

Jan. 29, 1929.

1,700,467

E. H. CLARK

TELEPHONE EXCHANGE SYSTEM

Filed Aug. 4, 1927

9 Sheets-Sheet 1

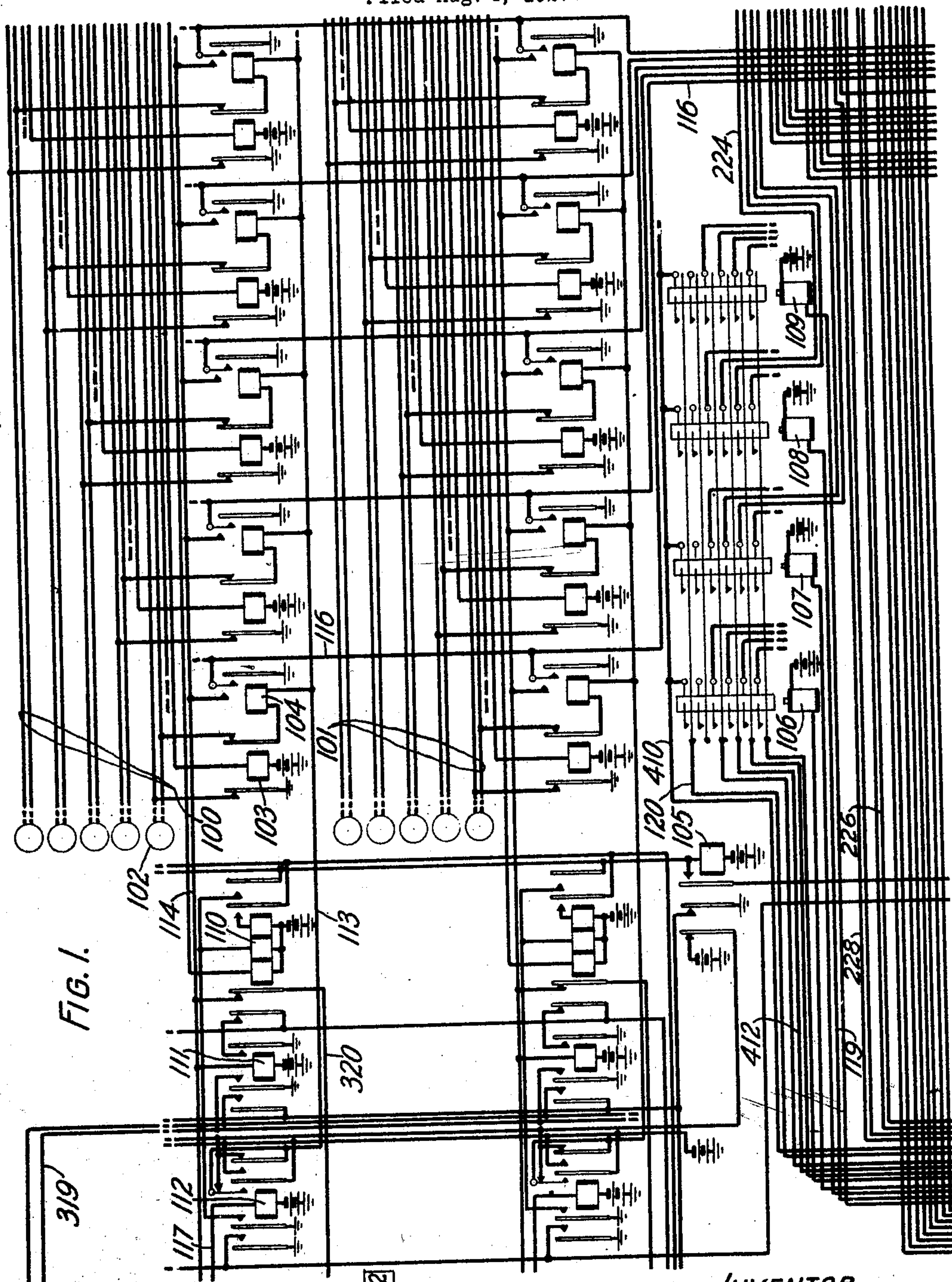


FIG. 1.

FIG. 10.

FIG. 3	FIG. 1	FIG. 2
FIG. 4	FIG. 7	
FIG. 5	FIG. 8	
FIG. 6	FIG. 9	

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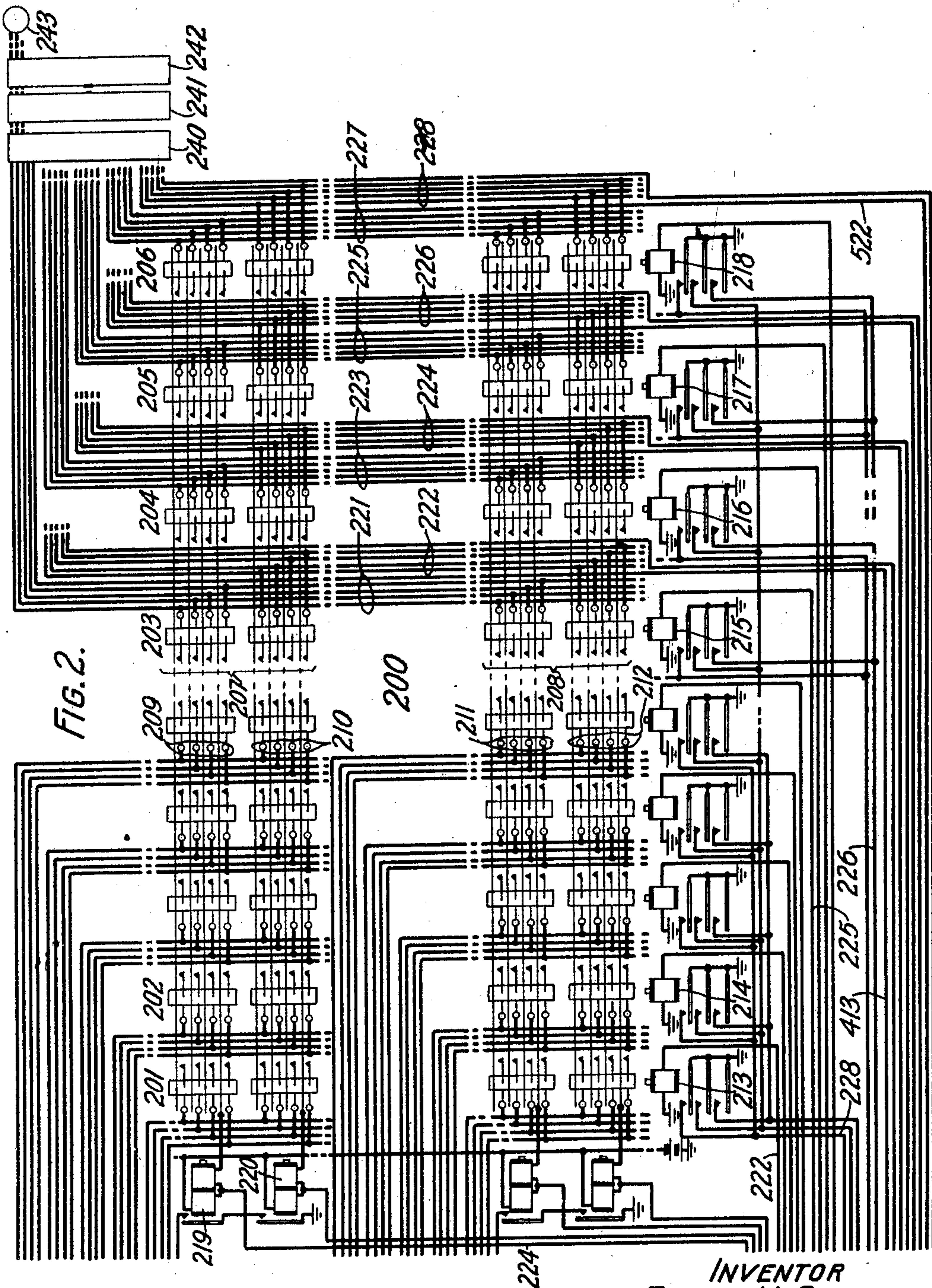
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9 Sheets-Sheet 2



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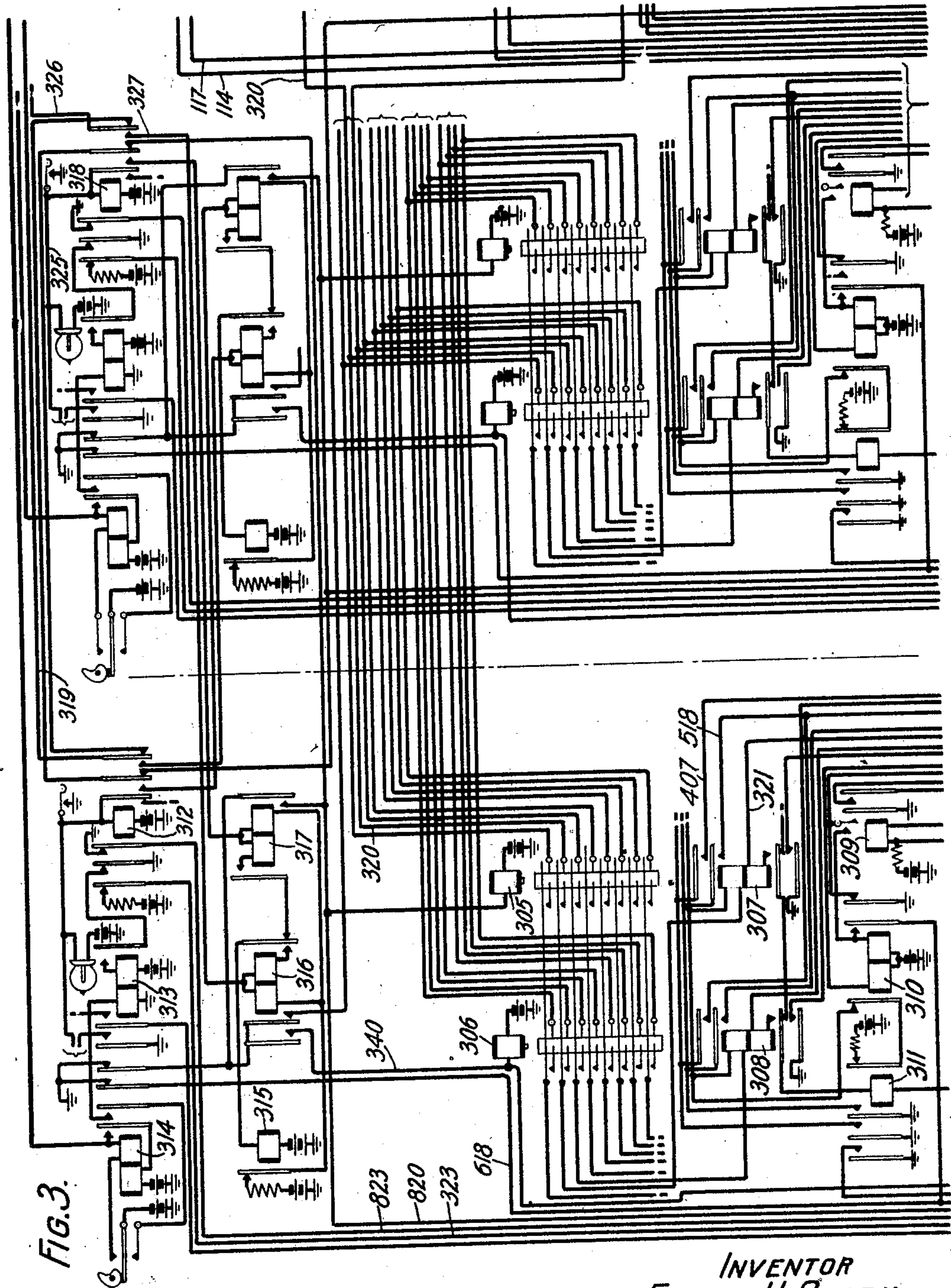
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9 Sheets-Sheet 3



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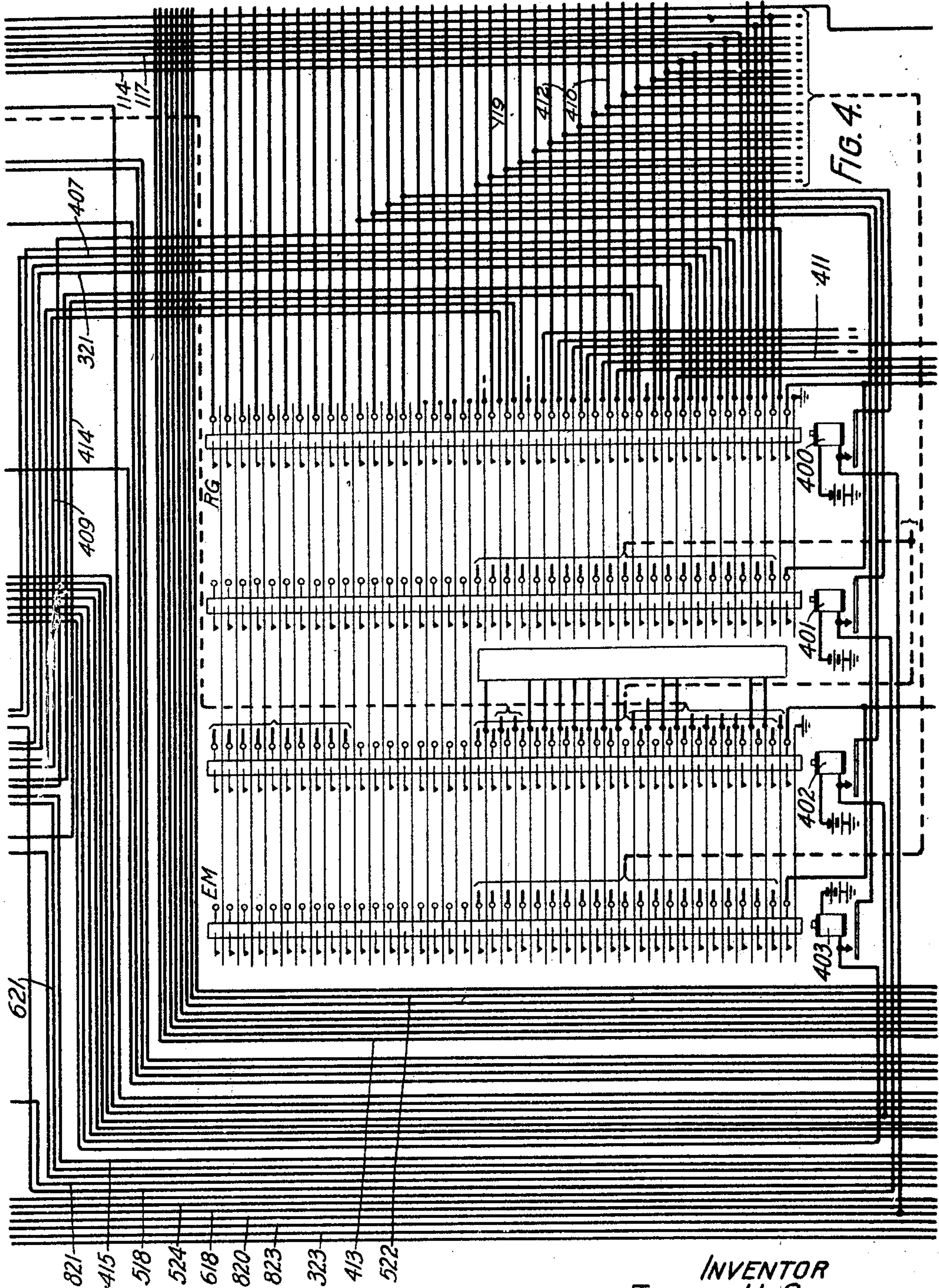
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9 Sheets-Sheet 4



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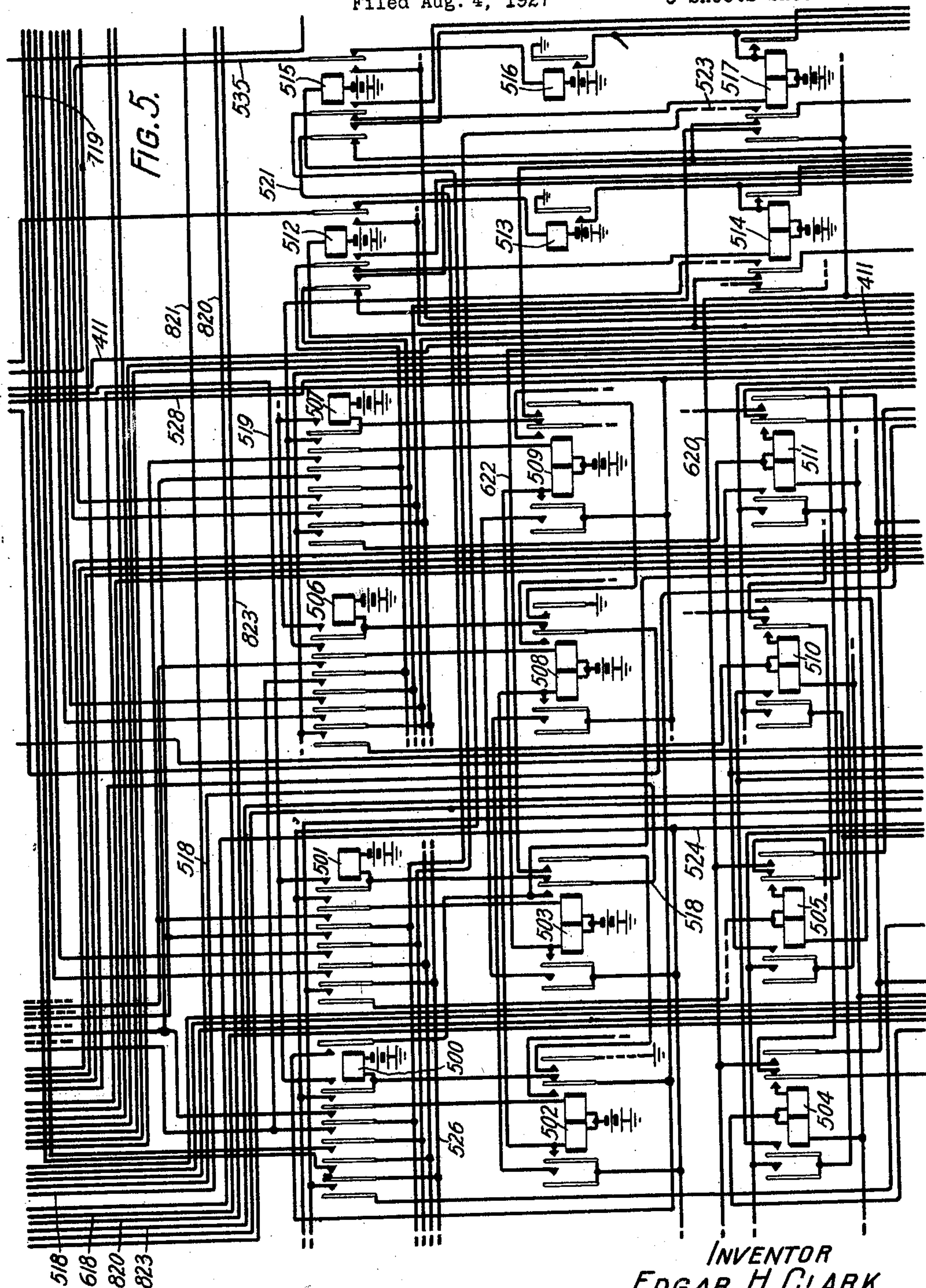
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Filed Aug. 4, 1927

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9 Sheets-Sheet 6

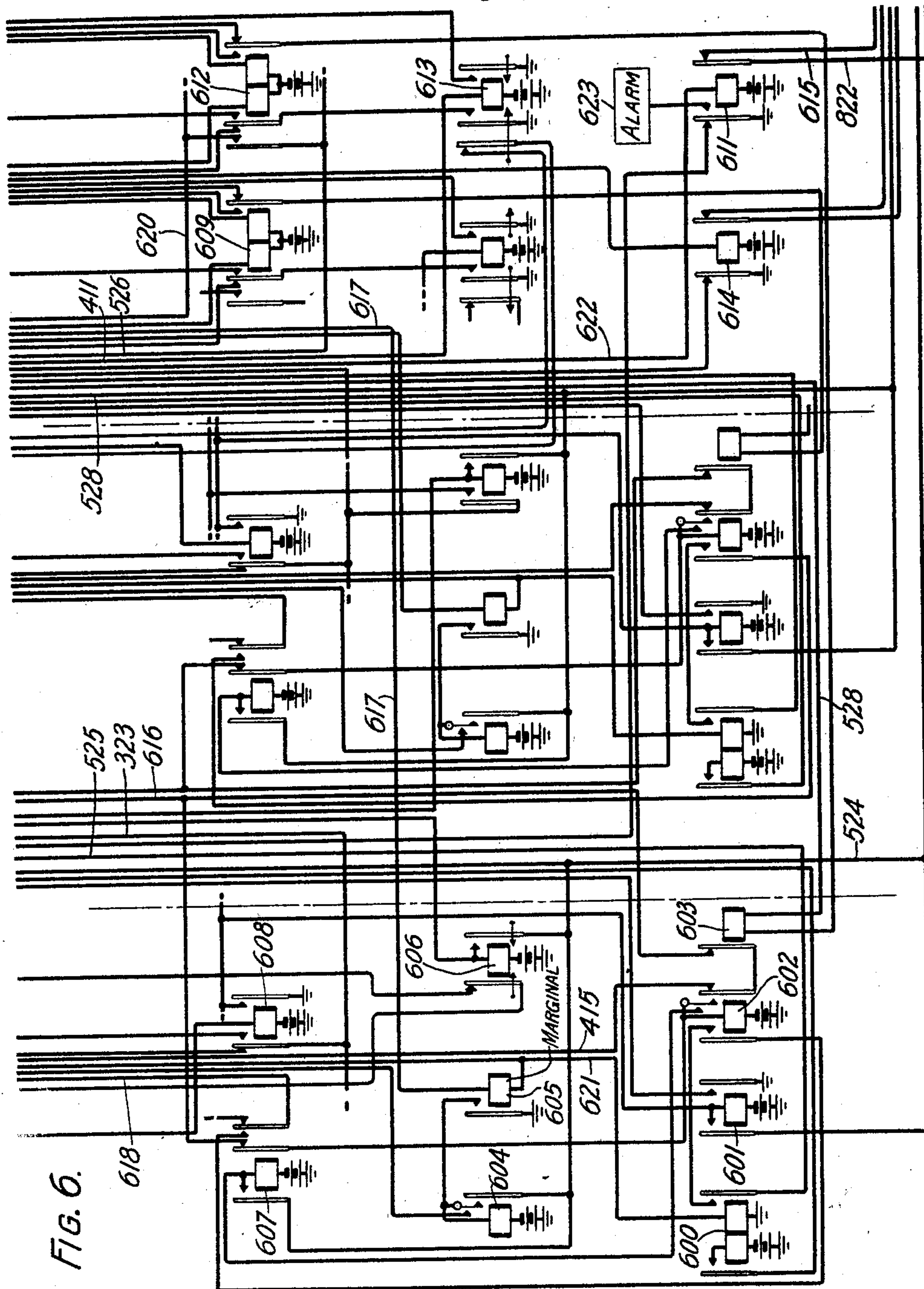


FIG. 6.

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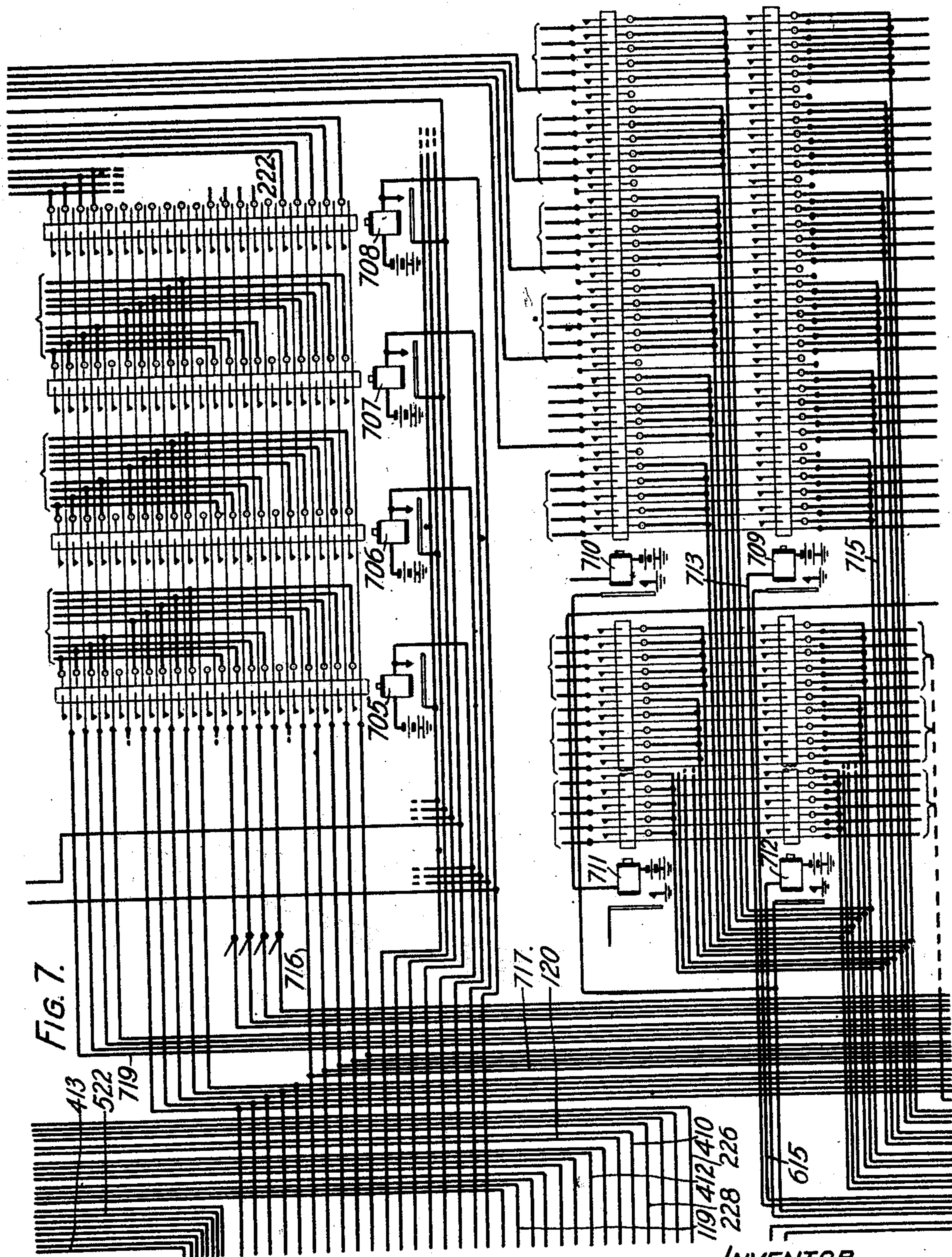
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9 Sheets-Sheet 7



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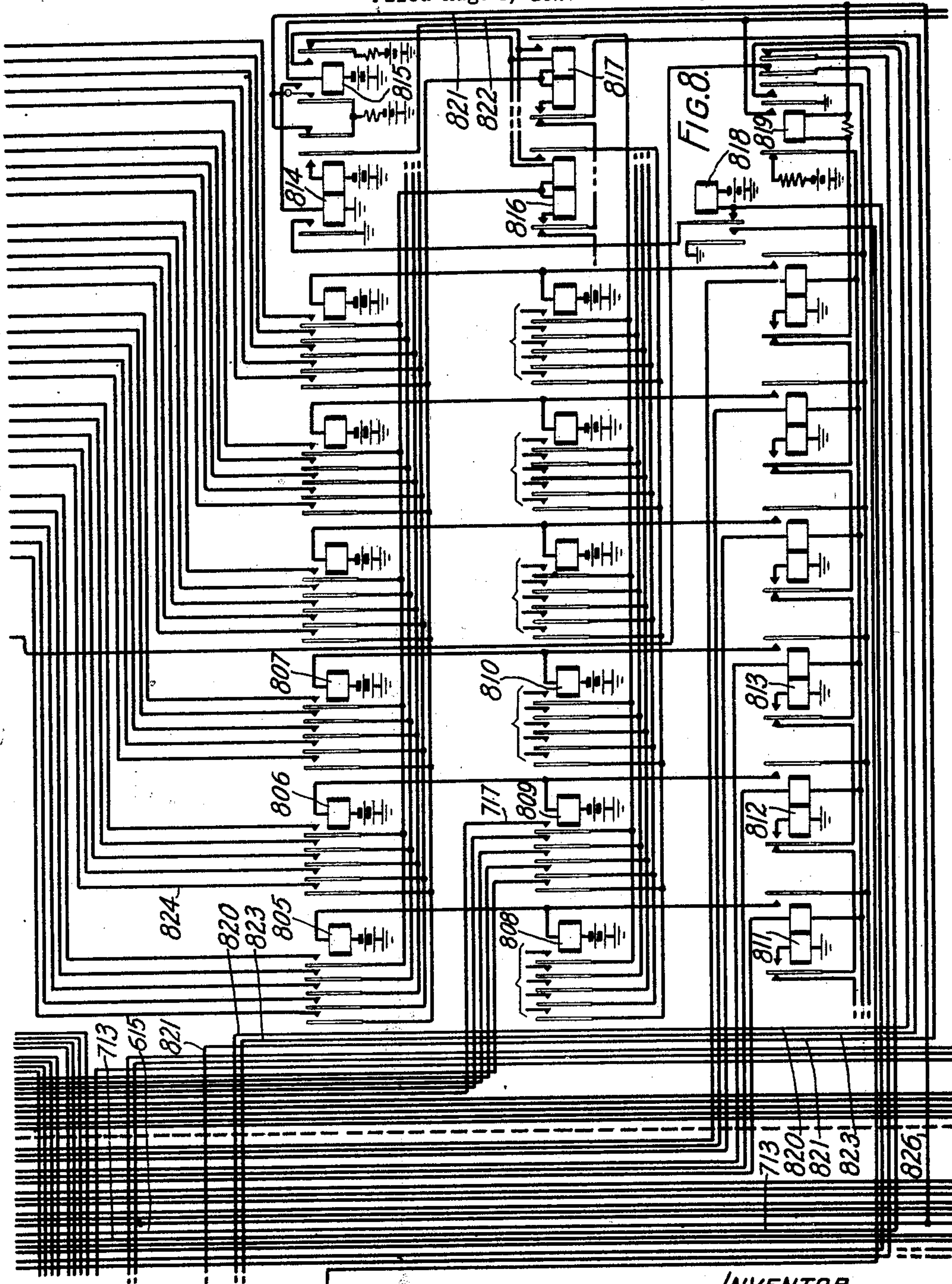
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9 Sheets-Sheet 8



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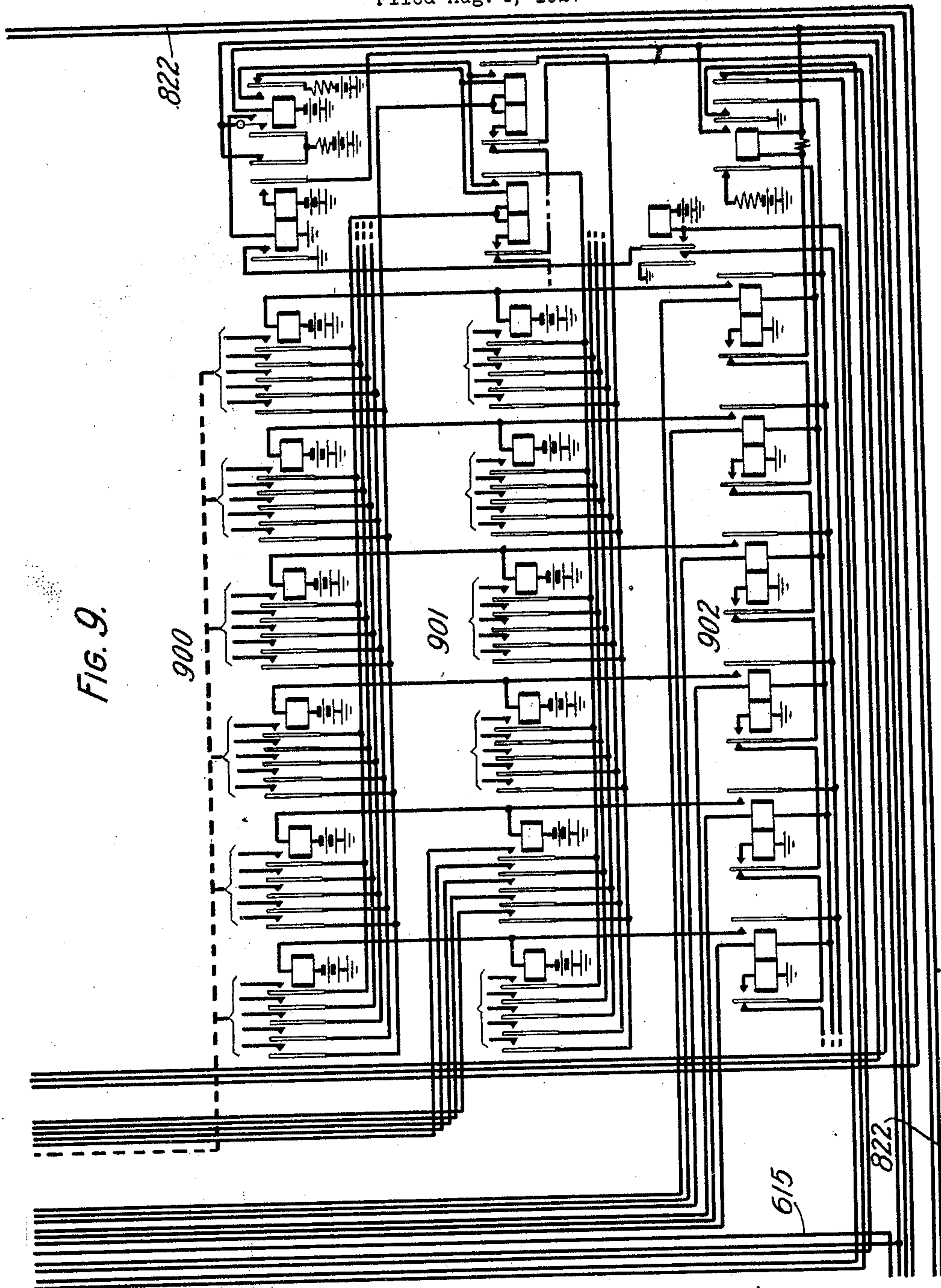
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9 Sheets-Sheet 9



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UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE SYSTEM.

Application filed August 4, 1927. Serial No. 210,516.

This invention relates to telephone exchange systems and its object is to improve the control and operation of automatic switches.

5 According to a feature of the invention, a master control circuit normally serves to control a plurality of line switches and a second master circuit normally controls another plurality of line switches to extend
10 calling lines, either control circuit, however, being capable under certain conditions of controlling all said line switches.

Another feature of the invention is a master circuit having group and individual relays for determining which of a plurality
15 of subscriber's line is to receive attention when calling, other calling lines being delayed temporarily.

According to a further feature, a plurality of trunks, arranged in groups and multiplied before a number of line switches, are tested, a plurality of groups at a time, until
20 an idle trunk is found.

According to a further feature, the line
25 relays do not start a master circuit in operation unless they are in condition to exercise full control over such master circuit by also operating certain other relays in the master circuit.

30 Referring to the drawing, Figs. 1 to 9 inclusive, when arranged in the order shown in Fig. 10, disclose the details of a system embodying the invention.

Fig. 1 shows a number of subscribers' lines
35 together with certain controlling apparatus.

Fig. 2 shows one of a number of coordinate line switches in which the subscribers' lines terminate.

40 Fig. 3 shows a portion of two master controlling circuits.

Fig. 4 illustrates the connectors for connecting the master circuits to the line switch frames.

45 Figs. 5 and 6 show portions of the two master circuits.

Fig. 7 illustrates connectors for connecting the master controlling circuits to the line switches.

50 Fig. 8 shows the group and units relays in one of the master circuits for determining the group of calling lines to receive attention.

Fig. 9 shows similar relays for the second master controlling circuit.

55 The line switches are of the coordinate

type such as disclosed and described in the patent to S. B. Williams 1,517,331, granted December 2, 1924 and in my copending application, Serial No. 39,883, filed June 27, 1925, Patent No. 1,659,083, granted February
60 14, 1928.

The present system contemplates the use of a master control circuit normally controlling each of two line switches and a second master controlling circuit for a second
65 pair of line switches. The subscribers' lines are distributed among the four line switch frames of the two pairs, no line appearing in more than one line switch. The trunks outgoing from the four line switches comprise a single group, each trunk appearing
70 in each of the four switches.

Normally, each master circuit controls its pair of line switches to extend the calling lines to the group of trunks independently
75 of the other master circuit. Certain provisions are made whereby interference is prevented when both master circuits are attempting simultaneously to extend calls. In the case of trouble in one of the master circuits, or if for any reason a master circuit is disabled or taken out of service, the circuits are so arranged that the other master controlling mechanism can control all four of
80 the line switches.

Referring to Fig. 2, the calling subscribers' lines appear in the line switch 200 and similarly in the other switches (not shown) in vertical rows of contacts. The vertical rows 201, 202, etc., are illustrated. The trunks
85 outgoing from the line switch also appear in vertical rows 203, 204, 205, 206, etc. Each switch is divided into a number of horizontal groups of which two groups 207 and 208 are illustrated. The group 207 includes a plurality of horizontal links 209, 210, etc. Likewise, the group 208 includes a number of links 211, 212, etc. It will be noted that the subscribers' lines 100 and 101 each appear before the links of a single horizontal group.
90 Each of the trunks 221 to 228 appears before one horizontal link in each of the horizontal groups.

The multi-contact relay 305 shown in Fig. 3 serves to connect the individual line circuits through to the horizontal group relays 307, 308, etc., in the master circuit which normally controls the pair of switches including the switch 200. The relay 306 is used in case of emergency to connect the in-
105 110

dividual line circuits appearing in the other pair of line switches to the first master control circuit. The relays shown to the right of the broken line in Fig. 3 perform similar functions in connection with the second master circuit.

In Fig. 4 the relay 400 connects the first master circuit with its normally associated pair of line switch frames while the relay 403 connects the first pair of frames in an emergency to the other master circuit. In a similar manner, the relays 401 and 402 connect the second master circuit to its normally associated pair of switch frames and in an emergency to the other pair of frames.

Figs. 5 and 6 show the testing equipment for both master control circuits. In order to test a group of trunks, there is provided a series of test relays in each master circuit. These relays are applied to the trunks in such a manner that all of the trunks in a pair of vertical rows are simultaneously tested. If they are all busy, the test relays are disconnected and immediately reconnected to test in the next pair of vertical rows. This procedure is continued until an idle trunk is found, which at the same time may be reached through an idle horizontal link. For example, the test relays may first be applied to the trunks appearing in the two vertical rows 205 and 206 of the line switch 200. If the calling line is in the horizontal group 207, then the test will be confined to the trunks appearing in this horizontal group. There will be a number of pairs of such trunks however. For instance, the trunks 227 and 225 may comprise the odd and even trunks, respectively, of the pair appearing before the horizontal link 209. The trunks 228 and 226 comprise the odd and even trunks, respectively, of the next pair appearing before the link 210. Similarly, there will be as many pairs of trunks as there are horizontal links in the group 207. In the master control circuit normally serving the switch 200 the relays 612 and 517 are the odd and even test relays, respectively. The relay 612 serves to test the trunk 227 and the relay 517 the trunk 225. The relay 516 which is associated with the relays 517 and 612 serves to test the corresponding horizontal link 209. Similarly, there will be a set of three relays for each of the remaining pairs of trunks and associated horizontal links. The test relays of the first master control circuit 612, 517, etc., are connected through the contacts of relay 501 for the purpose of testing the first pair of trunk verticals. If these are all busy the relay 501 is released and the test relays deenergized and then these relays are reconnected through succeeding relay 500 to similar test conductors in the next pair of trunk vertical rows. This process is continued until an idle trunk is found or until it is determined that all trunks are busy.

The other master circuit is similarly pro-

vided with a series of test relays including the relays 513, 514 and 609 which are applied through the contacts of relays 506, 507, etc., to the trunks in the associated frames.

Since a comparatively large number of lines are controlled by a single master circuit, it is necessary to make some provision for simultaneous calls. To this end the line vertical rows of contacts 201, 202, etc., in each pair of switches, are divided into a number of groups. In the control circuit each group is provided with a group relay, such as relays 811, 812, 813, etc. If a group consists of five vertical rows, then there are provided five units relays 816, 817, etc., which are applicable to all of the groups. In the case of simultaneous calls, a plurality of vertical group relays 811, 812, may be operated. By means of a lock-out circuit however, a preferred one will remain operated and the other will release. The vertical group relay which remains operated governs the operation of the corresponding pair of connector relays 805, 808, 806, 809, etc. The operated pair of connector relays associates the units relays 816, 817, with the selected group of calling lines and, depending upon which line in the group is calling, the corresponding one of these units relays is operated. The operated units relay finally determines the operation of the vertical magnet controlling the bar individual to the vertical row containing the selected calling line.

A detailed description of the system will now be given. For this purpose assume that the subscriber of line 102 initiates a call. The line relay 104 operates in a circuit from battery through the outer contact of relay 105, back contact of relay 112, conductor 113, winding of the relay 104, through the contacts of the cut-off relay 103 and the subscriber's loop to ground. Relay 104 places ground potential on conductor 114, causing the operation of the start relay 111. Start relay 111 closes operating circuits for relays 305, 400 and 709. These circuits may be traced from battery to the winding of relay 709, conductor 713, back contact of relay 819, conductor 820 and in parallel through the windings of relays 400 and 305 to conductor 820, thence through the back contact of relay 318, outer back of relay 312, conductor 319, to ground at the contact of the start relay 111. Relay 709 connects the contacts of the line relays through to the master control circuit. It also connects the vertical group relays 811, 812, 813, etc., to the line circuits. Relay 709 also operates the relay 815 in a circuit from battery through the winding of relay 815, conductor 822, contact of relay 611, conductor 615, to ground at the contact of relay 709. Since the line 102 is in the group represented by the group relay 812, relay 812 is operated in a circuit from ground through the contact of relay 104, conductor

116, contact of relay 709, conductor 715, right winding of relay 812, back contact of relay 819 to battery. Relay 812 locks in a circuit from battery through the outer right contact of relay 814, conductor 821, winding of relay 819 through the armatures and back contacts of all vertical group relays preceding relay 813 through the armature and front contact and left-hand winding of relay 813 to ground. Relay 819, in operating, releases the relay 709, disconnecting the line relay contacts from the master circuit. Relay 812 operates the relays 806 and 809 to connect the contacts of the line relays, of the group to receive the call, to the master circuit. These relays operate in a circuit from battery to their windings in parallel, contact of relay 812, contact of relay 819, conductor 823, to ground at the contact of relay 312.

Relay 817, individual to the vertical group 201, is now operated in the circuit from battery through the right back contact of relay 815, right winding of relay 817, outer contact of relay 806, conductor 824, conductor 116, to ground at the contact of relay 104. Relay 815 released upon deenergization of relay 709. Relay 817 locks in a circuit from battery to the winding of relay 815, conductor 822, contact of relay 611, conductor 615, conductor 826, armature and front contact and left winding of relay 817 and thence to ground as traced on conductor 116. Relay 815 reoperates in the circuit traced to prevent the subsequent operation of other vertical units relays.

At the time relay 305 operates, a circuit is closed for the horizontal group relay 307, traceable from battery through the contacts of relays 311 and 310 upper winding of relay 307, contact of relay 305, conductor 320, back contact of relay 110 to the grounded conductor 114. Relay 307 operates and locks in a circuit from battery through the back contacts of relay 814, conductor 821, winding of relay 311, back contact of relay 308, front contact and winding of relay 307, conductor 321, contact of relay 400 to the grounded conductor 114. Relay 307 operates relay 112 in a circuit from battery through the winding of relay 112, conductor 117, contact of relay 400, conductor 407, contact of relay 307, to ground at the contact of relay 311. Relay 112 closes an obvious circuit for relay 110. Relay 110, when operated, opens the energizing circuit of relay 307. Relay 112 closes an obvious circuit for connecting relay 708. Relay 708 connects the master circuit to the line switch 200.

The vertical magnet 213 is now operated to rotate the vertical line bar preparatory to extending the calling line 102 to an idle link circuit. The circuit of magnet 213 may be traced from ground through the winding thereof, conductor 222, contact of relay 708, conductor 716, conductor 717, contact of re-

lay 809, contact of relay 817, to battery at the right front contact of relay 815. The vertical magnet 213 closes a circuit from ground, through its contact, conductor 228, contact of relay 400, conductor 414, winding of relay 309 to battery. Relay 309 operates and closes an obvious circuit for relay 310.

The horizontal group relay 307 selects the horizontal connecting relay 108 which is individual to the horizontal group 207. Relay 108 operates in circuit from battery through its winding, conductor 119, contact of relay 400, conductor 409 to ground at the contact of relay 307.

It will next be described how the trunks outgoing from the line switch 200 are tested to determine which vertical magnet is to be operated. For this purpose the first of the connecting relays 501 is energized to associate the test relays with the trunks appearing in the first pair of vertical rows 205 and 206. The circuit for relay 501 may be traced from battery through its winding, back contact of relay 503, conductor 518, through the contact of relay 307 to ground at the contact of relay 311. A circuit is now closed for slow-operating relay 613 traceable from the grounded conductor 518, through the back contact of relay 503, front contact of relay 501, conductor 519, contact of relay 400, conductor 410, contact of relay 108, conductor 120, contact of relay 400, conductor 411, winding of relay 613 to battery. Relay 613 being slow requires an appreciable interval to attract its armatures. This allows sufficient time for the test relays to become adjusted.

Relay 612 tests the condition of trunk 227 in a circuit from battery, through the left winding of said relay, outer left contact of relay 515, conductor 521, contact of relay 501, conductor 522 to the sleeve conductor of the trunk 227. If the trunk is busy relay 612 operates. Relay 517 tests the trunk 225 in a circuit from battery, through the left winding of said relay, and thence over a path similar to that traced to the sleeve conductor of trunk 225. The relay 516 tests the horizontal link 209 before which the trunks 225 and 227 appear. The circuit for this purpose may be traced from battery, through the winding of said relay, contact of relay 515, conductor 535, contact of relay 400, conductor 412, contact of relay 108 to the test conductor of the link 209. If the link is busy the relay 516 operates and prepares obvious operating circuits for the test relays 517 and 612. Similar circuits are completed from other test relays (not shown) for testing the other trunks appearing in the same horizontal group and in the same two vertical rows. Assuming all the trunks in the rows 205 and 206 are busy, a circuit is completed, as soon as the relay 613 operates, traceable from ground, through the inner left contact of said relay, inner left front

contacts of relays 612 and 527 and through front contacts of all similar operated relays then through the conductor 523, through the front contact of relay 501 and the right winding of relay 503 to battery. Relay 503 operates, locks and opens the circuit of relay 501 permitting this latter relay to release. Relay 501 in releasing opens the circuit of relay 613 which also releases. As soon as relay 613 releases a circuit is closed from battery, through the winding of relay 500, back contact of relay 502, back contact of relay 613, inner right front contact of relay 503 to the grounded conductor 518. It will be noted that relay 503 locks through its left winding and contact, thence over conductor 524 to ground at the contact of relay 311. Relay 500 operates and locks in circuit from battery, through its winding, back contact of relay 502, front contact of relay 500, front contact of relay 503 to the grounded conductor 518. Relay 500 associates the test relays, which have been released by the deenergization of relay 501, with the trunks in the next pair of vertical rows 203 and 204. Slow relay 613 also has its circuit reclosed in a path leading through the front contact of relay 500, front contact of relay 503 to the grounded conductor 518. This procedure will continue until an idle trunk is found or until all trunks are determined to be busy. If an idle trunk is found in one of the rows 203 or 204 a corresponding test relay, such as the relay 517, remains deenergized.

When the relay 613 operates following the test which finds an idle trunk, it closes at its right contact a circuit for holding all operated test relays in their energized condition. At its left contact it completes a circuit for the relay 515. This circuit may be traced from ground through the left contact of relay 613, front contact of relay 612, left back contact of relay 517, to battery, through the winding of relay 515.

The apparatus is now ready to operate the selected vertical magnet on the switch frame. Before the circuit can be traced, however, it will be necessary to describe how one of the vertical relays 504, 505 has in the meantime been selected and operated. These relays are individual to a pair of vertical rows on a pair of line switches. At the time the connector relay 400 operates a circuit is closed for the relay 602 traceable from battery, through the winding of said relay, back contact of relay 607, conductor 616 to ground at the contact of relay 400. Relay 602 extends the grounded conductor 616 through to the winding of relay 607. Relay 607 operates and locks to the grounded conductor 524. At the time relay 515 operates as above explained, a circuit is completed from battery, through the left winding of the horizontal operating magnet 219, conductor 224, contact of relay 108, conductor 412, contact of relay 400, conductor

535, front contact of relay 515, conductor 617, winding of the marginal relay 605, right high resistance winding of relay 600 to ground. Due to the high resistance of the winding of relay 600, the marginal relay 605 and the horizontal magnet 219 do not operate. Relay 600, however, becomes energized. Thus, with the relay 600 operated and relay 602 energized, as above explained, a circuit is completed for operating the vertical relay 504. This circuit may be traced from battery, through the back contact of relay 312, conductor 323, left back contact of relay 608, left winding of relay 504, back contact of relay 606, front contact of relay 500, conductor 525, front contact of relays 600 and 602, front contact of relay 607, conductor 618 to ground at the back contact of relay 314. Relay 504 operates and locks in a circuit from battery, through the common lock-out relay 608, contact and right winding of relay 504 and thence to ground as above traced.

The trunk vertical magnet 215 is next energized in circuit from ground through its winding, conductor 225, contact of relay 708, conductor 719, front contact of relay 500, conductor 526, outer left contact of relay 612, conductor 620, front contact of relay 504, front contact of relay 608 to battery on the conductor 323.

Magnet 215 in operating closes a circuit from ground, through its lowermost contact, conductor 226, contact of relay 400, conductor 528, winding of relay 603, contact of relay 612, left front contact of relay 515 to the front contact of relay 500, conductor 413 to the sleeve conductor of trunk 221 and thence to battery in the selector switch 240. Relay 603 operates and opens the holding circuit of relay 602. Relay 602 releases.

The horizontal magnet 219 is operated in a circuit from battery, through the left winding of said magnet, conductor 224, contact of relay 108, conductor 412, contact of relay 400, conductor 522, front contact of relay 515, conductor 617, winding of relay 605, conductor 621, contact of relay 309, conductor 415, back contact of relay 602, contact of relay 603 to the grounded conductor 616. The relay 603 which was operated, as above explained, was immediately shunted down due to the application of ground potential on the sleeve conductor in the usual manner at the first selector switch 240. Magnet 219 rotates the horizontal rod and extends the calling subscriber's line 102 through the conductors of link 209 to the selected idle trunk 221. The magnet 219 locks through both its windings and contacts of the switch to the grounded sleeve conductor.

At the time relay 608 operates it closes an operating circuit for relay 601. Relay 601 operates and closes a circuit from ground, through its right contact, contact of relay 504, winding of relay 606 to battery. Relay 606

is slow to operate and requires an appreciable interval to attract its armatures. When relay 606 finally operates, it opens the circuit of relays 504 and 608 and these relays release.

When the connection is extended through the line switch a circuit is completed from battery, through the winding of the cutoff relay 103, thence through contacts of the switch to ground at the first selector 227. Relay 103 releases the line relay 104 which removes ground from the holding conductors, permitting all operated relays in the line switch and master control circuit to become deenergized. The connection is held from the selector switch which controls the circuit of the horizontal magnet 219. The vertical magnets 213 and 215 are also deenergized.

The connection may be extended over succeeding switches 241 and 242 to the called subscriber's line 243. When conversation is over the apparatus is released in the usual manner by removing ground potential from the holding conductors in the selectors. The removal of this potential allows the horizontal magnet 219 to release, restoring the line switch 200 to its normal position.

At the time the trunks are tested if all of them should be found busy a circuit is closed from battery through the winding of the all-trunks-busy relay 611, conductor 622, through contacts of the operated relays, such as 503, 502, etc., to ground. Relay 611 operates an alarm and a peg count register 623.

It may be noted at this point that the line relays, such as relay 104, are equipped with contacts which depend on the other. That is to say unless the first contact is in good condition no circuit is closed through the second contact. This is to prevent starting the master circuit in operation needlessly when the call will fail due to trouble at the other contact of the line relay.

A description will now be given of the operation when one of the master control circuits is taken out of service. Assume for this purpose that the master control circuit which normally serves the other pair of frames (not shown in the drawing) becomes disabled. Due to the fact that the master control circuit is disabled the relay 318 becomes operated after an interval in a circuit from battery, through its winding, thence over conductor 325 to ground. The ground potential is applied by any suitable timing mechanism not illustrated. Relay 318 transfers the start circuit 326 to conductor 327, thence through the left winding of relay 316 to battery, through the contact of relay 315. Relay 316 operates and locks in a circuit from battery, through the winding of relay 315, contact and right hand winding of relay 316 to grounded start conductor 326. Relay 315 opens the common operating circuit to prevent the subsequent operation of relay

317. Relay 316 at its inner left contact places ground on conductor 340 to operate relays 306 and 401. Relay 316 at its outer left contact closes a circuit for relay 711. These relays connect the master control circuit to the other pair of frames so that it may control said frames to extend calls therethrough, while the master circuit normally serving said frames is out of order. A further description of the manner in which the master circuit operates is not necessary in view of the complete description already given in connection with a normal operation.

What is claimed is:

1. In a telephone system, a plurality of switches having a master control circuit, a second plurality of switches having a master control circuit, circuits appearing in said switches, each master circuit normally controlling the switches with which it is associated, and means for rendering one of said master circuits effective to control the switches associated with the other master circuit.

2. In a telephone system, a plurality of switches having a master control circuit, a second plurality of switches having a master control circuit, circuits appearing in said switches, each master circuit normally controlling the switches with which it is associated, and means for rendering either master circuit effective to control the switches associated with the other master circuit.

3. In a telephone system, a plurality of line switches having a master control circuit, a second plurality of line switches having a master control circuit, lines appearing in said switches, each master circuit normally controlling the switches with which it is associated, and means effective when one master circuit is disabled for rendering the other master circuit effective to control all of said switches.

4. In a telephone system, a plurality of line switches having a master control circuit, a second plurality of line switches having a master control circuit, lines appearing in said switches, each master circuit normally controlling the switches with which it is associated, means responsive to the disabling of either master circuit for rendering the other master circuit effective to control all of said switches, and means for preventing a master circuit from attempting to control two switches at one time.

5. In combination, a plurality of switches having a master control circuit, a second plurality of switches having a master control circuit, lines appearing in said switches, each master circuit normally serving its associated switches, connectors for connecting each master circuit to the switches which it normally serves, other connectors for connecting either master circuit to the switches normally served by the other master circuit, and means for rendering either master circuit effective to

control both the switches it normally serves and the switches normally served by the other master circuit.

5 6. In combination, a plurality of line switches, lines appearing therein in groups, a common master control circuit including a plurality of group relays and a plurality of units relays, and means for operating a group relay and a units relay to determine the group
10 and the line in the group to be extended by one of said switches.

7. In combination, a number of line switches, lines appearing therein in groups and subgroups, a common control circuit including a group relay for each group and a subgroup relay for each subgroup in a group, means for operating a group relay to select a group and a subgroup relay to choose a subgroup therein, and means controlled by the
15 common control circuit for operating one of said switches to extend a calling line in the chosen subgroup.

8. In a telephone system, a line switch having rows of contacts, a group of trunks
25 appearing in said rows and divided in subgroups, each sub-group occupying a plurality of said rows, a device for testing the trunks of said group, and means for applying said device to test successively said sub-groups of
30 contacts.

9. In combination, a line switch having

rows of contacts, trunks appearing in said rows, a series of relays for making a simultaneous test of the trunks in a plurality of rows, and means for connecting said relays
35 in succession, each time to a plurality of rows of trunks.

10. In combination, line switches having rows of contacts, groups of trunks appearing in said rows, each trunk multiplied to all
40 switches, a common testing mechanism for making a succession of tests of the trunks, each test applying to the trunks in a plurality of rows, and means for connecting the testing mechanism first to one group of
45 trunks and then to succeeding groups.

11. In combination, a line switch, lines appearing therein in groups, a common master control circuit including a plurality of group and units relays, line relays, one for each of
50 said lines, a start relay for setting the master circuit in operation to control said line switch, a contact on each line relay for operating the start relay, and a contact on each line relay for operating said group and units relays,
55 said contacts so arranged that the start relay does not operate unless the line relay is in condition to operate said group and units relays.

In witness whereof, I hereunto subscribe my name this 1 day of August A. D., 1927.

EDGAR H. CLARK.