

June 9, 1925.

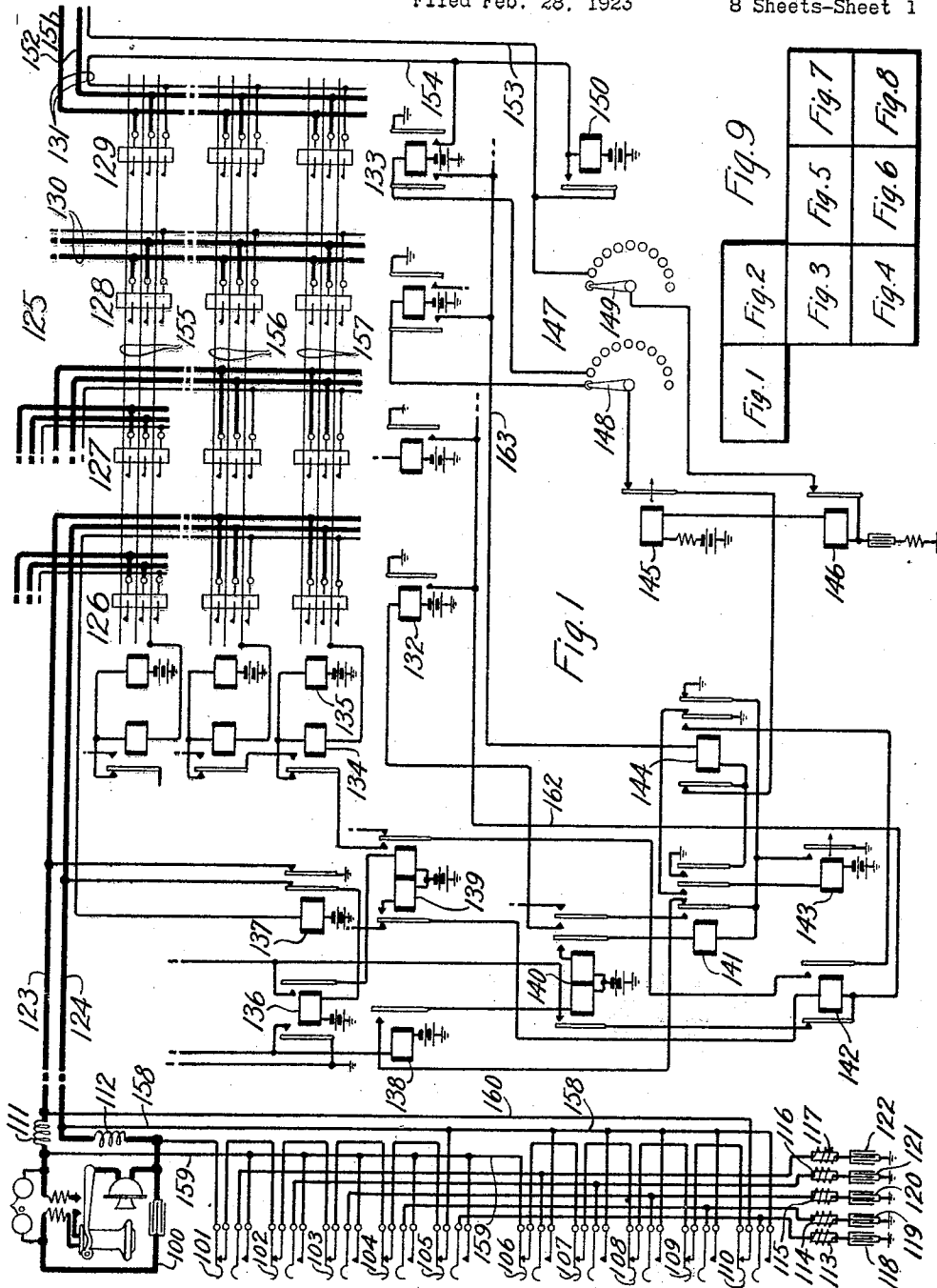
1,541,367

J. L. McQUARRIE

TELEPHONE EXCHANGE SYSTEM

Filed Feb. 28, 1923

8 Sheets-Sheet 1



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June 9, 1925.

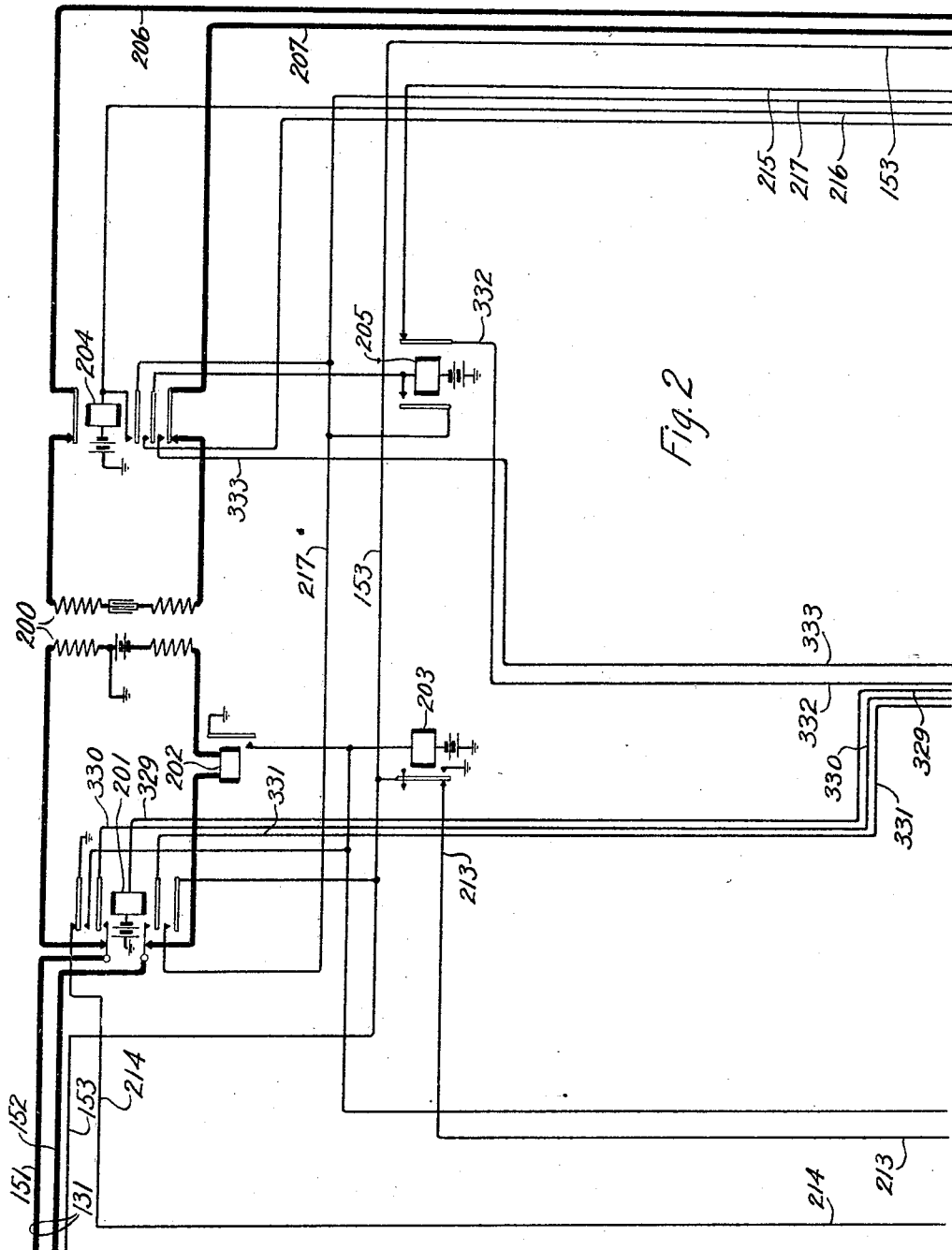
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8 Sheets-Sheet 2



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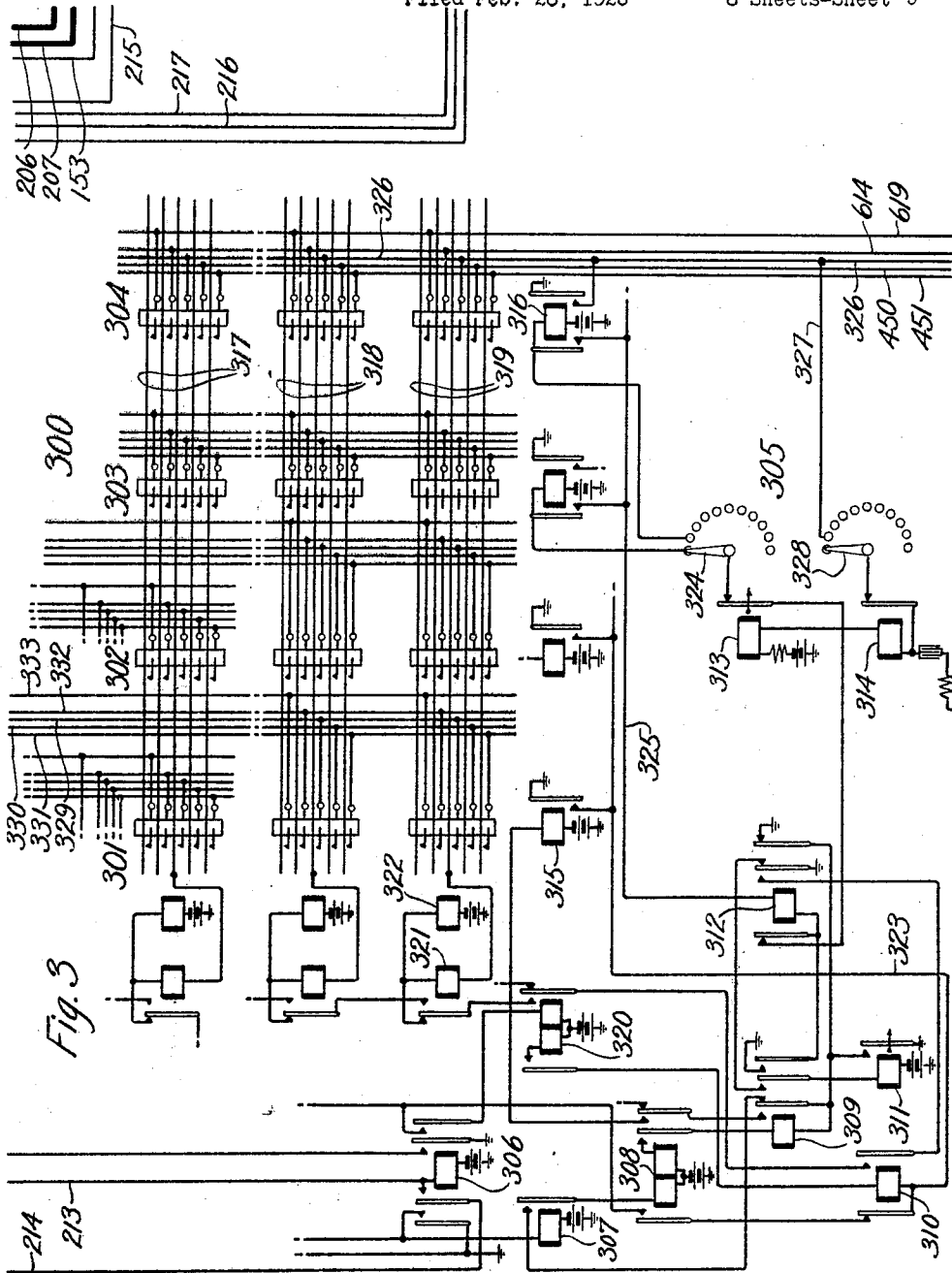
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8 Sheets-Sheet 3



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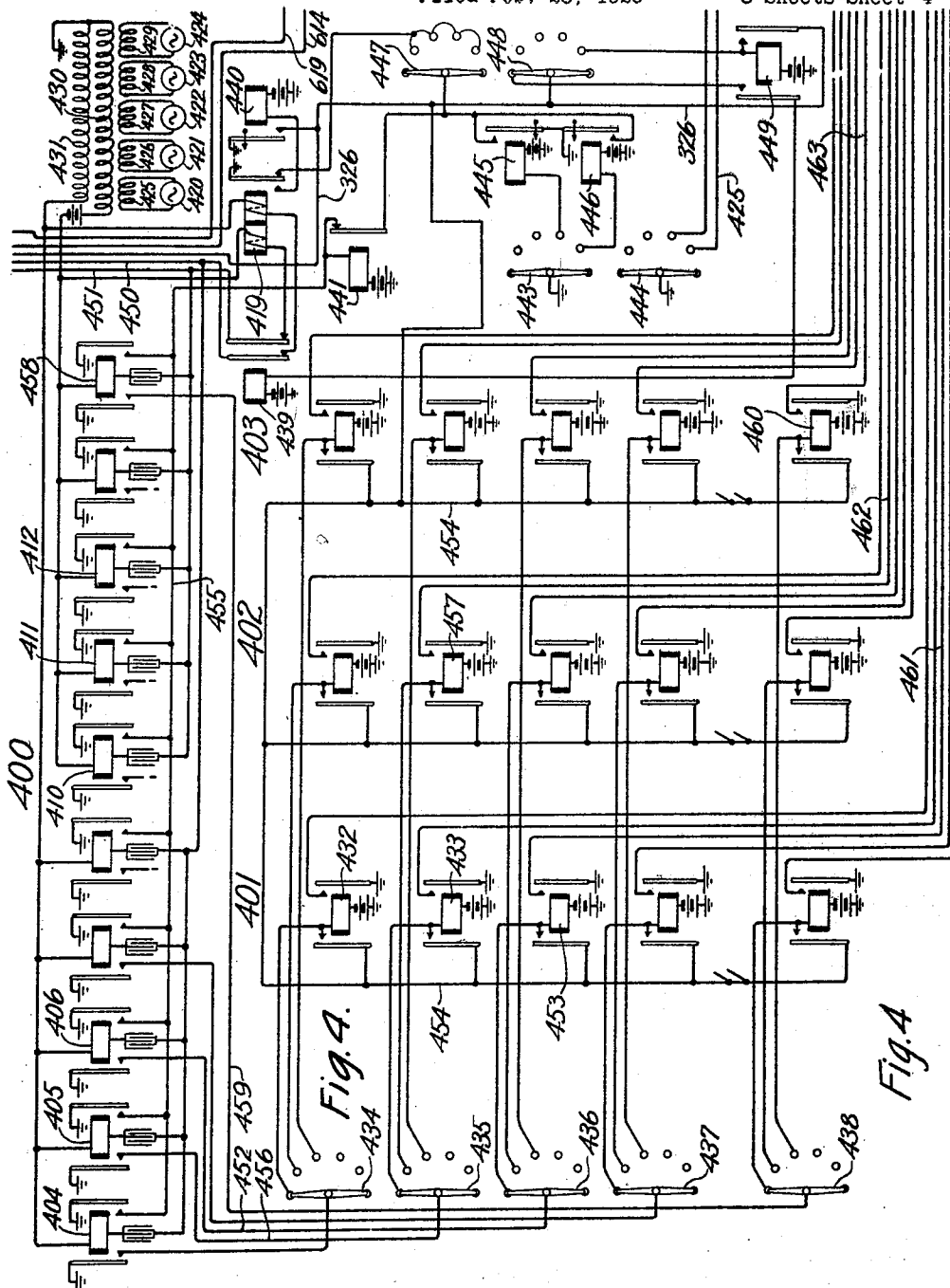
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8 Sheets-Sheet 4



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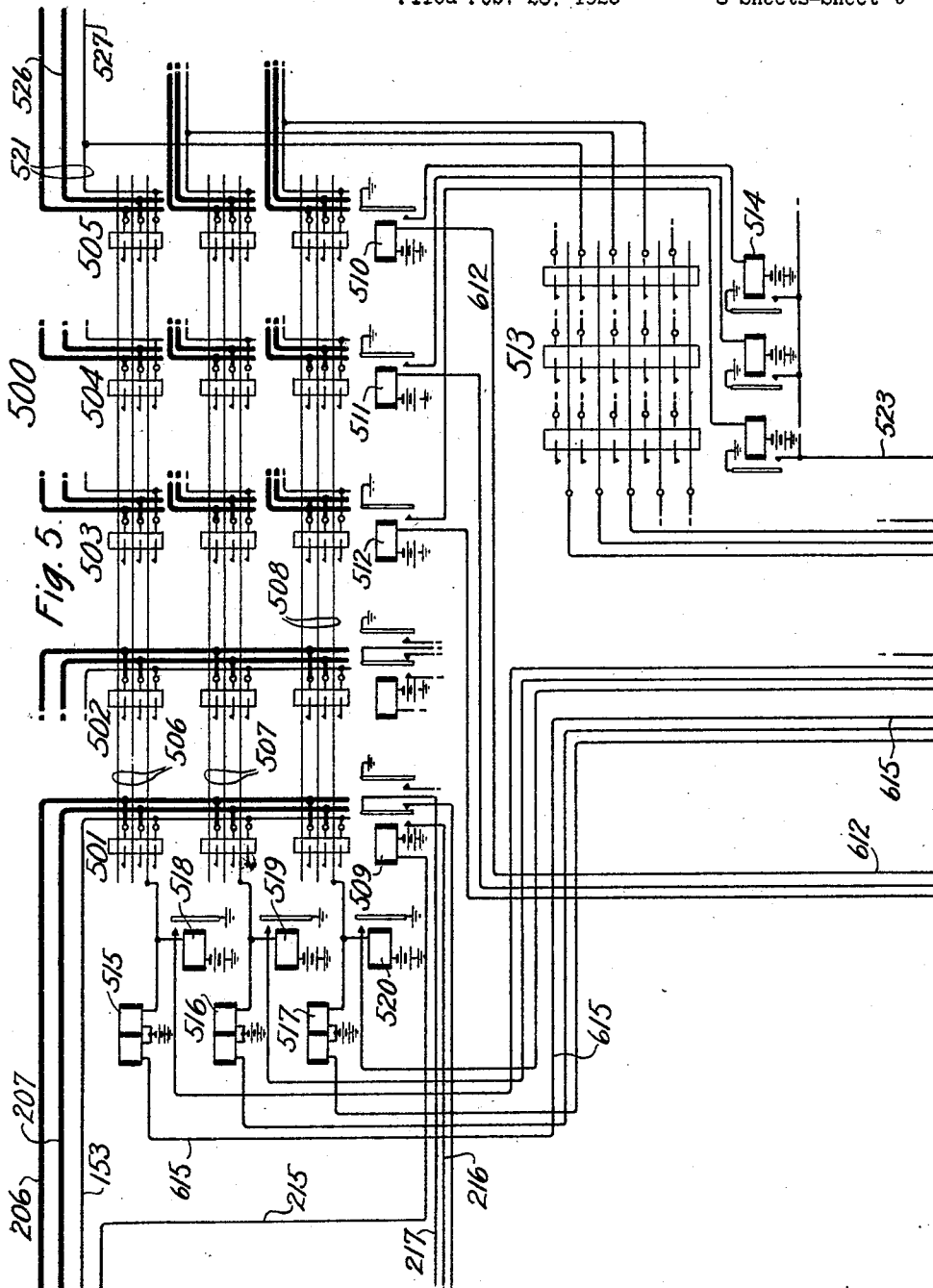
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TELEPHONE EXCHANGE SYSTEM

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8 Sheets-Sheet 5



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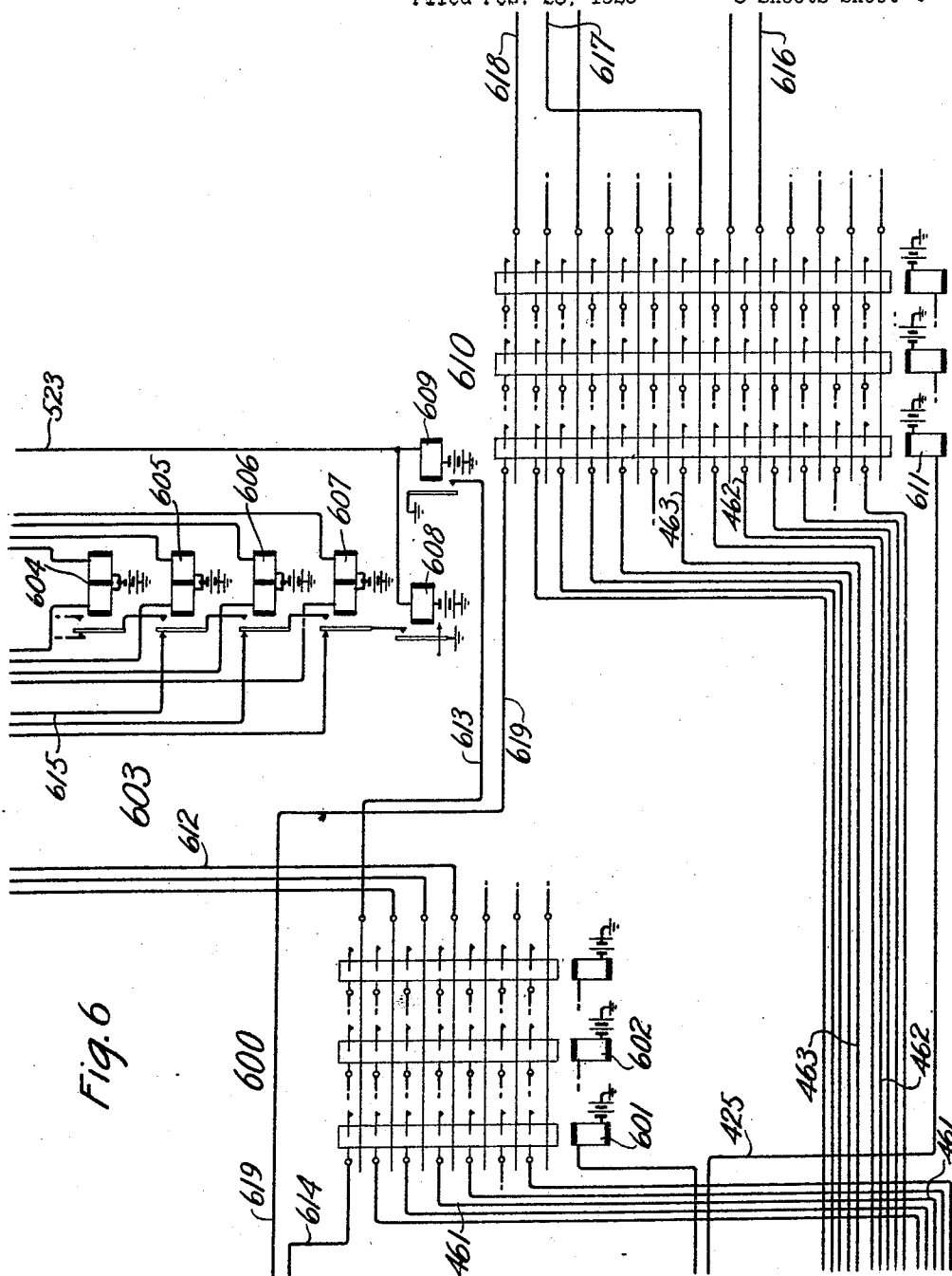
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TELEPHONE EXCHANGE SYSTEM

Filed Feb. 28, 1923

8 Sheets-Sheet 6



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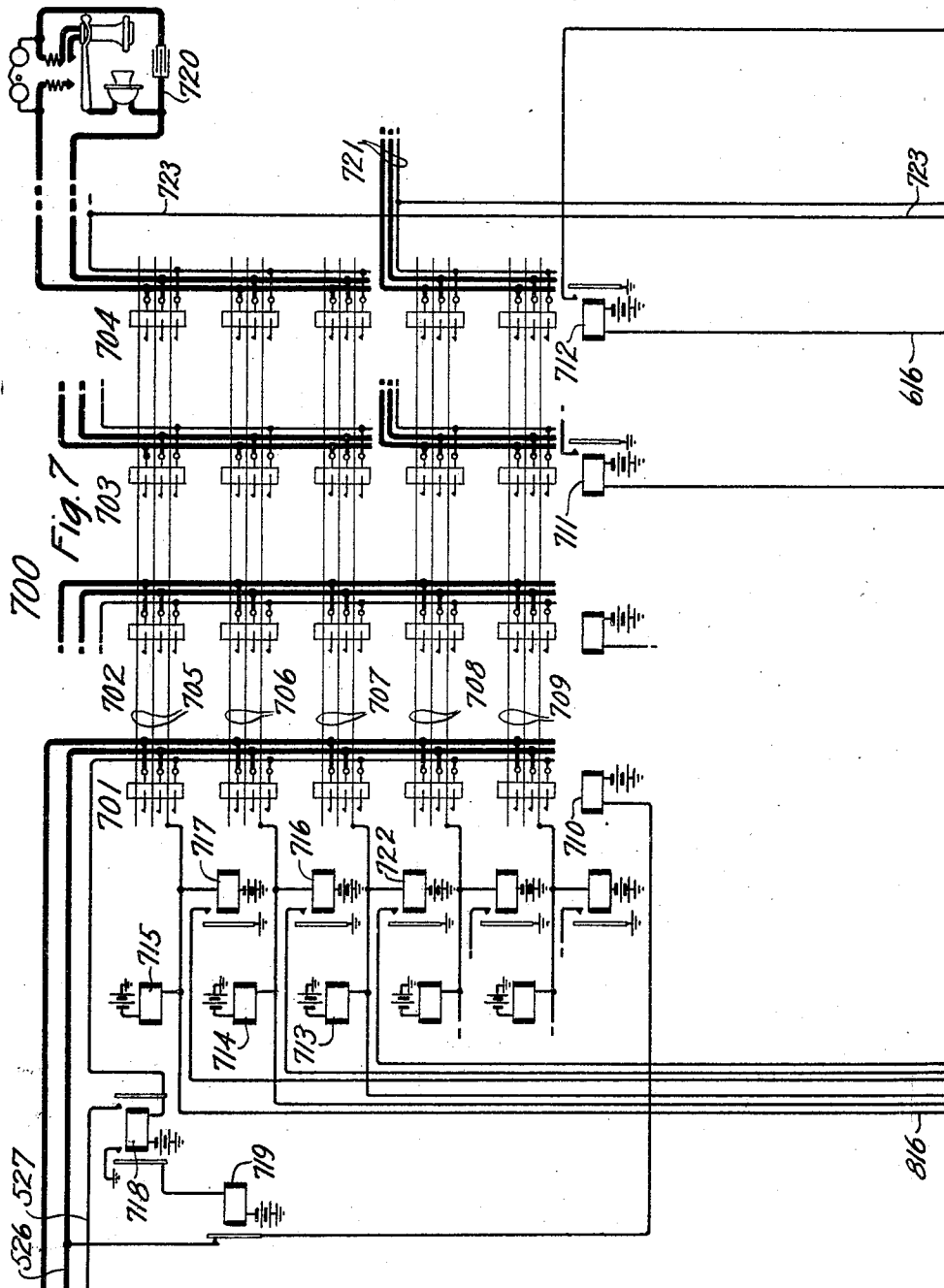
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TELEPHONE EXCHANGE SYSTEM

Filed Feb. 28. 1923

8 Sheets-Sheet 7



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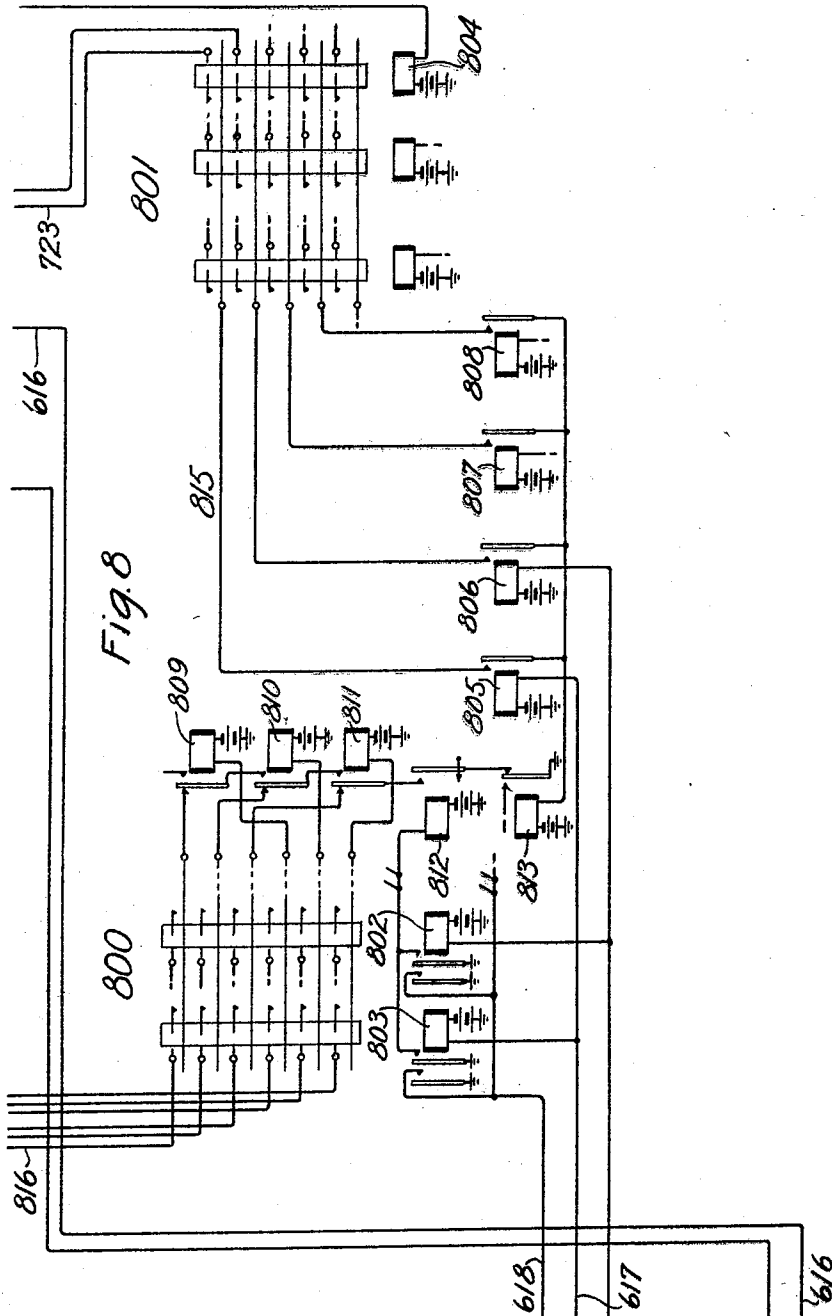
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J. L. McQUARRIE

TELEPHONE EXCHANGE SYSTEM

Filed Feb. 28, 1923

8 Sheets-Sheet 8



Inventor:
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Patented June 9, 1925.

1,541,367

UNITED STATES PATENT OFFICE.

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

TELEPHONE-EXCHANGE SYSTEM.

Application filed February 28, 1923. Serial No. 621,705.

To all whom it may concern:

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

This invention relates to telephone exchange systems and more particularly to systems employing automatic switching equipment for setting up connections.

The object of the invention is to control the selective operations of switches of the coordinate type by means of currents of different characteristics.

A feature of the invention relates to a system in which a plurality of sources of currents of differing frequencies are utilized for recording designations which serve to govern the selective operation of coordinate switches to establish connections.

These and other advantages of the invention will become more apparent from the following detailed description and also from the appended claims.

Considering the drawing, Figs. 1 to 8, inclusive, when arranged in the order shown in Fig. 9, disclose a telephone system embodying the principles of the invention and in such detail as to enable a full understanding thereof.

Fig. 1 shows one of a number of subscribers' lines terminating in a line switch of the coordinate type together with trunks outgoing from the line switch. Fig. 2 shows the details of one of these trunks. Fig. 3 illustrates a sender selector of the coordinate type employed for associating the different trunks with the common senders. Fig. 4 shows one of the common registering and controlling senders. Fig. 5 illustrates a first group selector of the coordinate type in which terminate the trunks incoming from the line switches. Fig. 6 shows controlling and testing equipment whereby the senders are associated with the group selectors and idle trunks selected. Fig. 7 shows a coordinate connector switch for completing connections to subscribers' lines. Fig. 8 shows a controlling and testing equipment associable with the connector switches for testing the condition of called lines.

The preliminary or line switch 125 comprises a plurality of horizontal link circuits

155, 156, 157, arranged in groups to interconnect the incoming subscribers' lines with outgoing trunks 130, 131 by means of contacts operated by electromagnets. The subscribers' lines occupy vertical rows of contacts 126, 127, each row comprising a plurality of lines and each line having access to a group of horizontal links. Each of the outgoing trunks occupies a complete vertical row 128, 129 having access to all horizontal links in the switch. The group selector switch 500 is of the same type comprising vertical rows of contacts 501, 502, 503, 504 and 505 and horizontal links 506, 507 and 508, there being as many links and vertical rows as is necessary for the given traffic conditions. The incoming trunks appear in vertical rows 501, 502, etc., each having access to all horizontal links. The outgoing trunks are divided into groups each group occupying a vertical row 503, 504, 505 and each trunk having access to a limited number of horizontal links.

The connector switch 700, also of the coordinate type, consists of vertical rows of incoming trunk contacts 701, 702, each trunk having access to all horizontal links 705, 706, etc. The subscribers' lines appearing in the switch may be divided into groups of ten, each group comprising a vertical row in the switch, such as rows 703 and 704. Each line has access to a group of horizontal links. For example, the subscriber's line 720 appears in the row 704 and is accessible to the horizontal links 705, 706 and 707. Similarly, line 721 lying in the same group is accessible to another group of horizontal links of which two, 708 and 709, are illustrated.

The sender selector switch 300 is arranged similar to the line switch 125. The incoming circuits individual to trunks appear in vertical rows 301, 302, each having access to a group of links 317, 318, 319, while the outgoing circuits which lead to senders appear in vertical rows 303, 304, each having access to all of the links in the switch. For example, the trunk circuit shown in full in Fig. 2 is represented in the sender selector switch 300 in the vertical row 301 and has access to the two links 318 and 319 and the sender shown in Fig. 4 is represented in the vertical row 304 having access to all links.

These switches are of the same general construction and operation as the switch

shown in the British Patent No. 183,438, issued to Western Electric Company, Limited, accepted September 6, 1923.

In order that the subscriber may control the selective operations of the coordinate switches to establish a connection with a wanted line, a number of register senders are provided at the central office available for the subscriber's use in making a call.

These senders comprise a plurality of sets of relay registers 401, 402 and 403. Each of these sets represents a digit in the wanted number and while only three sets are shown, it will be understood that more may be employed for larger systems. Furthermore, the sender includes a plurality of tuned relays 400 together with a number of sources of alternating current for different frequencies. Five of these sources 420, 421, 422, 423 and 424 are shown connected to the primary windings of a transformer. The first five relays 404, 405, 406, etc., of the set 400 are each arranged to operate on alternating current of a particular value and of a particular frequency. Similarly, each of the remaining five relays 410, 411, 412, etc., operate on alternating current of a particular frequency. The values of these relays are so taken that when alternating current of a particular frequency is flowing over the line, only one relay will respond thereto while the rest of the relays remain inactive. In this manner the relays may be selectively operated to register a digit of any value upon the register relays of the sender.

At the substation of the subscriber's line there is provided an operating set of keys or buttons 101 to 110, inclusive. Moreover, there are provided five inductance coils 113 to 117, inclusive, and five condensers 118 to 122, inclusive. The keys are so wired that by depression of the proper keys any one of the five sets of inductance coils and condensers may be connected either to the tip or ring side of the subscriber's line. This gives ten different alternating current circuits each selected to produce the resonant condition necessary for the operation of each of the ten different alternating current relays 400.

The sources of alternating current being of the same potential but of different frequencies are inductively connected to the two secondary windings 430 and 431 of the transformer. Each of these different sources of current induce electromotive force of the same frequency in each of the windings 430 and 431. These windings, however, are differentially arranged and being substantially equal, the result is that the induced electromotive forces neutralize each other normally.

A description will now be given of the detailed operation of the system in the es-

tablishment of a call between two subscribers' lines. When the subscriber at station 100 removes his receiver from the switchhook, a circuit is closed from battery through the winding of line relay 136, through the inner contact of cut-off relay 137, conductor 124, conductor 158, through the closed contacts of keys 105, 104, etc., thence through the switchhook to conductor 159, through the closed contacts of keys 106, 107, 108, etc., conductor 160, conductor 123, to ground at the outer contact of relay 137. Relay 136 operates and closes a circuit for the relay 138. Relay 138 completes a circuit for relay 140, which is individual to the vertical group of lines appearing in the row 126 of the switch. This circuit may be traced from battery through the left-hand winding of relay 140, contact of relay 138, innermost back contact of relay 141, outer right contact of relay 144, to ground. Relay 140 operates and closes a holding circuit for itself from battery through its right-hand winding and inner right contact, winding of relay 141 to ground at the outer right contact of relay 144. Relay 141 operates, opens the left-hand winding of relay 140 and closes a circuit from battery through the winding of slow-to-release relay 143, middle contact of relay 141, inner right back contact of relay 144, to ground. Relay 143 operates and closes a substitute holding circuit for relays 140 and 141.

As relays 140 and 141 operate a circuit is closed from battery through the winding of vertical magnet 132, outer right front contact of relay 140, inner right front contact of relay 141 to ground at the contact of relay 143. Magnet 132 prepares the contacts in the vertical row 126 and also closes a circuit from ground through its contact, conductor 162, left contact of relay 142, left contact of relay 140, right contact of relay 136, right-hand winding of relay 139 to battery. Relay 139 operates and locks in a circuit from battery through its left-hand winding and left front contact, winding of relay 142 to ground over conductor 162. The relay 139 is individual to the group of horizontal links containing links 156 and 157 to which the calling subscriber's line has access.

Relay 141 also completes a circuit from ground through its outermost contact, left contact of relay 144, contact of slow releasing relay 145, brush 148 (assuming the trunk allotter switch 147 to be standing in its second position), winding of the vertical trunk magnet 133 to battery. The magnet 133 operates and prepares the contacts in the row 129 for operation and closes a locking circuit from battery through its winding and left contact, conductor 163, winding of relay 144 to ground at the outer

contact of relay 141. Relay 144, however, being shunted by the above traced circuit does not operate at this time. Magnet 133 also establishes a circuit from ground through its right contact, winding of relay 150 to battery. Relay 150 then operates and ground is extended through its contact through the brush 149 of switch 147, contact and winding of stepping magnet 146, winding of relay 145 to battery. The stepping magnet 146 operates in this circuit and advances the switch 147 to the terminals representing the next idle trunk outgoing from the switch 125. When brush 148 disengages its second terminal the shunt is removed from relay 144 and this relay operates in series with the magnet 133. Relay 144 opens the circuit of relay 143 and this latter relay commences to deenergize.

While the relay 143 is maintaining its armature, however, a circuit is completed from ground through the inner right front contact of relay 144, right contact of relay 142, right front contact of relay 139, back contact of relay 134, horizontal magnet 135 to battery. The magnet 135 which is individual to the link 157 effects connection between said link and the incoming line and also between said link and the idle outgoing trunk 131. Immediately that the connection is effected a circuit is closed from battery through the winding of magnet 135, winding of relay 134, test conductor of link 157 over the test conductor 154 to ground at the contact of magnet 133. Relay 134 operates and extends the start circuit through to the next horizontal magnet in the group. Another circuit is closed from battery through the winding of cut-off relay 137 to the test conductor of link 157 and thence to ground as described. Relay 137 opens the circuit of relay 136 which deenergizes and releases relay 138.

At the time relay 150 operates a circuit is established from ground through the right contact of magnet 133, contact of relay 150, conductor 153, back contact of slow-to-release relay 203, conductor 213, winding of relay 306 to battery. Relay 306 operates and locks in a circuit from battery through its winding and inner left contact, conductor 214 to ground at the uppermost back contact of relay 201. Relay 306 closes a circuit from ground through its outer left contact and the winding of relay 307 to battery. Relay 307 operates and a circuit is completed from battery through the left winding of relay 308, contact of relay 307, innermost back contact of relay 309 to ground at the outer right contact of relay 312. Relay 308 operates and locks in a circuit from battery through its right-hand winding and inner right contact, winding of relay 309 to ground at the outer right contact of relay 312. Relay 309 energizes

in this circuit and closes a circuit from battery through the winding of slow-to-release relay 311, middle contact of relay 309 to ground at the inner right back contact of relay 312.

A circuit is now closed for the vertical operating magnet 315 controlling the row of contacts 301. This circuit leads from battery through the winding of said magnet, outer right front contact of relay 308, innermost front contact of relay 309 to ground at the contact of relay 311. Magnet 315 operates and prepares the contacts in the row 301. Magnet 315 also closes a circuit from ground through its contact, conductor 323, left contact of relay 310, left contact of relay 308, outer right contact of relay 306, right-hand winding of relay 320 to battery. Relay 320 operates and locks in a circuit from battery through its left-hand winding and left contact, winding of relay 310 to ground at the contact of magnet 315.

Relay 309 also closes a circuit from ground through its outermost contact, left contact of relay 312, contact of slow relay 313, brush 324 (assuming the allotter switch 305 to be standing on its second position terminal), winding of magnet 316 to battery. Magnet 316 operates and closes a circuit from battery through its winding and contact, conductor 325, winding of relay 312 to ground. Relay 312 being shunted by the circuit above traced does not operate at this time.

Magnet 316, now operating, prepares the contacts in the vertical row 304 and also closes a circuit from ground through its right contact, conductors 326 and 327, brush 328, contact and winding of stepping magnet 314, winding of relay 313 to battery. Magnet 314 steps the brushes 324 and 328 of the allotter switch to the first idle set of terminals representing an idle register sender. Relay 313 holds open the circuit to brush 324 until the switch comes to rest. When the brush 324 disengages its second position terminal, the shunt around the winding of relay 312 is opened and this relay operates in series with magnet 316.

Relay 312 opens the circuit of relay 311, which, being slow, requires an interval of time to release. During this interval, a circuit is closed from ground through the inner right front contact of relay 312, right contact of relay 310, right front contact of relay 320, back contact of relay 321 (assuming the link 319 to be idle), winding of the operating magnet 322 to battery. Magnet 322 operates the switch to connect the trunk through to the idle register sender. Immediately that the switch operates, a temporary holding circuit is closed from battery through the winding of magnet 322, relay 321, through the link circuit and contacts in

row 304, conductor 326 to ground at the right contact of magnet 316. Relay 321 operates and extends the start wire through to the next horizontal link.

Also, upon the operation of the sender selector 300, a circuit is closed from ground through the right contact of magnet 316, conductor 326, through contacts of the switch 300, thence over conductor 329, winding of relay 201 to battery. Relay 201 operates and closes a circuit from battery through the winding of relay 203 to ground at the uppermost front contact of said relay 201. Relay 201 also opens the holding circuit of relay 306, which, in turn, causes the release of relay 307. Another function of the relay 201 is to extend the tip and ring conductors of the trunk 131 through the sender selector switch 300 to the selected register sender shown in Fig. 4. This results in the closure of a circuit which may be traced from ground through the transformer winding 430, through battery, left-hand winding of relay 419, outer contact of relay 439, conductor 451, through the sender selector switch, conductor 331, inner lower front contact of relay 201, conductor 152, thence through the line switch 125 to conductor 124, conductor 158, through keys 105, 104, 103, through the substation apparatus, thence to conductor 159, through keys 106, 107, 108, etc., conductor 160, conductor 123, thence through the line switch 125, conductor 151, through the inner upper contact of relay 201, conductor 330, through the selector switch 300, conductor 450, inner contact of relay 439, right-hand winding of relay 419, winding 431 to ground. Direct current flowing in this circuit causes the energization of relay 419, which, in turn, causes the energization of slow-to-release relay 440.

The foregoing operations have all taken place in a brief space of time during which the slow relays 143 and 311 are still maintaining their energization. After the necessary interval, relay 143 releases and opens the holding circuit of relays 140 and 141. Relay 141 opens the circuit of magnet 132 which releases, causing the release of relays 142 and 139. Relay 141 also causes the release of magnet 133 and relay 144. The vertical magnets 132 and 133 are restored and the connection is now held by the maintained energization of magnet 135. This magnet is held operated in a circuit from battery through its winding, winding of relay 134, contacts of the switch 125, conductor 154, contact of relay 150, conductor 153 to ground at the contact of relay 203. Relays 137 and 150 are also held energized by the relay 203.

Relay 311 releases after an interval and in a similar manner brings about the release of relays 309, 308, 310, 312, 320 and the vertical magnets 315 and 316. The sender selec-

tor switch is held operated now by the magnet 322 which is energized in a circuit traceable by way of conductor 326 to ground at the contact of relay 440. Relay 201 is also held energized by ground on conductor 326.

Assume that the number of the called line 720 is 320. The calling subscriber accordingly first depresses the No. 3 key 103. The normal circuit over the calling line is interrupted and two other circuits are closed. The first of these circuits may be traced from ground through the winding 431 of the transformer, thence through the first five tuned relays 404, 405, 406 and the associated condensers, and in parallel through the right-hand winding of relay 419, inner contact of relay 439 to the conductor 450 over the line as above traced to conductor 123, conductor 160, through the keys 110, 109, 108 in series, conductor 159, thence through the contacts of key 103, coil 115, condenser 120, to ground. The other circuit closed by the key 103 may be traced from ground through the winding 430, battery, thence through the second five tuned relays 410, 411, 412 and their associated condensers and in parallel thereto through the left-hand winding of relay 419, outer contact of relay 439 to the conductor 451, thence over the line to conductor 124, impedance coil 112, through the substation apparatus to conductor 159, contacts of key 103, coil 115 and condenser 120 to ground. The characteristics of the first one of these circuits are such that the current induced in the secondary of the transformer by the source 422, for example, is of such a frequency that only the relay 406 of the first five relays responds thereto. Due to the characteristics of the second circuit above traced, as described in Patent No. 1,337,715, issued April 20, 1920 to J. L. McQuarrie, none of the sources of the current 420, 421, 422, etc. induce a current in the secondary of the transformer sufficient to operate any of the relays of the second group of five. Hence, but a single relay is operated due to the depression of key 103. This relay 406, in energizing, completes a circuit from ground through its left contact, conductor 452, brush 436 (position 1), winding of register relay 453 to battery. Relay 453 operates and locks through its left contact, conductor 454, to grounded conductor 326.

The relay 453 represents the digit 3 in the register 401. Although the registers 401, 402 and 403 are only shown with five relays each, it is understood that there may be as many relays for each register as the number of digits to be recorded requires.

The relay 406, in operating, also closes a circuit from ground through its right contact, conductor 455, winding of stepping magnet 441 to battery. Magnet 441 energizes preparatory to releasing the several brushes into their next position when the

circuit of said magnet is opened. As soon as the subscriber releases the button 103, relay 406 releases and the stepping magnet 441 deenergizes to advance the several brushes shown in the drawing from their first to their second position contacts.

Next, the subscriber depresses the key 102 representing the second digit and circuits similar to the ones above traced are completed including the tuned relays in series with the inductance 116 and condenser 121 at the substation. Due to the characteristics of these circuits, a current is induced of the frequency necessary to operate the relay 405 while none of the other tuned relays are able to respond. Relay 405 completes a circuit from ground through its left contact, conductor 456, brush 435 (position 2), winding of register relay 457 to battery. Relay 457 operates and locks through its left contact to the grounded conductor 454. Relay 405 also closes the circuit of stepping magnet 441 which, when the subscriber releases key 102 becomes deenergized and advances the control switch in position 3.

Lastly, the subscriber operates the key 110 representing the last digit. A circuit is now closed from ground through the winding 439 of the transformer, battery, through the relays 410, 411, 412 of the second five and their condensers and also in parallel thereto through the left-hand winding of relay 419, outer contact of relay 439, conductor 451, thence over the ring side of the line to conductor 158, contacts of key 110, reactance 113, condenser 118 to ground. Another circuit leads from ground through the winding 431, through the windings of relays 404, 405, 406 of the first five and their condensers and also in parallel thereto through the right-hand winding of relay 419, inner contact of relay 439, conductor 450, thence over the tip side of the line to conductor 123, reactance coil 111, through the substation apparatus through the keys 101 to 105, inclusive, conductor 158, contacts of key 110, coil 113, condenser 118, to ground. Due to the characteristics of the first circuit mentioned, as described in the above mentioned McQuarrie Patent No. 1,337,715, a current is induced therein by the source 424 of the necessary frequency to cause the energization of relay 458. None of the other relays are operated. Relay 458 closes a circuit from ground through its left contact, conductor 459, brush 438 (position 3), winding of register relay 460 to battery. Relay 460 locks to the grounded conductor 454. Relay 458 at its right contact closes a circuit for magnet 441 which magnet deenergizes when the subscriber releases key 110 and advances the brushes of the control switch into position 4.

The number now being recorded on the sender, the next operation to take place is to

associate this particular sender with the first group selector switch 500. The association of the sender takes place by means of the multi-contact relay device 600 comprising a number of multi-contact relays 601, 602, each individual to the different common senders and serving, when energized, to extend the control leads from the registers through to the operating magnets of the selector switch 500. The relay 601 being individual to the particular sender shown, a circuit therefor is completed by way of the brush 444 when the control switch reaches position 4. With the relay 601 operated and since register relay 453 is the only one operated in the register 401, a circuit is now completed for the vertical operating magnet 510 individual to the row 505 in which appears the group of trunks representing the first digit of the wanted number. This circuit may be traced from ground through the right contact of relay 453, conductor 461, contacts of relay 601, conductor 612, winding of magnet 510 to battery. The magnet operates and prepares the contacts of all trunks in the group. Magnet 510 in operating, completes a circuit from ground through its contact, winding of the multi-contact relay 514 to battery. The group of multi-contact relays 513, of which the relay 514 is one, serve to associate the test relays 603 with the test conductors of the respective trunks in the several groups of trunks outgoing from the switch 500. The relay 514 is individual to the group of trunks in the row 505 and, consequently, connects the right-hand windings of the several test relays 604, 605, 606, etc., to the test conductors of the several trunks individual to the group. The left-hand windings of these test relays lead to front contacts of relays 518, 519, 520 individual to the horizontal links 506, 507, 508. If any horizontal link is busy, its corresponding relay will be operated and a circuit closed for the left-hand winding of the corresponding test relay in the group 603.

Assuming that the trunk 521 is the first one to be idle simultaneously with the idle condition of its corresponding link 506, relay 605 is accordingly the first relay to be deenergized while all preceding relays 606, 607, etc., are energized either due to the left-hand winding, the right-hand winding or both windings thereof.

When the relay 514 operates, it completes a circuit from ground through its contact, over conductor 523, the windings of relays 609 and 608 in parallel, to battery. Relay 609 being a quick relay operates at once and completes a circuit from ground over its contact, conductor 613, contacts of relay 601, conductor 614, through the sender selector switch, conductor 332, back contact of relay 205, conductor 215, winding of the ver-

tical operating magnet 509 to battery. The magnet 509 operates and prepares the contacts of the incoming trunk. Magnet 509 completes a circuit from battery through the winding of relay 204, conductor 216, inner right front contact of magnet 509, conductor 217, lowermost contact of relay 201 to the grounded conductor 153. Relay 204 operates and locks through its innermost lower contact, conductor 217, thence through the contact of relay 201 to the grounded conductor 153.

After an interval of time, the slow relay 608 attracts its armature and a circuit is closed from ground, through the contact thereof, left front contacts of relays 607 and 606, left back contact of relay 605, conductor 615, left-hand winding of the horizontal operating magnet 515 to battery. Magnet 515 operates and connects the incoming trunk through the link 506 to the idle outgoing trunk 521 in the desired group. At the instant the connection is effected, a circuit is closed from battery through the right-hand winding of magnet 515 and in parallel through the winding of relay 518, through contacts of the switch to the grounded test conductor 153. The switch is held operated under the control of this circuit and relay 518 applies ground potential to the left-hand winding of the test relay 605 to identify this link as busy when a subsequent connection is attempted through the switch.

At the time the control switch of the sender advanced into position 4, a circuit was closed from battery through the winding of slow-to-operate relay 445, brush 443 (position 4) to ground. The relay 445 is so constructed that it requires an interval of time to operate which is sufficiently long to permit the foregoing operations to transpire. At the end of this interval, the relay 445 attracts its armature against the contact and a circuit is closed from ground through the contact of said relay, contact and winding of the stepping magnet 441 to battery. The magnet 441 interrupts its own circuit and advances the control switch out of position 4 and into position 5. While the switch is standing in position 5, a circuit is closed from battery through the winding of relay 449, brush 448 to ground on conductor 326. Relay 449 operates and locks through its right contact to the grounded conductor 326. Due to this advance, the relay 445 and relay 601 become deenergized. This results in the release of the vertical operating magnets 510 and 509 of the selector switch. Magnet 509, in releasing, closes a circuit from battery, through the winding of relay 205, middle lower front contact of relay 204, inner back contact of magnet 509, conductor 217, lower contact of relay 201 to grounded conductor 153. Relay 205 operates and locks

through its left contact. The magnet 510 causes the release of the multi-contact relay 514, which, in turn, causes the release of relays 608 and 609.

The next act to take place is the association of the sender with the testing and controlling equipment in Fig. 8 whereby the connector switch 700 may be operated in accordance with the last two digits of the called number. With the control switch in position 5, a circuit is closed from ground through the brush 441, conductor 425, winding of multicontact relay 611 to battery. Relay 611 which is one of a number of relays comprising the set 610, is individual to the senders shown and serves to connect that sender through to the controlling equipment shown in Fig. 8. With relay 611 operated, a circuit is closed from ground, through the right contact of the register relay 457, conductor 462, contact of relay 611, conductor 616, winding of the vertical operating magnet 712 to battery. The magnet 712 controls the vertical row 704 containing the group of subscribers' lines in which occurs the called line 720. Magnet 720 at its contact, completes a circuit for the multi-contact relay 804 in the group 801 which is individual to the group of lines containing the called line and serves to associate the test relays 805, 806, 807, etc., with the test conductors of the lines of such group.

Moreover, a circuit is closed from ground through the right contact of relay 460 of the register 403, conductor 463, contacts of relay 611, conductor 617, winding of multi-contact relay 803 to battery. Relay 803 is one of a number of relays in the group 800, each of which represents a different units digit and each of which serve to connect the test relays 809, 810, 811, etc., with the test conductors of the corresponding horizontal links in the switch 700 which have access to lines of the different units designations. Relay 803, in operating, closes a circuit from ground through its outer contact, conductor 618, contacts of relay 611, conductor 619, through the sender selector switch 300, conductor 333, lowermost front contact of relay 204, conductor 207, through contacts of the first selector switch 500, conductor 526, contact of relay 719, winding of the vertical operating magnet 710 to battery. Relay 803, in operating, connects the windings of the test relays 809, 810, 811, etc., to the contacts of relays 717, 716, 722 associated with the corresponding horizontal links 705, 706, 707 of the group which have access to the called subscriber's line 720. If the links 707 and 706 are busy, relays 722 and 716 apply ground potentials to the windings of relays 811 and 810 and these relays are operated. Assuming the link 705 is idle, the corresponding test relay 809 remains deenergized.

At the same time, a test is being made of the called subscriber's line 720. The test circuit for this purpose may be traced from test conductor of the line, over conductor 723, through contacts of relay 804, conductor 815, contact of relay 805 (relay 805 having operated in parallel with the relay 803), winding of relay 813 to battery. Assuming that the called line is idle, no ground potential exists on the test conductor, and, consequently, the relay 813 remains deenergized.

At the time relay 803 operated, it closed a circuit for the slow operating relay 812. After an interval has expired relay 812 attracts its armature and a circuit is closed from ground through the back contact of relay 813, contact of relay 812, front contacts of relay 811 and 810, back contacts of relay 809, contact of relay 803, conductor 816, winding of horizontal operating magnet 715 to battery. The magnet 715 operates and extends the incoming trunk over the idle link 705 to the called subscriber's line 720. When the switch 700 operates, a circuit is closed from battery, through the winding of relay 718, contacts of the switch 700, conductor 816, contacts of relay 803, thence through the contacts of the test relays to ground at the back contact of relay 813. Relay 718 operates and locks through its winding and back contact, conductor 527, through contacts of the switch 500 to the grounded test conductor 153. The ground on the test conductor 527 is thus extended through the right contact of relay 718 to complete a holding circuit for the link magnet 715 and for the relay 717. Relay 719 operates through a contact of relay 718. The connection is now held through switches 500 and 700 by means of ground on the conductor 153.

At the time the control switch of the sender moves into position 5, a circuit is closed by way of brush 443 for the slow operating relay 446. After the necessary interval has expired during which the switch 700 has been set, relay 446 attracts its armature and closes a circuit for the stepping magnet 441. Magnet 441 interrupts its own circuit and advances the control switch out of position 5 back into its normal position.

As the control switch moves back into its normal position, the brush 444 opens the circuit of relay 611 which releases and disconnects the sender from the controlling equipment of Fig. 8. This causes the release of relays 803, 812, 805, 804 and magnets 710 and 712. With the switch in its normal position, a circuit is closed from ground over conductor 326, brush 443, left contact of relay 449, winding of relay 439 to battery. Relay 439 operates and opens the holding circuit of relay 419. Relay 419 releases and opens the circuit of relay 440. After an interval, relay 440 deenergizes and removing

ground from conductor 326 permits the release of relays 449 and 439 and also of the register relays 453, 457 and 460.

Upon the removal of ground from the conductor 326, the holding circuits of magnet 321, relay 322 and relay 201 are opened. The magnet 322 causes the release of the sender selector switch 300 thereby restoring the register sender for subsequent use. Relay 201, upon releasing, completes the tip and ring conductors of the trunk 131 through to the left-hand windings of the repeating coil 200, thus including the calling subscriber's line in series with the repeating coil and battery. Relay 202 being included in circuit with the calling line operates and provides a substitute holding circuit for the slow relay 203. Relay 201, in releasing, also opens the circuits of relays 204 and 205 which becomes deenergized. Relay 204 completes a circuit for the called subscriber's line in series with the right-hand windings of repeating coil 200.

When the conversation has finished, the calling subscriber replacing his receiver on the switchhook opens the circuit of the supervisory relay 202 which releases the slow relay 203. After an interval, relay 203 removes ground potential from the conductor 153 whereupon the holding circuits of the line switch 125 and the selector switches 500 and 700 are opened, causing the complete connection to be restored.

Should the called line 720 be busy at the time it is selected and tested, a ground potential existing on the test conductor thereof causes the closure of a circuit by way of conductor 723, through the contact of relay 804, contact of relay 805, winding of relay 813 to battery. Test relay 813 operates and when later the slow relay 812 attracts its armature, the above traced circuit for the operation of one of the horizontal magnets is held opened due to the energized condition of relay 813. Thus, if the called line is busy, a connection is not established thereto, and the ground potential connected over the front contact of relay 813 may serve in any suitable manner to bring about a busy signal, notifying the calling subscriber of the condition of the called line.

For a more detailed understanding of the operation and control of switches in a system of this character, reference is made to the patent to S. B. Williams, No. 1,517,331, granted December 2, 1924.

What is claimed is:—

1. The combination in a telephone system of a coordinate selector switch having a plurality of contacts with operable links therebetween for establishing connections, a controlling mechanism for controlling the selective operation of said switch, and a plurality of sources of current of different character for setting said mechanism.

2. The combination in a telephone system of a plurality of coordinate selector switches having a plurality of incoming and outgoing trunk contacts with selectively operable links therebetween for establishing connections, a controlling mechanism for controlling the selective operation of said switches, and a number of sources of current of different character for setting said mechanism.

3. The combination in a telephone system of a coordinate selector switch having a plurality of link circuits for establishing connections, a register controlling mechanism for controlling the selective operation of said switch and a plurality of sources of current of different character for setting said register mechanism.

4. The combination in a telephone system of a coordinate selector switch having a plurality of links arranged to set up a number of co-existing connections, a controlling device for governing the selective operation of said switch, and a number of sources of current of different character for setting said controlling device.

5. In a telephone system, a coordinate selector switch comprising movable contacts and immovable links therebetween for establishing connections, a controlling mechanism for governing the selective operation of said switch, a plurality of sources of current of different character, and means selectively responsive to said currents for variably setting said controlling mechanism.

6. In a telephone system, coordinate selector switches having sets of parallel conductors, sets of movable contacts associated individually therewith and arranged in rows coordinate with said conductors, and means for moving said contacts into engagement with said conductors for establishing connections, a controlling mechanism for governing the selective operation of said switches, and a plurality of sources of current of different frequencies for setting said mechanism.

7. In a telephone system, a coordinate selector switch having conductors arranged in open grid, movable contacts associated individually therewith and disposed in rows at right angles thereto, and means for interengaging said conductors and said contacts for establishing connections between incoming and outgoing lines, a controlling mechanism for governing the operation of said switch, a plurality of sources of current of different frequencies, and tuned relays responsive to said currents for variably setting said controlling mechanism.

8. In a telephone system, coordinate selector switches having parallel conductors, movable contacts, each contact being adjacent to each of said conductors but normally out of engagement therewith, and means for moving said contacts into engagement with said conductors to establish connections, a controlling mechanism for governing the operation of said switches, and a plurality of sources of current of different frequency controlled by the calling party for setting said mechanism.

9. In a telephone system, incoming lines, outgoing lines, a coordinate selector switch having stationary horizontal links and sets of movable contacts disposed in vertical rows, each contact of said sets being in propinquity to each of said links and each of said links being arranged to engage two of said contacts simultaneously when establishing connections between said incoming and outgoing lines, a controlling device for governing the selective operation of said switch, a number of sources of current of different frequencies, circuits for said sources of current, and means controlled by the calling party to produce resonance in said circuits for the purpose of variably setting said controlling device in accordance with wanted designations.

In witness whereof, I hereunto subscribe my name this 27th day of February A. D., 1923.

JAMES L. McQUARRIE.