacts of cam 152 and brush 161 to the ring conductor 218 of the final selector. Similarly conductor 135 is extended over the right contacts of cam 154 and brush 160 to the tip conductor 201 of the final selector. The extension of these conductors permits the operation of the final selector under control of the previously described line relay in the link circuit.

At this time the line relay connects battery through the proper resistance to conductor 135 and therefore to conductor 201, operating relay 205. The subsequent operations of the final selector take place as described above in tracing a service connection until sequence switch 200 is advanced from position 6 to position 7, following final units selection. Relay 205 is released in position 6, by the sender. Ground is connected to the sleeve conductor 214 by cam 225 as previously described.

As soon as the final selections are completed ground is connected from the sender to conductor 131 over the back contact of relay 141, lower left contact of cam 142, left winding of relay 137 to battery. Relay 137 operates in this circuit and locks in a circuit through its right winding and right front contact, left contacts of cam 130, lower left and upper right contacts of cam 152, brush 161, conductor 218, lower contacts of cam 219, over the right back contact of relay 205, left contact of cam 224, upper right contact of cam 225 to ground in position 6 to 7½. Operation of relay 137 operates relay 141 which breaks the circuit through the left windings of relay 137. As soon as the final selector sequence switch reaches position 7, this circuit is also grounded over the upper right contact of cam 222 in position 7 to 8¼ of sequence switch 200.

In the meantime the operation of relay 137 connects ground over its left front contact, upper left and lower right contacts of cam 147, to conductor 135 and thence to conductor 201, completing a circuit from battery through resistance 250, winding of relay 237, lower left contact of cam 204, resistance 203, left contacts of cam 202, to conductor 201, operating relay 237 at position 6¾ only of sequence switch 200. It will be remembered that the locking circuit of relay 208 which is established as soon as sequence switch 200 reaches position 6 extends over the back contact of relay 237. With relay 237 operated as the sequence switch passes through position 6¾, this locking circuit is opened and relay 208 releases. Sequence switch 200 is advanced from position 7 to position 9 in a circuit extending from battery through the winding of magnet 200, upper left and lower right contacts of cam 210 to ground at the lower right contact of cam 222. With relay 208 released sequence switch 200 is immediately advanced out of position 9 to position 12, the circuit extending over the upper left contact of cam 223 to ground at the left back contact of relay 208. Sequence switch 200 will therefore be advanced out of position 9 whether the sleeve condition is normal or not and the test circuit of relay 233 will be ineffective. Similarly, the test whether the called line is one of a P. B. X. group and busy, is cancelled since the circuit for relay 237 is now open at the contact of relay 208. In turn, the test whether the line is busy or idle by relay 205, is cancelled since the circuit for this test also extends over an open contact of relay 208.

When sequence switch 200 arrives in position 12 a circuit is closed from battery through the winding of relay 208, lower left contact of cam 209, upper right contact of cam 242, to ground at the left back contact of relay 205. Relay 208 locks in a circuit from battery through its winding, left contacts of cam 209, right front contact of relay 208, upper contacts of cam 211, contact 212 of jack 213, sleeve conductor 214, brush 158 to ground at the upper left contact of cam 157. Relay 208 in operating advances sequence switch 200 to position 13 in a circuit extending through the winding of magnet 200, lower contacts of cam 215 to ground at the left front contact of relay 208.

Position 13 is the talking position of the final selector and the sequence switch remains in that position until the selector is released. In the meantime, the operation of relay 137 in position 10 of sequence switch 100 and position 6 to 8¼ of sequence switch 200 opens the holding circuit of relay 116 and closes a circuit from battery through the winding of relay 141, lower contacts of cam 162, to ground at the outer right front contact of relay 137. With relay 137 operated, ground is disconnected from conductor 132 and the sender and link dismissed. In positions 11 to 18 of sequence switch 100 the circuit of green lamp 122 will be extended directly to ground over the right contact of cam 129.

When the final selector sequence switch leaves position 8¼, ground is disconnected from conductor 218 and the locking circuit of relay 137 is therefore opened, permitting that relay to release. With relays 137 and 116 both released a circuit is closed from ground over the left back contact of relay 137, left contacts of cam 138, left back

contact of relay 116, lower contacts of cam 144, winding of sequence switch magnet 100 to battery, advancing the sequence switch from position 10 to position 12 which is the talking position for the incoming selector. The tip conductor 201 in position 12 is extended over brush 160 and the lower contacts of cam 154 through condenser 164, to the tip of jack 112 and cord 110. Ring conductor 218 is extended over brush 161, upper contacts of cam 152 through condenser 165 to the ring of jack 112 and cord 110.

The A operator may now listen in on the called line, challenge on the line or make whatever simple test may seem necessary to determine the condition thereof. Having reached a conclusion, she will then transmit the information to the subscriber at substation 105 and will then withdraw her cord from jacks 109 and 112.

The withdrawal of plug 111 opens the circuit of relay 113 and that relay releases relay 114. Relay 114 released closes a circuit from battery through the left winding of relay 137, lower contacts of cam 139 to ground at the right back contact of relay 114. Relay 137 operates and closes a circuit from battery through the winding of sequence switch magnet 100, upper left contact of cam 128 to ground at the left front contact of relay 137, advancing the sequence switch to position 14.

As sequence switch 100 leaves position 12 the ground which was connected over the upper left contact of cam 157 to the sleeve brush 158 is removed and relay 208 in the final selector releases. With relay 208 released, a circuit is closed from battery through right winding of relay 137 and its inner right front contact, lower contacts of cam 130, sleeve brush 158, terminal 163, conductor 214, contact 212 of jack 213, upper contacts of cam 211, right back contact of relay 208, lower left contact of cam 238, winding of relay 237, to ground at the lower contact of cam 225, operating relay 237 and holding relay 137 operated. It is to be noted that the energizing circuit of relay 137 was held closed until sequence switch 100 left position 13 affording sufficient time for the closure of this holding circuit. Likewise, it should be noted that battery through resistance 166 is connected in parallel with the winding of relay 137, and ground through resistance 251 is connected in parallel with relay 237 so that relay 237 will operate and only operate during release from a no-test connection.

It will be remembered that during the course of a regular call, in positions 15 to 15¼ of the final selector, relay 205 is connected over the loop of the called line to prevent the release of the final selector as long as the receiver is off the switchhook at the called station. The operation of relay 237 at this time opens this circuit for operating relay 205 and hence permits the release of the final selector independent of the called subscriber. The release of relay 208 following position 12 of sequence switch 100 also closes a circuit from battery through the winding of sequence switch magnet 200, upper left contact of cam 223, to ground at the left back contact of relay 208, advancing the sequence switch 200 from position 13 to position 16. Since relay 205 is non-operated at this time, a circuit is at once closed from battery through the winding of magnet 200, lower left contact of cam 223 to ground at the left back contact of relay 205 and the sequence switch is advanced to position 18.

When the sequence switch 200 reaches position 16 the circuit through relay 237 is opened and direct ground over the left contact of cam 225 is connected to sleeve conductor 214 to hold relay 137 operated until the final selector sequence switch leaves position 18. In position 18, the down-drive magnet 244 is operated as previously described and the selector restored to normal whereupon sequence switch 200 is advanced to position 1.

When sequence switch 200 leaves position 18, ground is disconnected from the sleeve conductor 214, and relay 137 is permitted to release. The release of relay 137 closes a circuit from battery through the winding of sequence switch magnet 100, upper left contact of cam 145 to ground at the right back contact of relay 137 advancing the sequence switch to position 15. A circuit is then closed from battery through the winding of sequence switch magnet 100, upper right contact of cam 145 to ground at the right back contact of relay 114 advancing the sequence switch to position 18.

In position 18 an obvious circuit is closed for down-drive magnet 167 and the incoming selector is returned to normal under the control of that magnet. When it reaches normal position, a circuit is closed from battery through the winding of magnet 100, lower left contact of cam 145, normal commutator segment 146, brush 147 to ground at the upper right contact of cam 121, advancing the sequence switch to position 1. The incoming and final selectors are now normal. The green lamp 122 remains lighted steadily until sequence switch 127 leaves position 18 whereupon that lamp is also extinguished indicating to the cordless operator that the trunk has been released and has restored to normal.

What is claimed is:

1. In a telephone system, a subscriber's line, a selector switch, means in said switch for testing the idle or busy condition of said

line, and means for testing for an unstandard condition on the test terminal of said line, said latter means effective if an unstandard condition is encountered to render said first means ineffective.

2. In a telephone system, a subscriber's line, a selector switch, means in said switch for testing the idle or busy condition of said line, a signal, and means for testing for an unstandard condition on the test terminal of said line, said latter means effective if an unstandard condition is encountered to render said first means ineffective and to operate said signal.

3. In a telephone exchange system, a subscriber's line, a selector switch, means in said selector switch for successively applying a plurality of tests to said line, and means controlled by said testing means to permit the completion of a connection to said line.

4. In a telephone exchange system, a subscriber's line, a selector switch, a plurality of relays in said selector switch for applying a plurality of tests to said line. means to successively associate said relays with said line, and means controlled by said relays to permit the completion of a connection with said line.

5. In a telephone system, a subscriber's line, a selector switch, means in said switch for testing the idle or busy condition of said line, means operative for rendering said testing means ineffective whereby said selector switch may be caused to establish a connection with a busy line, and means under the control of said latter means for restoring said switch.

6. In a telephone system, a subscriber's line, a selector switch, means in said switch for testing the idle or busy condition of said line, means operative for rendering said testing means ineffective whereby said selector switch may be caused to establish a connection with a busy line, means normally under the control of said line for causing the restoration of said switch, and means under the control of said second means for causing the restoration of said switch irrespective of the control of said line.

7. In a telephone system, a subscriber's line, a selector switch, means in said switch for testing for an unstandard condition on the test terminals of said line, means for testing the idle or busy condition of said line, and means operative for rendering both of said testing means ineffective whereby said selector switch may be caused to establish a connection with a line irrespective of its condition.

8. In a telephone exchange system, a subscriber's line, a selector switch, a plurality of relays in said selector switch for applying a plurality of tests to said line, means to successively associate said relays with said line, means controlled by said relays to permit the completion of a connection with said line, and means to prematurely operate one of said relays to render all of said tests ineffective whereby said selector may be caused to establish a connection with a line irrespective of its condition.

9. In a telephone exchange system, a subscriber's line. a selector switch, a plurality of relays in said selector switch for applying a plurality of tests to said line, means to successively associate said relays with said line, means controlled by said relays to permit the completion of a connection with said line, means to prematurely operate one of said relays to render all of said tests ineffective whereby said selector may be caused to establish a connection with a line irrespective of its condition, means normally under the control of said line for causing the restoration of said switch, and means for re-operating said relay to cause the restoration of said switch irrespective of the control of said line.

In witness whereof, I hereunto subscribe my name this 26th day of August, A. D., 1926.

WILLIAM C. JORDAN.