

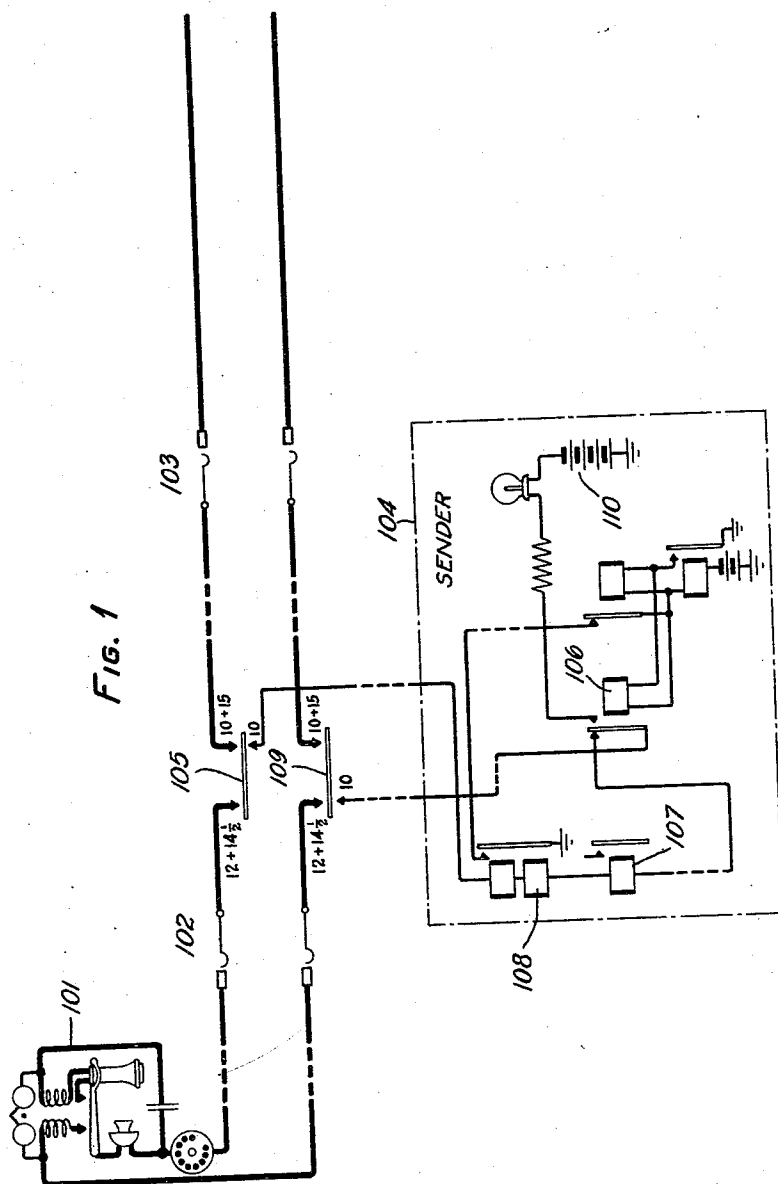
May 5, 1931.

R. E. COLLIS
TELEPHONE EXCHANGE SYSTEM

1,804,150

Filed Jan. 4, 1923

3 Sheets-Sheet 1



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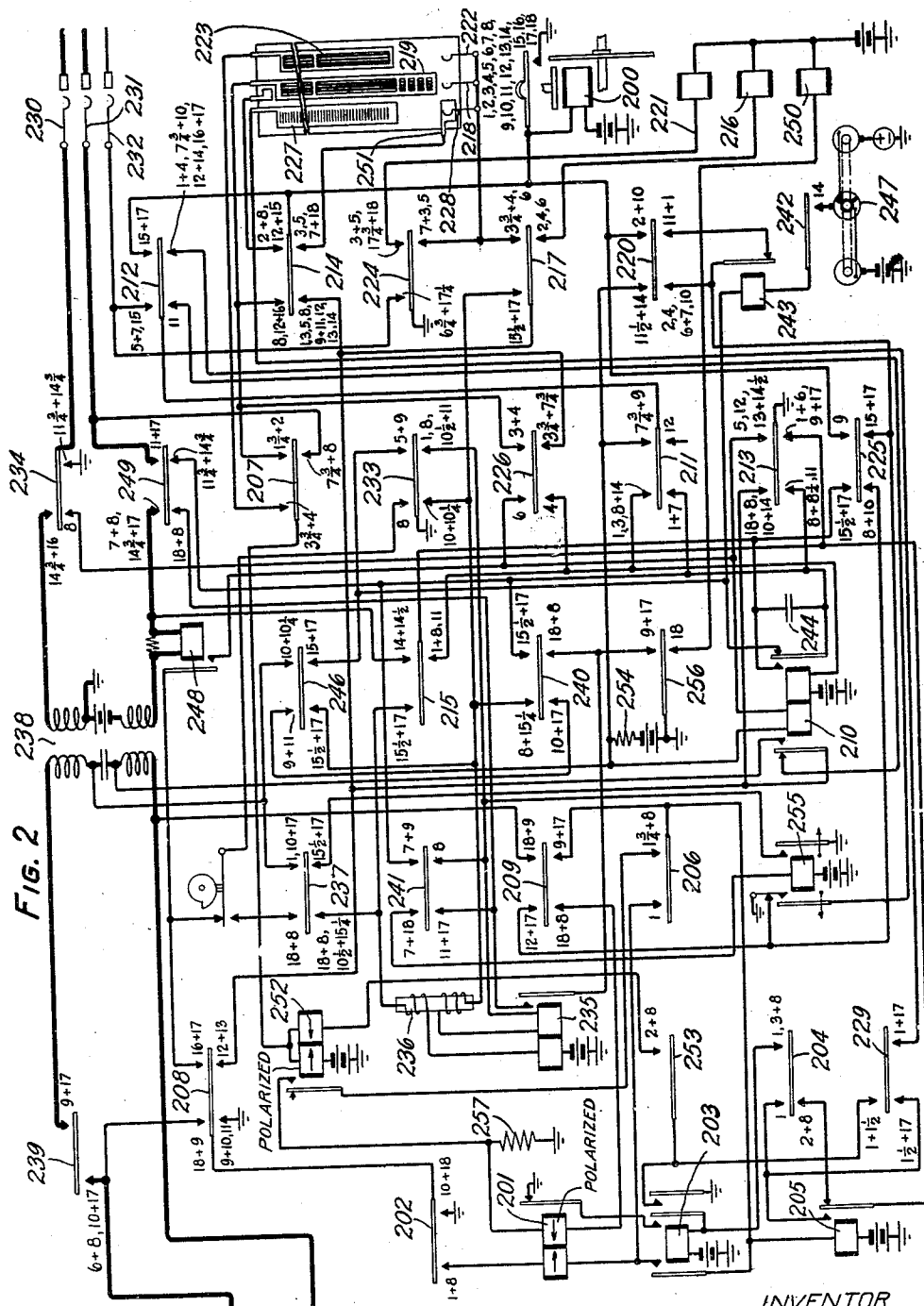
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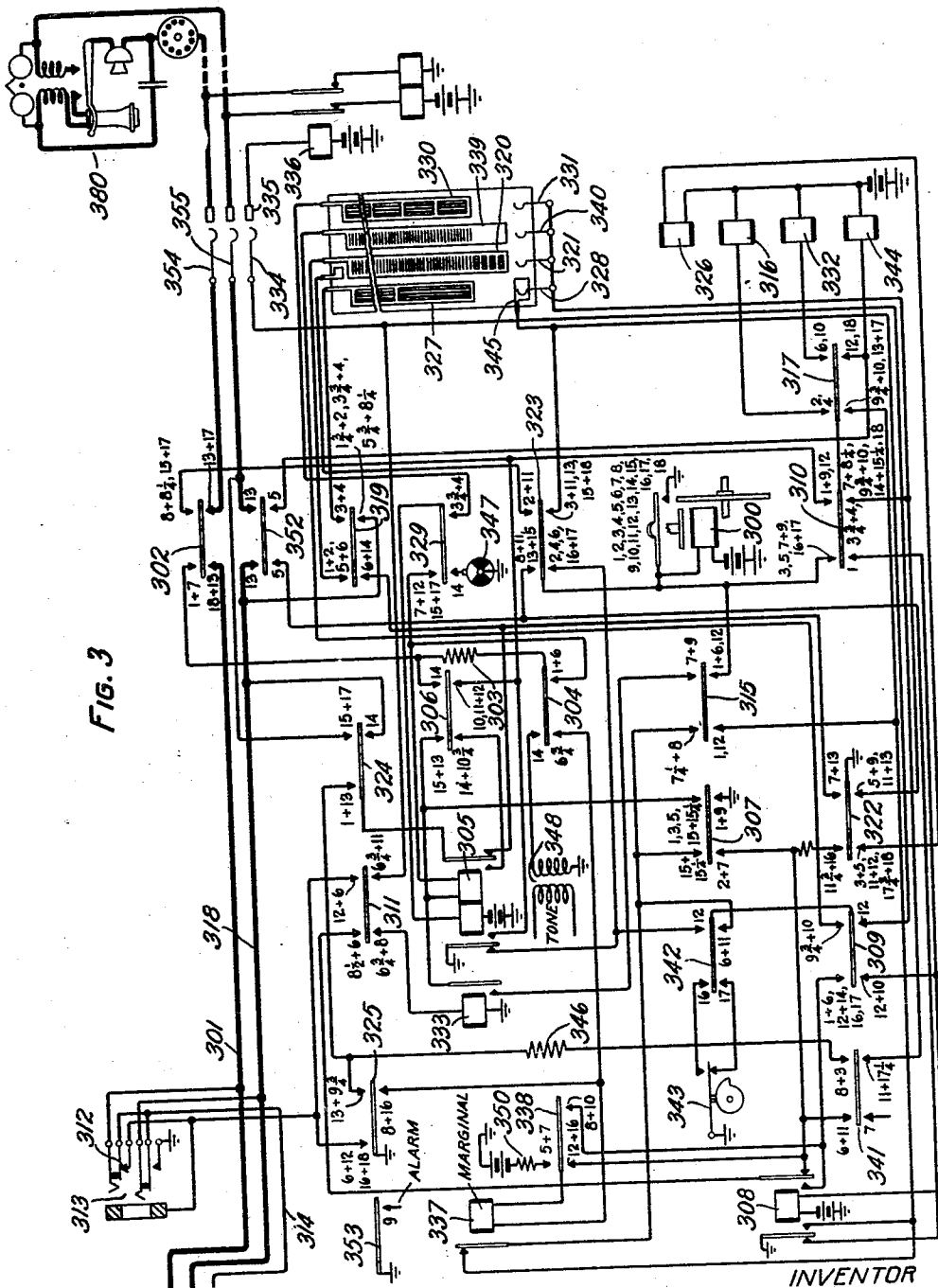


FIG. 3

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TELEPHONE EXCHANGE SYSTEM

Application filed January 4, 1929. Serial No. 330,350.

This invention relates to telephone exchange systems and more particularly to a system in which connections are established by machine switching equipment under the control of control devices over cables which store and discharge sufficient energy to interfere with rapid operation of the switching equipment and has for its object the enabling of the operation of such switching equipment in a manner to disregard reactionary cable energy.

In systems in which the control of automatic switches is effected by a central office sending mechanism through the transmission of reverte impulses from the switches to the sending mechanism, it is essential that the operations of the switching mechanism and sending mechanism be kept in synchronism in order that the switches shall be positioned accurately in accordance with the line designation which has been set up at the sending mechanism or sender by the calling subscriber or operator. In such systems, local district selectors are employed to extend connections to the proper district or office of the exchange and incoming and final selectors are employed in each district or office to further extend the connections to the terminals of the desired lines.

In accordance with the usual practice, the incoming selector is controlled by a control relay which is connected directly into the interoffice cable or trunk circuit extending back to the district selector, the trunk circuit forming part of a closed loop circuit commonly known as the fundamental circuit extending in well known manner through the winding of the stepping relay of the sending mechanism. During the advance of the selector switch, the stepping relay of the sender is operated by impulses transmitted to it over the fundamental circuit by the commutator of the switch until the sender is satisfied with respect to its particular setting when the fundamental circuit is opened at the sender to render the control relay of the switch currentless, whereby the advance of the switch is arrested. It is therefore apparent that the control relay of the switch must release immediately upon the satisfaction of the sender

or upon the opening of the fundamental circuit at the sender in order that the switch shall not overrun and thus position its brushes upon the wrong group or set of terminals.

Where the districts or offices of the exchange are located adjacent to each other, or not exceeding twelve or thirteen miles apart, the control relay of the switch functions quickly enough to provide accurate operation of the switch. If, however, the interoffice trunk comprises a cable of greater length, the control relay by reason of the capacity charge upon the cable, has a tendency to release more slowly following the opening of the fundamental circuit at the sender. It has been determined that the interval between the circuit opening at the sender and the release of the control relay of the switch during operation over a cable thirty miles in length is substantially increased to three times the interval obtained during operation over a cable two miles in length, which added to the usual delay in arresting the movement of the switch is sufficient to enable the switch shaft to advance the brushes beyond the desired position. This tendency of the switch to overrun is more apparent during the brush selection movement of the incoming selector and also since the final selector must be operated over approximately the same length of cable, applies equally well to the selective operations of the final selector switch.

Considerable improvement in the operation of selector switches over cables up to thirty miles in length has been attained through the use of circuits in accordance with the patent to L. H. Johnson No. 1,543,854, granted June 30, 1925 but satisfactory switch control over cables longer than thirty miles in length and up to fifty miles in length has been more difficult to attain. The present invention was developed with a view to extending considerably the length of cables over which accurate selector switch control might be attained.

In accordance with the present invention, one embodiment of which has been disclosed herein by way of example, means is provided in the incoming selector in which the long interoffice cable terminates, for quickly and

positively disconnecting the control relay of the selector from the cable or fundamental circuit immediately following the satisfaction of the sender with respect to any selective operation of the incoming selector or any selective operation of a final selector which may be reached through the incoming selector. More specifically, the control relay of the incoming selector is upon seizure of the interoffice cable or trunk circuit, connected to the tip conductor of the cable under the control of a polarized relay. This control relay in the usual manner controls the advance of the switch shaft in its selective movement and in accordance with the usual practice impulses are sent back over the interoffice cable by the switch commutator during the advance of the switch shaft to measure at the sender the amount of movement of the switch shaft. These impulses cause the intermittent energization and deenergization of the sender stepping relay to successively operate pairs of counting relays in the sender, the number of counting relays so operated being determined by the setting of the sender registers. When sufficient counting relays have been thus operated to measure the desired selective movement of the selector switch, the energization of one of the last pair of counting relays opens the fundamental circuit and at the same time applies current from a source of 110 volt potential to the ring conductor of the cable loop thereby causing the immediate response of the polarized relay in the selector, this relay being so characterized as to be unresponsive except to the current of 110 volts so applied. Immediately upon the energization of the polarized relay, the control relay at the selector is disconnected from the cable and deenergizes forthwith to arrest the further advance of the switch shaft. Inasmuch as the control relay is a sensitive relay, and is thus dissociated from the cable, the reactive discharge of the cable when it is opened at the sender has no delaying effect upon the deenergization of the control relay and such relay therefore very quickly releases.

Referring to the drawings Fig. 1 shows in diagrammatic form a subscriber's line, a central office sender, a line finder and a district selector for extending a connection to the incoming selector shown in detail in Fig. 2.

Fig. 2 shows an incoming selector and Fig. 3 shows a final selector and one of a plurality of subscribers' lines which may be reached over the brushes of such final selector.

Assuming that the subscriber at substation 101 desires to converse with a subscriber at substation 380, he will remove his receiver from the switchhook. Line finder 102 will thereupon operate to find the calling line and to extend it to a district selector 103 which is associated by any suitable means with a sender 104 shown in the dot-dash rectangle

in the lower portion of Fig. 1. When the sender is ready to receive dialing impulses, a tone will be returned to the substation after which the subscriber will dial the number of the wanted subscriber. District selector 103 will be operated under the control of the sender to select an idle incoming selector.

When the district selector has come to rest and the sender has advanced to a position for controlling incoming selections, a circuit is established from battery through the winding of relay 205, left contact of cam 206, left winding of polarized differential relay 201, left contact of cam 202, upper left contact of cam 208, over the tip conductor of the interoffice trunk, tip brush of selector 103, right contacts of cam 105, windings of pulsing relay 108 and overflow relay 107, back contact of counting relay 106, lower left and upper right contacts of cam 109, ring brush of selector 103, ring conductor of the interoffice trunk, upper right and lower left contacts of cam 209, right winding of relay 201 to ground through the resistance 257. The sender pulsing relay 108 and selector control relay 205 are energized over this circuit but relay 201 does not respond since it is adjusted and wound to respond only to the current from the source 110 at the sender. This source may, for example, be of 110 volts negative potential.

Relay 205 upon energizing establishes a circuit for relay 203 extending from battery through the winding of relay 203, upper contacts of cam 204, front contact of relay 205 to ground at the lower right contact of cam 213, relay 203 upon energizing closing a locking circuit for itself extending through its winding and inner right contact to ground at the back contact of relay 201. At its left contact relay 203 connects the winding of relay 205 directly to the fundamental circuit through the left winding of relay 201, and at its outer right contact establishes an energizing circuit for relay 210 extending from battery through the right winding of relay 210, upper left contact of cam 211, lower right contact of cam 212, right and upper left contacts of cams 229, to ground at the outer right contact of relay 203. Relay 210 operates and locks from battery through its right winding, lower contact of cam 215, right front contact of relay 210, lower left contact of cam 211, lower right contact of cam 212, thence as traced to ground at the outer right front contact of relay 203. At its left front contact relay 210 establishes a circuit for advancing sequence switch 200 out of position 1 into position 2, extending from battery through the winding of sequence switch magnet 200, lower left contact of cam 214, left front contact of relay 210, to ground at the upper left contact of cam 213. As the sequence switch passes into position 1½ the holding circuit of relay 210 is transferred over the left contacts

of cam 229 from ground at the front contact of relay 203 to ground over the front contact of relay 205 and the lower right contact of cam 213.

5 With sequence switch 200 in position 2 the circuit of updrive magnet 216 is closed and the incoming selector is advanced in a brush selecting movement. The circuit for magnet 216 extends from battery through the winding of magnet 216, lower contact of cam 217, left
10 front contact of relay 210, upper left contact of cam 213, to ground. As the selector moves upward, brush 218 makes contact with commutator strip 219, intermittently closing
15 a circuit from ground over the lower contact of cam 224, brush 218, conducting segments of strip 219, upper left contact of cam 207, to the midpoint between the windings of relay 252. Relay 252 which is differentially
20 wound and polarized slightly to hold its armature against its back contact by a circuit extending from battery through both of its windings over the contact of cam 253, to ground at the outer right contact of relay 203,
25 now intermittently energizes through the shunting of its right winding by brush 218 and closes a circuit in shunt of the windings of sender pulsing relay 108, extending from ground through resistance 257, front contact
30 of relay 252, right contact of cam 206, to a point in the fundamental circuit between the left winding of relay 201 and the winding of relay 205. Relay 205 is maintained energized over this circuit, but the sender pulsing
35 relay 108 deenergizes in the usual manner to operate the counting relays.

When the condition set up in the sender has been satisfied the fundamental circuit is opened at the back contact of relay 106 of the sender and a circuit is established from
40 the source 110 over the front contact of relay 106, contacts of cam 109, the ring brush of selector 103, upper right and lower left contacts of cam 209, right winding of relay
45 201 to ground through resistance 257. Relay 201 now receiving current in the proper direction and of sufficient strength energizes, opening the holding circuit of relay 203, which now deenergizes in turn disconnecting relay 205 from the interoffice trunk.
50 Since relay 205 is now entirely free from any connection to the interoffice cable, and is not therefore affected by any cable surges due to the capacity of the cable, it releases
55 quickly as soon as brush 218 engages the next insulating segment of strip 219 releasing relay 252. As soon as relay 205 releases it opens the holding circuit of relay 210 which in turn releases, opening at its left
60 front contact the circuit of up-drive magnet 216 permitting the selector to come to rest in a position to trip the proper brush-set upon a subsequent upward movement of the selector shaft. Relay 210 at its left back
65 contact also closes a circuit from battery

through the winding of sequence switch magnet 200, upper right and lower left contacts of cam 220, left back contact of relay 210, to ground at the upper left contact of cam 213 for advancing sequence switch 200
70 into position 3.

At the sender the operated counting relays are released in the well known manner, relay 106 disconnecting the source 110 and again establishing the fundamental circuit
75 at the sender. Upon the disassociation of the source 110 relay 201 releases and with the sequence switch 200 in position 3, relay 203 again operates over a circuit extending through its winding, right and lower con-
80 tacts of cam 204, back contact of relay 205 to ground at the lower right contact of cam 213, and locks over its inner right contact to ground at the back contact of relay 201. At its left contact relay 203 connects the
85 winding of relay 205 to the tip of the fundamental circuit thereby completing the fundamental circuit and causing the energization of the sender pulsing relay 108 and of the relay 205. The previously traced circuit
90 through the right winding of relay 210 is now established, operating relay 210 and advancing sequence switch 200 into position 4. In position 4 the updrive magnet 216 is re-
95 operated to cause the group selecting operation of the switch. After sequence switch 200 leaves position 3, relay 210 is maintained energized over the holding circuit previously traced. Trip magnet 221 is operated in a
100 circuit extending to ground at the upper right contact of cam 224, throughout positions 3 to 5 inclusive and is therefore operated at the time the selector starts its group
105 selecting movement, to cause the tripping of the selected set of brushes.

During the group selecting movement an intermittent circuit is completed from ground at the upper left contact of cam 213, left front contact of relay 210, upper right
110 contact of cam 217, brush 222, commutator strip 223, left contact of cam 207, to the midpoint between the windings of relay 252. Relay 252 responds to these intermittent impulses in the manner previously described and at its front contact causes the intermit-
115 tent shunting of the sender pulsing relay 108. When the sender is satisfied counting relay 106 energizes opening the fundamental circuit and connecting the source 110 through the right winding of relay 201 and
120 resistance 257 to ground. Relay 201 energizes unlocking relay 203, which upon deenergization disassociates relay 205 from the inter-office trunk.

As soon as the brush 222 engages the next
125 insulating segment of strip 223, relay 252 releases thereby permitting relay 205 to release quickly in turn releasing relay 210. Relay 210 upon deenergization opens at its left front contact, the circuit of updrive
130

magnet 216 to arrest the group selecting movement of the selector. The release of relay 210 also advances sequence switch 200 into position 5 over the same circuit that advanced it to position 3. At the sender the operated counting relays are released, the sender is prepared for the next selection control, and the circuit of relay 201 is opened whereupon relay 201 releases. With the sequence switch 200 in position 5, a local circuit is closed for relay 210, extending from battery through resistance 254, the left winding of relay 210, to ground at the upper right contact of cam 213. Relay 210 operates in this circuit and closes a circuit from battery through its right winding, lower right contact of cam 215, right front contact of relay 210, lower left contact of cam 211, upper left contact of cam 212, to sleeve brush 232. If the final selector connected to the first set of terminals of the selected group is busy, ground will be connected to the sleeve terminal and relay 210 will be held operated in this circuit. The operation of relay 210 closes the previously traced circuit for sequence switch 200 advancing it to position 6, in which position the holding circuit of relay 210, extending to the sleeve brush 232 is maintained.

With the sequence switch 200 in position 6, the updrive magnet 216 is again energized and the selector is advanced in a trunk hunting movement. As soon as an idle trunk is found, the holding circuit of relay 210 is opened. Until the brushes of the selector are centered on an idle trunk, relay 210 is maintained energized over its left winding, upper left and lower right contacts of cam 226, commutator strip 227, brush 228, upper right contact of cam 217, left front contact of relay 210, to ground at the upper left contact of cam 213. When relay 210 releases it connects ground over the upper right contact of cam 233, right back contact of relay 210, lower left contact of cam 211, upper left contact of cam 212 to sleeve brush 232, to render the final selector busy to other incoming selectors. With relay 210 released a circuit is also closed for advancing sequence switch 200 into position 8, which circuit may be traced from battery, winding of magnet 200, upper right and lower left contacts of cam 220, left back contact of relay 210, to ground at the upper left contact of cam 213.

As soon as sequence switch 200 reaches position 6¾ direct ground is connected over the left contact of cam 224 to sleeve brush 232, to hold the final selector busy.

As sequence switch 200 passes through position 7 a circuit is closed for operating slow releasing relay 255, extending from battery through the winding of relay 255, upper contacts of cam 241, right back contact of relay 210, to ground at the upper right contact of cam 233. Although relay 255 does not

perform any functions in positions 7 and 8 of the sequence switch, nevertheless it is energized during these positions so that the delay introduced by its releasing time, when relay 210 operates in position 9 as will be later described, will be of sufficient duration.

With sequence switch 200 in position 8, a circuit is established from battery through the winding of relay 203, upper right and lower left contacts of cam 204, back contact of relay 205, lower left contact of cam 234, brush 230, conductor 301, left contacts of cam 302, resistance 303, right contact of cam 304, right winding of relay 305 to ground over the right contacts of cam 307. Relay 203 energizes in this circuit but relay 305 cannot operate because of the resistance of relay 203. Relay 203 upon operating locks as previously described to the back contact of relay 201 and connects the winding of relay 205 to the tip of the fundamental circuit. Relay 205 and sender pulsing relay 108 now energize over the fundamental circuit. With relay 205 operated the circuit previously traced to ground through the right winding of relay 305 from the lower left contact of 234, is transferred over the front contact of relay 205, lower contacts of cam 229, lower right contact of cam 212, upper left contact of cam 211, to battery through the right winding of relay 210. At the same time a circuit is closed in parallel with the right winding of relay 210 from battery through resistance 254 over the upper right contact of cam 211 to the circuit just traced. The effect of this parallel circuit is to prevent the operation of relay 210 in series with relay 305, and to provide sufficient current to operate relay 305.

Relay 305 thereupon locks in a circuit which extends from the right winding of relay 305 over the left contacts of cam 306, right front contact of relay 305, left contact of cam 324, upper right contact of cam 325 to ground. The operation of relay 305 closes a circuit from battery through the winding of relay 308, lower left and upper right contacts of cam 310, left front contact of relay 305 to ground. Relay 308 locks over a circuit through its winding, left contacts of cam 309, right front contact of relay 308, upper contacts of cam 311, contact 312 of jack 313, sleeve conductor 314, brush 232, to ground at the left contact of cam 224. This locking circuit remains closed until sequence switch 300 leaves position 6. The operation of relay 308 at this time closes a circuit from battery through the winding of final selector sequence switch magnet 300, lower contacts of cam 315, to ground at the left front contact of relay 308, advancing the sequence switch into position 2.

With sequence switch 300 in position 2 a circuit is closed for high speed updrive magnet 316 extending from battery through the winding of magnet 316 upper left contact

of cam 317, upper right contact of cam 310, left front contact of relay 305 to ground. Under the control of magnet 316 the final selector is driven upward in a brush selecting movement. As brush 321 passes over commutator strip 320, a circuit is intermittently closed from ground over the lower right contact of cam 322, brush 321, strip 320, upper left and lower right contacts of cam 319, conductor 318, brush 231, lower right contact of cam 207, to the mid point between the windings of relay 252. Since with sequence switch 200 in position 8 and relay 203 energized the two windings of relay 252 are connected differentially between battery and ground over the contact of cam 253, and the front contact of relay 203, the intermittent connection of ground to the mid point between its windings causes the intermittent energization thereof and the intermittent shunting of the windings of sender pulsing relay 108. Relay 205 is however held energized over the front contact of relay 252. When the sender is satisfied counting relay 106 energizes connecting the source 110 to the tip conductor of the fundamental circuit causing the energization of relay 201 and the consequent release of relay 203. Relay 205, being disassociated from the fundamental circuit through the release of relay 203, releases as soon as its holding circuit is opened through the release of relay 252, the latter relay releasing as soon as brush 321 engages the next insulating segment of strip 320. Relay 205 upon releasing in turn releases relay 305. At the sender upon the energization of relay 106, the sender circuits are prepared for controlling the next selection movement of the final selector and relay 201 is released.

With relay 305 released, the circuit of magnet 316 is opened, permitting the final selector brushes to come to rest in position to trip the desired set of brushes. Relay 305 also closes a circuit extending from battery through the winding of sequence switch magnet 300, the lower left contact of cam 323, to ground at the left back contact of relay 305, advancing sequence switch 300 into position 3. With sequence switch 300 in position 3 the circuit of the trip magnet 326 is closed from battery through magnet 326, to ground at the lower left contact 322 preparatory to tripping the desired set of brushes upon the subsequent upward movement of the switch shaft.

When the sequence switch 300 reaches position 3, the previously traced circuit for relays 203 and 305 is again established but only relay 203 operates. Relay 203 upon operating again locks to the back contact of relay 201, and completes the fundamental circuit through the windings of the sender pulsing relay 108 and the winding of relay 205. Relay 205 energizes over the fundamental circuit again connecting the right winding

of relay 210 in series with the right winding of relay 305, whereupon relay 305 operates as before described locking itself operated and advancing sequence switch 300 into position 4. The circuit for advancing sequence switch 300 may be traced over the upper contacts of cam 310, to ground at the left front contact of relay 305. High speed magnet 316 is again operated and an intermittent circuit is completed for relay 252 over conductor 318 as previously traced, thence over the right contacts of cam 319, commutator strip 327, brush 328, the right contacts of cam 310, to ground at the left front contact of relay 305. In response to the connection of this intermittent ground to the windings of relay 252, relay 252 intermittently shunts the sender pulsing relay 108 and holds relay 205 operated. When the sender is satisfied the relay 201 is operated in the manner previously described to release relay 203, thereby disassociating relay 205 from the interoffice trunk. As soon as the brush 328 engages the next insulating segment of strip 327, relay 252 releases thereby opening the holding circuit of relay 205 which in turn releases and opens the previously traced circuit of relay 305. At the sender circuits are prepared in the well known manner for controlling units selection at the final selector and relay 201 is released. Relay 305 at its left back contact again establishes the previously traced circuit for advancing sequence switch 300 into position 5.

When the sequence switch 300 reaches position 5, the previously traced circuit for relays 203 and 305 is again established, but only relay 203 operates. Relay 203 upon operating again locks to the back contact of relay 201, and completes the fundamental circuit through the windings of sender pulsing relay 108, and the winding of relay 205. Relay 205 energizes over the fundamental circuit again connecting the right winding of relay 210 in series with the right winding of relay 305, whereupon relay 305 operates as before described, locking itself operated and advancing sequence switch 300 into position 6 over the previously traced circuit. In position 6, the holding circuit of relay 308 is transferred to a circuit through the lower left contact of cam 309, lower right contact of cam 342, back contact of relay 337 to ground at the left front contact of relay 308. A circuit is also completed from battery through the winding of low speed updrive magnet 332, upper right contact of cam 317, upper right contact of cam 310 to ground at the left front contact of relay 305.

In position 6 an intermittent circuit extending from the mid point between the windings of relay 252 over conductor 318 is completed over the lower right and upper left contacts of cam 319, commutator strip 320, brush 321 to ground at the lower right

contact of cam 322. Relay 252 thereby intermittently shunts the pulsing relay 108 of the sender and holds relay 205 operated. When the sender is satisfied relay 201 operates as previously described unlocking relay 203 which in turn disassociates relay 205 from the interoffice trunk. Until the selector brushes are properly centered on terminals of the selected line, relay 252 remains energized to hold relay 205 energized. When however, the brushes are centered and brush 321 engages the next insulating segment of strip 320, relay 252 releases releasing relay 205 which in turn releases relay 305. Relay 305 upon releasing opens the circuit of updrive magnet 332, and at its left back contact closes the previously traced circuit for advancing sequence switch 300 into position 7. At the sender the operated counting relays are released and relay 201 is thereby deenergized.

Sequence switch 300 upon reaching position 7 is immediately advanced into position 9 in a circuit extending from battery through the winding of magnet 300, upper left and lower right contacts of cam 310 to ground at the lower right contact of cam 322. When sequence switch 300 passes through positions $6\frac{3}{4}$ to 8 inclusive a circuit is closed from ground through the winding of relay 333, the lower contacts of cam 311 to the sleeve brush 334. If the called line is in normal condition, battery will be connected to the sleeve terminal through the cut-off relay 336, of the subscriber's line or if the line is busy this relay will be shunted by ground through a resistance. Relay 333 will operate unless the sleeve conductor is opened or is grounded through a low resistance such as would occur if the sleeve were accidentally grounded. If either of these last two un-normal conditions exists relay 333 will not operate and the circuit for operating relay 305 which will be traced hereinafter is open. When sequence switch 300 reaches position 9, relay 305 would then be deenergized and no circuit would be provided for advancing the sequence switch out of that position. An alarm is therefore operated over cam 353 after a measured interval. The release of the selector is then brought about manually.

When relay 333 operates indicating that the called line is normal and switch 300 reaches position $7\frac{1}{2}$ a circuit is closed from battery through the left winding of relay 305, upper contact of cam 329, right winding of relay 305, front contact of relay 333, upper contacts of cam 315, back contact of relay 337 to ground at the left front contact of relay 308. It will be recalled that relay 308 was locked to sleeve conductor 314 in positions 1 to 6 of sequence switch 300 and that when sequence switch 300 reached position 6, this holding circuit was transferred to ground at the left front contact of relay 308 which latter holding circuit is effective until the

sequence switch leaves position 10 or until relay 337 is operated. Relay 305 operates in the circuit above traced and locks in a circuit through its two windings, left contacts of cam 306, right front contact of relay 305, left contact of cam 324, upper right contact of cam 325, to ground until the sequence switch leaves position $9\frac{3}{4}$.

From the time that relay 305 released with sequence switch 300 in position 6 following units selection, until the sequence switch leaves position $8\frac{1}{4}$, ground is connected to conductor 318 over the lower contacts of cam 319, right back contact of relay 305, upper left contact of cam 324 and the upper right contact of cam 325, and as soon as position 7 is reached ground is connected to conductor 318 over the lower contacts of cam 319 from the upper right contact of cam 322. This circuit extends as previously traced to the windings of relay 252.

When the sequence switch 300 passes through position 8 to $8\frac{1}{4}$ direct ground is connected to conductor 301 over the lower left and upper right contacts of cam 302, right contacts of cam 310, and the lower right contacts of cam 322. Upon the release of relay 201, following the completion of units selection, relay 203 becomes energized in the circuit previously traced over contact 301, and locks to the back contact of relay 201. Since relay 252 is now energized, a circuit is established for relay 205 extending from battery through the winding of relay 205, right contact of cam 206, and the front contact of relay 252 to ground through resistance 202. It will be recalled that the circuit of relay 210 extended over conductor 301, and the front contact of relay 205, but that relay 210 could not operate in series with the resistance of relay 305 due to the shunt around its winding. However, the current through relay 210 when connected to direct ground as above described is sufficient to operate this relay. The operation of relay 210 advances sequence switch 200 into position 9 in which position a signal is transmitted to the sender as will be described hereinafter.

With relay 305 operated, a circuit is closed as soon as sequence switch 300 reaches position 9 for advancing it to position 10, which circuit extends from battery through the winding of magnet 300, upper contacts of cam 310, to ground at the left front contact of relay 305. While the sequence switch 300 is moving through positions $8\frac{1}{2}$ to 10, a circuit is closed from sleeve brush 334, lower right and upper left contacts of cam 311, right front contact of relay 308, right contact of cam 338, winding of relay 337, lower contact of cam 325 to ground. If brush 334 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 high resistance and ground will also be con-

5 nected thereto through a low resistance. Relay 337 is marginal so that it will not operate through so high resistance in parallel with the busy ground or in parallel with another private branch exchange test relay. In consequence relay 308 remains operated in its previously traced operating circuit. Relay 305 also remains operated in position 10 in a circuit which extends as previously traced to the upper left contact of cam 306 and is shifted in this position over the lower right contact of cam 306. With relay 308 operated, the sequence switch remains in position 10 and a circuit is completed from battery through the winding of low speed updrive magnet 332, upper right and lower left contacts of cam 317, to ground at the left front contact of relay 308.

20 When an idle line is encountered no ground will be connected to the sleeve terminal and the current will be sufficient to operate relay 337. Relay 337 will also operate through the lower resistances connected to the sleeve terminals of individual lines, and the last lines of private branch exchange groups whether busy or not. The operation of relay 337 opens the previously traced holding circuit of relay 308. An additional holding circuit for relay 308 exists at this time from ground at the left front contact of relay 308, lower left contact of cam 317, lower left contact of cam 310, brush 340, commutator strip 339, upper right and lower left contacts of cam 309 to the winding of relay 308 which insures that relay 308 will remain energized until the brush set is properly centered. The release of relay 308 opens the circuit of magnet 332 bringing the selector to rest and also closes a circuit from battery through the winding of magnet 300, upper left contact of cam 323, to ground at the back contact of relay 308, advancing the sequence switch into position 12. As soon as relay 308 releases, ground is connected to sleeve brush 334, extending from the left front contact of relay 305, lower contacts of cam 306, right front contact of relay 305, left contact of cam 324, through resistance 346, upper contacts of cam 341, right back contact of relay 308, upper left and lower right contacts of cam 311, to the sleeve brush 334 as a temporary busy condition.

55 While sequence switch 300 is passing through position 10 to position 10 $\frac{3}{4}$ with sequence switch 200 in position 9, the holding circuit of relay 305 is extended from the upper left contact of cam 306 over the right front contact of relay 305, the left contact of cam 324 to resistance 346, thence to the sleeve brush 334 as above traced. Assuming that the line is idle, as soon as sequence switch 300 leaves position 10, relay 305 will release and connect ground from the upper right contact of cam 322, over its right back contact, left contact of cam 324, through re-

sistance 346, to sleeve brush 334, over the path previously traced to make the line busy.

When the sequence switch reaches position 12 with relay 305 released, relay 308 is operated in a circuit through its winding, lower left contact of cam 309, upper right contact of cam 342, to ground at the left back contact of relay 305. Relay 308 in operating closes a circuit from battery through the winding of sequence switch magnet 300, lower contacts of cam 315, left front contact of cam 308, to ground advancing the sequence switch to the talking position 13. As soon as the sequence switch 300 reaches position 13, ground is connected over the upper right contact of cam 325, through resistance 346, the left contacts of cam 341, to the sleeve brush to hold the called line busy throughout conversation. Relay 308 when operated in position 12, locks over the left contacts of cam 309, right front contact of relay 308, upper contacts of cam 311, contact 312 of jack 313, sleeve conductor 314, brush 232, to ground at the upper left contact of cam 224. In the talking position, tip conductor 301 is extended over the lower contacts of cam 302 to the tip brush 354 and the tip of the called line. The ring conductor 318 is extended over the upper contacts of cam 352, to ring brush 355 and the ring of the called line.

In the meantime, the advance of the incoming selector sequence switch 200 to position 9 has taken place while sequence switch 300 was in position 8, as above described, and the incoming selector has functioned as follows: The advance of sequence switch 200 from position 8 opens the circuit of relay 210 and that relay releases. With sequence switch 200 in position 9 and relay 210 released, relay 255 is maintained energized over the circuit previously traced. Relay 205 is now connected over the right contacts of cam 209 to the ring conductor and ground is connected over the left contacts of cam 208 to the tip conductor of the fundamental circuit, reversing the direction of current thereover indicating to the sender that selections have been completed and that the district selector may be advanced to the talking position, following which operation the sender is released. Relay 205 operates in this circuit and closes a circuit through the right winding of relay 210 as previously traced. Relay 210 thereupon operates releasing relay 255 which after an interval releases and advances sequence switch 200 into position 10. This circuit may be traced from battery through the winding of magnet 200, the upper right and lower left contacts of cam 225, to ground at the left normal contacts of relay 255. When sequence switch 200 leaves position 9, relays 205 and 210 release. From position 10 sequence switch 200 is advanced into position 11 over a circuit extending from battery through the winding of magnet 200, the upper right and

lower left contacts of cam 220, the left back contact of relay 210, to ground at the upper left contact of cam 213.

In passing through positions 10 to 10 $\frac{1}{4}$ battery is connected through resistance 254, the upper contacts of cam 246, and the contacts of cam 239 to the tip conductor of the interoffice trunk and ground is connected over the lower left contact of cam 233 and the left contacts of cam 240 to the ring conductor of the trunk for the purpose of charging the interoffice cable prior to the connection of relay 235 therewith. As soon as the sequence switch reaches position 10 $\frac{1}{2}$, battery is connected through the left winding of relay 235, the upper winding of coil 236, the lower left and upper right contacts of cam 237, to the tip conductor of the trunk and ground is connected over the lower right contact of cam 233, the right winding of relay 235, the lower winding of coil 236, and the left contacts of cam 240 to the tip conductor of the trunk.

As soon as the sequence switch of the district selector has advanced to the talking position and the repeating coil thereat (not shown) is connected into the talking circuit, relay 235 operates in turn closing a circuit for relay 255 extending from battery through the winding of relay 255, the left contacts of cam 241, the contact of relay 235, to ground at the upper contact of cam 256. With relay 255 operated, a circuit is closed for relay 210 extending from battery through the right winding of relay 210, over the upper left contact of cam 211, the lower left contact of cam 212, to ground at the left front contact of relay 255. Relay 210 upon energizing locks through its right winding, the lower contact of cam 215, the right front contact of relay 210, to ground at the lower left contact of cam 213, and closes the previously traced circuit for advancing sequence switch 200 into position 12. After the sequence switch leaves position 11, ground for the right winding of relay 235 is supplied from the right contact of relay 255. As soon as the sequence switch leaves position 11, relay 210 releases.

In positions 12 and 13 a circuit is closed for advancing sequence switch 200 into the ringing position 14 which may be traced from battery through the winding of magnet 200, the lower left contact of cam 214, lower right contact of cam 208, to ground at the right contact of cam 202. The testing operations of the final selector above described take place quickly and that selector will now be in talking position 13. Therefore when sequence switch 200 reaches position 14 ringing current is connected over the interrupter 247, contact of cam 242, winding of relay 243, right back contact of relay 210, right contacts of cam 249, to the ring brush 231 and will be transmitted over the ring conductor 318 of the final selector, upper contacts of cam 352, brush 355, over the ring conductor to the

called subscriber's substation, back over the tip conductor, brush 354, lower contacts of cam 302, conductor 301, brush 230, lower right contact of cam 234 to ground.

When the called subscriber answers, relay 243 operates removing a short circuiting ground connected from the left winding of relay 210, over the upper left and lower right contacts of cam 220, the back contact of relay 243, the left back contact of relay 210, to ground at the upper left contact of cam 213, whereupon relay 210 energizes in a circuit from battery through resistance 254, left winding of relay 210 to ground at the upper right contact of cam 213. Relay 210 operates advancing sequence switch 200 into position 15. The operation of relay 210 temporarily supplies talking battery through position 14 $\frac{1}{2}$ of the sequence switch to the called subscriber over the lower right winding of repeating coil 238, winding of supervisory relay 248, upper right contact of cam 215, right front contact of relay 210, right contacts of cam 249 to the ring conductor, the tip conductor being grounded over the right contact of cam 234. When sequence switch 200 leaves position 14 $\frac{1}{2}$, relay 210 releases opening these temporary circuits, but circuits are closed in position 14 $\frac{3}{4}$ which overlap the temporary circuits sufficiently to prevent the release of relay 248. These circuits remain closed through position 16 and may be traced as follows: from outgoing tip conductor over the upper contact of cam 234 and the upper right winding of repeating coil 238 to ground and from the outgoing ring conductor over the upper contacts of cam 249, winding of relay 248, and the lower right winding of repeating coil 238 to battery, respectively, operating relay 248.

Sequence switch 200 is immediately advanced into position 16 in a circuit over the upper contacts of cam 212, upper left contact of cam 224 to ground. Relay 210 releases when the sequence switch passes from position 14 $\frac{1}{2}$ but reoperates under the control of relay 248 in a circuit extending from battery through resistance 254, the left winding of relay 210, front contact of relay 248, the upper right contact of cam 208, to ground at the right contact of cam 202. The connection of battery and ground to the tip and ring conductors of the interoffice trunk is now reversed for supervisory or message charging purposes. Battery is connected through the left winding of relay 235, the upper winding of coil 236, the left contact of cam 215, the right front contact of relay 210, upper right and lower left contacts of cam 240, lower left winding of repeating coil 238, to the ring conductor and ground is connected from the right front contact of relay 255, through the right winding of relay 235, the lower winding of coil 236, left contact of cam 217, left front contact of relay 210, right

contacts of cam 237, through the upper left winding of repeating coil 238 to the tip conductor.

When the calling subscriber restores his receiver to the switch hook at the end of conversation, relay 235 will be released opening the circuit of relay 255 which in turn releases. Relay 255 at its right contact disconnects ground from one winding of relay 235 to prevent its reoperation and closes a circuit for relay 205, extending from battery through the winding of relay 205, lower right and upper left contacts of cam 209 to ground at the left normal contacts of relay 255. Relay 205 upon energizing in this circuit closes a circuit for advancing sequence switch 200 into position 18, extending from battery through the winding of magnet 200, right contacts of cam 212, lower contacts of cam 229, front contact of relay 205 to ground at the lower right contact of cam 213.

With the sequence switch 200 in position 18, a circuit is closed from battery through the winding of downdrive magnet 250, lower contact of cam 256, to ground. The selector switch is restored to normal under the control of the downdrive magnet 250. As soon as it reaches normal, a circuit is closed from battery through the winding of sequence switch magnet 200, lower right contact of cam 214, normal commutator segment 251, brush 228, to ground at the lower contact of cam 224, advancing the sequence switch to position 1. While the sequence switch remains in position 18, ground is connected to the tip and ring terminals appearing in the bank of the district selector 103 to prevent false operation of the sender if this incoming selector is taken for use during its restoration. These circuits may be traced from the tip conductor over the upper left contact of cam 208 and the right contact of cam 202 to ground and from the ring conductor over the upper right and lower left contacts of cam 209, the right winding of relay 201 to ground through resistance 202.

When sequence switch 200 leaves position 17½ ground is removed from sleeve brush 232, permitting relay 308 to release. The release of relay 308 advances sequence switch 300 to position 16 in a circuit from battery through the winding of magnet 300, upper left contact of cam 323, to ground at the left back contact of relay 308.

In positions 15 to 15¼ of sequence switch 300 a circuit is closed from battery through the left winding of relay 305, upper contact of cam 329, right winding of relay 305, upper contacts of cam 307, back contact of relay 337, lower left contact of cam 317, lower right contact of cam 310, to ground at the lower right contact of cam 322. If the called subscriber has not restored his receiver to the switch hook, relay 305 locks in a circuit ex-

tending through its two windings as previously traced, left contacts of cam 306, right front contact of relay 305, upper right contact of cam 324, over the called subscriber's line, back to the right contacts of cam 302, left front contact of relay 305 to ground. If the called subscriber still fails to hang up his receiver, interrupter 343 will close its upper contact after an interval completing a circuit thereover, over the upper left contact of cam 342 and lower left contact of cam 309, through the winding of relay 308 to battery. Relay 308 operates and completes a circuit through the winding of sequence switch magnet 300, upper left contact of cam 310, lower left contact of cam 317, to ground at the left front contact of relay 308, advancing the sequence switch to position 17, releasing relay 308. After a predetermined interval interrupter 343 closes its lower contact and extends a circuit thereover, through the lower left contact of cam 342, and thence as traced through the winding of relay 308. Relay 308 again advances the sequence switch, this time to position 18 and releases. When the sequence switch leaves position 17, the holding circuit of relay 305 is opened and that relay releases.

If the called subscriber hangs up promptly the locking circuit above traced for relay 305 will be open and that relay will release in position 16. Sequence switch 300 is then advanced to position 18 in a circuit over the lower left contact of cam 323, to ground at the left back contact of relay 305.

In position 18 a circuit is closed for downdrive magnet 344, extending over the lower right contacts of cams 317, 310 and 322, to ground. The selector switch is restored to normal under the control of magnet 344, trip magnet 326 being operated. When the selector reaches its normal position, a circuit is closed from battery through the winding of sequence switch magnet 300, lower right contact of cam 323, normal commutator segment 345, brush 328 to ground at the lower right contact of cam 322 advancing the sequence switch to position 1.

The release of relay 308 when sequence switch 200 leaves position 17½ connects ground to sleeve conductor 314 from the lower contact of cam 325 through the winding of relay 337, lower left contact of cam 338, right back contact of relay 308 and the upper contacts of cam 311. This ground serves to mark the final selector busy to other incoming selectors. When sequence switch 300 arrives in position 16 ground over the left contact of cam 325 is substituted for ground through the winding of relay 337 continuing the busy indication until the selector is ready for reuse.

What is claimed is:

1. In a signaling system, a control device, a responsive device remote therefrom, a con-

trol circuit extending between said devices, a control relay in said responsive device in said control circuit and operable thereover, and a second relay in said responsive device in said control circuit and operable from said control device thereover for disassociating said control relay from said circuit.

2. In a signaling system, a control device, a responsive device, a control circuit extending between said devices, a control relay in said responsive device in said control circuit and operable thereover, means in said responsive device for revertingly controlling said control device, and a second relay in said responsive device in said control circuit and operable from said control device at the termination of said reverting control for disassociating said control relay from said circuit.

3. In a signaling system, a control device, a responsive device, a control circuit extending between said devices, a control relay in said responsive device operable over said control circuit, means in said responsive device for revertingly controlling said control device, a second relay in said responsive device operable over said control circuit for disassociating said control relay from said circuit, and means in said control device operable at the termination of a reverting control thereof for applying current of a particular character over said control circuit for operating said second relay.

4. In a signaling system, a control device, a responsive device, a control circuit extending between said devices, a control relay in said responsive device, means in said responsive device for revertingly controlling said control device, a second relay in said responsive device for connecting said relays in a series loop over said control circuit, said second relay being normally inoperative over said control circuit, and means in said control device operable at the termination of a reverting control thereof for applying current of a particular character over said control circuit for operating said second relay to disassociate said control relay from said control circuit.

5. In a signaling system, a control device, a responsive device, a control circuit extending between said devices, a control relay in said responsive device, means in said responsive device for revertingly controlling said control device, a second relay in said responsive device, means in said responsive device for connecting said relays in a series loop over said control circuit, said second relay being so polarized as to be normally inoperative over said control circuit, and means in said control device operable at the termination of a reverting control thereof for applying current of a particular character over said control circuit for operating said second

relay to disassociate said control relay from said control circuit.

6. In a signaling system, a control device, a responsive device, a control circuit extending between said devices, a control relay in said responsive device, means in said responsive device for revertingly controlling said control device, a second relay in said responsive device, means in said responsive device for connecting said relay in a series loop over said control circuit, said second relay being differentially wound and normally inoperative over said control circuit, and means in said control device operable at the termination of a reverting control thereof for altering the character of said control circuit whereby said second relay operates to disassociate said control relay from said control circuit.

7. In a signaling system, a control device, a responsive device, a control circuit extending between said devices, a control relay in said responsive device, means in said responsive device for revertingly controlling said control device, a second relay in said responsive device, means in said responsive device for connecting said relays in a series loop over said control circuit, said second relay being so polarized and differentially wound as to be normally inoperative over said control circuit, and means in said control device operable at the termination of a reverting control thereof for applying current of a particular character over one conductor of said control circuit for operating said second relay to disassociate said control relay from said control circuit.

8. In a telephone exchange system, a calling line, a selector switch and a connecting circuit for extending a connection from said line, a sending mechanism for controlling said switch, a fundamental switch controlling circuit comprising said connecting circuit extending between said mechanism and said switch, a control relay operable over said fundamental circuit for governing the extent of movement of said switch, means operative during the movement of said switch for revertingly controlling said sending mechanism, and a relay in said switch operable from said sending mechanism for disassociating said control relay from said fundamental circuit.

9. In a telephone exchange system, a calling line, a selector switch and a connecting circuit for extending a connection from said line, a sending mechanism for controlling said switch, a fundamental switch controlling circuit comprising said connecting circuit extending between said sending mechanism and said switch, a control relay operable over said fundamental circuit for governing the extent of movement of said switch, means operative during the movement of said switch for revertingly controlling said sending mechanism, a second relay in said switch operable

over said fundamental circuit for disassociating said control relay from said fundamental circuit, and means in said sending mechanism operable at the termination of a reverte control thereof for applying current of a particular character to said fundamental circuit for operating said second relay.

10. In a telephone exchange system, a calling line, a train of switches and a connecting circuit for extending a connection from said line, a sending mechanism for controlling said switches, a fundamental switch controlling circuit comprising said connecting circuit extending between said sending mechanism and the first switch of said train, a control relay in said first switch operable over said fundamental circuit for governing the extent of movement of said switches, means operative during the selective movements of said switches for revertevely controlling said sending mechanism, and a relay in said first switch operable from said sending mechanism for disassociating said control relay from said fundamental circuit.

11. In a telephone exchange system, a calling line, a train of switches and a connecting circuit for extending a connection from said line, a sending mechanism for controlling said switches, a fundamental switch controlling circuit comprising said connecting circuit extending between said sending mechanism and the first switch of said train, a control relay in said first switch operable over said fundamental circuit for governing the extent of movement of said switches, means operative during the selective movements of said switches for revertevely controlling said sending mechanism, a second relay in said first switch operable over said fundamental circuit for disassociating said control relay from said fundamental circuit, and means in said sending mechanism operable at the termination of a reverte control thereof for applying current of a particular character to said fundamental circuit for operating said second relay.

12. In a telephone exchange system, a calling line, a selector switch and a connecting circuit for extending a connection from said line, a sending mechanism for controlling said switch, a fundamental switch controlling circuit comprising said connecting circuit extending between said sending mechanism and said switch, a control relay operable over said fundamental circuit for governing the extent of movement of said switch, means operative during the movement of said switch for revertevely controlling said sending mechanism, a second relay in said switch for associating said control relay with said fundamental circuit and a third relay operable over said fundamental circuit from said sender for releasing said second relay to disassociate said control relay from said fundamental circuit.

13. In a telephone exchange, a calling line, a selector switch and a connecting circuit for extending a connection from said line, a sending mechanism for controlling said switch, a fundamental switch controlling circuit extending between said sending mechanism and said switch, a control relay operable over said fundamental circuit for governing the extent of movement of said switch, means operative during the movement of said switch for revertevely controlling said sending mechanism, a second relay in said switch for associating said control relay with said fundamental circuit, a third relay operable over said fundamental circuit for releasing said second relay to disassociate said control relay from said fundamental circuit, and means in said sending mechanism operable at the termination of a reverte control thereof for applying current of a particular character to said fundamental circuit for operating said third relay.

14. In a telephone exchange system, a calling line, a selector switch and a connecting circuit for extending a connection from said line, a sending mechanism for controlling said switch, a fundamental switch controlling circuit comprising said connecting circuit extending between said mechanism and said switch, a stepping relay in said sending mechanism and a control relay in said switch operable over said fundamental circuit for governing the extent of movement of said switch, a relay intermittently operative during the movement of said switch for shunting said stepping relay for controlling said sending mechanism and a relay in said switch operable from said sending mechanism for disassociating said control relay from said fundamental circuit.

15. In a telephone exchange system, a calling line, a selector switch and a connecting circuit for extending a connection from said line, a sending mechanism for controlling said switch, a fundamental switch controlling circuit comprising said connecting circuit extending between said mechanism and said switch, a stepping relay in said sending mechanism and a control relay in said switch operable over said fundamental circuit for governing the extent of movement of said switch, an electro-polarized differentially wound relay intermittently operative during the movement of said switch for shunting said stepping relay for controlling said sending mechanism and a relay in said switch operable from said sending mechanism for disassociating said control relay from said fundamental circuit.

In witness whereof, I hereunto subscribe my name this 2nd day of January 1929.

RAYMOND E. COLLIS.