Dec. 2, 1924. 1,517,315

W. A. RHODES

TELEPHONE EXCHANGE SYSTEM

Filed Dec. 6, 1920 5 Sheets-Sheet 1

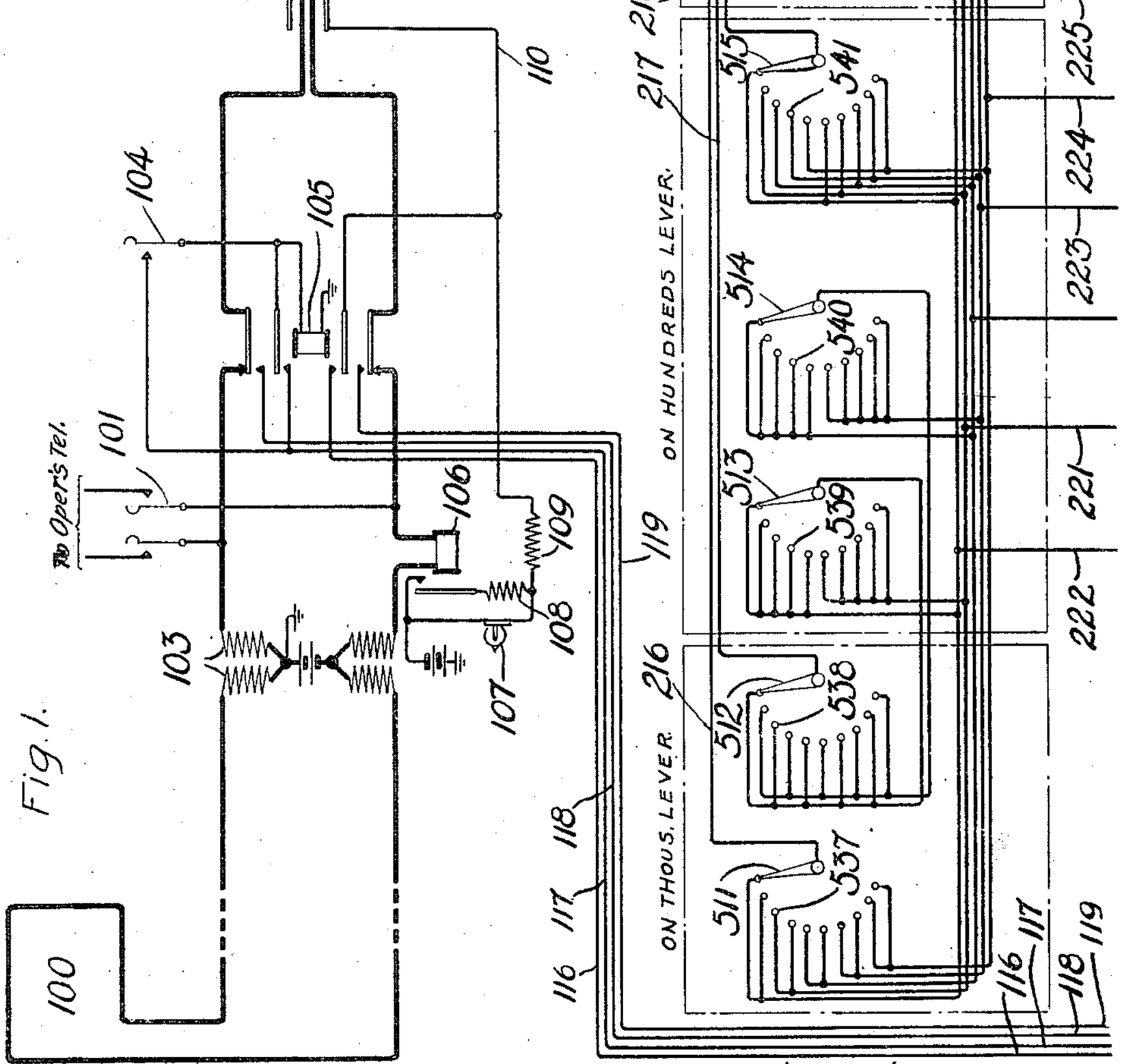

Fig. 1.

Inventor:
William A. Rhodes.
by gerfolk Att'y.

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W. A. RHODES

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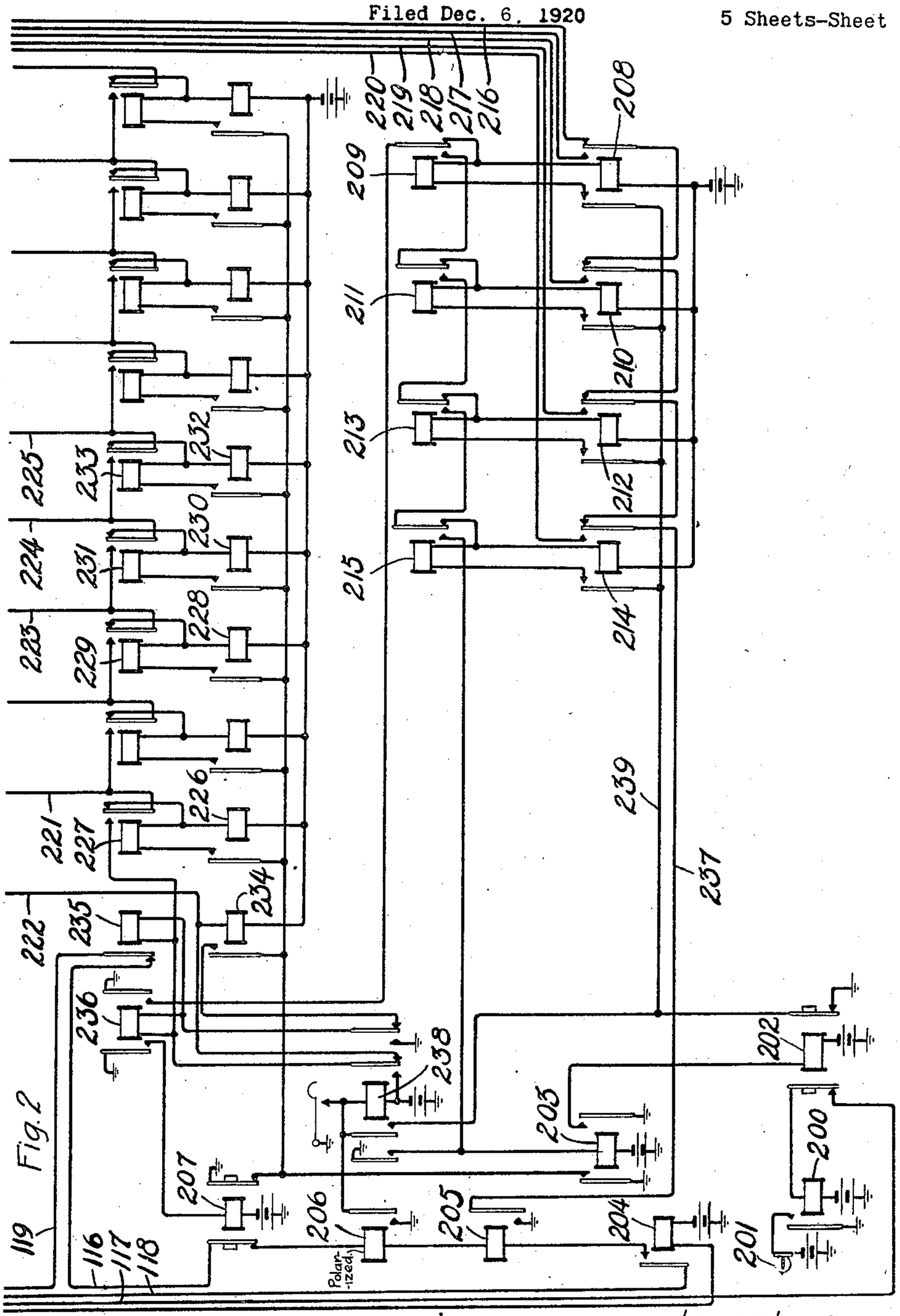

Fig. 2

Inventor:
William A. Rhodes.
by G. Fish Att'y.

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W. A. RHODES

TELEPHONE EXCHANGE SYSTEM

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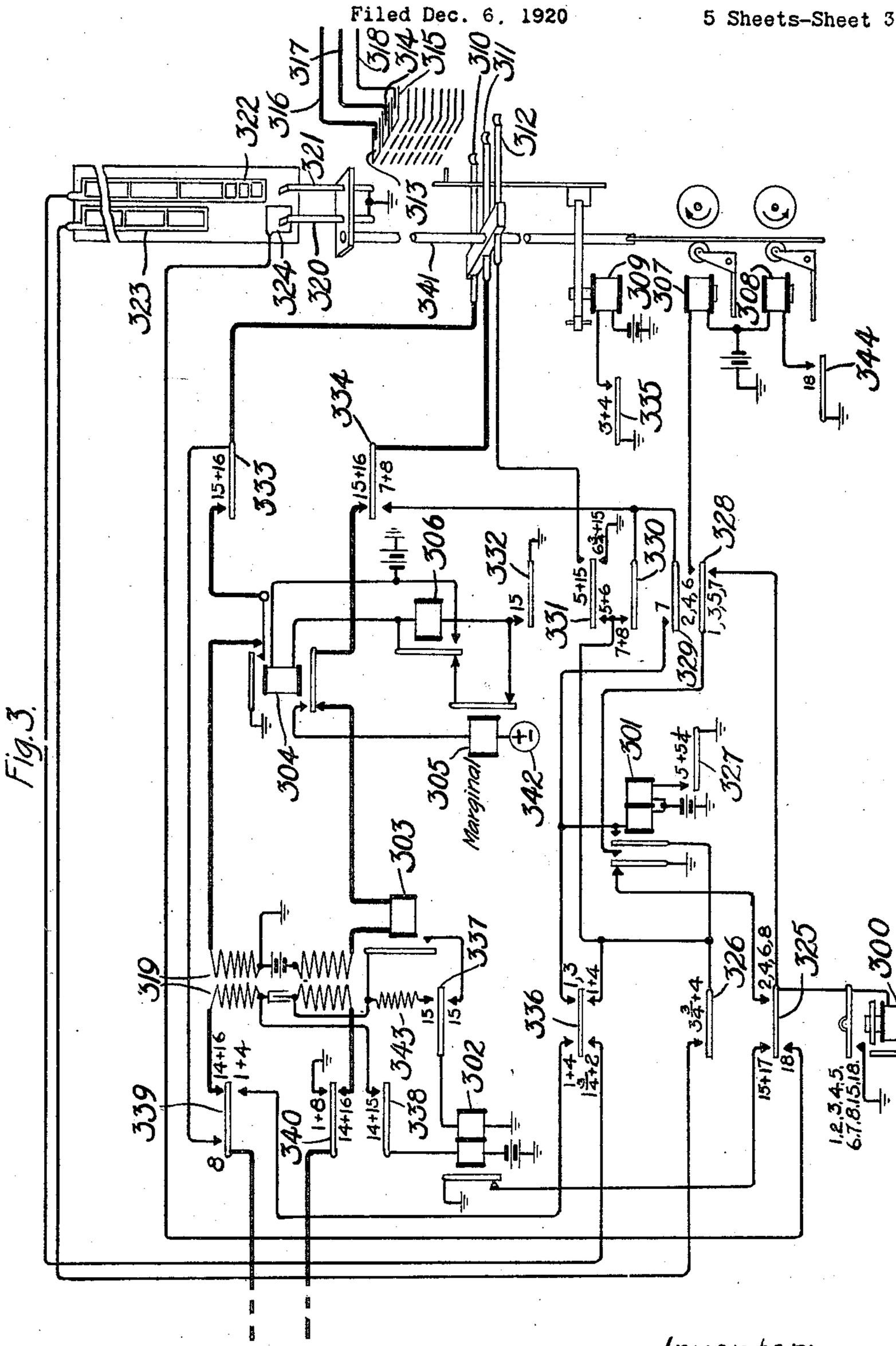

Fig. 3.

Inventor:
William A. Rhodes.

by gr Folk Att'y.

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W. A. RHODES

TELEPHONE EXCHANGE SYSTEM

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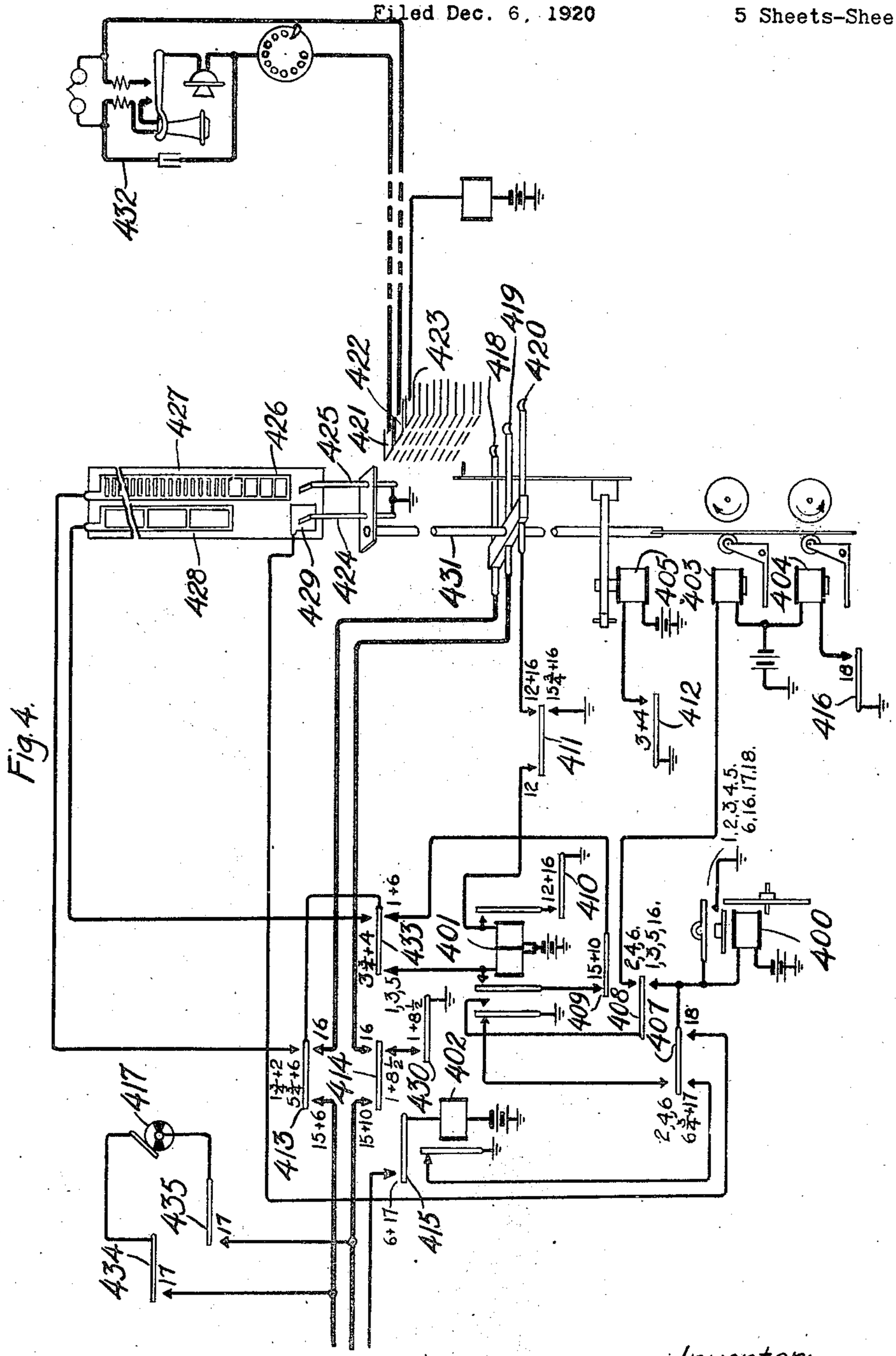

Fig. 4.

Inventor:
William A. Rhodes.

by g E Yoell Att'y.

Dec. 2, 1924. 1,517,315

W. A. RHODES

TELEPHONE EXCHANGE SYSTEM

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Fig. 5.

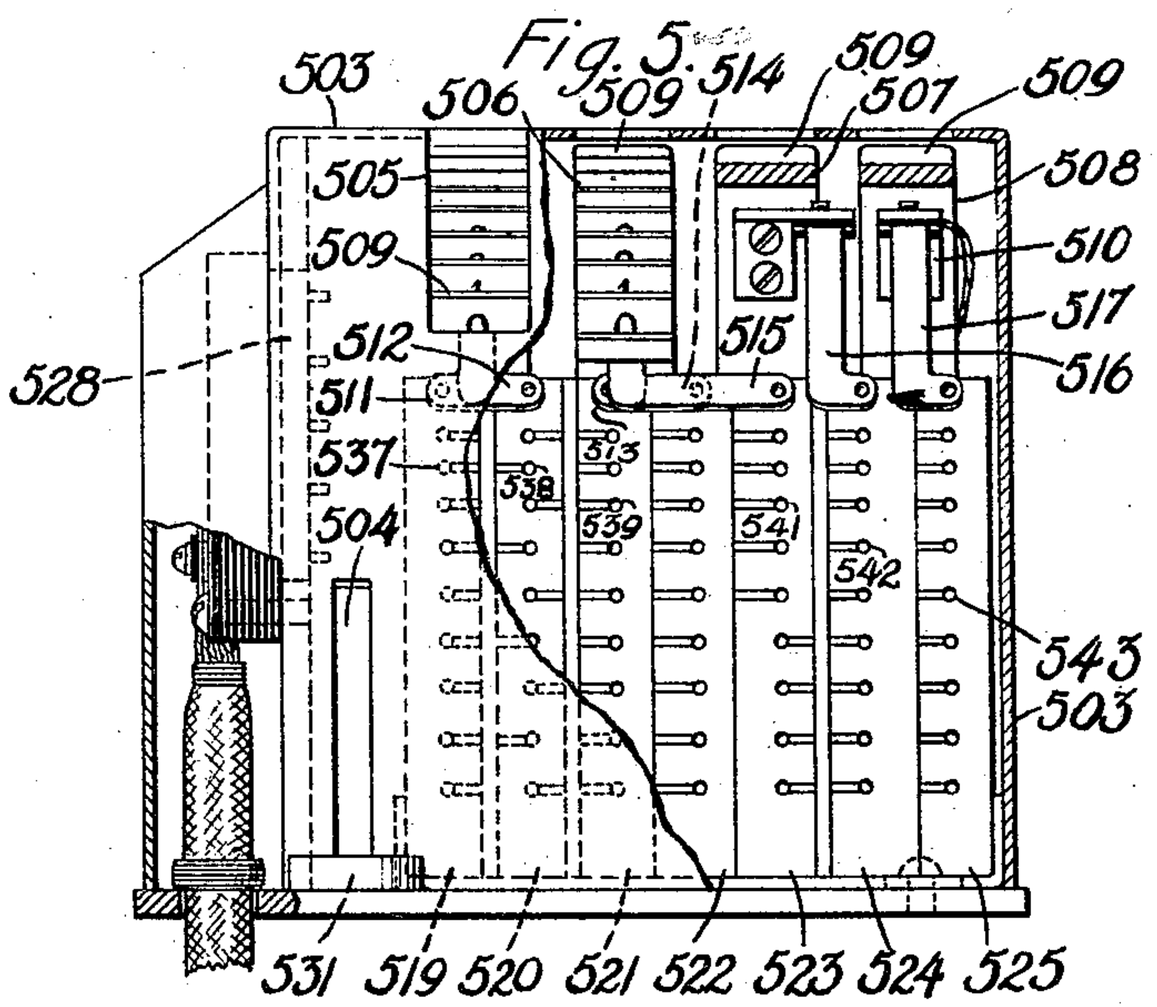
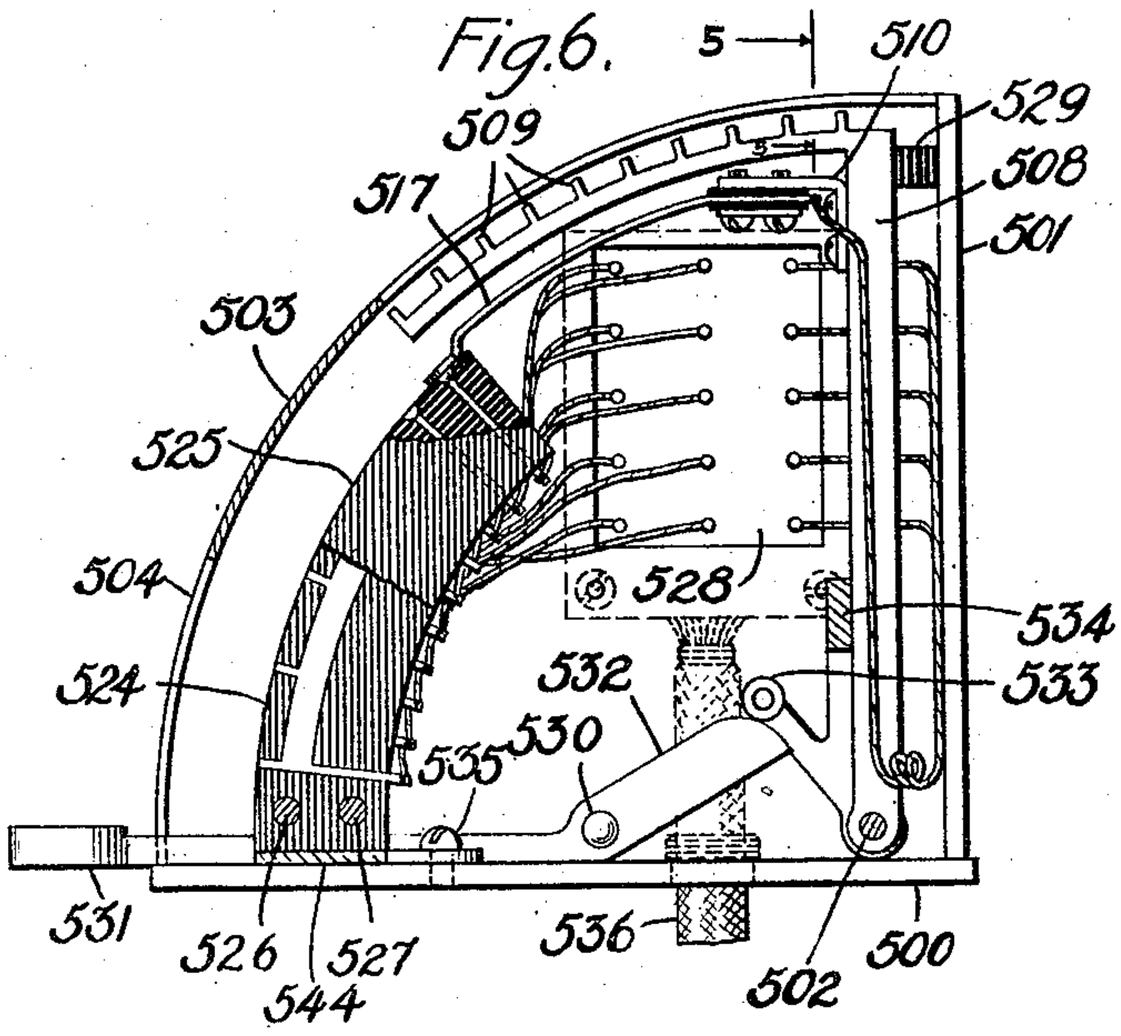


Fig. 6.



Inventor:
William A. Rhodes.
by Gifford Att'y.

Patented Dec. 2, 1924. 1,517,315

UNITED STATES PATENT OFFICE.

WILLIAM A. RHODES, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

TELEPHONE-EXCHANGE SYSTEM.

Application filed December 6, 1920. Serial No. 423,573.

To all whom it may concern:

Be it known that I, WILLIAM A. RHODES, residing at New York, in the county of New York and State of New York, 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 of the character wherein automatic switches are employed for setting up connections between subscribers' lines.

In telephone exchanges where certain offices are equipped with manual switching apparatus, such as operators' conecting circuits, for establishing talking connections while other offices are provided with machine switches it is necessary, in order to enable the establishment of interoffice connections, to provide the operators with means for controlling the selective movements of such switches. For this purpose, the operators' positions are provided with register sending mechanisms upon which the operator may record the designations of called lines and which thereafter operate to control the selective switches in the extension of the connection. The incoming calls may originate on local subscribers' lines terminating directly at the operator's position, or they may be extended to the operator's position over interoffice trunk lines from distant offices. In either event, the operator responds and ascertains the name of the called office and the number of the wanted line therein. On learning that the desired connection is one that must be built up through the agency of automatic switches, she proceeds to record the designation on the register sender at her position and by means of a cord circuit extends the calling line to the first of such switches. The switches are then positioned under the control of the sender to complete the connection to the wanted line.

Register senders of the class suitable for controlling selective switches of the type considered herein usually comprise a plurality of register switches, which may be operated either in a step-by-step manner, or by means of a constantly driven power member. Where the register senders are located in the same office with the automatic switches, a common source of power may be provided for operating both the registers and the switches. In systems of the character above outlined, however, the controlling senders are frequently situated in offices distant from the automatic switches. Consequently, it is desirable to obviate as far as possible the use of power equipment merely for the purpose of operating the sender registers.

With this in view, the present invention has for its object the provision of a register sender including a plurality of manually operable registers arranged to be variably adjusted to set positions, and which serve while in their set positions to determine the operation of a counting mechanism for controlling the selective movement of automatic switches.

A feature of the invention relates to an arrangement wherein a series of counting relays are variably operated in accordance with the set positions of the manually operable registers for controlling the automatic switches.

Other and further features of the invention will become apparent from a consideration of the following description and the appended claims.

In the drawing Figs. 1, 2, 3 and 4 with Fig. 2 placed beneath Fig. 1 and Figs. 3 and 4 taken in order to the right of Fig. 1, illustrate so much of a telephone exchange system as is necessary to an understanding of the invention.

Fig. 1 shows a subscriber's line incoming to an operator's position in a manual office and an operator's connecting circuit for extending the subscriber's line to a trunk outgoing to a distant office. This figure also illustrates diagrammatically a plurality of registers which are arranged to be manually set by the operator for recording the designations of subscribers' lines.

Fig. 2 shows a central office sender comprising a series of counting relays for controlling the automatic switches in a distant office.

Fig. 3 shows an incoming selector switch in a distant automatic office, which is reached by the trunk line leading from the operator's position in the manual office.

Fig. 4 shows a final selector switch which serves to further extend the incoming connections to the desired lines.

Fig. 5 is a front view showing the struc-

ture and mechanical details of the operator's register set. Certain parts of the structure have been broken away in order to expose the interior, while other parts are shown in section, such section being taken along the line 5—5 of Fig. 6.

Fig. 6 is a side view of the register set with certain parts removed in order to reveal the interior arrangement.

The automatic switches shown in Figs. 3 and 4 are of the well-known power driven type and may be in general of the same structure as the switch shown and described in detail in the patent to Craft & Reynolds No. 1,123,696, issued January 5, 1915.

Referring to Figs. 5 and 6, a description will first be given of the construction of the operator's register set before attempting to explain the circuit functions it performs in controlling the automat c switches. The housing portion of this device consists of two rectangular metallic plates 500 and 501, disposed at right-angles to one another and secured in any suitable manner. To further enclose the space provided by the plates 500 and 501, a cylindrical-shaped casing 503 is used as shown in Fig. 6 and may be suitably attached to members 500 and 501. Within the enclosure and disposed parallel to the base plate 500, is a bearing rod 502. The rod 502 extends throughout the entire length of the plate 500 and may be supported in any convenient manner, as for example in bear ngs, not shown, carried by the opposite ends of the casing 503.

Four sector-shaped registers 505, 506, 507 and 508 are rotatably mounted on the rod 502. Each of these register members such as register 508 shown in Fig. 6, is provided with an arcuate portion which carries projections 509. In the spaces between adjacent projections 509, a series of dentifying characters are inscribed such as the ten ordinals. With the registers in their normal position as shown in Fig. 6, the vertical portion of the member 508 bears aga nst a stop 529. In this position the arcuate portion of member 508 is disposed in full view of the operator by means of a rectangular opening cut in the casing 503. Observing in particular F g. 5, it is noted that each of the four different registers is provided with an individual window or slot in the casing 503. The projections 509 serve as finger-holds whereby the operator may rotate the sector register in a counter-clockwise d rection through a distance equivalent to any particular digit which she may desire to record. The lower extremity of the slot, through which the finger is inserted, serves as a stop to accurately determine the extent of the movement through which the register is rotated.

The four different register members are each provided with contact making brushes. Register 505 carries two brushes 511 and 512. Register 506 carries three brushes 513, 514 and 515. Each of the registers 507 and 508 is equipped with a single brush 516 and 517, respect.vely. Looking at Fig. 6, the method of attaching the brushes to the sector-shaped register is clearly illustrated. A small rectangular bracket 510 is secured to the member 508 by means of screws. The brush 517 is secured to the bracket 510 and insulated therefrom by suitable material. Similarly, the brushes 511, 512, 513, 514, 515 and 516 are attached to their respective register numbers. Where more than one brush .s carried by the same number, these brushes are insulated from one another as well as being insulated from other metallic parts of the device.

The contact making brushes just described are adapted to cooperate with series of terminals arranged in a circular-shaped bank. This bank consists of seven arcuate blocks 519, 520, 521, 522, 523, 524 and 525 constructed of insulat ng material. These arcuate blocks are assembled and secured to each other by means of rods 526 and 527 to provide the terminal bank, the front of which is best shown in Fig. 5. By means of an attaching plate 544 and screws 535, the assembled bank is securely mounted on the base plate 500 as best seen in Fig. 5. Each of the arcuate blocks 519, 520, 521, etc., is provided with a series of ten rad al channels in which terminal pins such as 537, 538, 539, 541, 542 and 543 are adapted to be inserted and secured. These terminal pins when fixed in place provide an arcuate row of ten terminals each, which align w th the brushes 511, 512, 513, 514, etc., in the rotation of the four register members. For example, the brush 511, carried by register member 505, engages the row of ten terminals of which terminal 537 is the third one; brush 512 engages the row of ten terminals of wh ch terminal 538 is also the third one; brush 513, carried by the register member 506, engages the series of ten terminals of which terminal 539 is the fourth and so on.

The terminal pins project through the arcuate insulating blocks 519, 520, 521, etc., as shown in Fig. 6. Connecting wires are soldered to the projecting ends of the terminal pins and extend to the distributing block 528 secured to the casing at the left-hand side of the device. The wires leading to the brushes carried by the registers are also connected to the distributing block 528 as shown in Fig. 6. From the distributing block the several conductors coming from the terminal bank and from the rotatable brushes are grouped in the form of the cable 536, which may be extended to any convenient point in the system where a redistribution of the various conductors is necessary.

When the operator inserts her finger in one of the finger holds and rotates the regis-

ter member, the vertical portion of the member bears against the longitudinal bar 534. This bar extends longitudinally before all of the four different registers and is attached for rotation to the bearing rod 502 as shown in Fig. 6. The rotation of the bar 534 by the rotating register member such as 505 causes the roller 533 to press against the cam surface of the lever 532. This action causes the key 531, which is attached to the opposite end of lever 532, to rotate upwardly in the slot 504 about the pivot 530. After the four different registers have been adjusted to their proper positions to record the four digits of a called number and the connection has been established and the operator wishes to restore the register device to normal, she simply depresses the restoring key 531 back to its normal position as shown in Fig. 6. By depressing the key 531, the lever 532 is caused to rotate about pin 530 and in turn the longitudinal bar 534 rotates about rod 502, thereby forcing the sector-shaped register members back to their restored positions against the stop 529.

The circuit arrangement shown in Figs. 1, 2, 3 and 4 will now be considered. When a call originates on a subscriber's line such as line 100, which may terminate directly before the operator's position in the manual office, shown in Fig. 1, or which may be extended to such position over an inter-office trunk line, the operator responds by means of her answering plug (not shown) and the calling line is thus extended to the repeating coil 103. The operator listens in and ascertains the wants of the calling subscriber. On learning, for example, that he wishes to obtain connection with a subscriber's line, which belongs to a distant automatic office, she causes a register sender to be associated with the cord circuit which she has taken for use and also proceeds to record the digits of the wanted number on the register device at her position. The operator then inserts the other plug of her cord circuit in the jack of a trunk line outgoing to the office in which the called subscriber's line terminates. From this point on the extension of the connection forward to the called subscriber's line is under the control of the register sender and requires no further effort on the part of the operator.

Having explained the construction of the operator's register mechanism and outlined in general the principle on which calls in a system of this character are handled, a detailed description will now be given of the operations concerned in the extension of a connection from the calling subscriber's line to a called subscriber's line. For this purpose, assume that the subscriber of line 100, which terminates in the manual office illustrated in Figs. 1 and 2, wishes to converse with the subscriber of line 432, which terminates in the multiple terminals of automatic switches in the distant mechanical office illustrated in Figs. 3 and 4. Upon initiating the call the subscriber at substation 100 causes, in the well-known manner, the illumination of the line lamp before the operator. In response she inserts the answering plug (not shown) of one of her cord circuits in the jack of the subscriber's line. She then depresses her listening key 101 and converses with the subscriber. On being informed that he wishes to obtain a connection with a subscriber's line in a distant mechanical office, the operator first manipulates an assignment key 104, the function of which is to associate the register sender shown in Fig. 2 with the cord circuit which she has chosen for use. The depression of key 104 completes a circuit from ground through the winding of relay 105, key 104, conductor 117, contact and left-hand armature of relay 202, winding of relay 200 to battery and ground. Relays 105 and 200 become energized in this circuit. Relay 105 locks up in a circuit from ground through its winding and inner upper armature and contact to the conductor 117, so as to remain energized after the operator releases key 104. Relay 200 closes a circuit for the illumination of lamp 201, which indicates to the operator that the sender shown in Fig. 2 was idle and has been associated with her cord circuit.

Next, the operator records on the registers at her position the digits of the called number communicated to her by the calling subscriber. Assume that the called office has a capacity of 10,000 lines and that the number of the desired line is 2345. The operator thereupon adjusts the thousands register 505, the hundreds register 506, the tens register 507 and the units register 508 in accordance with the corresponding digits of the desired number. Since the thousands digits is 2, the brushes 511 and 512 carried by member 505 are positioned on their No. 2 terminals 537 and 538, respectively. Since the hundreds digit is 3, the brushes 513, 514 and 515 of the hundreds register 506 are set on their No. 3 terminals 539, 540 and 541, respectively. Likewise for the tens and units registers the brushes 516 and 517 are positioned on their No. 5 and No. 6 terminals 542 and 543, respectively. Having registered the designation of the called line, the operator seizes the plug 111 of her cord circuit and inserts it in the jack 112 of an idle trunk line 114—115 outgoing to the desired distant mechanical office. The insertion of the plug 111 into the plug 112 completes a circuit from battery through the supervisory lamp 107, resistance 109, conductor 110, sleeve of plug 111, sleeve of jack 112, winding of relay 113 to ground. The lamp 107 is illuminated and relay 113 operates to connect the tip and ring sides of the

operator's cord circuit to the corresponding conductors of the out-going trunk. At the same time, a circuit is completed from battery through the winding of relay 204, conductor 116, inner lower armature and contact of relay 105, conductor 110, sleeve of plug 111, sleeve of jack 112 to ground through the winding of relay 113. Relay 204 becomes energized and closes the fundamental circuit from the sender through to the incoming selector switch at the distant mechanical office. This circuit may be traced from battery through the left-hand winding of relay 301, upper right-hand contact 336 (1), upper left-hand contact 336 (1+4), lower right-hand contact 339 (1+4), conductor 114, upper armature and contact of relay 113, tip of jack 112, tip of plug 111, uppermost armature and front contact of relay 105, conductor 118, armature and contact of relay 204, winding of relay 205, winding of relay 206, contact and left-hand armature of relay 207, contact and armature of relay 235, conductor 119, front contact and lowermost armature of relay 105, ring of plug 111, ring of jack 112, contact and lower armature of relay 113, conductor 115, upper right-hand contact 340 (1+8) to ground. Relay 301 and the stepping relay 205 becomes energized in the fundamental circuit, but relay 206 being polarized does not operate in view of the fact that current flows in the wrong direction. Relay 301 completes a circuit from ground through its outer armature and front contact, lower contact 328, (1), winding of sequence switch magnet 300 to battery and ground. Sequence 300 advances from position 1 into position 2. In this position the relay 301 remains energized in a circuit from battery through its left-hand winding and front contact and inner armature, lower right-hand and upper left-hand contacts 336 (1+4) to ground over the fundamental circuit as above traced. With the sequence switch 300 in position 2 and relay 301 energized, a circuit is completed for the updrive power magnet 307, traceable as follows: battery through the winding of magnet 307, upper contact 328 (2) to ground at the front contact and outer armature of relay 301. The magnet 307 energizes and causes the brush shaft 341 to be driven upwardly in the well-known manner.

When the stepping relay 205 becomes energized in the fundamental circuit, it completes a circuit from ground through its contact and armature, conductor 237, right-hand armature and back contacts of relays 214, 212, 210 and 208 in series, conductor 216, brush 511 of the thousands register, terminal 537, conductor 221, armature and back contact of counting relay 227, winding of relay 226 to battery and ground. Relay 226 becomes energized and closes a series circuit from battery through its winding and the winding of relay 227, contact and armature of relay 226 to ground at the contact and right-hand armature of relay 207. Relay 227, however, does not energize at this time, since its winding is shunted out by the direct circuit to ground at the armature and contact of the stepping relay 205. As the brush shaft reaches the first tripping position, brush 321 encounters the first metallic segment of commutator 322. A circuit is then closed from battery through the left-hand winding and front contact and inner armature of relay 301, lower right-hand contact 336 (1+4), lower left-hand contact 336 (1¾+2), commutator 322, brush 321 to ground. Relay 321 remains energized in this circuit while the stepping relay 205 in the fundamental circuit is shunted out and releases its armature. The shunt circuit is now removed from around the winding of relay 227 and this relay becomes energized in series with relay 226. When brush 321 disengages the first metallic segment of commutator 322, the shunt is removed from the winding of relay 205 and this relay again attracts its armature. The stepping circuit is now extended by way of conductor 221, armature and front contact of relay 227, inner right-hand armature and back contact of relay 238, winding of relay 234 to battery and ground. Relay 234 attracts its armature and completes a circuit from battery through the winding of said relay, back contact and inner right-hand armature of relay 238 through the windings of relays 236 and 235 in parallel, outer right-hand armature and back contact of relay 238, contact and armature of relay 234 to ground at the right-hand armature of relay 207. Relays 236 and 235 remain deenergized since their windings are shunted out by the direct circuit to ground at the stepping relay 205. As soon as the next brush tripping position is reached by the brush shaft 341, stepping relay 205 deenergizes and relays 236 and 235 lock up in series with the counting relay 234. Relay 235 opens the fundamental circuit. Relay 236 at its left-hand armature closes a circuit for relay 207. Relay 207 is constructed so as to attract its armatures slowly after its energizing circuit is completed and also to release its armatures slowly after the circuit is opened. Relay 236 also completes a circuit from ground through its right-hand armature and contact, armature and back contact of relay 209, winding of relay 208 to battery and ground. Relay 208 energizes and completes a circuit through its winding and the winding of relay 209 in series, contact and left-hand armature of relay 208, conductor 239 to ground at the right-hand armature and contact of relay 202. Relay 209, however, is not energized at this time, since its

winding is shunted out by the circuit above traced to ground at the right-hand armature of relay 236. After the necessary time has elapsed following the energization of relay 236, the slow operating relay 207 attracts its armatures and opens the locking circuits of all counting relays. Relay 235 deenergizes and again closes the fundamental circuits at its armature and contact. Relay 236 releases its armatures and opens the shunt around the winding of relay 209, whereby this relay energizes and locks up in series with relay 208. Relay 236 also opens the circuit of relay 207 which commences to deenergize. During the time relay 207 is operated the fundamental circuit is held open at the left-hand armature and contact of said relay.

As soon, after the opening of the fundamental circuit at the armature of relay 235, as the brush 321 engages the next insulating segment of commutator 322, relay 301 becomes deenergized. A circuit is then completed from ground through the outer armature and back contact of relay 301, upper right-hand contact 325 (2), winding of sequence switch magnet 300 to battery and ground, driving switch 300 out of position 2 and into position 3. Relay 301 on releasing also opens the circuit of the updrive power magnet 307, whereby the switch shaft 341 ceases its upward movement. With sequence switch 300 in position 3, the tripping magnet 309 is energized in a circuit including contact 335 (3+4). The magnet 309 rotates the trip spindle preparatory to tripping the selected set of brushes upon the next upward movement of the shaft 341.

After relay 207 becomes deenergized, and provided sequence switch 300 has reached position 3, the fundamental circuit is again completed and relay 301 energizes in series with the stepping relay 205. Relay 301 completes a circuit from ground through its outer armature and front contact, lower contact 328 (3), winding of sequence switch magnet 300 to battery and ground. Sequence switch 300 advances into position 4 and relay 301 remains energized in a circuit through its left-hand winding and front contact and inner armature, lower right-hand and upper left-hand contacts 336 (1+4), thence to ground as above described over the fundamental circuit. Relay 301 again closes the circuit for the updrive power magnet 307, this time in position 4 of sequence switch contact 328. Magnet 307 energizes and the brush shaft 341 is driven upwardly to select the proper group of trunk terminals.

The stepping relay 205, energizing in the fundamental circuit, closes a circuit from ground through its contact and armature, conductor 237, right-hand armatures and back contacts of relays 214, 212 and 210 in series, right-hand armature and front contact of relay 208, conductor 217, brush 512 of the thousands register, terminal 538, brush 513 of the hundreds register, terminal 539, conductor 222, winding of relay 234 to battery and ground. Relay 234 operates and prepares a holding circuit for itself in series with the windings of relays 236 and 235. These latter relays, however, do not energize so long as stepping relay 205 maintains its armature attracted.

As soon as the selected set of brushes 310, 311 and 312 reach the first group of terminals, the brush 320 engages a metallic segment of commutator 323. A circuit is thereby closed from battery through the left-hand winding and front contact and inner armature of relay 301, contact 326 (3¾+4), commutator 323, brush 320 to ground. This circuit causes the stepping relay 205 to be shunted. Relay 205 upon releasing its armature, opens the short-circuit around the windings of relays 236 and 235 and these relays lock up in series with relay 234. Relay 235 opens the fundamental circuit while relay 236 at its left-hand armature closes the energizing circuit of slow operating relay 207. Relay 236 at its right-hand armature completes a circuit from ground through the armature and front contact of relay 209, armature and back contact of relay 211, winding of relay 210 to battery and ground. Relay 210 attracts its armatures and closes a series circuit for itself and the winding of relay 211 to ground at the right-hand armature and contact of relay 202. Relay 211, however, does not energize due to the shunt circuit closed at the right-hand armature of relay 236. After an interval, relay 207 attracts its armatures and opens the locking circuits of the counting relays. Relay 236 opens the circuit of relay 207 and at its right-hand armature removes the shunt from around the winding of relay 211. Relay 211 now actuates and locks up to the grounded conductor 239 in series with relay 210. When the brush 320 engages the next insulating segment of commutator 323 following the opening of the fundamental circuit at the sender, relay 301 deenergizes and opens the circuit of the updrive power magnet 307. The brushes 310, 311 and 312, therefore, come to rest in operative relation to the selected group of terminals. Relay 301 also closes a circuit from ground through its upper armature and back contact, upper right-hand contact 325 (4), winding of sequence switch magnet 300 to battery and ground. Sequence switch 300 is driven out of position 4 and into position 5.

Immediately that sequence switch 300 reaches position 5, a circuit is closed from battery through the right-hand winding of relay 301, contact 327 (5+5¼) to ground.

Relay 301 operates and completes a circuit from ground through its outer armature and front contact, lower contact 328 (5), winding of sequence switch magnet 300 to battery and ground, driving said sequence switch out of position 5 and into position 6. When sequence switch 300 leaves position 5¼, the original energizing circuit of relay 301 is opened at contact 327. This relay, however, remains locked up, provided the first trunk in the selected group is busy. The holding circuit of relay 301 may be traced from battery through the left-hand winding and front contact and inner armature of said relay, lower left-hand contact 331 (5+6), upper right-hand contact 331 (5+15), brush 312 to the grounded test terminal 315 of the busy trunk. Relay 301 by remaining energized closes a circuit from ground through its outer armature and front contact, upper contact 328 (6), winding of the updrive power magnet 307 to battery and ground. The brushes 310, 311, and 312 are thus driven upwardly over the group of trunks in search of an idle one. As soon as the first idle trunk is encountered, the test brush 312 fails to find a ground potential on the test terminal thereof and the circuit of relay 301 is severed. This relay releases its armatures and opens the circuit of the updrive power magnet 307, causing the brushes to come to rest at the terminals of the idle trunk. Relay 301 also closes a circuit from ground through its outer armature and back contact, upper right-hand contact 325 (6) through the winding of sequence switch 300 to battery and ground, moving said sequence switch out of position 6 and into position 7. As sequence switch 300 reaches position 6¾, the selected trunk is rendered busy by means of ground potential being applied to the test terminal 315 over the following path: ground, through the lower right-hand contact 331 (6¾+15) upper right-hand contact 331 (5+15), brush 312 to the test terminal 315.

A circuit is now closed from battery through the left-hand winding of relay 301, upper contact 329 (7), lower contact 334 (7+8), brush 311, terminal 314, conductor 317, upper left-hand contact 414 (15+10) of sequence switch 400, lower right-hand contact 414 (1+8½) contact 430 (1+8½) to ground. Relay 301 becomes energized and locks up in a circuit from battery through its left-hand winding and front contact and inner armature, contact 330 (7+8), thence to ground as described at contact 430. Relay 301 by attracting its outer armature completes a circuit from ground through lower contact 328 (7) through the winding of sequence switch 300 to battery and ground. Sequence switch 300 is thereupon driven out of position 7 and into position 8.

The fundamental circuit is now extended from the sender through to the final selector switch shown in Fig. 4. This circuit may be traced from battery through the left-hand winding of relay 401, lower left-hand contact 433 (1), lower left-hand contact 413 (15+6), conductor 316, brush 310, upper left-hand contact 339 (8), conductor 114, thence as described through the stepping relay 205 and returning by way of conductor 115 to ground at the upper contact 340 (1+8). Relay 401 becomes energized in series with the stepping relay 205. Relay 401 closes a circuit from ground through its outer left-hand armature and front contact, lower contact 408 (1), winding of sequence switch magnet 400 to battery and ground. Sequence switch 400 moves out of position 1 and into position 2. Relay 401 remains locked up in position 2 of sequence switch 400 by means of the circuit from battery through the left-hand winding and contact and inner left-hand armature of relay 401, contact 409 (15+10), lower right-hand contact 433 (1+6) and thence to ground as described above. Relay 401 closes a circuit as follows for the updrive power magnet 403; battery, through the winding of said magnet, upper contact 408 (2) front contact and outer left-hand armature of relay 401 to ground. Magnet 403 causes the upward movement of the brush shaft 431 for the purpose of selecting the proper set of brushes.

Relay 205 upon energizing in the fundamental circuit closes a circuit from ground through its contact and armature, conductor 237, right-hand armature and back contact of relay 214, right-hand armature and back contact of relay 212, right-hand armature and front contact of relay 210, conductor 218, brush 515 of the hundreds register terminal 541, conductor 223, armature and back contact of relay 229, winding of relay 228 to battery and ground. Relay 228 attracts its armature and prepares a circuit for itself in series with the winding of relay 229. Relay 229 does not become energized since it is shunted out by the stepping relay 205 as above explained.

For each brush tripping position through which the brush shaft 431 is driven, the brush 425 encounters a metallic segment of the commutator 426. A circuit is thereby closed from battery through the left-hand winding and contact and inner left-hand armature of relay 401, contact 409 (15+10), lower right-hand contact 433 (1+6), upper right-hand contact 413 (1¾+2), commutator 426, brush 425 to ground. Each time this circuit is closed, the stepping relay 205 is shunted and an additional pair of counting relays are energized and locked up. When finally the last counting relays 236 and 235 are energized, the fundamental cir-

cuit is opened and the energizing circuit of relay 207 is completed. Furthermore, relay 236 at its right-hand armature closes the circuit from ground through the armature and front contact of relay 209, armature and front contact of relay 211, armature and back contact of relay 213, winding of relay 212 to battery and ground. Relay 212 becomes energized and closes a circuit for itself in series with the winding of relay 213, contact and left-hand armature of relay 212 to ground at the right-hand armature and contact of relay 202. Relay 213 does not become energized as its winding is short-circuited by the relay 236. Relay 207 energizes after an interval and the counting relays are released. Relay 236 in turn opens the energizing circuit of relay 207 and also removes the shunt from around the winding of relay 213. This latter relay now becomes energized in series with relay 212.

As soon, following the opening of the fundamental circuit at the armature and contact of relay 235, as the brush 425 engages the next insulating segment of commutator 426, the circuit of relay 401 is opened and said relay deenergizes. Relay 401 opens the circuit of the updrive power magnet 403 causing the brush shaft 431 to stop and also completes a circuit from ground through its outer left-hand armature and back contact, upper left-hand contact 407 (2), through the winding of sequence switch 400 to battery and ground. Sequence switch 400 advances from position 2 into position 3. In position 3, tripping magnet 405 is energized in a circuit including the contact 412 (3+4). Magnet 405 rotates the trip spindle to a position where it will be effective in tripping the selected set of brushes on the next upward movement of the shaft 431.

With the sequence switch 400 in position 3 and relay 207 deenergized, the fundamental circuit is closed for controlling the tens selective movement of the switch. The fundamental circuit in this case is the same as in the circuit heretofore traced with the exception that sequence switch 400 is standing in position 3 instead of position 1. Relay 401 becomes energized and closes a circuit from ground through its outer left-hand armature and front contact and lower contact 408 (3) for driving sequence switch 400 into position 4. In this position, relay 401 remains energized in a locking circuit from battery through its left-hand winding and contact and inner left-hand armature, contact 409 (15+10) and thence over the fundamental circuit as heretofore traced. Relay 401 also recloses the circuit for the updrive power magnet 403 and the brush shaft 431 is driven upwardly to select the proper group of ten terminals.

Stepping relay 205 at the sender upon energizing, closes a circuit from ground through its contact and armature, conductor 237, right-hand armature and back contact of relay 214, right-hand armature and front contact of relay 212, conductor 219, brush 516 of the tens register, terminal 542, conductor 224, armature and back contact of counting relay 231, winding of relay 230 to battery and ground. Relay 230 energizes and prepares a circuit for itself and relay 231. Each time the brushes 418, 419 and 420 pass over a group of ten terminals, the brush 424 engages a metallic segment of commutator 428 and the following circuit is closed to shunt the stepping relay 205 in the fundamental circuit: battery, through the left-hand winding and contact and inner left-hand armature of relay 401, contact 409 (15+10), lower right-hand contact 433 (1+6), upper right-hand contact 433 (3¾+4), commutator 428, brush 424 to ground. For each deenergization of stepping relay 205, a pair of counting relays are energized and locked up until finally the counting relays 235 and 236 are operated. Relay 235 opens the fundamental circuit and relay 236 causes the deenergization of relay 227. Relay 236 also closes a circuit from ground through its right-hand armature and contact, armature and front contact of relay 209, armature and front contact of relay 211, armature and front contact of relay 213, armature and back contact of relay 215, winding of relay 214 to battery and ground. Relay 214 energizes and prepares a circuit for itself and the winding of relay 215. After an interval, relay 207 attracts its armature and opens the locking circuit of the energized counting relays. Relay 236 in turn opens the energizing circuit of relay 207, which commences to deenergize. Relay 236 at its right-hand armature removes the shunt from around the winding of relay 215 and this latter relay locks up in series with relay 214.

After the fundamental circuit has been opened at the sender and brush 424 engages the next insulating segment of commutator 428, the circuit of relay 401 is opened. Relay 401 thereupon deenergizes and opens the circuit of the updrive power magnet 403. Relay 401 also completes a circuit from ground through its outer left-hand armature and back contact, upper left-hand contact 407 (4), through the winding of sequence switch magnet 400 to battery and ground. Sequence switch 400 moves out of position 4 and into position 5.

As soon as the slow operating relay 207 retracts its armatures, the fundamental circuit is again closed and relay 401 energizes in series with stepping relay 205 to control the units selective movement. Relay 401 at its outer left-hand armature and front con-

tact closes a circuit for driving sequence switch 400 out of position 5 and into position 6. In this position relay 401 remains locked up in the circuit above traced. Relay 402 is energized at this time in a circuit from battery through the winding of said relay, contact 415 (6+17), conductor 318, terminal 315, brush 312, upper right-hand contact 331 (5+15), lower right-hand contact 331 (6¾+15) to ground. Relay 401 also completes a circuit from battery through the winding of the updrive power magnet 403, upper contact 408 (6) to ground at the front contact and outer left-hand armature of relay 401. Magnet 403 energizes and the brushes 418, 419 and 420 are driven over the group of ten terminals to select the terminals of the called subscriber's line.

The stepping relay 205 completes a circuit from ground through its contact and armature, conductor 237, right-hand armature and front contact of relay 214, conductor 220, brush 517, terminal 543, conductor 225, armature and back contact of relay 233, winding of relay 232 to battery and ground. Relay 232 becomes energized and prepares a circuit for itself in series with the winding of relay 233. For each set of terminals passed over by the brushes 418, 419 and 420, the brush 425 engages a metallic segment of commutator 427 and the following circuit is established to shunt the stepping relay 205 in the fundamental circuit: battery, through the left-hand winding and contact and inner left-hand armature of relay 401, contact 409 (15+10), lower right-hand contact 433 (1+6), upper right-hand contact 413 (5¾+6), commutator 427 brush 425 to ground. Each time the stepping relay 205 deenergizes, a pair of counting relays are energized and locked up. When finally, the relays 236 and 235 are operated, the fundamental circuit is opened and the circuit of relay 207 is completed. Relay 236 also establishes a circuit from ground through its right-hand armature and contact, armatures and front contacts of relays 209, 211, 213 and 215 in series, winding of relay 203 to battery and ground. Relay 203 energizes before the relay 207 has time to attract its armatures. The energized counting relays are, therefore, held operated in a circuit closed to ground at the contact and left-hand armature of relay 203. Relay 203 also at its right-hand armature completes a circuit for relay 202. Relay 202 which is slow to attract its armatures operates after the lapse of a time interval and removes ground from the conductor 239. This permits the relays 208 to 215 inclusive to deenergize and retract their armatures. The release of relays 209, 213 and 215 opens the series energizing circuit for relay 203. Relay 203 deenergizes and opens the holding circuit of the counting relays. Relay 236 upon deenergizing opens the holding circuit of relay 207, which, after an interval of time, releases its armatures. At the time relay 202 attracts its armatures, the circuit of relays 200 and 105 is opened. Relay 200 deenergizes and causes the lamp 201 to be retired. Relay 105 also deenergizes and disconnects the fundamental circuit from the tip and ring conductors of the outgoing trunk 114 and 115 and extends said trunk through to the right-hand windings of the repeating coil 103 in the operator's cord circuit.

As soon, after the fundamental circuit is opened at the sender, as the brushes 418, 419 and 420 are accurately centered on terminals 421, 422 and 423 of the called subscriber's line, the brush 425 engages an insulating segment of commutator 427. Relay 401 is therefore deenergized and opens the circuit of the updrive power magnet 403. Relay 401, furthermore, closes a circuit including its outer left-hand armature and back contact and upper left-hand contact 407 (6) for driving sequence switch 400 out of position 6 and into position 16. A test of the condition of the called subscriber's line is made while sequence switch 400 is passing through position 12. Assume in this case that the called subscriber's line is idle when the test is made. The test circuit may be traced from battery, through the right-hand winding of relay 401, upper left-hand contact 411 (12), upper right-hand contact 411 (12+16), test brush 420 to the test terminal 423. Since the line is idle at this time no ground potential exists at terminal 423 and consequently, the relay 401 remains inactive. Sequence switch 400, therefore, comes to rest in position 16 which is the talking position.

As sequence switch 400 moves out of position 8½, its contacts 414 and 430 are opened and the heretofore traced circuit of relay 301 is severed. Relay 301 becomes deenergized and completes a circuit to ground, through its outer armature and back contact, upper right-hand contact 324 (8), winding of sequence switch 300 to battery and ground. Sequence switch 300 moves out of position 8 and into position 15, which is the ringing and talking position for this sequence switch. In position 15 a circuit is closed from battery through the winding of relay 304, armature and back contact of relay 306, armature and contact of relay 305, contact 332 (15) to ground. A circuit is also closed from battery, through the windings of relays 304 and 306 in series to ground at the contact 332. Relay 304 becomes energized, but relay 306 remains inert since its winding is shunted out by the circuit traced through the armature and contact of relay 305. Relay 304 closes a circuit from the

source of ringing current 342, through the winding of relay 305, front contact and lower armature of relay 304, upper contact 334 (15+16), brush 311, terminal 314, conductor 317, upper left-hand contact 414 (15+10), upper right-hand contact 114 (16), brush 419, terminal 422 over the loop of the called subscriber's line, terminal 421, brush 418, lower right-hand contact 413 (16), lower left-hand contact 413 (15+6), conductor 316, terminal 313, brush 310, contact 333 (15+16), upper armature and contact of relay 304 to ground. Since the relay 305 is marginal, it does not operate in series with the high resistance of the ringer at the called substation.

When, however, the called subscriber responds the resistance in series with relay 305 is so reduced that this relay attracts its armature and removes the short-circuit from around the winding of relay 306. Relay 306 thereupon energizes in series with relay 304. Relay 306 now completes a circuit from battery through its front contact, and armature and winding to ground at contact 332. This circuit shunts out the relay 304 and permits the same to release its armatures. Relay 304 opens the ringing circuit and closes the trunk conductors 316 and 317 through to the right-hand windings of the repeating coil 319. Since the called subscriber's receiver is off the switch-hook, a circuit is now completed from battery, through the lower right-hand winding of repeating coil 319, winding of relay 303, thence over the ring side of the line, through the loop of the called substation and returning over the tip side of the line through the upper right-hand winding of repeating coil 319 to ground.

Returning to the point where sequence switch 300 is driven from position 8 to 15, it will be noted that as said sequence switch arrives in position 14, a circuit is closed from battery, through the left-hand winding of relay 302, contact 338 (14+15), through the upper left-hand winding of repeating coil 319, upper right-hand contact 339 (14+16), conductor 114, upper armature and contact of relay 113, tip of jack 112, tip of plug 111, uppermost armature and contact of relay 105, upper right-hand winding of repeating coil 103 to ground. Relay 302 becomes energized through its left-hand winding. When sequence switch 300 reaches position 15, the following circuit is closed for the right-hand winding of said relay: battery, through the lower right-hand winding of repeating coil 103, winding of supervisory relay 106, back contact and lowermost armature of relay 105, ring of plug 111, ring of jack 112, contact and lower armature of relay 113, conductor 115, lower contact 340 (14+16), lower left-hand winding of repeating coil 319, resistance 343, upper contact 337 (15), right-hand winding of relay 302 to ground. Due to the high resistance 343 sufficient current does not flow in this circuit to permit the energization of relay 106. When, as explained, the called subscriber removes his receiver from the switchhook in response to the ringing of his substation bell, relay 303 becomes energized, a short-circuit is closed around the high resistance 343. The resistance 343 being thus removed from the circuit of relay 106, this relay attracts its armature and closes a circuit as follows to shunt out the supervisory lamp 107: battery through the contact of said relay, resistances 108 and 109, conductor 110 to ground through the winding of relay 113. The extinguishment of lamp 107 notifies the operator in the manual office that the called subscriber has responded.

After conversation has been completed, the called subscriber by replacing the receiver to the switchhook permits the deenergization of relay 303, which opens the shunt around resistance 343 and relay 106 in the operator's cord circuit again deenergizes. The lamp 107 now becomes illuminated and the operator knows that the called subscriber has hung up his receiver. In order to disconnect, she removes the plug 111 from jack 112 of the trunk circuit. The removal of the plug from the jack, opens the above traced circuit of relay 302. Relay 302 becomes deenergized and completes a circuit from ground through its armature and contact, upper left-hand contact 325 (15+17), through the winding of sequence switch 300 to battery and ground. Sequence switch 300 moves out of position 15 and into position 18. In this position a circuit is completed for the downdrive power magnet 308, including sequence switch contact 334 (18). The brush shaft 341 is restored to normal in the well-known manner and at which time a circuit is closed from battery through the winding of sequence switch 300, lower left-hand contact 325, normal segment 324, brush 320 to ground. Sequence switch 300 advances into position 1.

As sequence switch 300 moves out of position 15, it opens at its right-hand contacts 331, the holding circuit of relay 402. Relay 402 deenergizes and completes a circuit to ground, through its armature and contact, lower left-hand contact 407 (6¾+17), winding of sequence switch 400 to battery and ground. Sequence switch 400 moves out of position 16 and into position 18. In this position a circuit is closed including contact 416 (18) for the downdrive power magnet 404. Magnet 404 causes the restoration of the brush shaft 401. When said shaft reaches its normal position, a circuit is completed from battery through the winding of sequence switch magnet 400, lower

right-hand contact 407 (18), normal segment 429, brush 424 to ground. Sequence switch 400 thereupon advances out of position 18 and into position 1.

It will next be considered that the called subscriber's line 432 is busy at the time the sequence switch 400 of the final selector passes through position 12. This being the case, relay 401 is energized over the test circuit heretofore traced to the grounded test terminal 423. Relay 401 locks up in a circuit from battery through its right-hand winding and contact and right-hand armature to ground and contact 410 (12+16). When sequence switch 400 reaches position 16, it continues to advance into position 17 by means of the following circuit: battery, through the winding of said sequence switch, lower contact 408 (16), front contact and outer left-hand armature of relay 401 to ground. Since sequence switch 400 is now in position 17, ringing current is withheld from the subscriber's line by reason of the fact that the circuit leading to the brushes 418 and 419 is opened at contacts 413 and 414. With sequence switch 400 in position 17, the tip and ring conductors 315 and 317 are extended over contact 434 and 435 to the interrupter 417. At the first closure of this interrupter, the relay 305 is energized and ringing current is disconnected from the trunk in the manner above described. After the deenergization of relay 304, the interrupter 417 causes the successive energization and deenergization of relay 303. Relay 303 by closing and opening the shunt circuit around resistance 343 causes the supervisory relay 106 in the operator's cord circuit to become successively energized and deenergized. The flash of lamp 107 advises the operator that the called line is busy. She communicates this information to the calling subscriber and proceeds to disestablish the connection by removing plug 111 from the trunk jack 112. The incoming selector switch shown in Fig. 3 is restored to normal as heretofore described. When the test conductor 318 is opened, relay 402 releases its armature and sequence switch 400 at the final selector moves from position 16 to 18. In this position, the brush shaft is returned to normal and the sequence switch 400 is thereupon restored to position 1.

What is claimed is:

1. In a telephone exchange system, an automatic switch, a connecting circuit, means for extending a connection over said circuit to the automatic switch, a register controlling mechanism including a plurality of rotatable registers, manually operable means for adjusting said registers to their set positions, means for associating said mechanism with the connecting circuit, an impulse counting device operable in accordance with the set positions of said registers, and means controlled by said counting device for determining the operation of said automatic switch.

2. In a telephone exchange system, a plurality of automatic switches, a trunk circuit, means for extending a connection over said trunk to the automatic switches, a register controlling mechanism including a plurality of rotatable registers, manually operable means for adjusting said registers to their set positions, means for associating said mechanism with the connecting circuit, an impulse counting device controlled in accordance with the set positions of said registers and while the registers are in such positions, and means controlled by said counting device for determining the operation of said automatic switches.

3. In a telephone exchange system, a plurality of automatic switches, a trunk circuit, means for extending a connection over said trunk to the automatic switches, a register controlling mechanism including a plurality of rotatable registers arranged to be adjusted manually to their set positions, means for associating said mechanism with the connecting circuit, an impulse counting device controlled in accordance with the set positions of said registers and while the registers are in such positions, means controlled by said counting device for determining the operation of said automatic switches, and manual means for simultaneously restoring said registers to their normal positions.

4. In a telephone exchange system, automatic switches, a trunk circuit, means for extending a connection over said trunk to the automatic switches, a register controlling mechanism including a plurality of rotatable registers, manually operable means for adjusting said registers to their set positions, means for associating said mechanism with the trunk circuit, a series of counting relays operable in accordance with the set positions of said registers and while the registers are in such positions, and means controlled by said counting relays for determining the operation of the automatic switches.

5. In a telephone exchange system, automatic switches, a trunk circuit, means for extending a connection over said trunk to the automatic switches, a plurality of registers comprising series of stationary terminals, each series disposed on the arc of a circle, brushes for said registers, manually operable means for rotating each of said registers to engage said terminals, an impulse counting mechanism, means for associating said mechanism with the trunk circuit, and means for variably operating said mechanism in accordance with the settings of said registers to control the selective operations of said automatic switches.

6. In a telephone exchange system, automatic switches, an operator's position, a

trunk circuit, means at the operator's position for extending a connection over said trunk circuit to the automatic switches, a register controlling mechanism including a plurality of rotatable registers, manually operable means for adjusting said registers to their set positions, means for associating said mechanism with the trunk circuit, an impulse counting device operable in accordance with the set positions of said registers and while said registers are in such positions, and means controlled by said counting device for determining the operation of the automatic switches.

7. In a telephone exchange system, automatic switches, an operator's position, a trunk circuit, means at the operator's position for extending a connection over said trunk circuit to the automatic switches, a register controlling mechanism including a plurality of rotatable registers, manually operable means for adjusting said registers to their set positions, a key for associating said mechanism with the trunk circuit, an impulse counting device operable in accordance with the set positions of said registers and while said registers are in such positions, and means controlled by said counting device for determining the operation of the automatic switches.

8. In a telephone exchange system, automatic switches, an operator's position, a trunk circuit, means at the operator's position for extending a connection over said trunk circuit to the automatic switches, a register controlling mechanism including a plurality of rotatable registers arranged to be adjusted manually by the operator to their set positions, a key for associating said mechanism with the trunk circuit, an impulse counting device operable in accordance with the set positions of said registers and while said registers are in such positions, means controlled by said counting device for determining the operation of said automatic switches, and a manually operable key for simultaneously restoring said registers to their normal positions.

9. In a telephone exchange system, automatic switches, an operator's position, a trunk circuit, a plurality of connecting circuits at the operator's position for extending a connection over said trunk circuit to the automatic switches, a register controlling mechanism at said operator's position common to all said connecting circuits including a plurality of rotatable registers arranged to be adjusted manually by the operator to their set positions, a key for associating said mechanism with one of said connecting circuits, a series of counting relays operable in accordance with the set positions of said registers, means controlled by said counting relays for determining the operation of the automatic switches and manual means for simultaneously restoring said registers to their normal position.

In testimony whereof, I have signed my name to this specification this 1st day of December, 1920.

WILLIAM A. RHODES.