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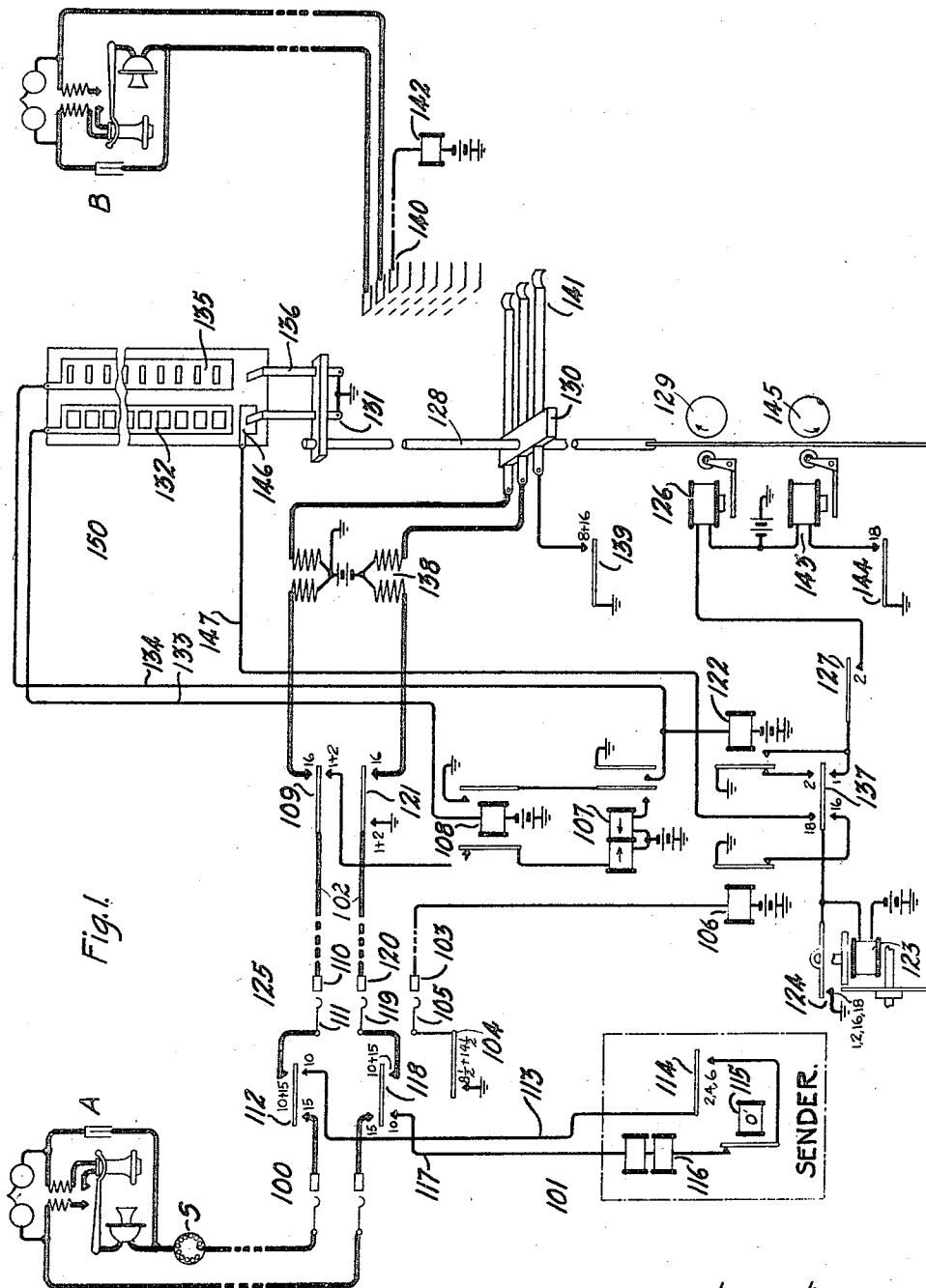
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C. L. GOODRUM

TELEPHONE EXCHANGE SYSTEM

Filed Dec. 29, 1920

2 Sheets-Sheet 1



Inventor:  
Charles L. Goodrum.

by E. R. Nowlan Atty.

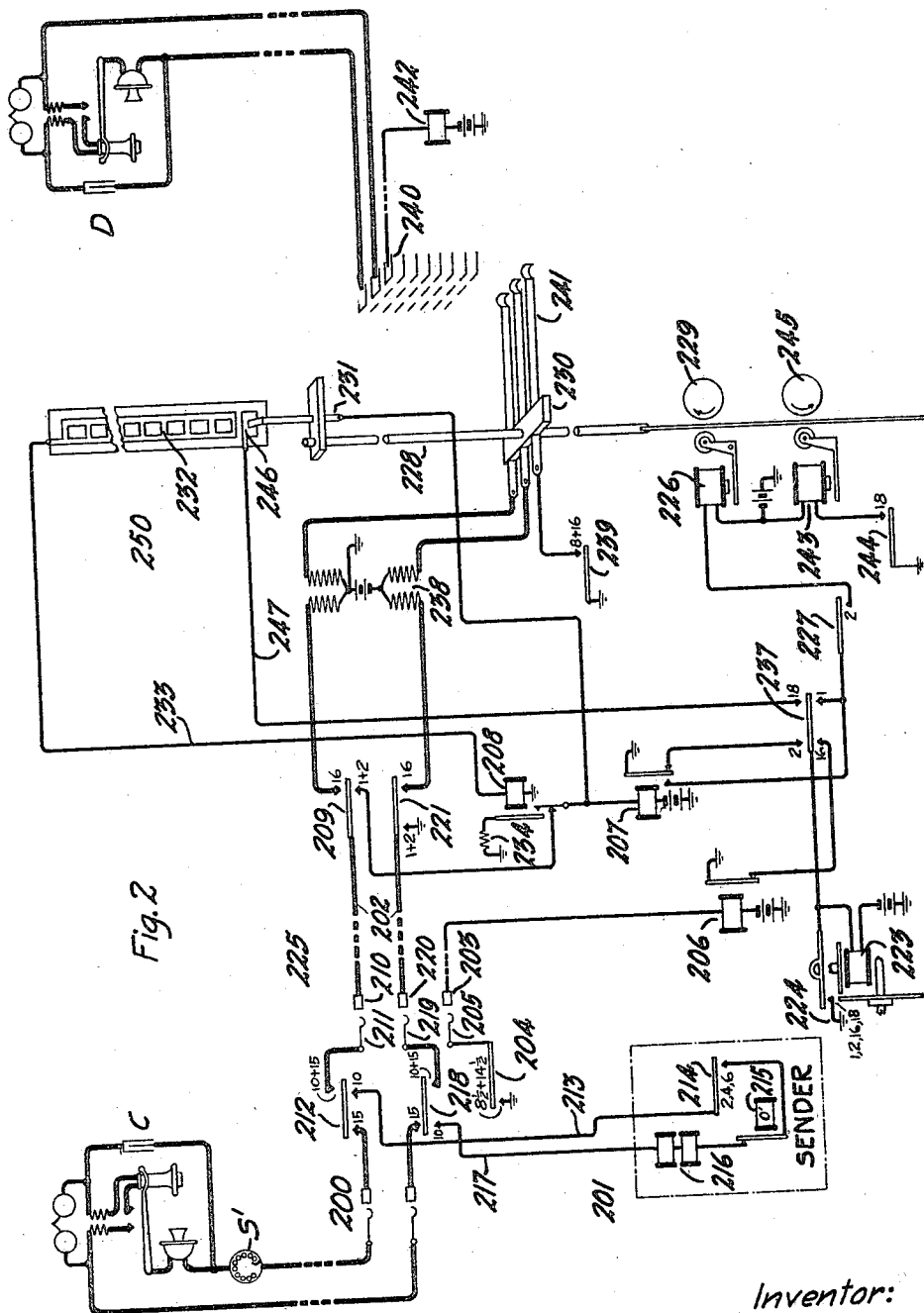
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## UNITED STATES PATENT OFFICE.

CHARLES L. GOODRUM, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

## TELEPHONE-EXCHANGE SYSTEM.

Application filed December 29, 1920. Serial No. 433,752.

*To all whom it may concern:*

Be it known that I, CHARLES L. GOODRUM, a citizen of the United States, residing at New York, in the county of New York, State of New York, have invented certain new and useful Improvements in Telephone-Exchange Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to a telephone exchange system, and more particularly, to a system in which connections are established by machine switching equipment.

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 office 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 sender by the calling subscriber. 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 desired lines.

In accordance with the usual practice, the selector switches are controlled by control relays which are connected directly to the trunk circuits in which the respective switches terminate, each trunk circuit forming part of a closed loop commonly known as the fundamental circuit extending in the well-known manner through the winding of the stepping or control relay of the sending mechanism. During the advance of a selector switch, the stepping relay of the sender is operated by pulses transmitted to it over the fundamental circuit by the commutator of the switch until the sender is satisfied with respect to the setting which is adapted to control that particular switch, 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 inaccurately.

Where the districts or offices of the exchange are located adjacent each other and therefore the interoffice trunk does not exceed twelve or thirteen miles in length, the control relays of the incoming selector and final selector function quickly enough to provide accurate operation of these switches.

If, however, the interoffice trunk comprises a cable of greater length, the control relays lose their sensitivity by reason of the capacity in the cable discharging through the windings of the control relays when the fundamental circuit is opened at the sender and thus, the control relays release more slowly. The interval between circuit opening at the sender and the arresting of the movement of a switch at a distant office or district which during operation over a short cable does not interfere with the accurate setting of the switch may be however, sufficient to enable the switch shaft to advance the brushes beyond the desired position when such a switch is operated over a long interoffice cable. This tendency of the switch to overrun is particularly noticeable during the group selection movement of the incoming selector and during the group selection movement of the final selector.

It is, therefore, the object of this invention to overcome the aforesaid tendency and to provide means for accurately controlling incoming and final selector switches over long interoffice cable loops.

More specifically, it is an object of this invention to provide means at a selector switch for intermittently opening the fundamental circuit at the switch for revertevely controlling the sender and for rendering the line relay of the switch sensitive to release when the fundamental circuit is opened at the sender upon the satisfaction of the sender.

The invention will now be described in connection with the accompanying drawings which disclose two embodiments of the invention. In the drawings, Fig. 1 illustrates one embodiment of the invention and discloses a calling subscriber's line and diagrammatic illustration of a subscriber's individual line switch, a district selector, an office sender and so much of the circuits of a final selector switch as is necessary to

disclose the present invention; and Fig. 2 illustrates a second embodiment of the invention and discloses substantially the same apparatus as disclosed in Fig. 1 with the exception that the circuits of the final selector switch are modified in accordance with this embodiment of the invention.

Inasmuch as the manner in which a connection is extended from the calling subscriber's line to the final selector switch is not essential to an understanding of this invention, the circuits of the subscriber's line switch, district selector switch and office sender have been disclosed only diagrammatically. For a full disclosure of these circuits and the manner in which they function reference may be had to the Patent 1,395,977, issued November 1, 1921, to F. A. Stearn and F. J. Scudder.

To simplify the disclosure, no incoming selector switch has been illustrated, but the interoffice trunk has been shown as terminating directly in a final selector switch. The disclosure in both Figs. 1 and 2 has been further simplified by disclosing a final selector switch which is provided with a single set of brushes having a single selective movement to select one of ten subscribers' lines terminating in the terminal bank of the switch. The final selector switch may be of the general type disclosed in the patent to J. N. Reynolds No. 1,103,623, issued July 14, 1914, but modified in Figs. 1 and 2 in accordance with the specific embodiments of the present invention.

The manner in which the system is organized will best be presented in connection with a description of the mode of its operation. The invention will first be described in connection with the embodiment disclosed in Fig. 1.

It will be assumed that the calling subscriber at substation A desires to establish a connection with the line of subscriber B, which line terminates in a distant office of the exchange. To initiate the call, the calling subscriber removes his receiver from the switchhook whereupon the individual line switch 100 functions in the well-known manner to extend a connection from the calling line to the district selector switch illustrated at 125. The calling subscriber then operates his impulse dial S in accordance with the designation of the desired line to set the registers (not shown) of the office sender 101. Following the setting of the registers of the office sender, the sender functions in the well-known manner in accordance with the office code which has been set up upon the code registers of the sender to set the brushes of the district selector switch 125 upon the terminals of an interoffice trunk 102, extending to the particular office of the exchange in which the line of the desired subscriber terminates.

Upon the extension of the connection to the interoffice trunk 102, which in the case assumed terminates in a final selector switch 150, the sequence switch (not shown) associated with the district selector 125 advances into position 10. Busy potential is now applied to the multiples of test terminal 103 of the trunk 102 from ground at cam 104 over test brush 105 and a circuit is also established over brush 105 and test terminal 103 for sleeve relay 106 of the final selector switch, which relay becomes energized and remains energized until the calling subscriber releases the connection.

With the sequence switch of the district selector in position 10, a fundamental circuit is established extending from the office sender 101 to the final selector which may be traced from battery through the left-hand winding of line relay 107, the left-hand armature and back contact of relay 108, the lower contact of cam 109 (1 to 2), bank terminal 110 and brush 111 of the district selector, the right-hand contacts of cam 112, conductor 113, cam 114 associated with the sequence switch (not shown) of the office sender, the armature and back contact of the O' counting relay 115, the winding of sender stepping relay 116, conductor 117, the lower contacts of cam 118, brush 119 and bank terminal 120 of the district selector and thence to ground at the left-hand contact of cam 121 (1 to 2).

The sender stepping relay 116 and the line relay 107 energize in this circuit, the sender stepping relay preparing a circuit in the well-known manner for counting relays associated with the sender and the line relay 107 closing a circuit for the control relay 122. The circuit of relay 122 may be traced from battery through the winding of relay 122 and thence to ground through the outer right-hand armature and front contact of relay 107. Relay 122 upon energizing closes a circuit for advancing sequence switch 123 out of position 1 and under the influence of master cam 124 into position 2. This circuit may be traced from battery through the magnet winding of sequence switch 123, the lower right-hand contact of cam 137 and thence to ground at the armature and front contact of relay 122. As soon as sequence switch 123 reaches position 2 with relay 122 energized, a circuit is established for the updrive magnet 126 which may be traced from battery through the winding of magnet 126, the contact of cam 127 (2), and thence to ground through the armature and front contact of relay 122. Under the influence of magnet 126, the depending portion of switch shaft 128 is pressed against the constantly rotating updrive drum 129 and the switch shaft is driven upwardly.

As the switch shaft approaches its first

selection position, that is, moves the brush set 130 into proximity to the lowermost set of bank terminals to which it has access, the shaft wiper 131 engages a conducting portion of the commutator segment 132, and a circuit is established for relay 108 which may be traced from battery through the winding of relay 108, conductor 133, segment 132 and to ground through shaft wiper 131.

Relay 108 upon energizing opens the fundamental circuit previously traced through the winding of sender stepping relay 116 and the left-hand winding of relay 107 whereupon these relays deenergize. Upon the deenergization of stepping relay 116 the sender functions in the well-known manner. As at the time relay 108 opens the fundamental circuit, the magnetic circuit of relay 107 is heavily saturated by reason of the operating current impressed upon its winding over the fundamental circuit, this relay will not deenergize quickly unless some provision is made for reducing the saturation of its magnetic circuit. This is accomplished by the provision of a differential winding upon relay 107 which becomes energized upon the energization of relay 108 and at the instant relay 108 opens the fundamental circuit. The circuit for energizing the differential winding of relay 107 may be traced from battery through the right-hand differential winding of relay 107, the inner right-hand armature and front contact of this relay, and thence to ground at the right-hand armature and front contact of relay 108. As soon as relay 107 deenergizes, the circuit through its right-hand winding is opened at the front contact of its inner right-hand armature, and at the front contact of its outer right-hand armature the previously traced circuit of relay 122 is opened. Relay 122 does not deenergize, however, until the set of brushes 130 has been positioned opposite the center of the first set of terminals in the bank, since this relay is maintained energized over a holding circuit which may be traced through its winding, conductor 134, commutator segment 135 and to ground at shaft wiper 136. This holding circuit for relay 122 insures that the circuit of the updrive magnet 126 will be maintained until the brush set has been advanced a complete step.

As the switch shaft 128 continues in its upward movement, the shaft wiper 131 engages an insulating portion of segment 132 and the circuit previously traced through relay 108 is opened whereupon the fundamental circuit is again established. It is to be noted that the fundamental circuit is reestablished by the deenergization of relay 108 prior to the positioning of the brush set opposite the first set of bank terminals and that, therefore, relay 107 reestablishes the

initial energizing circuit of relay 122 before the holding circuit of this relay is opened at commutator segment 135 and shaft wiper 136.

In this manner as the switch shaft 128 moves upwardly, relay 108 intermittently opens and closes the fundamental circuit whereby the sender stepping relay 116 is repeatedly deenergized and energized to cause the successive energization of pairs of counting relays associated with the sender. When the sender is satisfied with respect to its final selector setting, the O' counting relay 115 becomes energized and opens the fundamental circuit at the sender. Since at this instant the shaft wiper 131 is in engagement with a conducting portion of the commutator segment 132 and relay 108 is therefore energized, relay 107 is therefore deenergized and when shaft wiper 136 engages the next insulating portion of segment 135, no circuit exists for relay 122. Relay 122 thereupon deenergizes opening at its armature and front contact the previously traced circuit of the updrive magnet 126 to arrest the upward movement of the switch shaft. The brush set 130 therefore comes to rest upon the terminals of the desired line.

At the armature and back contact of relay 122, a circuit is closed for advancing sequence switch 123 out of position 2 and into position 16. This circuit may be traced from battery through the magnet winding of sequence switch 123, the upper right-hand contact of cam 137, and thence to ground at the armature and back contact of relay 122. With sequence switch 123 in position 16, relay 107 is disassociated from the conductors of the interoffice trunk 102 and the conductors of the trunk are extended over the upper contact of cam 109 (16), and the lower right-hand contact of cam 121 (16) to the left-hand windings of repeating coil 138. At the contact of cam 139, busy potential is connected to the multiples of test terminal 140 of the selected line B, through test brush 141 and the cut-off relay 142 of the called line is also energized over this circuit. Following the extension of the connection to the terminals of the called line, the office sender 101 is restored to its normal condition and disassociated from the circuits of the district selector at the contacts of cams 112 and 118 by the advance of the sequence switch of the district selector out of position 10 and into the talking position. The calling and called subscribers may now converse over the circuit shown in heavy lines, the calling subscriber obtaining talking current through the left-hand windings of repeating coil 138 and the called subscriber receiving talking current through the right-hand windings of repeating coil 138. In-

asmuch as the manner in which the terminals of the called line are tested to determine their idle or busy condition and the manner in which ringing current is applied to the called line do not concern the present invention, these functions will not be disclosed herein.

Upon the termination of the conversation between the subscribers, the calling subscriber restores his receiver to its switchhook and in the well-known manner causes the release of the district selector 125 and the release of the individual switch 100. Upon the restoration of the district selector to its normal position, the circuit previously traced through the winding of relay 106 is opened at the contact of cam 104 and relay 106 upon deenergizing closes a circuit for advancing sequence switch 123 into position 18. This circuit may be traced from battery through the magnet winding of sequence switch 123, the lower left-hand contact of cam 137, and thence to ground at the armature and back contact of relay 106. With sequence switch 123 in position 18, a circuit is established for the downdrive magnet 143 which may be traced from battery through the winding of magnet 143, and thence to ground at the contact of cam 144 (18). Magnet 143 upon energizing presses the depending portion of switch shaft 128 against the constantly rotating downdrive drum 145, thereby causing the restoration of the switch shaft into normal position. When the switch shaft reaches its normal position, the shaft wiper 131 engages the normal commutator segment 146 and a circuit is established for advancing sequence switch 123 into normal position, which circuit may be traced from battery through the magnet winding of sequence switch 123, the upper left-hand contact of cam 137, conductor 147, segment 146, and thence to ground through wiper 131. All of the apparatus employed in the establishment of the connection is now in normal position.

Referring now to Fig. 2 which discloses a second embodiment of the invention, the circuits function in the same manner as previously described up to the point where the fundamental circuit is established between the office sender 201 and the winding of line relay 207 of the final selector switch 250. This fundamental circuit may be traced from battery through the winding of relay 207, the normally closed contacts associated with the armature of relay 208, the lower contact of cam 209 (1 to 2), bank terminal 210 and brush 211 of the district selector switch 225, the right-hand contacts of cam 212 associated with the sequence switch (not shown) of the district selector, conductor 213, the contact of sender sequence switch cam 214, the armature and back contact of

the O' counting relay 215, the winding of sender stepping relay 216, conductor 217, the lower contacts of cam 218, brush 219 and bank terminal 220 of the district selector, and thence to ground at the left-hand contact of cam 221.

Relays 216 and 207 energize in this circuit, relay 216 functioning in the well-known manner and relay 207 closing a circuit for driving sequence switch 223 out of position 1 and under the influence of master cam 224 into position 2. This circuit may be traced from battery through the magnet winding of sequence switch 223, the lower right-hand contact of cam 237, the armature and front contact of relay 207 and thence to ground. With sequence switch 223 in position 2 and relay 207 energized, a circuit is established for the updrive magnet 226 which may be traced from battery through the winding of magnet 226, the contact of cam 227, and thence to ground through the armature and front contact of relay 207. Magnet 226 upon energizing presses the depending portion of switch shaft 228 against the constantly rotating updrive drum 229 to cause the switch shaft to be moved upwardly.

As the switch shaft advances the brush set 230 into proximity to the first set of terminals in the switch bank, the shaft wiper 231 engages a conducting portion of the commutator segment 232 and a circuit is thereupon established for relay 208 which may be traced from battery through the winding of relay 207, wiper 231, segment 232, conductor 233, and thence to ground through the winding of relay 208. Relay 208 upon energizing closes a holding circuit for relay 207 extending through the winding of relay 207 and the armature and front contact of relay 208 to ground through resistance element 234, and opens the fundamental circuit previously traced through the windings of relays 207 and 216. Sender stepping relay 216 now deenergizes and functions in the well-known manner, but relay 207 being now energized through resistance element 234 receives only sufficient current to hold its armature attracted so that upon a subsequent opening of this holding circuit, this relay is conditioned for releasing quickly.

As the switch shaft continues in its upward movement, wiper 231 engages an insulating portion of segment 232 and the circuit of relay 208 is opened whereupon it deenergizes and reestablishes the previously traced fundamental circuit. In this manner as the switch shaft continues in its upward movement, the fundamental circuit is intermittently opened and closed at the armature contacts of relay 208 and the sender stepping relay 216 thereupon alternately deenergizes and energizes to energize and lock up successive pairs of counting relays asso-

ciated with the sender until the O' counting relay 215 becomes energized upon the satisfaction of the sender.

Upon the energization of relay 215, the fundamental circuit is opened at the sender and as soon thereafter as the wiper 231 engages the next insulating portion of commutator segment 232, the circuit of relay 208 is opened and the holding circuit of relay 207 is disestablished. Since at this instant relay 207 is receiving only sufficient current to maintain its armature attracted, it quickly releases upon the opening of its holding circuit and at its armature and front contact opens the circuit of the updrive magnet 226 to arrest the updrive movement of the switch shaft and at its armature and back contact closes a circuit for advancing sequence switch 223 into position 16. This circuit may be traced from battery through the winding of magnet 223, the upper left-hand contact of cam 237, and thence to ground at the armature and back contact of relay 207.

From this point the circuits function in exactly the same manner as previously described in connection with Fig. 1. The apparatus employed in completing the connection from the calling subscriber's line C to the called subscriber's line D and for subsequently releasing the established connection is identical with that disclosed in Fig. 1 and has been designated in Fig. 2 with reference characters similar to those employed in Fig. 1, but with the hundreds prefix 2.

What is claimed is:

1. In a telephone exchange system, a calling line, a selector switch and a connecting circuit for extending a connection from said line, a control circuit comprising said connecting circuit extending to said switch, a control relay at said switch controllable over said control circuit, means under the control of said relay for operating said switch, means operated during the advance of said switch for intermittently opening said control circuit and means under the control of said last named means for rendering said relay quick to release.

2. 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 at said switch controllable over said fundamental circuit, means under the control of said relay for operating said switch, means operated during the advance of said switch for intermittently opening said fundamental circuit to revertively control said sending mechanism and means under the control of said last named means for rendering said relay quick to release.

3. 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 extending between said sending mechanism and said switch, a stepping relay at said sending mechanism and a control relay at said switch controllable over said fundamental circuit, means under the control of said control relay for operating said switch, means operated during the advance of said switch for intermittently opening said fundamental circuit to operate said stepping relay, means at said sending mechanism for opening said fundamental circuit, and means under the control of said second named means for rendering said control relay quick to release when said fundamental circuit is opened at said sending mechanism.

4. In a telephone exchange system, a calling line, a selector switch and a connecting circuit for extending a connection from said line, a control circuit comprising said connecting circuit extending to said switch, a control relay at said switch controllable over said control circuit, means under the control of said relay for operating said switch, a relay at said switch for opening said control circuit, a commutator, a wiper for cooperation with said commutator during the operation of said switch for operating said last named relay to intermittently open said control circuit and means under the control of said last named relay for rendering said control relay quick to release.

5. In a telephone exchange, a calling line, a selector switch and a connecting circuit for extending a connection from said line, a control circuit comprising said connecting circuit extending to said switch, a control relay at said switch for operating said switch, means operated during the advance of said switch for intermittently opening said control circuit and means under the control of said last named means for holding said control relay operated over a high resistance path during the intermittent opening of said control circuit.

6. 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 at said switch controllable over said fundamental circuit for operating said switch, means operated during the advance of said switch for intermittently opening said fundamental circuit and means under the control of said last named means for holding said control relay operated over a local re-

sistance path during the intermittent opening of said fundamental circuit whereby said relay is rendered quick to release when said fundamental circuit is opened at said sending mechanism.

5 7. 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 at said switch controllable over said fundamental circuit for operating said switch,

a relay operated during the advance of said switch for intermittently opening said fundamental circuit to revertively control said sending mechanism and for holding said control relay operated over a local resistance path during the intermittent opening of said fundamental circuit whereby said control relay is rendered quick to release when said fundamental circuit is opened at said sending mechanism. 20

In witness whereof, I hereunto subscribe my name this 27th day of December A. D., 1920. 25

CHARLES L. GOODRUM.