Dec. 1, 1925.

1,563,599

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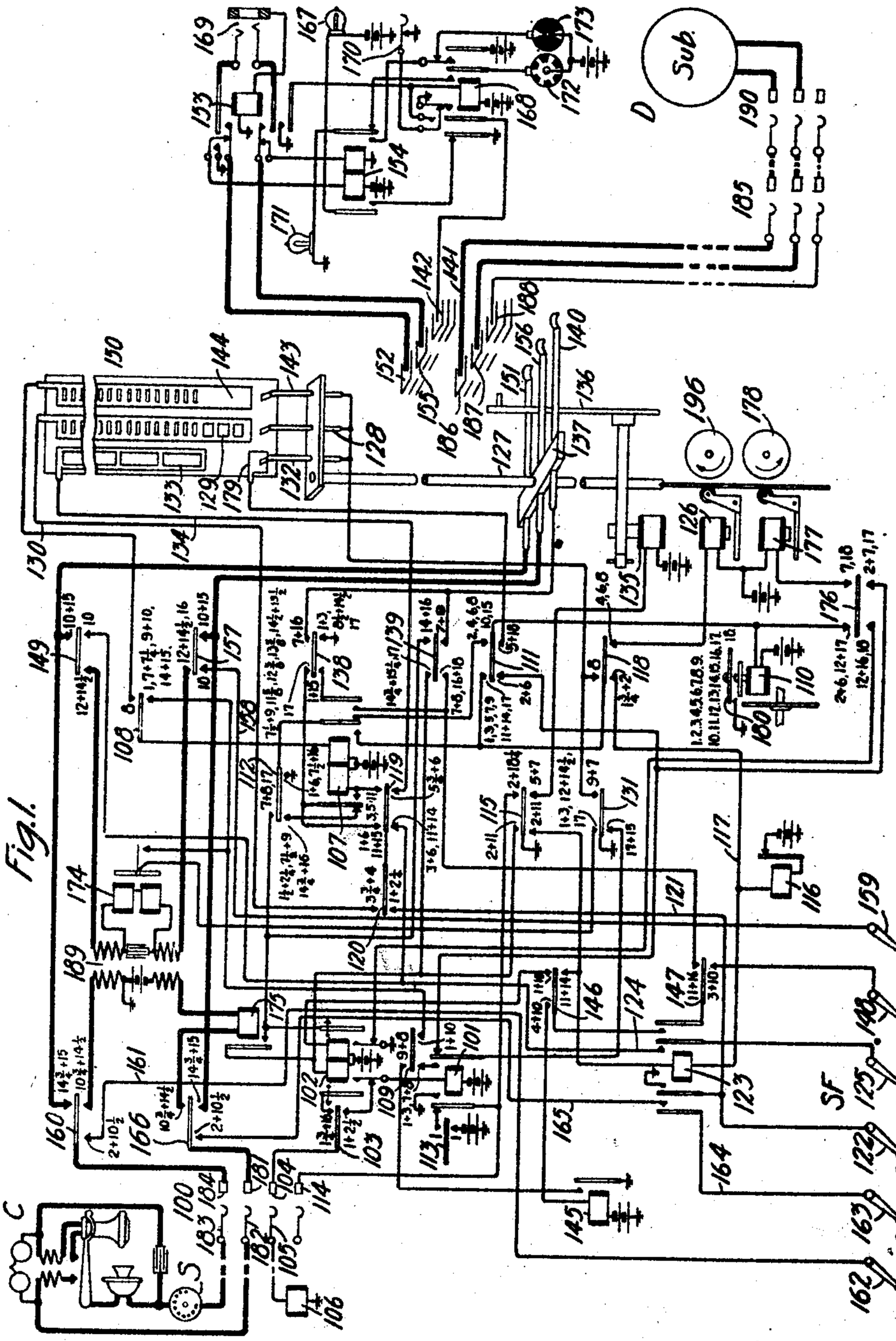
TELEPHONE EXCHANGE SYSTEM

Filed Sept. 19. 1923 6 Sheets-Sheet 1



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TELEPHONE EXCHANGE SYSTEM

Filed Sept. 19, 1923 6 Sheets-Sheet 2

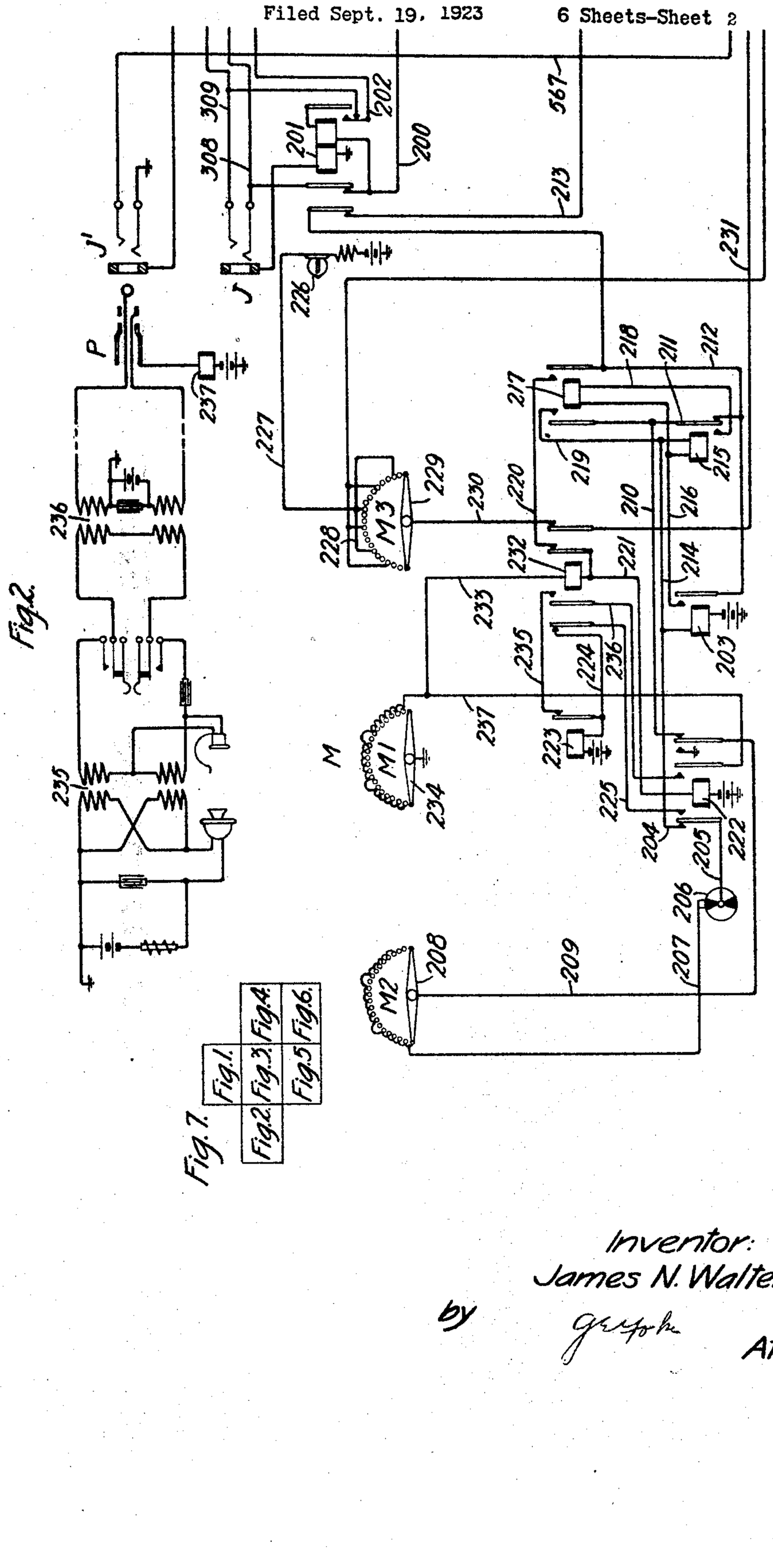

Fig.2.

Fig. 1.

Fig.1.	Fig.3.	Fig.4.
Fig.2.		Fig.5 Fig.6.

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TELEPHONE EXCHANGE SYSTEM

Filed Sept. 19. 1923 6 Sheets-Sheet 3

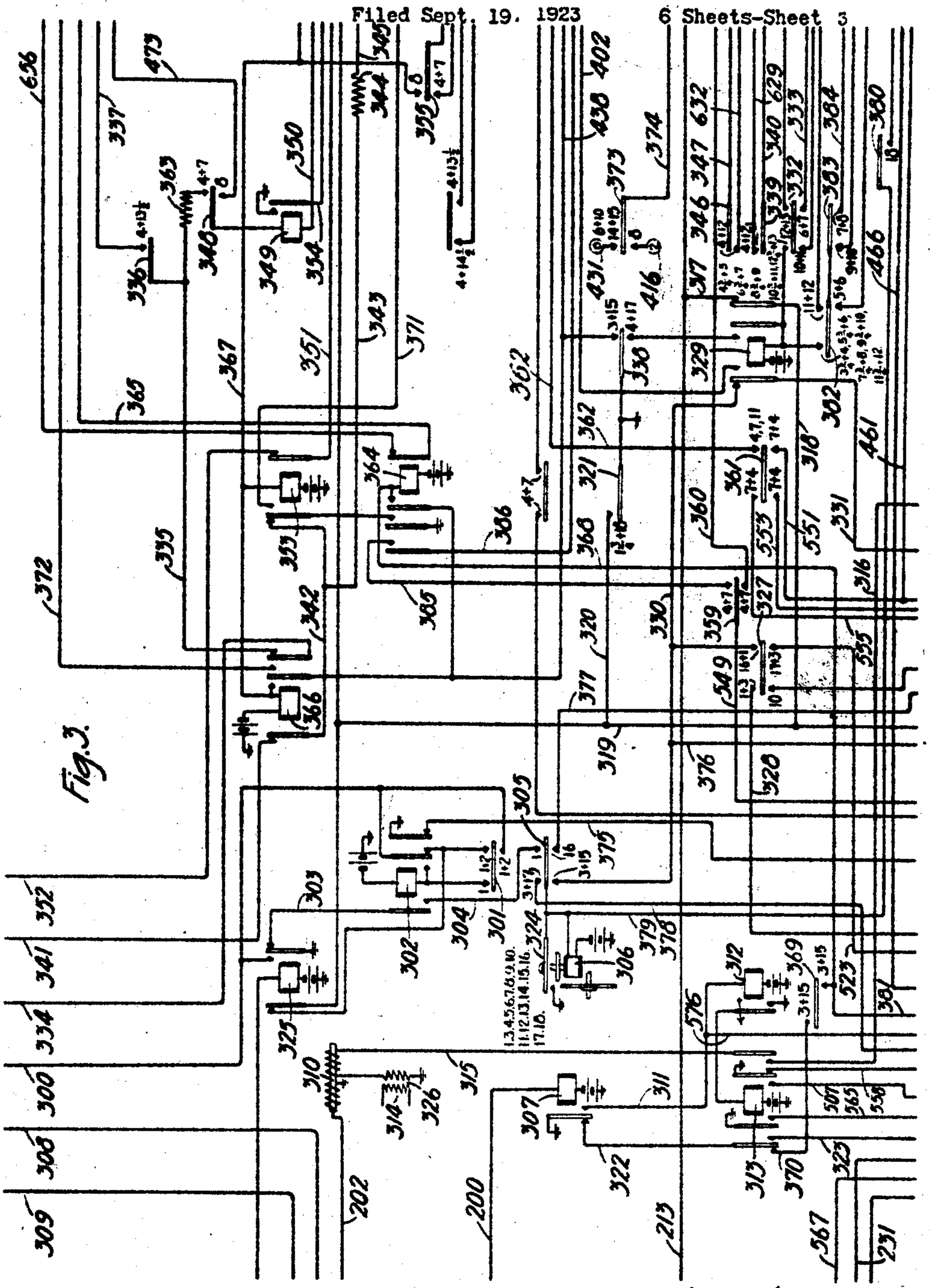

Fig. 3.

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TELEPHONE EXCHANGE SYSTEM

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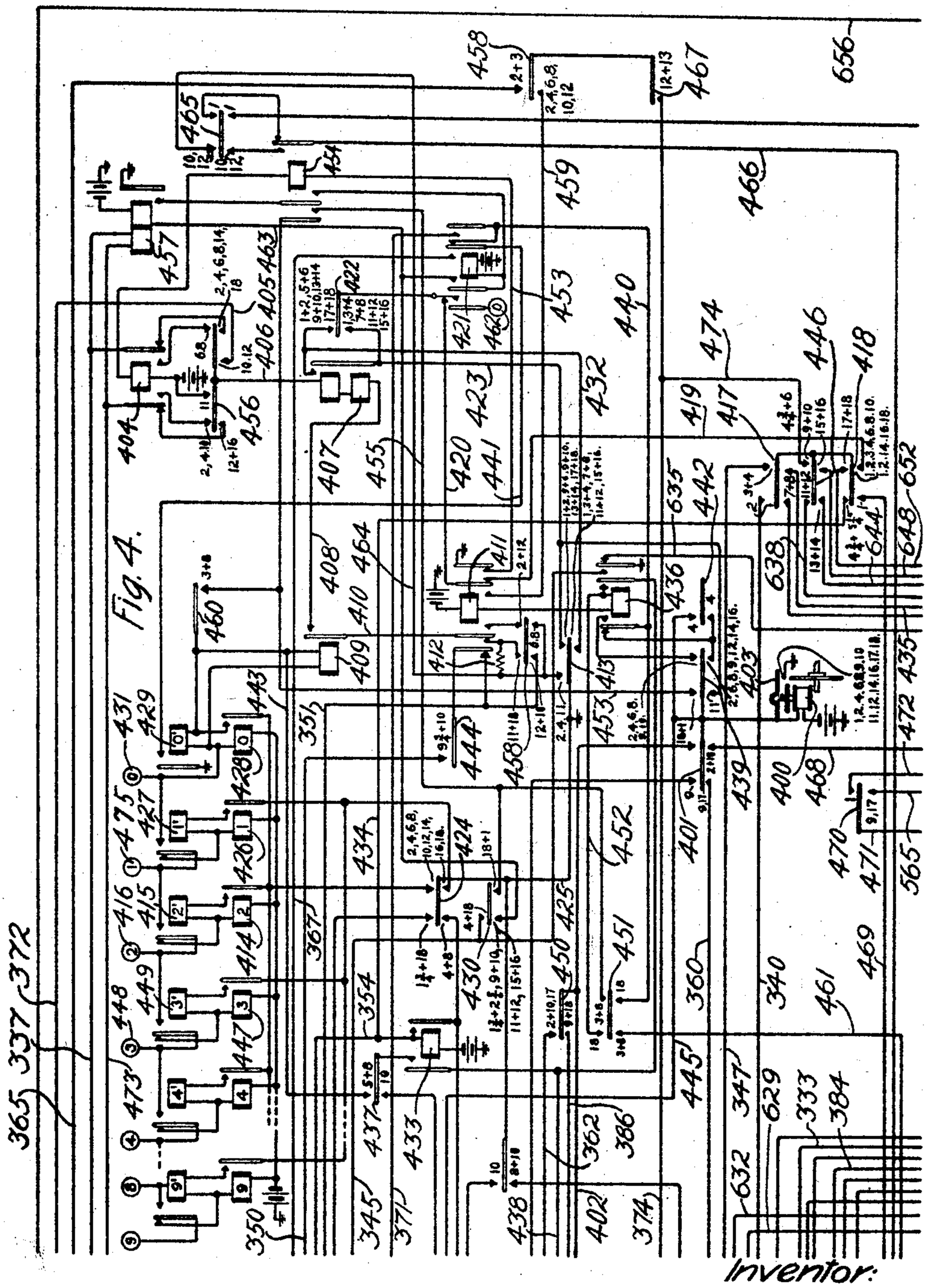

Fig. 4.

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TELEPHONE EXCHANGE SYSTEM

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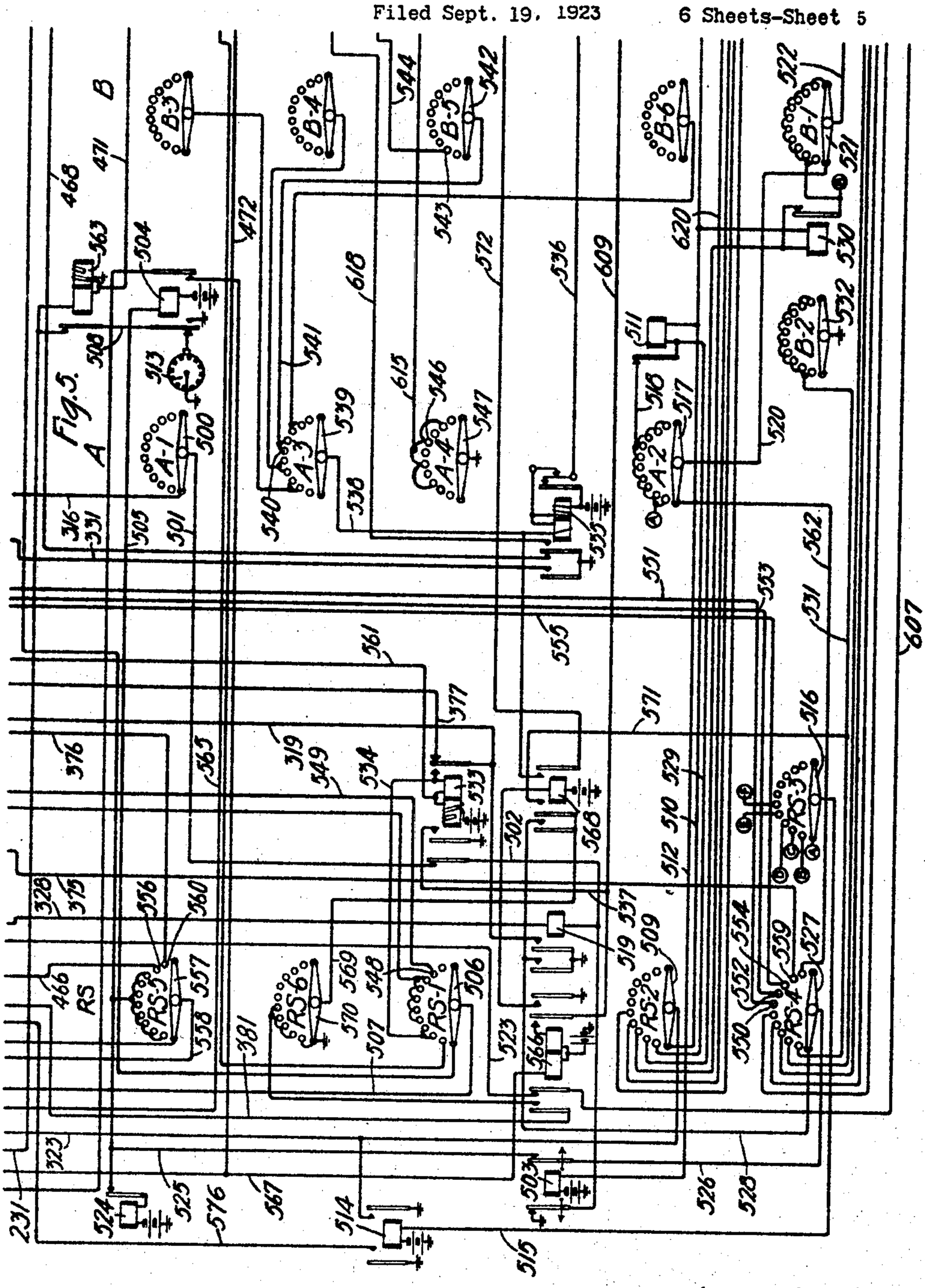
Fig. 5.



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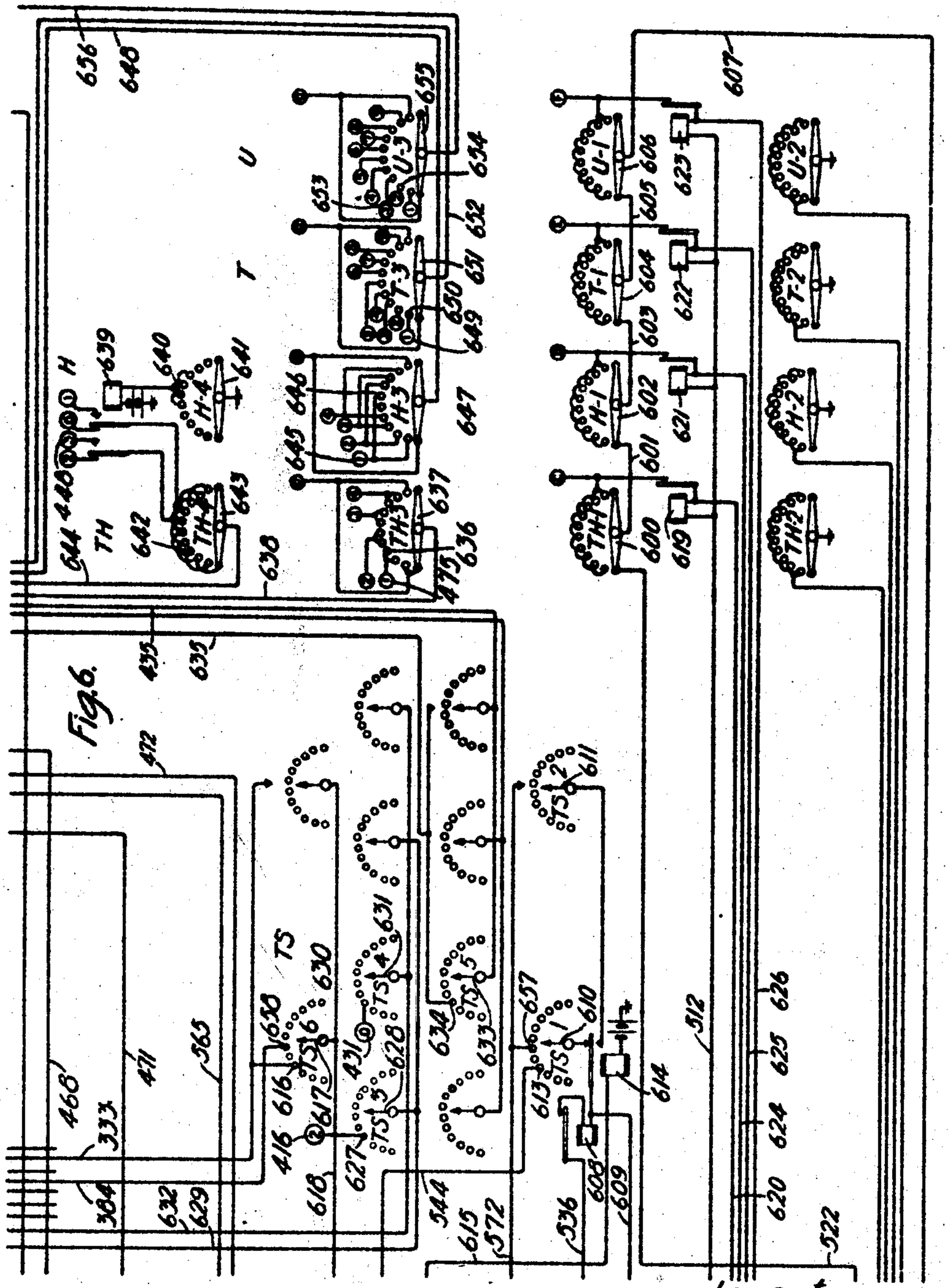
TELEPHONE EXCHANGE SYSTEM

Filed Sept. 19. 1923 6 Sheets-Sheet 6



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Patented Dec. 1, 1925. 1,563,599

UNITED STATES PATENT OFFICE.

JAMES N. WALTERS, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

TELEPHONE-EXCHANGE SYSTEM.

Application filed September 19, 1923. Serial No. 663,663.

To all whom it may concern:

Be it known that I, JAMES N. WALTERS, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain Improvements in Telephone-Exchange Systems, of which the following is a specification.

This invention relates to telephone exchange systems and more particularly to systems in which machine switching equipment is employed for establishing connections between subscribers' lines.

In some systems of the above mentioned character, a central office sender is employed which controls the selective movements of the mechanical switching equipment in accordance with the directory numbers of desired lines. The calling subscriber causes the numbers to be registered on the registers of the sender through the operation of an impulse sending dial. A plurality of central office senders common to a large number of subscribers' lines are provided and an idle one of these senders is selected for the use of a subscriber immediately following the removal of the subscriber's receiver from its switchhook upon the initiation of a call.

If, after initiating a call, the calling subscriber neglects to dial the number of a desired line and still maintains the receiver off the switchhook, apparatus in the sender is operated to allow a predetermined period of time for the subscriber to begin dialing. Upon the termination of this time period, the calling subscriber's line is automatically routed to a trouble desk and the sender is automatically released. This same operation would occur when the calling line or substation apparatus is out of order to the extent that the manipulation of the dial by the subscriber does not operate the registers in the sender. Upon the automatic release of the sender and the association of the calling line with a monitoring position of the trouble desk, a signal is lighted to indicate to the monitoring operator that such a line has been connected to her position. The monitoring operator thereupon connects a talking circuit to the line to make such investigation as is necessary.

If after initiating a call, a calling subscriber only partly dials the number of a desired line and still maintains the receiver off the switchhook, a predetermined period of time is allowed for the remaining numbers to be dialed and upon the termination of this time period a signal individual to the office sender is operated at a sender monitor's position on a trouble desk of the office switchboard. In response to this signal, the monitoring operator first challenges the calling subscriber, over a jack associated with the sender, to determine from the calling subscriber, if possible, the cause for the delay in establishing the connection. If no response is received from the calling subscriber or if the calling subscriber responds and it is apparent that the calling line is in trouble, it is then desirable to connect the calling line with a trunk circuit terminating at the trouble desk for further observation and until the trouble on a line is cleared and to release the sender so that it may revert to common use.

It is the object of this invention to provide means to automatically restore the office sender and to route the calling subscriber's line to an operator for observation, upon a delayed setting of the registers of said sender after a subscriber initiates a call.

This object is attained by special control circuits which are governed by a time counting device individual to the office sender. After a predetermined time interval a circuit is automatically established in such a manner that the sender is rendered busy and the translator switch of the sender is given an arbitrary setting to cause the sender to route the connection from the calling subscriber's line, through the subscriber's district selector, to a permanent signal trunk circuit terminating on the trouble desk. The sender is then automatically released and a signal is lighted in the trouble desk to indicate such connection to the operator.

This and other features of the invention may be more readily seen by reference to the following description considered in connection with the accompanying drawings in which:

Figure 1 shows one of a group of subscribers' lines terminating in a full mechanical office of the exchange, a diagrammatic illustration of a rotary line switch individual to the subscriber's line, a district selector by means of which the calling subscriber may extend connections into various districts and offices of the exchange, a sender

finder individual to the link circuit in which the district selector terminates, a permanent signal trunk circuit terminating in the terminal bank of the district selector and extending to the trouble desk of the office, and a diagrammatic representation of an incoming selector, final selector and called line.

Fig. 2 shows talking and signaling apparatus associated with an office sender for indicating to a monitoring operator the progress of the sender in controlling the establishment of the connection, together with jacks by means of which the operator may talk with the calling subscriber, or set the sender for routing a connection to the trouble desk directly through the district selector, and a portion of an operator's cord circuit for use with such jacks.

Fig. 3 shows a portion of the control circuits of the office sender and a class switch for altering the circuits of the sender in accordance with the class of the call which is to be established.

Fig. 4 shows a portion of the circuits of the sender comprising a stepping relay, a group of counting relays and a sequence switch for controlling these circuits.

Fig. 5 shows the code registers of the sender which are set in accordance with the first two code or office designation digits dialed by the calling subscriber and a steering switch which successively associates the code registers and the numerical registers shown in Fig. 6 with the dialing circuit extending to the subscriber's line.

Fig. 6 shows the translator switch which assumes a setting in accordance with the code set up upon the code registers of Fig. 5 and which controls the setting of the class switch of Fig. 3, and the routing of the desired connection. The numerical registers which are set by the calling subscriber in accordance with the numerical designation of the desired line are also shown in this figure.

Fig. 7 is a diagram showing the manner in which the several sheets of the drawing should be arranged to show as much of a complete organization of circuits as is necessary to disclose the invention.

The calling subscriber's line C is of the usual type provided with a transmitter, receiver and call bell and since it terminates in an automatic exchange, it is also equipped with an impulse sending dial S of the usual type.

The subscriber's line C terminates in an individual line switch 100 of the well-known step-by-step type. In order to simplify the drawing only the wipers of the switch have been indicated.

The district selector 150 disclosed in Fig. 1 is of the general type shown in the patent to E. B. Craft and J. N. Reynolds, 1,123,696, issued January 5, 1915. To simplify the drawing, only one of the five brush sets and a portion of the corresponding terminal bank of this switch have been disclosed. The incoming and final selectors 185 and 190 are of this same type but have been disclosed only diagrammatically herein. The sender finder SF, Fig. 1, the time measure switch M shown in Fig. 2 the register steering switch RS and code registers A and B, Fig. 5, and the numerical registers TH, H, T and U and the translator switch shown in Fig. 6, are of the well-known step-by-step type. With the exception of the sender finder SF and the translator TS, the wipers of these switches are restored by being advanced by their respective stepping magnets forwardly to normal position. Finder switch SF and translator switch TS have no normal position, the wipers thereof resting in contact with the setting of bank terminals last employed by the switches.

For controlling the circuits associated with the district selector and the circuits of the office sender, auxiliary switches are employed. The switches may be of the type disclosed in the patent to J. N. Reynolds and C. F. Baldwin, 1,127,808, issued February 9, 1915, and known in the art as "sequence switches". The permanent signal trunk shown in Fig. 1 and the monitoring operator's cord circuit diagrammatically illustrated in Fig. 2 are of the type fully disclosed and described in the Patent No. 1,509,851 to Edward F. Trapp, issued Sept. 30, 1924. The different pieces of apparatus employed in illustrating the manner in which the invention is to be practiced having now been briefly described, it is thought that a clearer understanding of the invention may be had from a description of the manner in which a calling line may be connected to the trouble desk.

Initiation of a call by the calling subscriber.

It will first be assumed that the calling subscriber removes his receiver from its switchhook and properly dials a desired number and that the connection is completely established in the usual manner. Upon the removal of the receiver from its switchhook, a starting circuit is established for the line switch 100 in the manner fully set forth in the Patent No. 1,505,171 to F. A. Stearn, issued August 19, 1924, and switch 100 starts hunting for an idle link circuit. The test terminals of busy link circuits are rendered busy by ground potential on the multiples of the test terminals 114 of such link circuits. This ground potential is connected thereto through armature contacts of sleeve relays corresponding to relay 101, or through the contacts of sequence switch cams corresponding to cam 115. As soon as the test wiper of switch 100 encounters the test terminal 114 of an idle link circuit,

which link circuit will be assumed to be the one disclosed in Fig. 1, battery potential will be encountered and the line switch 100 will stop with its wipers in engagement with the bank terminals connected to such idle trunk. Battery potential is connected to the test conductor 114 through the left-hand armature and normal contact of relay 101 and the contacts of cam 113 (1).

Upon the seizure of the link circuit terminating in the district selector 150, a circuit is established for sleeve relay 101 of the link, which may be traced from battery through the winding of relay 101, the normally closed contacts associated with the left-hand armature of relay 102, the lower contact of cam 103 (1 to 2½), bank terminal 104 and wiper 105 of line switch 100 and to ground through the winding of cut-off relay 106. Relay 101 energizes in this circuit and establishes a circuit for line relay 107 of the district selector 150, which circuit extends from battery through the right-hand winding of relay 107, the lower contact of cam 108 (1), the lower contacts of cam 109 and to ground through the right-hand armature and alternate contact of relay 101 and the lower contact of cam 131 (17 to 15). At the alternate contact of its left-hand armature, relay 101 connects ground potential to the multiples of test terminal 114 to mark the link circuit as "busy" to other line switches and at the normal contact of this armature disconnects the source of battery potential which up to the time the link circuit is seized marked the link as "idle".

Relay 107, upon energizing, closes a circuit for driving sequence switch 100 out of its normal position 1, into position 2, this circuit extending from battery through the magnet winding of the switch, the upper left-hand contact of cam 111 (1), the inner right-hand armature and alternate contact of relay 107 and to ground at the right-hand contact of cam 112 (1 to 6). Under the control of master cam 180, the sequence switch is driven into position 2, in which position a circuit is closed from battery through the left-hand winding of differential relay 102 and thence to ground at the upper left-hand contact of cam 115 (2 to 11). Relay 102, upon energizing, closes a locking circuit for sleeve relay 101 extending through the winding of relay 101, the make contact of the left-hand armature of relay 102, the upper contact of cam 103 (1¾ to 16), and thence as previously traced from ground through the winding of cut-off relay 106, this circuit being maintained through position 16 of the sequence switch or until relay 102 becomes deenergized. Upon reaching position 2, the sequence switch connects a new holding ground to test terminal 114, through the upper right-hand contact of cam 115 (2 to 18¼).

As soon as the sequence switch reaches position 1¾, a circuit is closed for the stepping magnet 116 of the sender finder SF extending from battery through the interrupter contacts and winding of magnet 116, conductor 117 the lower left-hand contact of cam 118 (1¾ to 2), the inner right-hand armature and alternate contact of relay 107 and thence to ground at the right-hand contact of cam 112. A circuit is also closed at this time through the winding of stepping magnet 116, the winding of relay 123 and thence to ground at the lower left-hand contact of cam 115 (2 to 11). Relay 123 does not energze at this time, however, since its winding is shunted by ground connected through the armature and contact of relay 107. As soon as the sequence switch 110 leaves position 1, the initial energizing circuit of relay 107 is opened at the lower contact of cam 108, but this relay remains locked over a circuit extending from battery through its left-hand winding, left-hand armature and alternate contact, the upper left-hand contact of cam 119 (1 to 6), the lower contact of cam 120 (1 to 2¼), conductor 121, test wiper 122 and to ground on busy terminals of the bank over which this wiper moves. As soon, however, as an idle sender mechanism is found, the wiper 122 will find no ground potential on the terminal corresponding to such idle sender and line relay 107 will thereupon deenergize, opening at its inner right-hand armature and alternate contact the circuit extending through the stepping magnet 116 and closing at the normal contact of this armature, a circuit for driving sequence switch 110 out of position 2 and into position 3. This circuit may be traced from battery through the magnet winding of sequence switch 110, the upper right-hand contact of cam 111 (2), the inner right-hand armature and normal contact of relay 107 and thence to ground at the right-hand contact of cam 112.

As soon as line relay 107 deenergizes, the shunt around the winding of relay 123 is removed at the inner right-hand armature and alternate contact of relay 107 and relay 123 energizes in series with stepping magnet 116, the current flowing through this circuit, however, not being sufficient to cause the energization of magnet 116. At the normal contact of its left-hand armature, relay 107 connects busy ground potential to the wiper 122, over conductor 121, the lower contact of cam 120, the upper left-hand contact of cam 119, the armature and contact of relay 107 and to ground through the lower contacts of cam 112, which busy ground potential is maintained until the sequence switch passes out of position 2¼ or until relay 123 has time to energize and connect busy ground potential to the wiper

122 over its inner left-hand armature and alternate contact.

Relay 123, upon energizing, in addition to connecting ground potential to the wiper 122, establishes a circuit extending over wiper 122, conductor 300, the lower right-hand and upper left-hand contacts of cam 301 and to battery through the winding of relay 302. Relay 302, upon energizing, closes a locking circuit for itself extending through its inner right-hand armature and alternate contact to conductor 300 independent of the contacts of cam 301 and at its left-hand armature and alternate contact establishes a circuit for advancing class sequence switch 306 out of position 1, and under the influence of master cam 324, into position 3. This circuit may be traced from battery through the magnet winding of switch 306, the upper right-hand contact of cam 305 (1), conductors 304 and 303 and to ground at the right-hand armature and normal contact of relay 325.

Relay 123, upon energizing, also establishes an impulsing circuit extending from the calling subscriber's line to the controlling relays of the register steering switch RS which may be traced from battery through the winding of relay 307, conductor 200, conductor 308, wiper 163 of switch SF, conductor 164, conductor 165, the left-hand contact of cam 166, bank terminal 181 and wiper 182 of the line switch 100, thence over the calling subscriber's line loop and through the impulse mechanism S, wiper 183 and bank terminal 184 of switch 100, the left-hand contact of cam 160 (2 to 10½), conductor 161, wiper 162 of the switch SF, conductors 309 and 202 and to ground through the left-hand winding of coil 310. Relay 307 energizes in this circuit and establishes a circuit for the slow-to-release relay 312 extending from battery through the winding of relay 312, conductor 311 and to ground at the armature contact of relay 307 and relay 312, upon energizing, establishes an obvious circuit for relay 313. With relay 313 energized, the source of dialing tone 314 is inductively associated through the right-hand winding of coil 310 with the impulsing circuit previously traced for transmitting a dialing tone to the calling subscriber to indicate to the subscriber that a sender has been associated with his line and is in readiness to receive impulses corresponding to the number of the line desired. This tone circuit may be traced from ground through the secondary winding of the tone coil 326, the right-hand winding of coil 310, conductors 315 and 316, wiper 500 and the normal terminal of bank A^1 of code register A, conductors 501 and 502 and thence to ground at the left-hand armature and normal contact of relay 503.

As soon as the office sender is seized and the class sequence switch 306 moves out of position 1 and into position 3, a circuit is established for starting the time measure mechanism at the monitoring position of the trouble desk to measure off a time period sufficient to allow the calling subscriber to complete dialing. This starting circuit may be traced from ground through the contact of cam 321 (1¾ to 18), conductors 320, 319, 318, 317, 213 and 212, the armature and normal contact of relay 215, conductors 211, 210 and 209, wiper 208 and the normal terminal of bank M^2 of switch M, conductor 207, the slow speed interrupter 206, conductors 205 and 204, and thence to battery through the winding of relay 203. Relay 203 energizes in this circuit as soon as interrupter 206 reaches a circuit closing position and closes a locking circuit for itself extending from battery through its winding, over conductor 214, through the winding of relay 215, conductor 216, the armature and contact of relay 203 and thence to conductor 212 and ground at the contact of cam 321 as previously traced. Relay 215 does not energize in this circuit until the interrupter 206 reaches an open position. When relay 215 does energize, a circuit is prepared for relay 217 which is effective as soon as interrupter 206 again reaches a circuit closing position. This circuit for relay 217 may be traced from battery through the winding of relay 203, conductors 204 and 205, interrupter 206, conductor 207, the normal terminal of bank M^2 and wiper 208 of switch M, conductors 209, 210 and 211, the armature and alternate contact of relay 215, conductor 218, the winding of relay 217, conductor 216 and thence to ground on conductor 212 through the armature contact of relay 203. Relay 217, upon energizing, closes a locking circuit for itself extending from battery through the winding of relay 203, conductors 214 and 219, the left-hand armature and contact of relay 217, conductor 211, the armature and alternate contact of relay 215, conductor 218, the winding of relay 217, conductor 216, the armature and contact of relay 203 and thence to ground on conductor 212.

At its right-hand armature contact, relay 217 establishes a circuit for relay 222 which may be traced from battery through the winding of relay 222, conductor 221, the inner right-hand armature and normal contact of relay 232, conductor 220, the right-hand armature and contact of relay 217 and to ground on conductor 212. Relay 222 now establishes a stepping circuit for advancing the switch M under the influence of the slow interrupter 206 which may be traced from battery through the winding of stepping magnet 223, conductors 224 and 225, the left-hand armature and alternate contact of relay 222, conductor 205, interrupter 206, conduc-

tor 207, the strapped terminals 1 to 6 of bank M^2 wiper 208, conductor 209 and thence to ground at the alternate contact of the outer right-hand armature of relay 222.

During the successive operation of relays 203, 215, 217 and 220 and the advance of the switch M from its normal position to position 4 sufficient time is measured to enable the calling subscriber to dial a part of the desired number. If at the time switch M reaches position 4, the number has not been partly dialed a circuit is automatically established to route the calling line to a trunk connected to a monitoring operator's position and to release the sender so that it may return to its normal position for use in making other service connections. Signal lamp 167, in the monitoring operator's position, is now lighted from a circuit established by connection of the calling line to the trunk circuit. Upon the lighting of lamp 167 the monitoring operator challenges the calling subscriber to obtain information regarding any trouble that might exist in the dialing subscriber's station and to give information if necessary. The quick release of senders is a considerable saving in their use. The detail operation will be hereinafter described.

When the number has been partly dialed at the time switch M has advanced to position 4, no circuit will be established for releasing the sender and switch M advances to position 7. Sufficient time has now been measured to enable the calling subscriber to have completely dialed the desired number. If at the time the switch M reaches position 7 the number has not been completely dialed, the switch M stops in position 7 since its circuit is interrupted at the wiper 208 and a circuit is established for the sender lamp 226 which may be traced from battery through the lamp 226, conductor 227, the No. 7 terminal, 228 of the bank M^3, wiper 229, conductors 230 and 231, conductor 508 and thence to ground at the armature and alternate contact of relay 504. Relay 504 is energized at this time since a circuit was established through its winding upon the energization of relay 313, which circuit extends from battery through the winding of relay 504, conductor 505, the normal bank terminal of bank RS^1, wiper 506, conductor 507 and thence to ground at the alternate contact of the inner right-hand armature of relay 313.

If at the time switch M reaches position 7 the steering switch RS has left normal position, that is, a part of the desired line number has been registered and the sender sequence switch 400 has not left normal position, or is waiting for the completion of registration in either positions 9 and 17, the lamp 226 will be lighted dimly through the winding of relay 563 and the connection to interrupter 513 or direct ground at relay 504 will be interrupted at the armature contact of relay 563. If sequence switch 400 is in position 1, the circuit for relay 563 may be traced from ground at the inner right-hand armature of relay 313, conductor 507, wiper 506, the No. 1 terminal of bank RS^1, conductor 472, the upper contact of cam 470, conductor 471, the left-hand winding of relay 563, conductor 231 and thence to battery through the lamp 226 as previously traced. With sequence switch 400 in either position 9 or 17 the circuit of relay 563 may be traced from ground at the inner left-hand armature of relay 313, over conductor 565, the lower contact of cam 470 and thence to battery through lamp 226 as previously traced.

If the register steering switch RS has moved off normal and the sender sequence switch is in any position other than positions 9 and 17, the lamp 226 will be flashed over the circuit previously traced to the armature and back contact of relay 563, conductor 508, the armature and normal contact of relay 504 and to ground through the fast interrupter 513. In response to either a bright, dim or flashing signal on lamp 226, the operator at the monitor's position challenges the calling subscriber in a manner to be hereinafter described. It will first be assumed that the calling subscriber proceeds within the required time interval to dial the digits of the desired number and that the calling subscriber desiring a connection with a line whose directory number is O A kland 3612 proceeds first to dial the code letters O A to set the registers A and B.

Setting the code registers.

In response to the impulses transmitted by the sending dial S, corresponding to the code letter O, relay 307 is intermittently deenergized and the wipers of the code register A are advanced six steps over a circuit which may be traced from battery, through the winding of relay 503, conductor 512, the winding of stepping magnet 511 of the register A, conductor 510, wiper 509 and the normal terminal of the bank RS^2, conductor 323, conductor 322 and thence to ground at the armature and back contact of stepping relay 307. Relay 503 is slow-to-release and maintains its energization during the transmission of the series of impulses through the winding of stepping magnet 511 and upon its initial energization opens at its left-hand armature contact the circuit previously traced over which dialing tone was transmitted to the calling subscriber's line. During the energization of stepping magnet 511 of the register A, relay 514 energizes in parallel with the winding of relay 511 over a circuit which may be traced from battery through the winding of relay 514, conductor 515, wiper 516, the normal terminal of bank

RS³, lead A, the off-normal terminals of bank A² of the A register as soon as this register advances out of its normal position, conductor 518, the armature and contact of magnet 511, conductor 510, the normal terminal of bank RS², wiper 509 and thence to ground on conductor 323 at the armature and back contact of stepping relay 307. Relay 514 energizes in this circuit and closes a locking circuit for itself independent of the armature contact of relay 307, which circuit extends over the circuit previously traced through the winding of relay 514, through the armature and back contact of magnet 511, conductor 323 and thence to ground at the right-hand armature and contact of relay 514. Relay 514 and stepping magnet 511 are thus maintained energized over this circuit until the stepping magnet 511 has moved its armature to substantially the full extent of its movement when the circuit through relay 514 is opened at the armature contact of magnet 511. Relay 514 thus insures that the stepping magnet 511 will operate to the full extent of its movement upon each energization thereof. At its left-hand armature and front contact, relay 514 closes a circuit over conductor 519 for maintaining the slow-to-release relay 312 energized during each step of the register A irrespective of the operation of stepping relay 307.

Upon the completion of the series of stepping impulses through the winding of magnet 511 of the register A, relay 503 deenergizes and at its left-hand armature and normal contact establishes a circuit for relay 519, which may be traced from ground at the left-hand armature and back contact of relay 503, through the winding of relay 519, conductor 328, the upper left-hand and lower right-hand contacts of cam 327, conductors 523 and 607, wiper 606 and normal terminal of bank U¹ of the units register U, conductor 605, wiper 604 and normal terminal of bank T¹ of the tens register T, conductor 603, wiper 602 and normal terminal of bank H¹ of hundred register H, conductor 601, wiper 600 and normal terminal of bank TH¹ of the thousands register TH, conductor 522, wiper 521 and the normal bank terminal of the bank B¹ of the code register B, conductor 520, wiper 517 and the off-normal terminals of the bank A² of the code register A, lead A, wiper 516 of the steering switch RS. conductor 515 and through the winding of relay 514 to battery. At its outer left-hand armature and alternate contact relay 519 closes a circuit from ground, over conductor 528, through wiper 527 in contact with the normal terminal of bank RS⁴, conductor 526, the right-hand armature and back contact of relay 503, conductor 525 and thence to battery through the armature contact and winding of stepping magnet 524 of the steering switch RS. Magnet 524 energizes in this circuit and advances the wipers of the steering switch into contact with the No. 1 terminals of the banks with which they are associated, the circuit of magnet 524 being opened at the normal terminal of bank RS⁴ as soon as the steering switch leaves normal position.

With the steering switch RS in position 1, a circuit is established for the stepping magnet 530 of the code register B which may be traced from battery through the winding of relay 503, conductor 512, winding of magnet 530, conductor 529, the No. 1 terminal of bank RS², wiper 509, conductor 323, the outer left-hand armature and front contact of relay 313, conductor 322 and to ground at the armature and back contact of relay 307, and magnet 530 in response to the successive deenergizations of stepping relay 307 in accordance with the code letter A dialed by the calling subscriber advances the wipers of the code register B into position 2. Each time the impulsing circuit is established through the winding of magnet 530, a circuit is established for relay 514 extending from battery through the winding of relay 514, conductor 515, wiper 516, the No. 1 terminal of bank RS³, lead B, the armature and back contact of magnet 530, conductor 529, and thence over the circuit previously traced to ground at the armature and back contact of stepping relay 307. In the manner previously described, relay 514 insures that the magnet 530 will be completely operated to cause the wipers of register B to be advanced a full step upon each energization of magnet 530.

Following the completion of the second series of code impulses, relay 503 deenergizes as previously described and again establishes the circuit of relay 519 which may be traced over the circuit previously described to conductor 522 and thence through wiper 521, the off-normal terminals of bank B¹ of code register B, lead B, the No. 1 terminal of bank RS³, wiper 516 and thence to battery through the winding of relay 514. Relay 519, upon energizing, closes a circuit for advancing the register steering switch RS out of position 1, into position 2. The circuit of magnet 524 for advancing switch RS may be traced at this time from battery through the winding and armature contacts of magnet 524, conductor 525, the right-hand armature and normal contact of relay 503, conductor 526, wiper 527, and the No. 1 bank terminal of the bank RS⁴, conductor 531 and thence to ground through the off-normal terminals of bank B² of code register B and wiper 532.

As soon as the steering switch RS reaches position 2, a circuit is established for relay 533 which may be traced from battery

through both windings of relay 533, conductor 534, the No. 2 terminal of bank RS^1, wiper 506, conductor 507 and thence to ground at the alternate contact of the inner right-hand armature of relay 313. Relay 533, upon energizing, locks through its right-hand armature and alternate contact to ground at the contact of cam 321, over conductors 319 and 320, and at the contact of its inner left-hand armature establishes a circuit for advancing the translator switch TS, Fig. 6.

Setting the translator switch and class switch.

The circuit for advancing the translator switch may be traced from battery through the normally closed right-hand armature contacts of relay 535, conductor 536, the armature contacts and winding of stepping magnet 608 of the translator switch TS, conductors 609 and 537 and thence to ground at the inner left-hand armature contact of relay 533. The translator switch under the influence of stepping magnet 608 advances its wipers until one of the test wipers 610 or 611 encounters a bank terminal upon which test potential has been placed through bank terminals and wipers of the code registers A and B, when a circuit is closed for relay 535. In the case assumed, code register A has been set in position 6 and the code register B has been set in position 2 and, therefore, the circuit of relay 535 may be traced from battery through the normally closed right-hand armature contacts and low resistance left-hand winding of relay 535, conductor 538, wiper 539 and bank terminal 540 of bank A^3 of register A, conductor 541, wiper 542 and bank terminal 543 of bank B^5 of register B, conductor 544, test terminal 613 and test wiper 610 of translator switch TS, the armature and normal contact of switching relay 614 and thence to ground at the armature contact of relay 533, over conductors 609 and 537. Relay 535, upon energizing in this circuit, opens the operating circuit of stepping magnet 608 at its right-hand armature contacts and removes the shunt from around its right-hand high resistance winding, so that relay 535 is maintained energized in the circuit previously traced through both of its windings.

Had the first code letter been R instead of O, then the code register A would be standing in position 7 and the switching relay 614 would therefore be energized over a circuit extending from battery through its winding, conductor 615, terminal 564 of the bank A^4 and to ground through wiper 547 and, therefore, the test wiper 611 would be employed for testing purposes rather than wiper 610. Banks B^3, B^4 and B^6 of the code register B are cross connected to test terminals in the banks TS^1 and TS^2 of the translator switch TS as desired to enable the translator switch to assume various positions corresponding to combinations of positions assumed by the code registers A and B.

The translator switch is now set in the proper position for controlling the class switch 306 and for controlling the district brush, district group, office brush and office group selections required to attain access to the office desired, which, in the case assumed is the O A kland office, or a mechanical office requiring the setting of the class switch into position 7.

Upon the energization of relay 535, a circuit is closed to advance the class switch 306 out of position 3 which may be traced through the magnet winding of switch 306, the lower left-hand contact of cam 305 (3 to 15), conductor 330, the left-hand armature and normal contact of relay 329, conductor 331 and thence to ground at the alternate contact of the outer left-hand armature of relay 335. The class switch 306 continues to advance until class relay 329 becomes energized. Upon the class switch reaching a position corresponding to the class setting of the translator switch TS, if it be assumed that the switch TS has been set in position 4 for routing a call to the O A kland office, then when class switch 306 reaches position 6¾ a circuit is established for relay 329 which may be traced from battery through the winding of the relay, the upper left-hand and lower right-hand contacts of cam 332, conductor 333, terminal 616 of bank TS^6, wiper 617, conductors 618 and thence to ground at the alternate contact of the inner left-hand armature of relay 535. Relay 329, upon energizing, closes a locking circuit for itself extending through its winding and the contact of its inner right-hand armature to ground through the lower contact of cam 338 (4 to 17), and at the normal contact of its right-hand armature opens the circuit previously traced over conductor 213, whereupon relays 215 and 217 become deenergized and the counting of time by switch M is stopped. Upon the removal of ground potential from conductor 213, relay 232 becomes energized in series with relay 222 over a circuit extending from battery through the winding of relay 222, conductor 221, the winding of relay 232, the strapped bank terminals of bank M^1 of switch M, to ground at wiper 234, it being assumed that wiper 234 has been advanced through the operation of stepping magnet 223 to some position between its normal position and position 7.

Upon the energization of relay 232, a restoring circuit is established for the switch M which may be traced from battery through the winding of stepping magnet 223, the armature contacts of this magnet, conductor 235, the inner left-hand armature

and contact of relay 232, conductor 236, the inner right-hand armature and contact of relay 222, conductor 237, the strapped bank terminals of bank M^1 of switch M and to ground through wiper 234. As the wipers of switch M pass position 7, the circuit of sender lamp 226 is maintained open at the outer right-hand armature and contact of relay 232, so that the lamp 226 is not operated. As soon as the wipers of switch M reach position 8, the circuits previously traced through the windings of relays 232 and stepping magnet 223 are opened and wiper 234 of the switch M is arrested with its wipers standing in position 8, which position is a normal position for the switch.

Relay 329, upon energizing, also closes a circuit for advancing the sequence switch 400 of the office sender out of position 1 and into position 2 preparatory to controlling the district selector in its brush selection movement. This circuit may be traced from battery through the magnet winding of switch 400, the upper right-hand contact of cam 401 (1), conductor 402, the left-hand armature and alternate contact of relay 329, conductor 331 and thence to ground at the outer left-hand armature and contact of relay 535. To insure the movement of sequence switch 400 from one stopping position to another, the circuit of the magnet of the switch is maintained over the master cam contact 403.

Setting the numerical registers.

Following the dialing of the code letters of the desired line designation, the calling subscriber dials the four numerical digits. In response to the dialing of the first thousands digit 3, the thousands register TH is advanced into position 3 through the operation of the stepping magnet 619. The circuit of stepping magnet 619 may be traced from battery through the winding of relay 503, conductor 512, winding of magnet 619, conductor 620, the No. 2 terminal of bank RS^2 and thence over the circuit previously traced to ground at the armature and back contact of stepping relay 307. During the transmission of each impulse through the winding of magnet 619, relay 514 is energized over a circuit extending through its winding, conductor 515, wiper 516, the No. 2 terminal of the bank RS^3, lead C, the armature and back contact of stepping magnet 619, conductor 620 and thence to ground over the circuit previously traced. Following the setting of the thousands register TH, the steering switch RS advances into position 3 preparatory to controlling the setting of the hundreds register H.

In a simliar manner with steering switch RS in positions 3, 4 and 5, the hundreds, tens and units registers H, T and U are set by their respective stepping magnets 621, 622 and 623 over conductors 624, 625 and 626 respectively and the terminals of bank RS^4 of the steering switch and during the operation of these magnets, relay 514 is energized to insure the proper operation of the magnets over leads D, E and F, respectively, and the Nos. 3, 4 and 5 terminals of bank RS^3 of the steering switch.

District brush selection.

With sequence switch 110 of district selector 150 in position 3 and the sender sequence switch in postion 2, a fundamental circuit is established extending from the office sender through the winding of the control relay 107 of the district selector for controlling the district selector in its brush selection movement. This fundamental circuit may be traced from battery through the left-hand winding of relay 107, the upper right-hand contact of cam 119 (3), the lower left-hand contact of cam 119 (3 to 6), conductor 124, the inner right-hand armature and contact of relay 123, wiper 125 of sender finder switch SF, conductor 334, conductor 335, the contact of class switch cam 336 (4 to 13½), conductor 337, the right-hand armature and back contact of relay 404, the lower right-hand contact of cam 405, conductor 406, winding of sender stepping relay 407, conductor 408, the armature and normal contact of relay 409, conductor 410, the inner left-hand armature and back contact of relay 411, resistance element 412 and thence to ground through the left-hand contact of cam 413 (2). Line relay 107 of the district selector and stepping relay 407 of the office sender are energized in this circuit.

Relay 107, upon energizing, closes a circuit for driving sequence switch 110 of the district selector out of position 3 and into position 4. This circuit extends from battery through the magnet winding of sequence switch 110, the upper left-hand contact of cam 111 (3), the inner right-hand armature and front contact of relay 107 and thence to ground at the right-hand contact of cam 112 (1 to 6). With the district selector sequence switch 110 in position 4, a circuit is now closed for the updrive magnet 126 which extends from battery through the winding of magnet 126, the right-hand contact of cam 118 (4), the inner right-hand armature and front contact of relay 107 and to ground at the right-hand contact of cam 112. Magnet 126, upon energizing, presses the depending portion of switch shaft 127 against the constantly rotating updrive drum 196, thereby causing the upward movement of the switch shaft. Upon the movement of sequence switch 110 out of position 3, the initial energizing circuit of relay 107 which extends through its left-hand winding and the upper right-hand contact of cam 119 is opened at the contact of cam 119, but

a locking circuit for relay 107 is closed at this time through its left-hand winding, left-hand armature and front contact and to the fundamental circuit previously traced through the left-hand contacts of cam 119.

As the switch shaft 127 approaches its first brush selection position, the shaft wiper 128 engages the first conducting portion of commutator segment 129 and a shunt circuit is established around the winding of the sender stepping relay 407 which may be traced from battery through the left-hand winding, left-hand armature and front contact of relay 107, the upper left-hand contact of cam 119 (1 to 6), the upper contact of cam 120 (3¾ to 4), conductor 130, segment 129, wiper 128 and thence to ground at the right-hand contact of cam 131 (9 to 7). Relay 107 is maintained energized over this shunt circuit, but sender stepping relay 407 is caused to deenergize. As the switch shaft 127 continues in its upward movement, the wiper 128 engages an insulating portion of segment 129 and the shunt circuit previously traced is opened, whereby the sender stepping relay 407 again energizes. Thus, during the upward movement of the switch shaft, the sender stepping relay 407 is intermittently energized and deenergized.

Under the assumption that the translator switch has been set into position 4, a circuit is established upon the first energization of stepping relay 407 following the establishment of the fundamental circuit, which may be traced from battery through the No. 2 counting relay 414, the armature and normal contact of the No. 2′ counting relay 415, lead 416, Fig. 6, terminal 627 of bank TS³ of the translator switch, wiper 628, conductor 629, class switch cam 339, conductor 340, the upper left-hand contact of cam 417 (2), the lower right-hand contact of cam 418 (2), conductor 419, conductor 420, the normally closed contacts associated with the outer left-hand armature of relay 421, the upper contact of cam 422 (1 to 2), the armature contact of stepping relay 407, conductor 423 and thence to ground through the upper contact of cam 413 (1 to 2). Counting relay 414, upon energizing in this circuit, closes a locking circuit for itself extending from battery through its winding, the winding of counting relay 415, the armature and front contact of relay 414, the upper contact of cam 424 (2) and thence to ground on conductor 425. Counting relay 415 does not energize, however, until relay 407 deenergizes at the time the wiper 128 of the district selector engages the first conducting portion of segment 129. Upon the energization of relay 415, the lead 416 is extended through the armature and alternate contact of relay 415, the armature and normal contact of the No. 1′ counting relay 427 and thence to battery through the winding of the No. 1 counting relay 426. Upon the second deenergization of stepping relay 407, relay 427 becomes deenergized and connects lead 416 to the No. 0 counting relay 428 and in response to the next deenergization of stepping relay 407, the No. 0′ counting relay 429 is energized, closing a circuit for driving sequence switch 400 out of position 2 and into position 4. This circuit may be traced from battery through the winding of sequence switch magnet 400, the lower right-hand contact of cam 439 (2), the left-hand armature and normal contact of relay 436, conductor 440, the inner right-hand armature and normal contact of relay 421, conductor 441 and thence to ground at the armature and contact of the No. 0′ counting relay 429.

Sequence switch 400 upon leaving position 2 opens the locking circuits of all counting relays which have been locked up at the right-hand contacts of cam 424 (2). At the time the No. 0′ counting relay 429 energized in response to the last deenergization of stepping relay 407, relay 409 is energized in parallel therewith, opening at its armature and back contact the previously traced fundamental circuit extending through the windings of stepping relay 407 and control relay 107 of the district selector 150. As soon thereafter as the wiper 128 engages the next insulating portion of segment 129, the circuit of relay 107 is opened and this relay deenergizes, closing a circuit for driving the district selector sequence switch 110 out of position 4 and into position 5, this circuit extending from battery through the magnet winding of sequence switch 110, the upper right-hand contact of cam 111 (4), the inner right-hand armature and back contact of relay 107 and thence to ground at the right-hand contact of cam 112. As soon as relay 107 deenergizes the circuit previously traced through the updrive magnet 126 is opened at the inner right-hand armature and front contact of relay 107 and the upward movement of the switch shaft is arrested. With sequence switch 110 in position 5 and the sender sequence switch 400 in position 4, the fundamental circuit previously traced is again established and relays 107 and 407 again energize. Relay 107, upon energizing, causes the movement of the district sequence switch 110 from position 5 to position 6, the initial energizing circuit of relay 107 being opened as previously described at the upper right-hand contact of cam 119 as soon as the sequence switch leaves position 5, but relay 107 remaining energized over the fundamental circuit through its left-hand winding and the front contact of its left-hand armature and the left-hand contacts of cam 119.

As soon as the sender sequence switch 400 reaches position 3, a circuit is established through the right-hand winding of relay 102

at the district selector which may be traced from battery through the winding of relay 102, the upper right-hand contact of cam 146 (1 to 10), the outer right-hand armature and front contact of relay 123, the lower contact of cam 147 (3 to 10), wiper 148 of switch SF, conductor 341, conductors 342 and 343, resistance element 344, conductor 345 and thence to ground on conductor 425 through the upper contact of sender sequence switch cam 430 (4 to 18). Relay 102 is differentially wound, but due to the inclusion of resistance element 344 in the circuit of its right-hand winding the current flowing through the right-hand winding is not sufficient to differentially release the relay. As soon as sequence switch 110 reaches position 4, relay 145 becomes energized over a branch of the above traced circuit extending through the upper left-hand contact of cam 146 (4 to 10) through the winding of relay 145 to battery. Relay 145, upon energizing, prepares a circuit for energizing relay 107 when sequence switch 110 reaches position 9 as will be hereinafter described.

District group selection.

As soon as sequence switch 110 reaches position 6, the circuit previously traced for the updrive magnet 126 of the district selector is again established through the right-hand contact of cam 118 (6) and the inner right-hand armature and front contact of relay 107 and in the manner previously described switch shaft 127 is again driven upwardly. Since at this time, however, the tripping spindle 136 has been rotated by the tripping magnet 135 which was energized in position 5 of sequence switch 110 over a circuit extending from battery through the winding of magnet 135 and the lower right-hand contact of cam 115 (5 to 7), the third set of brushes is now tripped upon the initial upward movement of switch shaft 127 and during the continued upward movement of the shaft the brushes travel over the bank with which they are associated. The remaining four sets of brushes on the switch shaft are not tripped at this time and are, therefore, functionless. As the switch shaft approaches its first group selection position, wiper 132 engages the first metallic portion of the group selection segment 133 of the commutator and a circuit is closed in shunt of the winding of the sender stepping relay 407 which may be traced from battery through the left-hand winding, left-hand armature and front contact of relay 107, upper left-hand and lower right-hand contacts of cam 119, conductor 134, segment 133, wiper 132 and thence to ground at the right-hand contact of cam 131 (9 to 7). Relay 107 is maintained energized over this circuit and the sender stepping relay 407 becomes deenergized. As the switch shaft continues in its upward movement and the wiper 132 engages the first insulating portion of segment 133, the shunt circuit is opened and sender stepping relay 407 again energizes. In this manner during the further movement of the switch shaft in its group selection movement, the sender stepping relay 407 is intermittently energized and deenergized.

Upon the first energization of the stepping relay 407 a circuit is closed for the No. 0 counting relay 428, it being assumed that the calling subscriber has dialed such a code as to set the translator switch into position 4. This circuit may be traced from battery through the winding of relay 428, lead 431, lead 431, Fig. 6, terminal 630 of bank TS⁴ of the translator switch, wiper 631, conductor 632, the contact of class switch cam 346, conductor 347, the upper right-hand contact of cam 417 (3 to 4), the lower right-hand contact of cam 418 (4), conductors 419 and 420, the lower contact of cam 422 (3 to 4), the armature contact of relay 407, conductor 432 and thence to ground through the lower contact of cam 413 (3 to 4). Counting relay 428, upon energizing, closes a locking circuit for itself extending through the winding of the No. 0′ counting relay 429, through the armature and front contact of relay 428 and thence to ground through the upper contact of cam 424 (4). Upon the first deenergization of stepping relay 407, relay 429 energizes in parallel with relay 409 and closes at its armature and front contact a circuit for advancing sequence switch 400 out of position 4. This circuit may be traced from battery through the magnet winding of sequence switch 400, the contacts of cam 442, the left-hand armature and normal contact of relay 436, conductor 440, conductor 441 and thence to ground at the armature contact of relay 429. Upon leaving position 4 the locking circuit extending through the windings of the counting relays 428 and 429 is opened at the contact of cam 424 and these relays thereupon deenergize. Relay 409, upon energizing, opens the fundamental circuit at its armature and back contact thereby causing the deenergization of line relay 107 of the district selector as soon as wiper 132 engages the next insulating portion of segment 133.

Relay 107, upon deenergizing, opens at its inner right-hand armature and front contact the previously traced circuit of the updrive magnet 126 thereby arresting the upward movement of the switch shaft for positioning the tripped set of brushes on the first set of terminals of the first group of terminals of the bank. At its inner right-hand armature and back contact relay 107 closes the previously traced circuit for driv-

ing sequence switch 110 out of position 6 and into position 7. In position 7, relay 107 energizes over a circuit extending from battery through its right-hand winding, the lower contact of cam 108 (7 to 7¼), the lower contacts of cam 109 and thence to ground through the alternate contact and right-hand armature of relay 101 and the lower contact of cam 131. Relay 107, upon energizing, closes a circuit for driving sequence switch 110 out of position 7 and into position 8, which circuit may be traced from battery through the magnet winding of the sequence switch, the upper left-hand contact of cam 111 (7), the inner right-hand armature and alternate contact of relay 107, the upper contact of cam 112 (7 to 8) and thence to ground at the right-hand armature and front contact of relay 102.

Trunk hunting at the district selector.

A soon as sequence switch 110 leaves position 7, the initial energizing circuit of relay 107 is opened at the lower contact of cam 108, but relay 107 locks up over a circuit extending from battery through its left-hand winding and left-hand armature contact, the right-hand contacts of cam 138, the outer right-hand armature and front contact of relay 107, the lower contacts of cam 139 (7 to 8) to the test brush 140 and if the first trunk of the second group is busy, to ground at the test terminal of such busy trunk. Upon reaching position 8 with relay 107 energized, a circuit is established for the updrive magnet 126 which may be traced from battery through the magnet 126, the lower right-hand contact of cam 118 (8), the inner right-hand armature and front contact of relay 107 and thence to ground at the right-hand contact of cam 112. The updrive magnet 126 upon energizing again drives the switch shaft upwardly in search of an idle trunk in the selected group. So long as the test brush 140 encounters the terminals of busy trunks, relay 107 remains locked up. When, however, an idle trunk is encountered which it will be assumed is the trunk terminating in terminals 186, 187 and 188 extending to an idle incoming selector 185, the locking circuit of relay 107 is opened and relay 107 deenergizes as soon as the brushes 151, 156 and 140 have been properly centered on the bank terminals of the selected trunk. Until the brushes are so centered, relay 107 remains locked up over a circuit extending through its right-hand winding, the upper contact of cam 108 (8), the brush centering segment 144, shaft wiper 143, the upper contact of cam 118 (8), the inner right-hand armature and front contact of relay 107 and thence to ground at the right-hand contact of cam 112. Upon deenergizing, the circuit of the updrive magnet 126 is opened at the inner right-hand armature of relay 107 and the upward movement of the switch shaft is thereby arrested and a circuit is closed at the inner right-hand armature and back contact of relay 107 for driving sequence switch 110 out of position 8 and into position 9. Upon reaching position 8½, busy ground potential is connected to the multiples of test terminal 188 of the selected trunk over brush 140 and the right-hand contacts of cam 138.

Relay 145 being energized at this time as hereinbefore described, a circuit is established as soon as sequence switch 110 reaches position 9 for again energizing relay 107, which circuit may be traced from battery through the right-hand winding of relay 107, the lower contact of cam 108 (9 to 10), the lower right-hand and upper left-hand contacts of cam 109 and thence to ground at the armature contact of relay 145. Relay 107 upon energizing in this circuit closes a circuit through its inner right-hand armature and front contact for advancing sequence switch 110 out of position 9 and into position 10, in which position the fundamental circuit is extended over conductors 124 and 158 and through contacts of cams 149 and 157, through brushes 151 and 156, respectively, of the district selector switch to the line relay (not shown) of the incoming selector switch 185.

It will be assumed that the line of the desired subscriber may be reached without employing an office selector and that, therefore, the translator switch TS in position 4 establishes a circuit for advancing the sender sequence switch 400 through positions 6 and 8 which are ordinarily employed for controlling the selective movements of office selectors, into position 10, in which position a fundamental circuit is established for controlling the selective movements of the incoming selector. When, therefore, sequence switch 400 leaves position 4 following the completion of district group selection and passes through positions 4¾ to 5¼, a circuit is established for relay 433 which may be traced from battery through the winding of relay 433, conductor 434, the upper left-hand contact of cam 418 (4¾ to 5¼), the lower right-hand contact of cam 417 (4¾ to 6), conductor 435, wiper 633, terminal 634 of bank TS^5 of the translator switch, conductor 635 and thence to ground at the outer right-hand armature and back contact of relay 436. Relay 433, upon energizing, closes a locking circuit for itself extending through the lower left-hand contact of cam 424, which locking circuit is maintained energized until sequence switch 400 leaves position 8. At its left-hand armature and contact relay 433 closes a locking circuit for counting relays 428 and 429 which may be traced from battery through winding of re-

lay 428, the winding of relay 429, conductor 443, the upper contact of cam 437 (5 to 8), the left-hand armature and contact of relay 433, conductor 438 and thence to ground through the upper contact of cam 338 (3 to 15). The No. 0′ counting relay 429 is thus maintained energized until sequence switch 400 leaves position 8 and at its armature and contact maintains the driving circuit of sequence switch 400 closed so that sequence switch 400 is driven into position 10.

Trunk test.

With sender sequence switch 400 in position 10 a fundamental circuit is closed through the winding of trunk test relay 349, Fig. 3, for testing the operative condition of the selected inter-office trunk. This fundamental circuit may be traced in part from wiper 151 of selector 150, the right-hand contacts of cam 149 (10), conductor 124, the inner right-hand armature and front contact of relay 123, wiper 125, conductor 334, conductor 335, resistance element 363, the contact of cam 348 (4 to 7), winding of relay 349, conductor 350, the contact of cam 444 (9¾ to 10), the outer left-hand armature and back contact of relay 411, conductor 351, conductor 352, wiper 159 of switch SF, conductor 158, the lower contacts of cam 157 and thence to brush 156. If the trunk tested is in proper operating condition, that is, has no open conductors, relay 349 energizes and at its armature contact closes a circuit over conductor 354 for energizing relay 433. Relay 433, upon energizing, closes a circuit for advancing sequence switch 400 into position 11, which circuit may be traced from battery through the magnet winding of switch 400, conductor 445, the lower contact of class switch cam 355 (4 to 7), the lower contact of cam 437 (10), the left-hand armature and contact of relay 433 and thence to ground over conductor 438 and the upper contact of cam 338 (3 to 15).

With sequence switch 400 in position 11 a local energizing circuit is established for relay 407 which may be traced from battery, through the right-hand contact of cam 456 (11), conductor 406, windings of relay 407, conductor 408, the armature and back contact of relay 409, the inner left-hand armature and back contact of relay 411, resistance element 412 and thence to ground at the left-hand contact of cam 413 (11). Relay 407, upon energizing, closes a circuit for advancing sequence switch 400 into position 12 which may be traced from battery through the magnet winding of sequence switch 400, the lower left-hand contact of cam 429 (11), conductor 423, the armature and contact of relay 407, conductor 432 and thence to ground through the lower contact of cam 413 (11 to 12).

Incoming brush selection.

With sequence switch 400 in position 12 a fundamental circuit is established extending from the office sender to the incoming selector switch which may be traced in part from brush 151 of the district selector over the circuit previously traced to conductor 335, the contact of cam 336, conductor 337, the left-hand winding of overflow relay 457, the left-hand armature and back contact of relay 404, the lower contact of cam 456 (12 to 16), conductor 406, the windings of stepping relay 407, conductor 408, conductor 410, the inner left-hand armature and back contact of relay 411, the left-hand contacts of cam 458, conductor 351 and thence as previously traced to brush 156 of the district selector. The current flowing in this circuit is not in the proper direction to operate the polarized relay 457, but sender stepping relay 407, however, energizes in this circuit. Under the assumption that the numerical designation of the desired line is 3612 and that the calling subscriber has therefore set the thousands register TH into position 3, a circuit is now established for the No. 1 counting relay 426 extending from battery through the winding of relay 426, the armature and back contact of relay 427, lead 475, lead 475, Fig. 6, terminal 636 of bank TH^3, wiper 637, conductor 638, the upper contact of cam 446 (11 to 12), the lower right-hand contact of cam 418 (12), conductor 419 and thence over the circuit previously traced through the armature contact of relay 407 and to ground at the lower contact of cam 413 (11 to 12).

In the well-known manner the counting relays are operated and locked up in succession during the brush selection movement of the incoming selector 185 until the No. 0′ counting relay 429 is energized in parallel with relay 409, when the fundamental circuit is opened and a circuit is closed as previously traced for advancing sequence switch 400 into position 14. When switch 400 leaves position 12, the locking circuits of the energized counting relays are opened at the contact of cam 424 (12).

Incoming group selection.

With sequence switch 400 in position 14 the fundamental circuit previously traced through the windings of sender stepping relay 407 is again closed. Relay 407, upon energizing, establishes a circuit for the No. 3 counting relay 447, it being assumed that the calling subscriber has set the hundreds register into position 6. The circuit of relay 447 may be traced from battery through the winding of relay 447, the armature and back contact of the No. 3′ counting relay 449, lead 448, lead 448, Fig. 6, the outer armature and front contact of relay 639, which relay

is energized at this time over terminal 640 of bank H^4 and wiper 641, terminal 642 of bank TH^4 of the thousands register TH, wiper 643, conductor 644, the lower left-hand contact of cam 446 (13 to 14), the lower right-hand contact of cam 418 (14), and thence over the circuit previously traced through the contact of relay 407 to ground at the upper contact of cam 413 (13 to 14). Counting relay 447, upon energizing, locks up through the winding of No. 3′ counting relay 449, the armature and contact of relay 447 and to ground through the contact of cam 424. In the well-known manner during the group selection movement of the incoming selector 185, the counting relays operate and lock up in succession until the No. 0′ counting relay 429 energizes in parallel with relay 409, when the fundamental circuit is opened to arrest the selective movement of the incoming selector and sequence switch 400 is advanced in a manner previously described into position 16.

Final brush selection.

With sequence switch 400 in position 16, the fundamental circuit above traced is again established through the windings of sender stepping relay 407 and the winding of the control relay (not shown) of the final selector 190. Upon the energization of relay 407 in this circuit, a circuit is established for the No. 1 counting relay 426 which may be traced from battery through the winding of relay 426, the armature and back contact of the No. 1′ counting relay 427, lead 475, lead 645, Fig. 6, terminal 646 of the bank H^3 of the hundreds register H, wiper 647, conductor 648, the lower right-hand contacts of cams 446 and 418 and thence through the armature contact of relay 407 to ground at the lower contact of cam 413 (15 to 16). Relay 426 locks up in the well-known manner through the winding of the upper No. 1′ counting relay 427 and during the brush selection movement of the final selector 190 the counting relays operate in succession until the No. 0′ counting relay 429 energizes in parallel with relay 409, when the fundamental circuit is opened to arrest the selective movement of selector 190 and the circuit previously traced is established for advancing sequence switch 400 out of position 16 into position 17.

If at the time sequence switch 400 reaches position 17 the calling subscriber has completed dialing and the register steering switch RS has advanced into position 9, a circuit is established for advancing sender sequence switch 400 out of position 17 into position 18, preparatory to controlling final tens selection. This circuit may be traced from ground at the inner right-hand armature of relay 313, conductor 507, wiper 506, terminal 548 of bank RS^1 of switch RS, conductor 549, the lower contact of class switch cam 359 (4 to 7), conductor 360, the lower left-hand contact of cam 401 (17) and through the magnet winding of sequence switch 400 to battery.

It is to be noted in this connection that as soon as the calling subscriber completed the dialing of the units digit of the desired number, the steering switch RS was advanced into position 6, whereupon a circuit was established for advancing it into position 7, which may be traced from battery through the winding and armature contact of stepping magnet 524, conductors 525 and 526, wiper 527, bank terminal 550 of bank RS^4, conductor 551, the right-hand contacts of class switch cam 361, conductor 362, the contact of cam 450, conductor 402, the left-hand armature and front contact of relay 329, conductor 331 and thence to ground at the armature contact of relay 535. Upon reaching position 7 switch RS is advanced into position 8 over a similar circuit extending through the winding of magnet 524, through wiper 527, bank terminal 552, conductor 553, the lower left-hand and upper right-hand contacts of cam 361 and thence over the circuit previously traced to ground at the contact of relay 535 and the switch is further advanced into position 9 over wiper 527, terminal 554, conductor 555, the upper contacts of cam 361 and thence to ground over the circuit previously traced.

Final tens selection.

With sequence switch 400 in position 18, the fundamental circuit previously traced is established through the winding of the control relay (not shown) of final selector 190 and the windings of sender stepping relay 407. Relay 407, upon energizing, prepares a circuit for the No. 1 counting relay 426, it being assumed that the calling subscriber has set the tens register T in position 1. The circuit of relay 426 may be traced from battery through the winding of relay 426, the armature and back contact of the No. 1′ counting relay 427, lead 475, lead 649, Fig. 6, terminal 650 of bank T^3, wiper 651, conductor 652, the right-hand contacts of cam 418 and thence to ground through the armature contact of stepping relay 407 and the upper contact of cam 413 (17 to 18). Relay 426, upon energizing, locks up in the well-known manner through the winding of the No. 1′ counting relay 427 and during the tens selection movement of the final selector 190, the counting relays operate in succession until the No. 0′ counting relay 429 energizes in parallel with relay 409, when the fundamental circuit is opened to arrest the selective movement of the final selector and relay 429 establishes a circuit for energizing relays 411 and 436.

The circuit of relays 411 and 436 may be

traced from battery through the windings of these relays, conductor 452, the upper left-hand and lower right-hand contacts of cam 451 (18), conductor 440, the inner right-hand armature and back contact of relay 421, conductor 441 and thence to ground at the armature contact of No. 0′ counting relay 429. Relay 436, upon energizing, closes a locking circuit for itself and for relay 411 which may be traced through the windings of these relays, the inner right-hand armature and front contact of relay 436 and thence over conductor 438 to ground at the upper contact of cam 338 (3 to 15). Relay 436, upon energizing, connects ground to conductor 345 for maintaining relay 145 at the district selector energized after sequence switch 400 leaves position 18 and opens cam contact 430. Relay 411 at its outer right-hand armature and front contact establishes a circuit which may be traced over conductor 453 and through the windings of relays 454 and 404 to battery. A circuit is now established for advancing sequence switch 400 out of position 18 and into position 2, the energization of relays 411, 436, 454 and 404 being thus effective to change the circuits of the sender to operate with sequence switch 400 in its second revolution. The circuit for advancing sequence switch 400 may now be traced from battery through the magnet winding of switch 400, the upper left-hand contact of cam 439 (18 to 1), conductor 453, the outer left-hand armature and front contact of relay 454, conductor 455, the right-hand contact of cam 430 (18 to 1), and thence to ground on conductor 425.

Final units selection.

With sequence switch 400 in position 2, the fundamental circuit extending from the control relay of the final selector 190 through the winding of the sender stepping relay 407 may be traced in part from brush 151 over the circuit previously traced to conductor 337 the left-hand winding of relay 457, the left-hand armature and front contact of relay 404, the upper left-hand contact of cam 456 (2), conductor 406, the windings of sender stepping relay 407, conductor 408, the armature and back contact of relay 409, conductor 410, the inner left-hand armature and front contact of relay 411, the upper right-hand and lower left-hand contacts of cam 458 and thence over the circuit previously traced to brush 156 of the district selector 150.

Relay 407 energizes in this circuit and establishes a circuit for the No. 2 counting relay 414, it being assumed that the calling subscriber has set the units register U into position 2 in response to the dialing of the last numerical digit. The circuit of relay 414 may be traced from battery through the winding of relay 414, the armature and back contact of the No. 2′ counting relay 415, lead 416, lead 653, Fig. 6 bank terminal 654 of bank U^3, wiper 655, conductor 656, the right-hand armature and back contact of wipe-out relay 364, conductor 365, the contacts of cam 458, conductor 459, the inner right-hand armature and front contact of relay 411, conductor 420 and thence as previously traced through the armature contact of stepping relay 407, to ground at the upper contact of cam 413 (1 to 2). Counting relay 414 in the well-known manner locks up through the winding of the No. 2′ counting relay 415 and during the units selection movement of the final selector 190, the counting relays operate and lock up in succession until the No. 0′ counting relay 429 energizes in parallel with relay 409, when the fundamental circuit is opened to arrest the selective movement of selector 190 and the sequence switch 400 is advanced into position 4. The circuit of sequence switch 400 may be traced from battery through the magnet winding of switch 400, the upper right-hand contact of cam 439 (2), the left-hand armature and front contact of relay 436, conductor 440, conductor 441, thence to ground at the armature contact of the No. 0′ counting relay 429.

Since no stations digits have been dialed by the calling subscriber the No. 0′ counting relay 429 remains locked to cause sequence switch 400 to advance directly from position 2 into position 10. The locking circuit of relay 429 may be traced from battery through the windings of relay 428 and 429, the contact of cam 460 (3 to 8), the outer left-hand armature and front contact of relay 454, conductor 455, the upper right-hand and lower left-hand contacts of cam 451 (3 to 8), conductor 461, conductor 551, the right-hand contacts of class switch cam 361, conductor 362, the upper contact of cam 450 (2 to 10), conductor 402, the left-hand armature and front contact of relay 329, conductor 331 and thence to ground at the outer left-hand armature and front contact of relay 535.

Talking selection.

Following units selection the sequence switch of the incoming selector is advanced to reverse the direction of current flow over the fundamental circuit in the manner fully described in the Patent No. 1,505,171 to F. A. Stearn, issued Aug. 19, 1924, hereinbefore referred to and with the sender sequence switch 400 in position 10, both the sender stepping relay 407 and polarized overflow relay 457 energize. Relay 457 energizes at this time since its two windings operate cumulatively, its right-hand winding being energized over a circuit extending over conductor 463, to ground on conductor 425 through the lower left-hand contact of

cam 430 (9 to 10) and upon energizing, closes a circuit for relay 421 which may be traced from battery through the winding of relay 421, the inner left-hand armature and contact of relay 454 and thence to ground at the armature contact of relay 457. Relay 421, upon energizing, closes a locking circuit for itself extending from battery through its winding, conductor 463, the lower left-hand contact of cam 430 (9 to 10) to ground on conductor 425.

Relay 407, upon energizing over the fundamental circuit, establishes a circuit for the No. 0 counting relay which may be traced from battery through the winding of relay 428, lead 431, lead 462, the outer left-hand armature and front contact of relay 421, the upper contact of cam 422, the armature and front contact of relay 407, conductor 423 and thence to ground at the upper contact of cam 413 (9 to 10). The No. 0 counting relay 428 locks up through the winding of the No. 0′ counting relay 429, which latter relay becomes energized as soon as the sequence switch of the incoming selector advances to open the fundamental circuit. When the fundamental circuit is opened the current flowing through the left-hand winding of relay 457 is cut off and its energization is no longer maintained by its right-hand winding only. Upon the energization of relay 429, a circuit is closed for energizing advance relays 353 and 366 which may be traced from battery through the windings of these relays in parallel, conductor 367, the inner right-hand armature and alternate contact of relay 421, conductor 441 and thence to ground at the armature contact of relay 429. Advance relay 366, upon energizing, closes a locking circuit for itself and for advance relay 353 extending through the inner right-hand armature of relay 366 and to ground at the upper contact of class switch cam 338 (3 to 15).

Advance relay 366, upon energizing, opens the circuit previously traced extending through the winding of relay 145, which in turn, opens the locking circuit of control relay 107 thereby advancing sequence switch 110 out of position 10 and into position 11. The circuit for sequence switch 110 may be traced from battery through the magnet winding of the sequence switch, the upper right-hand contact of cam 111 (10), the inner right-hand armature and back contact of relay 107 and to ground at the right-hand contact of cam 112. As soon as sequence switch 110 leaves position 10½, the dialing circuit previously traced over the left-hand contacts of cams 160 and 166 is opened, thereby causing the deenergization of relays 307, 312 and 313. A circuit is now closed for wipe-out relay 364 which may be traced from battery through the winding of this relay, conductor 368, the contacts of class switch cam 369 (3 to 15), conductor 370, conductor 322 and thence to ground at the armature and back contact of relay 307. Relay 364, upon energizing, closes a locking circuit for itself extending through its inner left-hand armature and contact and thence to ground at the upper contact of cam 338 (3 to 15), and at its intermediate left-hand armature established a circuit for advancing the sender sequence switch 400 out of position 10 and into position 11. This circuit may be traced from battery through the magnet winding of sequence switch 400, the upper right-hand contact of cam 439 (10), the left-hand armature and front contact of relay 436, conductor 440, the outer right-hand armature and front contact of relay 421, conductor 371, the left-hand armature and front contact of relay 353 and thence to ground at the intermediate left-hand armature and contact of relay 364.

With sequence switch 400 in position 11 the locking circuit of relay 421 is opened and relay 407 is connected into a local circuit for removing the effect of the polarizing current which previously flowed through its winding and the winding of relay 457 and for the purpose of advancing the sequence switch 400 into position 12. The circuit of relay 407 may be traced from battery through the right-hand contact of cam 456 (11), conductor 406, the windings of stepping relay 407, conductor 408, conductor 410, the inner left-hand armature and front contact of relay 411, the upper contacts of cam 458, resistance element 412 and thence to ground at the left-hand contact of cam 413 (11). Upon the energization of relay 407, a circuit is established for advancing sequence switch 400 into position 12 which may be traced from battery through the magnet winding of switch 400, the lower left-hand contact of cam 439 (11), conductor 423, the armature and front contact of stepping relay 407, conductor 432, and thence to ground at the lower contact of cam 413 (11 to 12). The circuits of the sender are now in condition for controlling talking selection at the district selector 150.

A fundamental circuit is now established between the control relay 107 of the district selector and the office sender which may be traced from battery through the left-hand winding of relay 107, the upper right-hand contact of cam 119 (11), the lower left-hand contact of cam 119 (11 to 14), conductor 124, the inner right-hand armature and front contact of relay 123, wiper 125 of switch SF, conductor 334, the outer right-hand armature and front contact of advance relay 366, conductor 372, the left-hand contact of cam 405 (12), conductor 406, the winding of stepping relay 407, conductor 408, the armature and back contact of relay 409, conductor 410, the inner left-hand armature and

front contact of relay 411, the upper contacts of cam 458, resistance element 412, conductor 464, the left-hand contacts of cam 465 (12), the right-hand armature and alternate contact of relay 454, conductor 466, terminal 556 of bank RS^5, wiper 557, conductor 558 and thence to ground at the inner right-hand armature and back contact of relay 313. Relays 107 and 407 energize in this circuit, relay 107 closing a circuit as previously traced for driving sequence switch 110 out of position 11 and into position 15, unless this circuit is interrupted at the armature contacts of relay 107 prior to the sequence switch reaching position 15. As soon as sequence switch 110 leaves position 11, the initial energizing circuit of relay 123 is opened at the lower left-hand contact of cam 115 (2 to 11), but relay 123 is maintained energized over the circuit extending through the winding of magnet 116, the winding of relay 123, the lower contact of cam 146 (11 to 14), the outer right-hand armature and front contact of relay 123, the upper contact of cam 147 (11 to 16), the outer right-hand armature and front contact of relay 107 and thence to ground through the lower contacts of cam 112. As soon as sequence switch 110 leaves position 11, the initial energizing circuit of relay 107 is opened at the upper right-hand contact of cam 119, but relay 107 remains locked to the fundamental circuit through its left-hand winding, left-hand armature and front contact and through the left-hand contacts of cam 119.

During the rotation of sequence switch 110 from position 11 toward position 15, an intermittent ground is connected to the fundamental circuit in shunt of the windings of sender stepping relay 407 which may be traced from battery through the left-hand winding, left-hand armature and front contact of relay 107 and thence to ground through the upper left-hand and lower right-hand contacts of cam 138, this shunt circuit being closed in positions 11⅝, 12⅝ and 13⅝.

At the office sender upon the energization of sender stepping relay 407 in the fundamental circuit, since the class switch has been set into position 7 for a full mechanical call, a circuit is established for the No. 0′ counting relay 428 which may be traced from battery through the winding of relay 428, lead 431, lead 431, Fig. 3, the upper contact of class switch cam 373 (6 to 10), conductor 374, the contact of cam 467 (12 to 13), the lower contact of cam 458 (12), conductor 459, the inner right-hand armature and front contact of relay 411, conductor 420, the lower contact of cam 422, the armature contact of sender stepping relay 407, conductor 432 and thence to ground at the lower contact of cam 413. Relay 428, upon energizing, looks up through the winding of the No. 0′ counting relay 429, upon the first deenergization of relay 407. When sequence switch 110 is passing through position 11⅝, the No. 0′ counting relay 429 energizes in parallel with relay 409, relay 409 opening the fundamental circuit and causing thereby the release of relays 107 and 407. Relay 107, upon deenergizing, opens the previously traced circuit extending through the winding of sequence switch magnet 110 for arresting sequence switch 110 in position 12.

With sequence switch 110 of the district selector in position 12, the brushes 151 and 156 of the district selector are connected over the contacts of cams 149 and 157 to the right-hand windings of repeating coil 189 and to the windings of polarized relay 174 and the calling subscriber's line is connected through contacts of cams 160 and 166 to the winding of supervisory relay 175 and the left-hand windings of repeating coil 189. In the manner fully set forth in the aforesaid patent to F. A. Stearn, the called subscriber's line is tested and ringing current is applied thereto.

Release of the office sender.

Following talking selection and the deenergization of relay 107, the holding circuit for relay 123 is opened and relay 123, upon deenergizing, opens the circuit of relay 302. A circuit as now closed for advancing the steering switch RS into position 10 which may be traced from ground at the outer right-hand armature and back contact of relay 302, conductor 375, terminal 559 of bank RS^4 of switch RS, wiper 527, conductor 526, the right-hand armature and normal contact of relay 503, conductor 525 and thence through the armature contacts and winding of stepping magnet 524 to battery. With steering switch RS in position 10, a circuit is now closed for advancing the class switch 306 out of position 7 and into position 16, which circuit may be traced from battery through the magnet winding of switch 306, the lower left-hand contact of cam 305 (3 to 15), conductor 330, conductor 376, terminal 560 of bank RS (5) of switch RS, wiper 557, conductor 558 and thence to ground at the inner right-hand armature and back contact of relay 313.

As soon as class switch 306 leaves position 15, the locking circuits of advance relays 353 and 366, of wipe-out relay 364 and of transfer relays 411, 436, 454 and 404 are opened at the upper contact of cam 338 (3 to 15), and these relays thereupon deenergize.

With class switch 306 in position 16, the right-hand operating winding of relay 533 is shunted over conductor 561, the lower left-hand and upper right-hand contacts of cam

327, conductor 330, conductor 376, terminal 560 of bank RS⁵ of switch RS, wiper 557, conductor 558 and thence to ground at the armature contact of relay 313, and relay 533 upon deenergizing closes a circuit for advancing class switch 306 into position 17 and opens the locking circuit of relay 535. The circuit for advancing class switch 306 into position 17 may be traced from battery through the magnet winding of switch 306, the lower right-hand contact of cam 305 (16), conductor 377, the right-hand armature and back contact of relay 533 and thence to ground on conductor 319 at the contact of class switch cam 321. Relay 535, upon deenergizing, closes a circuit for advancing sender sequence switch 400 out of position 12 into normal position 1, which may be traced from battery through the magnet winding of switch 400, the lower right-hand contact of cam 401 (2 to 18), conductor 468 and thence to ground at the inner left-hand armature and back contact of relay 535.

With class switch 306 in position 17, a restoring circuit for the units register U is established which may be traced from ground at the inner right-hand armature and back contact of relay 313, over conductor 558, wiper 557, terminal 560, conductor 376, conductor 330, the right-hand contacts of cam 327, conductor 523, conductor 607, wiper 606 and the off-normal terminals of bank U¹ of the units register U, the armature contacts and magnet winding of stepping magnet 623, conductor 512 and thence to battery through the winding of slow-to-release relay 503. Relay 503 and stepping magnet 623 energize in this circuit, the magnet 623 causing the wipers of the units register to be restored to normal position. As soon as wiper 606 reaches its normal position, the grounded conductor 607 is connected through wiper 606 and the normal terminal of bank U¹, over conductor 605, wiper 604 and off-normal terminals of bank T¹ of the tens register T, the armature contacts and magnet winding of stepping magnet 622, conductor 512, thence to battery through the winding of relay 503. Through the operation of magnet 622, the tens register T is restored to normal position. In a similar manner all of the registers including the code registers A and B are restored to their normal positions. Following the restoration of register A and the deenergization of slow-to-release relay 503 which is maintained energized in series with the windings of the stepping magnets during the restoration of the registers, a circuit is established for advancing steering switch RS out of position 10 into its normal position, which circuit may be traced from ground on conductor 607, through the wipers and normal bank terminals of the numerical and code registers, conductor 562, the No. 10 terminal of bank RS⁴, wiper 527, conductor 526, the right-hand armature and back contact of relay 503, conductor 525 and thence to battery through the armature contacts and winding of stepping magnet 524. As soon as steering switch RS reaches normal position, the circuit of magnet 524 is opened at the wiper 527.

With steering switch RS in normal position, a circuit is established for advancing class switch 306 into pos tion 18, which circuit may be traced from battery through the magnet winding of switch 306, the upper left-hand contact of cam 305 (3 to 17), conductor 378, the normal contact of bank RS⁵, wiper 557, conductor 558 and thence to ground at the inner right-hand armature and back contact of relay 313. When the class switch leaves position 17, the locking circuit of class relay 329 is opened at the lower contact of cam 338 (4 to 17). With sender sequence switch 400 in position 1 and class switch 306 in position 18, a circuit is established for advancing class switch 306 into normal position 1 which may be traced from battery through the magnet winding of switch 306, conductor 379, class switch cam 380 (18), conductor 469, the lower contacts of cam 418 (1), conductor 419, the inner right-hand armature and back contact of relay 411, conductor 420, the normal contacts of the outer left-hand armature of relay 421, the lower contact of cam 422 (1), conductor 423 and thence to ground at the upper contact of cam 413. The circuits of the office sender are now entirely restored to normal condition and the sender is available for use in establishing other connections.

Restoration of the connection upon the termination of the conversation.

Upon the movement of the district sequence switch into position 12 for establishing the talking circuit through the repeating coil 189 of the district link, the circuit of relay 102 was opened at the upper left-hand contact of cam 115 (2 to 11), but relay 102 is held energized over the armature and front contact of relay 175 and the right-hand armature and front contact of relay 102 during conversation or so long as the calling subscriber maintains his receiver off the switch-hook. Upon the termination of the conversation and the restoration of the calling subscriber's receiver to its switchhook, relay 175 becomes deenergized and opens the circuit of relay 102, which in turn, opens the circuit of relay 101. Upon the deenergization of relay 102, a circuit is established for advancing sequence switch 110 out of position 12 and into position 17 which may be traced from battery through the magnet winding of switch 110, the left-hand contacts of cam 176 and thence to ground at the normal contacts of the right-hand armature of relay 102. Upon the deenergization of

relay 101, sequence switch 110 is advanced out of position 17 into position 18 over a circuit which may be traced from battery through the magnet winding of switch 110, the upper left-hand and lower right-hand contacts of cam 176, at the right-hand armature and back contact of relay 101 to ground at the lower contact of cam 131 (17 to 15).

With sequence switch 110 in position 18 a circuit is established for the downdrive magnet 177 which may be traced from battery through the winding of magnet 177, the upper right-hand and lower left-hand contacts of cam 176 and thence to ground at the normal contacts of the right-hand armature of relay 102. Magnet 177, upon energizing, presses the depending portion of switch shaft 127 against the constantly rotating downdrive drum 178, thereby moving the switch shaft downwardly into normal position. As soon as the switch shaft reaches normal position, a circuit is established for advancing sequence switch 110 from position 18 into normal position 1 which may be traced from battery through the magnet winding of switch 110, the lower right-hand contact of cam 111 (5 to 18), the normal commutator segment 179, shaft wiper 132 and thence to ground at the upper right-hand contact of cam 131 (9 to 7).

Upon the opening of the circuit through relay 101, cut-off relay 106 of the calling subscriber's line becomes deenergized and in the well-known manner the subscriber's individual line switch 100 is restored to normal position. When sequence switch 110 leaves position 14½, the holding circuit over the right-hand contacts of cam 138 and test brush 140 is opened and the release of incoming selector 185 and of final selector 190 is initiated and takes place in the well-known manner. All of the apparatus employed in the establishment of the connection between the lines of the calling subscriber C and the called subscriber D has now been restored to normal condition.

Automatic release of sender and routing of call to trouble desk.

Let it be assumed that parts of the sender have been actuated in response to a calling line as previously described and that switch M has moved to position 4 before any part of the desired number has been dialed by the subscriber.

It will be remembered that at this point of operation switch RS is in its normal position and an actuating circuit has been established to operate relay 504. A circuit is therefore established for actuating relay 566 which may be traced from battery through the left winding of relay 566, right contact and armature of relay 504, brush 229 and its associated contact at position 4, conductor 230, right outer contact and armature of relay 232, conductor 231, normal contact and armature of relay 563 to ground through armature and contact of relay 504. Relay 566 upon energizing establishes an obvious energizing circuit for relay 568, opens the circuit extending over conductor 607 and at its inner right-hand armature and front contact establishes a locking circuit for itself which is effective as soon as relay 533 becomes energized as hereinafter described.

Relay 568 upon energizing closes a circuit for advancing the register steering switch RS from normal position through position 1 into position 2. The steering switch is advanced from normal position into position 1 by a circuit which may be traced from battery through the winding and armature contacts of stepping magnet 524, conductors 525 and 526, wiper 527, the normal terminal of bank RS^4, conductor 528 the outer left-hand armature and front contact of relay 568, conductor 569, wiper 570 and thence to ground at the normal terminal of bank RS^6. Upon reaching position 1, switch RS is further advanced into position 2 over a circuit which may be traced from battery through the winding and armature contacts of magnet 524, conductors 525 and 526, wiper 527, the No. 1 terminal of bank RS^4, conductors 531 and 571, the inner left-hand armature and front contact of relay 568, conductor 569 and thence to ground through wiper 570 and the No. 1 terminal of bank RS^6. When the switch RS reaches position 2, relay 533 becomes energized over a circuit extending through its windings, conductor 534, the No. 2 terminal of bank RS^1, wiper 506, conductor 507 and thence to ground at the inner right-hand armature and front contact of relay 313.

At its right-hand armature and front contact relay 568 establishes a circuit for placing battery potential upon a bank terminal of the translator switch for governing the setting of the translator switch for routing a connection to a trunk circuit terminating in the trouble desk. The circuit over which battery potential is applied may be traced from battery through the right-hand armature contacts and left-hand winding of relay 535, the right-hand armature and front contact of relay 568, conductor 572 and thence to bank terminal 657 of bank TS^1 of the translator switch. With relay 533 now energized the translator switch is started and under the influence of its stepping magnet 608 rotates its wipers until the test wiper 610 engages the bank terminal 657. As soon as the wiper 610 engages terminal 657, relay 535 becomes energized to stop the movement of the translator switch and to initiate the movement of class sequence switch 306 out of position 3 as hereinbefore described. Under the assumption that the translator switch TS has stopped in

position 6, a circuit becomes established for relay 329 for arresting the class switch in position 8 as soon as the class switch reaches position 7¾ which may be traced from battery through the winding of relay 329, the upper left-hand contact of cam 382 (7¾ to 8), the lower right-hand contact of cam 383, conductor 384, terminal 658 of bank TS^6 of the translator switch, wiper 617, conductor 618, thence to ground through the inner left-hand armature and front contact of relay 535.

With the class sequence switch 306 set in position 8, the office sender proceeds to set the district selector in the manner previously described, but in this instance upon an idle trunk of a group extending to the trouble desk of the office, in the case assumed the trunk shown in Fig 1. Following the setting of the district selector, the sender sequence switch 400 moves into position 10, in which position a trunk test is made as previously described. If the selected trunk is in operative condition, that is, neither talking conductor of the trunk is open, battery potential will be applied to the incoming end of the trunk through the windings of the trunk relay 154, Fig. 1, and the trunk test relay 349 will become operated over a circuit which may be traced from battery through the left-hand winding of relay 154, the normally closed contacts associated with the upper armature of relay 153, bank terminal 152, brush 151, the right-hand contacts of cam 149, conductor 124, the inner right-hand armature and front contact of relay 123, wiper 125 of switch SF, conductor 334, conductor 335, the contact of cam 336, conductor 337, the left-hand winding of relay 457, conductor 473, the lower contact of cam 348 (8), the winding of relay 349, conductor 350, the contact of cam 444 (9¾ to 10), the outer left-hand armature and back contact of relay 411, conductor 351, the right-hand armature and back contact of relay 353, conductor 352, wiper 159 of switch SF, conductor 158, the lower contacts of cam 157, brush 156, bank terminal 155, the normally closed contacts associated with the intermediate armature of relay 153 and thence to ground through the right-hand winding of relay 154. Relay 349, upon energizing, closes a circuit over conductor 354 and through the winding of relay 433. Relay 433, upon energizing, closes a circuit for advance relays 353 and 366 which may be traced from battery through the windings of these relays in parallel, over conductor 367, the upper contact of class switch cam 355 (8), the lower contact of cam 437 (10), the left-hand armature and front contact of relay 433, conductor 438 and thence to ground at the upper contact of class switch cam 338 (3 to 15). Relay 366, upon energizing, closes a locking circuit for itself and for relay 353 extending through its inner right-hand armature and front contact and thence to ground at the upper contact of cam 338.

Upon the energization of advance relays 353 and 366, the sequence switch 110 of the district selector 150 is advanced into position 11, whereupon the previously traced fundamental circuit is established between the winding of control relay 107 and the winding of sender stepping relay 407 for controlling talking selection. Upon the energization of relay 407 in this circuit, a circuit is established for the No. 2 counting relay 414 which may be traced from battery through the winding of counting relay 414, the armature and back contact of No. 2′ counting relay 415, lead 416, Fig. 3, the lower contact of cam 373 (8), conductor 374, conductor 474, the upper right-hand contact of cam 446 (9 to 10), the lower right-hand contact of cam 418 (10), conductor 419, the inner right-hand armature and back contact of relay 411, the normally closed contacts associated with the outer left-hand armature of relay 421, the upper contact of cam 422 (9 to 10), the armature and front contact of relay 407 and thence to ground at the upper contact of cam 413 (9 to 10). At the district selector the energization of relay 107 establishes a circuit for sequence switch 110 which in passing through positions 11⅝, 12⅝ and 13⅝ closes the previously traced shunt circuit for shunting the windings of sender stepping relay 407. In response to the energizations and deenergizations of sender stepping relay 407, the counting relays operate in succession until the No. 0′ counting relay 429 energizes in parallel with relay 409, whereupon the fundamental circuit is opened and through the deenergization of relay 107 at the district selector the sequence switch 110 is arrested in position 14.

Following talking selection at the district selector, relays 302, 307, 312 and 313 at the office sender become deenergized and the circuits of the office sender are restored to normal condition in the manner hereinbefore described, with the exception that the register steering switch RS is advanced out of position 2 and into position 9 immediately upon the deenergization of relay 313 over a circuit extending from battery through the winding and armature contacts of stepping relay 524, the strapped terminals of bank RS^5 of switch RS, wiper 557, conductor 558 and thence to ground at the inner right-hand armature and back contact of relay 313.

With sequence switch 110 of the district selector in position 14 a circuit is established over the brushes of the selector switch, which may be traced from battery through the left-hand winding of trunk relay 154, the normally closed contacts associated with the upper armature of relay 153, bank terminal

152, brush 151, the upper right-hand and lower left-hand contacts of cam 149, the upper right-hand winding of repeating coil 189, the winding of polarized relay 174, the lower right-hand winding of repeating coil 189, the upper left-hand and lower right-hand contacts of cam 157, brush 156, bank terminal 155, the normal contacts associated with the intermediate armature of relay 153 and thence to ground through the right-hand winding of relay 154. The current flowing through this circuit is in the proper direction to energize relay 154, but relay 174 is not effectively energized. Relay 154, upon energizing, establishes a circuit for the auxiliary signal lamp 167 which may be traced from battery through lamp 167, the left-hand armature and contact of relay 154 and thence to ground at the outer left-hand armature and normal contact of relay 168, and at its right-hand armature and front contact establishes a circuit for slowly flashing the trunk lamp 171, which circuit may be traced from battery through the slow interrupter 173, the normal contacts of the outer right-hand armature of relay 168, the right-hand armature and front contact of relay 154 and thence to ground through lamp 171.

The operator at the sender monitor's position of the trouble desk noting the flashing of lamp 171 inserts the plug P of one of her cord circuits, such as shown in Fig. 2, in the jack 169 indicated by the flashing trunk lamp 171. Upon the insertion of the plug in the jack a circuit is established from battery on the sleeve conductor of the cord, over the sleeve contacts of the plug P and jack 169 to ground through the winding of cut-off relay 153. Cut-off relay 153, upon energizing, disconnects the windings of trunk relay 154 from the trunk circuit and locks the trunk relay 154 in a local circuit which may be traced from battery through the left-hand winding of relay 154 and to ground through the make contacts associated with the upper armature of relay 153. At its lowermost armature and contact relay 153 establishes a circuit for make busy relay 168, which latter relay closes a locking circuit for itself extending through the make contacts associated with its inner left-hand armature and to ground through the disconnect key 170. Relay 168, upon energizing, disconnects the slow interrupter 173 from the circuit previously traced through lamp 171 and associates a steady source of current with the circuit of this lamp for maintaining it illuminated and at its outer left-hand armature opens the circuit of auxiliary lamp 167. At its inner left-hand armature and front contact relay 168 connects ground to the multiples of test terminal 142 for maintaining the selected trunk circuit busy to other district selectors.

Upon the connection of the operator's cord circuit with the trunk circuit and the disconnection of the windings of relay 154 from the trunk circuit, battery current is supplied for the windings of polarized relay 174 from battery at the right-hand windings of repeating coil 236, Fig. 2, and current now flows through the windings of relay 174 in such a direction as to cause the effective energization of this relay. A circuit is now established for relay 107 which may be traced from battery through the right-hand winding of this relay, the lower contact of cam 108 (14 to 15), the armature and contact of relay 174 and thence to ground at the upper left-hand contact of cam 131 (12 to 14½). Relay 107, upon energizing, closes a circuit for advancing sequence switch 110 out of position 14 and into position 15 which may be traced from battery through the magnet winding of sequence switch 110, the upper left-hand contact of cam 111 (11 to 14), the inner right-hand armature and front contact of relay 107 and thence to ground at the right-hand contact of cam 112. Sequence switch 110 upon leaving position 14½ opens the circuit of relay 107, but relay 107 now remains locked over its left-hand winding, left-hand armature and front contact, the upper contacts of cam 138, test brush 140 and thence to ground on test terminal 142 and remains locked until the operator initiates the release of the connection.

With sequence switch 110 in position 15, a talking circuit is established between the calling subscriber's line and the operator's position, over the upper contact of cam 160 and the lower right-hand contact of cam 166, through switch brushes 151 and 156, bank terminals 152 and 155, alternate armature contacts of relay 153, thence over tip and ring contacts of jack 169 and plug P to the tip and ring strands of the operator's cord circuit, the calling subscriber's line being supplied with talking current from the battery associated with the repeating coil 236 of the operator's cord circuit.

The operator at the trouble desk now attempts to talk to the calling subscriber and upon receiving no response proceeds to take the necessary steps to have the trouble on the calling line cleared. After the necessary steps have been taken plug P is withdrawn from the jack 169. Upon the withdrawal of the plug the windings of relay 154 are again associated with the conductors of the trunk circuit and relay 154 remains energized over the calling subscriber's line loop until the calling subscriber restores his receiver to its switchhook or until the subscriber's line is opened by the trouble man who is in search of trouble on such subscriber's line. When relay 154 deenergizes since at this time relay 168 is energized, a circuit is established from battery through the fast interrupter 172, the inner right-hand armature and front contact of relay

168, the right-hand armature and back contact of relay 154 and to ground through lamp 171 and lamp 171 flickers to signal the trouble operator that the trouble on the calling line which is associated with the permanent signal trunk has been cleared.

In response to the flickering of lamp 171, the operator opens the key 170 thereby releasing relay 168 which disconnects ground potential from test terminal 142 and thereby releases relay 107 of the district selector. Relay 107 upon deenergizing establishes the circuit previously traced for advancing sequence switch 110 out of position 15 and into position 16. Upon leaving position 15¼, the locking circuit of relay 102, which circuit was maintained over the upper contacts of cam 139 and to ground through the right-hand armature and front contact of relay 102 from the time the talking circuit was cut through from the calling line to the operator's position, is opened and relay 102 deenergizes thereby opening the circuit of sleeve relay 101. With relays 101 and 102 deenergized, the relays of the district selector and the release of the individual line switch 100 proceed in the manner hereinbefore described.

Unfinished dialing. District selection only completed.

If the calling subscriber does not finish dialing the complete number, sender lamp 226 is illuminated dimly as previously described to signify to the monitoring operator that the calling subscriber has not finished dialing and for some reason has not released the connection with the sender. The operator noting the dim lamp inserts the plug P of her cord circuit in the jack J, challenges the calling subscriber and upon receiving no response inserts the plug P in the jack J′, whereupon relays 566 and 568 become energized. The energizing circuit for relay 566 may be traced from grounded battery through the left winding of relay 566, tip spring of jack J′, tip conductor of plug P, right upper winding of repeating coil 236 to ground. The operation of relay 566 establishes an obvious energizing circuit for relay 568. Since it is assumed that the subscriber has dialed sufficient digits to advance the steering switch RS beyond position 1, the translator switch and class switch are set at this time in accordance with the code which the subscriber has dialed and the sender circuits start to function to set the district selector in accordance with the office code which the subscriber has dialed. With steering switch RS in a position beyond position 1 and relay 566 energized, a circuit is established for the wipe-out relay 364 which may be traced from battery through the winding of this relay, conductor 368, conductor 381, the outer left-hand armature and front contact of relay 566, strapped terminals of bank RS^6 of switch RS, wiper 570, conductor 569, the inner left-hand armature and front contact of relay 568, conductors 571 and 531, the off-normal terminals of bank B^2 of code register B and thence to ground through wiper 532. Relay 364, upon energizing, locks to ground on conductor 438 through the upper contact of cam 338 (3 to 15), and at its intermediate left-hand armature and front contact connects direct ground to conductor 342 whereupon the current flowing through the right-hand winding of differential relay 102 of the district selector is increased to such an extent that this relay becomes differentially balanced and deenergizes.

Relay 102, upon deenergizing, opens the circuit of relay 101 whereupon a circuit is established for advancing sequence switch 110 into position 7, this circuit extending from battery through the winding of sequence switch magnet 110, the lower left-hand contact of cam 111 (2 to 6), the right-hand armature and back contact of relay 101 and thence to ground at the lower left-hand contact of cam 131 (17 to 15). With sequence switch 110 in position 7, a circuit is established for the downdrive magnet 177 extending from battery through the winding of this magnet, the right-hand contacts of relay 176 (7), the right-hand armature and back contact of relay 101 and thence to ground at the lower left-hand contact of cam 131. Magnet 177, upon energizing, presses the depending portion of switch shaft 127 against the downdrive drum 178 thereby driving the switch shaft downwardly into normal position. When the switch shaft reaches normal position a circuit is closed over normal commutator segment 179 for advancing sequence switch 110 into normal position, which circuit may be traced from battery through the magnet winding of switch 110, the lower right-hand contact of cam 111 (5 to 18), normal segment 179, shaft wiper 132 and thence to ground at the right-hand contact of cam 131 (9 to 7).

When sequence switch 110 leaves position 10½, the impulsing circuit previously traced through the winding of register control relay 307 is opened and relay 307 thereupon deenergizes, opening the circuits of relays 312 and 313. From this point the office sender is restored to normal condition as hereinbefore described.

Unfinished dialing. Selection proceeded beyond the district selector.

If the calling subscriber has dialed sufficient digits to advance the register steering switch RS to a position such that selection has proceeded beyond the district selector at the time dialing is stopped, then when

the monitoring operator in response to the flickering of lamp 225 inserts the plug P in the jack J′ and relays 566, 568 and 364 become energized as hereinbefore described, it becomes necessary in order to release the sender to set the incoming and final selector switches. The district selector has been controlled as previously described in accordance with the setting which the translator switch TS has taken from the A and B code registers and following the completion of district group selection, and the sender sequence switch 400 has advanced into position 9. With sender sequence switch 400 in position 9 and wipe-out relay 364 energized, a circuit is established for advancing sequence switch 400 into position 10 for testing the trunk extending to the incoming selector 185. This circuit may be traced from battery through the magnet winding of switch 400, the lower left-hand contact of cam 401 (9), conductor 360, the right-hand contacts of cam 359 (4 to 7), conductor 385, the outer left-hand armature and front contact of relay 364, conductor 386, the lower contact of cam 450 (9 to 18), conductor 402, the left-hand armature and front contact of relay 329, conductor 331, thence to ground at the outer left-hand armature and front contact of relay 535.

Incoming brush and group selection and final brush selection now take place as previously described in positions 12, 14 and 16, respectively, of sequence switch 400, such selections being controlled from banks TH^3, TH^4 and H^4, and H^3 of the thousands and hundreds registers if these registers have received a setting by digits dialed by the calling subscriber, or if they have not been set by the calling subscriber then selection is controlled from No. 0 counting relay leads connected to the normal bank terminals of banks TH^3 and H^3.

The purpose of controlling selection from the normal bank terminals of the numerical registers in case the registers have not been set by the calling subscriber is to effect minimum selective movements of the selector switches to bring about a quicker establishment of the connection and consequently a quicker release of the connection and of the sender.

Following the final brush selection the sender sequence switch 400 moves into position 17 as previously described, from which position it is immediately advanced into position 18 by reason of the circuit previously traced over conductors 385 and 386, through the armature contact of wipe-out relay 364. In position 18 tens or final group selection is made after which sequence switch 400 advances as hereinbefore described into position 2 for controlling units selection. If neither the tens nor units registers have been set by the calling subscriber, these registers will control final tens and units selections over the No. 0 counting relay leads connected to the normal terminals of their banks T^3 and U^3. During units selection, however, the circuit hereinbefore traced from wiper 655 of the units register U, over conductor 656, through the right-hand armature and contact of relay 364, conductor 365 and thence to ground, is opened at the right-hand armature contact of wipe-out relay 364, and consequently, the final selector switch advances to the telltale position, causes the advance of the incoming selector and releases as fully set forth in the Patent No. 1,505,171 to F. A. Stearn, issued Aug. 19, 1924.

At the sender since no circuit is established for counting relays during final units selection, relay 409 does not energize and therefore upon the advance of the incoming selector and the reversal of current over the fundamental circuit, overflow relay 457 operates as hereinbefore described and establishes a circuit for relay 421 which at its left-hand armature and front contact establishes a circuit for the No. 0 counting relay. In the manner previously described the No. 0′ counting relay energizes and establishes a circuit for advance relays 366 and 353 and since at this time wipe-out relay 364 is energized, a circuit is established for advancing sender sequence switch 400 out of position 2 and into position 11. This circuit may be traced from battery through the magnet winding of sequence switch 400, the upper right-hand contact of cam 439, the left-hand armature and front contact of relay 436, conductor 440, the outer right-hand armature and front contact of relay 421, conductor 371, the left-hand armature and front contact of relay 353 and thence to ground at the intermediate left-hand armature and contact of relay 364.

Talking selection is then made as hereinbefore described, following which the office sender is released. Since at the time talking selection is completed relays 101 and 102 are deenergized, the district selector and incoming selector are released in the well-known manner.

It having been assumed that the calling subscriber's receiver has been inadvertently left off the hook following the incomplete dialing, the district selector 150 will immediately become associated through the sender finder SF with a new office sender and after a predetermined time interval, the monitoring switch M rotates to position 4 where it is arrested in its forward movement. The calling line is now routed to the trouble desk and the sender released in the same manner as described under the sub-heading "Automatic release of sender and routing of call to trouble desk."

Trouble at the sender.

If trouble is found with the sender it may be taken from active service by the monitoring operator through the insertion of a plug having ground connected to its sleeve contact in jack J′, whereupon make busy relay 325 of the sender becomes energized and at its right-hand armature and front contact connects ground to conductor 300 for making the sender busy to all sender finders having access thereto. The operator may then communicate with the calling subscriber over jack J associated with the sender and inform the subscriber that the sender is out of order and that he should hang up the receiver and reinitiate the desired call.

If the calling subscriber partly dials a call number a lamp is first lighted in the monitoring operator's position and the operator may free the sender as described under "Unfinished dialing," "District selection only completed" or "Unfinished dialing, selection proceeded beyond district selection."

What is claimed is:

1. In a telephone exchange system, a calling subscriber's line, a selector switch for extending a connection from said line, a register sender for controlling said switch, means associated with said calling line for setting the registers in said sender, a time measuring device and means controlled by said time measuring device to set up a special registration on said sender.

2. In a telephone exchange system, a calling subscriber's line, a selector switch for extending a connection from said line, a register sender for controlling said switch, a sending dial associated with said calling line for setting the registers of said sender, and means automatically operated to set said sender upon the failure of the calling subscriber to dial the desired number.

3. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, means associated with said calling line to set the registers of said sender, a trunk circuit, and means automatically operated, upon the delayed setting of said registers by the calling subscriber, to set said sender and to control the extension of said calling line to said trunk circuit.

4. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, means associated with said calling line for setting the registers of said sender, a trunk circuit, an operator's position, a signaling device associated with said operator's position, means automatically operated upon the delayed setting of said registers to give said sender a special setting and to control the extension of said calling line to said trunk circuit, and means to operate said signal upon the extension of said calling line to said trunk circuit.

5. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, means associated with said calling line for setting the registers of said sender, a trunk circuit, an operator's position, a signaling device associated with said operator's position, means automatically operated upon the delayed setting of said registers to give said sender a special setting and to control the extension of said calling line to said trunk circuit, and means effective upon the response of said operator to said signaling device to associate said operator's talking circuit with said calling line.

6. In a telephone exchange system, a calling subscriber's line, a sending dial associated with said calling line, a sender, means in said sender to respond to an initiated call, means in said sender to respond to said sending dial, and means automatically operated to release said sender upon the failure of the calling subscriber to dial a number.

7. In a telephone exchange system, a calling subscriber's line, a trunk circuit, a selector switch, a register sender for controlling said switch, means associated with said calling line for setting the registers of said sender, a time measuring device, means controlled by said time measuring device to set up a special registration on said sender, means to operate said selector switch in accordance with said special registration to establish connection from said calling line to said trunk, and means to restore said sender to its normal condition.

8. In a telephone exchange system, a calling subscriber's line, a trunk circuit, a selector switch, a plurality of register senders, means to extend said calling line to said selector switch, means to associate an idle register sender with said selector switch, means associated with said calling line for setting the registers of said associated sender, a time measuring device, means controlled by said time measuring device to set up a special registration on said sender, means to operate said selector switch in accordance with said special registration to establish connection from said calling line to said trunk circuit, and means to release said sender.

In testimony whereof, I have signed my name to this specification this 18th day of September 1923.

JAMES N. WALTERS.