

Jan. 5, 1932.

T. H. ROBERTS

1,840,132

TELEPHONE SYSTEM

Filed Sept. 30, 1930

39 Sheets-Sheet 1

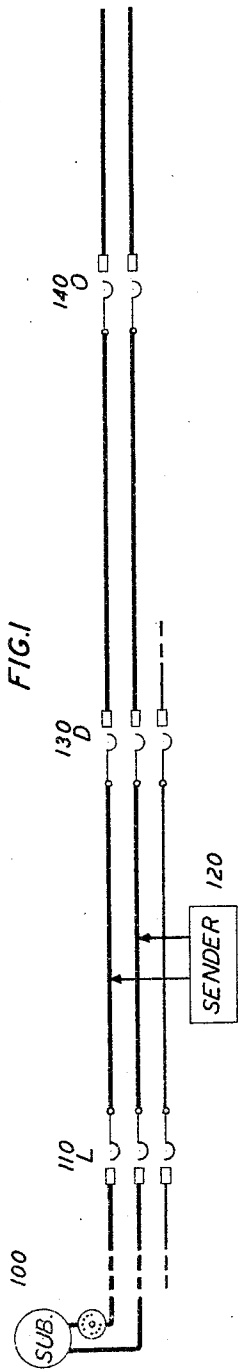


FIG. 42

FIG. 1	FIG. 2	FIG. 3 FIG. 39 & 40	FIG. 4	FIG. 5	
	FIG. 6	FIG. 9	FIG. 14	FIG. 19	FIG. 22
FIG. 8	FIG. 7	FIG. 10	FIG. 15	FIG. 20	FIG. 23
		FIG. 11	FIG. 16	FIG. 21	FIG. 24
		FIG. 12	FIG. 17	FIG. 27	FIG. 25 FIG. 31
		FIG. 13	FIG. 18	FIG. 28	FIG. 32
				FIG. 29	FIG. 33
				FIG. 30	FIG. 34
					FIG. 26
					FIG. 35
					FIG. 36
					FIG. 37
					FIG. 38

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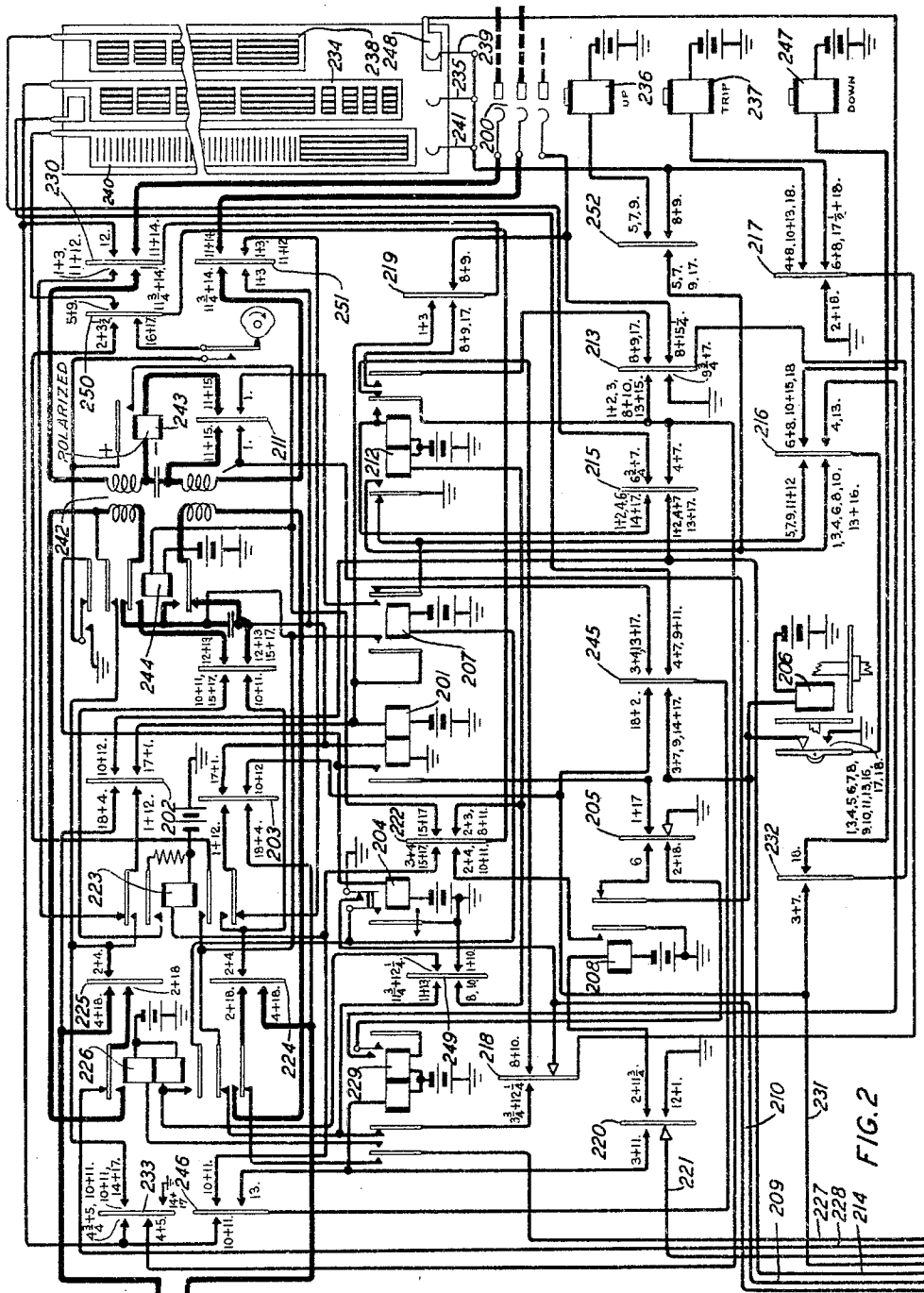
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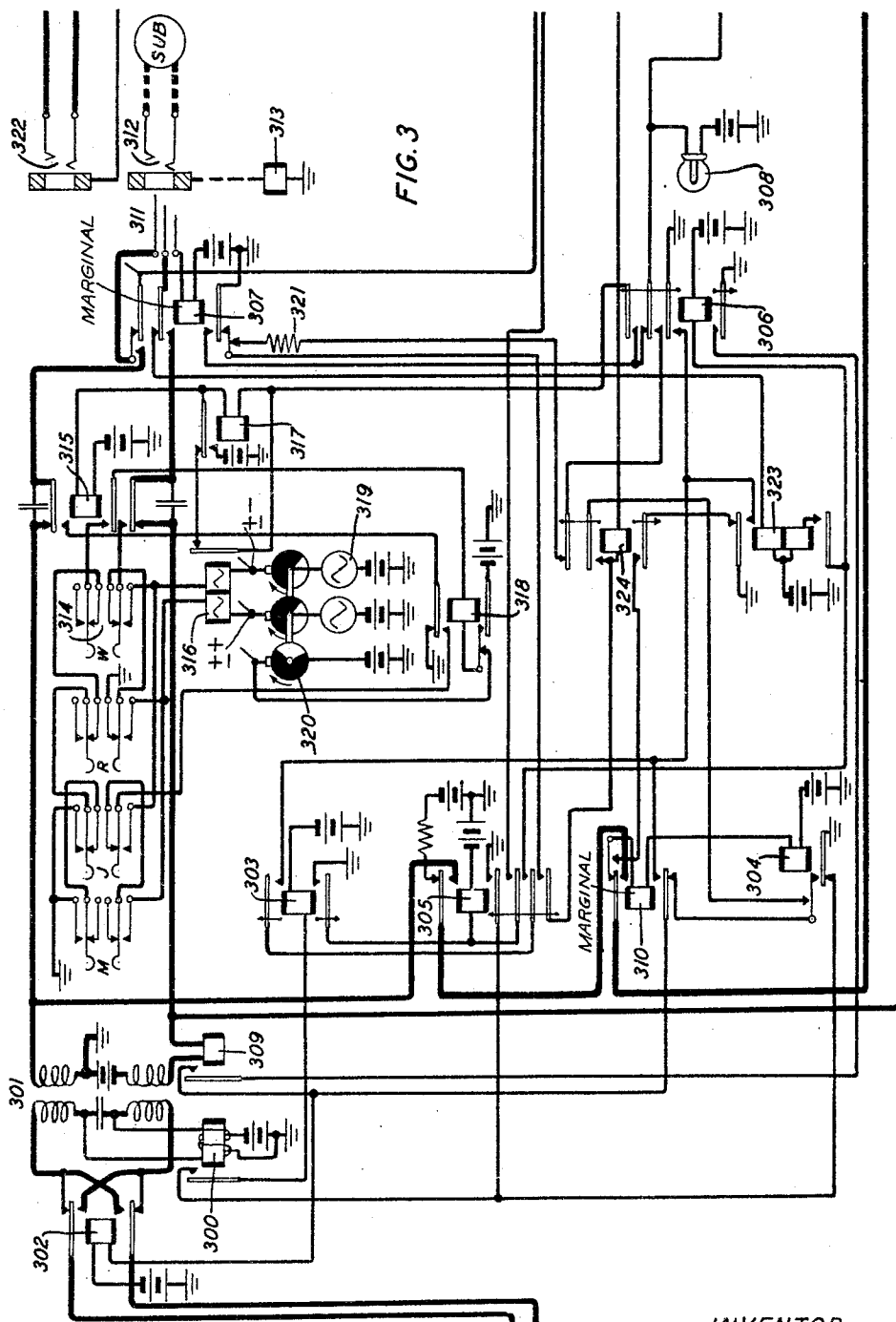


FIG. 3

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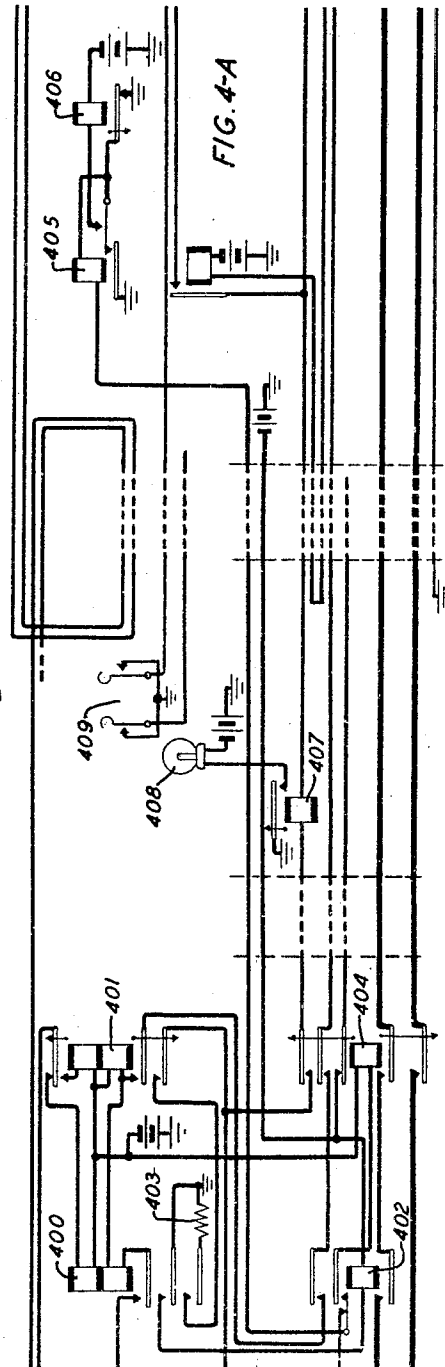
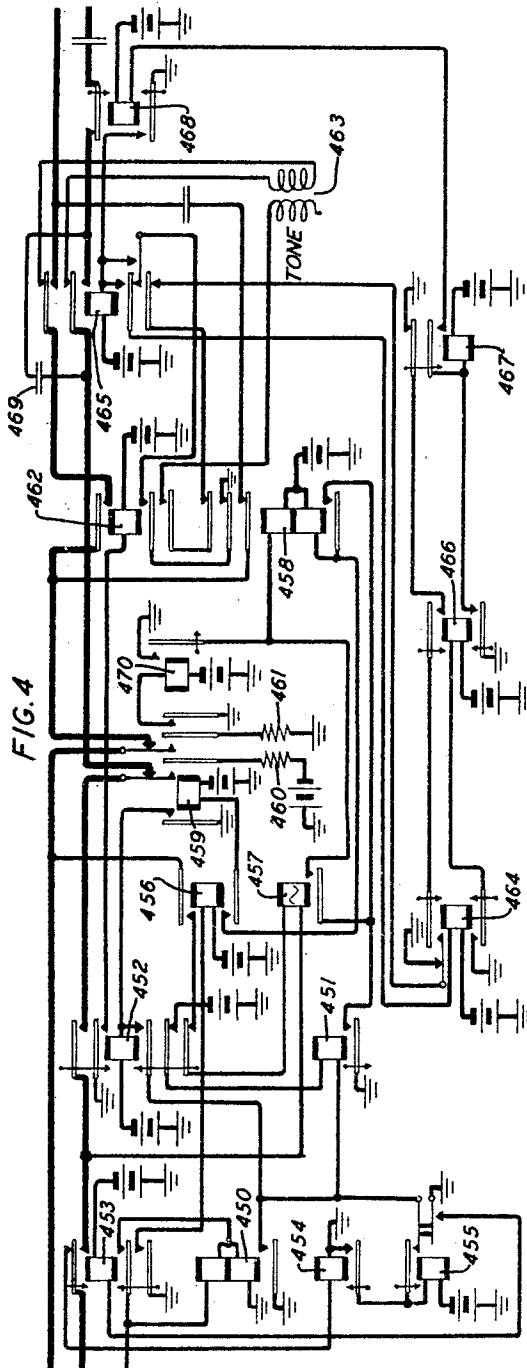
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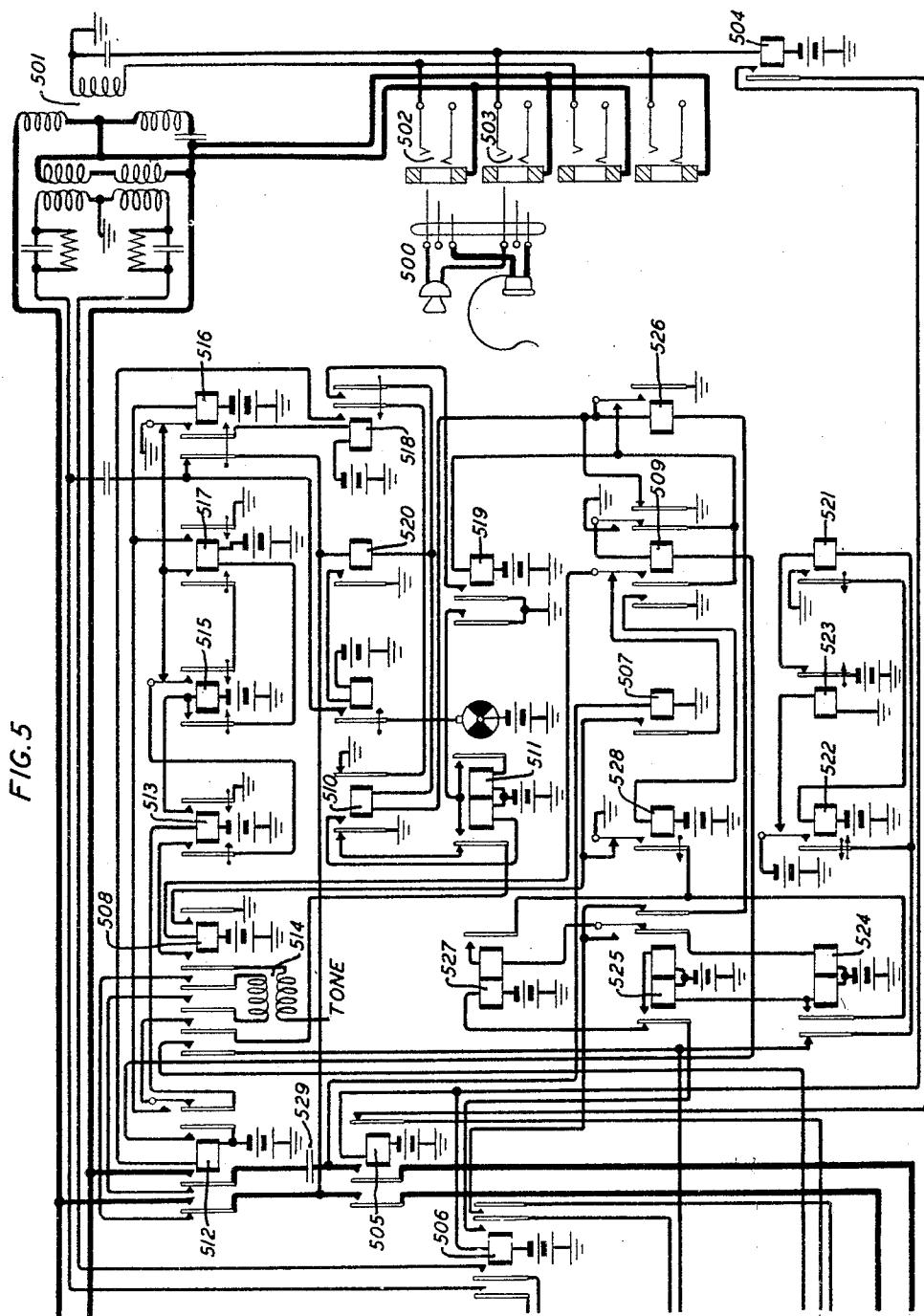


FIG. 5

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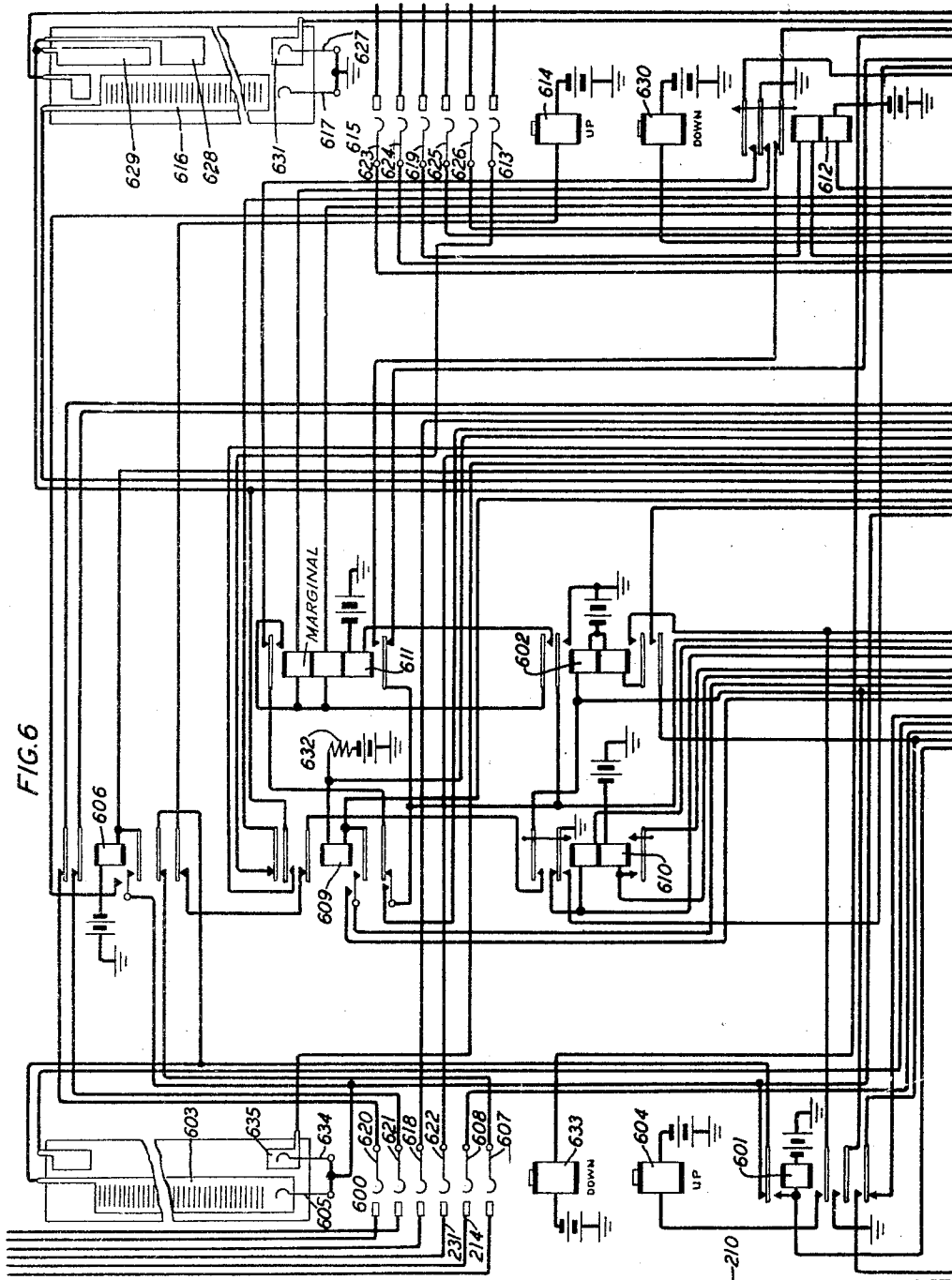
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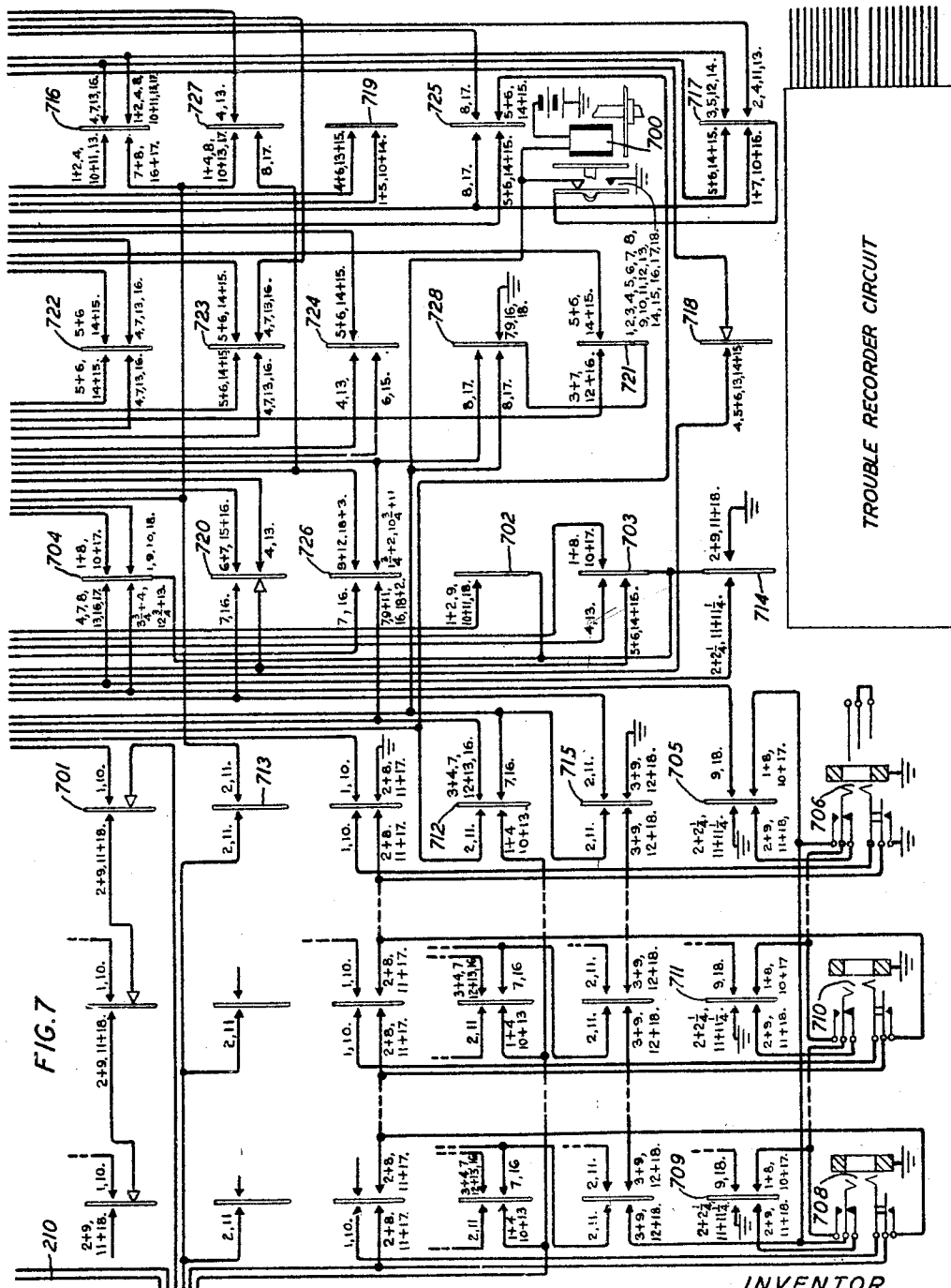


FIG. 7

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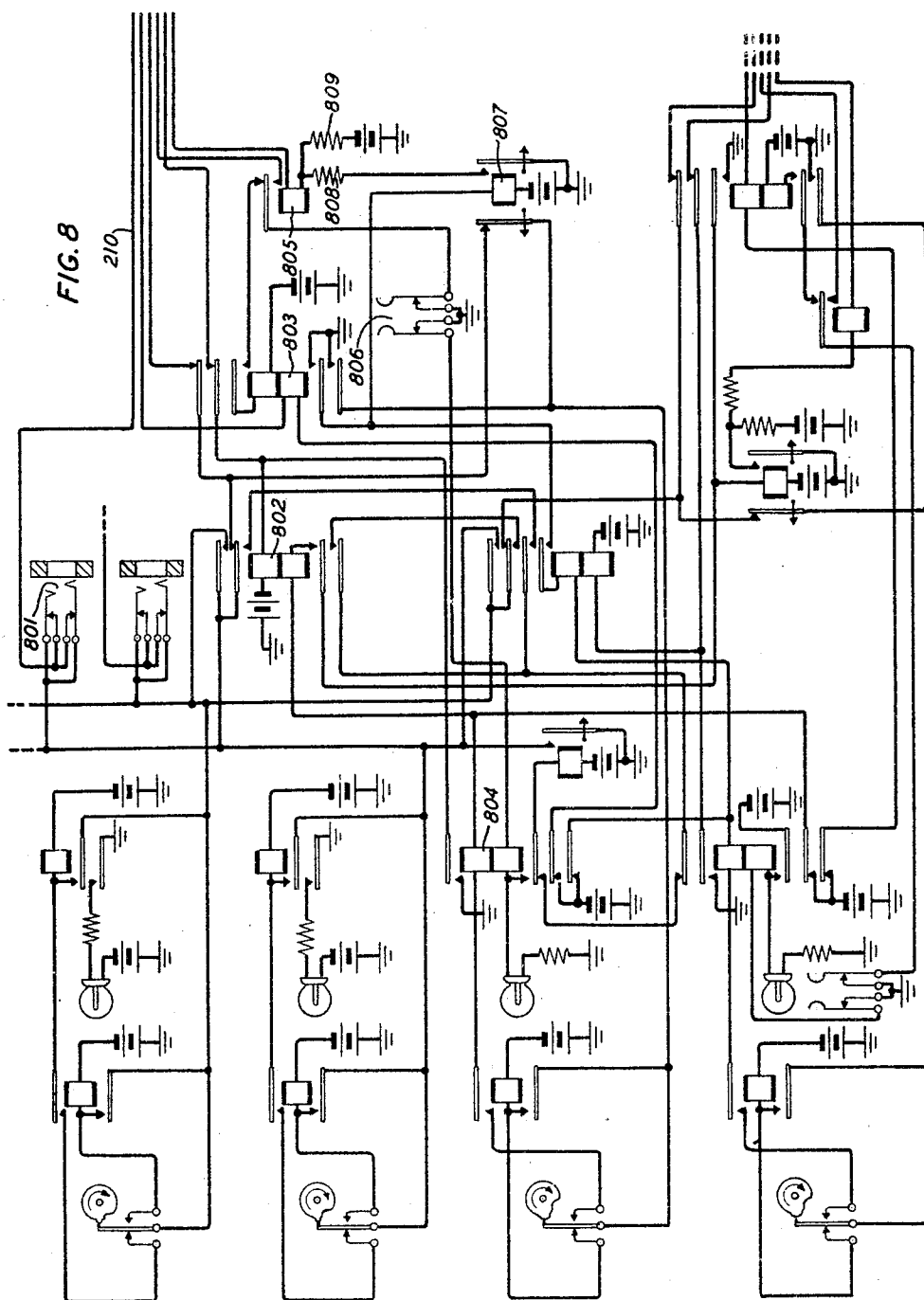
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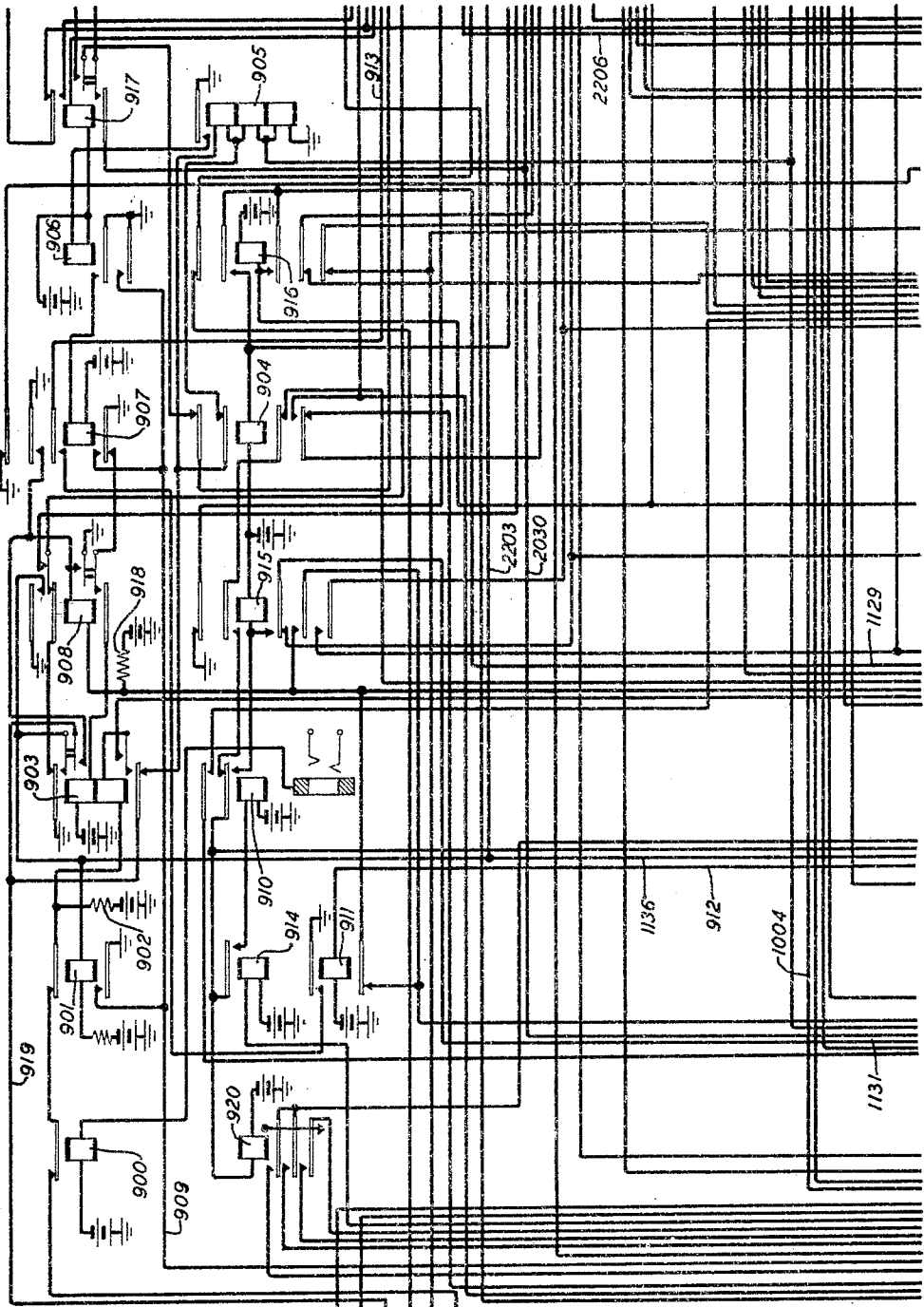


FIG. 9

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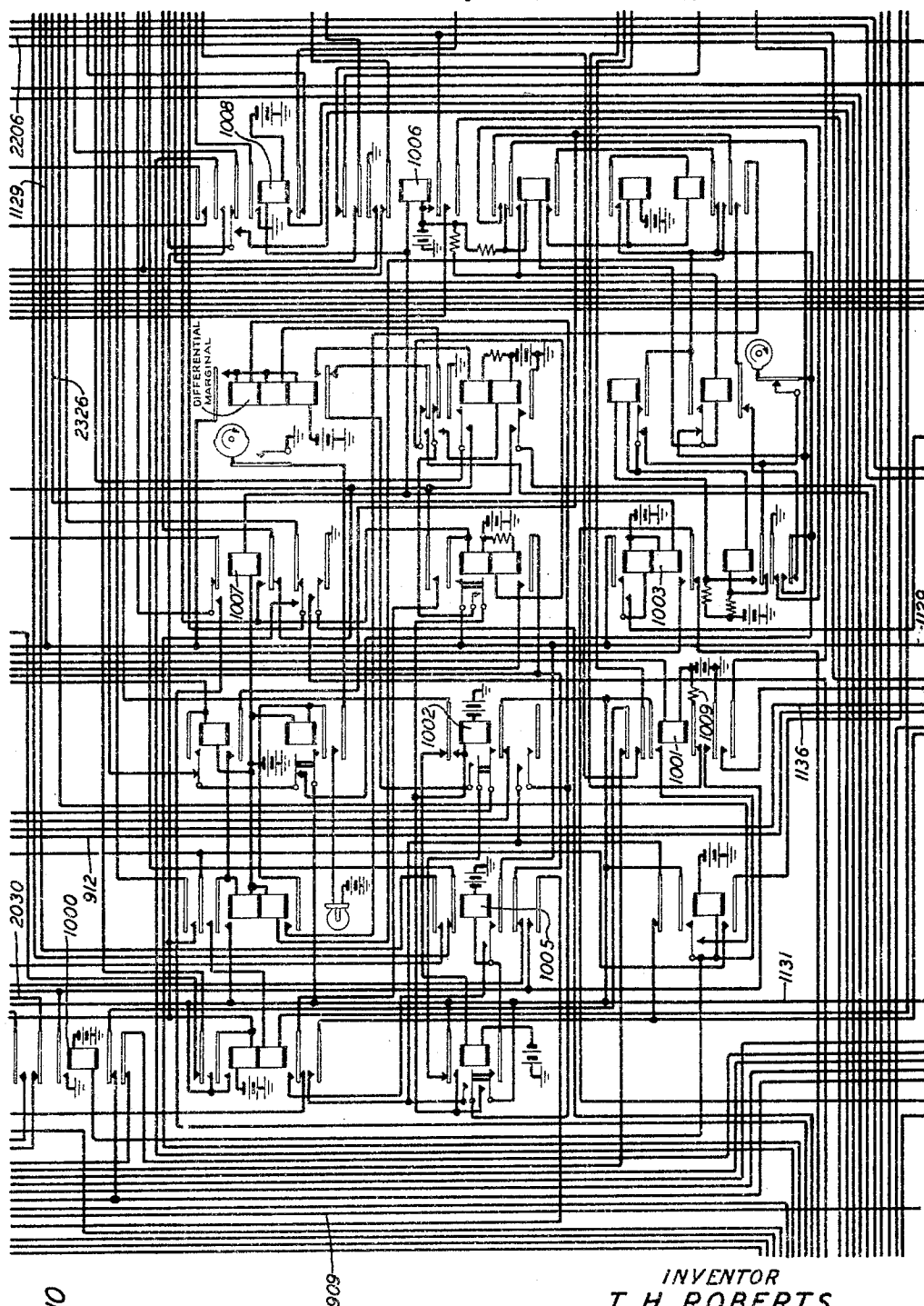


FIG. 10

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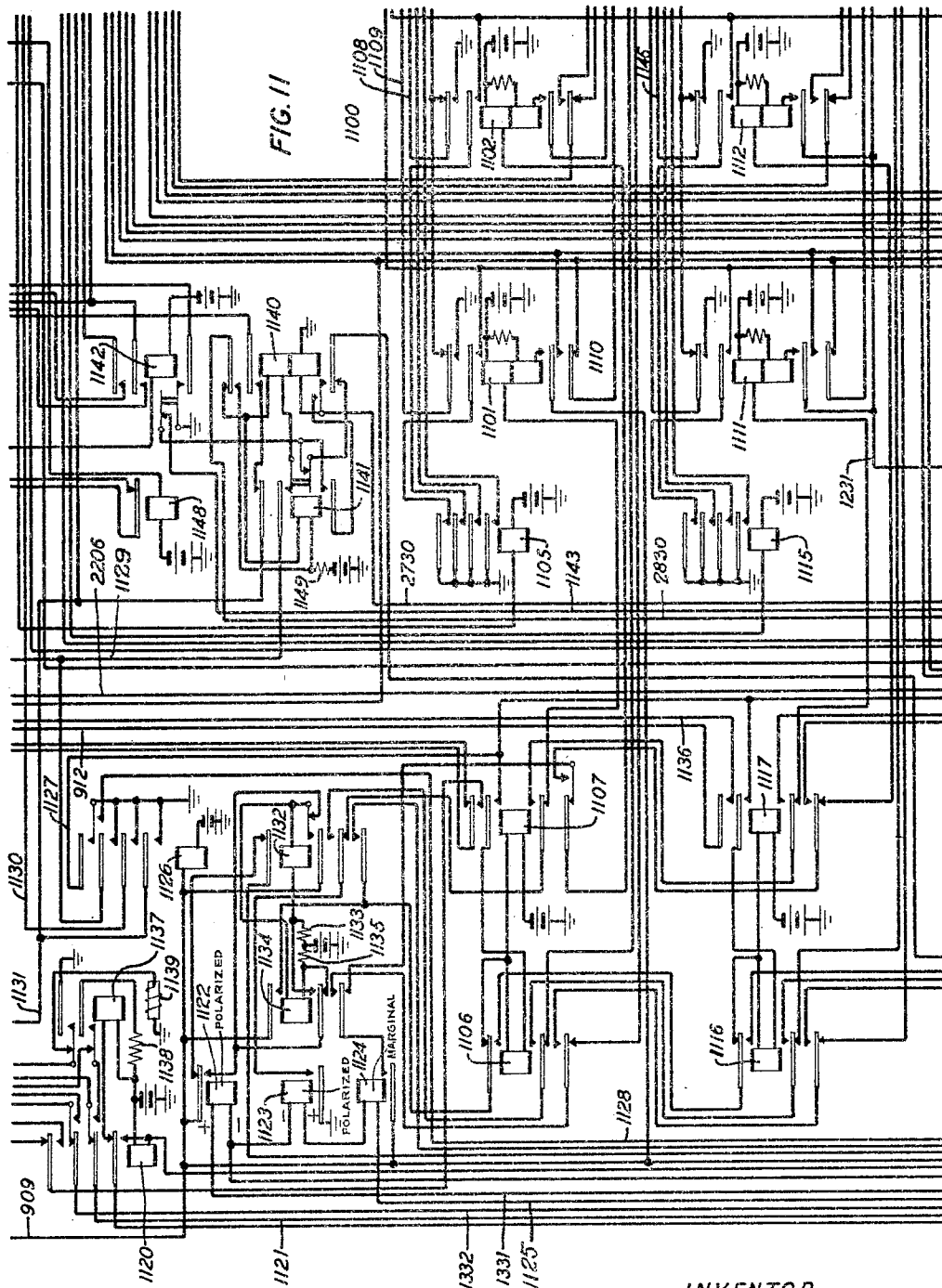
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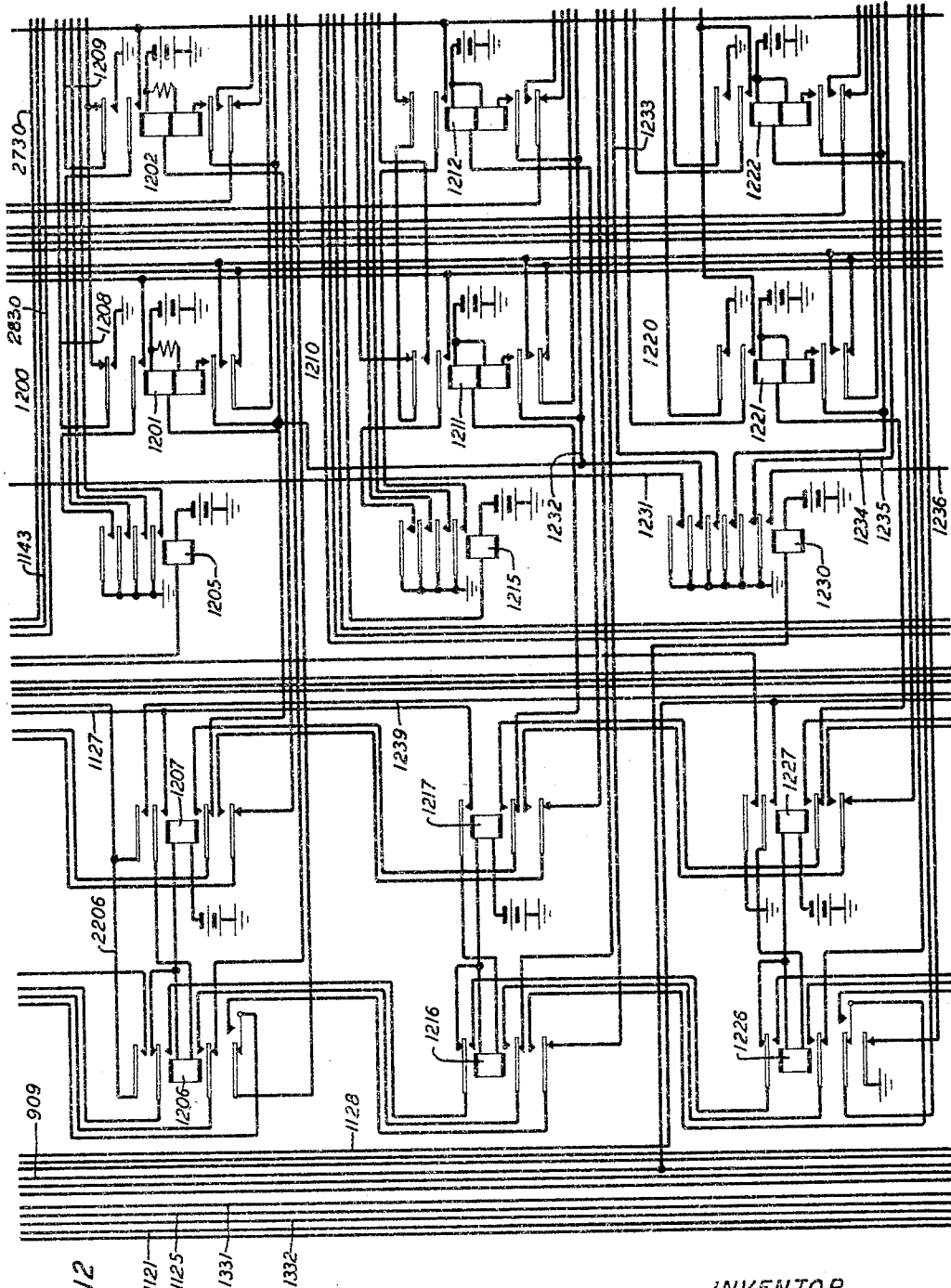


FIG. 12

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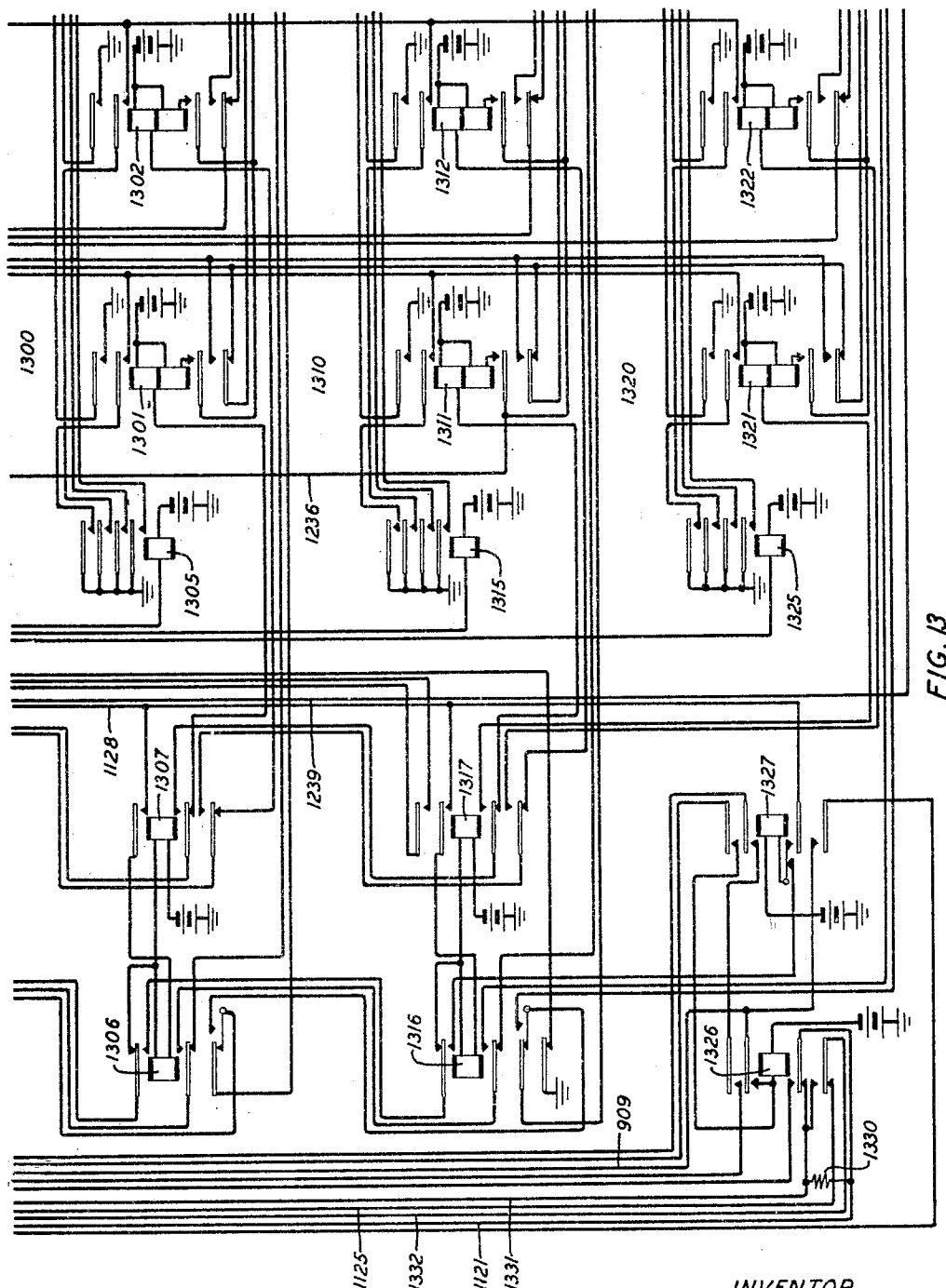


FIG. 13

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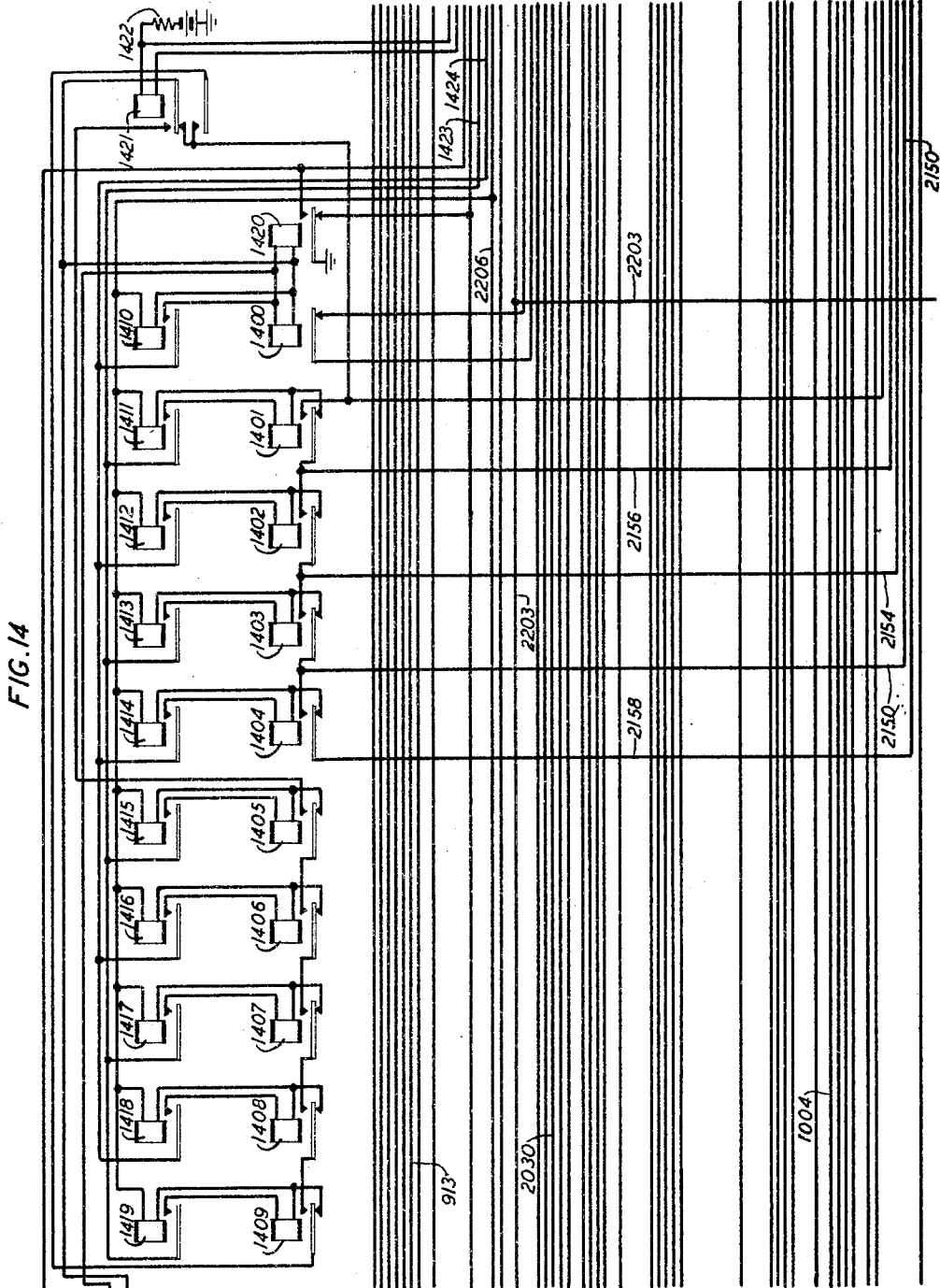
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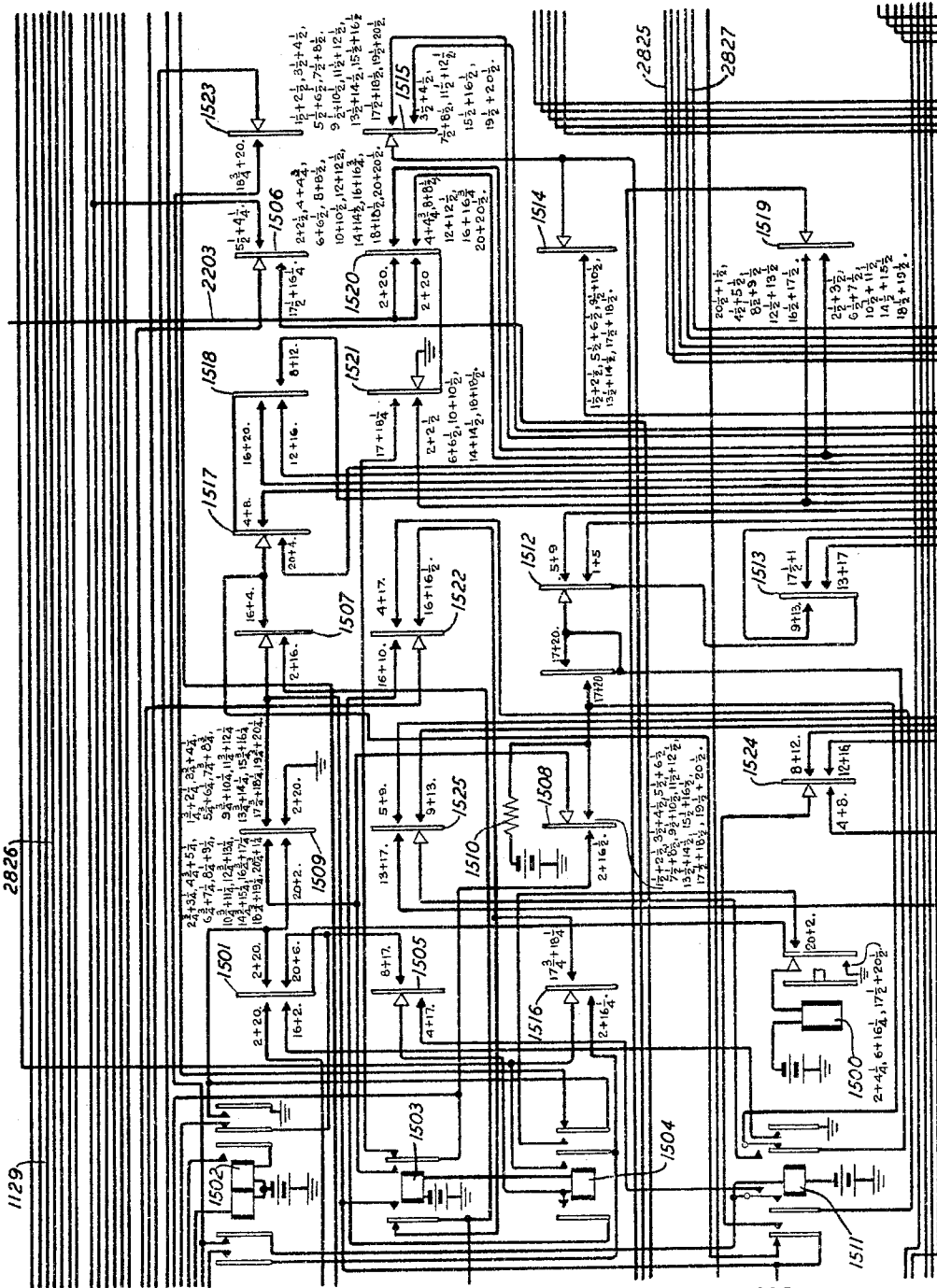
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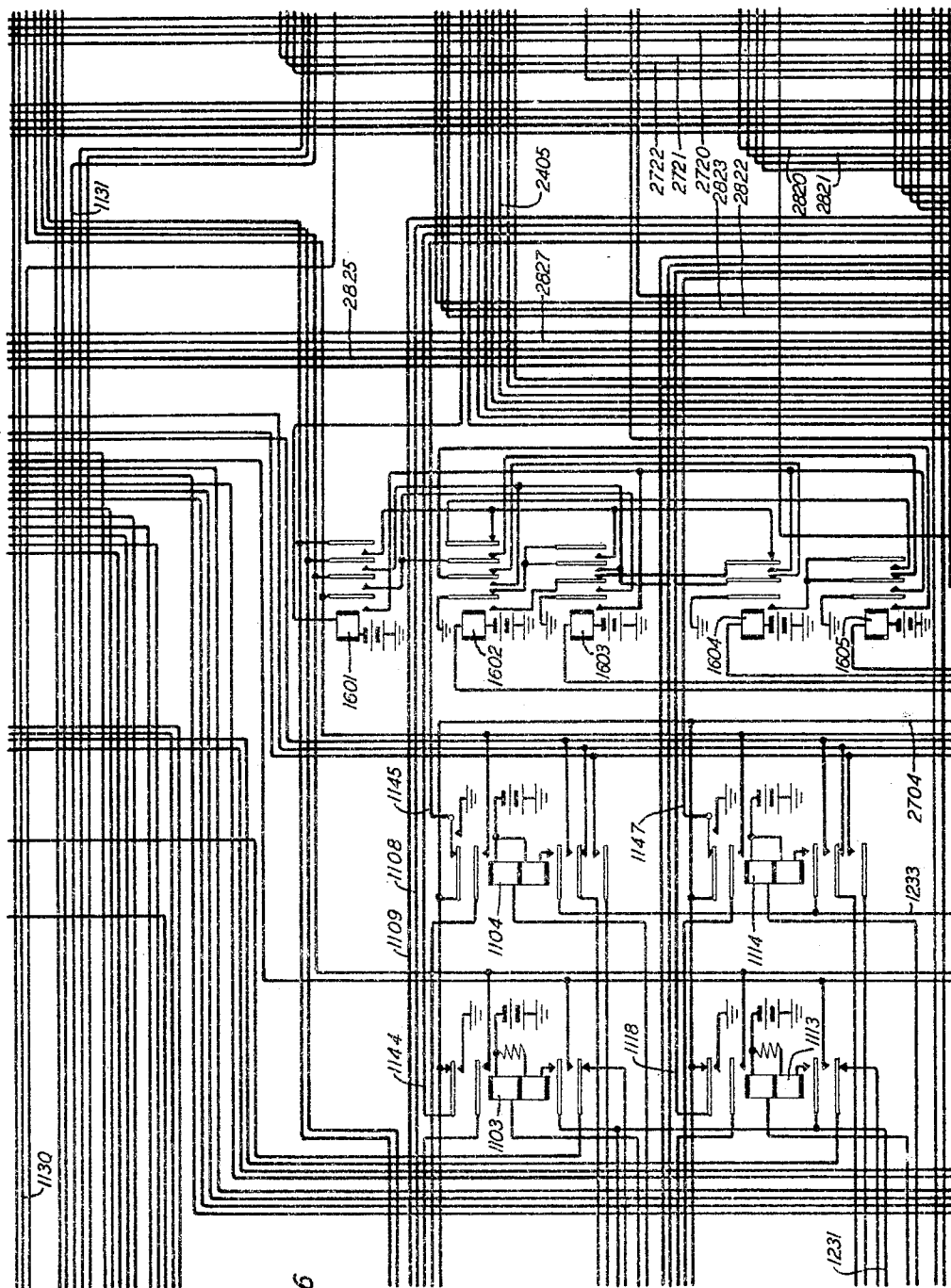


FIG. 16

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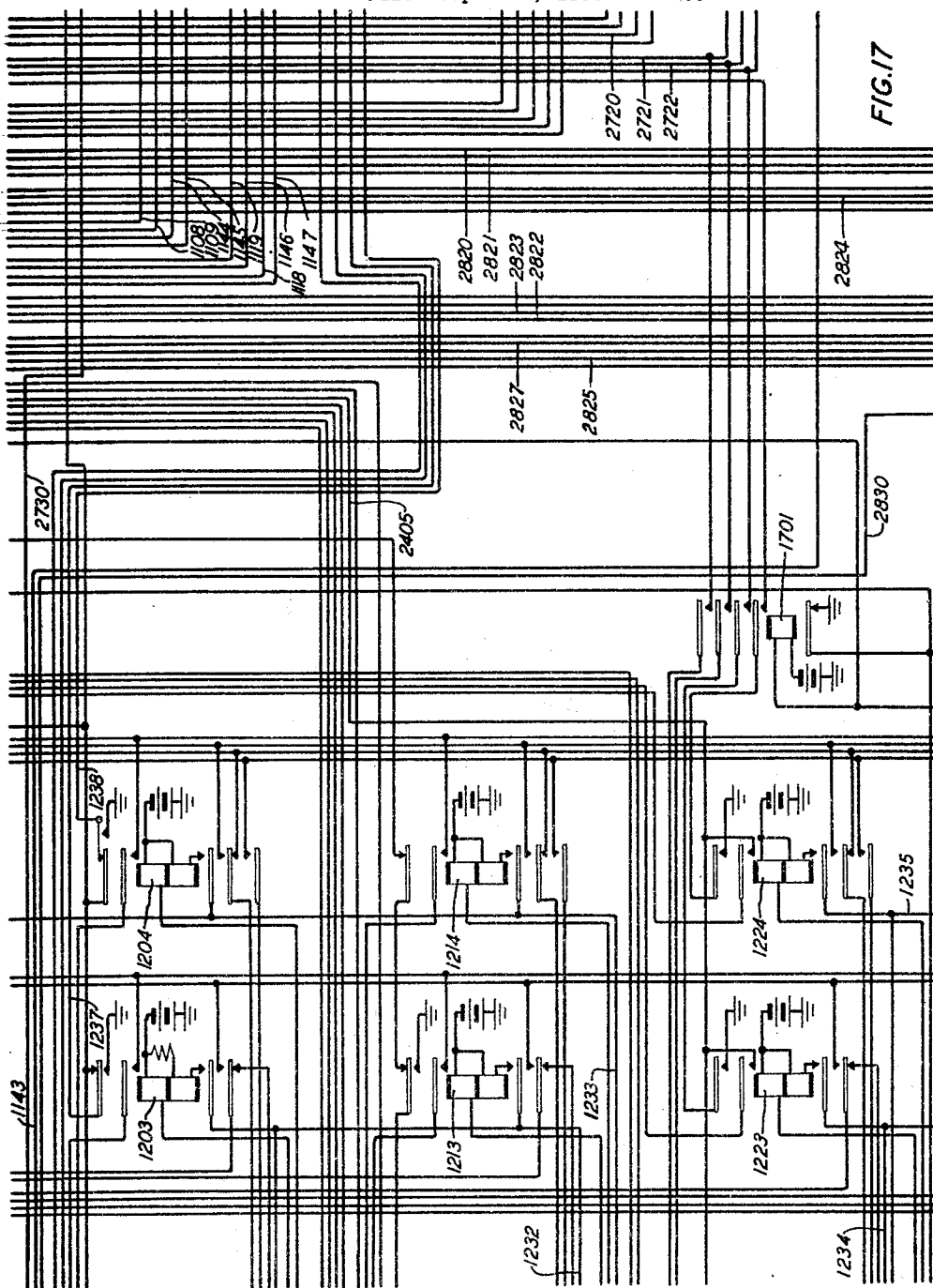
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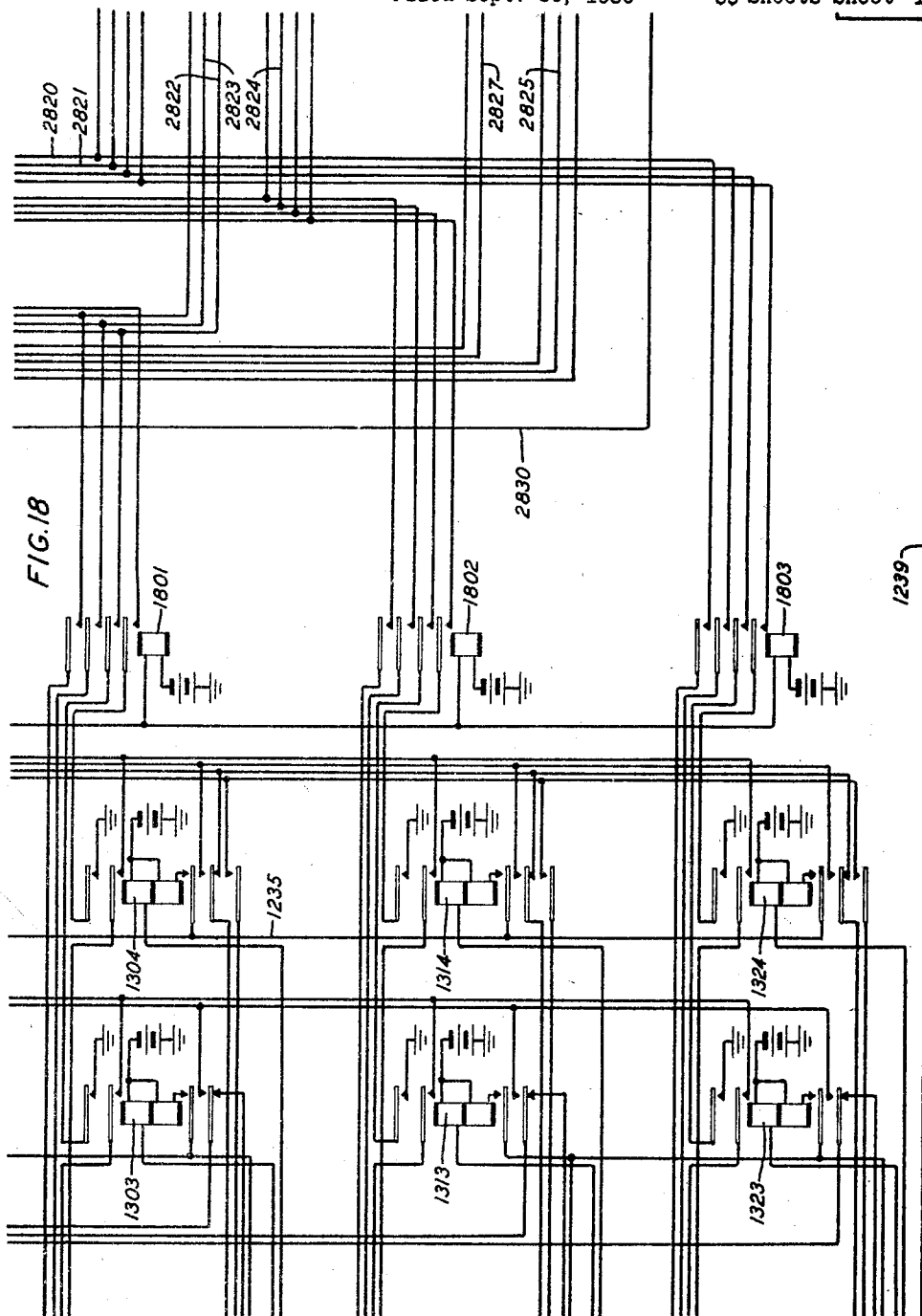
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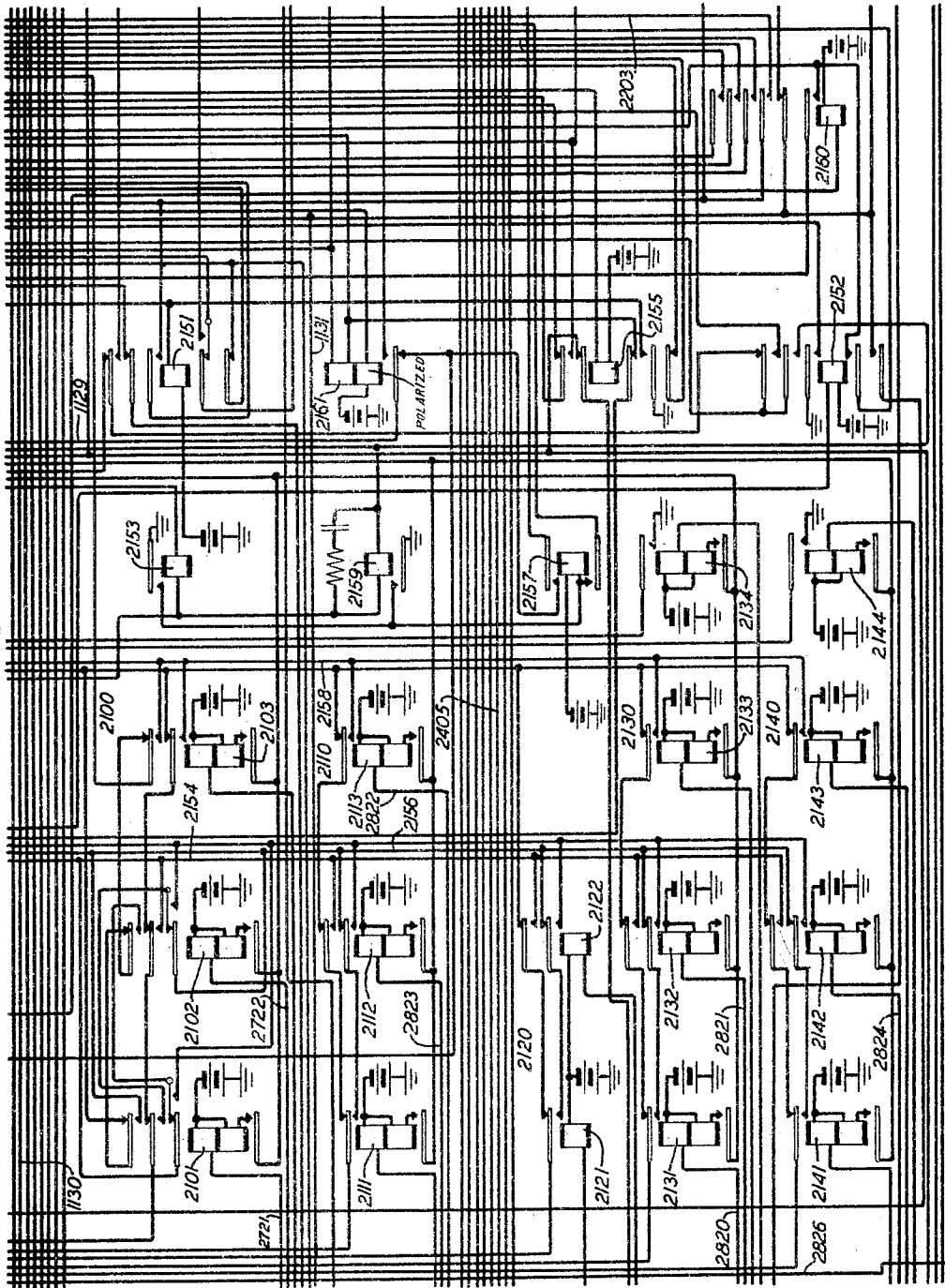


FIG. 21

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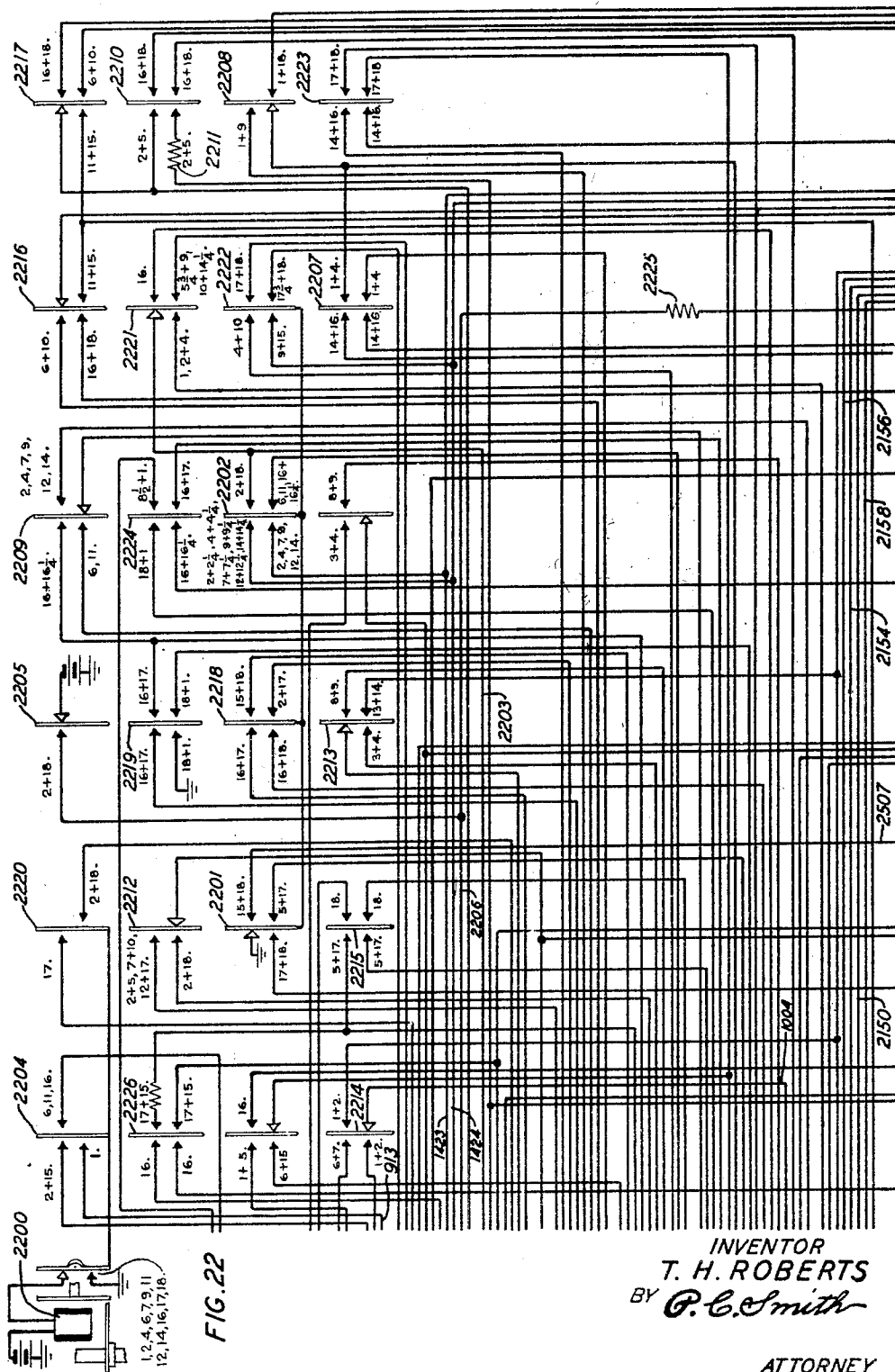
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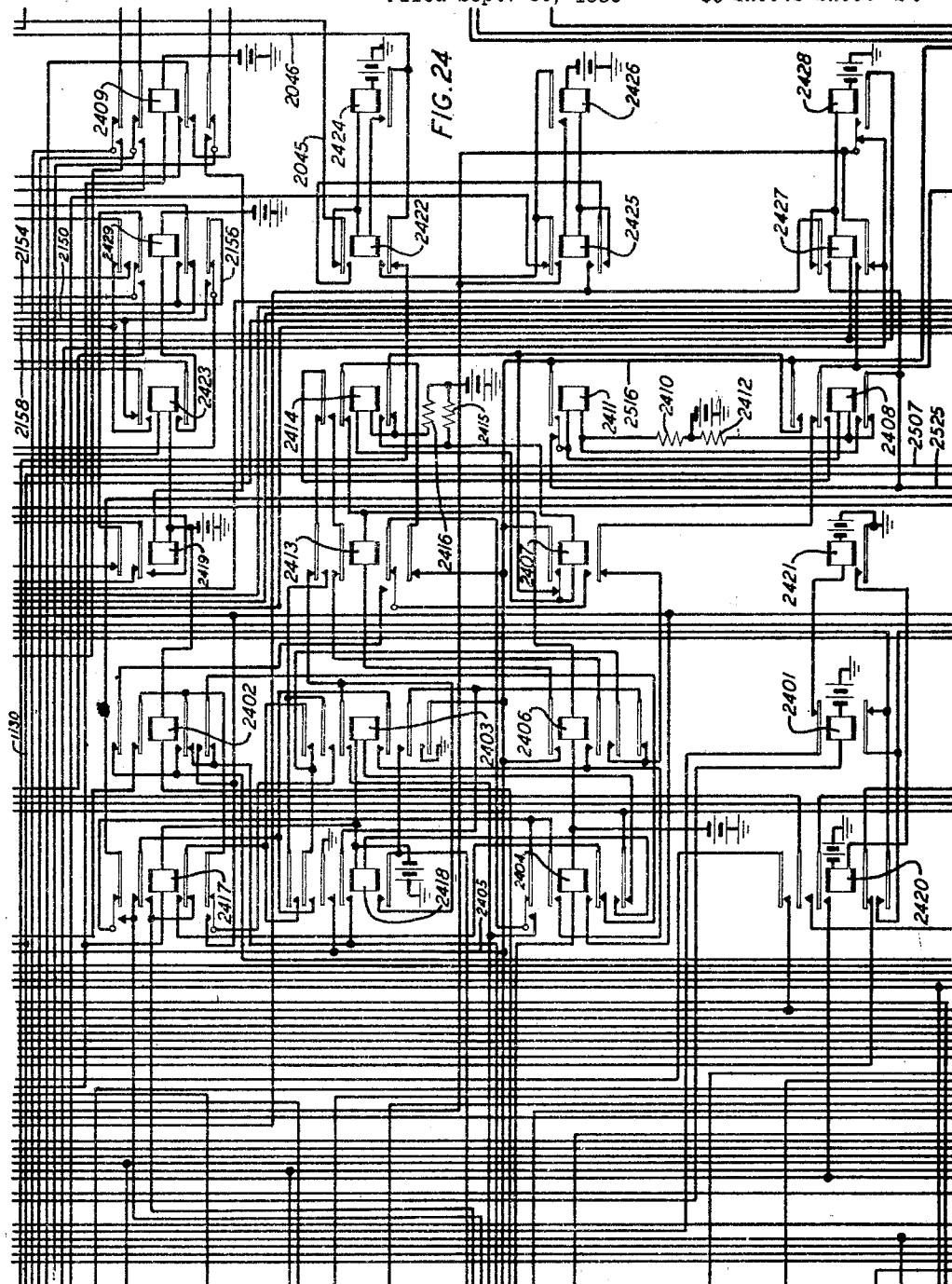
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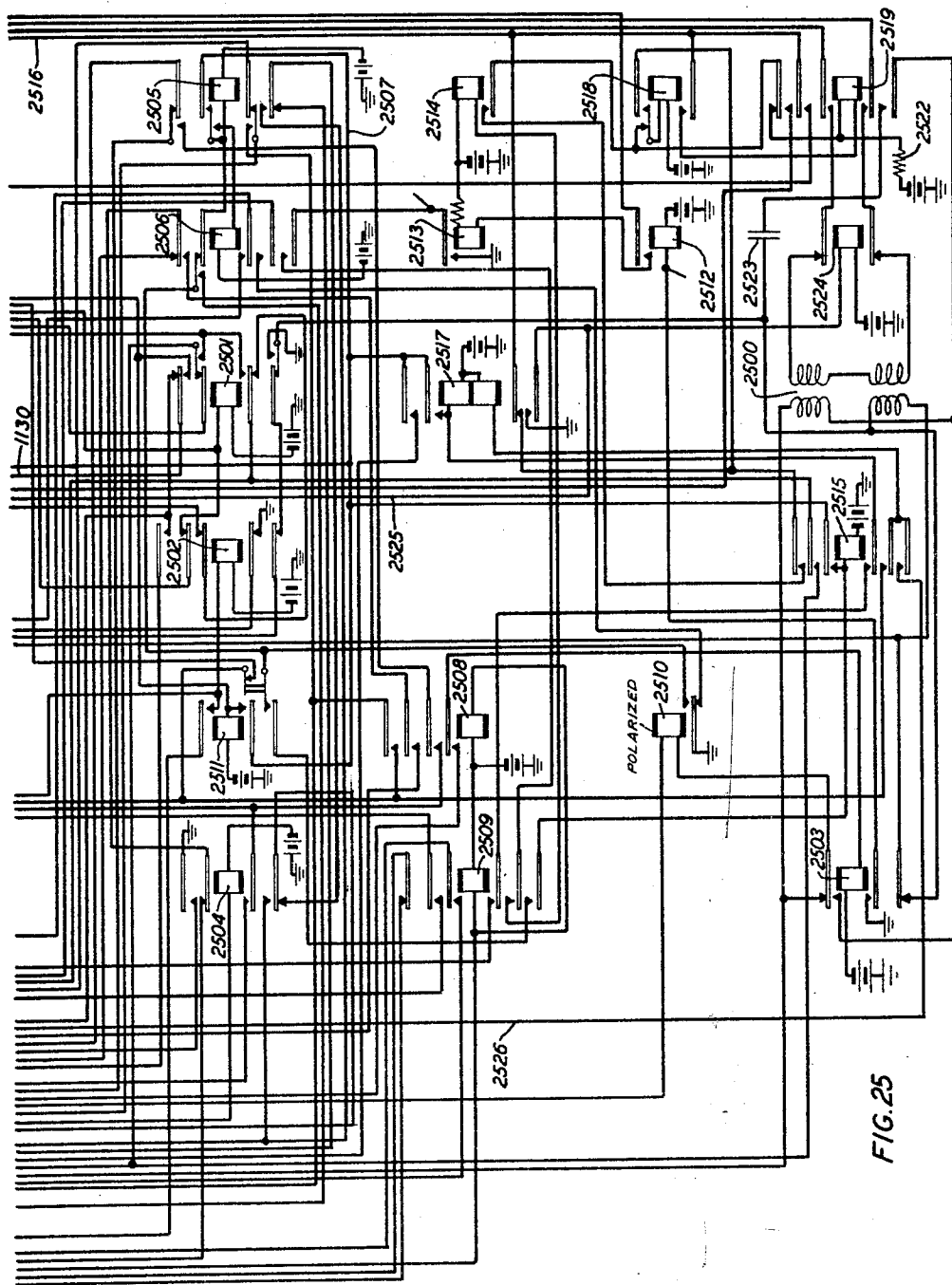
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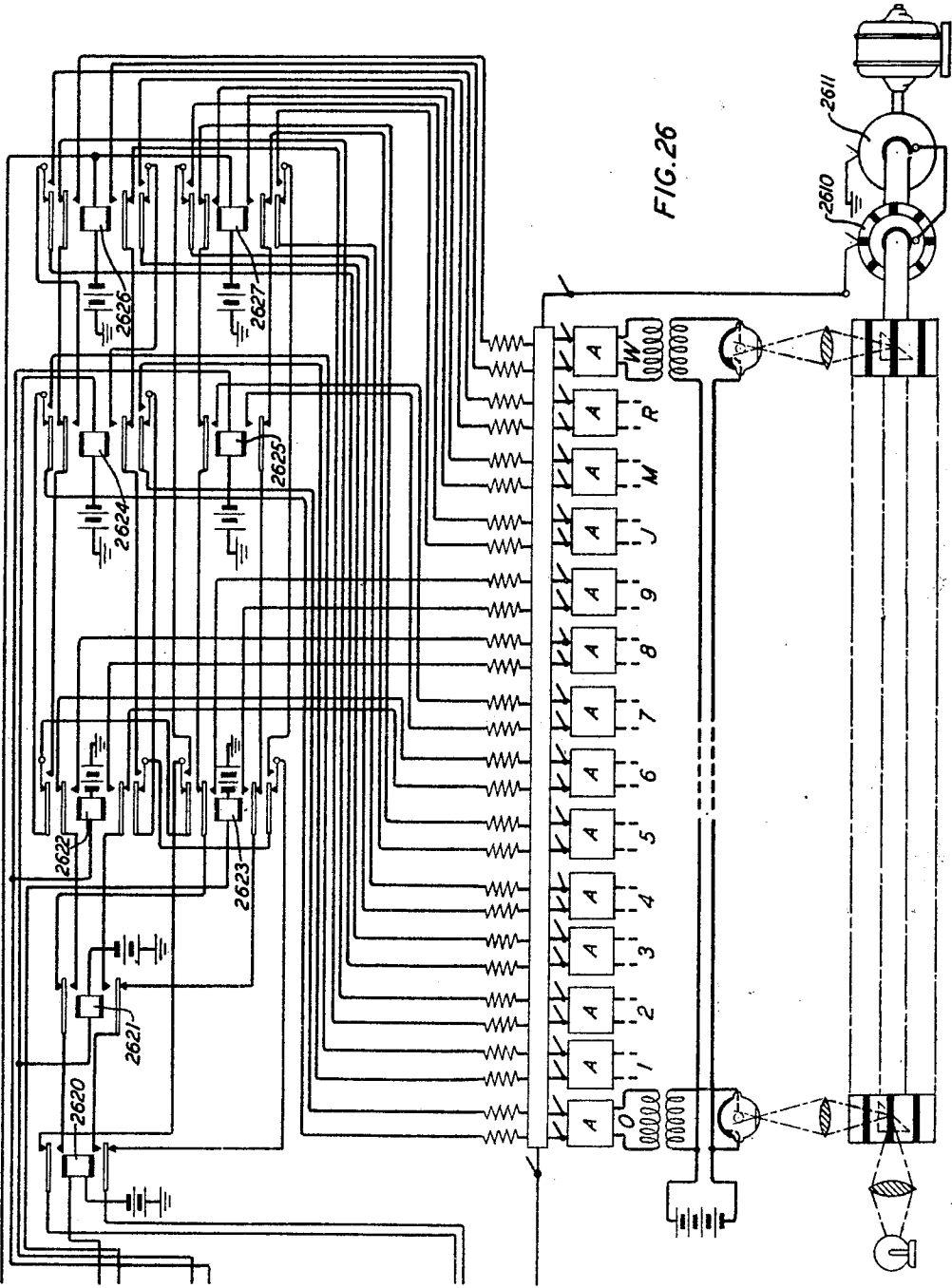
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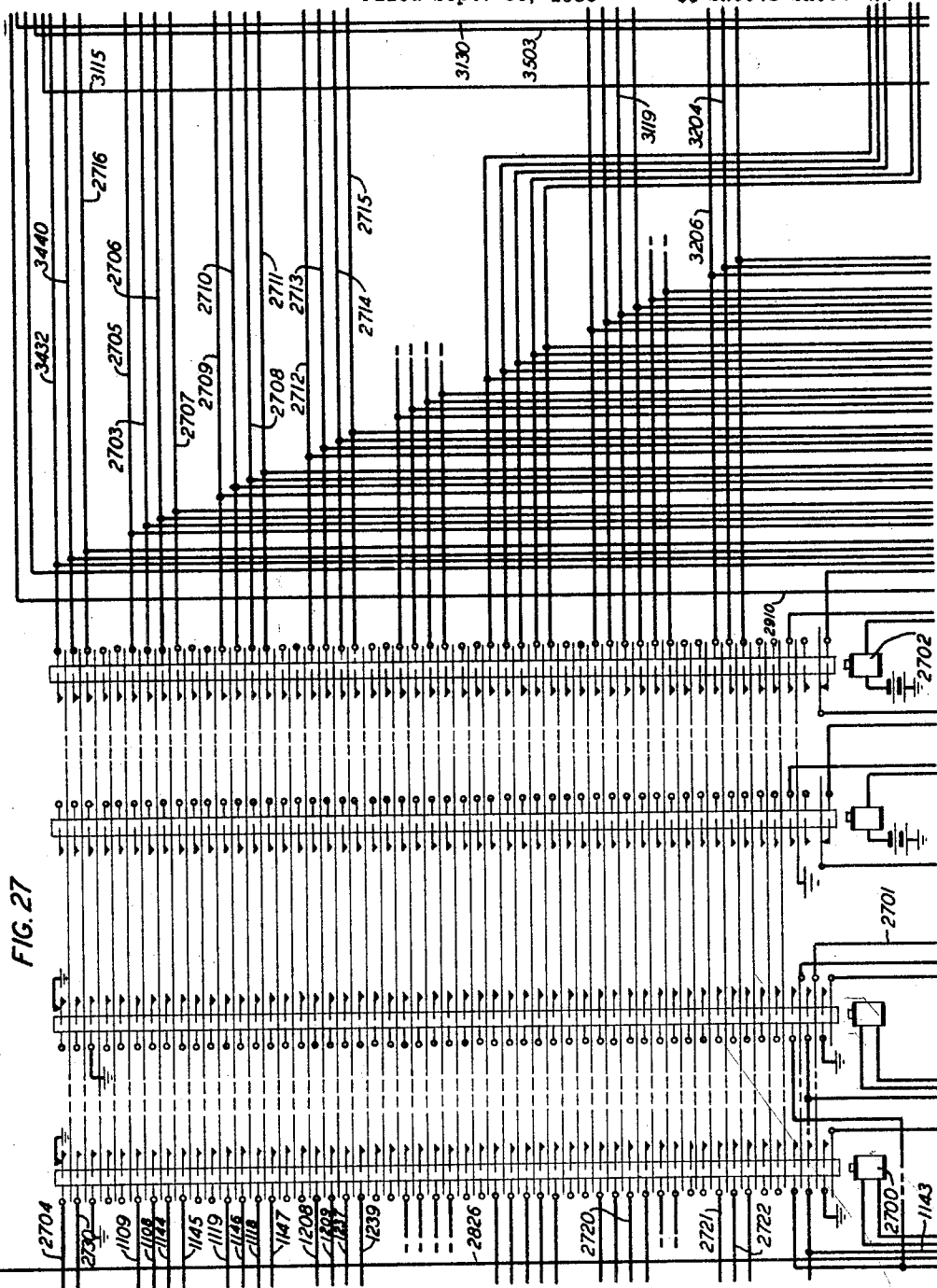


FIG. 27

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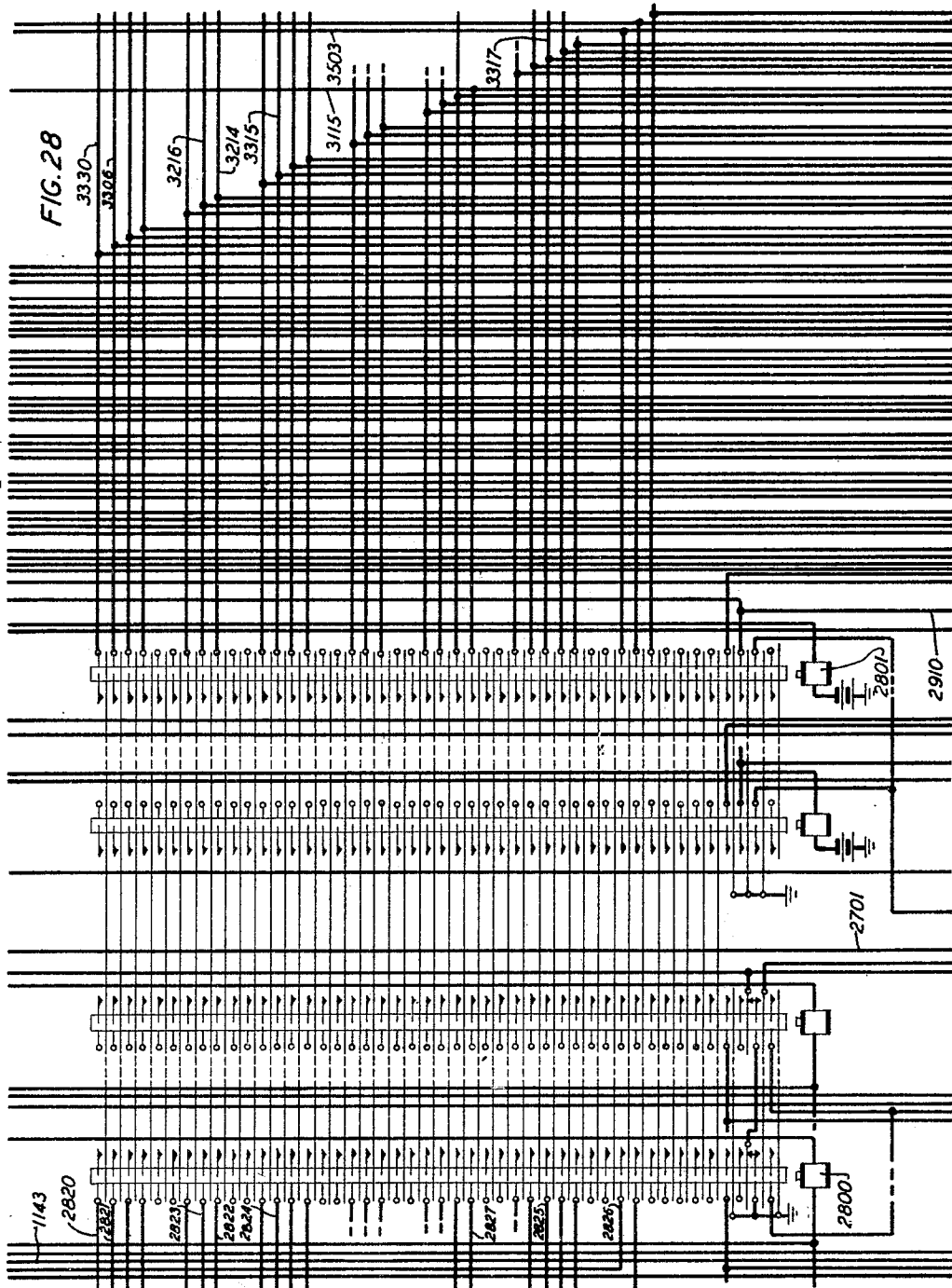
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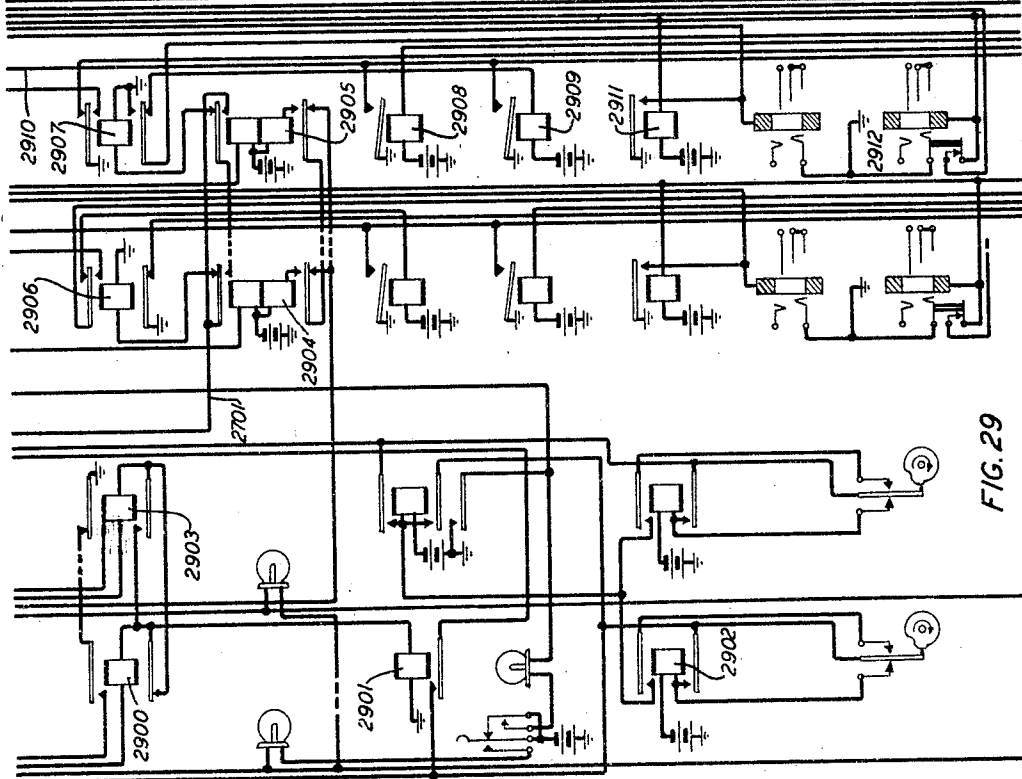


FIG. 29

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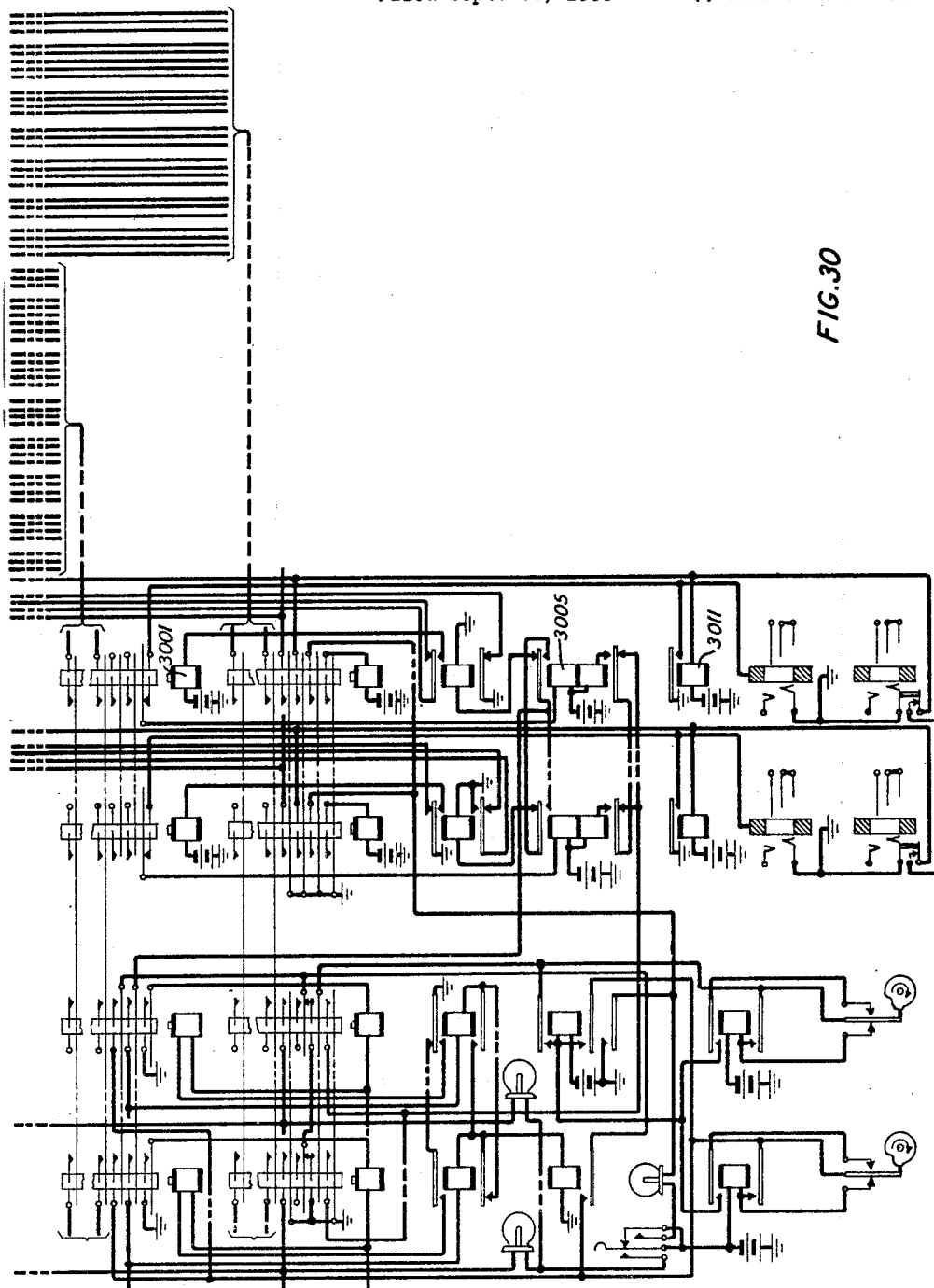


FIG. 30

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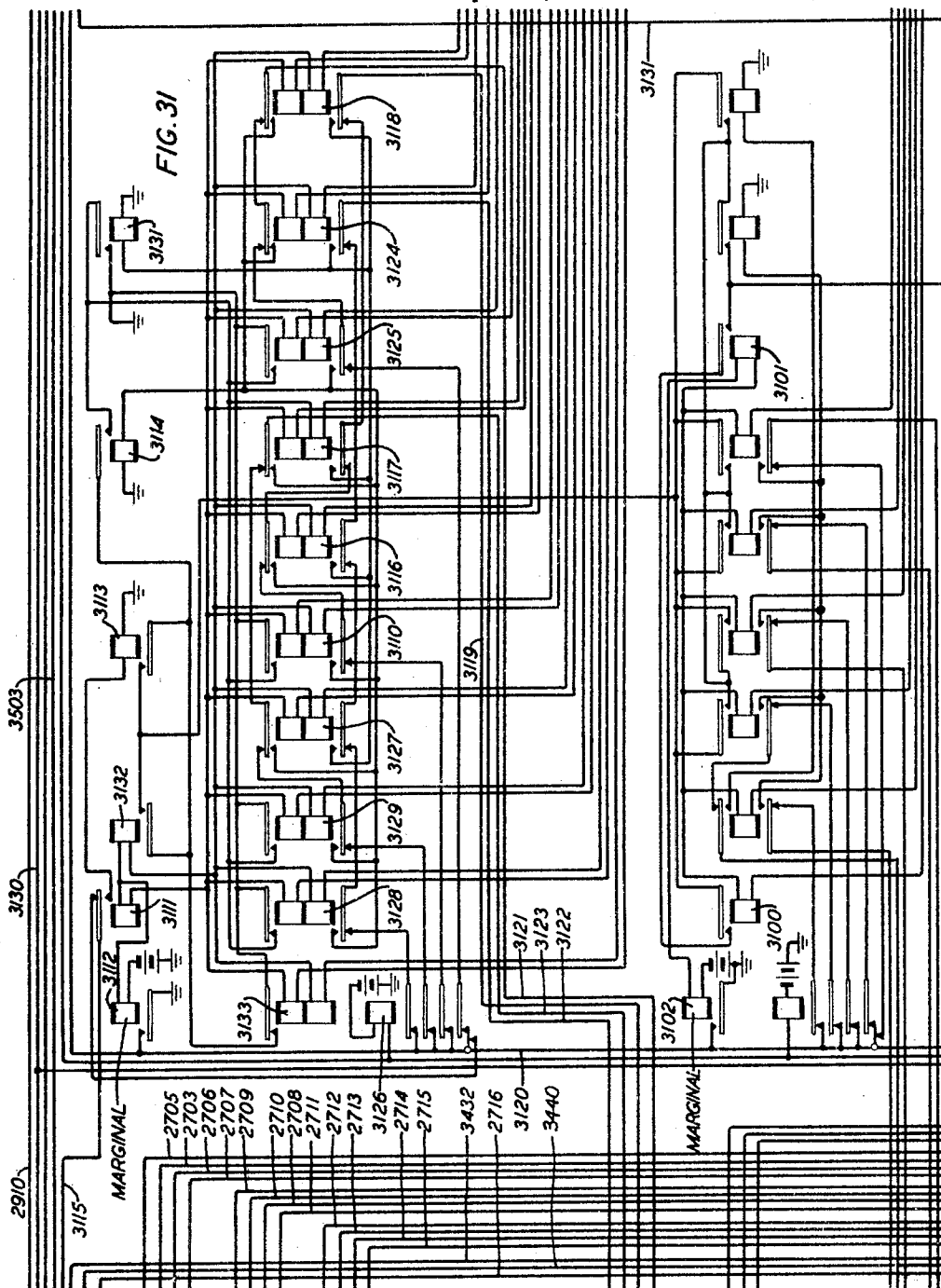
T. H. ROBERTS

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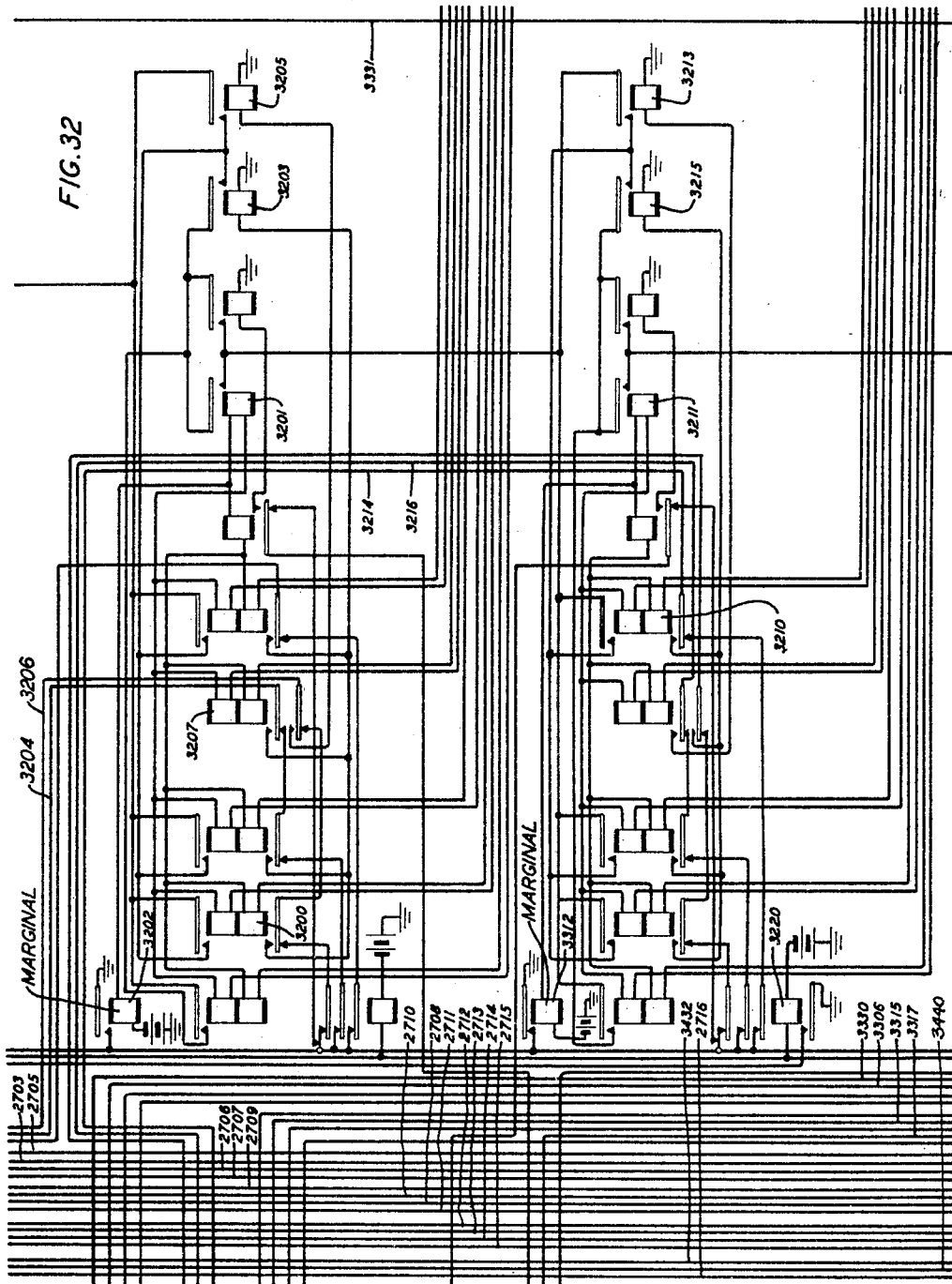
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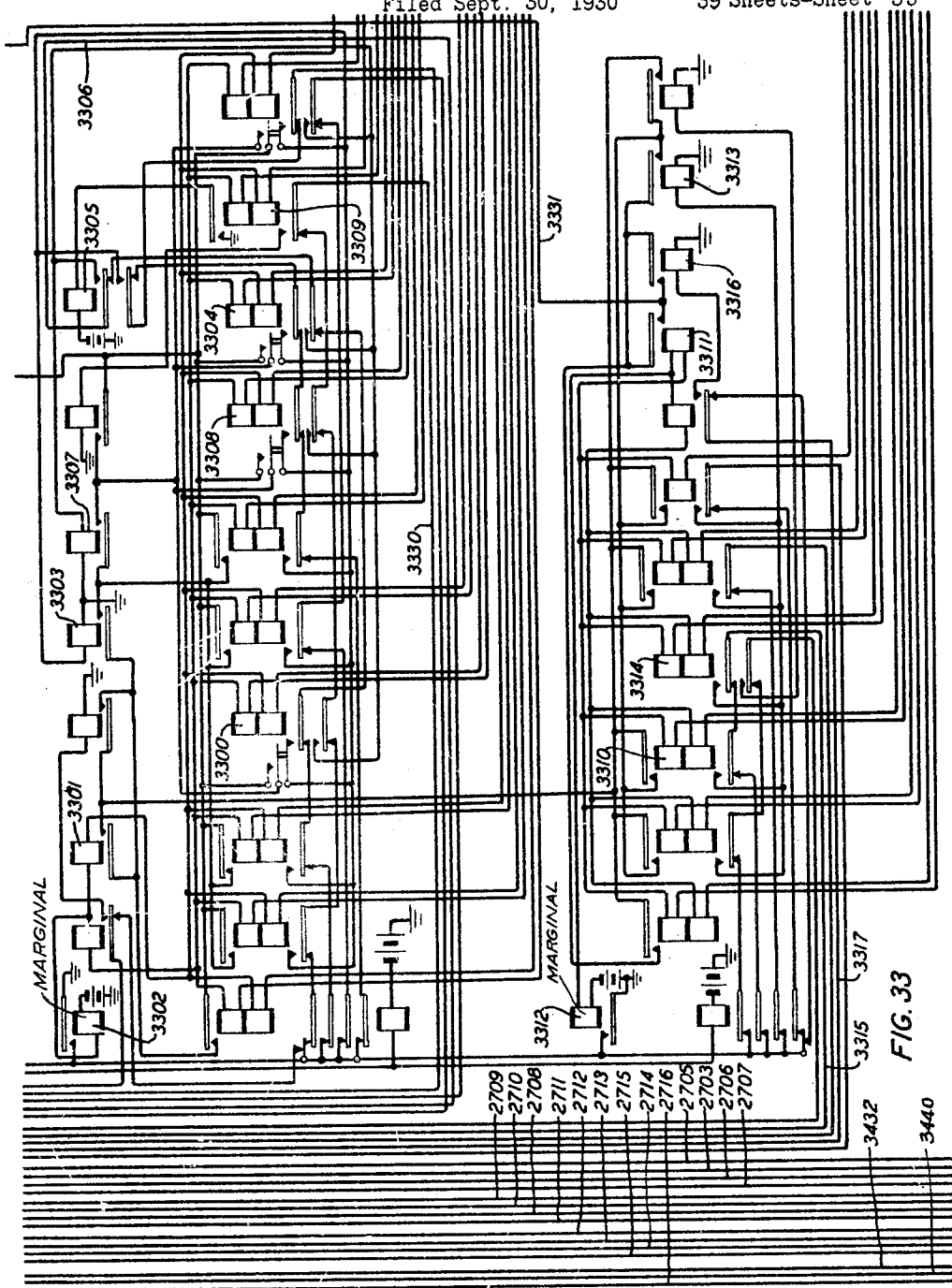
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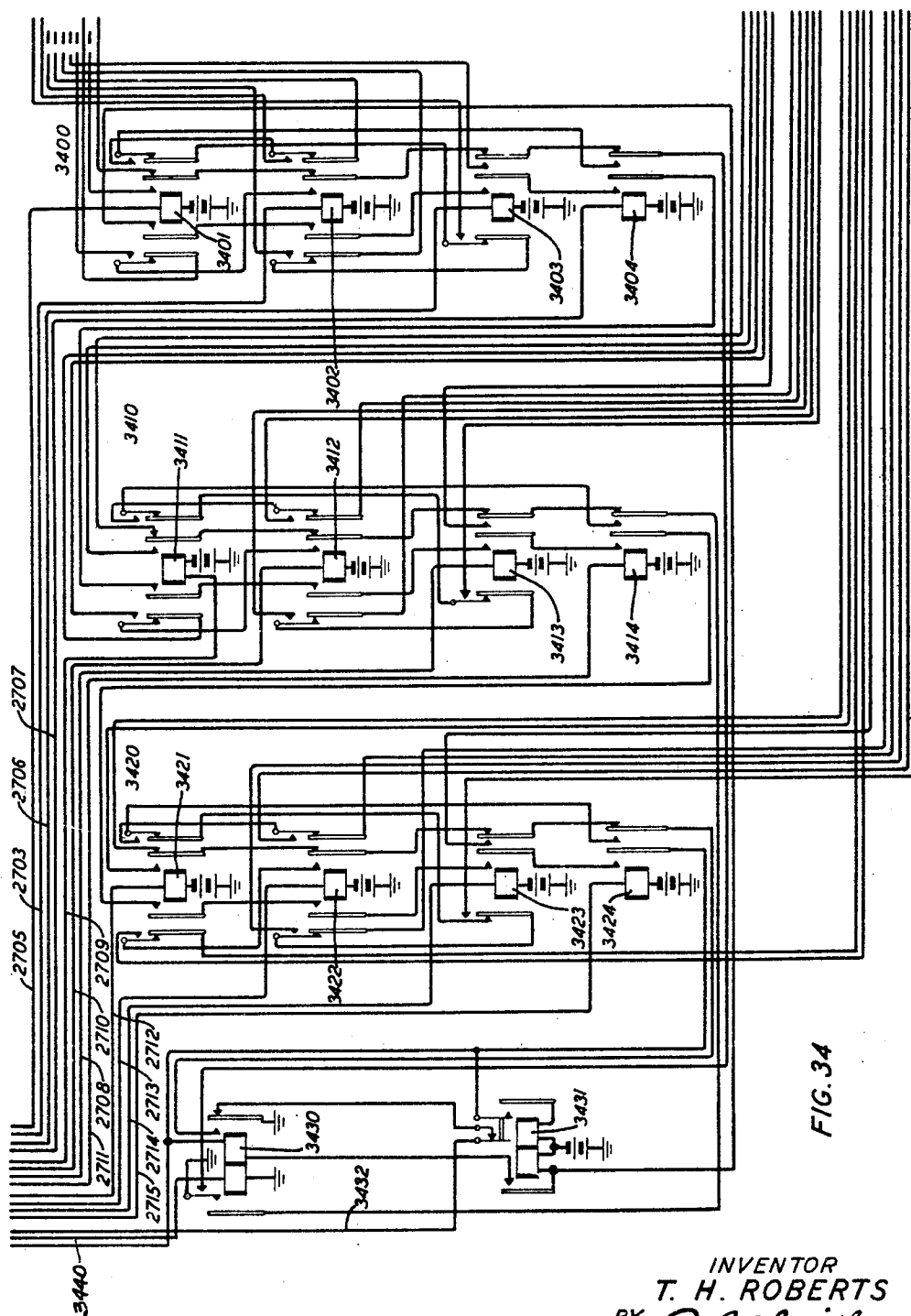


FIG. 34

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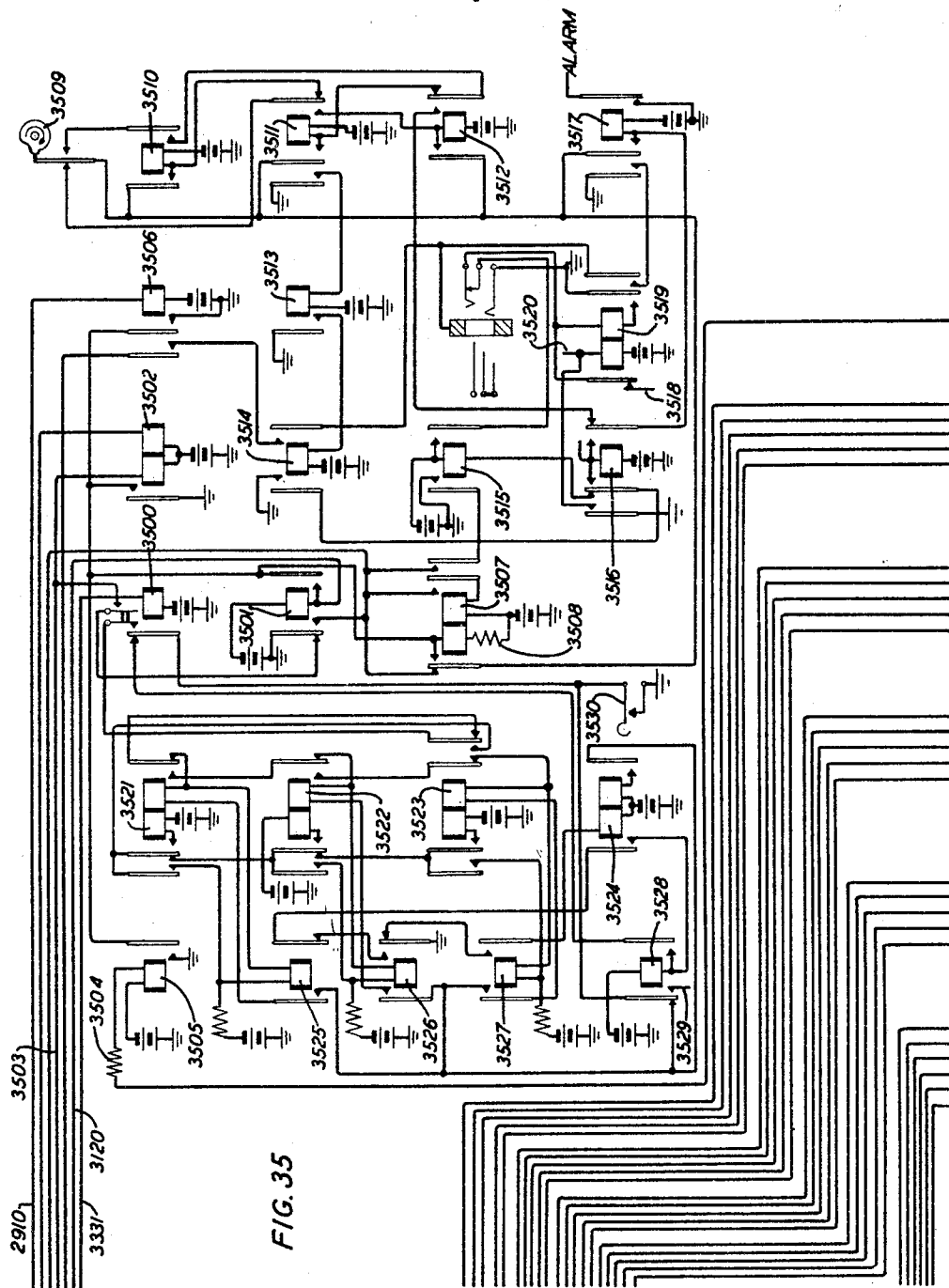
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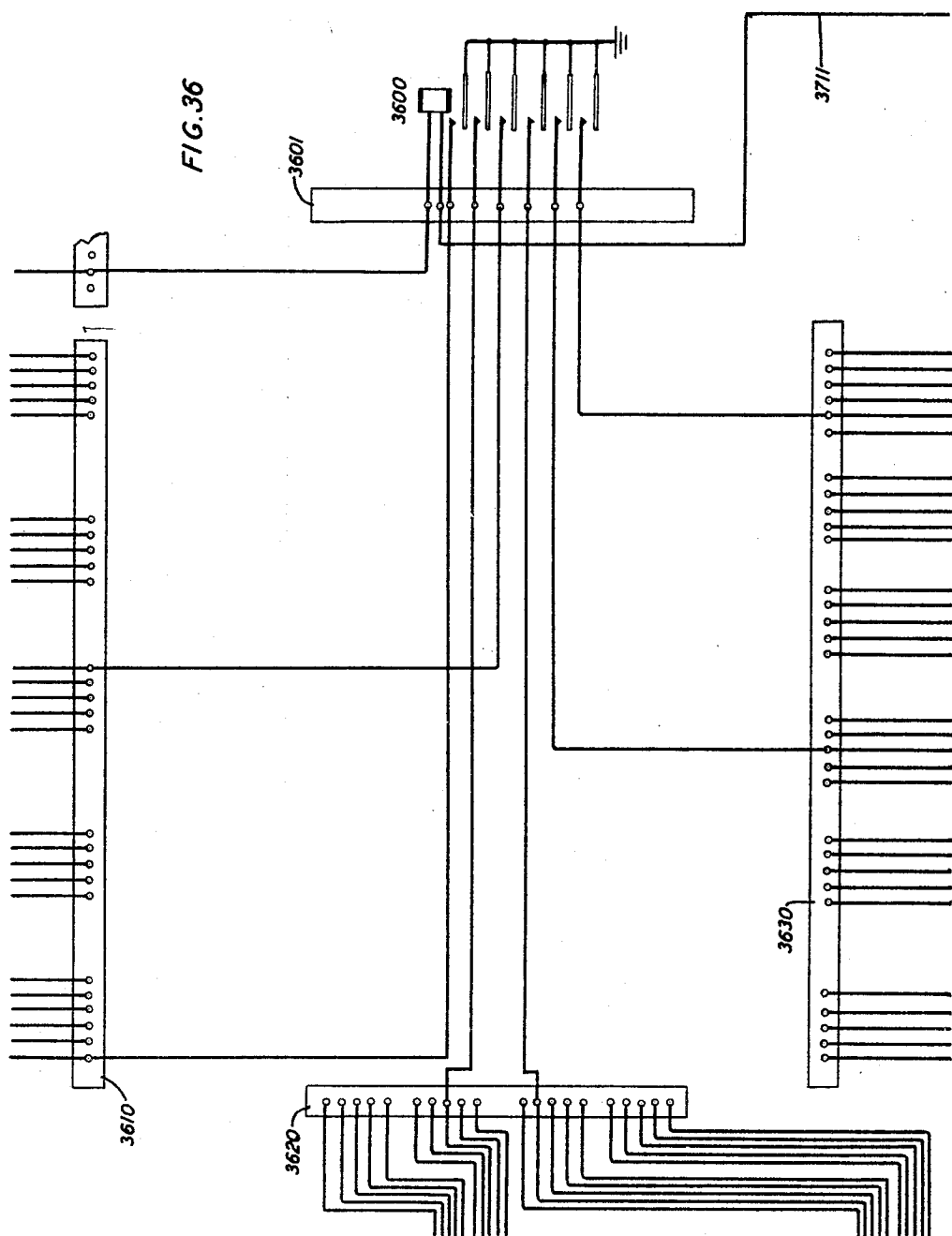
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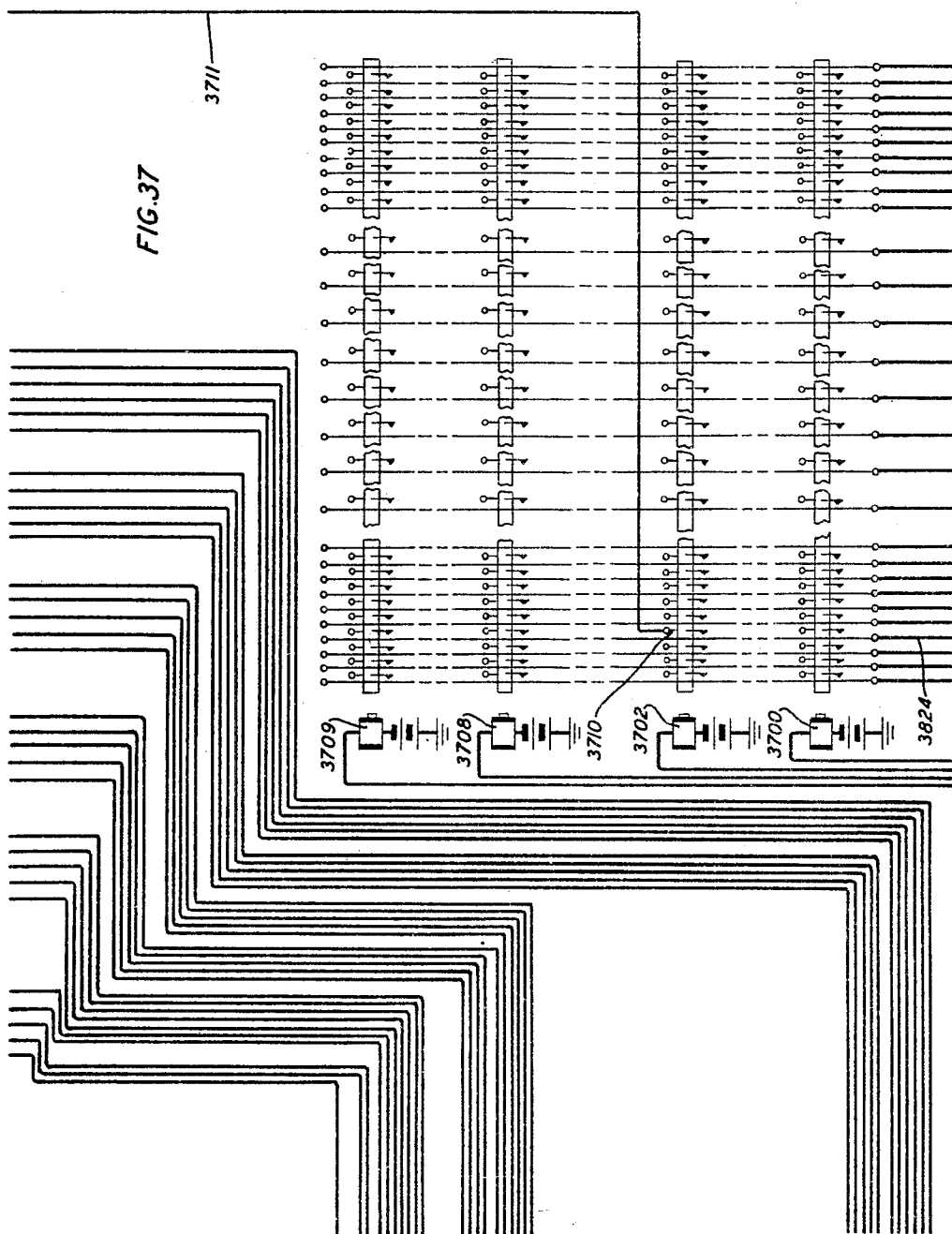
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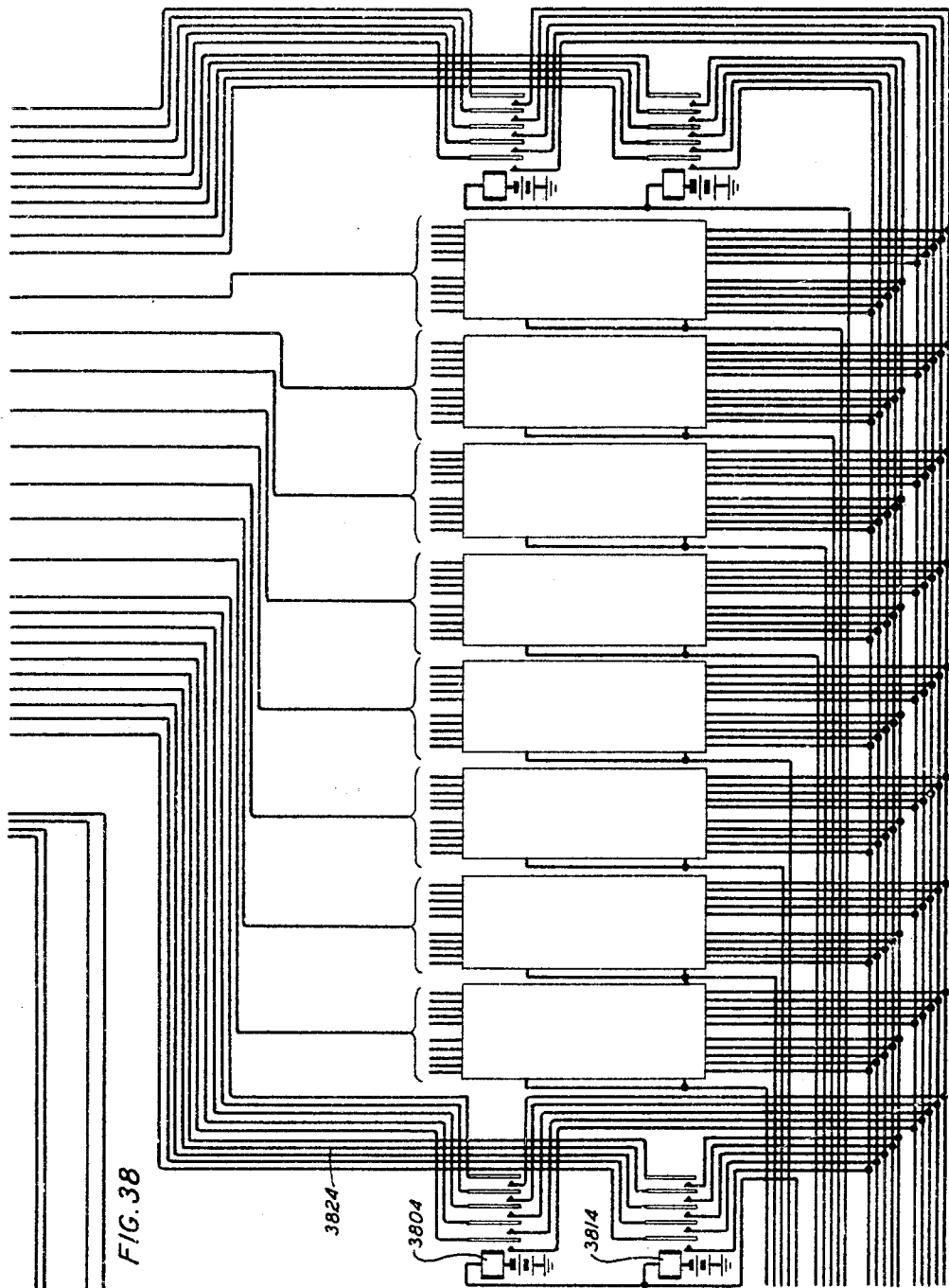
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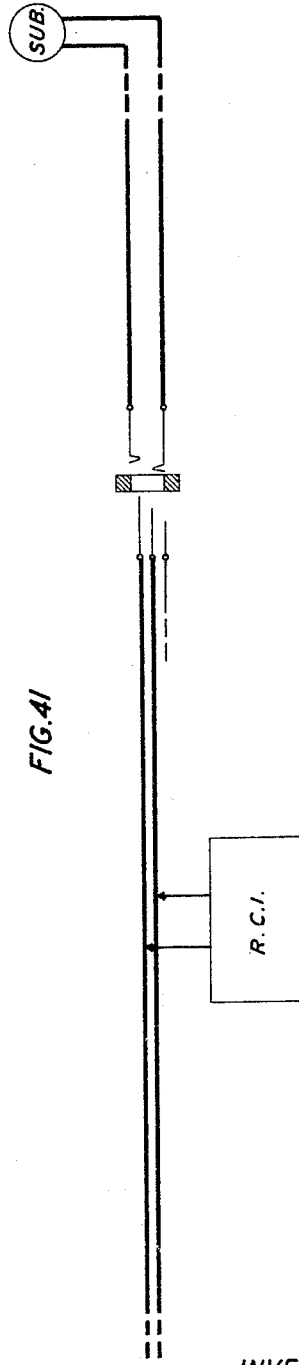
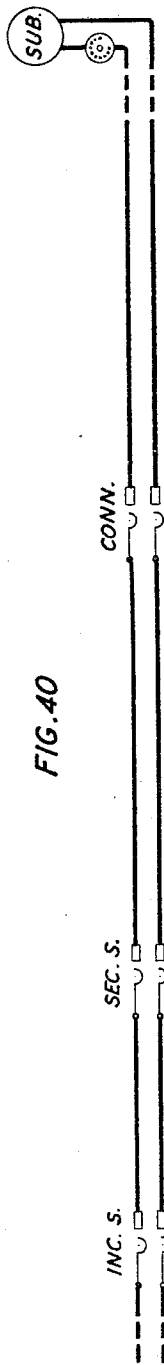
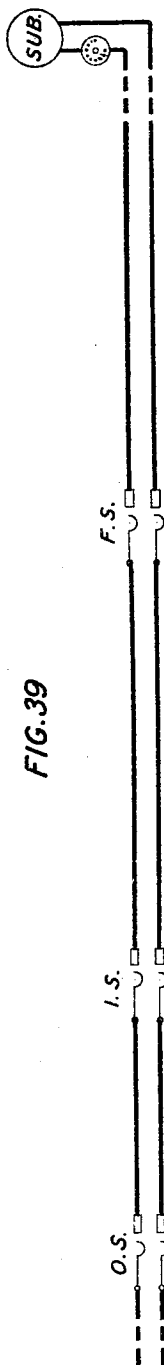
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UNITED STATES PATENT OFFICE

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TELEPHONE SYSTEM

Application filed September 30, 1930. Serial No. 485,434.

This invention relates to telephone systems in which connections are established by means of automatically operable apparatus and has for its object to increase the flexibility and efficiency of such apparatus.

With the expansion of telephone systems and the inclusion of systems employing different kinds of apparatus in the same exchange area it has become necessary to provide means for interconnecting such systems. This problem may be conveniently solved by the use of tandem distributing points into which calls may be routed and at which equipment may be provided for reaching any type of office.

The present invention contemplates the provision of a register sender in which the numbers of wanted subscribers may be registered and by which calls may be extended to wanted subscribers' offices where they may be completed by revertive pulses or simulated dial pulses or to which the number may be transmitted by means of dial pulses, code pulses or automatically generated voice currents.

In the embodiment disclosed herein by way of example the numerical values of the dial pulses and the voice currents are controlled by the registers and the same apparatus is used to successively associate the pulsing and voice current generators with the connection and with the registers. This embodiment also provides for transmitting a variable number of sets of pulses corresponding to certain digits of the office code as well as the number of the subscriber.

In the establishment of a connection the subscriber originating a call will cause the registration of the number of the wanted subscriber on the registers of the sender of his local office. That sender will thereupon automatically cause the selection of a trunk outgoing to the tandem office and will transmit the recorded designation to the tandem sender associated with the selected trunk. When the code digits have been recorded, a decoder is associated with the tandem sender and the office designation decoded into a set of registrations for controlling the selection of the proper office and the activation of the

necessary equipment for controlling the operation of the apparatus at the selected office. If the call is to be extended to a panel type office the counting relays are operated in accordance with revertive pulses from the distant office to determine the extent of motion of the selectors thereat. If the call is to be extended to a step-by-step type office a pulsing interrupter is rendered effective to transmit simulated dial pulses to the distant office. If the distant office is a manual office equipped with relay call indicators, a code impulser is employed, and if the distant office is a manual office not so equipped, a mechanism for generating and transmitting voice currents is taken into use. Under some circumstances, the connection may be extended directly to an operator without the use of either of these transmitting mechanisms.

The invention will be more clearly understood from a detailed consideration of the operation of the system as a whole. The drawings which set forth the invention include the following figures:

Fig. 1 shows in diagrammatic form the selectors and sender at the local office of the calling subscriber;

Fig. 2 shows a district selector;

Fig. 3 shows a call announcement trunk circuit for completing connections;

Fig. 4 shows an emergency listening arrangement for use in connection with the trunk of Fig. 3;

Fig. 5 shows an operator's telephone circuit for use in connection with the trunk of Fig. 3;

Figs. 6, 7 and 8 show a link circuit for associating the district selector of Fig. 2 with the sender;

Figs. 9 and 10 show certain control relays at the sender;

Figs. 11, 12 and 13 show a part of the incoming registers and the transfer relays;

Fig. 14 shows the counting relays which control selection;

Fig. 15 shows the relay call indicator impulser sequence switch;

Figs. 16, 17 and 18 show the remainder of the incoming registers and certain relays controlled thereby;

Figs. 19 and 22 show the sender controlling sequence switches;

Figs. 20 and 21 show the selection control registers of the sender;

5 Figs. 23, 24 and 25 show the relays which control the transmission of step-by-step pulses or call announcement;

Fig. 26 shows the call announcer mechanism and control relays;

10 Figs. 27, 28, 29 and 30 show the decoder connector and its control circuits;

Figs. 31, 32 and 33 show the outgoing registers of the decoder;

15 Fig. 34 shows the incoming registers of the decoder;

Fig. 35 shows the control relays of the decoder;

Fig. 36 shows the cross-connecting rack of the decoder;

20 Figs. 37 and 38 show the decoding relays of the decoder;

Fig. 39 shows diagrammatically the terminating equipment at a panel type office;

25 Fig. 40 shows diagrammatically the terminating equipment at a step-by-step office;

Fig. 41 shows diagrammatically the terminating equipment at a relay call indicator office;

30 Fig. 42 shows the manner in which the related drawings should be arranged.

Extension of call to wanted office

When the subscriber at substation 100 originates a call, his line is extended by 35 means of line finder 110 to the sender 120 and district selector 130. He manipulates his dial in accordance with the designation of the wanted subscriber and this designation is recorded on the registers of the sender and is 40 translated or decoded to determine the nature of the wanted office and the route by which it is to be reached. Assuming that the wanted subscriber is reached through a tandem office, the sender then controls the 45 district selector 130 and the office selector 140 to select a trunk outgoing to the tandem office and terminating in district selector 200. The operations which take place at the originating office are essentially the same as described in U. S. Patent 1,589,402, granted to 50 O. H. Kopp, June 22, 1926.

When the trunk is found, a relay is connected across the tip and ring conductors at the sender completing a circuit from battery 55 through the right winding of relay 201, lower right and upper left contacts of cam 202, over the tip conductor through the office selector 140 and district selector 130 to the relay of the sender 120 and back over the ring conductor 60 of the district selector 130 and office selector 140 lower left and upper right contacts of cam 203, left winding of relay 201, to ground. Relay 201 operates, closing a circuit from battery through the winding of relay 204, 65 front contact of relay 201, right contacts of

cam 205 to ground. Relay 204 in operating disconnects ground from conductor 209 to mark the district to the district finder 600 of the link. It also closes an obvious circuit for relay 207. Relay 207 connects ground 70 from the left back contact of relay 212, right front contact of relay 207, lower contacts of cam 211 to start conductor 210 leading to the start circuit of Fig. 8.

The start circuit serves to connect the district selectors one at a time with link circuits as they become available. The selectors and links are normally divided into two groups and the start circuit controls transfer 75 between groups when necessary because of trouble or busy conditions. A similar start circuit is disclosed in U. S. Patent 1,567,072, granted December 29, 1925 to W. H. Matthies. 80

The link circuit sequence switches stand, when out of use, in position 9 or 18 and are 85 advanced one at a time to position 1 or 10 to allot the link for use. Assuming that the link shown in Figs. 6 and 7 is ready for use, the connection of ground to conductor 210 completes a circuit extending through jack 90 801, upper back contact of relay 802, outer upper back contact of relay 803, right contacts of cam 701 to the winding of relay 601 and battery. Relay 601 closes a circuit from ground at its middle lower contact to the upper 95 winding of relay 602 and battery. Relay 601 also closes a locking circuit for itself over commutator strip 603, brush 605, upper right contact of cam 704, right contact of cam 703, to ground at the inner upper contact of relay 100 602. Relay 602 locks through its lower winding and inner lower contact, contact of cam 702, right contact of cam 703 to ground at the inner upper contact of relay 602. With 105 relays 601 and 602 operated, a circuit is closed from battery over the middle lower contact of relay 804, lower winding of relay 803, lowermost front contact of relay 601, outer lower contact of relay 602, lower right contact of cam 704, right contact of cam 703 to ground 110 at the inner upper contact of relay 602. Relay 601 also closes a circuit from battery through the up-drive magnet 604 of the district finder 600, inner lower front contact of relay 601, to ground over the locking circuit of relay 602. District finder 600 is 115 moved upward under the control of this circuit in search of the district selector marked by the absence of ground on the terminal served by brush 607. Relay 803 locks through 120 its upper winding and inner upper contact, back contact of relay 805 to ground at key 806. It also closes a circuit from ground at its inner lower contact through the winding of relay 807. In addition it opens the energizing circuit of relay 601. As the district 125 finder moves upward, relay 601 is held operated between segments of commutator 603 over the lower back contact of relay 606 and brush 607 of the district finder to ground in 130

the district selector circuits other than that of Fig. 2.

When the district selector 200 has been found, relay 601 releases as soon as it moves off the conducting segment of commutator 603. The release of relay 601 opens the circuit of up-drive magnet 604 and brings the district finder to rest. It also closes a circuit from battery through the winding of sequence switch magnet 700 of the link circuit, lower back contact of relay 601, outer lower front contact of relay 602, lower right contact of cam 704, right contact of cam 703 to ground at the inner upper front contact of relay 602. Sequence switch 700 is advanced to position 2 in this circuit. As soon as relay 601 releases, ground is connected to brush 607 over the inner lower back contact of relay 606, upper back contact of relay 601 upper right contact of cam 704, right contact of cam 703 to ground at the inner upper front contact of relay 602, to prevent another district finder from selecting this set of terminals. With the link sequence switch 700 in position 2, this circuit is grounded over the right contact of cam 714. A circuit is closed in position 2 of sequence switch 700 from ground over the upper left and lower right contacts of cam 705, contact of jack 708, lower left and upper right contacts of cam 709 to the winding of the relay corresponding to relay 602 in the next link, to allot that link provided its sequence switch is standing in position 9 or 18. If not, the circuit extends over the lower right contact of cam 709 to the next link which will be allotted if ready.

With sequence switch 700 in position 2, a circuit is closed from ground at the right contact of relay 807, through resistance 808, winding of relay 805, left contacts of cam 712, brush 608 of the district finder, conductor 214, left contacts of cam 215 to the right winding of relay 212 and battery. Relay 212 locks over its inner right front contact to ground over the left contacts of cam 213, and extends this locking ground back to the winding of relay 805 which now operates in series with battery and resistance 809. Relay 212 disconnects ground from the start conductor 210 and closes a circuit from ground at its left front contact over the lower left contact of cam 216, to the winding of sequence switch magnet 206 and battery, advancing the sequence switch to position 3. As soon as sequence switch 206 leaves position 1, ground is connected over the left contact of cam 217, lower right contact of cam 218 to conductor 209 to prevent the selection of this district by any other district finder.

The operation of relay 805 as above described, closes a circuit from ground over key 806, front contact of relay 805, contacts of cam 713, winding of relay 609, resistance 632, and battery. Relay 609 locks over its middle lower front contact to ground over

the contacts of cam 714. It also extends this ground over its inner lower front contact, upper contacts of cam 715 to the winding of sequence switch magnet 700 and battery, advancing sequence switch 700 to position 3. This sequence switch is immediately advanced to position 4 over the upper right contact of cam 717, lower back contact of relay 611 to ground over the right contacts of cams 703 and 714. The operation of relay 805 opens the locking circuit of relay 803 and that relay releases, in turn releasing relay 807. Relay 805 releases as soon as sequence switch 700 leaves position 2. When sequence switch 700 reaches position 3, relays 609 and 602 release.

In position 4 of sequence switch 700 the link circuit hunts for an idle sender. A circuit is closed from battery, through the lower winding of relay 612, upper left and lower right contacts of cam 716, lower back contact of relay 611 to ground over the right contacts of cams 703 and 714. Relay 612 closes a circuit from battery through the lower winding of relay 610, contacts of cam 718, outer upper front contact of relay 612, upper back contact of relay 611, lower back contact of relay 609 to ground over the right contacts of cams 703 and 714. When sequence switch 700 reaches position $3\frac{3}{4}$ a circuit is closed from battery through the upper winding of relay 602, lower left contact of cam 704 to ground at the contacts of cam 714. With relays 612 and 602 operated, a circuit is closed from battery through the lower winding of relay 611, outer upper contact of relay 602, upper winding of relay 611 to ground at the inner upper front contact of relay 612. Relay 611 being marginal does not operate in this circuit but an additional circuit is closed in parallel with the upper winding of relay 611 through the middle winding of that relay, contacts of cam 719, outer upper back contact of relay 609 to brush 613 of the sender finder. When relay 610 operated, it closed a circuit from battery through the winding of up-drive magnet 614, outer lower back contact of relay 606, inner upper back contact of relay 609, outer upper front contact of relay 610, lower left contact of cam 704, to ground at the right contact of cam 714. The sender finder 615 is advanced in search of an idle sender under the control of magnet 614.

An idle sender is characterized by battery through a resistance, such as resistance 902, connected to the terminal to which brush 613 has access. Assuming that the sender shown is the first idle sender, when brush 613 engages the corresponding terminal leading to this sender, a circuit is closed from battery through resistance 902, upper back contact of relay 901, contact of relay 900, brush 613, and thence to the middle winding of relay 611 as above traced. Relay 611 now operates and closes a locking circuit for itself

from battery through its middle winding as above traced and thence over its upper front contact, lower back contact of relay 609, to ground over the right contacts of cams 703 and 714. It also opens the circuit of relay 610 but relay 610 remains operated over the lower contacts of cam 720 until brush 617 moves off the conducting segment of commutator strip 616 thus insuring that the brush set is properly centered. When relay 610 releases it opens the circuit of the up-drive magnet 614 and brings the sender finder 615 to rest. It also releases relay 612 which is made slow to release to provide ample time for relay 611 to operate and lock. Relay 611 also closes a circuit from battery through the winding of sequence switch magnet 700, lower right contact of cam 717, upper back contact of relay 612 as soon as that relay releases, lower front contact of relay 611 to ground over cams 703 and 714, advancing sequence switch 700 to position 5. As soon as sequence switch 700 leaves position 4 relay 602 releases.

With sequence switch 700 in position 5, a circuit is closed from ground through the lower and middle windings of relay 905, inner upper contact of relay 904, lower back contact of relay 903, conductor 919, brush 619, of the sender finder, upper winding of relay 612, contacts of cam 721, brush 618, conductor 221, lower left and upper right contacts of cam 220 to the winding of relay 208 and battery. Relay 208 operates in this circuit and connects ground over its right front contact, lower contacts of cam 222, to the left winding of relay 212 and battery. Relay 212 in operating connects ground over its left front contact, lower left contact of cam 216 to the winding of sequence switch magnet 206 and battery, advancing the sequence switch to position 4.

Relay 905 also operates in the circuit of relay 208, in turn operating relay 906 and relay 907. Relay 907 operates relay 908 which locks over its inner lower front contact and closes a circuit for operating relay 901. The operation of relays 906, 907 and 901 connects ground to the conductor 909 operating relays 1126 and 1230 to supply off-normal ground to the various parts of the sender. With relay 1126 operated ground is connected to conductor 1131 and over the lower back contact of relay 1002 to the winding of relay 920 and battery. Relay 920 prepares circuits which become effective later.

Relay 901 in operating disconnects battery from brush 613 and releases relay 611. The release of relay 611 closes a circuit from battery through the winding of sequence switch magnet 700, upper right contact of cam 717, lower back contact of relay 611, to ground at the right contacts of cams 703 and 714, advancing sequence switch 700 to position 6. With sequence switch 700 in position 6

brush 620 is connected over the outer upper back contact of relay 606, upper contacts of cam 722 to brush 623. Brush 621 is connected over the inner upper back contact of relay 606, upper contacts of cam 723 to brush 624. Brush 618 is connected over the contacts of cam 721 through the upper winding of relay 612 to brush 619. Brush 622 is connected over the lower left and right contacts of cam 724 to brush 625. Brush 608 is connected over the lower contacts of cam 725 to brush 626. Brush 607 is connected to ground over the inner lower back contact of relay 606, upper back contact of relay 601 and cams 704 and 714. Brush 613 is disconnected at this time. The link circuit remains in position 6 as long as the sender is connected with the district selector.

When relay 208 operated it closed a circuit from ground over its front contact, left contacts of cam 222, winding of relay 223 to battery.

While sequence switch 206 was passing through positions 1 to 3 inclusive the tip conductor was extended over the left contacts of cam 202, upper back contact of relay 223, upper left contact of cam 230, upper left contact of cam 219 to the right winding of relay 201 and battery and the ring conductor was extended over the left contacts of cam 203, outer lower back contact of relay 223, lower contacts of cam 251 to the left winding of relay 201 and ground holding relay 201 operated. When relay 223 operates it closes the incoming pulsing circuit from the tip conductor over the left contacts of cam 202, outer upper front contact of relay 223, upper right and lower left contact of cam 225, upper back contact of relay 226, conductor 223, brush 620, to brush 623 through the link, outer lower back contact of relay 1000, next to the inner upper back contact of relay 1120, conductor 1121, inner lower back contact of relay 1326 in parallel with resistance 1330, conductor 1331, windings of relays 1122, 1123 and 1124 in series, conductor 1125, outer lower back contact of relay 1326, conductor 1332, next to the outer upper back contact of relay 1120, inner lower back contact of relay 1000, outer upper back contact of relay 1001, from brush 624 to brush 621 through the link circuit, conductor 227, outer left back contact of relay 229, outer lower back contact of relay 226, upper contacts of cam 224, outer lower front contact of relay 223, left contacts of cam 203 to the ring conductor. When sequence switch 206 reaches position 4 the tip conductor is extended over the left contacts of cam 225 and the upper back contact of relay 226 to conductor 228, while the ring conductor is extended over the left contacts of cam 224, outer lower back contact of relay 226, outer left back contact of relay 229 to conductor 227, rendering the

incoming pulsing circuit independent of relay 223.

The operation of relay 223 disconnects battery and ground through the windings of relay 201 from the tip and ring conductors leading to the sender 120 thus releasing a relay at that sender which initiates the transmission of relay call indicator impulses. Relay 201 is held operated after relay 223 operates and until the sequence switch leaves position 3½ over a circuit from battery through its right winding, left front contact of relay 207, inner lower front contact of relay 223, upper left front contact of cam 250, lower left contact of cam 222 to ground at the front contact of relay 208. As soon as sequence switch 206 reaches position 3¾ a new holding circuit is closed over the inner lower back contact of relay 226, inner left back contact of relay 229, left contact of cam 218 to ground at the left contact of cam 217.

Relay 1122 is polarized to respond to negative impulses; relay 1123 is polarized to respond to positive impulses; relay 1124 is marginal so that it responds to heavy impulses of either sort received over the pulsing circuit above traced. Assuming that the called subscriber's number is Chelsea 5678 the following code will be transmitted from sender 120.

C	2	Heavy		Light
		Negative		Negative
H	4	Light	Positive	Light
		Negative		Negative
35 E	3	Heavy		Light
		Negative		Negative
	0	Light		Light
		Negative		Negative
	5	Heavy		Heavy
		Negative		Negative
	6	Light	Positive	Heavy
		Negative		Negative
40	7	Heavy		Heavy
		Negative		Negative
	8	Heavy	Positive	Heavy
		Negative		Negative

The first code impulse which, as shown above, is a heavy negative causes the operation of relay 1122 and 1124. Relay 1122 in operating connects ground from conductor 909 over its front contact, normal contact and winding of relay 1132, resistance 1133 to battery. Relay 1132 operates and locks to conductor 909 over its lower alternate contact. Relay 1132 closes a circuit from battery through resistance 1135, winding of relay 1134, alternate contact of relay 1132 to conductor 909 to prepare for the operation of relay 1134. Relay 1134 is prevented from operating at this time by ground connected over the contact of relay 1122 and the back contact of relay 1134 to resistance 1135 in shunt of the winding of relay 1134. Relay 1124 in operating connects ground from conductor 909 over its front contact, outer lower back contact of relay 1134, outer lower back contact of relay 1107 to the upper winding of relay 1102 of the tandem hundreds register 1100, and battery. Relay 1102 locks through its lower winding to grounded con-

ductor 1231. When the pulse terminates relays 1122 and 1124 release. Relay 1122 removes the shunt from around the winding of relay 1134 which now operates. With relay 1134 operated a circuit is closed from battery through the winding of relay 1107, upper back contact of relay 1106, upper front contact of relay 1134 to grounded conductor 909. Relay 1107 locks through the winding of relay 1106, inner upper front contact of relay 1107 to grounded conductor 1127. Relay 1106 is shunted by the operating ground for relay 1107 until relay 1134 releases. The next pulse received is a light negative pulse and therefore relay 1122 operates alone. It closes a circuit from ground over conductor 909, front contact of relay 1122, lower front contact of relay 1134 to resistance 1133 in shunt of the winding of relay 1132 which now releases. The first lower contact of relay 1132 is a make-before-break contact so that relay 1134 is held operated over the normal contact of relay 1132 and the front contact of relay 1122 to conductor 909 until the pulse terminates at which time relay 1134 also releases. When relay 1134 releases relay 1106 operates in the locking circuit of relay 1107. Relays 1107 and 1106 transfer the circuits controlled by relays 1122, 1123 and 1124 to the tandem tens register 1110. It will be apparent that only relay 1102 is operated in the tandem hundreds register 1100.

During the reception of the first pulse of the next digit relay 1122 is operated alone as above described and in turn operates relay 1132. At the end of the pulse relay 1134 is also operated, closing a circuit from battery through the winding of relay 1117, upper back contact of relay 1116, inner upper front contact of relay 1106 to grounded conductor 909 over the front contact of relay 1134. The second pulse of this digit is a positive pulse causing the operation of relay 1123. Relay 1123 closes a circuit from ground over its front contact, middle lower front contact of relay 1132, inner lower front contact of relay 1106, inner lower back contact of relay 1116 to the upper winding of relay 1113 and battery. Relay 1113 locks through its lower winding to grounded conductor 1231. The third pulse of the digit causes the operation of relay 1122 which releases relays 1132 and 1134 as previously described and permits the operation of relay 1116 in the locking circuit of relay 1117. Relay 1113 alone of the tandem tens register 1110 is operated.

With relay 1117 operated a circuit is closed from battery through the winding of relay 911, conductor 912, outer upper contact of relay 1117, conductor 1136 to ground at the outer upper front contact of relay 908. Relay 911 in operating connects ground over its front contact, innermost upper contact of re-

lay 907, conductor 913, lower left contact of cam 2204 to the winding of sequence switch magnet 2200 and battery, advancing sequence switch 2200 to position 2. In position 2 a circuit is closed from ground over the upper left contact of cam 2201, upper right contact of cam 2202 to conductor 2203. This circuit provides a holding circuit for relay 911 and also provides off-normal ground for a number of other circuits.

The first pulse of the third digit is a positive pulse. A circuit is therefore closed from ground at the front contact of relay 1123, outer lower back contact of relay 1132 which has not been operated as yet, inner lower front contact of relay 1107, inner lower front contact of relay 1117, inner lower back contact of relay 1207 to the winding of relay 1201 and battery. Relay 1201 locks through its lower winding to grounded conductor 1232. The second pulse which is a heavy negative pulse causes the operation of relays 1122 and 1124 as above described. Relay 1124 closes a circuit from grounded conductor 909, outer lower back contact of relay 1134, outer lower front contacts of relays 1107 and 1117, outer lower back contact of relay 1207 to the winding of relay 1202 and battery. Relay 1202 also locks to grounded conductor 1232. The operation of relay 1122 in response to this pulse and to the following light negative pulse causes the operation and release of relays 1132 and 1134 to bring about the operation and locking of relays 1207 and 1206. Relays 1201 and 1202 are therefore operated in the tandem units register.

Assuming that the called subscriber's number includes no stations digit the next digit received will consist of two light pulses which are the equivalent of the digit zero. No register relay in stations register 1210 will be operated but relays 1216 and 1217 will be operated by the operation of relay 1122 to advance the circuit to the next register.

The remaining digits are recorded in a manner similar to that above described on registers 1220, 1300, 1310 and 1320 resulting in the operation and locking of relays 1222 and 1224 of thousands register 1220, relays 1301 and 1304 of hundreds register 1300, relays 1312 and 1314 of tens register 1310 and relays 1321, 1322 and 1324 of units register 1320.

Relays 1326 and 1327 operate in a slightly different manner from the other transfer relays. The operation of relay 1134 during the transmission of the units digit closes a circuit from battery through the winding of relay 1327 and its normal contact, upper front contacts of relays 1316, 1306, 1226, 1216, 1206, 1116 and 1106, upper contact of relay 1134 to grounded conductor 909. Relay 1327 locks over its lower alternate contact to grounded conductor 1128. It also prepares a circuit from battery through the winding of relay

1326, outer upper contact of relay 1327 to the upper back contact of relay 1132, back contact of relay 1122 and grounded conductor 909. This circuit is not completed until relay 1122 releases the second time at the completion of the digit. Relay 1326 in operating locks to grounded conductor 909. With relays 1326 and 1327 operated the connection of the tip and ring conductors to relay 1122 is altered to render that relay responsive to a final heavy positive pulse. This altered circuit may be traced from brush 623, to conductor 1121, as before, and thence over the inner lower front contact of relay 1326, and the winding of relay 1122 in parallel with resistance 1330, outer lower front contact of relay 1326, to conductor 1332 and back to brush 624 as previously traced. Relay 1122 operates in response to the heavy final positive pulse causing the operation of relay 1132 which prepares the circuit for relay 1134 as before. When relay 1122 releases relay 1134 operates. At this time the operation of relay 1134 closes a circuit from grounded conductor 909, upper front contact of relay 1134, outer lower front contact of relay 1132, inner upper front contact of relay 1327, outer upper front contact of relay 1326 to the winding of relay 1120 and battery.

When relay 1327 operated a circuit was closed from battery through the winding of relay 1137, inner back contact of relay 1120, outer lower front contact of relay 1327 to grounded conductor 909. Relay 1137 is released when relay 1120 operates but two circuits are momentarily closed, one from battery through resistance 1138, inner upper front contact of relay 1137, next to the inner upper front contact of relay 1120 to the tip conductor and from ground over the upper front contact of relay 1137, outer lower contact of relay 920, next to the outer upper front contact of relay 1120 to the ring conductor charging the interoffice trunk to prevent the false operation of relay 914 due to capacity of the trunk if the trunk is opened at this time. When relay 1137 completely releases the ring conductor is extended over its upper back contact to resistance 1139 and ground. The tip conductor is extended over next to the inner upper front contact of relay 1120, inner upper back contact of relay 1137 to the winding of relay 914 and battery.

Following the transmission of the final heavy pulse, the sender 120 is disconnected from the district selector 130 and the district selector connects a relay across the tip and ring conductors which completes the circuit of relay 914. Relay 914 closes a circuit from battery through the winding of relay 910, front contact of relay 914, lower back contact of relay 1002 to grounded conductor 1131. Relay 910 in turn closes an operating circuit for relay 915 to grounded conductor 1131 and relay 915 locks directly to conductor

1131. These relays prepare circuits to care for the dismissal of the sender if the call is abandoned at this stage of the establishment of the connection.

5 When relay 1207 operated during the reception of the third code digit, a circuit was closed from battery, over the contacts of cam 2205, conductor 2206, upper front contact of relay 1207, conductor 1239 to the wind-
10 ings of relays 2800 and 2700 in the decoder connector to prepare these relays for operation. When relay 1206 operated after the complete registration of the tandem units digit a circuit was closed from battery over
15 conductor 2206, outer upper front contact of relay 1206, lower back contact of relay 1140, lower back contact of relay 1141, back contact of relay 1142, conductor 1143 and thence through the windings of relays 2900 and 2901
20 to ground. Relay 2900 is individual to the sender shown terminating in the decoder connector shown in Figs. 27 and 28. The decoder connector consists of a plurality of multi-contact relays, whose contacts are multiplied together in groups to form channels.
25 Each sender is connected to the contacts of one pair of multi-contact relays and each decoder is connected in multiple to the contacts of a pair of relays in each channel. Therefore with the sender relays and a pair of
30 decoder relays in the same channel operated, the sender is connected with a decoder over a large number of conductors. The connector is arranged to prevent double connections and to give service in nearly the order
35 of demand. A clearer understanding of these safeguards may be obtained from a consideration of U. S. Patent 1,700,456, granted January 29, 1929 to F. A. Stearn.

40 Relay 2900 operates in the circuit above traced and, if this channel of the decoder connector is idle, closes a circuit from ground over the back contacts of relays corresponding to relay 2900 but individual to other send-
45 ers, front contact of relay 2900, to the winding of relay 2700 to which battery is connected over conductor 1239 as above described. Relay 2700 now operates, connecting ground over its lowermost contact to the
50 winding of relay 2800 which is also supplied with battery over conductor 1239. The operation of these two relays connects a plurality of conductors from the sender toward a decoder. Relay 2900 in operating disconnects ground through the winding of relay
55 2901 from the other similar relays individual to other senders. Relay 2901 also operates and prepares to sound an alarm if the connector remains operated too long. With relay 2700 operated battery over the start conductor 1143 is extended to conductor 2701 and thence to the winding of relay 2906, relay 2907 or a similar relay according to which
60 decoders are busy or idle. Assuming that the decoder appearing as first choice in this

channel is busy, relay 2904 will be operated and the circuit above traced will extend over the front contact of relay 2904 and the back contact of relay 2905 to the winding of relay 2907 and ground. Relay 2907 closes a circuit
70 from ground at its upper front contact to the winding of relay 2702. Relay 2702 in turn connects ground to the winding of relay 2801. Relays 2702 and 2801 connect the conductors of the sender through to the conductors of the decoder in preparation for transferring the designation to the decoder and the decoder information back to the sender. The operation of relay 2907 also disconnects ground from the windings of relays 2908 and 2909 and these relays release connecting ground to the conductor 2910 to prepare for the operation of an alarm if the decoder does not operate properly. Relay 2702 in operating opens the circuit of relay 2905 and relay 2801 connects ground to the windings of relays 2911 and 3011 as well as the other relays individual to this decoder and appearing in other channels of the decoder connector. Relay 3011, for example, closes a circuit over the normal contact of relay 3001 to the winding of relay 3005 operating that relay to mark this decoder busy in the corresponding channel. Similarly this decoder is marked busy to all channels with which it is not in use. For a complete detailed description of the operation of the decoder connector including the cooperation between channels reference may be made to the above identified Stearn patent.

100 The decoder comprises a set of incoming registers 3400, 3410 and 3420 which are positioned to correspond with the setting of the tandem hundreds, tandem ten and tandem units registers respectively. These settings are translated to operate additional sets of relays which mark a point to identify the routing indicated by operating a corresponding relay. This relay in turn sets a group of outgoing registers which control the settings of the selection control registers of the sender. As soon as the decoder and the sender are connected together circuits are closed over the front contacts of the operated register relays to the windings of the corresponding relays of the incoming registers of the decoder. These circuits may be traced as follows: from ground at the outer upper front contact of relay 1102, over conductor 1108 through the decoder connector to conductor 2703 and the winding of relay 3402 and battery; from ground at the outer upper front contact of relay 1113, conductor 1118, through the decoder connector to conductor 2708, and the winding of relay 3413 and battery; from ground over the outer upper front contact of relay 1201, conductor 1208 through the decoder connector to conductor 2712, winding of relay 3421 and battery; from ground at the outer upper front contact of
120
125
130

relay 1202, conductor 1209 through the decoder connector to conductor 2713 and the winding of relay 3422 and battery. Relays 3402, 3413, 3421 and 3422 are operated corresponding to the operated relays of the code registers.

At the same time ground is connected over the right back contact of relay 3430, right back contact of relay 3431 to conductor 3432 through the decoder connector to conductor 2704. This ground is extended over the outer upper back contacts of the unoperated relays of registers 1100, 1110 and 1200 to the windings of the corresponding relays of the incoming registers of the decoder. For example conductor 2704 is connected over the outer upper back contact of relay 1101, conductor 1109, through the decoder connector to conductor 2705, winding of relay 3401 and battery. Without tracing the remaining circuits in detail, it may be stated that relays 3401, 3403, 3404, 3411, 3412, 3414, 3423 and 3424 are operated in this manner. Therefore all of the relays of registers 3400, 3410 and 3420 are operated if the conductors connecting the tandem registers of the sender and the incoming registers of the decoder are unbroken. With these relays operated a circuit is closed from ground over contacts of relays 2700 and 2702, conductor 2716, inner right front contacts of relays 3424 and 3423, inner left front contacts of relays 3422 and 3421, inner right front contacts of relays 3414 and 3413, inner left front contacts of relays 3412 and 3411, inner right front contacts of relays 3404 and 3403, inner left front contacts of relays 3402 and 3401, left winding of relay 3431 and battery. Relay 3431 operates and locks from battery through its right winding to conductor 2716. It also closes a holding circuit through its left winding and left contact, right winding of relay 3430 to conductor 2716, but relay 3430 cannot operate since it is shunted by the chain circuit above traced. As soon as relay 3431 operates it disconnects ground from conductor 2704. If none of the incoming conductors is grounded falsely the relays, corresponding to non-operated tandem register relays, release. If any of these conductors is grounded, ground will be connected back to conductor 2704 and hold these relays operated. Assuming that these relays release, the chain circuit is opened and relay 3430 operates. Relay 3430 supplies ground over its contacts to the contacts of the registers. Three circuits are closed: (1) from ground at the inner left contact of relay 3430, back contact of relay 3404, right back contact of relay 3403, inner right front contact of relay 3402, outer left back contact of relay 3401, winding of relay 3702 to battery; (2) from ground at the outer left contact of relay 3430, back contact of relay 3414, outer right front contact of relay 3413, windings of relays 3804 and 3814 to battery; (3) from ground at the

right contact of relay 3430, back contact of relay 3424, right back contact of relay 3423, inner right front contact of relay 3422, to the outer left front contact of relay 3421. With the first two circuits closed, this third circuit extends over the fourth contact of relay 3814, conductor 3824, over the fourth contact of relay 3702 to conductor 3711, through the winding of route relay 3600 at connecting rack 3601, resistance 3504, winding of relay 3505 to battery. Relay 3505 in operating provides ground for starting the timing operation to sound an alarm in case the circuit of relay 3600 becomes permanently grounded.

Relay 3600 in operating prepares six circuits for operating relays in the six outgoing registers of the decoder. The first of these circuits may be traced from ground at the first contact of relay 3600 over cross-connecting rack 3610, to winding of relay 3100 of the class register, winding of relay 3101, winding of relay 3102 to battery. The second circuit extends over cross-connecting rack 3620, upper winding of relay 3200 of the district brush register, winding of relay 3201, to battery through the winding of relay 3202. A third circuit may be traced over cross-connecting rack 3610, upper winding of relay 3110 of the compensating resistance register, winding of relay 3111, winding of relay 3112 to battery. A fourth circuit extends over rack 3620, upper winding of relay 3210 of the office brush register, winding of relay 3211, to the winding of relay 3212 and battery. A fifth circuit extends over cross-connecting rack 3630, lower winding of relay 3300 of the district group register, winding of relay 3301, winding of relay 3302 and battery while the sixth circuit extends over cross-connecting rack 3630, upper winding of relay 3310 of the office group register, winding of relay 3311, winding of relay 3312 to battery. Relays 3102, 3112, 3202, 3212, 3302 and 3312 are marginal. If the wiring between the routing relay and the register relays or any other wiring should become crossed so that more than one of the register relays are connected to ground, the corresponding marginal relay of this series would be operated closing a circuit from ground over its contact to conductor 3120 and the winding of relay 3501, which blocks the establishment of the connection as will be described hereinafter.

The relays of the outgoing decoder registers prepare circuits for setting the selection control registers of the sender. Relay 3111 in operating closes a circuit from ground through the winding of relay 3113, front contact of relay 3111, conductor 3115, through the decoder connector to conductor 2827, upper winding of relay 2014, and battery. Relays 2014 and 3113 operate in this circuit. Relay 3110 closes a circuit from ground through the winding of relay 3114, lower

front contact of relay 3110, upper back contact of relay 3116, lower back contact of relay 3117, lower back contact of relay 3118, conductor 3119, through the decoder connector to conductor 2720, upper winding of relay 2023 to battery. Relays 2023 and 3114 operate. Relay 3100 does not close any circuit leading to the sender registers. Relay 3200 closes a circuit from ground through the winding of relay 3203, inner lower front contact of relay 3200, outer lower back contact of relay 3207, conductor 3206 through the decoder connector to conductor 2721, upper winding of relay 2101 and battery. Relays 2101 and 3203 operate in this circuit. Relay 3210, closes a circuit from ground through the winding of relay 3215, lower front contact of relay 3210, conductor 3214, through the decoder connector to conductor 2822, upper winding of relay 2113 and battery. Relay 3300 in operating closes a circuit from ground through the winding of relay 3303, inner lower front contact of relay 3300, outer lower back contact of relay 3304, inner lower back contact of relay 3305, conductor 3306, conductor 2821, upper winding of relay 2132, to battery. Relay 3300 also closes a circuit from ground through the winding of relay 3307, outer lower front contact of relay 3300, outer lower back contact of relay 3308, back contact of relay 3309, conductor 3330, conductor 2820, upper winding of relay 2131, and battery. Relay 3310 closes a circuit from ground through the winding of relay 3313, lower front contact of relay 3310, inner lower back contact of relay 3314, conductor 3315, conductor 2824, upper winding of relay 2142 and battery.

When all of the registers have been set, a circuit is closed from ground over the upper front contact of relay 3110, contact of relay 3114, contact of relay 3113, contact of relay 3100, contact of relay 3101, contacts of relays 3200, 3203 and 3201, contacts of relays 3210, 3215 and 3211, inner lower contact of relay 3300, contacts of relays 3307, 3303 and 3301, upper contact of relay 3310, contacts of relays 3313 and 3311 to conductor 3331, winding of relay 3500 and battery. This circuit serves, as is pointed out hereinafter, to indicate the fact that all of the registers have been positioned. Relay 3500 closes a circuit from ground at the back contact of relay 3501, provided that relay has not been operated, to the winding of relay 3502 and battery to start the timing relays in case the release does not take place promptly. It also closes a circuit from this same ground over conductor 3503, through the decoder connector, conductor 2826, to the lower winding of relay 1003 and battery. Relay 1003 locks to grounded conductor 1129, and closes a circuit over its inner upper front contact, winding of relay 1142 to battery. Relay 1142 supplies locking ground for relays 2012, 2013, and 2015 direct-

ly. It also provides locking ground over the right contacts of cam 2207 for relays 2101 to 2103 and 2131 to 2134 in positions 1 to 4 of sequence switch 2200, over the left contacts of cam 2208 for relays 2011, 2111 to 2113 and 2141 to 2144 in positions 1 to 9 of sequence switch 2200 and over the lower contacts of cam 2208 for relays 2001 to 2005, 2014 and 2021 to 2024 in positions 1 to 18 of sequence switch 2200. It is therefore apparent that the selection control register relays are now locked under the control of relay 1142.

With relays 1142 and 1003 operated, the start conductor 1143 is opened releasing relay 2900 which in turn releases relays 2700 and 2800. The release of relay 2700 opens the circuit of relay 2907 which in turn opens the circuit of the relays corresponding to relay 2905 in the other channels. However, a locking circuit exists for these relays over the back contacts of relays corresponding to them, but belonging to decoders appearing earlier in the sequence to prevent interfering with a call which may be in process of extension. Relay 2907 also recloses the operating circuits for relays 2908 and 2909.

With relays 2700 and 2800 released the conductors connecting the decoder with the sender are all opened and all of the relays in the decoder which were operated are now released so that the decoder returns to service with other senders.

The sender is now ready to control selections. Relay 1142 in operating closes the fundamental circuit to control the district brush selection. This circuit may be traced from battery through the right winding of relay 212, left contacts of cam 215, conductor 214, from brush 608 to brush 626 through the link circuit, outer lower contact of relay 916 inner upper front contact of relay 1142, right contacts of cam 2209, winding of stepping relay 2000, upper winding of relay 2161, back contact of relay 1400, resistance 2211, left contacts of cam 2210, upper back contact of relay 916, from brush 625 to brush 622 through the link circuit, conductor 231, left contact of cam 232, lower left contact of cam 213 to ground. Relays 212 and 2000 operate in this circuit but relay 2161 is so polarized as not to operate at this time. Relay 212 locks over its inner right front contact and the lower right contact of cam 215 to the fundamental circuit as traced. It also closes a circuit from ground over its left contact, lower left contact of cam 216, winding of sequence switch magnet 206 to battery advancing the sequence switch to position 5. When sequence switch 206 leaves position 4 relay 223 releases. In position 5 the operating circuit of relay 212 is opened and the relay is dependent on its locking circuit. A circuit is prepared at this time from battery through the right winding and the inner right contact of relay 212, left contacts of cam 233, commutator

strip 234, brush 235, upper right and lower left contacts of cam 217, to ground.

In position 5, relay 212 also closes a circuit from battery through the winding of updrive magnet 236, upper right and lower left contacts of cam 232 to ground at the left front contact of relay 212. The district selector is moved upward in its brush selecting movement under the control of magnet 236. As it moves upward the circuit above traced over commutator strip 234, is intermittently closed holding relay 212 operated and shunting the winding of the stepping relay 2000 in the sender.

When relay 2000 operated it closed a circuit from ground at the inner lower back contact of relay 2031, contact of relay 2000, outer lower back contact of relay 2031, conductor 2030, upper back contact of relay 1000 conductor 1004, lower contacts of cam 2214, middle upper front contact of relay 2101, inner upper back contact of relay 2102, conductor 2156, back contact of counting relay 1401, winding of relay 1411, conductor 2206 to battery over the contacts of cam 2205. Relay 1411 operates in this circuit closing a locking circuit for itself through the winding of relay 1401, contact of relay 1411, conductor 1423, to ground over the lower left contact of cam 2202 and the upper left contact of cam 2201. Relay 1401 cannot operate at this time since its winding is shunted by the operating ground for relay 1411. Each time that the intermittent circuit is closed over the commutator strip 234, relay 2000 releases opening the circuit above traced. At the first release of relay 2000, relay 1401 operates in the locking circuit of relay 1411 and transfers the circuit closed over conductor 2156 to the back contact of relay 1421 and the winding of relay 1410. In a similar manner relay 1410 is operated in response to the reoperation of relay 2000 when brush 235 encounters an insulating segment of strip 234 and relays 1400 and 1420 operate in the locking circuit of relay 1410 when relay 2000 is released by the brush 235 encountering a conducting segment of the strip 234. Relays 1400, 1410 and 1420 lock over conductor 1424 to ground by way of the upper left contacts of cams 2202 and 2201. Relay 1400 opens the fundamental circuit and causes the release of relay 212.

Relay 212 in releasing opens the circuit of the updrive magnet 236 and brings the district selector to rest. The circuit of relay 212 is opened at the commutator strip 234 as soon as the brush moves off the conducting segment which released relay 2000 for the last time. With relay 212 released a circuit is closed over the left back contact of that relay, upper left contact of cam 216 to the winding of sequence switch magnet 206 and battery, advancing the sequence switch to position 6. In this position the trip mag-

net 237 is operated over the contacts of cam 217, preparing to trip the brushes on the next upward movement of the district selector. The operation of relay 1420 closes a circuit from ground over its front contact, upper back contact of relay 917, upper left contact of cam 2204 to the winding of sequence switch magnet 2200 and battery advancing the sequence switch out of position 2. As soon as the sequence switch leaves position 2 the locking circuit for the odd numbered counting relays is opened and when it leaves position $2\frac{1}{4}$ the locking circuit for the even numbered counting relays is opened so that relay 1420 releases, opening the circuit for magnet 2200 and bringing the sequence switch to rest in position 4, since it is advanced from position 3 over its local cam.

With sequence switch 206 in position 6 and sequence switch 2200 in position 4 the fundamental circuit is again closed as above traced and relays 212 and 2000 operate as before. Relay 212 locks over a similar circuit to that above traced but the intermittent circuit controlled by the commutator may now be traced over the right contacts of cam 215, commutator strip 238, brush 239 to ground over cam 217. Relay 212 in operating advances the sequence switch to position 7 in a manner similar to that previously described. The counting relay circuit now extends from ground over the contact of relay 2000, to conductor 2030 as previously traced, left contacts of cam 2213, upper front contact of relay 2131, inner upper front contact of relay 2132, to conductor 2150, back contact of relay 1403, winding of relay 1413, to battery over conductor 2206 and cam 2205 as above described. Following four intermittent pulses from commutator 238, relays 1400 and 1420 are operated as before, opening the fundamental circuit and causing the release of relay 212 as soon as the conducting segment of the commutator is passed. The release of relay 212 at this time advances sequence switch 206 to position 8.

Relay 212 is now operated in a local circuit over the lower contacts of cam 249 and advances sequence switch 206 to position 9. In this position the updrive magnet 236 is again operated. Relay 212 is only held operated in position 9 provided the first outgoing trunk in the group on which the district selector has been positioned is busy. The circuit extends from battery, through the right winding and inner right contact of relay 212, upper right and lower left contacts of cam 213, to the sleeve brush of the district selector 200, which is marked busy by ground if the outgoing trunk is in use. Relay 212 is held operated between sleeve terminals by a circuit through the left winding of relay 212, lower right contact of cam 222, upper right contact of cam 250, commutator strip 240, brush 241, lower contacts of cam 252 to ground at the left

front contact of relay 212. This assures the stopping of the brushes on the first idle set of terminals. When an idle office selector has been found relay 212 releases advancing sequence switch 206 to position 10. As soon as relay 212 releases, ground is connected to the sleeve brush of the district selector over the lower right and upper left contact of cam 213, right back contact of relay 212, upper right contact of cam 218 to ground at the lower left contact of cam 217. As soon as sequence switch 206 reaches position $9\frac{3}{4}$, direct ground is connected over the lower contacts of cam 213, to the sleeve brush. In position 10 relay 212 is operated in a circuit from battery through its left winding, lower contacts of cam 222 to ground at the right contact of relay 208. Relay 212 in operating advances sequence switch 206 to position 11, in which position it remains operated under the control of relay 208. In position 11 the fundamental circuit is extended through to the relay of the office selector. This circuit may be traced through the district selector from brush 608 of the link, conductor 214, upper right and lower left contacts of cam 202, upper back contact of relay 223, upper left and lower right contacts of cam 250 to the tip brush of the district selector 200, and from brush 622, conductor 231, lower right and upper left contacts of cam 203, lower back contact of relay 223, right contacts of cam 251 to the ring brush of the district selector. The circuits of the office, incoming and final selectors have not been shown in detail since they are well known in the art and their operation is similar to that of the district selector.

Returning now to the sender, the operation of relay 1420 causes the advance of sequence switch 2200 to position 6 in the manner above described for advancing it from position 2 to position 4. In position 6 a circuit is provided for testing the condition of the trunk leading to the office selector and the condition of the office selector itself. This circuit extends as described above through the district selector and the link and extends in the sender from the fundamental tip and brush 626 over the outer lower back contact of relay 916, inner upper front contact of relay 1142, lower contacts of cam 2209, through resistance 2040, lower front contact of relay 2014, winding of relay 2153, left contacts of cam 2215, upper winding of relay 2161, back contact of relay 1400, inner upper back contact of relay 2501, lower back contact of relay 2301, lower back contact of relay 2401, outer lower back contact of relay 2502, outer lower back contact of relay 2501, lower back contact of relay 2503, upper contacts of cam 2216, back contact of relay 2021, through resistances 2043 and 2042, back contact of relay 2022, lower right and upper left contacts of cam 2217, upper back contact of relay 916, to the fundamental ring at brush 625.

When the office selector is found and is connected through to the sender, this circuit is completed and if the trunk is in proper condition and the battery supplied from the office selector is in the right direction, relay 2153 operates but relay 2161 does not. Relay 2153 in operating closes an obvious circuit for relay 2157, which locks over its lower front contact, and the lower right contact of cam 2202, to ground as long as sequence switch 2200 remains in position 6. A circuit is closed from battery through the winding of relay 2504, front contact of relay 2157, upper back contact of relay 2031, to grounded conductor 1129. Relay 2504 operates and closes a circuit for relay 2041. Relay 2041 in operating closes a circuit from ground over its inner lower front contact, upper right contact of cam 2204 to the winding of sequence switch magnet 2200 and battery, advancing the sequence switch to position 7.

In position 7 the fundamental circuit is established for making office brush selection. The circuit extends at this time as previously traced through the windings of relays 2000 and 2161 and over the back contact of relay 1400. From there it extends as traced for the test of the office trunk over the inner upper back contact of relay 2501, outer lower back contact of relay 2301, lower contact of relay 2401, lower back contacts of relays 2502 and 2501, lower back contact of relay 2503, over the upper contacts of cam 2216, back contact of relay 2021, through compensating resistances 2043 and 2042, back contact of relay 2022, lower right and upper left contacts of cam 2217, to the fundamental ring. The counting relay circuit extends at this time as above traced over the contacts of relays 2031 and 2000 to conductor 2030, and over the upper back contact of relay 1000, conductor 1004, lower right and upper left contact of cam 2214, upper back contact of relay 2111, outer upper back contact of relay 2112, upper front contact of relay 2113 to conductor 2158, lower back contact of relay 1404, winding of relay 1414, to battery over conductor 2206. Relays 1404, 1403, 1402, 1401, 1400, 1420, 1414, 1413, 1412, 1411 and 1410 operate as before described. Relay 1400 opens the fundamental circuit as before and relay 1420 advances sequence switch 2200 into position 8, whence it is advanced by its local cam to position 9, releasing the counting relays as previously described.

In position 9 the fundamental circuit is reclosed for the purpose of making office group selection. The counting relay circuit extends from ground over the contacts of relays 2031 and 2000, upper contacts of cam 2213, upper back contact of relay 2141, outer upper front contact of relay 2142, to conductor 2154, back contact of relay 1402, winding of relay 1412 to battery over conductor 2206. Relays 1402 and 1412, 1401 and 1411,

1400, 1410 and 1420 operate as above described. As before the operation of relay 1400 opens the fundamental circuit and permits the release of relay 2000 and the operating relay of the office selector, causing the office selector to hunt for an idle trunk outgoing to an incoming selector at the distant office. Relay 1420 closes a circuit for advancing sequence switch 2200 out of position 9. Sequence switch 2200 is advanced immediately from position 9 to position 16, since the locking conductor 1424 for relay 1420 is held closed over the lower left contact of cam 2222, until the sequence switch leaves position 15. The positions between 11 and 15 are reserved for controlling a second office selector where it is required. In the present disclosure this second office selector has been omitted and the equipment necessary for making such selections has also been omitted both from the sender and from the decoder.

The selection of an outgoing trunk to a distant office takes place in the manner above described, irrespective of the nature of that distant office. It is, of course, to be understood that different offices are identified by different office designations and are reached over different groups of trunk circuits. The incoming registers of the sender are therefore given different settings and the decoder operates different route relays similar to relay 3600 in accordance with the designations. These route relays set the selection control registers to control the selection of the proper group of trunks. The operations within the tandem office therefore differ for different offices only in the number of counting relays operated and the extent of movement of the district and office selectors. If the group of trunks outgoing to a particular office appears in the terminal bank of the district selector, the office selections are omitted, as described hereinafter.

The operation in controlling the completion of the connection at the distant office differs with the nature of the office, and the decoder route relays prepare the sender for such different operation by operating the class relays 2001 to 2005 in accordance with the type of the wanted office. The manner in which the sender performs its functions in controlling the various kinds of offices will now be described.

Completion of call at panel dial office

For convenience the completion of a call to a panel type office will be described first. On the assumption that the call being traced is one to a panel office, none of the class relays 2001 to 2005 is operated and relay 2151 is also non-operated. A circuit is therefore closed, as soon as sequence switch 2200 reaches position 5, which may be traced from battery through the winding of sequence

switch magnet 1900, right contact of cam 1901, inner upper back contact of relay 2151, outer upper front contact of relay 1142, to ground over the lower right and upper left contacts of cam 2201. Sequence switch 1900 is advanced to position 6 in this circuit.

When sequence switch 2200 left position 4 the locking circuit for the relays of register 2100 and register 2130 was opened and those relays released. When sequence switch 2200 left position 9, the relays of register 2110 and register 2140 were also released. When sequence switch 2200 reaches position 15 a circuit is closed from ground over the upper left contact of cam 2201, upper right contact of cam 2218, inner upper back contact of relay 2155, through the windings of relays 1701, 1801, 1802 and 1803 in parallel to battery. The operation of these relays connects the numerical registers 1220, 1300, 1310 and 1320 with the registers 2100, 2110, 2140 and 2130 respectively. These relays are now reoperated in accordance with the setting of the numerical registers to control selections at the district office. It will be remembered that the relays 1222 and 1224 of register 1220 were operated. A circuit is therefore now closed from battery through the winding of relay 2102, conductor 2722, third contact of relay 1701 to ground at the upper outer contact of 1222. The operation of relay 1224 closes a circuit from ground at its outer upper front contact over the first contact of relay 1701 to the winding of relay 2121 and battery. This relay constitutes a part of the register 2120 which controls group selection by the incoming selector. Relay 1301 closes a circuit from ground over its outer upper contact, top contact of relay 1801, winding of relay 2111 and battery while relay 1304 closes a circuit from ground over its outer upper contact, first contact of relay 1801, to the winding of relay 2122 and battery. Relay 1312 closes a circuit from ground over its upper front contact, the third contact of relay 1802, winding of relay 2142, and battery. Relay 1314 closes a circuit over the first contact of relay 1802, to the winding of relay 2144 and battery while relays 1321, 1322 and 1324 cause the operation of relays 2131, 2132 and 2134. These registers are now ready to control selections at the distant office. Sequence switch 2200 in position 15 also closes a circuit from ground over the upper contacts of cam 2201, conductor 2507, lower winding of relay 2031 to battery. Relay 2031 locks over its upper front contact to grounded conductor 1129, opening the circuit by which the office selector was tested and preparing the circuit for testing the interoffice trunk. Relay 2031 also reverses the direction of current flow over the contact of relay 2000 to save wear on that contact.

When sequence switch 2200 reaches position 16, a circuit is closed for testing the in-

teroffice trunk. This circuit may be traced from the fundamental tip to the lower right contact of cam 2209 and thence over the upper left contact of cam 2209, back contact of relay 2152, outer upper back contact of relay 2151, resistance 2040, front contact of relay 2014, winding of relay 2153, middle lower front contact of relay 2031, inner lower back contact of relay 2155, back contact of relay 1400, and thence as previously traced over contact of relay 2501, etc., to the upper right and lower left contacts of cam 2216, back contact of relay 2302, front contact of relay 2023, resistance 2043, back contact of relay 2024, upper contacts of cam 2217, to the fundamental ring. The testing circuit thus traced cannot be closed before the registers have been positioned since a circuit is closed from ground over the back contact of relay 1701, left contacts of cam 2207, inner lower back contact of relay 2151, to conductor 1424 holding relay 1400 operated. This circuit prevents the closure of the testing circuit until relay 1701 is operated to cause the setting of the registers. When the outgoing trunk has been found and the incoming selector is ready to make selections battery and ground are connected to the fundamental circuit and relay 2153 operates, in turn operating relays 2157, 2504, and 2041. Relay 2041 closes a circuit from battery through the winding of sequence magnet 2200, right contact of cam 2204 to ground at the inner lower front contact of relay 2041, advancing sequence switch 2200 to position 17. In this position a circuit is closed from battery through the winding of sequence switch magnet 1900, upper right and lower left contacts of cam 1902, to ground over the left contacts of cam 2201, advancing sequence switch 1900 to position 7. Sequence switch 2200 is immediately advanced from position 17 to position 18 over the left contact of cam 2220, and the lower right contacts of cams 1903 and 1904.

The incoming and final selectors are under the control of sequence switch 1900. With sequence switch 1900 in position 7 the fundamental circuit extends from the fundamental tip over the lower back contact of relay 916, inner upper front contact of relay 1142, lower back contact of relay 2151, right contacts of cam 2215, lower right and upper left contacts of cam 1905, winding of relay 2000 and thence as traced for the test of the interoffice trunk back to the fundamental ring. Since relay 2031 is now operated the counting relay circuit may be traced from ground at the outer lower front contact of relay 2031, front contact of relay 2000 inner lower front contact of relay 2031, conductor 2030, inner upper back contact of relay 1000, conductor 1004, right contacts of cam 1906, outer upper back contact of relay 2103, outer upper front contact of relay 2102, inner upper back con-

tact of relay 2101, conductor 2154, back contact of relay 1402, winding of relay 1412 to battery. After the winding of relay 2000 has been shunted three times to cause the selection of the third brush of the incoming selector, relay 1400 operates opening the fundamental circuit and relay 1420 operates closing a circuit from ground over its front contact, upper back contact of relay 917, back contact of relay 1148, lower left contact of cam 1901 to the winding of sequence switch magnet 1900 and battery, advancing it out of position 7. Conductors 1423 and 1424, carrying the locking circuits for the counting relays extend to ground at this time over the lower left contact of cam 1904 and over the right contacts of cam 1904 respectively and are held closed until the sequence switch leaves positions 7 and 7 $\frac{1}{4}$. Sequence switch 1900 is advanced from position 8 to position 9 over its local cam. It is to be noted that the circuit for advancing the sequence switch extends over the back contact of relay 1148. Circuits are prepared for this relay over the contacts of cam 1907. In positions 7 to 9 the circuit is extended over the right contact of cam 1907 to ground at the lower back contact of relay 1316, and in positions 11 to 13 the circuit extends to ground over the lower back contact of relay 915. Therefore if the hundreds register 1300 has not been positioned at the time the incoming brush selection is completed sequence switch 1900 cannot be advanced for the next selection and if the incoming registers have not been completely set, sequence switch 1900 cannot be advanced into position to make final selections.

We have assumed that the registration has taken place in the proper length of time. Therefore sequence switch 1900 has now been advanced to position 9. In position 9 the fundamental circuit is the same as was traced in position 7 of sequence switch 1900. The counting relay circuit at this time, however, extends over the contacts of relays 2000 and 2031, left contacts of cam 1906, upper front contact of relay 2121, inner upper front contact of relay 2022, conductor 2150, lower back contact of relay 1403, winding of relay 1413 to battery. Four pulses of current will bring about the operation of relays 1400 and 1420 causing the selection of fourth group of trunks outgoing from the incoming selector. The incoming selector will hunt for a trunk leading to an idle final selector in substantially the manner described for the district selector. Relay 1400 opens the fundamental circuit and relay 1420 advances sequence switch 1900 to position 11 in the manner previously described.

As sequence switch 1900 passes through position 10, a circuit is closed from the fundamental tip to the lower right contact of cam 1905 as previously described and from

thence over the upper right contact of cam 1905, through resistances 1908 and 2040, upper right and lower left contacts of cam 1902, to the fundamental ring. The connection of these resistances across the circuit discharges the electrical charge which may have accumulated due to the capacity of the trunk and prepares for making final selections.

Final brush, final tens and final units selections take place in positions 11, 13 and 15, respectively. The fundamental circuit extends at this time as above traced for incoming selections. The counting relay circuits may be traced as follows: In position 11 for final brush selection from ground over the contacts of relays 2031 and 2000, conductor 2030, inner upper back contact of relay 1000, conductor 1004, upper right and lower left contacts of cam 1909, upper front contact of relay 2111, inner upper back contact of relay 2112, to conductor 2156, lower back contact of relay 1401, winding of relay 1411 to battery, therefore two pulses are required to satisfy the counting relays and the final selector uses the second brush in making selections. The counting relay circuit for final tens selection extends as just traced to the upper right contact of cam 1909 and thence over the lower right contact of that cam, upper back contact of relay 2141, outer upper front contact of relay 2142, to conductor 2154. Two pulses of current serve to operate relays 1402 and 1412, 1401 and 1411. It will be noted that the circuit normally extends from the front contact of relay 1401, over the back contact of relay 1421 to the winding of relay 1410. Since relay 2144 is also operated a circuit is closed for relay 1421 over the lower contacts of cam 1910 to ground at the front contact of relay 2144. Therefore the operation of relay 1401 extends the counting relay circuit over the outer front contact of relay 1421, to the back contact of relay 1409 and the winding of relay 1419. Five additional pulses result in the operation of relays 1405 to 1409 and 1415 to 1419. From the front contact of relay 1405 the counting relay circuit extends over the inner upper contact of relay 1421 to the winding of relay 1410, causing it to operate and operate relays 1400 and 1420 which open the fundamental circuit and advance the switch 1900 in the usual manner following the reception of eight pulses. The counting relay circuit for final units selection extends from cam 1909 over the upper left contact of that cam, upper front contact of relay 2131, inner upper front contact of relay 2132, conductor 2150, and the winding of relay 1413. Relay 2134 being operated closes a circuit over its upper front contact, upper right contact of cam 1910, for relay 1421, so that nine pulses are required to satisfy the counting relay condition.

Following the completion of final units se-

lection sequence switch 1900 is advanced to position 16, in which position a circuit is prepared to respond to the reversal of battery produced by the incoming selector. This circuit is the same as traced for the making of final selections. However, due to the reversed nature of the battery, relay 2161 is operated in addition to relay 2000. With relay 2161 operated a circuit is closed from grounded conductor 1129, front contact of relay 2161, inner lower back contact of relay 2505, upper contacts of cam 1911, winding of relay 917 to battery. Relay 2000 also operates closing a circuit from ground to conductor 2030, outer lower front contact of relay 917, winding of relay 1410 to battery. Relay 917 closes a circuit through relays 1410 and 1400 and 1420 in series, inner lower contact of relay 917, outer upper contact of relay 904 to ground at the upper left and lower right contacts of cam 1904. Relays 1400 and 1420 cannot operate as long as relay 2000 holds the circuit of relay 1410 closed. Following the completion of the test circuit in the sender, the incoming selector removes the reversed battery and relay 2000 releases. Relay 2161 locks in a circuit from battery through its lower winding, lower contacts of cam 2212, inner lower back contact of relay 2505, inner lower front contact of relay 2161 to grounded conductor 1129. The release of relay 2000 permits relays 1400 and 1420 to operate in circuit with relay 1410. Relay 1400 as usual opens the fundamental circuit and relay 1420 connects ground over its front contact, upper front contact of relay 917, lower contacts of cam 1912, winding of relay 916 to battery. Relay 916 locks over its lower front contact, to grounded conductor 1129. Relay 916 opens the fundamental tip and the fundamental ring and closes a circuit from battery through the winding of relay 904, upper front contact of relay 916 to grounded conductor 1129. Relay 904 in operating opens the shunt around the upper winding of relay 905 which is of high resistance, thus introducing this resistance into the circuit of relay 208. When relay 904 operates the holding circuit for relays 1400, 1410 and 1420 is opened and they release.

The increase in resistance included in the circuit of relay 208 causes that relay to release in turn releasing relay 212. The release of relay 212 closes a circuit over its left back contact, and the upper left contact of cam 216 to the winding of sequence switch magnet 206 advancing the switch to position 13. As soon as sequence switch 206 reaches position 12 ground is connected over the lower right contact of cam 220 to conductor 221 and through the link to conductor 919. The connection of ground to conductor 919 releases relay 905 which is also connected to ground. The release of relay 905 in turn releases relay 906 and relay 907. The release of relay 907

closes a circuit from battery through the upper winding of relay 903, lower front contact of relay 908 to ground at the lower back contact of relay 907. Relay 903 in operating
 5 connects ground from conductor 919 over its lower front contact, lower back contact of relay 1005, middle lower front contact of relay 915 to resistance 918 and battery in shunt of the winding of relay 908 thus caus-
 10 ing relay 908 to release. Relay 903 also locks through its lower winding to ground on conductor 919. It also connects ground to conductor 1136 in place of that supplied by relay 908. It will be noted that battery through
 15 resistance 902 and the lower winding of relay 903 is now connected to conductor 919, in parallel with battery through the resistance 918. This produces a low resistance circuit over conductors 919 and 221 to ground.

20 It will be remembered that the upper winding of relay 612 was connected between conductors 919 and 221 when the link circuit cut through the conductors from the district selector to the sender. This low resistance
 25 circuit now causes the operation of relay 612. Relay 612 in operating closes a circuit from battery through the lower winding of relay 610, contacts of cam 718, outer upper front contact of relay 612, upper back contact of
 30 relay 611, lower back contact of relay 609 to ground over the right contacts of cams 703 and 714. If the sender finder is standing on one of its last twenty terminals a circuit is closed at this time from ground over
 35 brush 627, commutator strip 628 or 629 depending on which group of ten terminals the sender is standing on, upper right and lower left contacts of cam 720, lower front contact of relay 610, lower winding of relay 610 to
 40 battery holding relay 610 operated. With relay 610 operated a circuit is closed from battery through resistance 632, winding of relay 609, lower left and upper right contacts of cam 716 to ground at the inner upper front
 45 contact of relay 610. With relay 609 operated a circuit is closed from battery through down drive magnet 630, lower contacts of cam 722, outer lower front contact of relay 609 to ground at the right contacts of cams
 50 703 and 714. Magnet 630 causes the sender finder to be restored to its normal position at which time ground is connected over commutator segment 631, lower contacts of cam 723 to resistance 632 and battery in shunt of
 55 the winding 609 which now releases. When relay 610 operated it closed a circuit from ground over its inner upper front contact, upper left contact of cam 717, to the winding of sequence switch magnet 700 and battery
 60 advancing the sequence switch to position 7. The advance of the sequence switch from position 6 opens the circuit of relay 612 and causes that relay to release. In position 7 relay 610 is held operated in a circuit from
 65 battery through its lower winding and lower

front contact, left contacts of cam 720, middle and inner lower front contacts of relay 609, upper left contact of cam 704 to ground at the right contact of cam 714. When relay
 70 609 releases because of the shunting of its winding by brush 627, relay 610 also releases. The release of relay 610 closes a circuit from ground over its inner upper back contact, left contacts of cam 726, right contacts of cam
 75 712, to the winding of sequence switch 700 and battery advancing the sequence switch to position 8. With sequence switch 700 in position 8, relay 609, is reoperated in a circuit from battery through resistance 632,
 80 winding of relay 609, lower contacts of cam 716, lower back contact of relay 611 to ground over the right contacts of cams 703 and 714. A second circuit is closed from battery through the winding of relay 606, left con-
 85 tacts of cam 727, and thence over the lower contacts of cam 716 to ground as traced from the winding of relay 609. Relay 606 locks over its outer lower front contact, upper right contact of cam 704, to ground over the right
 90 contact of cam 714. It also closes a circuit from battery through the winding of down drive magnet 633 of the district finder, upper contacts of cam 725, inner lower front contact of relay 606 to ground over the locking cir-
 95 cuit of that relay as above traced. When the district finder has been restored to normal a circuit is closed from ground over the right contact of cam 714, upper right contact of cam 704, commutator brush 634, segment 635,
 100 left contacts of cam 728, to the winding of sequence switch magnet 700 and battery, advancing sequence switch 700 to position 9. When sequence switch 700 leaves position 8 relays 606 and 609 release. The link sequence
 105 switch remains in this position until the next link in the series is advanced to position 2. At this time a circuit is closed from battery through the upper winding of relay 602, upper right and lower left contacts of cam
 110 705, contact of make busy jack 706 and thence over the lower right and upper left contact of cam 711 of the next link to ground. The advance of sequence switch 700 from position 6 opens the incoming tip and ring conductors,
 115 disconnects conductor 221 from conductor 919 and connects ground over the right contact of cam 728 and the left contact of cam 721 to conductor 221 as long as sequence switch 700 remained in position 7. It also
 120 opens the fundamental tip and ring conductors. However, ground remains connected to brush 607 and conductor 209, over the right contact of cam 714 and the upper right contact of cam 704 until relay 606 operates
 125 in position 8.

When the link circuit disconnected conductor 221 from conductor 919, relay 903 released. Relay 903 in releasing provides cir-
 130 cuits for advancing sequence switches 1900

and 2200 to position 1. The circuit for advancing sequence switch 1900 may be traced from battery through the winding of that magnet, upper left contact of cam 1901, inner upper back contact of relay 908 to ground at the outer upper contact of relay 903. The circuit for magnet 2200 may be traced from battery through that magnet, right contact of cam 2220, outer upper back contact of relay 908, to ground at the upper back contact of relay 903. When these sequence switches reach position 1, relay 901 which has been held operated from off-normal ground connected to conductor 2203 by these sequence switches, releases. The release of relay 901 opens the circuit of off-normal relays 1126 and 1230. The release of these relays unlocks all the relays which have not already been released. The release of relay 901 also connects battery through resistance 902, over the back contacts of relays 901 and 900 to the terminal accessible to brush 613 of the link, marking the sender as available for another call.

As sequence switch 206 reaches position $11\frac{3}{4}$ the tip brush of the district selector is connected over the lower contacts of cam 230 to the upper right winding of repeating coil 242, winding of relay 243, upper contacts of cam 211, lower right winding of repeating coil 242, upper contacts of cam 251 of the ring brush of the district selector. The tip and ring brushes are connected to battery and ground at the incoming selector but the direction is such that relay 243 which is polarized does not operate. When sequence switch 206 leaves position 12, the fundamental tip and ring including conductors 214 and 231 are disconnected from the tip and ring brushes of the district selector. When sequence switch 206 reaches position $11\frac{3}{4}$ a circuit is closed from battery through the lower winding of relay 226, upper contacts of cam 249, inner left back contact of relay 229, left contact of cam 218, to ground at the lower left contact of cam 217. Relay 226 locks over its inner lower front contact to ground at the left front contact of relay 204. Relay 226 in operating connects the incoming tip conductor over the left contacts of cam 225, upper front contact of relay 226, upper left winding of repeating coil 242, inner upper back contact of relay 244, front contact of relay 207, to the right winding of relay 201 and battery and connects the incoming ring conductor over the left contacts of cam 224, outer lower front contact of relay 226, lower left winding of repeating coil 242, lower back contact of relay 244, to the left winding of relay 201, and ground. Relay 201 is now held operated over the incoming trunk and in turn holds relays 204 and 207 operated. When the called subscriber answers, battery and

ground is reversed to the circuit of relay 243 and that relay operates closing a circuit from battery through the winding of relay 244, contact of relay 243, upper back contact of relay 244, front contact of relay 201 to ground over the right contacts of cam 205. Relay 244 in operating locks over its uppermost front contact and the front contact of relay 243. Relay 244 also reverses the connection of battery and ground through the windings of relay 201 to the incoming trunk for supervisory purposes.

When the called subscriber disconnects relay 243 releases in turn releasing relay 244 which restores the connection of battery and ground to the incoming trunk as an indication that the call has been terminated. When the calling subscriber restores his receiver to the switchhook the apparatus at the local office is restored and the loop circuit at the distant office is opened, in turn releasing relay 201. Relay 201 releases relays 204 and 207. The release of relay 207 opens the circuit through the right winding of relay 201 to prevent the reoperation of that relay, should the trunk be reselected before the district selector restores to normal. With relay 207 released a circuit is closed from ground over the left back contact of relay 212, right back contact of relay 207, upper right contact of cam 245, lower right contact of cam 246, left winding of relay 229 to battery. Relay 229 locks over its outer right front contact to ground over the lower contacts of cam 205. It also connects ground over the lower contacts of cam 205 and its inner and outer right front contacts, lower right contact of cam 216 to the winding of sequence switch magnet 206 and battery, advancing sequence switch 206 to position 16. A circuit is then closed from ground over the left back contact of relay 212, right back contact of relay 207, upper right and lower left contacts of cam 245, to the winding of sequence switch magnet 206 and battery, advancing sequence switch 206 to position 18. Relay 204 in releasing opens the locking circuit of relay 226, which also releases, opening the tip and ring conductors to prevent the completion of an incoming circuit for trunk test should the district selector be seized before the selector reaches normal. In position 18 a circuit is closed from battery through down drive magnet 247, right contact of cam 232, to ground at the lower left contact of cam 213. The district selector is restored to normal in this circuit at which time a circuit is closed from ground over the lower left and upper right contacts of cam 217, brush 239, normal commutator segment 248, upper right contact of cam 216 to the winding of sequence switch magnet 206 and battery restoring the sequence switch to

position 1. The district selector is now ready for another call.

Completion of call using relay call indicator

5 In the establishment of a connection to a subscriber located in a manual office equipped with a relay call indicator the designation is to be transmitted to the distant office by means of code impulses similar to those employed in setting the incoming registers. Sequence switch 1500 is employed in generating and transmitting the code pulses. The connection progresses in the manner above described until the trunk is reached leading to the distant office with the exception that the route relay operated by the decoder causes relays 2001 and 2002 to be operated to indicate the class of the call. With relay 2002 operated a circuit is closed from battery through the winding of relay 2155, next to the inner upper contact of relay 2002, lower contacts of cam 2208, to ground at the lower front contact of relay 1142. Relay 2155 in turn closes a circuit for relay 2151. When sequence switch 2200 reaches position 5 a circuit is closed from battery through the winding of sequence switch magnet 1500, lower right contact of cam 1501, right back contact of relay 1502, middle upper back contact of relay 1006, outer upper front contact of relay 2001, uppermost front contact of relay 2002, to ground over the lower right and upper left contacts of cam 2201. The impulser sequence switch 1500 is advanced in this circuit to position 17, which is the starting position for direct relay call indicator calls in which only the numerical designation is transmitted. Relay 2002 in operating also closes a circuit from battery through the winding of relay 2152, innermost upper front contact of relay 2002, to ground over the lower contacts of cam 2208, and the lower front contact of relay 1142. When sequence switch 1500 passes through positions 8 to 17, a circuit is closed from battery through the windings of relays 1503 and 1504, upper contacts of cam 1505, right back contact of relay 1502, to ground as traced for the circuit which advanced sequence switch 1500.

It has been assumed that no office selector was employed in establishing a connection to this manual office. Therefore relay 2011 would have been operated by the decoder and locked up as described for other register relays. With relay 2011 operated, as soon as the district selections have been completed and sequence switch 2200 is advanced out of position 4, the locking circuit for relays 1400, 1410 and 1420 is maintained through positions 4 to 10 over a circuit which may be traced over the front contact of relay 1410, conductor 1424, upper front contact of relay 2011, upper left contact of cam 2222 to ground at the upper left contact of cam 2201.

With relay 1420 held operated sequence switch 2200 is advanced to position 11. Before this position is reached a circuit is closed from ground at the upper left contact of cam 2201, lower left contact of cam 2222, to conductor 1424 holding relay 1420 operated through position 15 thus causing the advance of sequence switch 2200 to position 16. A branch of this holding circuit extends from conductor 1424, lower front contact of relay 2151, left contacts of cam 2223, inner lower back contact of relay 915 to grounded conductor 1131, and in parallel with the back contact of relay 915, over the upper back contact of relay 1007, left contacts of cam 1506, upper back contact of relay 1006, inner upper front contact of relay 2001, lower front contact of relay 2152, to grounded conductor 1131. These holding circuits insure that the interoffice trunk is not tested until after all of the digits have been registered as indicated by the operation of relay 915, and the call indicator impulser switch has reached the starting position indicated by the arrival at position 17. When these things have occurred relays 1410, 1400 and 1420 and the remaining counting relays release.

The fundamental circuit is then closed from the fundamental tip over the back contact of relay 916, upper front contact of relay 1142, lower right and upper left contacts of cam 2209, middle upper front contact of relay 2152, winding of relay 2159, left contacts of cam 2215, upper winding of relay 2161, back contact of relay 1400 and thence as previously traced over contacts of relays 2501, etc. to the upper right and lower left contacts of cam 2216, lower back contact of relay 2302, upper front contact of relay 2023, resistance 2043, back contact of relay 2024, upper contacts of cam 2217, upper back contact of relay 916 to the fundamental ring. When connection is made to the trunk outgoing to the manual office, battery and ground are connected at that office to the interoffice trunk and thence to the fundamental circuit. Relay 2159 operates in this circuit but the battery is so polarized that relay 2161 does not. The operation of relay 2159 closes an obvious circuit for relay 2157, which locks over the lower right contact of cam 2202 until sequence switch 2200 has left position 16 $\frac{1}{4}$. Relay 2157 causes the operation of relay 2504 as previously described and relay 2504 operates relay 2041. Relay 2041 in operating closes a circuit from battery through the winding of relay 2160, next to the uppermost front contact of relay 2002, upper back contact of relay 1005, inner upper front contact of relay 2151, lower contacts of cam 2224, outer lower front contact of relay 2041 to ground. Relay 2160 locks in a circuit which may be traced through the winding of that relay over the next to the uppermost contact of relay 2002,

upper back contact of relay 1005, second upper front contact of relay 2160, to grounded conductor 2203. Relay 2041 also closes a circuit from battery through the winding of sequence switch magnet 2200, right contact of cam 2204, to ground at the inner lower front contact of relay 2041 advancing sequence switch 2200 to position 17. In position 17 the fundamental circuit is held closed and may be traced from the front contact of relay 1142 over the upper front contact of relay 2041, upper contacts of cam 2219, middle upper front contact of relay 2152, winding of relay 2159, and thence as previously traced back to the fundamental ring. The locking circuit of relay 2157 is opened as soon as sequence switch 2200 leaves position $16\frac{1}{4}$ but that relay is held operated as long as relay 2159 remains operated.

When the operator at the distant office is ready to receive the designation the circuit is opened, either automatically or by the manual operation of a key by the operator and relay 2159 releases in turn releasing relay 2157, if the sequence switch has left position $16\frac{1}{4}$ as well as relays 2504 and 2041. At the manual office a bridge is connected across the tip and ring conductors containing relays similar to relays 1122, 1123 and 1124 for the reception of the pulses. With relay 2041 released and relay 2160 operated and locked, the fundamental tip is extended from the front contact of relay 1142, over the upper back contact of relay 2041, third upper front contact of relay 2160, lower back contact of relay 1008 to the left armature of relay 1503 and the lower left contact of cam 1507. The fundamental ring is extended from the back contact of relay 916 over the upper contacts of cam 2217, back contact of relay 2024, through resistance 2043, upper front contact of relay 2023, back contact of relay 2013, inner lower back contact of relay 2041, fourth upper front contact of relay 2160, upper back contact of relay 1008 to the right armature of relay 1503, and the left contact of cam 1508. The release of relay 2041 also closes a circuit from battery through the left winding of relay 1502, outer lower back contact of relay 1007, fifth upper contact of relay 2160, outer lower back contact of relay 2041, to ground at the lower front contact of relay 2155. The operation of relay 1502 starts the rotation of sequence switch 1500. The circuit for this purpose may be traced from battery through the winding of sequence switch magnet 1500, upper right contact of cam 1501 to ground at the outer right front contact of relay 1502.

As the impulser sequence switch 1500 rotates one pulse is generated in passing each position, and each pulse lasts one full position or a half position each side of the center. The pulses generated in the even numbered

positions are either light negative or heavy negative and those of the odd numbered positions are either light positive or blank according to the settings of the incoming register relays. As the switch passes an even numbered position, ground is connected over the right contacts of cam 1509 to the fundamental tip and as it passes odd numbered positions, ground is connected over the lower right and upper left contacts of cam 1509 to the fundamental ring. Light negative impulses are generated by the connection of battery through high resistance 1510, over the lower right contact of cam 1508, to the fundamental ring, while heavy negative pulses are generated over a circuit which may be traced from the lower right contact of cam 1508, right back contact of relay 1511, contacts of cam 1512 or 1513, through contacts of the register relays, to contacts of cams 1514 and 1515 and thence over inner upper back contact of relay 1001, left front of relay 1502, contacts of cam 1516 or relay 1504, resistance 2225, to battery over the contacts of cam 2205. Positive pulses are generated over a circuit which may be traced from the tip conductor over either the front contact of relay 1503, contacts of cam 1507 or left back contact of relay 1511, contacts of cam 1517, or 1518, through the contacts of the register relays to contacts of cam 1519, lower back contact of relay 1001, through high resistance 1009 to battery. When no pulse is to be sent the fundamental tip is connected over the back contact of the register relays to ground over cam 1520 for a quarter of a position. The result is that both fundamental tip and fundamental ring are grounded for a quarter position to discharge the cable and then the fundamental is opened for the remaining three-quarters of a position to create a blank pulse. In the position just ahead of the starting positions 5 and 17 this ground is continued for a slightly longer time to guard against the switches starting from a little past the center of the position.

Assuming that the numerical designation of the subscriber in the manual office is the same as that of the subscriber in the panel office just described, no station designation has been recorded and two light negative pulses will be sent out to indicate that fact. In the first transmitting position of the sequence switch 1500, as sequence switch 1500 moves from position 17 the tip conductor is open and the ring conductor is connected in positions 17 to $17\frac{1}{4}$ to ground over the upper left and lower right contacts of cam 1509, transmitting an open pulse. In position $17\frac{3}{4}$ to $18\frac{1}{4}$ the tip conductor is grounded over the right contacts of cam 1509 and the ring conductor is connected in positions $17\frac{1}{2}$ to $18\frac{1}{2}$ over the right contacts of cam 1508 to high resistance 1510 and battery, transmitting a light negative pulse. Since none of

the stations' register relays are operated the tip conductor will be connected over the lower left and upper right contacts of cam 1507, upper left contacts of cams 1517 and 1518, lower back contact of relay 1213, lower back contact of relay 1211, upper right contact of cam 1520, lower right contact of cam 1521 to ground until sequence switch 1500 reaches position $18\frac{1}{2}$. As soon as sequence switch 1500 leaves position $18\frac{1}{2}$ the battery connected to the ring conductor is disconnected. In positions $18\frac{1}{2}$ to $19\frac{1}{2}$ the tip conductor is opened and the ring conductor is connected to ground from positions $18\frac{3}{4}$ to $19\frac{1}{4}$ over the contacts of cam 1509. The next transmitting period, that is, from $19\frac{1}{2}$ to $20\frac{1}{2}$ finds the tip conductor grounded over cam 1509 from positions $19\frac{3}{4}$ to $20\frac{1}{4}$, while the ring conductor is connected as before over the contacts of cam 1508 to battery through resistance 1510. In this manner the pulses corresponding to the stations' digits are transmitted.

As sequence switch 1500 passes from position 20 to position 2 of the next revolution ground is supplied to cam 1509 over the outer right front contact of relay 1502. In positions $20\frac{3}{4}$ to $1\frac{1}{4}$ the ring conductor is grounded over cam 1509 and the tip conductor is open as previously described. In position $1\frac{3}{4}$ to $2\frac{1}{4}$ the tip conductor is grounded over cam 1509 and the ring conductor is connected to battery through high resistance 1510 over cam 1508. A parallel circuit extends over the right back contact of relay 1511, upper left and lower right contacts of cam 1512, lower front contact of relay 1222, middle lower front contact of relay 1224, upper contacts of cam 1515, inner upper back contact of relay 1001, left front contact of relay 1502, left contacts of cam 1516, resistance 2225, to battery over cam 2205. In position $2\frac{3}{4}$, plus $3\frac{1}{4}$ the ring conductor is grounded and the tip conductor is opened while in position $3\frac{3}{4}$ to $4\frac{1}{4}$ the circuits above traced are closed to transmit a second heavy negative impulse. Thus two heavy negative impulses are transmitted to correspond to the thousand digits of the numerical designation. The remaining digits are transmitted in a similar manner. When sequence switch 1500 reaches position 10 in the second revolution, relays 1503 and 1504 release. The tip conductor then is controlled exclusively by cam 1507 and the ring conductor by cam 1508, while relay 1503 prepares for the final positive pulse. The hundreds digit is transmitted in positions 3 to 8; the tens digit in positions 9 to 12 and the units digit in positions 13 to 16. In positions 16 to $16\frac{1}{2}$ the tip conductor is connected over the left back contact of relay 1503, lower contacts of cam 1522, to ground over inner lower back contact of relay 916 and the upper left contacts of cams 2218 and 2201.

When sequence switch 1500 reaches position $17\frac{3}{4}$ the tip conductor is connected over the left back contact of relay 1503, upper contacts of cam 1516, through resistance 2225 to battery over cam 2205, while the ring conductor is connected over the right back contact of relay 1503, upper left and lower right contacts of cam 1521 to ground, thus transmitting a heavy pulse in the direction opposite to that formerly transmitted, that is, a heavy positive pulse. Sequence switch 1500 is advanced from position 1 at the end of its first revolution by a circuit closed over its local cam, outer right front contact of relay 1504 to ground at the outer right contact of cam 1502. Since relay 1504 is released at the time sequence switch 1500 completes its second revolution, the sequence switch comes to rest having completed that revolution. In positions 19 and 20 the fundamental circuit is opened since relay 1503 is now released.

When sequence switch 1500 reaches position $18\frac{3}{4}$ a circuit is closed from ground over the right front contact of relay 1502, right back contact of relay 1504, contacts of cam 1523, inner lower back contact of relay 1007, winding of relay 916 to battery. Relay 916 functions in the manner described for panel calls to bring about the advance of the district and the release of the sender.

If the call is to be completed through a second tandem office, relay 2002 is operated alone to indicate that the whole designation is to be transmitted. With relay 2002 operated a circuit is closed from battery through the winding of relay 1511, left back contact of relay 1502, outer upper back contact of relay 2001, uppermost front contact of relay 2002, to ground over the lower right and upper left contacts of cam 2201, when sequence switch 2200 reaches position 5. Relay 1511 prepares a locking circuit for itself over its middle left front contact, upper right and lower left contacts of cam 1522, inner lower back contact of relay 916, to ground over the upper left contacts of cams 2218 and 2201. This circuit is completed when sequence switch 1500 has been advanced to its starting position and the sequence switch 2200 is ready to make the test of the outgoing trunk. With relay 1511 operated a circuit is closed from ground at its outer right front contact, lower left contact of cam 1501, to the winding of sequence switch magnet 1500 and battery, advancing sequence switch 1500 to its starting position 5 for the transmission of tandem call indicator impulses. When sequence switch 1500 reaches position 5 a circuit is closed for operating relays 1503 and 1504 over the left contacts of cam 1505 and the inner left contact of relay 1511 to the operating circuit of that relay. Relay 1504 locks over its left front contact as above described.

The transmission of impulses starts with

sequence switch 1500 in position 5. In positions 5 to 8 the tandem hundreds digit is transmitted under control of register 1100. In positions 9 to 12 the tandem tens digit is transmitted under control of register 1110 and in positions 13 to 16 the tandem units digit is transmitted under control of register 1200. The transmission of positive pulses is controlled during these positions over the outer left front contact of relay 1511 and cam 1524 and the transmission of negative pulses is controlled over the inner right front contact of relay 1511 and cam 1525. Relay 1511 is held operated until sequence switch 1500 leaves position 17 at which time the circuit assumes the condition it was in while making a direct call indicator call and the call proceeds from that point as above described.

Completion of call, using call announcer machine

If the call is to be completed at a manual office equipped for receiving call announcements from the sender, the route relay operated by the decoder indicates this fact to the sender by operating relay 2004. The call announcer mechanism is shown in Fig. 26 and comprises fourteen units for generating voice currents, each unit corresponding to a different digit or letter. Each unit comprises a drum on which is mounted a plurality of photographic vocal records of the particular digit, a light source, a lens system, a photoelectric cell, a repeating coil and an amplifier. The drums are constantly rotated by a common shaft which also carries certain synchronizing cams. As the drums rotate, the records are translated by the photoelectric cells back into voice currents which take the place of an operator's voice. With relay 2004 operated relay 2155 also operates in turn operating relay 2151. In addition relay 2004 closes a circuit from battery through the windings of relays 2508 and 2509 in parallel, outer upper front contact of relay 2004, lower back contact of relay 2005, lower contacts of cam 2208 to ground at the lower front contact of relay 1142. With relay 2508 operated a circuit is closed from battery through the winding of relay 2503, innermost contact of relay 2508, upper right contact of cam 2218 to ground at the upper left contact of cam 2201, when sequence switch 2200 reaches position 15 following the selection of the distant office.

Assuming that the trunk circuit of Fig. 3 is the first idle trunk of the group outgoing to the wanted manual office, a circuit is closed as soon as the trunk is found, which may be traced from battery through the right winding of relay 300 at the manual office, lower left winding of repeating coil 301, lower back contact of relay 302 to the ring brush of the district selector 200, right contacts of cam 251, lower back contact of relay 223, upper

left and lower right contacts of cam 203, conductor 231, brush 622, through the link circuit to brush 625 over the fundamental ring, upper back contact of relay 916, upper contacts of cam 2217, upper back contact of relay 2024, resistance 2043, upper front contact of relay 2023, lower back contact of relay 2302, lower left and upper right contacts of cam 2216, through the lower left winding of repeating coil 2500, lower back contacts of relays 2501 and 2502, lower back contact of relay 2401, lower back contact of relay 2301, inner upper back contact of relay 2501, back contact of relay 1400, upper winding of relay 2161, winding of polarized relay 2510, upper front contact of relay 2503, upper left winding of repeating coil 2500, outer upper front contact of relay 2151, upper back contact of relay 2152, upper left and lower right contacts of cam 2209, inner upper front contact of relay 1142, lower back contact of relay 916 to the fundamental tip, brush 626, through the link circuit to brush 608, and conductor 214, upper right and lower left contacts of cam 202, upper back contact of relay 223, upper left and lower right contacts of cam 230, to the tip brush of the district selector 200, upper back contact of relay 302, upper left winding of repeating coil 301, to the left winding of relay 300 and ground.

If the fundamental circuit is complete through the sender, relay 300 operates, closing a circuit from battery through the winding of relay 303, front contact of relay 300 to ground at the lower back contact of relay 304. Relay 303 in operating closes an operating circuit for relay 305 which in turn extends its operating ground by way of its inner lower front contact, and the upper back contact of relay 401 to the upper winding of relay 400 and battery. Relay 305 also closes a substitute ground for holding relay 303 operated. Relay 400 in operating closes a locking circuit for itself extending from battery through the lower winding of relay 401, lower winding and inner lower front contact of relay 400, winding of relay 324, lowermost front contact of relay 305 to ground at the inner lower back contact of relay 307. Relays 324 and 401 operate in this circuit while relay 400 remains operated. Relay 400 closes a circuit from ground through resistance 403, outer lower contact of relay 400, outer lower contact of relay 401, to lamp 308 and battery, causing that lamp to light as a guard signal. Relay 400 also closes a circuit from ground over its middle lower contact, through the winding of relay 402 to battery through the position splitting circuit. Relay 402 in turn closes a circuit from battery through the winding of relay 404, inner upper front contact of relay 402, through the splitting circuit to the winding of relay 405, and ground at the back contact of relay 406. Relay 405 locks over its

lower front contact and operates relay 406 to remove the operating ground from the circuit of relay 404. Relays 402, 404, 405 and 406 function to cause the connection of the operator's telephone with trunks in a predetermined order, but since this forms no part of the present invention the splitting relays belonging to other trunks have been omitted.

When the operator occupies her position, she inserts the plug of her headset 500 into jacks, such as jacks 502 and 503, thereby closing a circuit from ground through the right winding of repeating coil 501, tip of jack 502, through the transmitter of the headset 500, tip of jack 503, winding of relay 504 and battery. Relay 504 operates closing a circuit for relays 505 and 506 in parallel over the front contact of relay 504 to ground through the splitting circuit. Relays 505 and 506 prepare the circuits of the operator's telephone equipment. The operation of relay 404 closes a circuit from ground through the winding of relay 507, inner left front contact of relay 505, outer lower front contact of relay 404 through the winding of the supervisory relay 309 to battery and ground. Relays 507 and 309 operate in this circuit. At the same time a circuit is closed from battery through the winding of relay 304, winding and upper back contact of relay 310, lower contact of relay 402, inner lower front contact of relay 404, outer left front contact of relay 505, winding of relay 520, winding of relay 510 to ground at the outer right back contact of relay 509. Relay 304 operates in this circuit but relay 310 being marginal does not. Relay 304 in operating closes a circuit from ground over its outer front contact, lower back contact of relay 310, to the winding of relay 302 and battery. Relay 302 reverses the connection of the windings of relay 300 to the tip and ring conductors leading to the sender, causing the operation of relay 2510 and a series of other operations which will be described hereinafter. Relay 304 also provides a locking circuit for relay 324.

Relay 507 in operating closes a circuit from ground at the back contact of relay 528, front contact of relay 507, left normal contact of relay 509 to the winding of relay 508 and battery. Relay 508 in operating closes a circuit from ground through resistance 403, outer lower contacts of relays 400 and 401 upper front contact of relay 404, winding of pilot relay 407, which lights the pilot lamp 408, outer left front contact of relay 508, left back contact of relay 524, winding of relay 521, back contact of relay 523 and battery. This circuit causes relay 521 to operate in parallel with the lamp 308. Relay 521 closes an obvious circuit for relay 522, and relay 522 closes a circuit for relay 523. Relay 522 in operating connects direct battery to the

circuit of relay 521 in shunt of lamp 308 which is darkened by this shunt. The operation of relay 523 disconnects battery from the winding of relay 521 and that relay releases in turn releasing relay 522 and relay 523. As soon as relay 523 closes at its back contact, relay 521 reoperates and the cycle of operations is repeated to flash lamp 308. All of these relays are slow to release and relay 522 is in addition slow to operate to cause the timed flashing of the lamp.

Relay 508 in operating closes a circuit from ground at the left back contact of relay 510, left back contact of relay 511, fourth left contact of relay 508, right back contact of relay 512 to the winding of relay 513 and battery. Relay 513 in turn closes a circuit for relay 515 which extends its operating ground to the winding of relay 517 and this relay in turn operates relay 516, which operates relay 518. Relay 518 closes a circuit from battery through the winding of relay 512, inner right contact of relay 518 to ground at the right contact of relay 510. Relay 512 closes a holding circuit for relay 516 over its outer right front contact, the fourth left contact of relay 514, left back contact of relay 511, left back contact of relay 510 to ground. This chain of relays with the exception of relays 508 and 512 are all slow to operate. When relay 508 operated it connected the secondary winding of repeating coil 514 over the left back contacts of relay 512 to the tip and ring conductors including condenser 529. It also closed a circuit from a source of tone through the primary winding of coil 514, first left contact of relay 508, to the contact of relay 513. Relay 513 in operating extended this circuit over the left normal contact of relay 515 to ground at the left normal contact of relay 516. When relay 515 operated it opened the circuit; when relay 517 operated it reclosed it and relay 516 finally reopened it thus causing the transmission of two impulses of tone to the originating office. However, since the originating office is a panel office, these tones have no effect at the present time.

The operation of relays 402 and 404 also close a locking circuit for relay 401 from battery through its lower winding and inner lower front contact, upper front contact of relay 402, inner upper front contact of relay 404, outer right front contact of relay 506, right back contact of relay 525, winding of relay 526, to ground at the outer right back contact of relay 509. Relay 526 locks over its outer right contact to ground directly. It also connects ground over its front contact, the winding of relay 519 and battery. When relay 518 operates just prior to the operation of relay 512, a circuit is closed from ground over the inner left front contact of relay 519, outer right front contact of relay 518, to the winding of relay 520, in shunt of the winding

of relay 510. This reduces the resistance in series with relay 310 to such a point that that relay now operates connecting the tip conductor over the front contact of relays 305 and 310 to the front contacts of relay 512 and thence to the operator's telephone, so that the operator may receive the announcement. The operation of relay 512 opens the circuit of relay 513 and that relay releases which in turn releases relay 515 and relay 517. Relay 516 is held operated as previously described. The operation of relay 512 closes a circuit from battery over the inner right front contact of relay 512, winding of relay 509 and its right back contact, to ground at the right front contact of relay 526. Relay 509 locks over its right front contact and removes ground from the circuit of relay 526 but that relay holds over its own front contact. Relay 509 closes an obvious circuit for relay 528, and also closes a circuit from ground over the front contact of relay 526, inner left front contact of relay 509 to the winding of relay 508 to hold that relay operated. The operation of relay 310 opens the circuit of relay 302 and restores the direction of battery and ground through the windings of relay 300 to the inter-office trunk.

The direction of current flow over the inter-office trunk and the fundamental circuit, when first established is such that relay 2510 operates in turn closing a circuit from ground over its front contact, inner upper back contact of relay 2506 to the winding of relay 2505 and battery. Relay 2505 locks over its middle upper front contact, conductor 2507, upper contacts of cam 2201 to ground, and also connects this same ground to the winding of relay 2506 which also operates. When relay 302 operates reversing the current flow over the fundamental circuit, relay 2161 operates, and relay 2510 releases. The operation of relay 2161 under these conditions closes a circuit from grounded conductor 1129, over the front contact of relay 2161, inner lower front contact of relay 2505, uppermost front contact of relay 2508, lower normal contact of relay 2511, inner lower back contact of relay 2303, to the winding of relay 2501 and battery. Relay 2501 in operating connects reversed battery to the fundamental circuit to meet the reversed battery on the trunk circuit for the purpose of operating a relay in a two-wire office selector circuit if such an office selector is included in the circuit. Although no such two-wire office selector was included in the present connection, the sender must be prepared to take care of such a selector. Relay 2501 therefore connects ground over its outer lower front contact to the fundamental ring and battery over the contacts of cam 2505, through low resistance 2525, and the inner upper front contact of relay 2501 to the fundamental tip.

Relay 2501 also closes a circuit from battery through the winding of relay 2511, outer upper front contact of relay 2501, to grounded conductor 1130. Relay 2511 locks over its inner lower front contact to ground over conductor 2507 and the upper contacts of cam 2201. Relay 2511, in operation, opens the circuit of relay 2501 which releases. Relay 2501 will remain operated long enough, however, to perform the desired function.

When the connection of battery over the trunk is restored just before the operator's telephone is connected with the inter-office trunk, relay 2161 releases and relay 2510 again operates. When relay 2503 operated it closed an obvious circuit for relay 2512 and this relay in turn connected the winding of relay 2513 over its front contact to the interrupter contacts carried by the shaft of the call announcer machine. Each time that this interrupter contact closes the circuit of relay 2513 is closed to ground over interrupters 2610 and 2611 and relay 2513 is intermittently operated. After relay 2506 operates a circuit is closed from ground over the front contact of relay 2513, outer lower contact of relay 2506, middle lower front contact of relay 2509, to the winding of relay 2514 and battery so that relay 2514 also operates intermittently. Relays 2512, 2513, and 2514 are common to a group of five senders, each sender having a separate make contact on relay 2514.

When direct battery is restored to the fundamental circuit, and relay 2510 reoperates, a circuit is closed from ground over the front contact of that relay, lower front contact of relay 2511, lower contact of relay 2509, to the winding of relay 2515 and battery. Relay 2515 initiates the operation of the call announcement. Assuming that the numerical designation of the called subscriber is the same as for the first call traced, no station designations will be provided and none of the station relays will be operated. Therefore after the thousands digit has been recorded as indicated by the operation of relay 1227, and relay 2509 operated as above described, a circuit is closed from ground over the upper front contact of relay 1227, inner upper front contact of relay 2509, the upper back contacts of relays 1214, 1213, 1212 and 1211, winding of relay 2402 to battery, as an indication that no stations digit is to be pronounced. When the tens digit has been registered as indicated by the operation of relay 1317, and sequence switch 2200 has reached position 15, a circuit is closed from battery through the winding of relay 2403, outer lower back contact of relay 2404, outer upper front contact of relay 2509, over the front contact of relay 1317, to ground over the upper right contact of cam 2218, and the upper left contact of cam 2201. As soon as relay 2514 operates following the opera-

tion of relay 2515 a circuit is closed from battery through the winding and normal contact of relay 2518, front contact of relay 2514, outer upper front contact of relay 2515, lower back contact of relay 2517, conductor 2516, to ground at the lowermost front contact of relay 2403. Relay 2518 locks over its upper front contact to the lower back contact of relay 2517 and grounded conductor 2516. The operation of relay 2514 which causes the operation of relay 2518, also connects ground to the uppermost back contact of relay 2519, to resistance 2522 and battery in shunt of the winding of relay 2519. When relay 2518 operates a circuit is closed from battery through resistance 2522, winding of relay 2519, lower front contact of relay 2518, to conductor 2516 and ground. When relay 2514 opens the shunt around relay 2519 that relay operates. This prevents the premature starting of the announcement and the mutilation of the first digit.

The operation of relay 2519 also connects condenser 2523 between the left windings of repeating coil 2500 to care for the transmission of the announcement. Relay 2519 connects the right windings of repeating coil 2500 over the back contacts of relay 2524, inner upper and lower front contacts of relay 2519, to the armatures of relay 2620 and thence over contacts of relays 2621 to 2627, to the announcer units according to the setting of the sender registers. When relay 2403 operated it closed a circuit from ground over its lowermost front contact, to conductor 2405. Assuming that the numerical designation of the called party is the same as that first described, this ground will be extended over the inner upper front contact of relay 1222, to the winding of relay 1604 and battery, and over the inner upper contact of relay 1224, to the winding of relay 1602 and battery. When relay 2519 operated, a circuit was closed from battery through the winding of relay 1601, middle lower front contact of relay 2403, lower back contact of relays 2406 and 2407, upper back contact of relay 2408, middle upper front contact of relay 2519 to grounded conductor 2516. With relays 1601, 1602 and 1604 operated a circuit is closed from ground over the inner front contact of relay 1602, back contact of relay 1603, outer front contact of relay 1604, inner front contact of relay 1601, outer upper back contact of relay 2409, to the winding of relay 2620 and battery. The circuit of the right winding of repeating coil 2504 therefore extends over the front contacts of relay 2620, back contacts of relays 2621, 2623, 2625 and 2627 to the call announcer unit prepared to speak the digit 5. At the end of the silent period this digit will be pronounced and will be heard by the operator whose head set is shown in Fig. 5.

During this announcement relay 2514 is

again operated, closing a circuit from battery through resistance 2410, winding of relay 2411 and its normal contact, conductor 2525, outer upper front contact of relay 2519, contact of relay 2514, outer upper contact of relay 2515, lower back contact of relay 2517, to ground over conductor 2516. Relay 2411 closes a locking circuit for itself over its upper front contact, to grounded conductor 2516. It also closes a circuit from battery through resistance 2412, winding of relay 2408, upper front contact of relay 2411 to ground over its locking circuit. However, relay 2408 cannot operate since it is shunted by ground from the operating circuit of relay 2411 which is connected to the winding of relay 2408 over its lower back contact. At the end of the pronouncement relay 2514 releases and permits relay 2408 to operate in the circuit above described.

The operation of relay 2408 opens the circuit of relay 1601 and closes a circuit from battery through the winding of relay 1305, inner upper front contact of relay 2403, outer upper back contact of relay 2413, upper back contact of relay 2414, inner upper front contact of relay 2408, middle upper front contact of relay 2519 to grounded conductor 2516. With relay 1305 operated ground is supplied to the armature of relays 1301 to 1304. It will be remembered that relays 1301 and 1304 were operated heretofore, therefore ground is connected over the inner upper front contact of relay 1301, outer lower back contact of relay 2409 to the windings of relays 2621 and 2624 in parallel, and over the inner upper front contact of relay 1304, upper back contact of relay 2409 to the winding of relay 2620. With relays 2620, 2621 and 2624 operated, the announcing circuit extends over the front contacts of relay 2620, front contacts of relay 2621, back contacts of relay 2622, to the number 6 announcer unit, ready to pronounce the digit 6 as soon as the silent period is finished.

The next operation of relay 2514 connects ground to conductor 2525 as above described. Since relay 2408 is operated, ground is extended over the lower front contact of relay 2408, to resistance 2411 in shunt of the winding of relay 2411 which now releases. When relay 2411 releases, relay 2408 is held operated over the upper normal contact of relay 2411 to grounded conductor 2525, as long as relay 2514 remains operated. When relay 2408 operated a circuit was closed from ground at the lower front contact of relay 2403, conductor 2516, outer upper front contact of relay 2408, normal contact and winding of relay 2407, resistance 2415 to battery. Relay 2407 operates and locks over its inner upper contact to conductor 2516 independent of the contact of relay 2408 and also closes a circuit from battery through resistance 2416, winding of relay 2414, upper front contact of

relay 2407, to conductor 2516 and ground, but relay 2414 is shunted by a branch of the operating circuit of relay 2407. When relay 2514 releases the second time the holding circuit
 5 for relay 2408 is opened and that relay releases removing the shunt from relay 2414, and permitting that relay to operate. The operation of relay 2414 closes a circuit from battery through the winding of relay 2406,
 10 inner upper front contact of relay 2414, outer lower back contact of relay 2413, to grounded conductor 2516. Relay 2406 closes a locking circuit for itself through the winding of relay 2413, upper front contact of relay 2406
 15 to grounded conductor 2516, but relay 2413 is prevented from operating due to the closure of a shunt around its winding over the operating circuit of relay 2406. With relays 2406 and 2414 operated and relay 2408 released no
 20 talking circuit is closed so that a pause is introduced to simulate the customary method of splitting the number between the hundreds and tens digits.

When relay 2514 operates for the third
 25 time, a circuit is again closed for relay 2411 which locks and prepares a circuit for relay 2408 as above described. When relay 2514 releases at the end of the third talking period, during which no announcement was transmitted,
 30 relay 2408 operates and closes a circuit from grounded conductor 2516, upper front contact of relay 2408, lower front contact of relay 2414, to resistance 2415 and battery, shunting the winding of relay 2407
 35 which releases but closes a holding circuit for relay 2414 over its upper normal contact as long as relay 2408 remains operated. A circuit is then closed from battery through the winding of relay 1315, inner upper back
 40 contact of relay 2417, inner lower front contact of relay 2403, inner lower front contact of relay 2406, inner upper back contact of relay 2413, outer upper front contact of relay 2414, upper front contact of relay 2408, to
 45 ground over the middle upper front contact of relay 2519 and conductor 2516. Relay 1315 provides ground to the inner upper armatures of relays 1311 to 1314. With relays 1312 and 1314 operated, circuits are closed from
 50 ground over the inner upper front contact of relay 1312, inner lower back contact of relay 2409, to the windings of relays 2622 and 2625 in parallel and over the inner upper front contact of relay 1304, upper back contact of
 55 relay 2409 to the winding of relay 2620 and battery. The announcing circuit is therefore prepared over the front contacts of relay 2620, back contacts of relay 2621, back contacts of relay 2623, front contacts of relay
 60 2625 to the seventh announcer unit for announcing the digit 7.

When relay 2514 operates for the fourth time a shunt is closed to the winding of relay 2411 which releases and closes a holding circuit
 65 for relay 2408 as above described. Dur-

ing this time the digit 7 is being announced. At the end of the period, when relay 2514 releases, relay 2408 also releases and opens the holding circuit for relay 2414 which now releases and permits the operation of relay
 70 2413 in the locking circuit of relay 2406. At this time a circuit is closed from battery through the winding of relay 1325, inner lower back contact of relay 2417, uppermost front contact of relay 2403, outer lower
 75 front contact of relay 2406, back contact of relay 2407, upper back contact of relay 2408, middle front contact of relay 2519 to grounded conductor 2516. Relay 1325 supplies ground to the inner upper armatures
 80 of relays 1321 and 1324 and since relays 1321, 1322, and 1324 are operated, circuits are closed over the front contacts of those relays to operate relays 2621, and 2624 in parallel, 2622, and 2625 in parallel and relay
 85 2620. A circuit is therefore prepared from the secondary winding of the repeating coil 2500 over the front contacts of relay 2620, front contacts of relay 2621, front contacts of relay 2622, to the No. 8 announcer
 90 unit.

During the next, fifth, announcing period relay 2514 is operated, operating relay 2411, and relay 2408 operates when relay 2514 releases. The operation of relay 2408
 95 closes a circuit for relay 2407 as above described which prepares a circuit for relay 2414 in the same manner. During this period the digit 8 is pronounced.

With relays 2413 and 2407 operated and
 100 relay 2408 released a circuit is closed from battery through the upper winding of relay 2517, inner lower front contact of relay 2505, inner lower front contact of relay 2509, outer upper back contact of relay 2402, lower
 105 front contact of relay 2413, lower front contact of relay 2407, inner upper back contact of relay 2408, middle upper front contact of relay 2519, to grounded conductor 2516. The operation of relay 2517 opens the locking
 110 circuit of relay 2518 which releases in turn releasing relay 2519. It also closes an obvious circuit for relay 2524 which opens the connection between the repeating coil 2500 and the call announcer machine. Relay 2517 closes a circuit from battery
 115 through the winding of relay 904, outer upper front contact of relay 2517, conductor 2507 to ground at the upper contacts of cam 2201. Relay 904 in operating performs the same function as described heretofore. However, since relay 916 is not operated, the fundamental circuit is held closed until the
 120 advance of the district closes a substitute circuit for relay 300. The advance of the district and the release of the link and sender take place in the manner above described.
 125

When the operator at the manual office has received the announcement she disconnects
 130

her position equipment from the trunk by operating release key 409. The operation of key 409 closes a circuit from ground over the contact of that key, inner right front contact of relay 506, left back contact of relay 525 to the winding of relay 527 and battery. Relay 527 closes a locking circuit for itself, from battery through the right winding of relay 524, inner right back contact of relay 525, right winding and right contact of relay 527, to ground at the left front contact of relay 528. Relay 524 locks through its left winding to this same ground and extends its locking ground to the left winding of relay 525, which also operates. Relay 525 locks through its right winding and left front contact to ground at key 409. Relays 527 and 525 close a circuit from ground at the left contact of relay 528, right front contact and winding of relay 527, right front contact of relay 525, outer right front contact of relay 506, inner upper front contact of relay 404, outer upper front contact of relay 402, to the right front contact and lower winding of relay 401 in shunt of the winding of relay 400. Relay 400 therefore releases opening the circuit for relays 402 and 403 which in turn open the circuit for relay 401. Relay 524 opens the circuit over which lamps 308 and 408 were flashed. Relay 525 opens the circuit of relay 526 which in turn opens the circuit of relay 508 permitting relays 516, 518, 512, 509, 528, 524 and 527 to release in succession. Relay 525 remains operated until the operator releases key 409. The release of relay 400 also opens the circuit of relay 324 and that relay releases. With relay 324 released, a circuit is closed from battery through lamp 308 middle upper front contact of relay 306, upper back contact of relay 324, through the resistance 321 to ground at the back contact of relay 307 until the plug is inserted in the jack acting as a guard signal. The release of relay 324 also opens the locking circuits of relays 304 and 310 and these relays also release. Relay 304 recloses the original operating circuit for relay 303. After operating key 409, the operator closes one of the ringing keys according to the designation received, for example, key 314. She then tests the subscriber's jack in the usual manner and if the subscriber's line is idle inserts plug 311 in jack 312. Relay 307 operates in series with relay 313. The operation of relay 307 completes the tip conductor from the tip of the plug 311 to the upper armature of relay 315, and also closes a circuit from ground over its lower front contact, inner upper front contact of relay 306, over the right back contact of relay 316, upper back contact of relay 317, to the winding of relay 315 and battery. Relay 315 extends the tip conductor to ground at the upper back contact of relay 318, and extends the ring conductor over its lower front

contact and alternate contact of key 314, right winding of relay 316 to source of ringing current 319.

When the receiver is removed from the switchhook at the called station, in response to the ringing current, the resistance of the ringing circuit is decreased sufficiently to allow relay 316 to operate. The operation of this relay opens the shunt around the winding of relay 317 which is now included in the circuit of relay 315. This relay in operating closes battery over its front contact in shunt of the winding of relay 315 thus locking under the control of relay 307. Relay 315 releases extending the tip and ring conductors over its back contacts to the winding of relay 309 and the right windings of repeating coil 301 and battery. Relay 309 therefore operates closing a circuit from battery through the winding of relay 302, front contact of relay 309 to ground at the lower front contact of relay 306, reversing the flow of current through the windings of relay 300. This reversal causes the operation of relay 243 and the operations controlled thereby as described.

If the automatic connection of the operator to the trunk is not followed by the announcement, or the operator does not understand the pronouncement as transmitted from the sender, she can get the correct number from the calling subscriber by inserting plug 311 in an emergency listening jack 322. The insertion of plug 311 in jack 322 closes a circuit from battery through the winding of relay 307, over the sleeves of plug 311 and jack 322, upper and lower windings of relay 450 to ground. Relay 450 operates but the resistance of this relay is so high that relay 307 is not operated at this time. The operation of relay 450 closes in a circuit from ground over its front contact, winding of relay 452 to battery at the inner lower back contact of relay 451. At the same time a circuit is closed from battery through the winding of relay 323, upper back contact of relay 307 over the ring of plug 311 and jack 322, upper back contact of relay 453 to the winding of relay 454 and ground. Relay 323 locks in a circuit from battery through its lower winding and lower contact of relay 305, upper contact of relay 303 to ground at the upper front contact of relay 323. It also closes the operating circuit of relay 306 in parallel with this locking circuit. Relay 306 connects ground at its inner front contact to the locking circuit of relay 323 thus holding both relays operated. Relay 306 prepares the ringing circuit as before. Relay 454 locks over its lower contact, winding of relay 455, and battery. Relay 455 in turn locks over its upper contact to ground at the lower contacts of relay 450, in turn connecting ground over its lower front contact, to the winding of relay 453, which opens the circuit of relay 454 and connects the ring conductor through to

the armature of relay 452. Relay 453 also closes a shunt around the high resistance upper winding of relay 450, permitting relay 307 to operate and extinguish lamp 308. Relay 453 also closes an obvious circuit for relay 456 which connects alternating current relay 457 across the tip and ring conductors by way of the front contact of relay 456, and the outer lower back contact of relay 452.

10 Ringing was started by the operation of relay 307 as above described and relay 457 responds thereto, closing a circuit from ground over the front contact of relay 451, front contact of relay 457, upper winding of relay 458 to battery. Relay 458 locks through its lower winding to ground at the front contact of relay 451 independent of relay 457. It also connects ground over its lower front contact, lower front contact of relay 456 to the winding of relay 459 and battery. Relay 459 in turn closes an obvious circuit for relay 452 which connects the ring conductor through to the contacts of relay 459. Relay 452 opens the circuit of relay 451 which releases after an interval. Relay 459 also connects the ring conductor to battery through resistance 460, and the tip conductor to ground through resistance 461. This provides a circuit for operating relay 316 which cuts off the ringing current and causes the operation of relay 317 as above described. It also extends the tip and ring conductors through to the windings of relay 309. In addition relay 459 closes an obvious circuit for relay 470 which closes a holding circuit for relay 458. Relay 452 operates relay 462 which connects the tip conductor through to the secondary winding of tone coil 462. When relay 451 releases, relays 458, 459 and 470 release, transferring the tip and ring from battery and ground to the armatures of relay 465 and the secondary of the tone coil.

The primary circuit of tone coil 463 is closed over the outer lower front contact of relay 462, the back contact of relay 458, outer lower back contact of relay 465 to ground at the normal contact of relay 464. Relay 462 in operating also closes a circuit from battery through the winding of relay 464, lower back contact of relay 465, inner lower front contact of relay 462 to ground at the back contact of relay 458. After an interval relay 464 disconnects ground at its upper front contact from the primary winding of tone coil 463. It also closes an obvious circuit for relay 466, which in operating extends the tone circuit over its upper front contact to ground at the upper back contact of relay 467. It also causes the operation of relay 467 which operates extending its operating circuit to the winding of relay 468 and battery. In addition relay 467 opens the tone circuit having completed the transmission of two impulses of tone back over the trunk of Fig. 3.

65 These impulses of tone are of course ineffec-

tive in the present case but this emergency listening circuit is also used in the case of straightforward calls, or relay call indicator calls. Condenser 469 permits the operator at the position to hear that the tone has been transmitted. The operation of relay 468 causes relay 465 to operate and extend the tip and ring conductors through to the operator's telephone 500. Relay 465 locks over its outer lower front contact, inner lower front contact of relay 462 to ground at the middle upper contact of relay 458, and extends this ground to the winding of relay 464 holding that relay as well as relays 466, 467 and 468 operated.

The connection of the secondary winding of tone coil 463 across the tip and ring conductors causes the operation of relay 309 to again operate relay 302 and bring about the reoperation of relay 2161 if the sender has not been released. With relay 2161 operated a circuit is closed from grounded conductor 1129, front contact of relay 2161, inner lower front contact of relay 2505, uppermost front contact of relay 2508, middle lower front contact of relay 2515, the lower winding of relay 2517 and battery, thus causing the series of operations previously described to take place, resulting in the advance of the district and the release of the sender and link.

The operator may now ask the calling subscriber for the wanted number.

If the number to be pronounced had been greater than 9,999 then the stations digit would have been 1 and relay 1211 of the stations register would have been operated. Under this condition when relay 2509 operated, a circuit is closed from battery through the winding of relay 2404, upper front contact of relay 1211, outer upper back contacts of relays 1212, 1213 and 1214, inner upper front contact of relay 2509, to ground at the uppermost front contact of relay 1227. With relay 2404 operated a circuit is closed from battery through the winding of relay 2418, lower front contact of relay 2404, outer upper front contact of relay 2509, outer upper contact of relay 1317, upper right contact of cam 2218 to ground at the upper left contact of cam 2201. The cycle of operations of relays 2408 and 2411, 2407 and 2414, 2406 and 2413 progresses in the manner above described, but the digits to be pronounced in the various positions are changed. The first digit to be pronounced is the stations digit 1 and therefore a circuit is closed from battery through the winding of relay 1215 over the inner upper front contact of relay 2418, lower back contact of relay 2406, lower back contact of relay 2407, upper back contact of relay 2408 to ground over the middle upper front contact of relay 2519 when all of the transfer relays are in normal condition, instead of through the winding of relay 1601.

The circuit of relay 1601 is now closed over

the lower front contact of relay 2418, upper back contact of relay 2413, upper back contact of relay 2414, over the upper front contact of relay 2408, and the thousands digit is therefore pronounced in the second period after relays 2411 and 2408 have been operated. Similarly with relays 2407 and 2414 operated and relays 2408 and 2411 released, the circuit extends to relay 1305 of the hundreds register. When relay 2408 and relay 2411 have reoperated relay 2407 is shunted down and relay 2414 held operated and none of the registers is effective, thus introducing the pause between the hundreds and tens digit as before described. During the next interval relays 2411 and 2408 are released and the tens register relay 1315 is operated over the inner upper back contact of relay 2417, next to the outer upper front contact of relay 2418, outer lower contact of relay 2406, lower back contact of relay 2407, and the upper back contact of relay 2408. The release of relay 2408 also releases relay 2414 permitting relay 2413 to operate in series with relay 2406. In the next period, therefore, with relay 2408 reoperated relay 1325 is operated, and in the period following that with relay 2408 released, relay 2517 will operate to initiate the release of the sender.

If the called number is under 9,999 and has a stations digit neither relay 2404 nor relay 2402 will be operated. Relay 2403 operates under the control of relay 2509. Under this condition the digits are pronounced as first described. However, following the announcement of the units digit, with relays 2406, 2413, 2407, 2408 and 2411 operated the circuit of relay 2417 is open at the contact of relay 2408, and a circuit is closed from battery through the winding of relay 1215, inner lower back contact of relay 2402, outer lower back contact of relay 2417, middle upper front contact of relay 2403, upper front contact of relay 2413, upper back contact of relay 2414, to ground over the upper front contact of relay 2408. A circuit is also closed from ground over the upper front contact of relay 2408, upper back contact of relay 2414, upper front contact of relay 2413, middle upper front contact of relay 2403, outer lower back contact of relay 2417, inner upper back contact of relay 2402, upper back contact of relay 2304, to the windings of relays 2626 and 2627, to transfer the announcing circuit from the numerical digit announcing units to the letter announcing units. Assuming that relay 1212 is operated, the operation of relay 1215 closes ground over the inner upper front contact of relay 1212 inner lower back contact of relay 2409, to the windings of relays 2622 and 2625. Therefore a circuit is prepared from the right winding of repeating coil 2500, over the back contacts of relay 2620, back contacts of relay 2623, front contacts of relay 2622, back contacts of

relay 2624, front contacts of relay 2626, to the W announcing unit causing the announcement of the stations designation W. The subsequent release of relay 2408 causes the operation of relay 2517 and the initiation of the release of the sender.

Completion of call to step-by-step dial office

If the call is to be completed by step-by-step switches, the decoder causes the operation of a route relay which in turn causes relay 2005 to be operated alone if only the numerical designation is to be transmitted, and relays 2004 and 2005 to be operated together if the complete designation is to be transmitted. In the establishment of such a call, directive pulses are generated by means of interrupter 2307. Interrupter 2313 which is carried by the same shaft but is open when interrupter 2307 is closed, and vice versa, controls the counting relays to determine the number of pulses to be transmitted. The same transfer relays are used for rendering the registers successively effective as in the call announcer type of call.

The transfer of the complete designation will first be described. With relays 2004 and 2005 operated, a circuit is closed from battery through the windings of relays 2417, 2304 and 2409 in parallel, fourth upper contact of relay 2005, lower contacts of cam 2208 to ground at the lower front contact of relay 1142. Relay 2155 is operated over the third upper contact of relay 2005 to the same ground, and in turn operates relay 2151. Under these conditions when sequence switch 2200 reaches position 16, for making the test of the outgoing trunk, the fundamental circuit extends from the fundamental tip, over the lower back contact of relay 916, inner upper front contact of relay 1142, lower right and upper left contacts of cam 2209, back contact of relay 2152, upper front contact of relay 2151, upper back contact of relay 2503, winding of relay 2510, upper winding of relay 2161, back contact of relay 1400, inner upper back contact of relay 2501, lower back contact of relay 2301, lower back contact of relay 2401, outer lower back contacts of relays 2502 and 2501, lower back contact of relay 2503, upper right and lower left contacts of cam 2216, back contact of relay 2302, through the compensating resistance 2043 or 2042 depending on the setting of this register, upper contacts of cam 2217, outer upper back contact of relay 916 to the fundamental ring. When the outgoing trunk has been selected and is ready to function, direct battery is received over the fundamental circuit by relay 2510 which operates, in turn operating relay 2505 and relay 2506 as previously described.

The step-by-step office is arranged when receiving calls from a panel office to remove battery and ground and connect a bridge

across the trunk. When this occurs relay 2510 releases, but relays 2505 and 2506 are locked up as described in connection with the call announcer call. The release of relay 2510 closes a circuit from ground over its back contact, middle lower front contact of relay 2506, inner lower contact of relay 2304, to the winding of relay 2301 and battery. Relay 2301 closes obvious circuits for relay 2305 and relay 2302. The operation of these relays indicates that the step-by-step trunk is ready for receiving pulses. These relays in operating short-circuit the windings of relays 2510 and 2161 so that the fundamental circuit extends from the link as above traced over the fundamental tip to the upper front contact of relay 2151 and thence over the outer lower front contact of relay 2301, inner upper back contact of relay 2501, outer upper front contact of relay 2302, inner lower back contact of relay 2501, inner upper back contact of relay 2502, outer lower front contact of relay 2302, outer upper back contact of relay 2501 to grounded conductor 1130, and over the fundamental ring to the upper right contact of cam 2216 as previously traced, lower back contact of relay 2503, outer lower back contacts of relays 2501 and 2502, back contact of relay 2401, middle lower front contact of relay 2301 back contact of relay 2308 in parallel with interrupter 2307, resistance 2225, to battery over the contacts of cam 2205.

With relay 2301 operated a circuit is closed from battery through the winding of relay 2421, upper back contact of relay 2401, inner lower front contact of relay 2301 to ground at the inner lower back contact of relay 2502. Relay 2421 in operating closes a circuit for relay 2420. Relay 2302 also closes a circuit from battery through resistance 2309, winding of relay 2310, outer upper back contact of relay 2311, inner lower back contact of relay 2312, inner lower front contact of relay 2302, upper back contact of relay 2501 to grounded conductor 1130. Relay 2310 operates only if the contact of interrupter 2313 is open. If not, a circuit is closed from battery through resistance 2309, over the lower back contact of relay 2310, upper back contact of relay 2312, middle back contact of relay 2311 over the interrupter 2313, lower front contact of relay 2302 to ground over the upper back contact of relay 2501 and conductor 1130. This shunts the winding of relay 2310 and prevents its operation, for the purpose of preventing a mutilated first pulse. When interrupter 2313 opens relay 2310 operates, preparing a circuit from battery through the winding of relay 2315, back contact of relay 2308, outer lower front contact of relay 2310, upper back contact of relay 2312, middle upper back contact of relay 2311 to interrupter 2313 so that when the interrupter

again closes relay 2315 operates. Relay 2315 closes a locking circuit for itself through the winding of relay 2308, upper front contact of relay 2315, outer lower back contact of relay 2312, left contacts of cam 2226 to ground at the back contact of relay 1420. Relay 2308 cannot operate until the interrupter 2313 opens the shunt around its winding to the operating circuit of relay 2315. With relay 2308 operated the connection of battery to the fundamental circuit is under the control of interrupter 2307.

If relay 2013 had been operated from the decoder, indicating that the 1,000 ohm resistance 2044 should be included in the fundamental circuit during pulsing to a step-by-step office, the operation of relay 2302 opens a second shunt around resistance 2044 which was held closed at the lower back contact of relay 2302 until that relay operated. Resistance 2044 would now be included in the fundamental circuit. The operation of relay 2305 also connected 500 ohm resistance 2306 between the tip and ring conductors of the fundamental circuit.

Following the operation of relay 2304 and relay 1227, relay 2402, or relay 2404, or neither, are operated according to the stations digit recorded on register 1210. For the present call it will be assumed that no stations digit has been recorded and relay 2402 is operated. When sequence switch 2200 reaches position 15 following the operation of relay 1317 a circuit is closed from battery through the winding of relay 2403, outer lower back contact of relay 2404, outer lower front contact of relay 2304, outer upper front contact of relay 1317 to ground over the upper right contact of cam 2218 and the upper left contact of cam 2201.

As soon as relay 2403 operated a circuit was closed from ground over its lower front contact, second upper front contact of relay 2005, inner upper front contact of relay 2004, conductor 2046, lower back contact of relay 2422, to the winding of relay 1105 and battery. Relay 1105 supplies ground to the armatures of relays 1101 to 1104. Assuming that the tandem hundreds digit for the present call was nine, relays 1103 and 1104 will be operated and circuits closed from ground over the inner upper front contact of relay 1103, inner upper front contact of relay 2409, to the winding of relay 2316 and battery, and over the inner upper front contact of relay 1104, upper outer front contact of relay 2409 to relay 2317 and battery. These relays in operating determine the number of pulses to be transmitted to the step-by-step office.

In pulsing to a panel office the digit zero is the first digit and the number of pulses transmitted for that digit is one, so that the pulses for the remaining digits are transmitted as one more than the number actually recorded. In step-by-step pulsing on the

other hand zero is the last or tenth digit and the number of pulses transmitted is the same as the number recorded. Therefore in the present case preparation should be made for transmitting nine pulses. The first opening
 5 of the contact of interrupter 2307 following the operation of relay 2308, transmits a pulse to the step-by-step office. At this time, interrupter 2313 has its contact closed, completing
 10 a circuit from ground over the inner lower front contact of relay 2302, contact of interrupter 2313, middle upper contact of relay 2311, upper back contact of relay 2312, lower
 15 front contact of relay 2310, lower front contact of relay 2308, inner upper back contact of relay 2419, inner lower back contact of relay 2314, inner lower front contact of relay 2316,
 20 upper back contact of relay 2423, conductor 2150, lower back contact of relay 1403, winding of relay 1413 to battery over conductor 2206. When relay 2307 closes its contact at the termination of the first impulse, interrupter 2313 opens its contact allowing relay
 25 1403 to operate in the locking circuit of relay 1413, in the usual manner. Therefore as each pulse is sent out to the step-by-step office, one of the pairs of counting relays is operated and locked. The locking circuits for the even and odd counting relays extend over
 30 conductors 1424 and 1423 to the upper front contacts of relay 2310, inner upper normal contact of relay 2311 to grounded conductor 1130. Since relay 2317 is operated, a circuit is closed from battery through the winding
 35 of relay 1421, inner upper front contact of relay 2317 to ground at the inner lower front contact of relay 2310. Therefore when relay 1401 has been operated following the third pulse, the circuit is extended over the lower
 40 front contact of relay 1421, to the lower back contact of relay 1409, winding of relay 1419 and battery, so that during the next five pulses relays 1405 to 1409 and 1415 to 1419 inclusive are operated. During the ninth
 45 pulse the circuit extends over the front contact of relay 1405, inner front contact of relay 1421 to the winding of relay 1410. At the end of the ninth pulse relays 1400 and 1420 operate in the locking circuit of relay
 50 1410.

Relay 1400 has no function during step-by-step calls. Relay 1420 in operating opens the locking circuit of relays 2315 and 2308 and closes a circuit from battery through the
 55 winding of relay 2312, and its lower normal contact, next to the inner back contact of relay 2311, upper front contact of relay 2305, to ground at the front contact of relay 1402. Relay 2312 further opens the locking circuit of relays 2315 and 2308. Relay 2312
 60 closes a circuit from battery through resistance 2318, winding of relay 2319, upper front contact of relay 2312, to ground at the inner upper back contact of relay 2310, but relay
 65 2319 is prevented from operating by ground

from the front contact of relay 1420, connected over the lower back contact of relay 2319 to resistance 2318 in shunt of the winding of relay 2319. The release of relay 2308 connects the shunt over its upper contact
 70 around interrupter 2307 to prevent the transmission of further pulses to the step by step office. Relay 2312 also opens the operating circuit of relay 2315 to prevent its premature reoperation. Relay 2312 closes a locking
 75 circuit for itself over its lower front contact, inner back contact of relay 2311 to grounded conductor 1130. Relay 2312 also opens the operating circuit for relay 2310 which in releasing recloses the shunt around
 80 its winding. Relay 2310 also opens the locking circuits for the counting relays permitting them to release. As soon as relay 2310 releases, the circuit above traced for relay 2319 is closed but relay 2319 does not operate until
 85 relay 1420 has released opening the shunt around the winding of relay 2319.

In order to allow time for the step-by-step selector to hunt and seize an idle outgoing trunk it is necessary to count off a period
 90 of time between digits. For this purpose the operation of relay 2319 closes a circuit from battery through the winding of relay 1414, back contact of relay 1404, conductor 2158, lower front contact of relay 2319, next to the
 95 outer upper back contact of relay 2311, interrupter 2313, inner lower front contact of relay 2302, upper back contact of relay 2501 to grounded conductor 1130. Relays 1414, 1413, 1412, 1411 and 1410 as well as 1404, 1403,
 100 1402, 1401, and 1400 and 1420 are operated. The circuits controlling relay 1421 are opened by the release of relay 2310 so that five pulses only are transmitted. When relay
 105 1420 operates it closes a circuit from ground over its front contact, upper front contact of relay 2305, inner lower front contact of relay 2319, outer lower back contact of relay 2303 to the winding of relay 2311 and battery. Relay 2311 operates, disconnecting interrupter
 110 2313 from the counting relay circuit, opening the locking circuit for the counting relays extending over the upper contacts of relay 2319, inner back contact of relay 2311 to grounded conductor 1130, opening the locking
 115 circuit of relay 2312 and locking to ground at the front contact of relay 1420 to insure the release of that relay before relay 2311 also releases. The release of relay 2312 also releases relay 2319 and relay 2311 releases as soon as relay 1420 releases so that
 120 the circuit is now ready to transmit another set of impulses.

When relay 2315 operated it closed a circuit from ground over its lower contact, fifth
 125 upper contact of relay 2005, middle upper front contact of relay 2004, conductor 2045, upper back contact of relay 2422, winding of relay 2424 to battery. Relay 2424 closes a locking circuit for itself through the wind-
 130

ing of relay 2422, front contact of relay 2424, conductor 2046, inner upper front contact of relay 2004, second upper contact of relay 2005, to ground at the outer lower front contact of relay 2403. Relay 2422 is prevented from operating in this locking circuit by the operating ground of relay 2424 which is in shunt of the winding of relay 2422. When relay 2315 releases following the transmission of the first digit, relay 2422 operates. Relay 2422 in operating opens the circuit of relay 1105 and closes a circuit for relay 1115 over the upper back contact of relay 2425. Relay 1115 connects ground to the armatures of relays 1111 to 1114 of the tandem tens register and, assuming that relay 1113 alone is operated a circuit is closed from ground over the inner upper contact of that relay, inner upper front contact of relay 2409, to the winding of relay 2316 and battery.

When relays 2311 and 2312 have both released the circuit of relay 2310 is reestablished and as soon as interrupter 2313 opens the shunt around the winding of that relay, relay 2310 operates. As before it closes a circuit for operating relay 2315 which locks in series with relay 2308, relay 2308 operating following the next opening of interrupter 2313. Since relay 2316 alone is operated the counting relay circuit extends from ground over interrupter 2313, next to the outer back contact of relay 2311, upper back contact of relay 2312, front contact of relay 2310, front contact of relay 2308, inner back contact of relay 2419, inner lower back contact of relay 2314, inner lower front contact of relay 2316, upper back contact of relay 2423, to conductor 2150, back contact of relay 1403, winding of relay 1413 and battery preparing for the transmission of four impulses. At the end of the fourth impulse relay 1420 operates performing the functions above described. When relay 2315 is operated the second time, it again connects ground to conductor 2045, which is now connected over the upper front contact of relay 2422, lower back contact of relay 2425 to the winding of relay 2426 and battery. Relay 2426 locks through the winding of relay 2425, front contact of relay 2426, front contact of relay 2422, to ground over conductor 2046. At the end of the second digit relay 2425 is permitted to operate, transferring the circuit controlled over connector 2045 to the upper back contact of relay 2427 and the winding of relay 2428. It also opens the circuit of relay 1115 and closes the circuit of relay 1205, over the back contact of relay 2427, upper front contact of relay 2425, lower front contact of relay 2422, to ground over conductor 2046.

The remaining pulses are controlled in a similar manner by the interrupters, the counting relays and the register relays. During the third digit relay 2428 is operated and a circuit prepared for relay 2427. When re-

lay 2427 operates at the close of the third digit, the transfer relay circuit controlled by relay 2315, is extended over the front contact of relay 2427 to conductor 2525 where it controls relays 2411 and 2408 in the manner described for call announcer calls. It also extends connector 2046 to the inner upper armature of relay 2408 so that relay 2408 now controls the operation of the register grounding relays. During the transmission of the fourth digit relay 2411 is operated after which relay 2408 is operated. During the transmission of the fifth digit relay 2411 is shunted down and at the end of that digit relay 2408 is released. During the sixth digit relay 2411 is reoperated followed by relay 2408 and during the seventh digit relay 2411 is again shunted down and relay 2408 released. The first operation of relay 2408 operates relay 2407 and the first release operates relay 2414, which in turn operates relay 2406. The second operation of relay 2408 shunts down relay 2407 and its second release permits the release of relay 2414 and the operation of relay 2413 in the locking circuit of relay 2406, in the manner previously described. When relay 2408 releases, following the completion of the seventh digit a circuit is closed from battery through the winding of relay 2303, and its upper back contact, lower back contact of relay 2320, outer lower front contact of relay 2402, inner lower back contact of relay 2404, inner lower front contact of relay 2417, outer upper front contact of relay 2403, outer lower front contact of relay 2406, lower back contact of relay 2407, upper back contact of relay 2408, lower front contact of relay 2427, upper front contact of relay 2425, lower front contact of relay 2422, to ground over conductor 2046. Relay 2320 operates, following the operation of relay 2303, from battery through the winding of relay 2320, lower front contact of relay 2303, lower back contact of relay 2320, and thence over the circuit traced for operating relay 2303, to ground. Relay 2303 locks over its inner upper front contact to ground at the upper contacts of cam 2201. Relay 2320 also locks to ground at the upper contacts of cam 2201, and opens the operating circuit of relay 2303.

Relays 2312 and 2319 operate as previously described and relay 2310 releases to count off an interval measured by five pulses similar to that included between digits. This is for the purpose of allowing the step-by-step office sufficient time to recognize that pulsing is completed. When relay 1420 operates a circuit is closed from ground over the front contact of relay 1420, front contact of relay 2305, inner lower front contact of relay 2319, outer upper front contact of relay 2320, outer upper back contact of relay 2502 to the winding of relay 2501 and battery. Relay 2501 in operating opens the shunt extending over its inner upper back contact

and the outer lower front contact of relay 2301 around the windings of relays 2161 and 2510. It also connects battery from cam 2205 through resistance 2225, over its inner upper front contact to the fundamental tip in place of the ground supplied over its outer upper back contact, and connects ground to the fundamental ring over its lower front contact, in place of the battery formerly supplied over the lower front contact of relay 2301.

The reverse battery on the fundamental circuit causes relay 2161 to operate in turn operating relay 2401 over the inner upper front contact of relay 2302 and the inner lower front contact of relay 2503. Relay 2401 releases relays 2421 and 2420. With relays 2320 and 2501 operated and relay 2420 released, a circuit is closed from battery through the winding of relay 2502, lower back contact of relay 2420, outer lower front contact of relay 2320, outer upper front contact of relay 2501, to grounded conductor 1130. Relay 2502 in operating releases relay 2501. When relay 2501 releases a circuit is closed from battery through the winding of relay 916, upper front contact of relay 2502, upper back contact of relay 2501 to grounded conductor 1130. Relay 916 functions in the manner previously described to cause the advance of the district selector and the release of the link and the sender.

If the outgoing call is to a step-by-step office using five digits, the call will be made in essentially the same manner as the seven digit call just described, except that relay 2005 alone is operated. Therefore the first operation of relay 2315, causes the operation of relay 2428 over a circuit which may be traced from battery through the winding of relay 2428, back contact of relay 2427, outer upper back contact of relay 2004, fifth upper contact of relay 2005, to ground at the lower front contact of relay 2315, instead of operating relay 2424. The first digit transmitted is controlled by the tandem units register 1200. Only the digits two to nine are used for a first digit in calls to a five digit area.

If the call is to be completed to a step-by-step office employing only four digits, the class relay 2005 is operated alone as in the case of a five digit class. However, the tandem units digit set up in such a case will be zero or one. In case this digit is zero or one, as soon as relay 2403 operates, a circuit is closed from battery through the windings of relays 2428 and 2427 in series, over the outer upper back contact of relays 2314, 2316 and 2317 which will not be operated with such a setting of the tandem units register, outer upper front contact of relay 2301, inner upper back contact of relay 2004, second upper front contact of relay 2005 to ground at the outer lower front contact of

relay 2403. The immediate operation of relays 2428 and 2427 transfers the conductors controlled by relay 2427 directly to the armatures of relay 2408 causing the transmission of the thousands pulse first.

If the stations register is set for the digit 1 it is an indication that a call for a number over 9,999 is to be made. In this case relays 2404 and 2418 are operated while relays 2402 and 2403 remain normal. After the first three digit pulses have been sent in the case of a seven digit area call or after the first digit pulses have been sent in the case of a five digit area call, or before any digit has been sent in the case of a four digit call, the stations digit will be sent, which will be a 1, followed by the thousands, hundreds, tens and units digits. Otherwise the call will be made as described heretofore.

If the call is to a subscriber having a party line number, the pulses are sent as described for a seven, five or four digit call until the pulses of the units digit have been sent. Relay 2403 will have been operated but neither relay 2404 nor relay 2402 nor relay 2418 will have been operated. In this case after the transmission of the units digit a circuit will be closed from battery through the winding of relay 1215, outer lower back contact of relay 2402, inner lower back contact of relay 2404, inner lower front contact of relay 2417, outer upper front contact of relay 2403, outer lower front contact of relay 2406, lower back contact of relay 2407, upper back contact of relay 2408 to ground over the front contact of relay 2427 as previously described. Relay 1215 will supply ground to the inner upper armatures of relays 1211 to 1214, causing the operation of corresponding relays 2314, 2316, 2317 or 2419, in accordance with the setting of the register. Assuming that the stations designation is R, relays 1211 and 1212 will have been operated and therefore relays 2419 and 2314 will have been operated. A circuit is also closed from battery through the winding of relay 2423, outer upper front contact of relay 2304, over the inner upper, inner lower and outer lower back contacts of relay 2402, inner lower back contact of relay 2404, inner lower front contact of relay 2417, outer upper front contact of relay 2403, outer lower front contact of relay 2406, and thence to ground as traced hereinbefore. With relay 2423 and 2314 operated, a circuit is closed from battery through the winding of relay 2429, lower front contact of relay 2423, outer upper front contact of relay 2314 to the outer upper front contact of relay 2304, and thence to ground as traced for the circuit of relay 2423. With these relays operated the counting relay circuit extends from ground over interrupter 2313, next to the outer back contact of relay 2311, upper back contact of relay 2312, front contacts of relays 2310 and 2308, upper front contact

of relay 2419, outer lower front contact of relay 2314, inner lower front contact of relay 2429, to conductor 2156, and thence through the winding of relay 1411 to battery. A circuit is closed from battery through the winding of 1421, inner upper front contact of relay 2429, to ground at the inner lower front contact of relay 2310, so that after two impulses have been transmitted the circuit will be transferred to the winding of relay 1419, and five more impulses will be transmitted in order to operate relay 1420 and bring the pulsing to a close.

It may be noted at this time that relays 2314, 2315, 2317, 2419 are operated in accordance with the setting of the incoming registers which are set according to a panel code, while the outgoing pulses are transmitted according to the step-by-step code which calls for zero as the last digit. Therefore relay 2317 is operated alone to indicate the digit 5 but only five pulses are to be transmitted. By the panel code the operation of relay 2517 indicates that more than five pulses are to be transmitted and the operation of relay 2317 is normally employed to operate relay 1421 and add five pulses to the number of pulses indicated by the other register relays. The circuit of relay 1421 extends from battery through resistance 1420, winding of relay 1421, inner upper front contact of relay 2317, to ground at the lower front contact of relay 2310. This circuit is closed whenever relay 2317 is operated. With relay 2317 alone operated, the counting relay circuit extends from battery through the winding of relay 1414, back contact of relay 1404, conductor 2158, outer upper back contact of relay 2429, inner lower back contacts of relays 2316 and 2314, inner back contact of relay 2419 to ground over the front contact of relay 2308. In order to prevent the operation of relay 1421, since only five pulses are to be transmitted, a circuit is closed from battery through resistance 1422, middle upper front contact of relay 2317, upper back contacts of relays 2316, 2314, 2419 and 2429 to ground at the inner lower front contact of relay 2310 in shunt of the winding of relay 1421 to prevent its operation under this condition.

Most of the relays of Fig. 10 are employed in responding to the improper completion of a connection and in controlling a trouble recorder. Since this trouble recorder and its operation forms the subject matter of a copending application, these operations will not be described in the present specification.

Returning now to the decoder, it will be remembered that when relay 2801 operated it connected ground to conductor 2910, operating relay 3506, relay 3506 in turn supplying locking ground for relay 3501 if that relay is operated. The winding of relay 3501, is connected to battery at one side and to conductor 3120 at the other side. Conductor

3120 is connected over the back contacts of relays 3126, etc., to the conductors outgoing to the sender which are not used to control registration. For example, consider the compensating resistance register. In that register relay 3110 was operated and closed a circuit from ground through the winding of relay 3114, lower front contact of relay 3110, upper back contact of relay 3116, lower back contact of relay 3117, lower back contact of relay 3118, to conductor 3119. Conductor 3121 is connected over the upper back contacts of relays 3118, 3124, lower back contact of relay 3125, to the lowermost armature of relay 3126 and conductor 3120. Conductor 3122 is connected over the lower back contacts of relays 3124, 3116, 3127, and 3128, to the inner armature of relay 3126 and conductor 3120, while conductor 3123 is connected over the upper back contact of relays 3124 and 3127, lower back contact of relay 3129, to the second armature of relay 3126. Therefore each of the unused conductors is connected through contacts of relay 3126, to the winding of relay 3501. If a false ground is connected to any one of these conductors, relay 3501 will be operated. If a short circuit exists between two of these conductors, the ground properly connected to the one conductor will be transmitted back over the other one through the winding of relay 3501 causing it to operate. Inspection of the remaining decoder registers will show that a similar condition exists in them so that relay 3501 acts as a detector of false ground or cross connections.

It will be remembered that the circuit of relay 3110 extended through the winding of relay 3112. If, due to crosses at the connecting rack or in the cable between the cross connecting rack and the register, two of the operating circuits are grounded, relay 3112 which is marginal will operate and connect ground to conductor 3120 to operate relay 3501. If relay 3501 is operated, the ground by which relay 3500 operates relay 1003 is disconnected. If any of the operative circuits are open, relays such as relays 3114 or 3113 connected to the operative conductor cannot operate and the chain circuit traced above for relay 3500 is not closed.

The chain circuit of relay 3500 is arranged to check the fact that all of the circuits controlled by a particular relay have been closed. Referring again to the compensating resistance register, those relays which ground one conductor to the sender cause the operation of relay 3114, those which ground two conductors operate relays 3114 and 3131. The operating circuits of the register relays extend either through relay 3111, in which case relay 3113 is also operated or through relay 3132. The operation of either relay 3113 or 3132, indicating that the register relay circuit is complete, closes one point in

the link of the chain controlled by this register. The operation of one of the relays which grounds only one lead closes a second point in the link which is completed at a third point by relay 3114. If one of the relays which grounds two leads is operated relay 3113 closes the second point. Relay 3133 which grounds none of the conductors, closes a substitute for the second and third points in the link. Each of the registers completes its corresponding link in the same manner. The district group register has one relay which grounds three leads and in that case an extra relay is necessary to complete that particular link. Therefore if a register relay fails to close the proper number of conductors, the chain circuit cannot be completed.

When relay 3506 operated it closed a circuit from ground over its inner contact, left winding of relay 3507 and battery. Relay 3507 extends its operating ground over its left front contact to interrupter 3509. When interrupter 3509 closes its left contact a circuit is closed from ground connected to its contact over the right back contact of relay 3511, winding of relay 3510, to battery. Relay 3510 locks under the control of relay 3507. When interrupter 3509 closes its right contact ground is extended over the front contact of relay 3510 and the back contact of relay 3512 to the winding of relay 3511. When interrupter 3509 closes its left contact again a circuit is closed over the left front contact of relay 3511, to the winding of relay 3512 and battery. When relay 3511 operates, it locks under the control of relay 3507 and connects ground over its left front contact to relay 3513 which operates, in turn connecting ground to relay 3514 and battery. Relay 3514 operates relay 3515 over the back contact of relay 3516. With relay 3512 operated the next closure of the right contact of interrupter 3501 extends a circuit from ground over the front contacts of relays 3510 and 3512, back contact of relay 3516 to the winding of relay 3517. Relays 3512 and 3517 also lock under the control of relay 3507. Since all of these relays 3510, 3511, 3512 and 3517 lock under the control of relays 3507 and 3506 they release at any time that the decoder is released.

If, however, the decoder is not released by the time that these operations have taken place, when relay 3515 operates it connects battery to conductor 3518 to cause the association of a trouble indicator with the decoder. When the trouble indicator has been connected with the circuit, relay 3519 is operated over conductor 3520 and closes a locking circuit for itself from battery over the right front contact of relay 3515, right winding and right front contact of relay 3519 to ground. With relay 3519 operated a circuit is closed from ground at the outer left front contact of relay 3517, outer right front con-

tact of relay 3519, right front contact of relay 3514, outer left front contact of relay 3506, to the windings of relays such as relays 3126 and 3220 associated with each of the registers. These relays disconnect relay 3501 from the conductors outgoing to the sender to permit the sender relays to release and relay 3220 connects ground to the right winding of relay 3502 and battery, supplying a substitute holding ground for the relays of Fig. 35, and over conductor 3130 through the decoder connector, conductor 2830, upper back contact of relay 1140, winding of relay 1141, resistance 1149 to battery.

Relay 1141 in operating opens the start circuit of the decoder connector causing the release of the decoder connector and decoder. It closes a locking circuit for itself through the upper winding of relay 1140, inner upper front contact of relay 1141, to off normal conductor 1129, but relay 1140 cannot operate until the decoder has been disconnected from the sender.

Relays 3515 and 3707 together supply ground over the normal contact of jack 2912 to the winding of relay 2911. When relay 2702 releases, a circuit is closed from battery through the upper winding of relay 2905, normal contact of relay 2702 to ground at the contact of relay 2911. Relay 2905 is therefore held operated under the control of relays 3515, 3506 and 3507, holding the decoder out of service for an interval. When the decoder is released relays 3506, 3511, 3513, 3514 and 3515 release but will be slow enough in doing so to prevent the reselection of this decoder by the sender. When relay 1140 operates following the disconnection of the decoder the start circuit is extended over the lower front contact of relay 1141, inner lower front contact of relay 1140 to battery as previously traced. This causes the reselection of a decoder which takes place in the manner previously described, except that a circuit is closed from ground through the left winding of relay 3430 over conductor 3440 through the decoder connector, conductor 2730, outer lower front contact of relay 1140, outer upper front contact of relay 1206, conductor 2206, to battery over cam 2205, operating relay 3430 at once and eliminating the check of the conductors connecting the code registers with the incoming registers of the decoder as described for a first trial. If the decoder does not operate correctly on the second trial the ground connected to conductor 2830 shunts relay 1141, again opening the start circuit. Since relay 1140 is locked independently, the start conductor is held open and no additional attempt is made to complete the call. These circuit features of the decoder form the subject matter of an application in the name of W. W. Carpenter, Serial No. 423,313, filed January 25, 1930. If the decoder is not released promptly the

operation of relay 3517 causes an alarm to be sounded.

If it is desired to make a peg count of the use of the decoder, key 3530 is operated supplying ground to the left armature of relay 3500. Ten successive operations of relay 3500 causes a cycle of operations of relays 3521 to 3528. Relay 3528 which is the last to operate grounds conductor 3529 to operate a meter.

10 What is claimed is:

1. In a telephone system, an automatic switch, a register sender, means for recording the designation of a called office and the number of a called subscriber at that office, means in said sender for controlling said automatic switch to extend a connection to a wanted office and means to transmit the number of the called subscriber to said office by directive pulses, code pulses of varying strength and polarity or voice currents in accordance with the nature of the office to which the call has been extended.

2. In a telephone system, a first office, a second office employing operators, a third office employing step-by-step switches, a plurality of registers in said first office, means to record wanted subscribers numbers on said registers, means to extend connections to said second and third offices, means to generate voice currents representing the elements of called numbers, means to generate directive pulses, means for connecting said voice current generating means or said pulse generating means to an extended connection in accordance with the office to which said connection has been extended and means common to said two generating means for bringing either of said generating means under the successive control of said registers.

3. In a telephone system, a first office, a second office employing operators, a third office employing step-by-step switches, a plurality of registers in said first office, means to record wanted subscribers numbers on said registers, means to extend connections to said second and third offices, means to generate voice currents representing the elements of called numbers, means to generate directive pulses, means for connecting said voice current generating means or said pulse generating means to an extended connection in accordance with the office to which said connection has been extended, means common to said two generating means for bringing either of said generating means under the successive control of said registers, and separate means for determining the numerical value of the currents or pulses to be transmitted.

4. In a telephone system, a first office, a second office employing operators, a third office employing step-by-step switches, a plurality of registers in said first office, means to record wanted subscribers numbers on said registers, means to extend connections to said second and third offices, means to generate

voice currents representing the elements of called numbers, means to generate directive pulses, means for connecting said voice current generating means or said pulse generating means to an extended connection in accordance with the office to which said connection has been extended, means common to said two generating means for bringing either of said generating means under the successive control of said registers, separate means for determining the numerical value of the currents or pulses to be transmitted, and means common to said two generating means operated under the control of the registers for operating said separate determining means.

5. In a telephone system, a first office, a second office employing operators, a third office employing step-by-step switches, a plurality of registers in said first office, means to record wanted subscribers numbers on said registers, means to extend connections to said second and third offices, means to generate voice currents representing the elements of called numbers, means to generate directive pulses, means for connecting said voice current generating means or said pulse generating means to an extended connection in accordance with the office to which said connection has been extended, and a relay sequence switch common to said generating means for bringing either of said generating means under the successive control of said registers for causing the sequential transmission of the digits of a number.

6. In a telephone system, a first office, a second office employing operators, a third office employing step-by-step switches, a plurality of registers in said first office, means to record wanted subscribers numbers on said registers, means to extend connections to said second and third offices, means to generate voice currents representing the elements of called numbers, means to generate directive pulses, means for connecting said voice current generating means or said pulse generating means to an extended connection in accordance with the office to which said connection has been extended, a relay sequence switch common to said two generating means for bringing either of said generating means under the successive control of said registers for causing the sequential transmission of the digits of a number, and means common to said generating means for varying the order of transmission of said digits.

7. In a telephone system, a first office, a second office employing operators, a third office employing step-by-step switches, a plurality of registers in said first office, means to record wanted subscribers numbers on said registers, means to extend connections to said second and third offices, means to generate voice currents representing the elements of called numbers, means to generate directive pulses, means for connecting said voice cur-

rent generating means or said pulse generating means to an extended connection in accordance with the office to which said connection has been extended, a relay sequence switch common to said two generating means for bringing either of said generating means under the successive control of said registers for causing the sequential transmission of the digits of a number, means under the joint control of said sequence switch and said voice current generating means to introduce a pause between certain digits and means under the joint control of said sequence switch and said pulse generating means to cancel said pause.

8. In a telephone exchange system, an automatic switch, means for recording the number of a wanted subscriber, means to generate pulses, means to associate said pulsing means with said automatic switch to operate said switching means under the control of said recording means, means for counting the number of impulses transmitted, means controlled by said counting means for disabling said pulsing means and means to reoperate said counting means to measure a time interval following the operation of said switch.

9. In a telephone exchange system, a plurality of automatic switches, means for recording the number of a wanted subscriber, means to generate pulses, means to associate said pulsing means with said automatic switches to operate said switches, means under the control of said recording means for counting the number of impulses transmitted, means controlled by said counting means for disabling said pulsing means and means to reoperate said counting means to measure a time interval following the operation of each of said switches.

10. In a telephone exchange system, an automatic switch, means for recording the number of a wanted subscriber, means to generate pulses, means to associate said pulsing means with said automatic switch to operate said switch, means under the control of said recording means for counting the number of impulses transmitted, means controlled by said counting means for disabling said pulsing means, and means to reoperate said counting means to a predetermined extent to measure a time interval following the operation of said switch.

11. In a telephone exchange system, an automatic switch, means for recording the number of a wanted subscriber, means to generate pulses, means to associate said pulsing means with said automatic switch, a plurality of counting relays, means to operate said plurality of counting relays under the control of said recording means for counting the number of impulses transmitted, means controlled by said counting relays for disabling said pulsing means, and means to reoperate a predetermined number of said

counting relays to measure a time interval following the operation of said switch.

12. In a telephone system, a first office, a plurality of other offices, means at said first office to register the digits of a wanted subscriber's number including an office designation and a numerical designation, means for generating directive pulses, means at said first office operated under the control of said office designation to extend a connection to any one of said other offices, means thereupon effective to operate said pulse generating means to transmit a plurality of said recorded digits to said other office to control the completion of the connection and means also under the control of said registered office designation to determine how many of said digits shall be transmitted to said other office.

13. In a telephone exchange system, a first office, a plurality of other offices, means at said first office to register the digits of a wanted subscriber's number including an office designation and a numerical designation, means for generating directive pulses, means at said first office operated under the control of said office designation to extend a connection to any one of said other offices, means thereupon effective to operate said pulse generating means to transmit a plurality of said recorded digits to said other office to control the completion of the connection, and means also under the control of said registered office designation to determine whether the digits of said recorded office designation shall be transmitted to said other office.

14. In a telephone exchange system, a first office, a plurality of other offices, means at said first office to register the digits of a wanted subscriber's number including an office designation and a numerical designation, means at said first office operated under the control of said office designation to extend a connection to any one of said other offices, means thereupon effective to transmit a plurality of said recorded digits to said other office to control the completion of the connection and means also under the control of said registered office designation to determine how many digits of said recorded office designation shall be transmitted to said other office.

15. In a telephone exchange system, a first office, a plurality of other offices, means at said first office to register the number of a wanted subscriber including an office designation and a numerical designation, means at said first office operated under the control of said office designation to extend a connection to any one of said other offices, means thereupon effective to transmit a plurality of said recorded digits to said other office to control the completion of the connection, means also under the control of said registered office designation to determine how many digits of the office designation shall be transmitted to

said other office, and means under the control of a particular part of said office designation to prevent the transmission of any digits of said office designation.

5 16. In a telephone exchange system, a first office, other offices, automatic switches at said other offices, a plurality of registers at said first office, means to operate said registers to record the digits of a called subscriber's office
10 designation and numerical designation, means under the control of said office designation to control the extension of a connection to one of said other offices, pulse generating means, means to associate said pulse
15 generating means with said extended connection to transmit sets of pulses to control the automatic switches at said other office, means to successively associate said generating means and said registers to control the number
20 of pulses in each set to be transmitted to said other office, and means also under the control of said registered office designation for determining which registers shall be associated with said generating means.

25 17. In a telephone exchange system, a first office, other offices, automatic switches at said other offices, a plurality of registers at said first office, means to operate said registers to record the digits of a called subscriber's office designation and numerical designation,
30 means under the control of said office designation to control the extension of a connection to one of said other offices, pulse generating means, means to associate said pulse generating means with said extended connection to transmit sets of pulses to control the
35 automatic switches at said other office, a chain of relays to successively associate said generating means and said registers to control the number of pulses in each set to be transmitted, and means also under the control of said registered office designation for determining which of said chain of relays
40 shall be initially energized to control the number of sets of impulses to be transmitted.
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18. In a telephone exchange system, a first office, other offices, automatic switches at said other offices, a plurality of registers at said
50 first office, means to operate said registers to record the digits of a called subscriber's office designation and numerical designation, means under the control of said office designation to control the extension of a connection to one of said offices, pulse generating
55 means, means to associate said pulse generating means with said extended connection to transmit sets of pulses to control the automatic switches at said other office, a chain of relays to successively associate said pulse
60 generating means and said registers to control the number of pulses in each set to be transmitted, means also under the control of said registered office designation for determining which of said chain of relays shall be
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initially energized to control the number of sets of impulses to be transmitted, and means under the control of a particular one of said registers for canceling the corresponding set of impulses.

19. In a telephone system, a first office, a second office, a register sender for said first office, means to record the designation of a wanted subscriber on said register sender, means under the control of said sender to extend a connection between said first office and
70 said second office, means in said sender to generate voice currents corresponding to the elements of telephonic designations, means responsive to the establishment of said connection to transmit to said second office the
75 voice currents corresponding to the recorded designation, means automatically responsive to the completion of said transmission to disassociate said generating means from said connection, and means controlled at said second office for disassociating said generating means from said connection.

In witness whereof, I hereunto subscribe my name this 29th day of September, 1930.

THOMAS H. ROBERTS.

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