Feb. 7, 1933. W. B. STRICKLER 1,896,757

TELEPHONE EXCHANGE SYSTEM

Filed Nov. 5, 1931 34 Sheets-Sheet 1

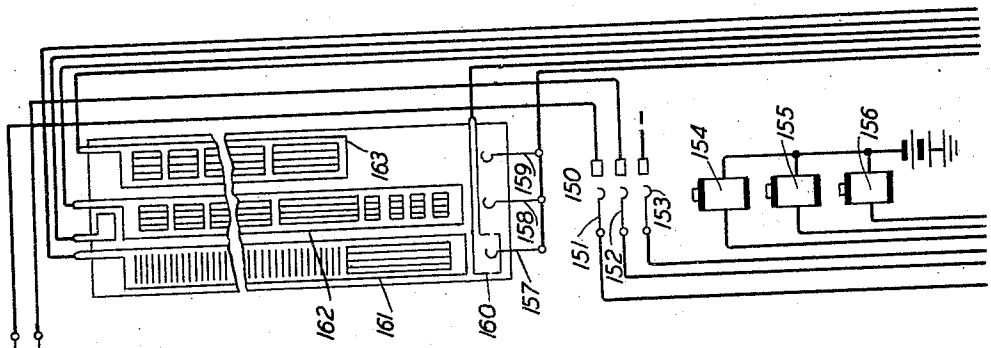


FIG. 1-A

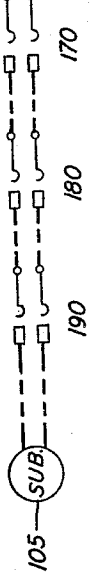
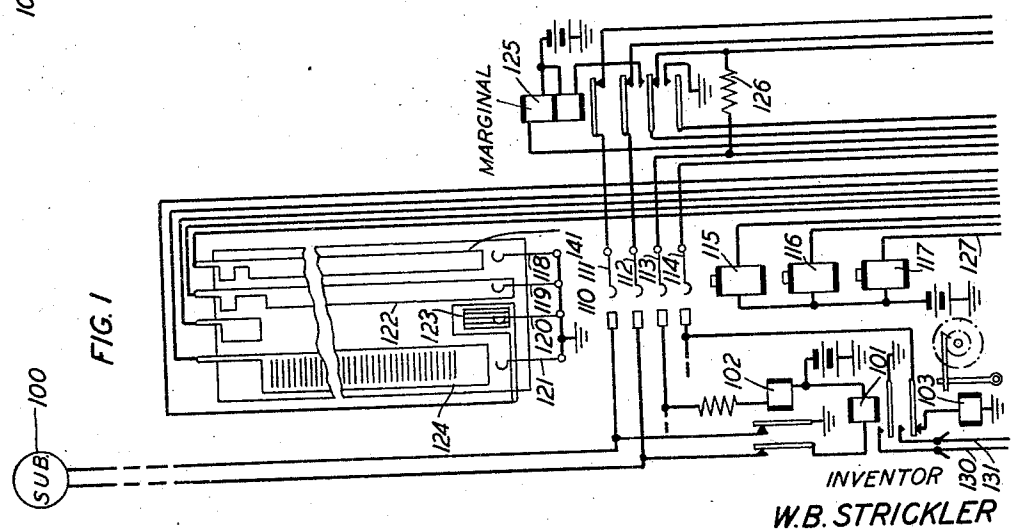


FIG. 35

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

FIG. 1



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TELEPHONE EXCHANGE SYSTEM

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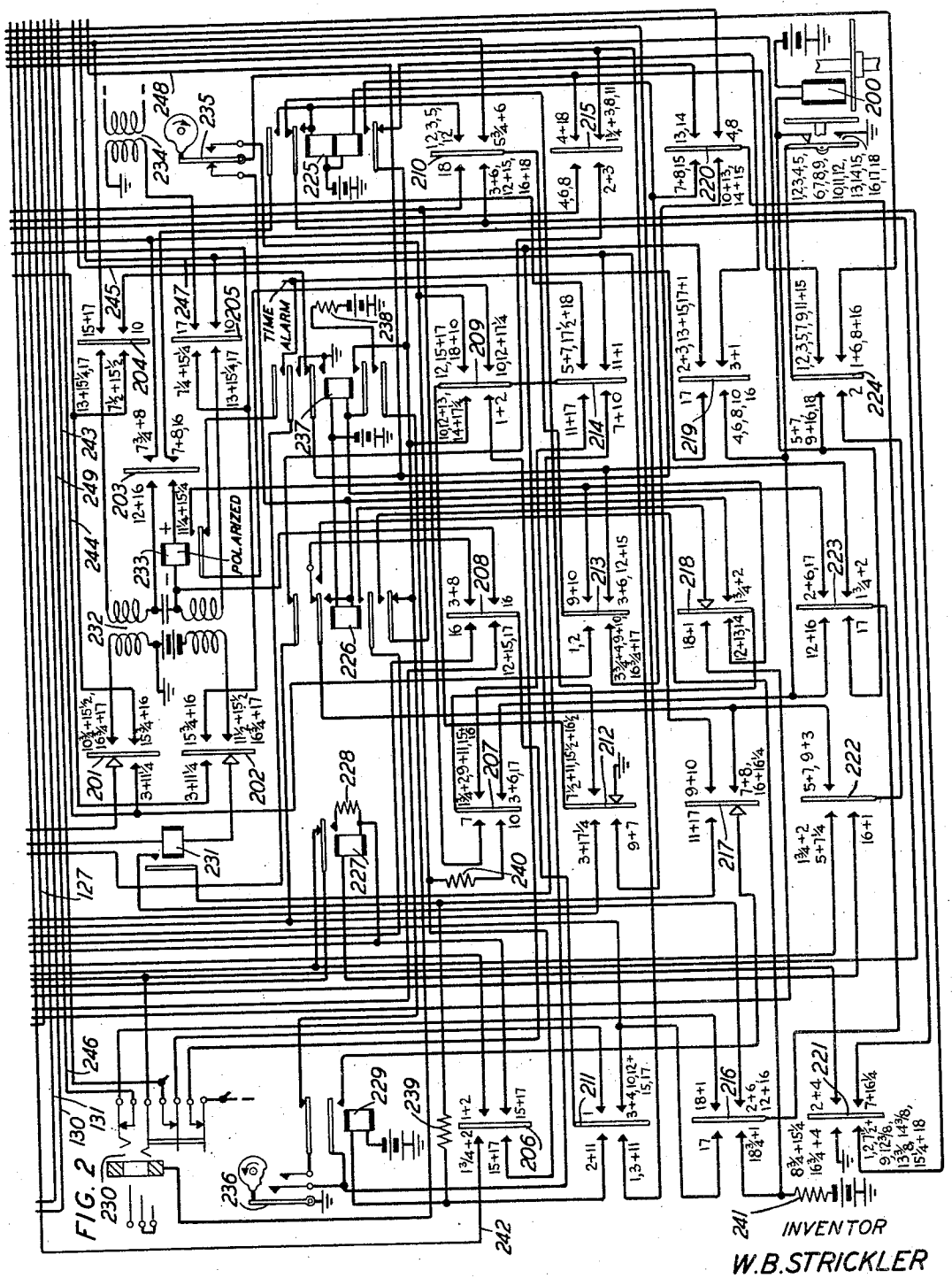

FIG. 2

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TELEPHONE EXCHANGE SYSTEM

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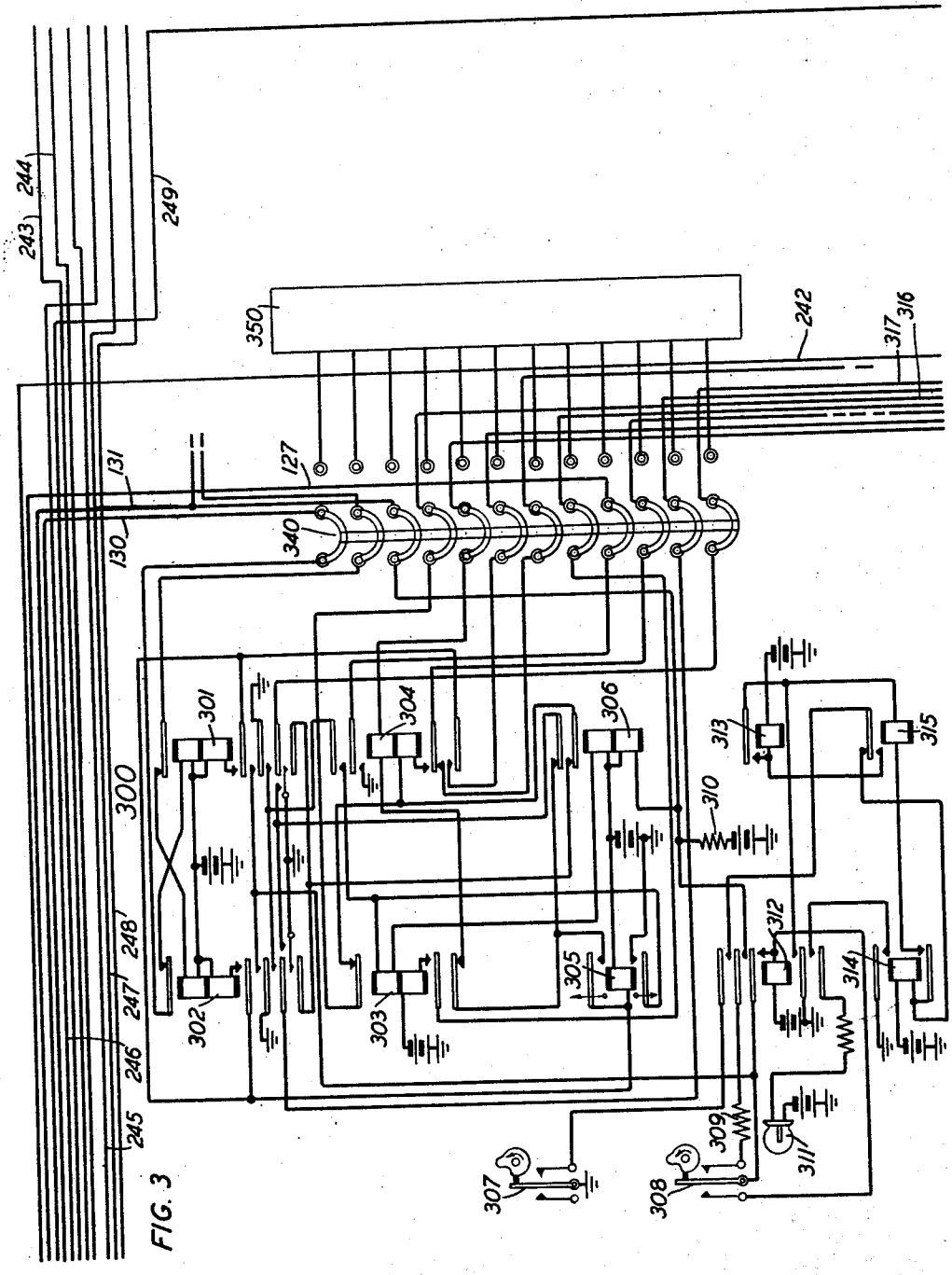

FIG. 3

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TELEPHONE EXCHANGE SYSTEM

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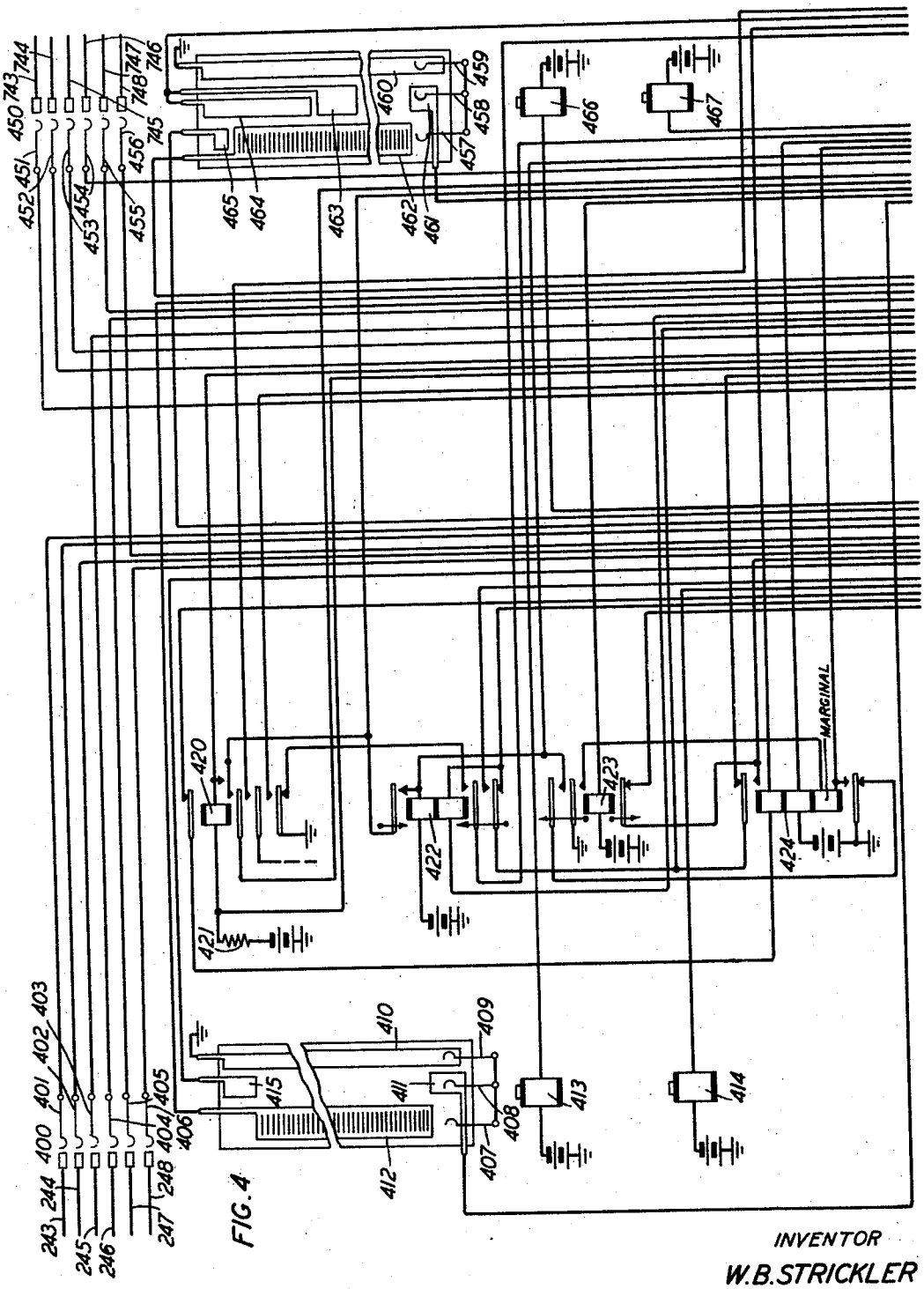

FIG. 4

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TELEPHONE EXCHANGE SYSTEM

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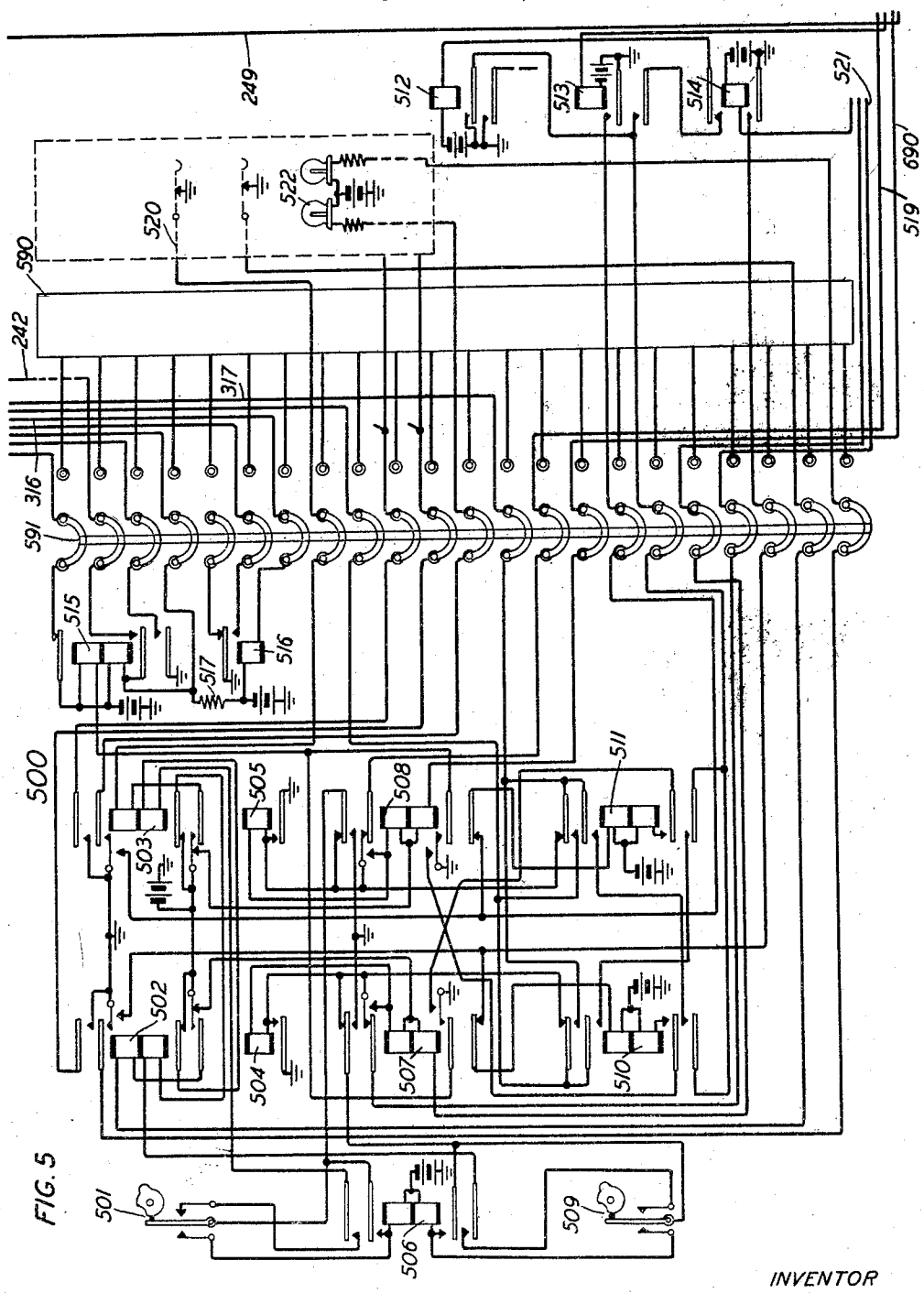

FIG. 5

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TELEPHONE EXCHANGE SYSTEM

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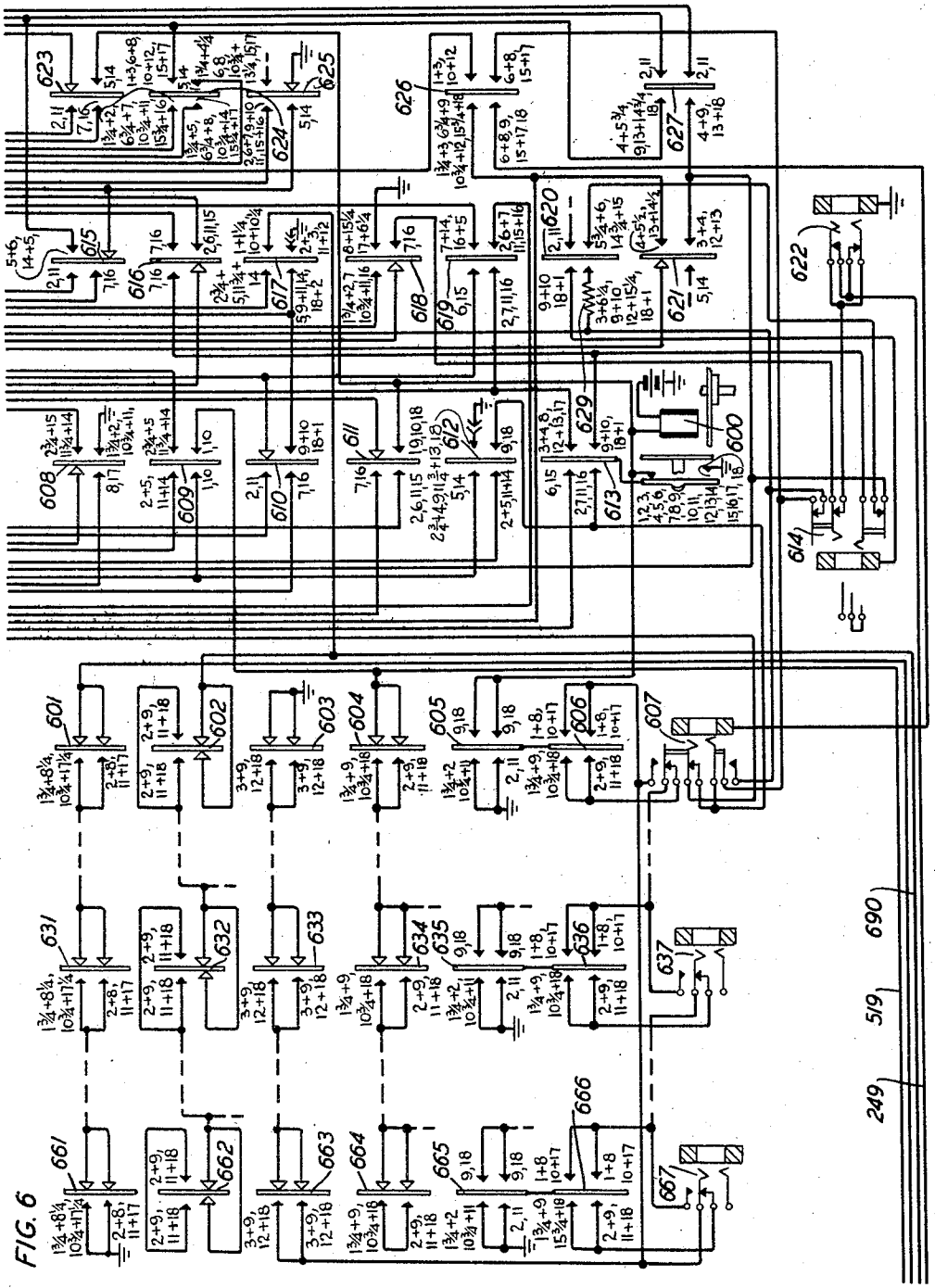

FIG. 6

INVENTOR
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TELEPHONE EXCHANGE SYSTEM

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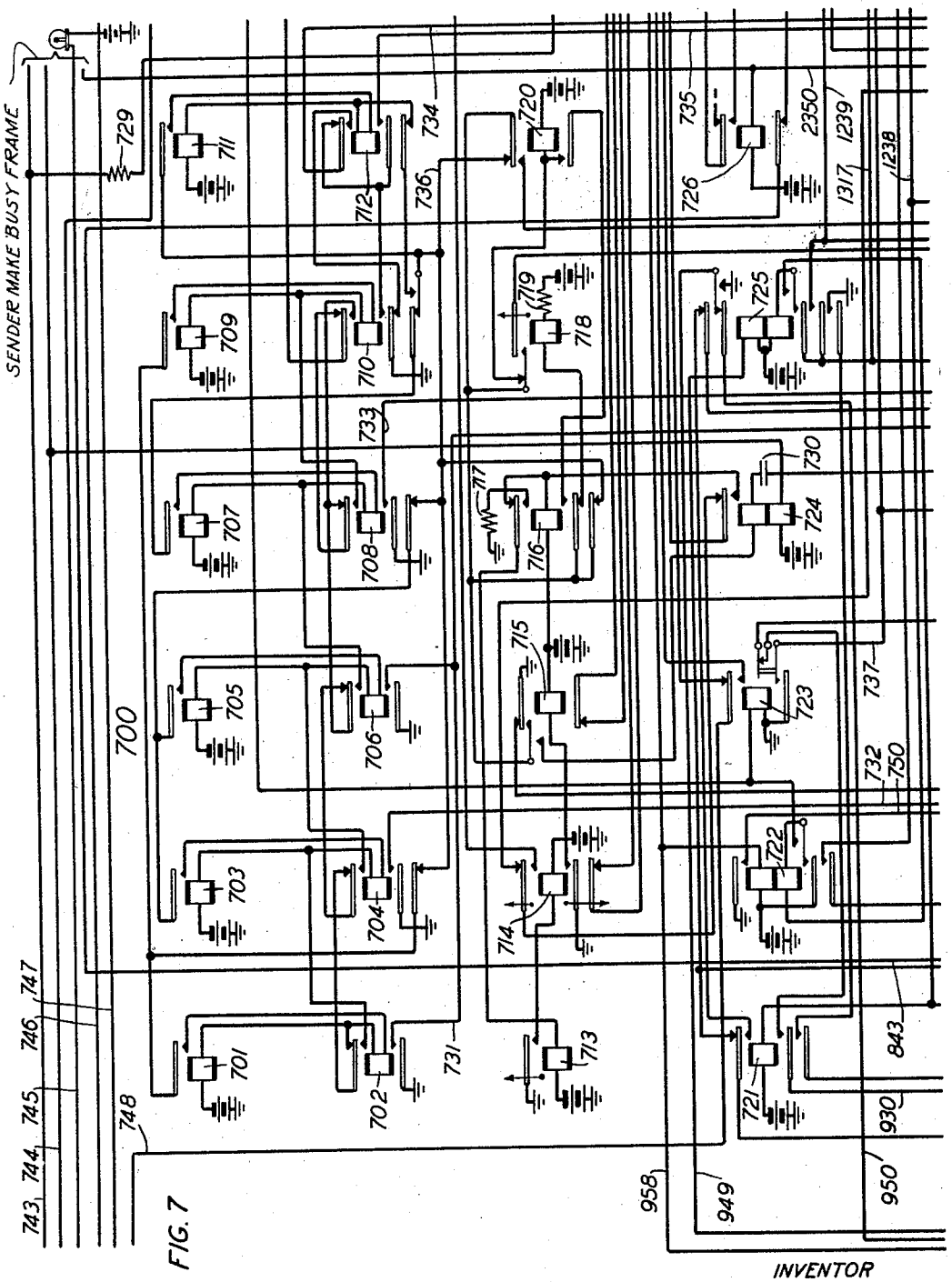

FIG. 7

INVENTOR
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TELEPHONE EXCHANGE SYSTEM

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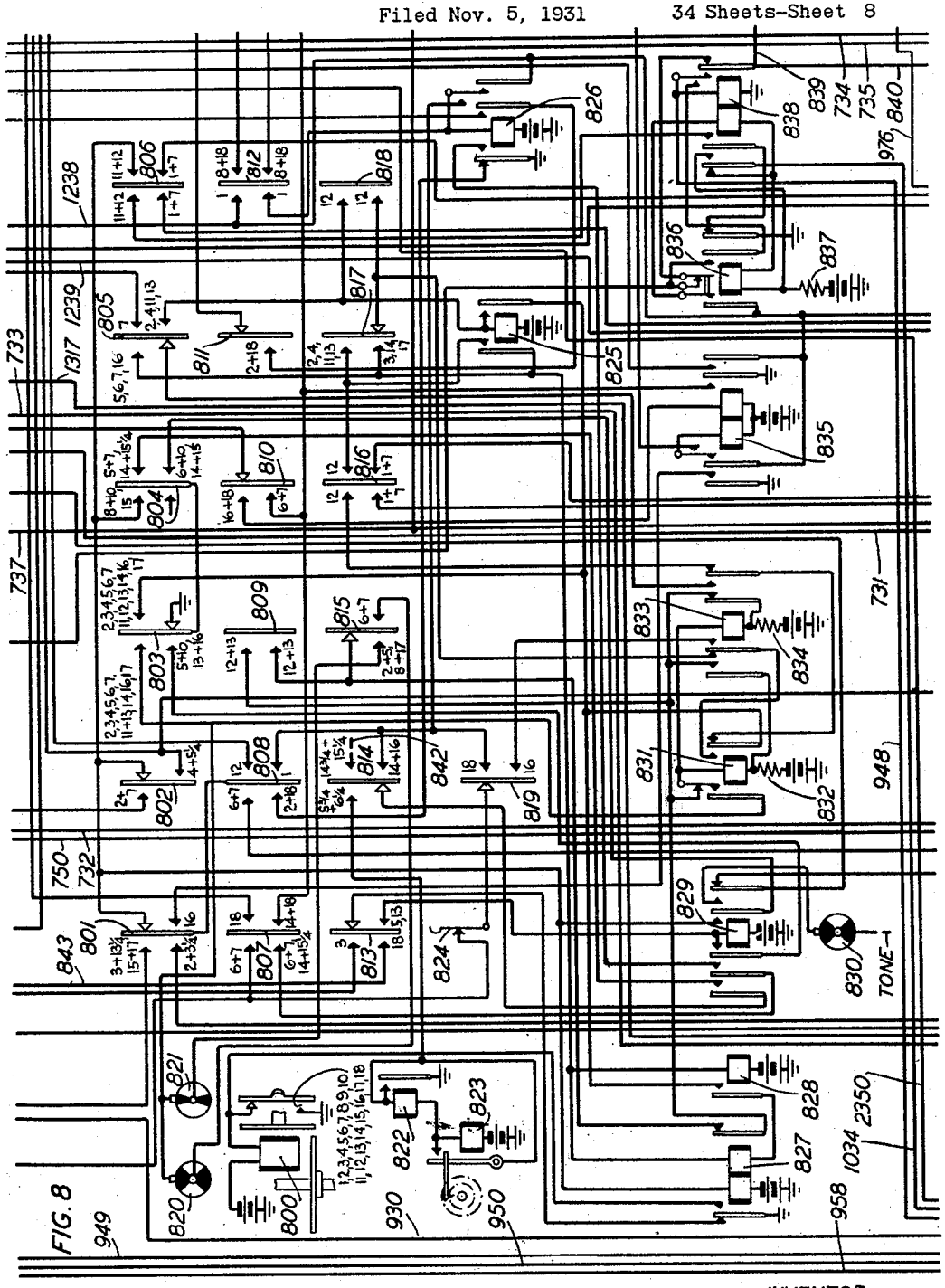

FIG. 8

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TELEPHONE EXCHANGE SYSTEM

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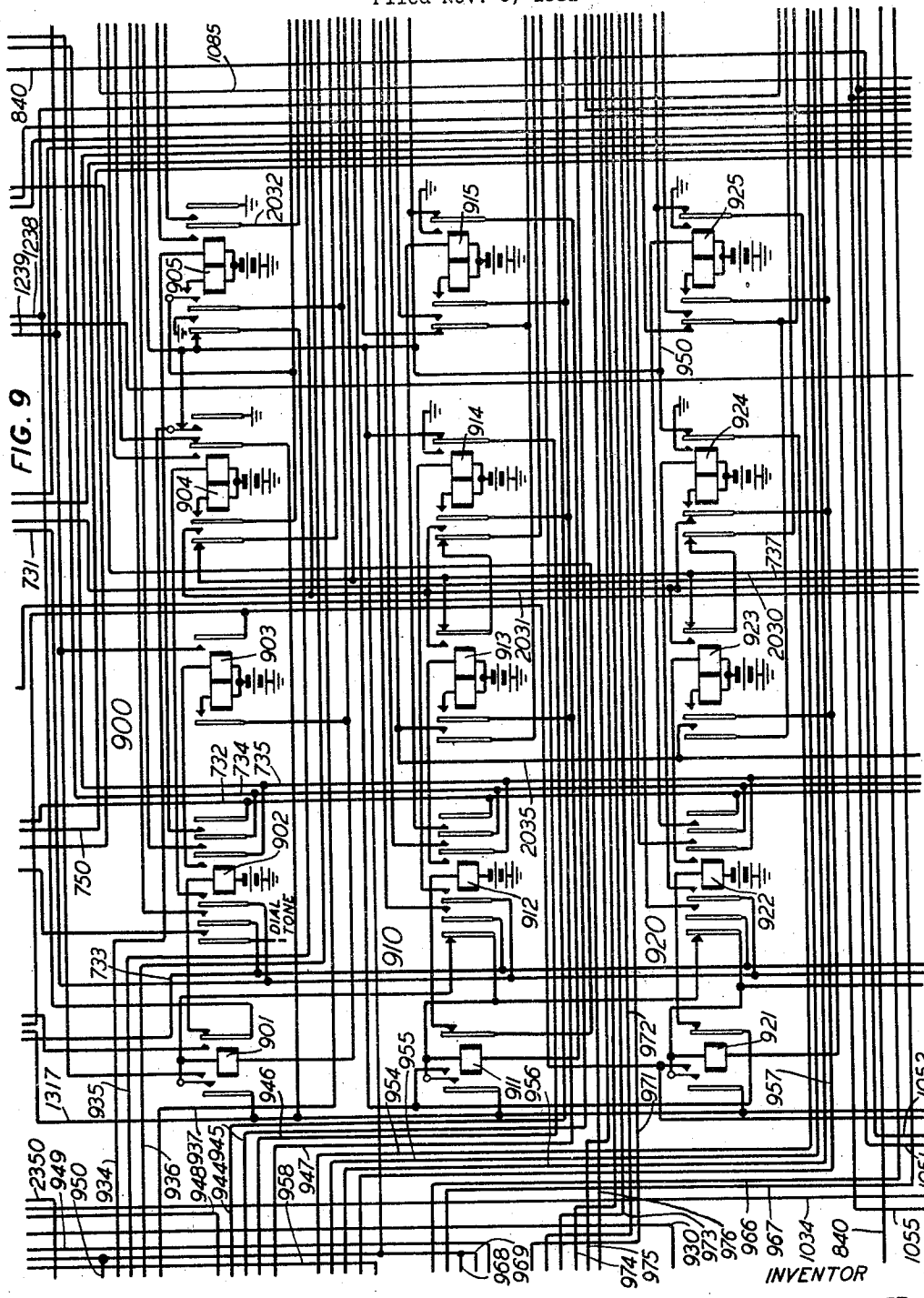

FIG. 9

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TELEPHONE EXCHANGE SYSTEM

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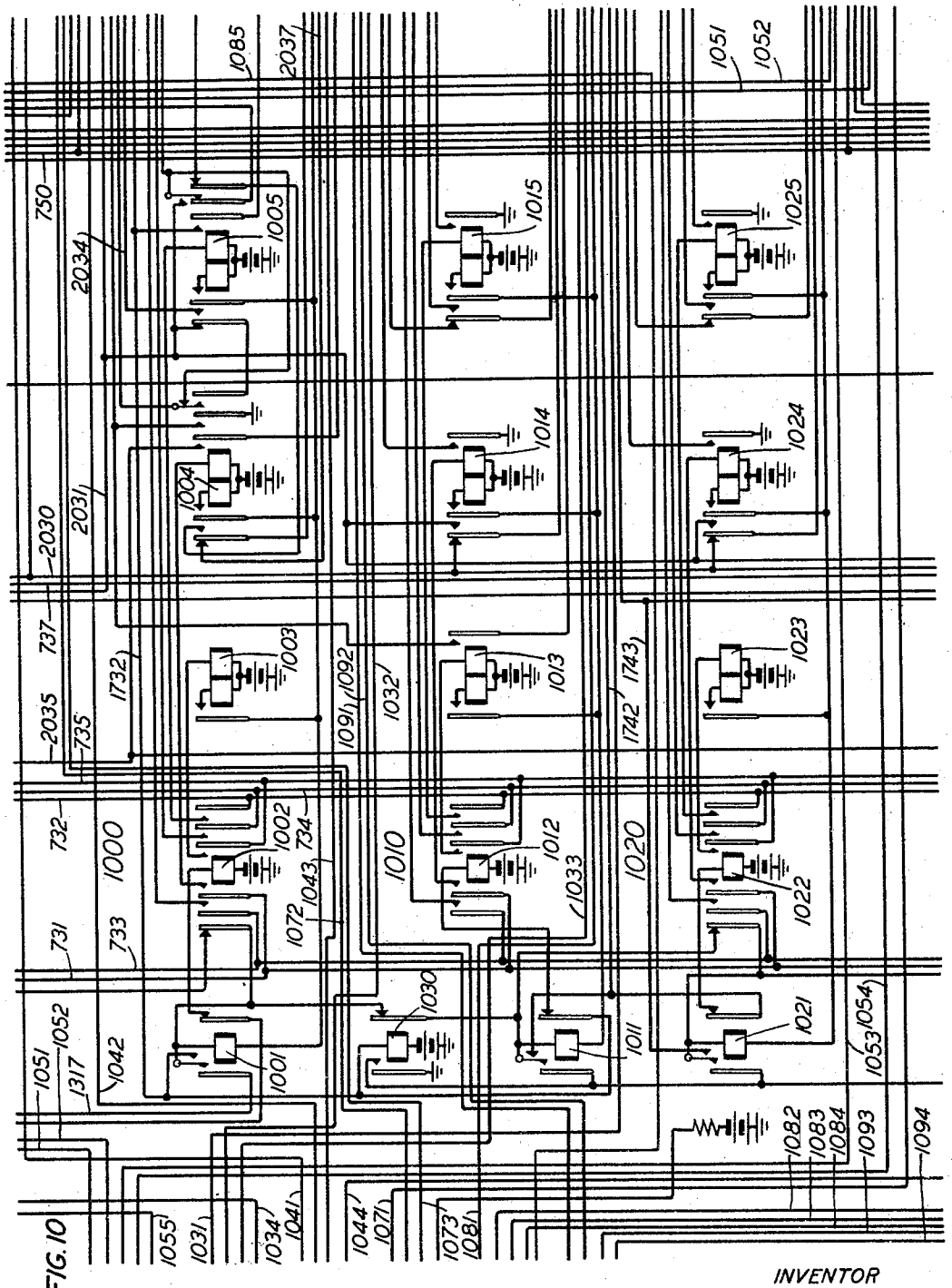

FIG. 10

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TELEPHONE EXCHANGE SYSTEM

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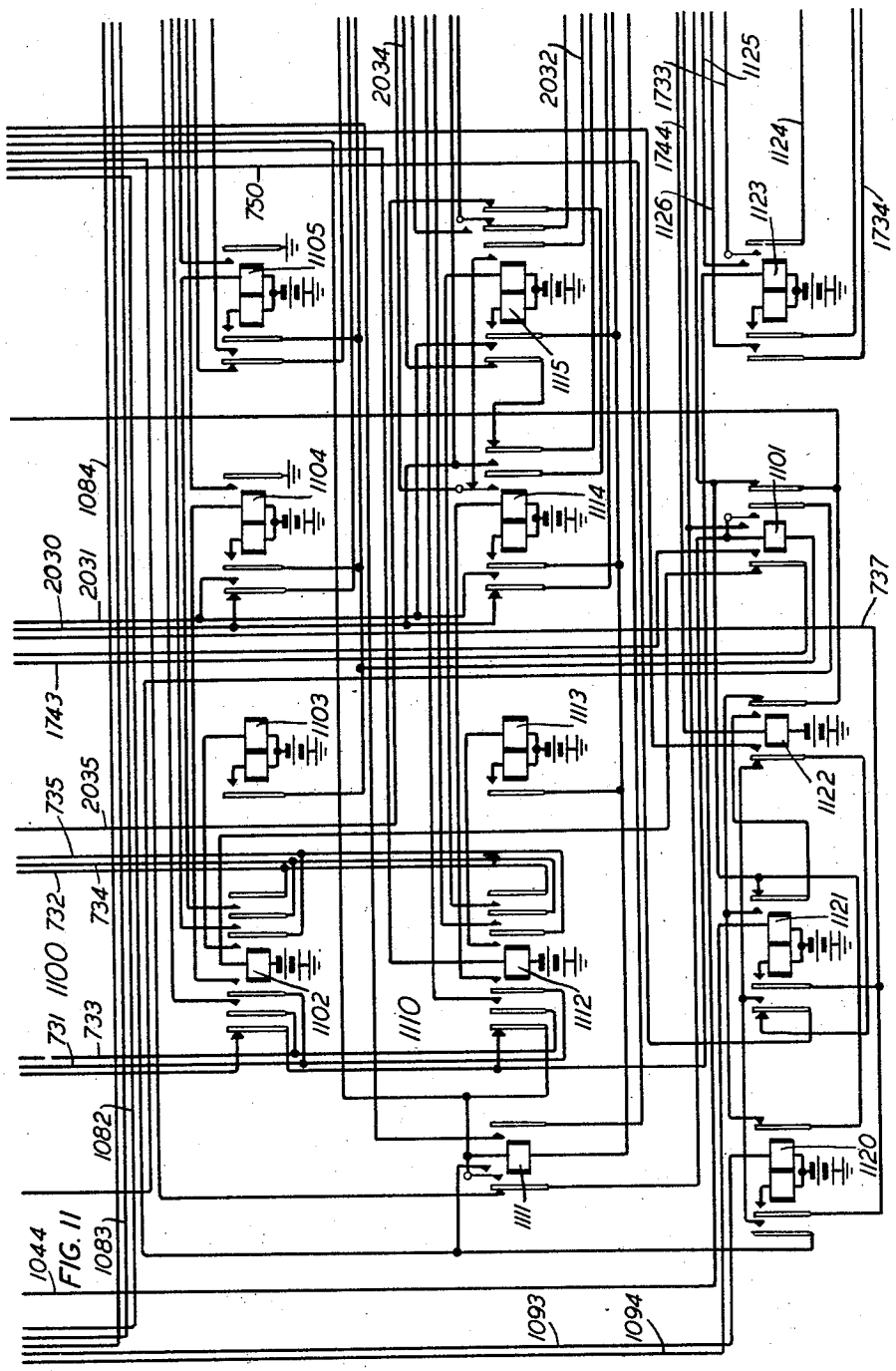

FIG. 11

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TELEPHONE EXCHANGE SYSTEM

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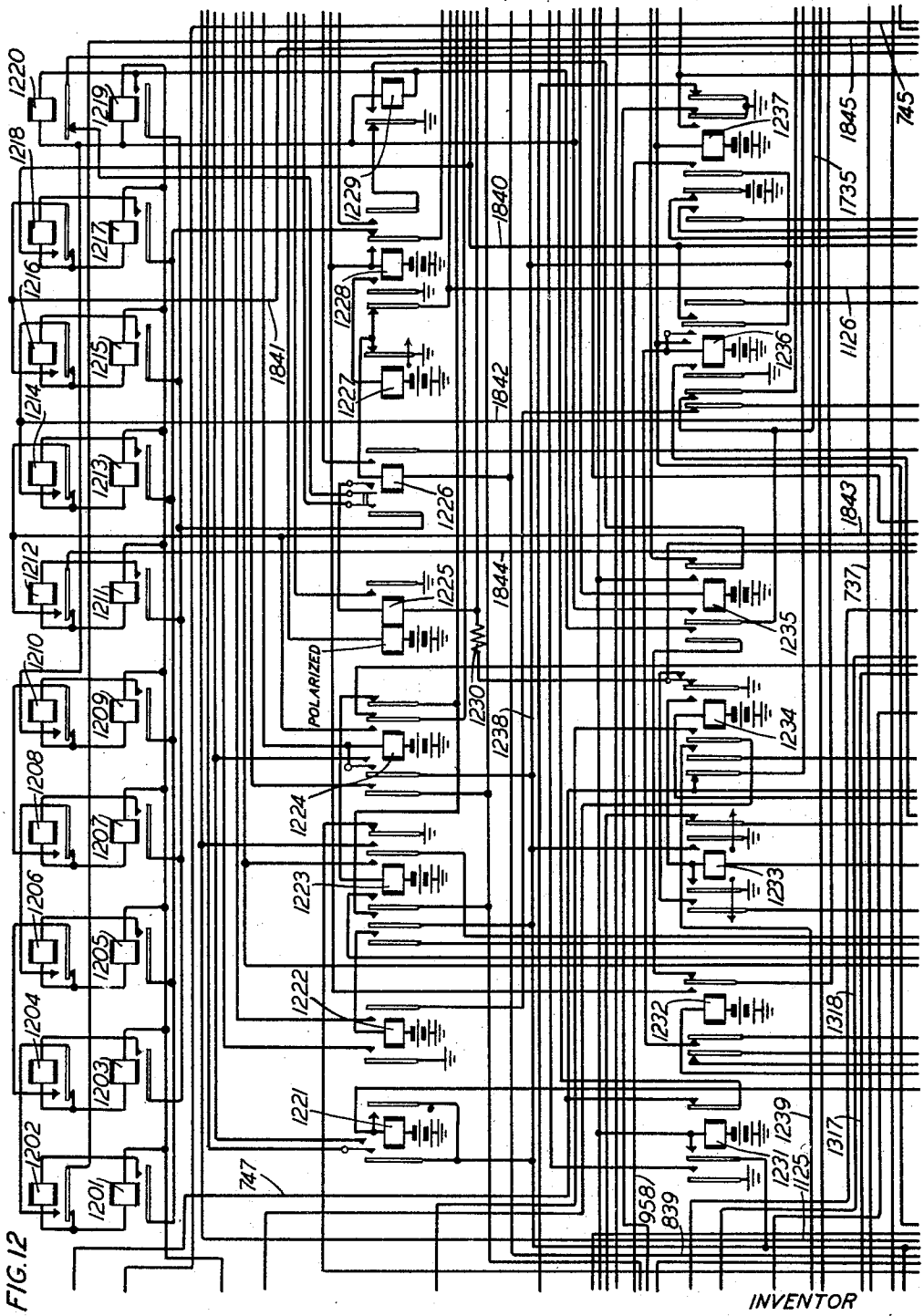

FIG. 12

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TELEPHONE EXCHANGE SYSTEM

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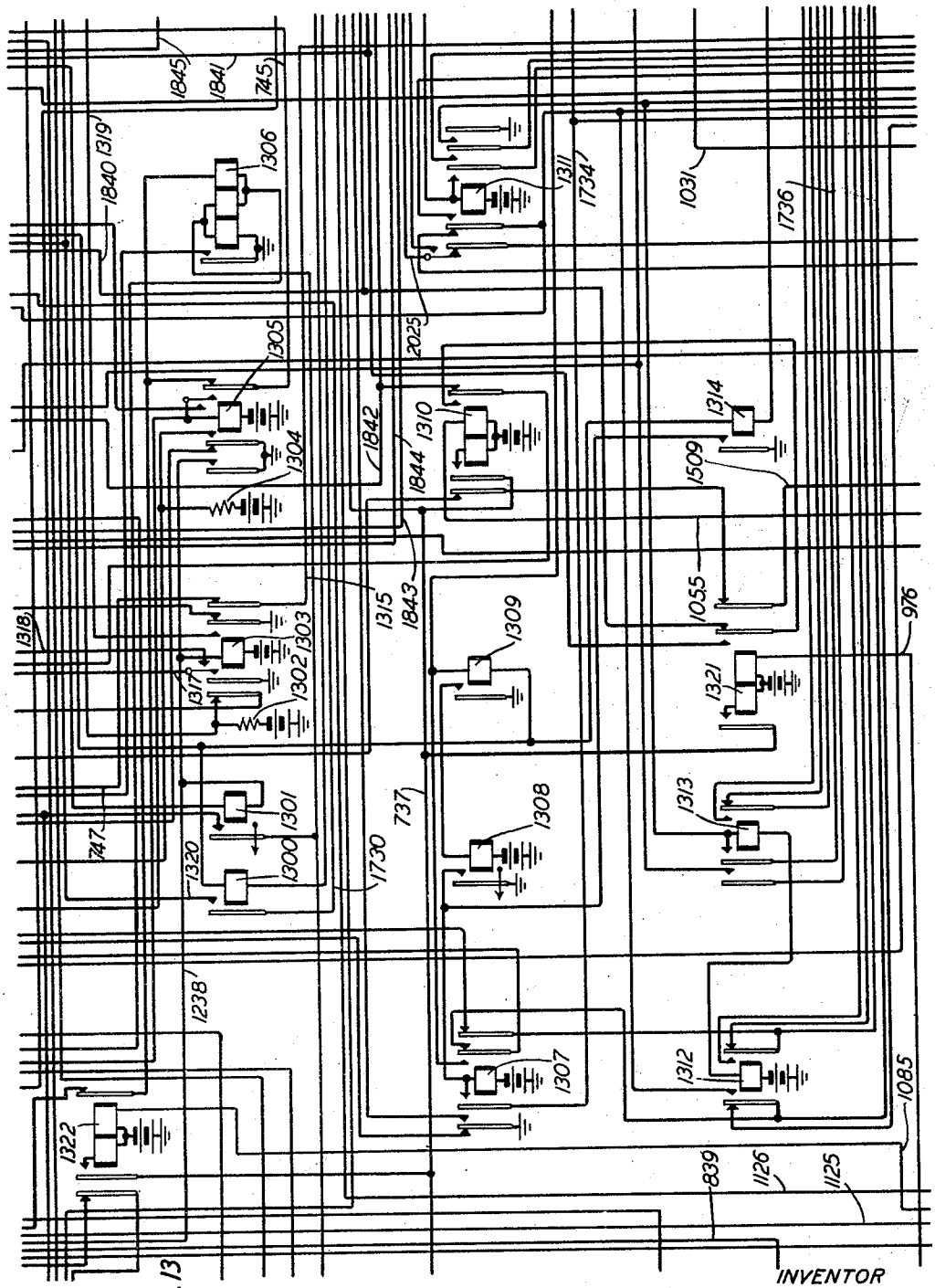

FIG. 13

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TELEPHONE EXCHANGE SYSTEM

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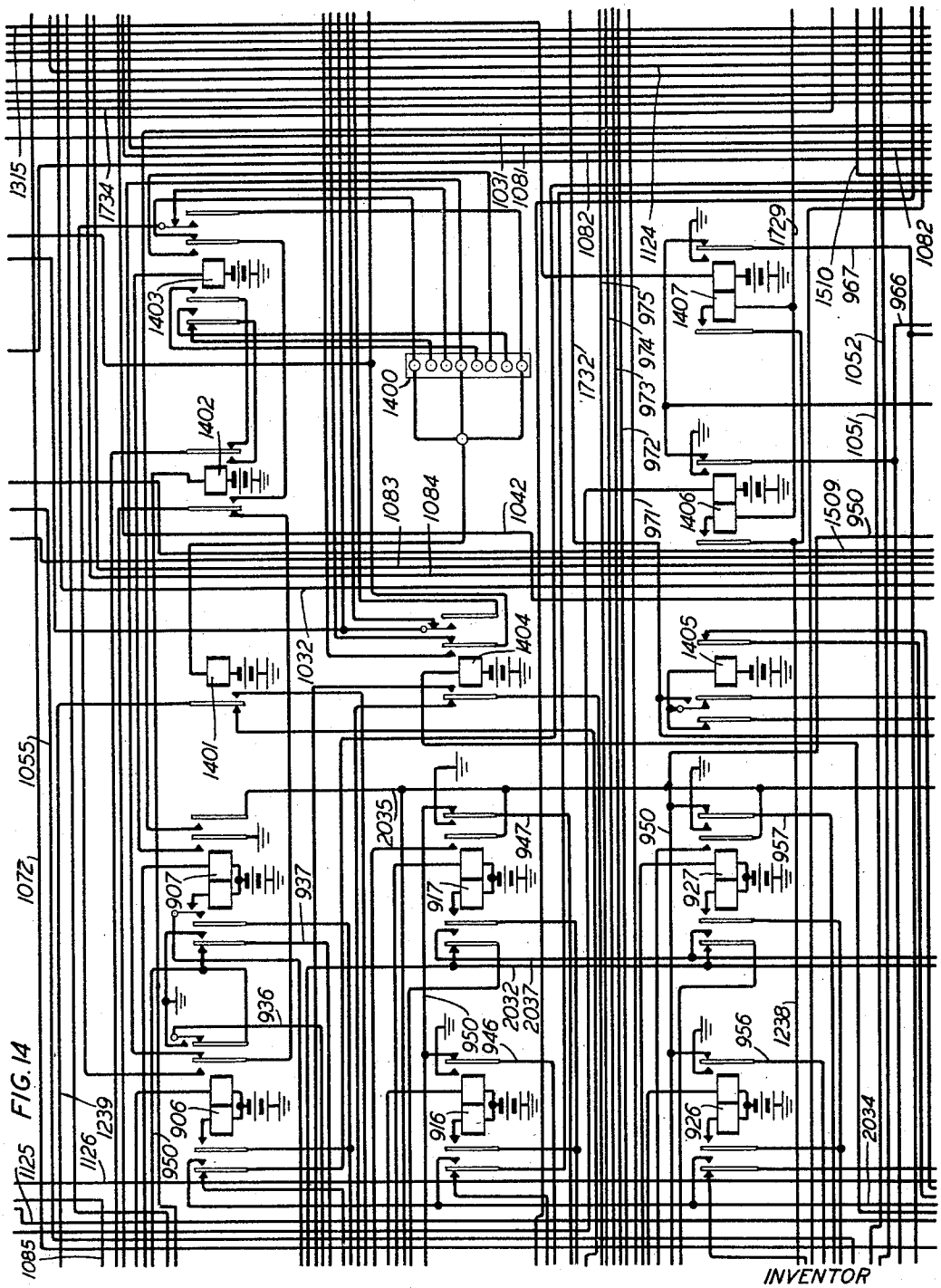

FIG. 14

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TELEPHONE EXCHANGE SYSTEM

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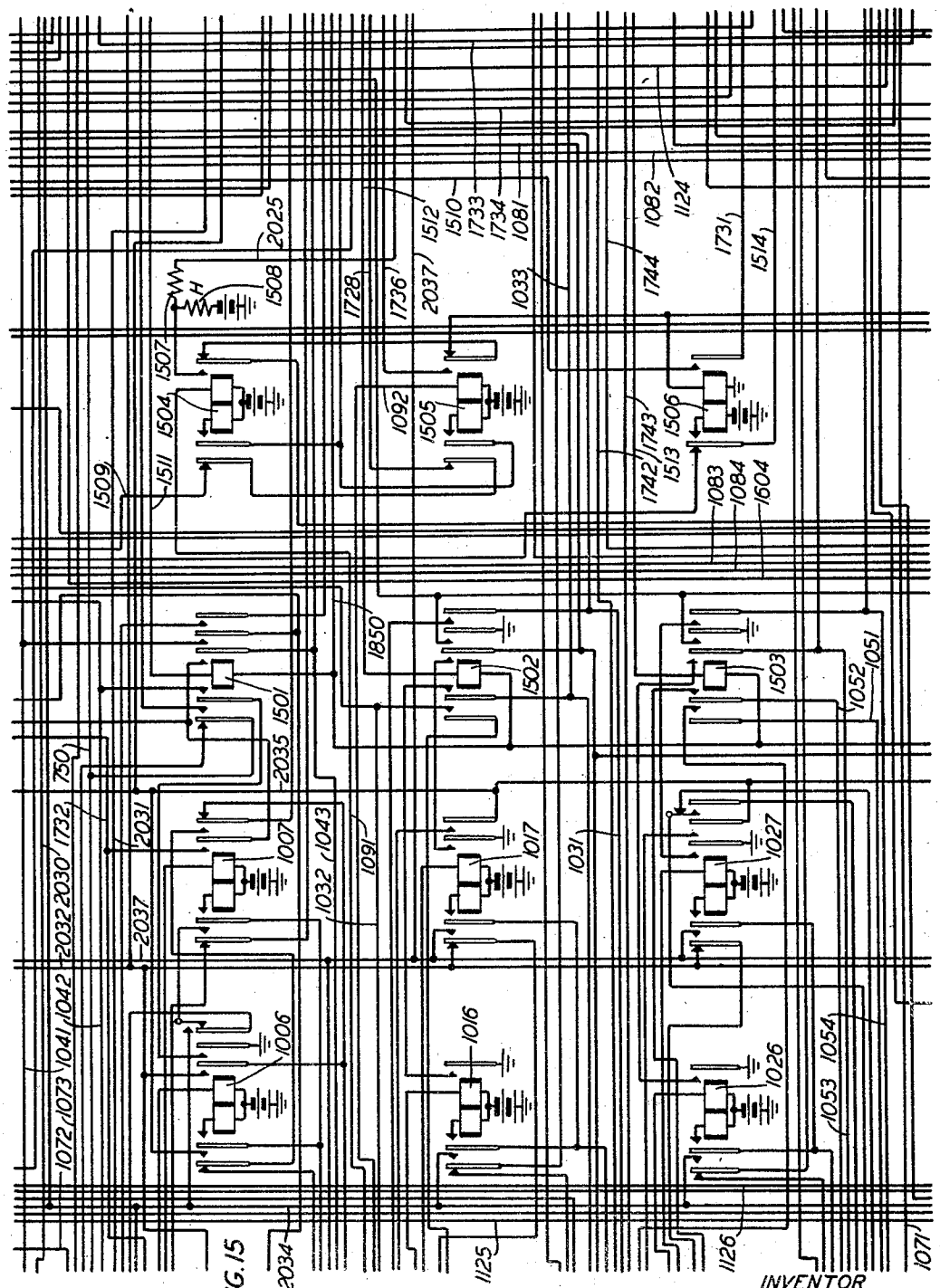

FIG. 15

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TELEPHONE EXCHANGE SYSTEM

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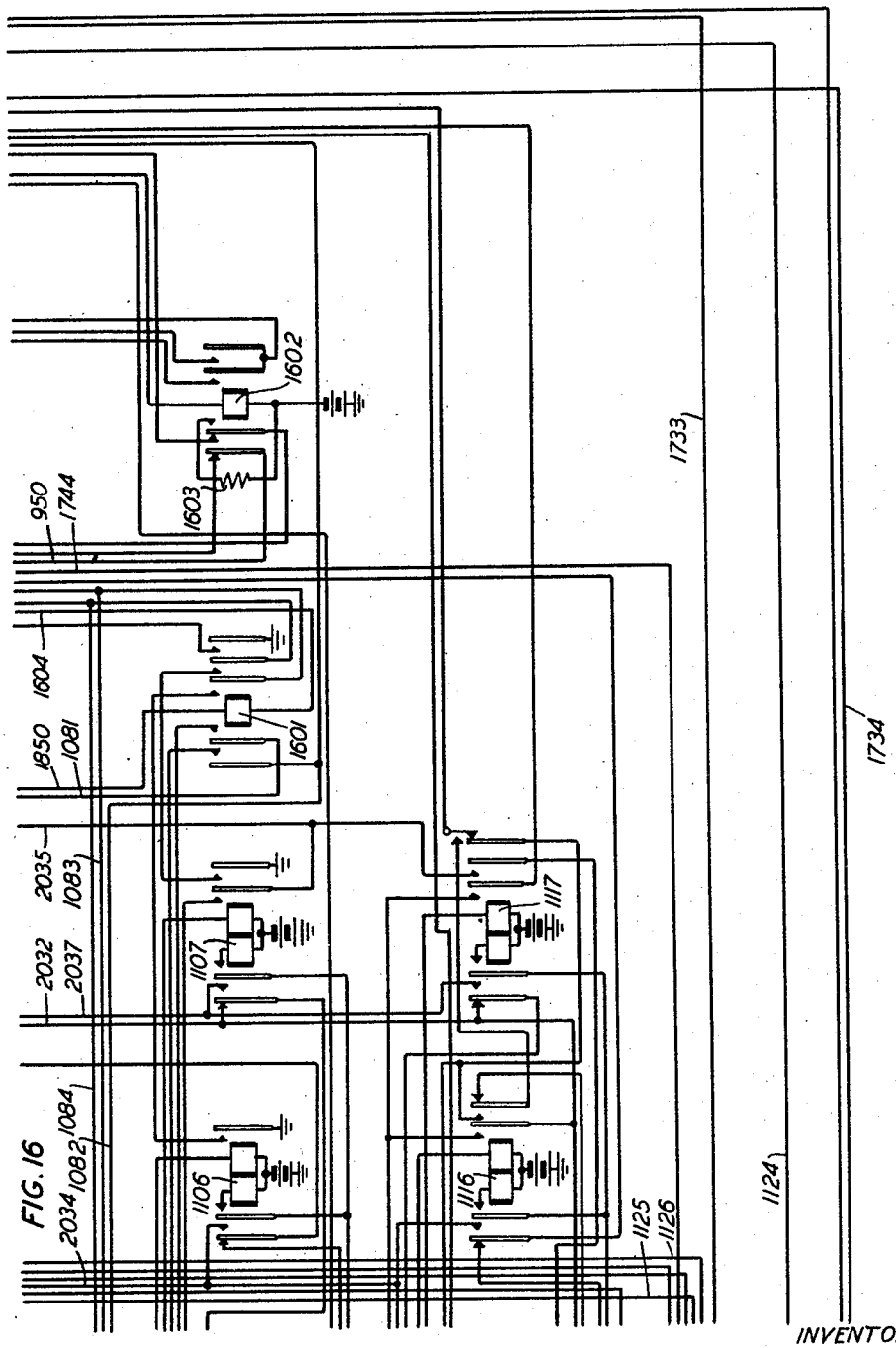

FIG. 16

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TELEPHONE EXCHANGE SYSTEM

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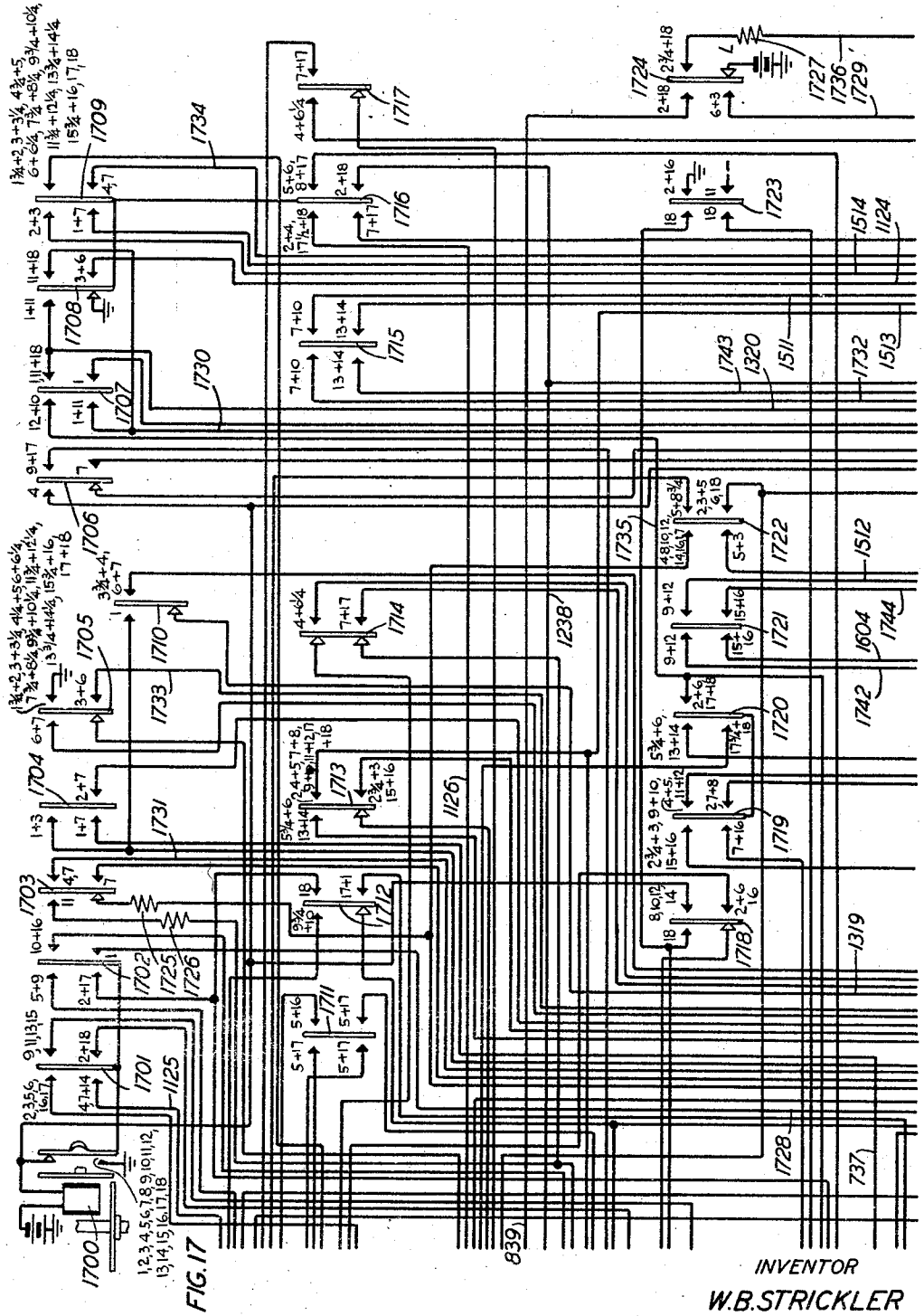

FIG. 17

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TELEPHONE EXCHANGE SYSTEM

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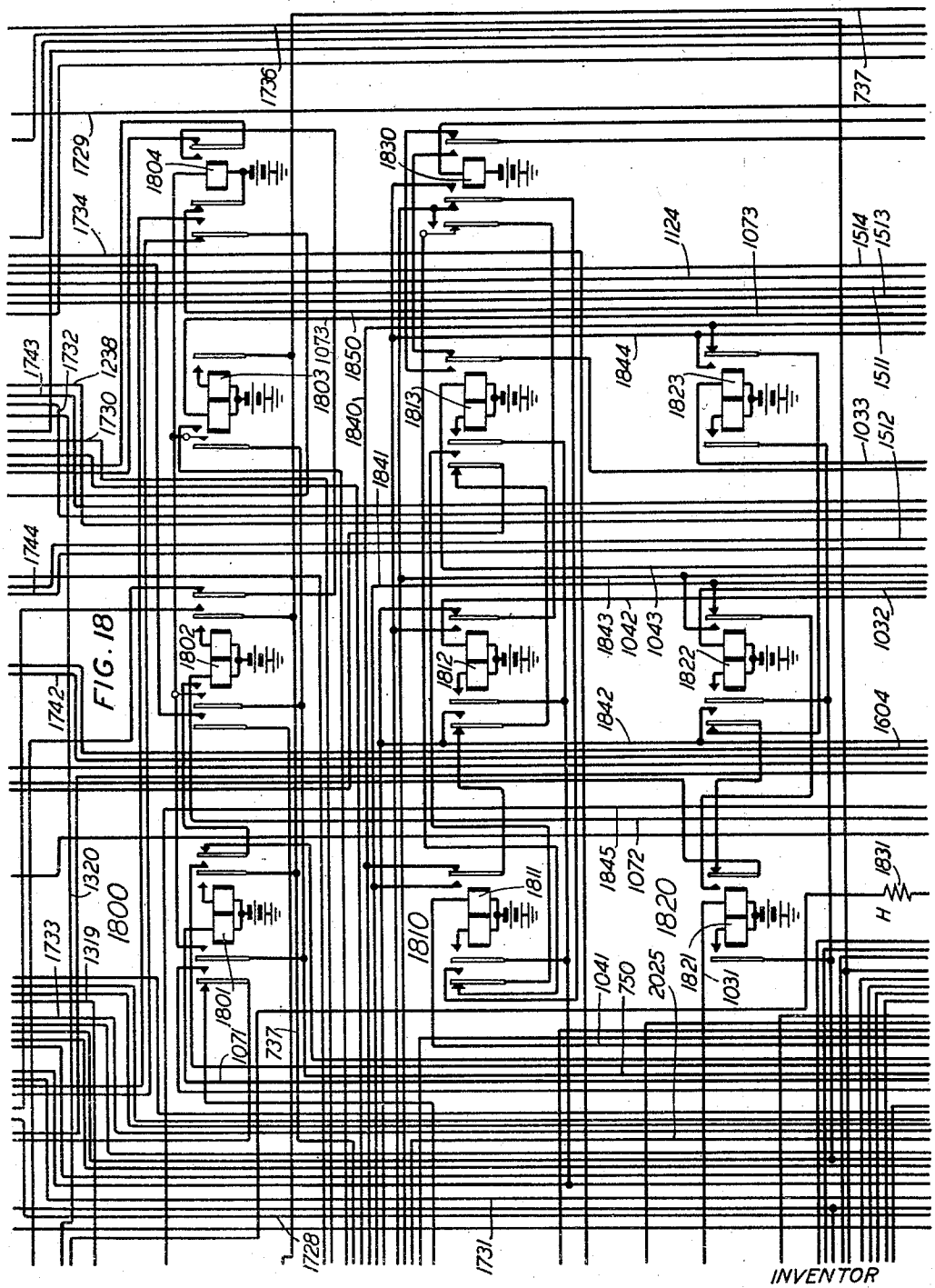

FIG. 18

INVENTOR
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TELEPHONE EXCHANGE SYSTEM

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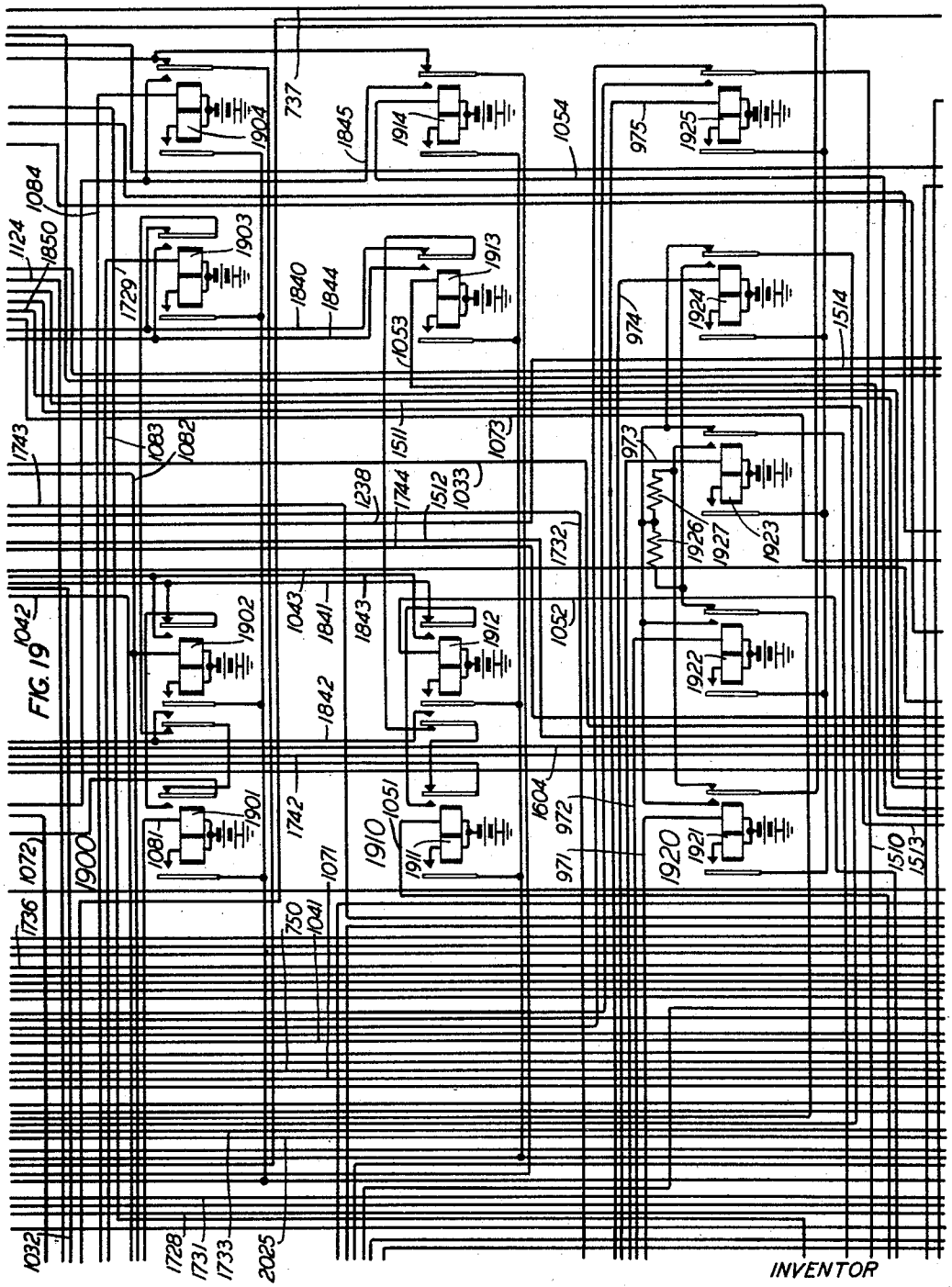

FIG. 19

INVENTOR
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TELEPHONE EXCHANGE SYSTEM

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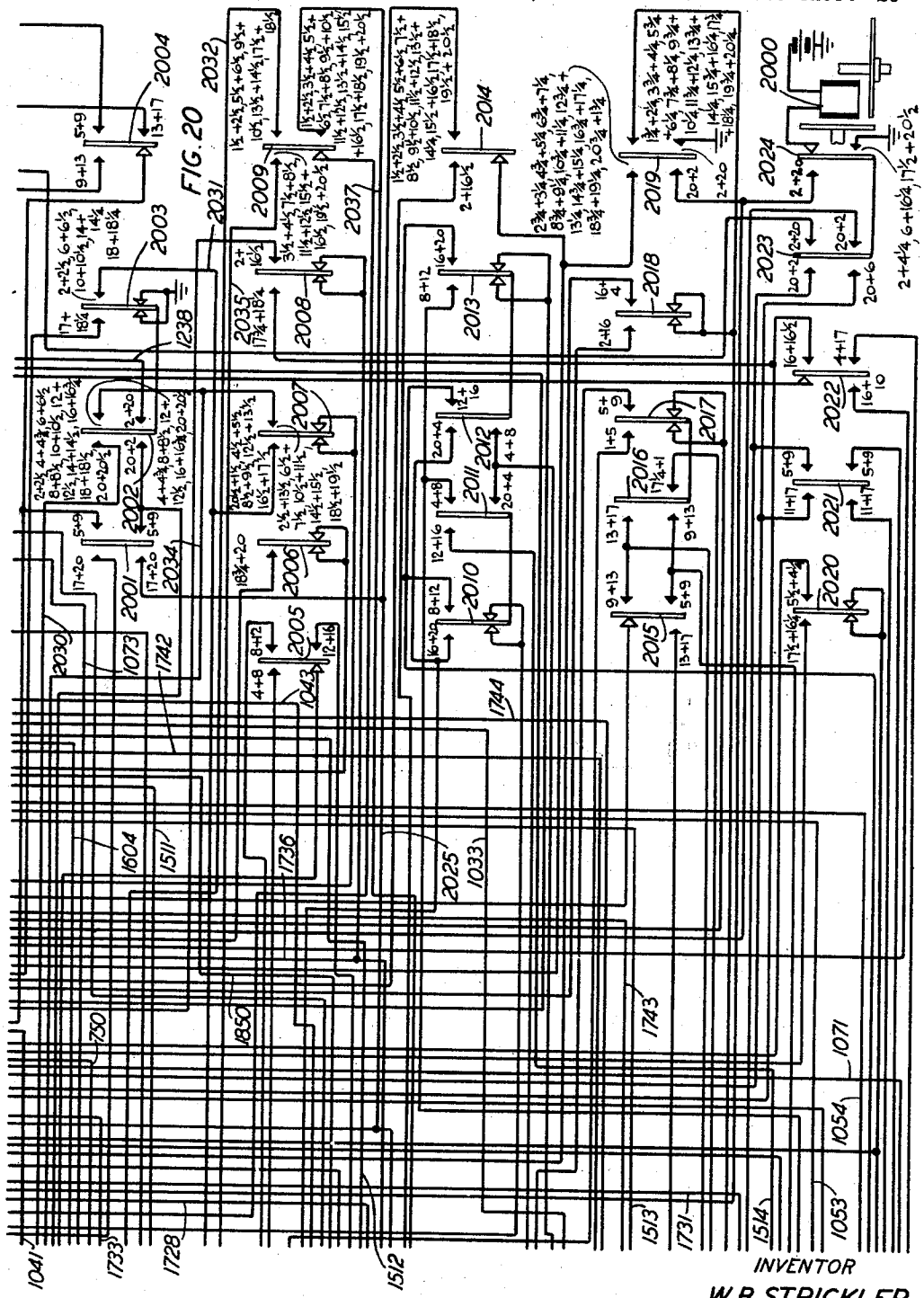

INVENTOR
W. B. STRICKLER
BY P. C. Smith
ATTORNEY

Feb 7, 1933. W. B. STRICKLER 1,896,757

TELEPHONE EXCHANGE SYSTEM

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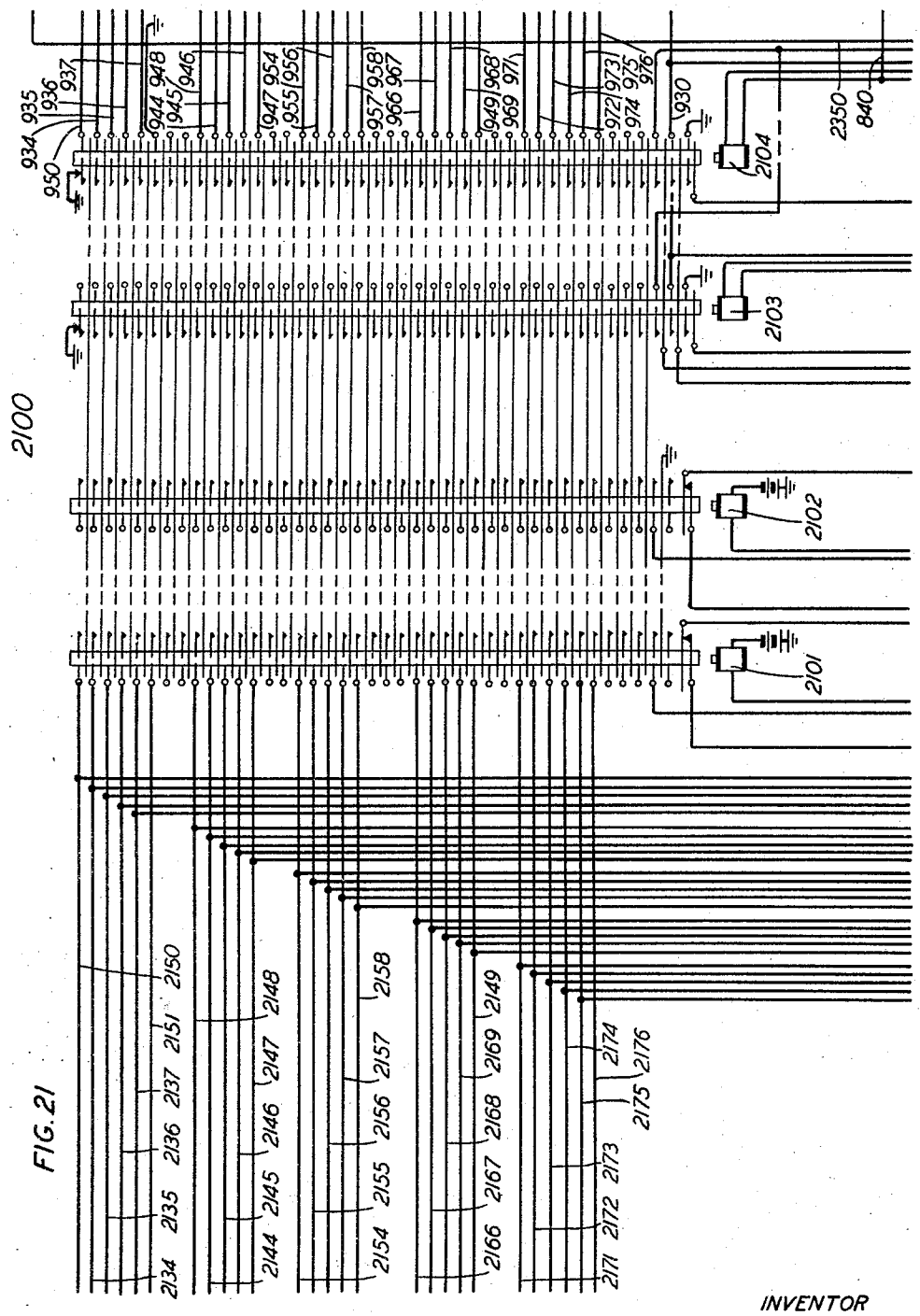

FIG. 21

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Feb 7, 1933. W. B. STRICKLER 1,896,757

TELEPHONE EXCHANGE SYSTEM

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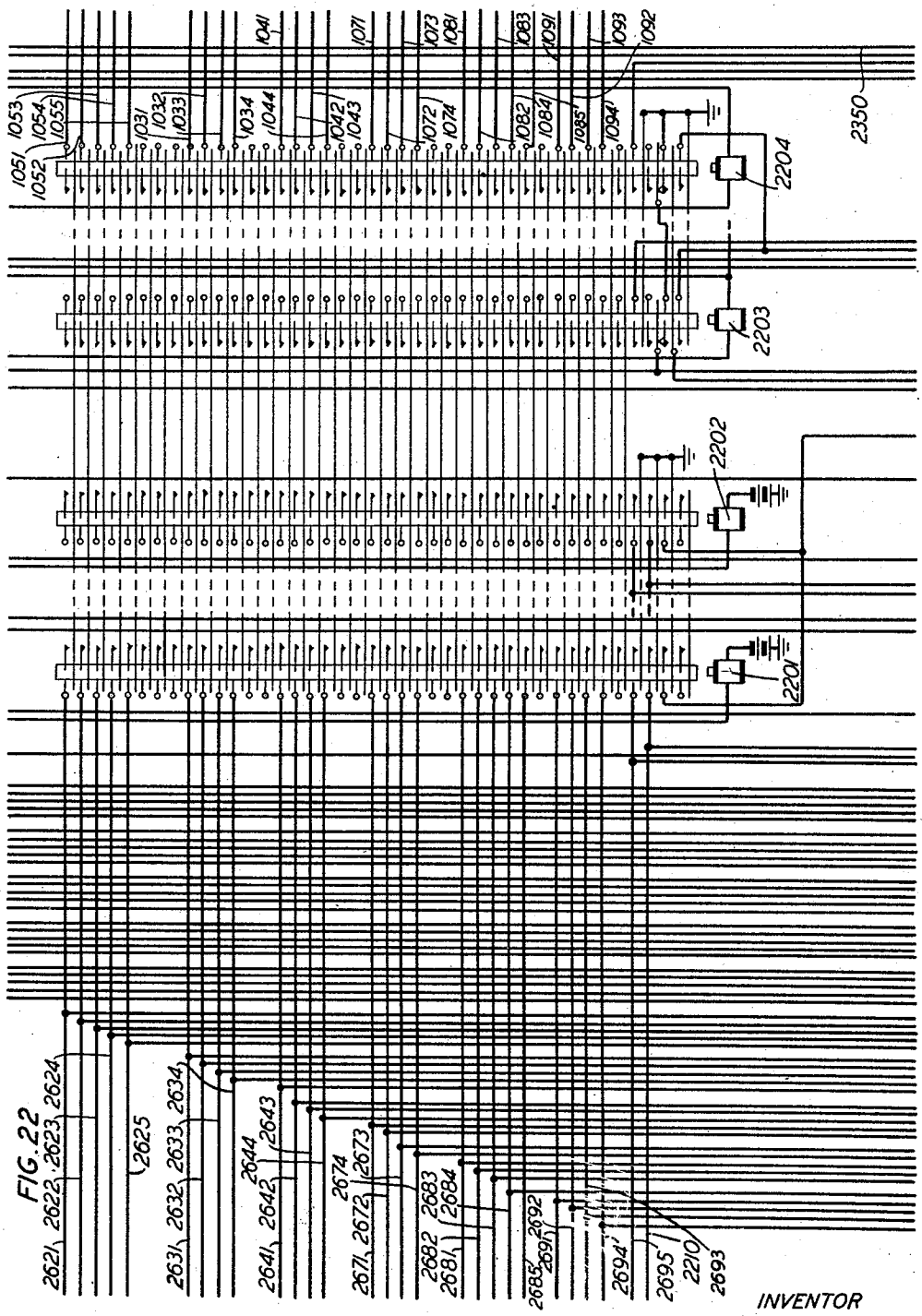

FIG. 22

INVENTOR
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Feb. 7, 1933. W. B. STRICKLER 1,896,757

TELEPHONE EXCHANGE SYSTEM

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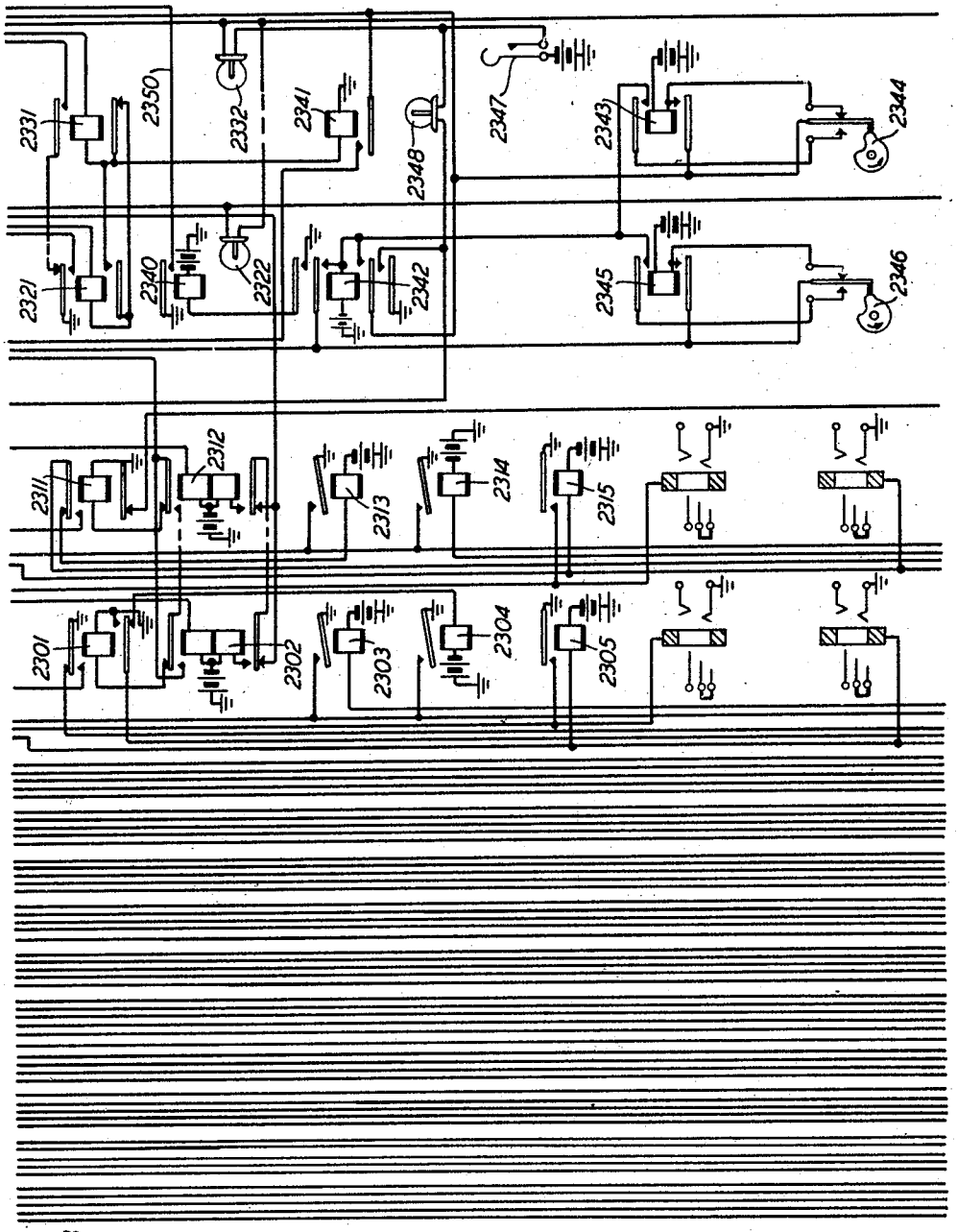

FIG. 23

INVENTOR
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TELEPHONE EXCHANGE SYSTEM

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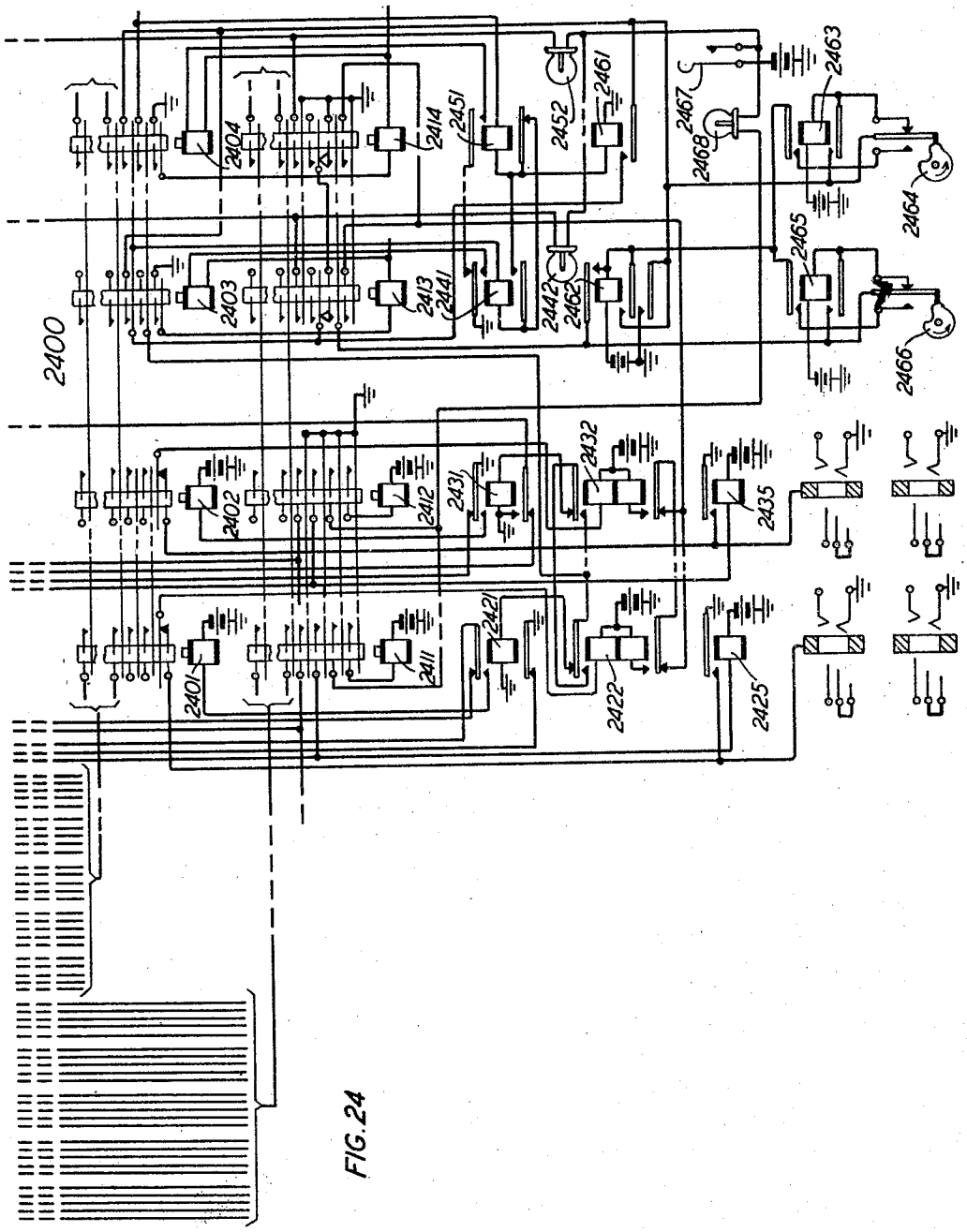

FIG. 24

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TELEPHONE EXCHANGE SYSTEM

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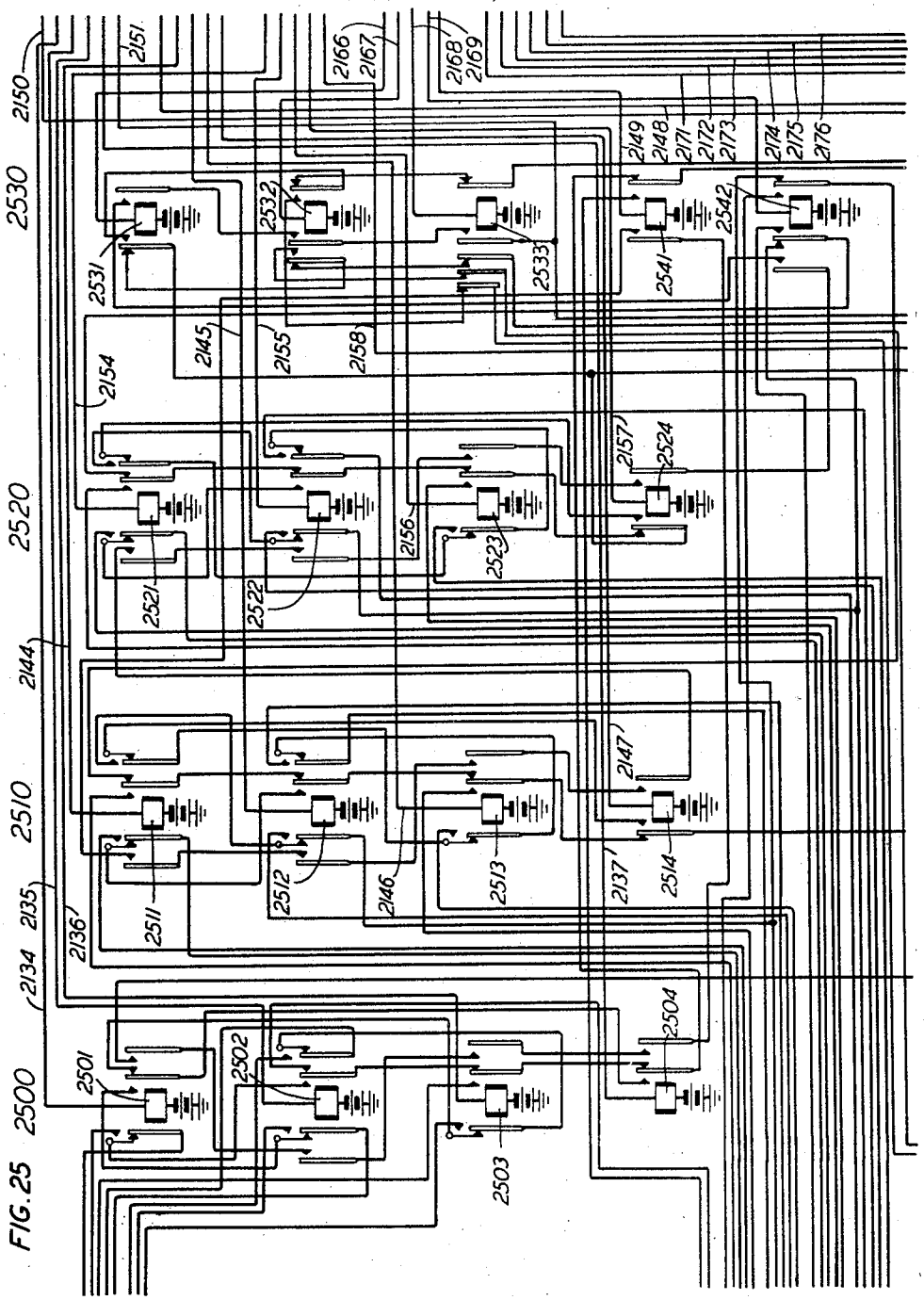

FIG. 25

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Feb. 7, 1933. W. B. STRICKLER 1,896,757

TELEPHONE EXCHANGE SYSTEM

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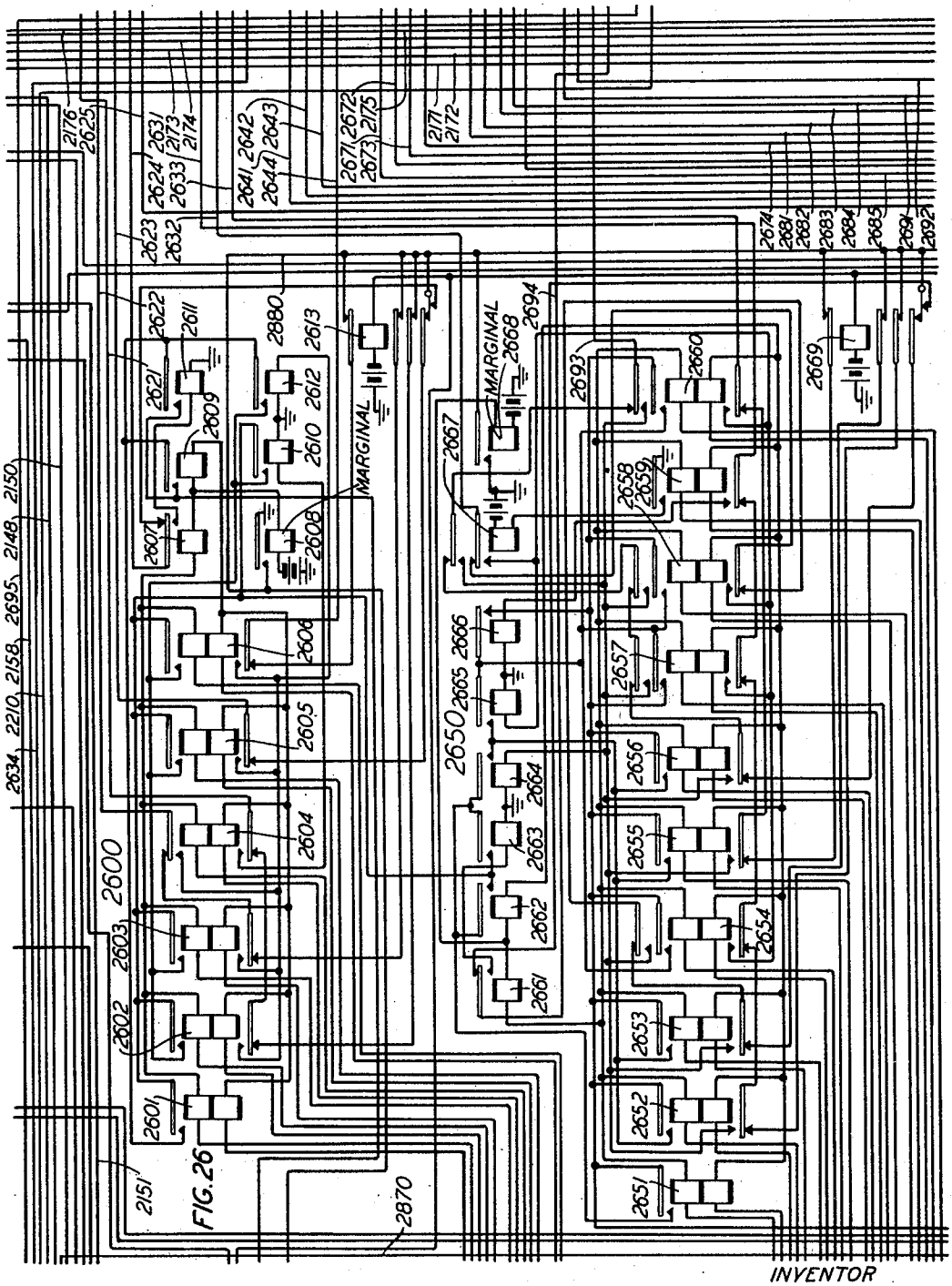

FIG. 26

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TELEPHONE EXCHANGE SYSTEM

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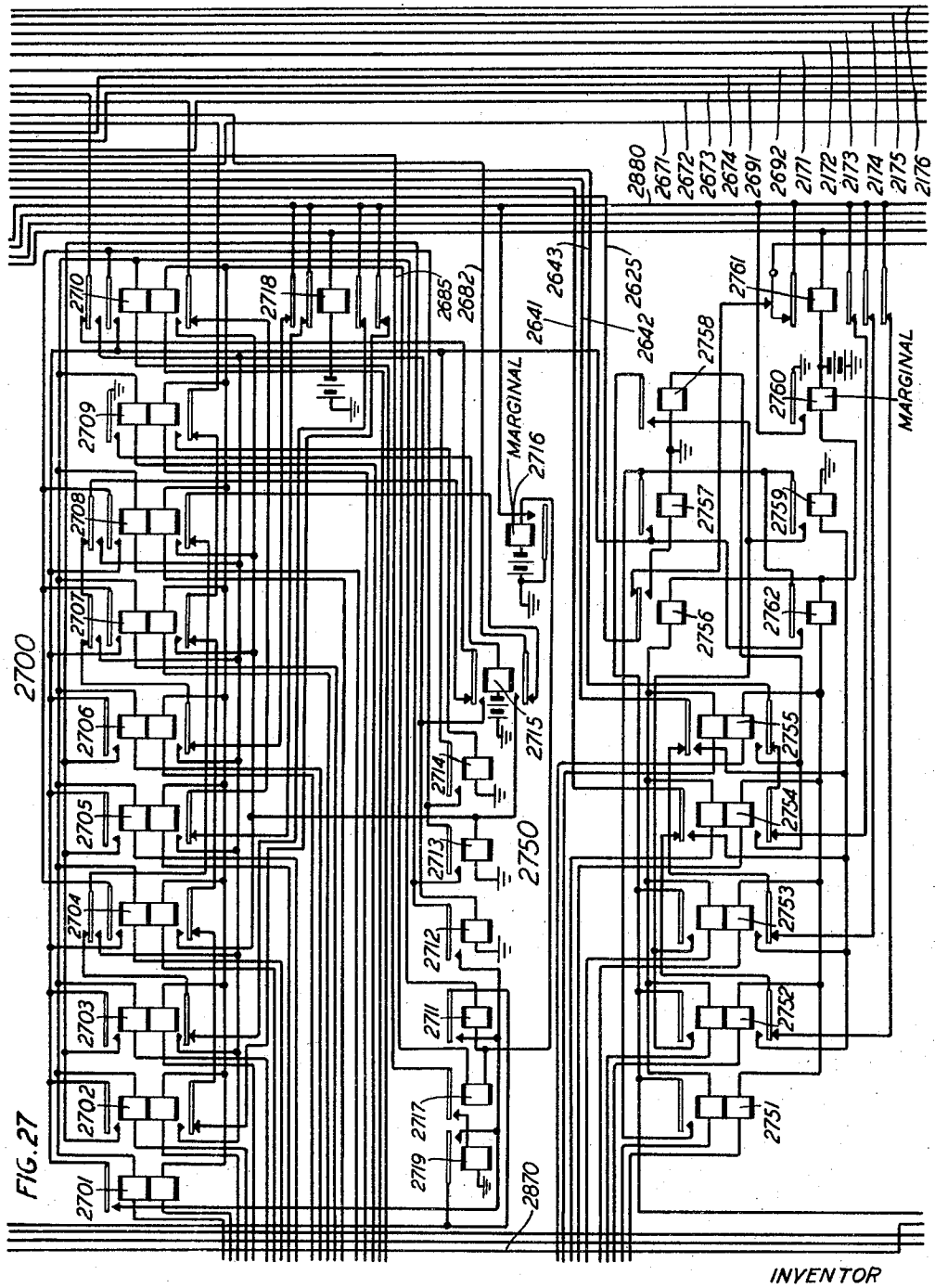

FIG. 27

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TELEPHONE EXCHANGE SYSTEM

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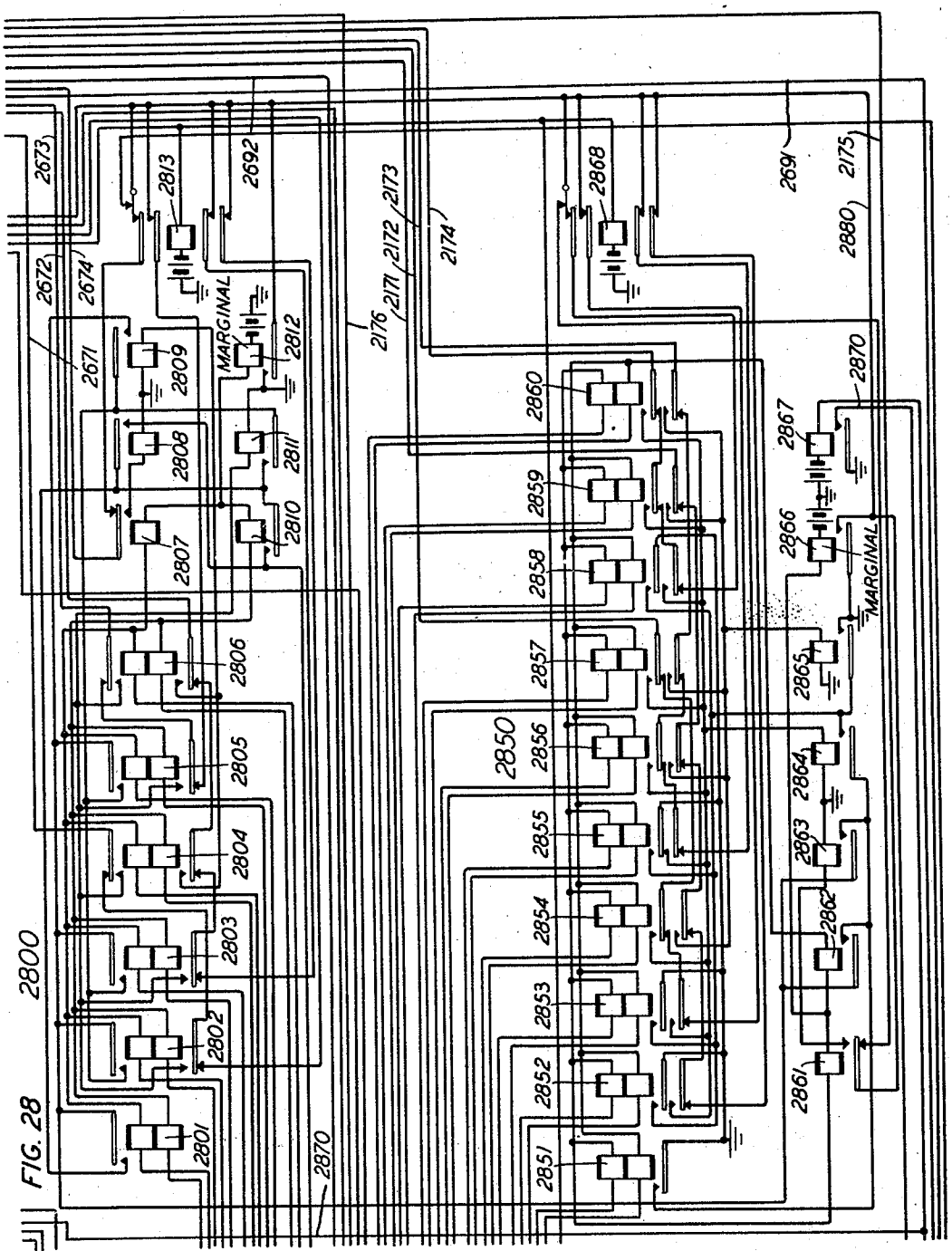

FIG. 28

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TELEPHONE EXCHANGE SYSTEM

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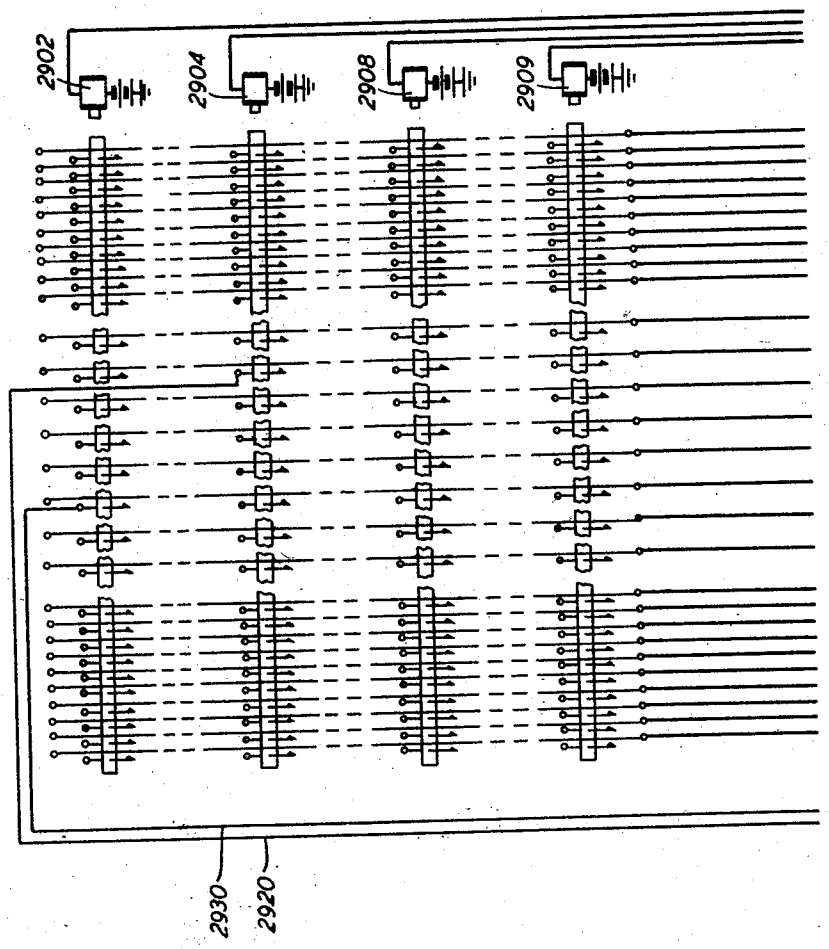

FIG. 29

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TELEPHONE EXCHANGE SYSTEM

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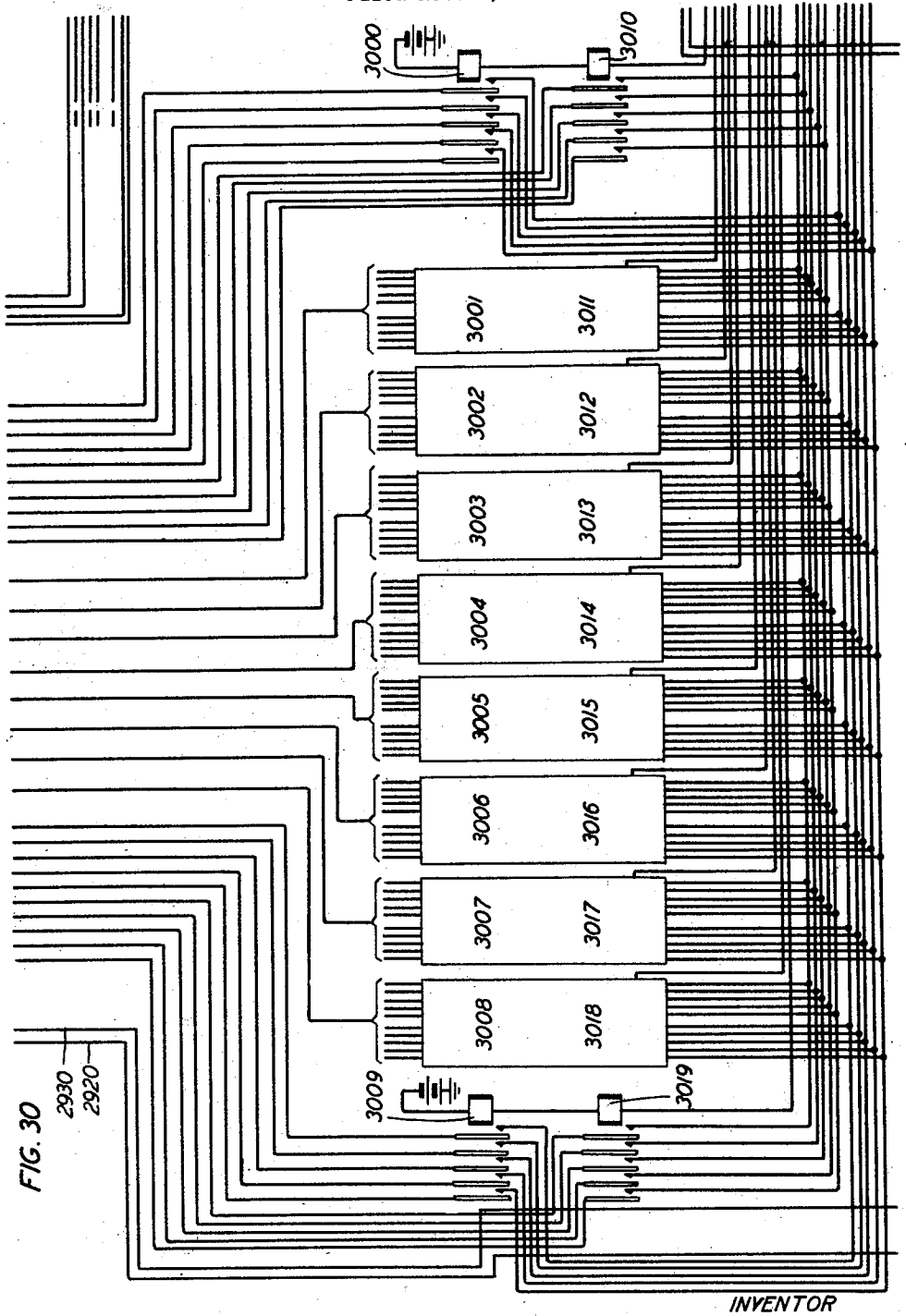

FIG. 30

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TELEPHONE EXCHANGE SYSTEM

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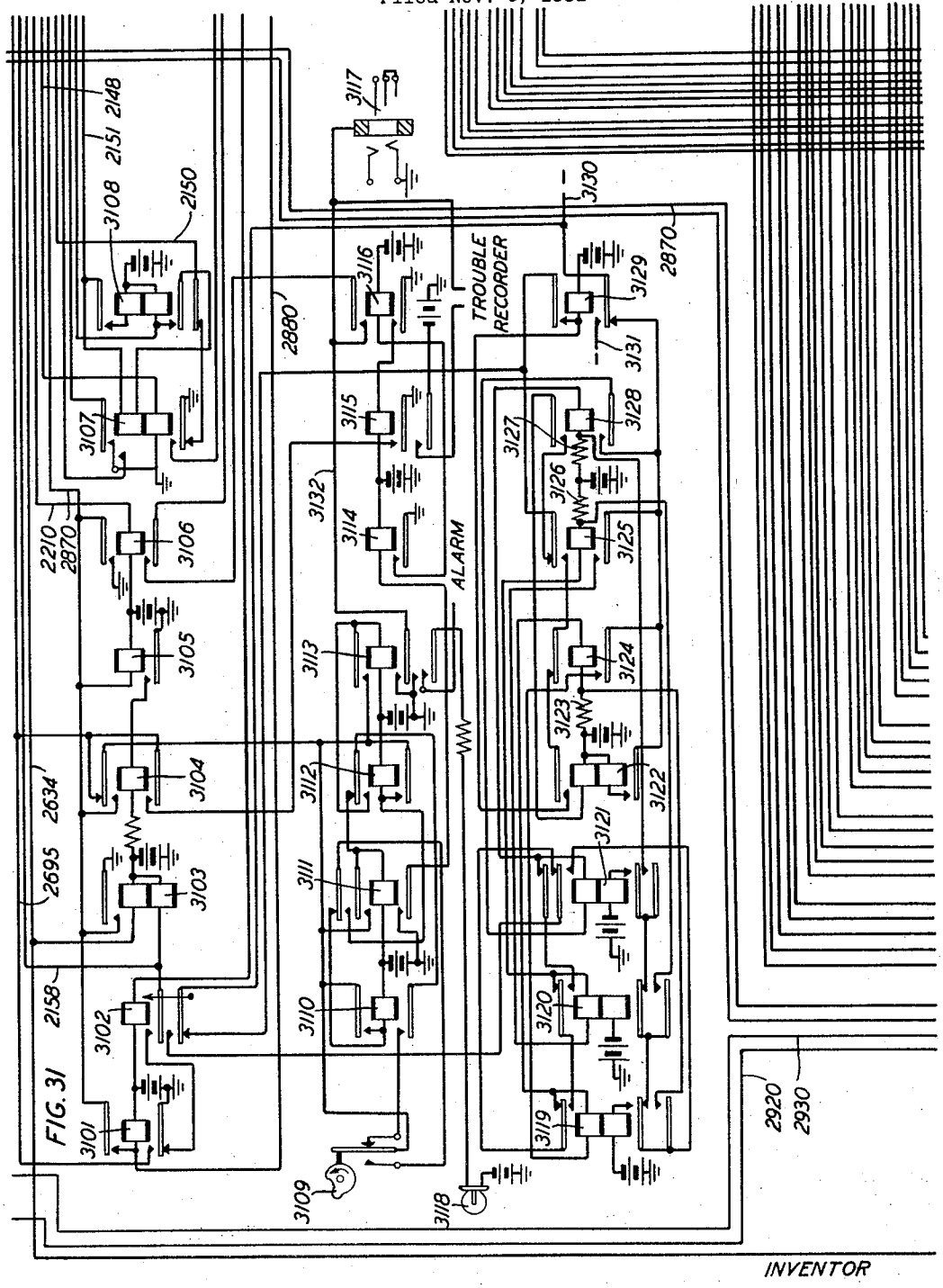

FIG. 31

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TELEPHONE EXCHANGE SYSTEM

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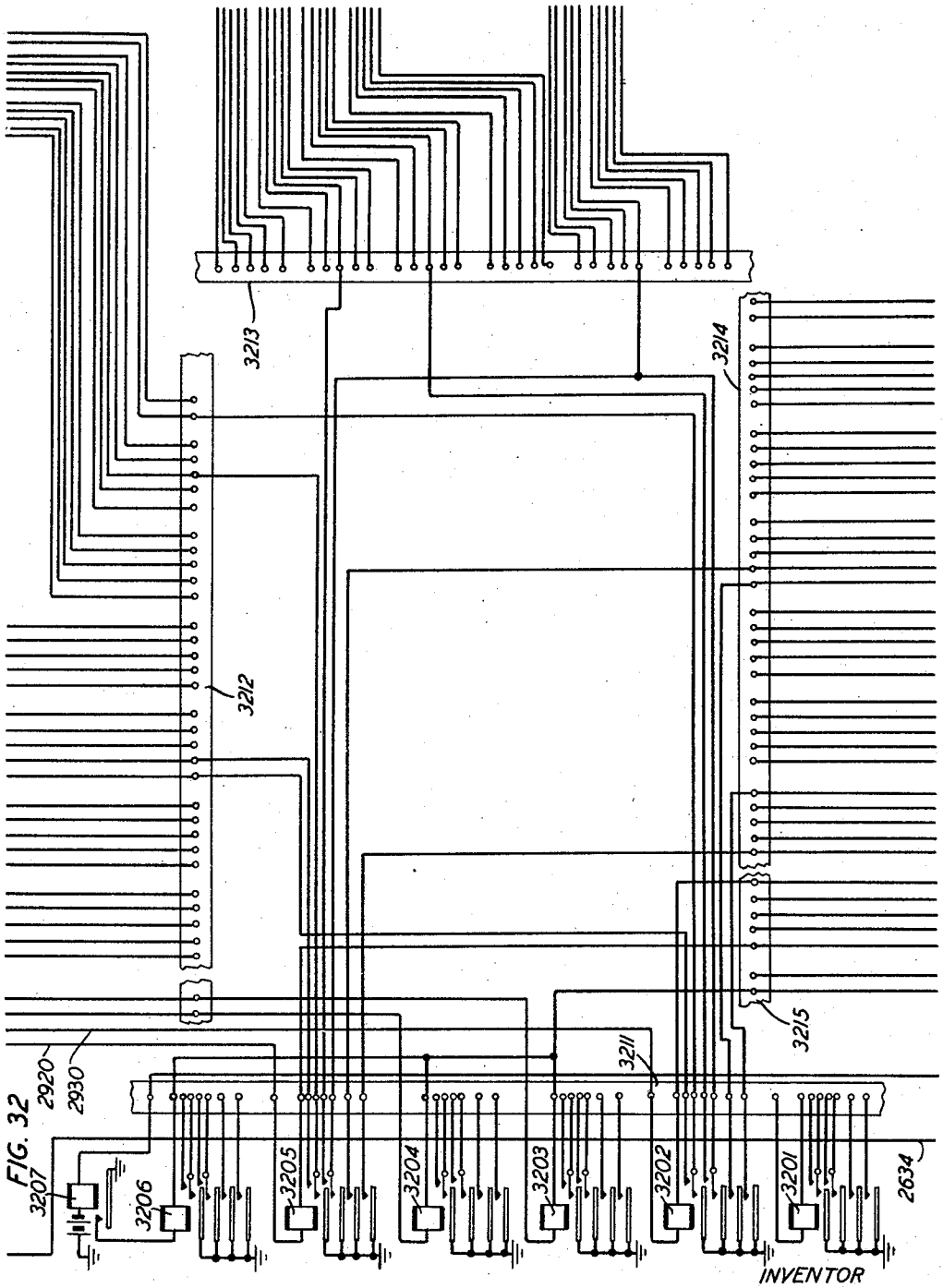

FIG. 32

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TELEPHONE EXCHANGE SYSTEM

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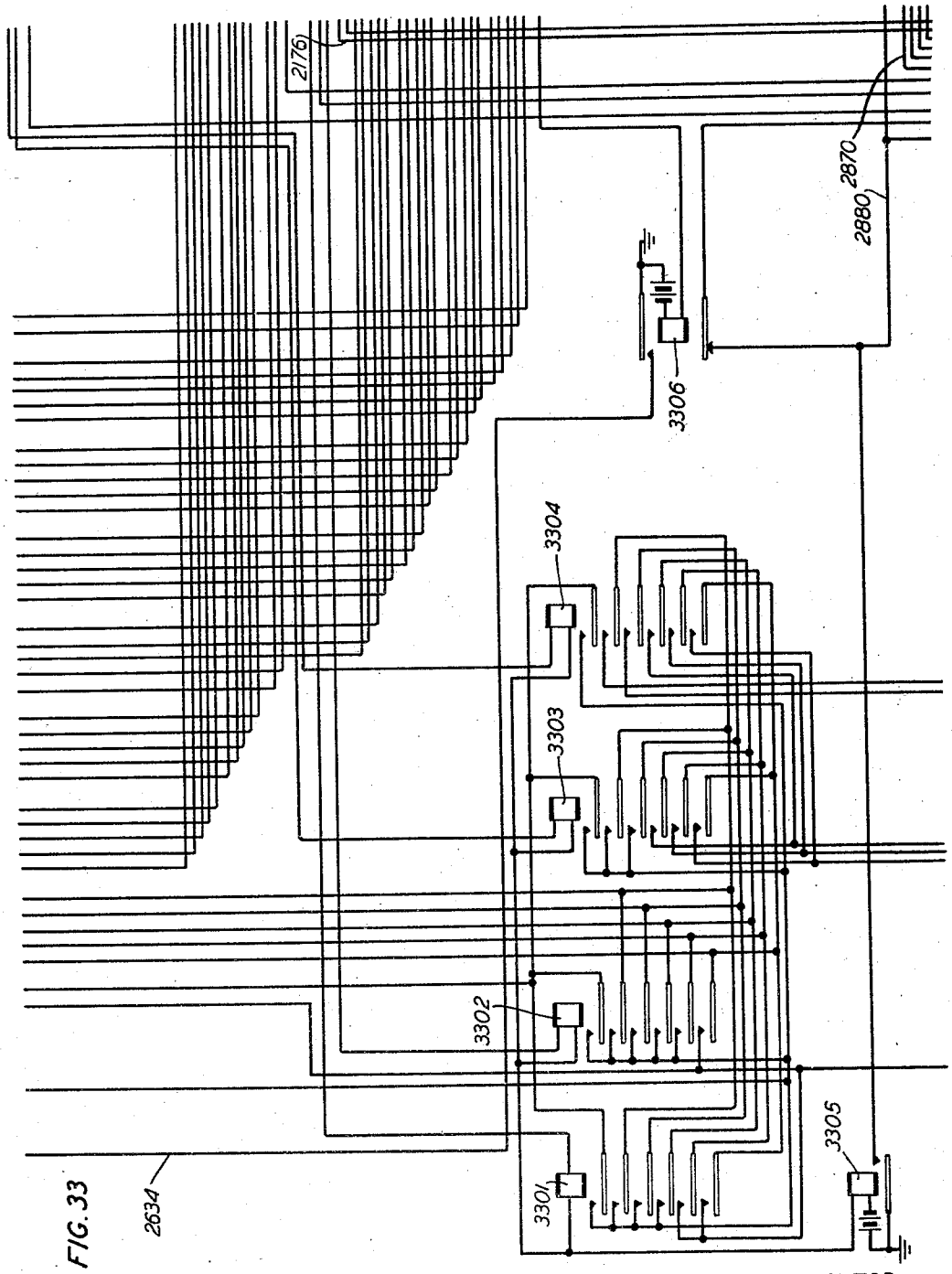

FIG. 33

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TELEPHONE EXCHANGE SYSTEM

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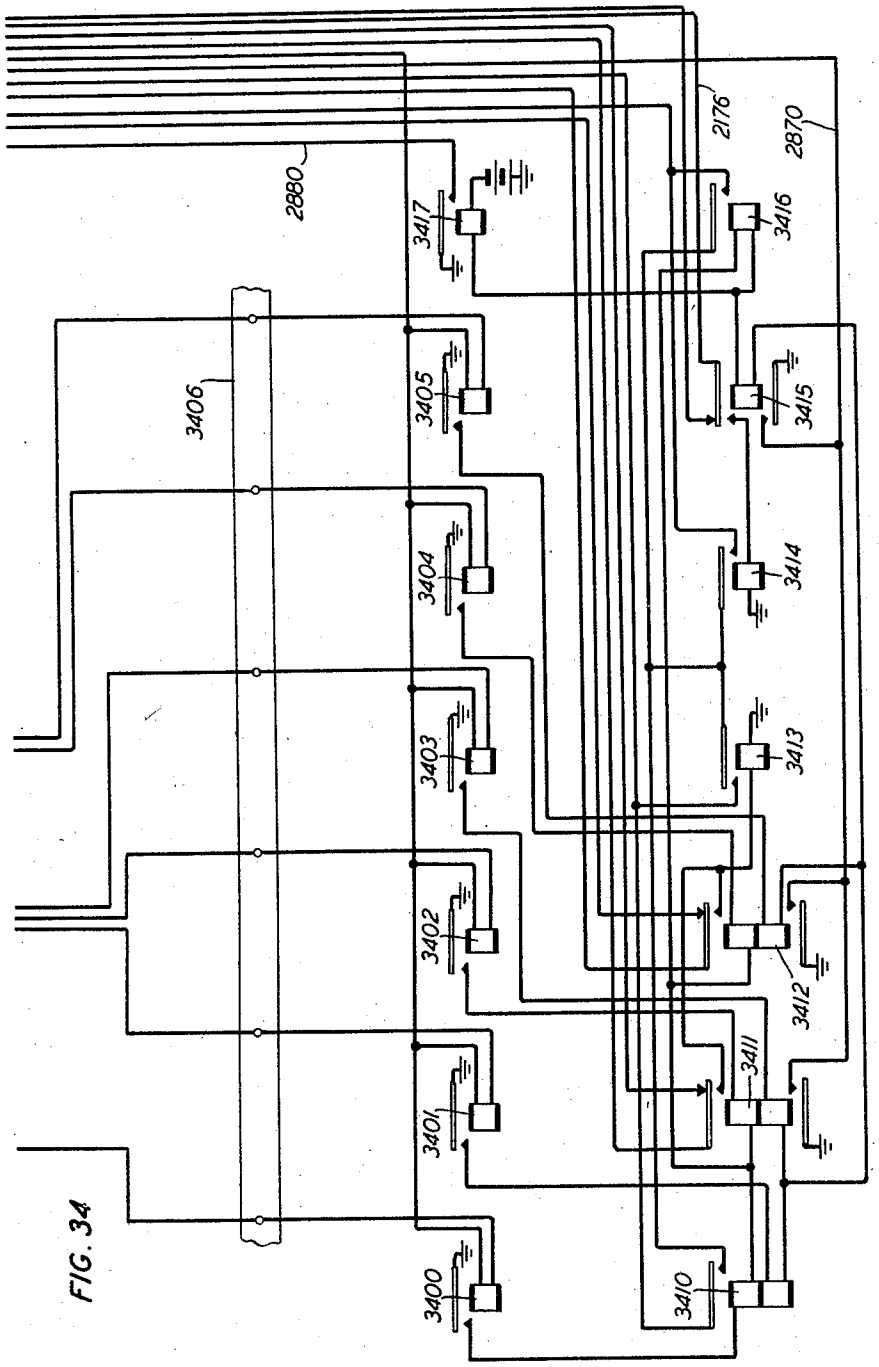

FIG. 34

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BY P. C. Smith
ATTORNEY

Patented Feb. 7, 1933 1,896,757

UNITED STATES PATENT OFFICE

WALTER B. STRICKLER, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

TELEPHONE EXCHANGE SYSTEM

Application filed November 5, 1931. Serial No. 573,059.

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

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

It has heretofore been proposed, as for example in the patent to J. N. Walters No. 1,563,599 granted December 1, 1925, that in the event the calling subscriber neglects to dial after initiating a call and still maintains the receiver off the switchhook, to measure a definite time interval in the sender and to then set registers of the sender to automatically route a connection from the calling line to a trunk circuit terminating at a trouble position on the A operator's switchboard and to then release the sender in order that the sender shall not be maintained unduly out of service. The monitoring operator may then connect with the trunk circuit to make such investigations as are necessary. It has also been proposed in this patent that in the event a calling subscriber only partially dials the number of a desired line and still maintains the receiver off the switchhook, to measure a definite time interval to permit the remaining digits of the desired line number to be dialed and to then signal the trouble or monitoring operator who may then plug directly in upon the sender to challenge the subscriber for the purpose of determining, if possible, the cause of the delay in dialing. If the sender becomes stuck so that it fails to respond to dial impulses transmitted by the calling subscriber the monitoring operator is given a further distinctive signal in response to which he may make the sender which has failed busy so that it may be traced by the maintenance force.

Since the operations which the monitoring operator performs are largely of a mechanical nature, it has been considered desirable to provide automatic means for disposing of partial dialing and stuck sender conditions, thereby permitting the removal of much of the sender monitoring equipment heretofore employed, thus simplifying the dial switching A operator's position and improving the traffic by relieving the A operator of much of the sender monitoring work. It is therefore the object of the present invention to provide means whereby the assistance of the monitoring operator is to a greater extent dispensed with.

In accordance with the invention, one embodiment of which is disclosed herein by way of example, provision is made in the sender for measuring a time interval after the sender has been seized by a calling subscriber and the subscriber fails to dial and does not hang up to route the call from the calling line to a trunk terminating at the monitoring position of the dial switching A board and to then release the sender for use on other calls. Provision is also made for measuring a predetermined time interval after the subscriber dials some of the digits of a desired line number to enable him to completely dial the remaining digits and in the event that he does not complete dialing to apply a distinctive tone from the sender to the calling line to warn the subscriber to hang up and to dial again, to then release the sender and to release the apparatus which has become associated with the calling line in response to the initiation of the call as though the calling subscriber had placed his receiver upon the switchhook. If the calling subscriber in response to the tone signal does not then hang up a new sender is seized and if he does not again dial the newly seized sender then routes a connection to a trunk circuit extending to the monitoring position.

In case the first sender became stuck so that

it did not respond properly to impulses dialed by the calling subscriber provision is made for transmitting a tone to the calling subscriber, for priming the sender to cause it to restore and if it does not restore within a predetermined interval to light a lamp signal on the sender make-busy frame. Provision is also made through the addition of a key to the make-busy frame of the sender to render the priming of the sender ineffective and to thereby hold the sender from releasing so that it may be checked for trouble by the maintenance force.

A clearer understanding of the invention may be obtained from a consideration of the following detailed description read in connection with the accompanying drawings in which:

Figs. 1 and 2 show a calling subscriber's line and a line finder and district selector circuit;

Fig. 1A shows a portion of the district selector; a called subscriber's line and a diagrammatic showing of an office selector, incoming selector and final selector for completing a connection between the calling and called lines;

Fig. 3 shows a trip circuit for associating the start circuit with the calling line;

Fig. 5 shows the start circuit for initiating the operation of the link circuit;

Figs. 4 and 6 show a link circuit for associating a sender with the district selector;

Figs. 7 to 20 show the sender circuit;

Fig. 7 showing the pulse receiving relays;

Fig. 8 the time alarm switch;

Figs. 9 to 11 a part of the incoming registers;

Fig. 12 the counting relays;

Fig. 13 the stepping relay and other control relays;

Figs. 14 to 16 the remainder of the incoming registers;

Fig. 17 the control sequence switch;

Figs. 18 and 19 the selection control registers; and

Fig. 20 the relay call indicator impulser switch;

Figs. 21 to 24 show the decoder connector;

Figs. 25 to 34 show the decoder;

Fig. 25 showing the incoming registers;

Figs. 26 to 28 the outgoing registers;

Figs. 29 and 30 the decoding arrangement;

Fig. 31 certain control relays and timing relays;

Fig. 32 the cross connecting racks;

Fig. 33 the service class relays; and

Fig. 34 the zone relays;

Fig. 35 shows the manner in which the other figures should be arranged.

Call to full mechanical three-digit office

When the subscriber at substation 100 initiates a call, removal of the receiver from the switchhook (not shown) closes a circuit from battery through the winding of line relay 101, outer back contact of cut-off relay 102, through the substation circuit, inner back contact of cut-off relay 102 to ground. Relay 101 connects ground to conductor 130 extending to trip circuit 300, and connects the terminal to which brush 114 has access to conductor 131, thus initiating the operation of the trip, start and link circuits and the associated line finder.

The trip circuit 300 shown in Fig. 3 is one of ten similar circuits serving a group of four hundred subscribers' lines. The purpose of the circuit is to trip the proper set of brushes on the line finder which hunts for the calling line and to insure that calls be served one at a time and in order. The gang switch 340 serves to connect the trip circuit with the line and with the start circuit 500, and permits the rapid transfer to the emergency trip circuit 350 should trouble arise.

The start circuit 500 is common to the ten trip circuits and serves to bring about the association of calling subscribers' lines with district selectors and senders without interference. The gang switch 591 which connects the start circuit 500 with the trip circuit 300 and the link circuit also serves to transfer these circuits into connection with the emergency start circuit 590 in case of trouble.

The link circuit of Figs. 4 and 6 is one of a group of link circuits serving half of the group of four hundred subscribers' lines. When idle the link circuit associates itself with an idle district selector and advances to a sub-allotted position. The link circuits are arranged in a chain and when one link circuit is taken for use the next is advanced to an alloted position, therefore only one link circuit is ready for use at a time. The link circuits serve to connect a calling line through a line finder district selector circuit with a sender for recording the number of the wanted line and for controlling the establishment of the connection.

The trip circuit 300 and the start circuit 500 are similar to those disclosed in U. S. Patent 1,567,072 granted to W. H. Matthies, December 29, 1925, while a link circuit similar to that of Figs. 4 and 6 is described in Patent 1,690,206 granted to A. Raynesford, November 6, 1928.

The connection of ground to conductor 130, which is common to a group of twenty lines, completes a circuit through switch 340, back contact of relay 302, upper winding of relay 301 to battery. Relay 301 connects ground over its lowermost front contact, inner contact of relay 306, upper contact of relay 303, switch 340, conductor 316 to gang switch 591, through the winding of relay 516 of the start circuit 500 to battery. It also closes a circuit from ground over the next to lower front contact, outer contact of relay

306, lower back contact of relay 303, upper winding of relay 304, switches 340 and 591, upper back contact of relay 515 to battery. Relay 304 operates and locks in a circuit from ground over the lowermost contact of relay 301, inner back contact of relay 306, lower winding and inner lower front contact of relay 304, over the back contacts of similar relays in the other trip circuits to the start circuit 500 and through the lower winding of relay 515 and resistance 517 in parallel to battery.

Relay 515 operates connecting battery through its lower winding and through resistance 517 in parallel to conductor 242. With relays 304 and 515 operated a holding circuit is completed for relay 301 from ground at the outer front contact of relay 515, outer lower front contact of relay 304, inner front contact and lower winding of relay 301 to battery. This circuit also extends in parallel with the lower winding of relay 301 to the winding of relay 305 and battery. Relay 305 lock over its upper front contact, outer back contact of relay 306, next to the lower front contact of relay 301 to ground and thereby closes an additional locking circuit for relay 301. Relay 305 closes a circuit from ground over its lower front contact, outer upper front contact of relay 304, front contact of relay 301, conductor 317, outer back contact of relay 511, inner back contact of relay 508, conductor 519, lower contacts of cam 609, to brush 406 of the trunk finder 400. This finder has been positioned on the terminals leading to an idle district selector and the district selector sequence switch has been advanced to position 2 in the manner described hereinafter, so that the above traced circuit extends over the lower contacts of cam 609, brush 406, conductor 248, right contacts of cam 223, winding of relay 226 to battery. Relay 226 initiates the operation of line finder 110.

Relay 304 also closes a circuit from battery through the trip magnet 117 of line finder 110 over conductor 127 to ground at its inner upper front contact. Relay 305 also closes a circuit from battery through the upper winding of relay 306, upper winding of relay 303, lower front contact of relay 305 to ground. Relay 303 operates in this circuit, but relay 306 cannot. Relay 303 opens the circuit of relay 516 and that relay releases unless its circuit is maintained at some other trip circuit belonging to this group of lines.

When relay 226 operates as above described, it locks over its inner upper front contact, upper contacts of cam 222, back contact of relay 227, commutator strip 122, brush 119 to ground. Relay 226 also closes a circuit from battery through the up-drive magnet 115 of the line finder 110, inner lower front contact of relay 226, right contacts of cam 218, outer lower front contact of relay 226, upper right contact of cam 209, lower right contact of cam 212 to ground. The line finder 110 is moved upward in search of the calling line under the control of magnet 115. When the line finder has passed the tripping zone so that the brushes have been made operative, brush 120 encounters the conducting part of commutator strip 123 completing a circuit from ground over brush 120, segment 123, upper contacts of cam 203, conductor 242 through make-busy keys (not shown) and thence over the inner front contact of relay 515 to the winding of relay 515 and resistance 517 in shunt of the winding of relay 304. Relay 304 now releases, in turn releasing trip magnet 117. When brush 120 leaves the segment 123, relay 515 also releases to restore the operating circuit for the relays such as relay 304 in the other trip circuits. When the line finder finds the calling line a circuit is closed from ground over the upper contacts of cam 221, winding of relay 227, brush 114, outer front contact of relay 101, conductor 131 which extends to the lower winding of relay 306 and the resistance 310 in parallel. Relay 227 operates in this circuit connecting ground over commutator strip 122, front contact of relay 227, through resistance 228 in parallel with its winding, permitting relay 306 to operate. Relay 306 opens the locking circuit of relay 305 and the holding circuit of relay 301. The release of relay 305 opens the energizing circuit of relay 303 and that relay releases unless held locked because relay 516 is held operated from some other trip circuit.

In the start circuit at the same time that the operation of relay 305 connected ground to conductor 519 to operate relay 226, this ground also extended through the winding of relay 505, upper winding of relay 508, outer lower back contact of relay 503 to battery. Relay 505 operates in this circuit, locking to ground at its front contact independent of relay 305, but relay 508 does not operate at this time. However, when relay 226 operates to start the line finder, it also connects ground over the upper right contact of cam 209, outer lower front contact of relay 226, upper right contacts of cams 218 and 207, conductor 247, brush 405, lower left and upper right contacts of cam 617, conductor 690, lower winding of relay 508 to battery. Relay 508 now operates, short-circuiting relay 505, opening the operating circuit of relay 226 and locking to ground at the front contact of relay 305. Relay 508 also closes a circuit through the upper winding of relay 515 for holding that relay operated. When the calling line is found, the operation of relay 227 also opens the locking circuit for relay 226 and that relay releases, opening the circuit of up-drive magnet 115, bringing the line finder to rest. The release of relay 226 releases relay 508 completing the

restoration of the start circuit 500. Relay 226 released closes a circuit from battery through the winding of cut-off relay 102, brush 113, resistance 126, lower back contact of relay 125, outer upper back contact of relay 226, lower contacts of cam 215, lower contacts of cam 212 to ground. Relay 102 in operating opens the circuit of the line relay 101 which in turn disconnects ground from conductor 130 releasing relays 301 and 306 in the trip circuit and relay 227 in the district selector, and reconnects message register 103 with the terminal engaged by brush 114. The release of relay 301 completes the restoration of the trip circuit 300 to normal.

The trip circuit 300 and the start circuit 500 are each equipped with means to guard against faulty operation. When either relay 301 or 302 operates it connects ground to the armature of interrupter 308. Interrupter 308 operates relay 312 and after a predetermined interval causes the operation of relay 306 which performs the same functions as though it had been operated by the finding of the calling line and frees the trip circuit for use with other calls. With relay 312 operated, interrupter 307 operates relays 314, 315 and 313 in turn if the trip circuit does not return to normal and lamp 311 is lighted and an alarm sounded.

The same circuit which operates relay 505 connects ground over the upper back contact of relay 508 to interrupter 501. Interrupter 501 operates relays 506 and 503 in turn. Relay 503 disconnects battery from relay 508 and closes a holding circuit for itself over key 520. It also connects ground to lamp 522 and to a pilot alarm. In addition it operates relay 511 which transfers the circuits controlled by relay 305 from relay 505 and conductor 519 to relay 504 and conductor 521 belonging to the other groups of link circuits and lines so that failure on the part of one group of link circuits will cause all calls to be served by the other group. These circuits are described in detail in the above identified Matthies patent.

When relay 226 operates to start the line finder it also transmits a signal to the link circuit to start hunting for a sender. The circuit for this purpose is the same as that used for operating relay 508 as far as brush 405 whence it extends over the right contacts of cam 610 through the winding of relay 420, resistance 421 to battery. Relay 420 locks over its lower front contact to ground over the upper left and lower right contacts of cam 625. It also closes a circuit from ground over its lowermost front contact, right contacts of cam 611, winding of magnet 600 to battery, advancing the link sequence switch to position 2 in which position relay 420 releases. In position 2 a circuit is closed from battery through the winding of relay 423, upper right and lower left contacts of cam 619, upper back contact of relay 424, lower left and upper right contacts of cam 618 to ground. Relay 423 prepares relay 424 for testing for an idle sender and connects ground over its inner upper contact to the lower winding of relay 424 which is connected over the left contacts of cam 624 through the middle winding of relay 424 to battery and over the lower left and upper right contacts of cam 624 through the upper winding of relay 424, back contact of relay 420, upper contacts of cam 626 to brush 454. Relay 424 is so wound that this combination of circuits renders it quick to operate when the proper condition is found and quick to release if some other link has just tested the same sender. Relay 423 also closes a circuit from battery through the upper winding of relay 422, upper front contact of relay 423 to ground at the lower back contact of relay 424. Relay 422 in operating completes a circuit from battery through the winding of up-drive magnet 467, upper contacts of cam 623, inner lower front contact of relay 422 to ground at the outer lower back contact of relay 420. The sender selector 450 is therefore driven upward under the control of magnet 467.

Idle senders are characterized by battery through 270 ohms resistance and, assuming that the sender shown is the first idle one encountered, a circuit will be closed from battery through resistance 1302, left back contact of relay 1303, lower back contact of relay 726, conductor 746, brush 454 to ground through the upper and lower windings of relay 424. Relay 424 operates in this circuit and closes a locking circuit for itself from ground over its lower front contact, lower left and upper right contacts of cam 624, upper winding of relay 424 to battery over brush 454 as above traced. This circuit so alters the potential on brush 454 that no other link circuit which may be hunting can stop on this sender. The operation of relay 424 opens the circuits of relays 422 and 423 which now release. With relay 423 released and relay 424 operated, sequence switch 600 is advanced to position 3 in a circuit over cam 613, contacts of jack 607, back contact of relay 423, upper front contact of relay 424 to ground over the lower left and upper right contacts of cam 618.

While sequence switch 600 was in position 2, a circuit was closed from ground over the left contacts of cam 605, right contacts of cam 606, to the next link circuit in the sequence which is the first one shown, over a contact of jack 667, left contacts of cam 666 and the right contacts of cam 665 to the sequence switch of that link to advance the link into position 1 in readiness for use. Likewise with the link sequence switch 600 in position 2, a circuit is closed from ground over the lower right and upper left contacts

of cam 608, brush 401, conductor 243, upper left contact of cam 213, upper right contact of cam 210, upper winding of relay 225 to battery. Relay 225 locks over its inner upper contact to ground over the left contacts of cam 221. When relay 226 releases after the calling line has been found, a circuit is closed from battery through the winding of sequence switch magnet 200, upper right contact of cam 224, lower front contact of relay 225, lower back contact of relay 226, upper right contact of cam 209 to ground, advancing sequence switch 200 to position 3. When sequence switch 200 leaves position 2, relay 225 releases. When sequence switch 200 reaches position 3 the circuit of cut-off relay 112 is closed to ground over the upper left and lower right contacts of cam 212, holding the cut-off relay operated under the control of relay 125 until the sequence switch leaves position 17¼.

With sequence switch 600 in positions 2¾ and 3 conditions are set up to identify the service to which the calling subscriber is entitled. Subscribers are grouped in accordance with the zone to which they have free access and the rate at which they are to be charged for distant zones. Different groups of subscribers are served by different groups of link circuits and link circuits are provided with means for telling the senders the group to which the calling subscriber belongs. This is done by establishing one of two conditions on the tip side of a fundamental circuit leading to the sender, and one of two conditions on the ring side of the fundamental circuit, before the fundamental circuit is employed for making selections. These conditions are either open circuit or direct ground, connected to brush 456 over cam 612 or open circuit or ground connected to brush 455 over cam 617. It has been assumed that the service to which subscriber 100 is entitled may be identified by open circuit, on brush 456 and ground to brush 455 from which the circuit may be traced over conductor 747, outer right back contact of relay 1303, conductor 1315, to the right winding of relay 1407 and to battery.

With sequence switch 200 in position 3, when sequence switch 600 also reaches position 3, a circuit is closed from battery through the windings of relays 229 and 125 in parallel, over contacts of cam 211, conductor 245, brush 403, lower right and upper left contacts of cam 621, brush 453, conductor 745, right back contact of relay 1305, outer left contact of relay 1232, middle and left windings of relay 1306 to ground. Relay 125 is marginal and does not operate at this time. Relay 229 operates, but is ineffective in this position of the selector sequence switch.

Relay 1306 also operates in this circuit, in turn operating relay 1234 which closes a circuit from battery through resistance 1304, winding of relay 1233 to ground at the right front contact of relay 1234. Relay 1233 locks to ground at its inner left contact and connects ground to conductor 1238 which carries off-normal ground to all parts of the sender circuit. The connection of ground to conductor 1238 completes a circuit over the left contacts of cam 812 through the winding of relay 826 to battery, starting the timing operation which will be described hereinafter. It also operates relay 1303 which removes battery from conductor 746 to remove the idle condition, connects ground to conductors 1317, 1318 and 1319. It also completes a circuit over conductor 1238 through the winding of relay 1301 to battery at the left back contact of relay 1237 which prepares for the subsequent release of the sender. In addition it completes a circuit over the back contact of relay 901, through the winding of relay 902 to battery, operating relay 902 in preparation for the reception of the first digit.

The removal of battery from conductor 746 releases relay 424, which closes a circuit from battery through the winding of sequence switch magnet 600, upper right contact of cam 613, back contact of relay 424 to ground over the lower left and upper right contacts of cam 618. Sequence switch 600 is advanced to position 5 in this circuit. In position 5 the sender and district selector are connected together over the following circuits: Conductor 243 of the district selector is connected to conductor 743 of the sender over brush 401, upper contacts of cam 608 to brush 451; conductor 244 is connected to conductor 744 over brush 402, upper contacts of cam 609 and brush 452; conductor 247 is connected to conductor 747 over brush 405, left contacts of cam 617 and brush 455; conductor 248 is connected to conductor 748 over brush 406, left contacts of cam 612 and brush 456. The circuit connecting conductor 245 with conductor 745 extends in position 5 from brush 403, left contacts of cam 627, upper winding of relay 424, upper back contact of relay 420, upper contacts of cam 621 to brush 453. This circuit is maintained in preparation for the advance of the link circuit. No circuits are closed over either conductor 246 or conductor 746 at this time.

As soon as sequence switches 200 and 600 reach position 3 the dialing circuit is closed, which may be traced from battery through the lower winding of relay 724, over conductor 744 through the link circuit to conductor 244, left contacts of cam 202, winding of relay 231, middle back contact of relay 125, brush 112, through the subscriber's substation and dial (not shown), back to line finder brush 111, inner back contact of relay 125, left contacts of cam 201, conductor 243, through the link circuit to conductor 743, resistance 729 to ground at the outer right back contact of

relay 1237. Relay 724 operates in this circuit and closes a circuit from battery through the winding of relay 716, front contact of relay 724 to ground at the inner back contact of relay 1237. Relay 716 in operating, connects ground through resistance 717 to the winding of relay 713 which also operates in turn operating relays 714 and 715. With relay 715 operated, a circuit is closed from ground over the inner front contact of relay 715, upper winding of relay 724 through condenser 730, right back contact of relay 829, outer left front contact of relay 902 to the source of dial tone. A tone is thereby induced in the primary winding of relay 724 from whence it extends to the subscriber's line informing him that he may proceed to dial.

When the subscriber operates his dial for the first digit, relay 724 releases momentarily as each pulse is received. Relay 716 releases each time that relay 724 releases, but is not as quick to operate as relay 724 so that it may or may not reoperate each time that relay 724 does. Relays 713 and 714, on the other hand, are definitely slow to release so that they do not release during the possible short openings of their circuits and relays 716, 713, 714 and 715 remain operated during the intervals between digits. When relay 724 closes its back contact in response to the first pulse, it connects ground over the upper front contact of relay 714, inner left front contact of relay 1234, over the upper back contacts of relays 710, 708, 706, 704, and 702 to the winding of relay 701 and battery. Relay 701 operates, locking through the winding of relay 702, front contact of relay 701, lower back contact of relay 704, conductor 736, back contact of relay 720 to ground at the outer upper front contact of relay 715. The release of relay 716 closes a circuit from battery through resistance 719, winding of relay 718, inner back contact of relay 716 to ground at the outer upper contact of relay 715. Relay 718 is slow to release so that it remains operated even if relay 716 may momentarily break its operating path. At the end of the first impulse relay 724 reoperates and relay 702 operates and locks in the circuit of relay 701. The operation of relay 702 closes a circuit from ground, over the lower front contact of relay 702 to conductor 731. With relay 902 operated this completes a circuit over the inner left contact of relay 902 through the right winding of relay 904 to battery operating that relay.

When the next pulse is received, the circuit controlled by relay 724 extends, as above traced, to the armature of relay 702 and over the front contact of that relay to the winding of relay 703. Relay 703 locks through the winding of relay 704, front contact of relay 703, back contact of relay 708, to conductor 736. Relay 704 does not operate until the end of the pulse at which time it opens the locking circuit of relays 701 and 702, which release in turn releasing relay 904. It also connects ground to conductor 732 and over the outer right contact of relay 902, to the right winding of relay 905 and battery operating that register relay.

The third pulse causes the operation of relays 705 and 706 in turn and relay 706 grounds conductor 731 reoperating relay 904. Relays 705 and 706 lock in parallel with relays 703 and 704 which remain operated so that relay 905 also remains operated. The fourth pulse operates relays 707 and 708 which open the locking circuits of relays 703 to 706, releasing relays 904 and 905. Relay 708 also connects ground to conductor 733 and over the middle left contact of relay 902 to the winding of relay 906 and battery.

At the fifth pulse, the circuit controlled by relay 724 extends over the front contact of relay 708 to the winding of relay 709 and battery. Relay 709 operates locking through the winding of relay 710, front contact of relay 709, back contact of relay 704 to conductor 736. At the end of the pulse relay 710 operates opening the locking circuit of relays 707 and 708 thereby releasing relay 906. It also closes a circuit from ground over its inner lower front contact, upper back contact of relay 712 to conductor 734, over the middle right contact of relay 902 to the winding of relay 907 and battery. In addition it closes a circuit from grounded conductor 736, alternate contact of relay 710, lower back contact of relay 712, winding of relay 711 to battery. Relay 711 locks in series with relay 712 over its front contact to conductor 736. Therefore, the locking circuit of relays 711 and 712 is independent of the remaining counting relays. Relays 712 does not operate at this time being shunted by the operating circuit of relay 711.

At the sixth pulse, the circuit controlled by relay 724 extends over the front contact of relay 710, the back contacts of relay 706, 704 and 702 to the winding of relay 701. This relay locks through the winding of relay 702, as before, grounding conductor 731. The seventh pulse operates relays 703 and 704, releasing relays 701 and 702 and grounding conductor 732 in the same manner as the second pulse. Relay 704 also opens the locking circuit of relays 709 and 710 and these relays release permitting relay 712 to operate in the locking circuit of relay 711. With relay 712 operated, a new circuit is closed for relay 907 over the front contact of relay 712 and the back contact of relay 710 so that relay 907 is held operated.

The eighth pulse causes the operation of relays 705 and 706 in the same manner as the third pulse. Relays 703 and 704 remain operated and conductors 732 and 731 are

grounded causing the operation of relays 904 and 905. The ninth pulse causes the operation of relays 707 and 708, releasing relays 703 to 706 as well as relays 904 and 905 and operating relay 906 instead.

The tenth pulse reoperates relays 709 and 710 releasing relays 707, 708 and 906. With relay 712 operated, the operation of relay 710 opens the circuit for relay 907 and closes instead a circuit from ground over the inner lower front contact of relay 710, lower front contact of relay 712, conductor 735, inner right contact of relay 902 to the right winding of relay 903 and battery.

When the last pulse of the digit has been received, relays 730 and 716 remain operated for a considerable length of time. The circuit of relay 718 is thereby opened and a circuit closed from battery through the winding of relay 720, normal contact of relay 718 to ground at the front contact of relay 715. Relay 720 closes a holding circuit for itself under the control of relay 716. It also connects ground from the front contact of relay 715, over the front contact of relay 720, outer left back contact of relays 1112, 1102 and 1022, back contact of relay 1030, outer left back contacts of relays 1002, 922 and 912 to the winding of relay 901 and thence over a left front contact and the left winding of the operated relays of register 900 to battery. This provides a locking circuit for the register relays as well as an operating circuit for relay 901. It may be noticed, however, that the locking circuit of relay 904 is only closed when either relay 905 or 907 is also operated. This is for the purpose of preventing the registration of a false preliminary pulse, since the digit 1 is not used for the first digit of any office code, and any false preliminary pulses are unable to lock up the first register. The operation of relay 720 also releases any of the recording counting relays which were operated.

As above mentioned, this sender is equipped for use with either two or three digit office codes during the growth of an exchange area. Since the sender will ultimately be used only for three digit office codes, the circuit is arranged normally to record the first three digits on registers 900, 910 and 920. The office codes are so selected that the two digit codes may be identified by the first digit of the office code, i. e., if the register 900 is positioned in accordance with a digit which indicates a three digit office code, the operation of relay 901 prepares register 910 for operation, while if register 900 is positioned in accordance with a digit which indicates a two digit office code, circuits will be prepared whereby relay 901 prepares the register 920 to receive the second digit.

Relay 901 in operating locks over its outer left contact to grounded conductor 1317. It also opens the circuit of relay 902, disconnecting the relays of register 900 from the recording relays. In addition it extends ground from conductor 1317 over its inner left contact, to the armature of relay 1401, whence the circuit extends, if relay 1401 is not operated, over the back contact of relay 911 to the winding of relay 912 to prepare register 910, but if relay 1401 is operated over the back contact of relay 921 through the winding of relay 922 to prepare register 920. According to the present disclosure the digits 2, 5 and 9 have been used to indicate two digit codes. Therefore, if any of these three digits have been set up on register 900 relay 1401 will be operated. For example, assume that the digit 2 has been recorded. It will be remembered that two pulses cause the operation of relay 905. With relay 905 operated and locked, a circuit is closed from ground over the outer right contact of relay 905 through the winding of relay 1402 to battery. A circuit is therefore closed from battery through the winding of relay 1401, cross-connecting rack 1400, inner right back contact of relay 1403, front contact of relay 1402, inner right back contact of relay 904 to ground at conductor 1317. Similarly, if the digit 9 is dialed resulting in the operation of relays 906 and 907, relay 1403 is operated over the inner right contact of relay 907, and relay 1401 is operated over the outer right front contact of relay 1403, inner right front contact of relay 906, left back contact of relay 1402, right back contact of relay 904 to conductor 1317. Circuits are prepared over connecting rack 1400 to ground at conductor 1317 for each of the possible first digits. Relay 1401 is cross-connected to those points on the rack 1400 which are to be used as two digit office codes. It is apparent that initially all of the digits may indicate two digit codes and as the number of offices increases, one digit at a time may be taken for use with three digit codes by merely cutting the connection between relay 1401 and the corresponding points on rack 1400.

Assuming that the called subscriber's number is Halifax 3678 which requires the three digit code 4—2—5 to be used, relay 912 is operated as above described and the next operation of the dial brings about the registration of the second digit on register 910. When the last pulse has been received, the register relays lock in series with relay 911 which in turn locks to conductor 1317, opens the circuit of relay 912 and connects ground from conductor 1317 over the inner front contact of relay 911 and the back contact of relay 921 to the winding of relay 922 to prepare for recording the third digit on register 920. It may be noted that the digit 1 may be recorded on either the second or third digit code register, since the locking circuits of relays 914 and 924 extend to the windings of relays 911 and 921 in the same manner as the other register relays.

Following the registration of the office code

the numerical digits are recorded, the thousands digit on register 1000, the hundreds digit on register 1010, the tens digit on register 1020 and the units digit on register 1100. If the call is one that is to be completed at a manual office where station digits are employed, this digit will be recorded on register 1110. Following the registration of the thousands digit, the operation of relay 1001 extends conductor 1317 over its inner left contact to the windings of relays 1012 and 1030 in parallel. Relay 1030 supplies locking ground for registers 1010, 1020 and 1100. Station register 1110 obtains locking ground through relay 1101. The operating circuit for the cut-in relay 1112 of the station register extends over the lower contacts of cam 816 to the back contact of relay 1111 and the front contact of relay 1101.

The operation of relay 901 following the registration of the first digit, closes a circuit from battery through the winding of sequence switch magnet 1700, lower right contact of cam 1702, conductor 1728, left back contacts of relays 1505 and 1504, conductor 1509, outer right back contact of relay 1321, left back contact of relay 1310, outer left front contact of relay 1234, conductor 1239, inner left front contact of relay 901 to ground at conductor 1317. Sequence switch 1700 advances to position 2 in this circuit connecting ground over the lower left contact of cam 1708 and the lower right contact of cam 1716 to conductor 1238 as long as the switch remains out of position 1.

At this time also a circuit is closed from battery over the lower right and upper left contacts of cam 1724, winding of relay 1226, left back contact of relay 1227 to ground, operating relay 1226 to prepare for the closing of the fundamental circuit.

When the office code digits have been registered as indicated by the operation of relay 921, a circuit is closed from battery through the winding of relay 721, inner left front contact of relay 921 to grounded conductor 1317. Relay 721 is operated, initiating the operation of the decoder by completing a circuit from battery over the lower right and upper left contacts of cam 1724, conductor 839, right back contact of relay 838, left back contact of relay 836, lower back contact of relay 723, inner lower front contact of relay 721 to conductor 930. Battery over conductors 839 and 840 is supplied to the windings of relays 2104 and 2204 individual to this sender in the decoder connector.

The decoder connector comprises a plurality of groups of multi-contact relays arranged in pairs. One pair is provided for each sender and the senders are divided into convenient size groups according to the traffic, each group constituting a particular channel. There is a pair of relays for each decoder in each channel so that any sender may be served by any decoder. The circuits for operating the decoder connector are so arranged as to prevent interference between senders needing a decoder at the same time and to make each decoder a first choice in certain channels. For a detailed description of these circuits reference may be made to Patent 1,700,456 to F. A. Stearn, granted January 29, 1929.

The connection of battery to conductor 930 completes a circuit through the windings of relays 2331 and 2341 in series to ground. Relay 2331 in operating opens the operating circuits for the other sender relays such as relay 2321 and also closes a circuit from ground over the back contacts of the other sender relays, front contact of relay 2331, winding of relay 2104 to battery over conductor 840. Relay 2104 operates, connecting the sender with a portion of the cross wires of the connector. It also closes a circuit for relay 2204 to battery over conductor 840 which completes the connection of the sender with the cross wires of the connector. Relay 2341 prepares circuits for sounding an alarm if the multi-contact relays fail to operate or release properly.

The operation of relay 2104 extends the start conductor 930 over the contact of relay 2104 to the armature of relay 2312. If the decoder corresponding to this relay is busy, relay 2312 will be operated and the circuit will be further extended until a relay corresponding to an idle decoder is reached. Assuming that relay 2312 is operated and relay 2302 is the first unoperated relay, the circuit extends over the front contact of relay 2312 to the armature and back contact of relay 2302, winding of relay 2301 to ground. Relay 2301 closes an obvious circuit for relay 2101 which in operating completes the circuit of relay 2201 thus connecting the sender directly to the decoder. The operation of relay 2301 opens the circuits of relays 2303 and 2304 which connect ground to conductor 2210 in preparation for operating an alarm. Relay 2201 connects ground over its contacts to the windings of relays 2305, 2425 and all similar relays in the other sections of the connector. Since relay 2101 is operated relay 2305 is ineffective, but in those channels where the multi-contact relay has not been operated the corresponding channel busying relay is operated. For example, in channel 2400, relay 2425 operates relay 2422.

The decoder itself comprises a set of receiving registers, a set of decoding relays, a set of routing relays and a set of outgoing registers. The incoming registers include registers 2500, 2510 and 2520 for recording the three digits of the office code and register 2530 for recording the class of service indication set up in the sender. Relay 2541 is operated from the permanent signal relay 725 which is operated by the timing switch

800, if the subscriber fails to dial the first digit. Relay 2541 operates routing relay 3204 directly, to set up a routing by which the call may be extended to a permanent signal trunk leading to an operator's position. Relay 2542 is operated only from senders serving operators' positions and serves to permit the use of certain codes employed only by operators.

The set of decoding relays includes eight multi-contact relays 2902 to 2909, operated in accordance with the first digit of the office code, and ten pairs of relays 3000 and 3010 to 3009 and 3019, operated in accordance with the second digit of the office code. Receiving register 2520 which is positioned in accordance with the third digit of the office code connects ground over the contacts of relays 3000 to 3019 to the cross wires extending before the multi-contact relays 2902 and 2909, to ground a point corresponding to the recorded designation. This point is cross-connected to one of the routing relays such as relays 3201 to 3205. As many of these routing relays are provided as there are different routes to be used in connecting with the wanted offices. Also included in the decoding arrangement is the group of relays 3301 to 3304 which are operated in accordance with the setting of the class-of-service register 2530. These relays serve to complete the circuits of routing relays corresponding to routes which are restricted to any subscriber.

The outgoing registers comprise the zone register of Fig. 34, class register 2800, compensating resistance register 2850, district brush register 2750, district group register 2700, office brush register 2650 and office group register 2600. These registers ground transmitting conductors to the sender. The major function of these registers is to cause the setting of the correspondingly named registers of the sender, although they also transmit certain minor information as well. The zone register controls the operation of zone relays 1504 and 1505 and jointly with register 2750 determines talking selection. Register 2600 informs the sender when office selections are to be skipped while register 2650 controls relays 1120 and 1121 and register 2700 controls relay 1322 which function in connection with the timing switch 800.

As soon as relays 2104 and 2101 have operated the receiving circuits for the decoder are completed. Assuming that the office code registered consists of the digits 4, 2, 5, relays 906, 915 and 927 will have been operated in registers 900, 910 and 920 respectively. The following circuits will, therefore, be closed: From ground at the outer right contact of relay 906, conductor 936 through the decoder connector to conductor 2136, winding of relay 2503 to battery; from ground at the right front contact of relay 915, conductor 945 through the decoder connector to conductor 2145, winding of relay 2512 to battery; from ground at the right front contact of relay 927, conductor 957 through the decoder connector to conductor 2157 through the winding of relay 2524 to battery.

It will be remembered that relay 1407 was operated from the link circuit to identify the class of service to which the calling line 100 was entitled. Relay 1407 locks in a circuit from battery over the lower contacts of cam 1724, conductor 1729 through the left winding of relay 1407 to grounded conductor 1238. Relay 1407 also closes a circuit from ground over its right front contact, conductor 967 through the decoder connector to conductor 2167 through the winding of relay 2532 to battery.

At the same time a circuit is closed from ground over the back contact of relay 3107, back contact of relay 3108, conductor 2150, through the decoder connector to conductor 950, over the back contact of relay 725 which is operated when a permanent signal occurs, conductor 949 through the decoder connector to conductor 2149, winding of relay 2541 to battery. Conductor 950 is also connected over conductors 968 and 969 through the decoder connector to conductors 2168 and 2169 and through the windings of relays 2533 and 2542 respectively to battery. In addition conductor 950 is extended over the back contacts of all of the non-operated register relays to the conductors which would be grounded by them if operated. For example, it is connected over the outer right back contact of relay 904 to conductor 934, over the outer left back contact of relay 905 to conductor 935 and over the outer left back contact of relay 907 to conductor 937. Conductors 934, 935 and 937 are connected through the decoder connector to conductors 2134, 2135 and 2137 and the windings of relays 2501, 2502 and 2504 respectively. In a similar manner relays 2511, 2513 and 2514 are operated over the back contacts of the unoperated relays of register 910 and relays 2521, 2522 and 2523 are operated over the back contacts of the unoperated relays of register 920. Conductor 950 also extends over the outer left back contact of relay 1602 and the right back contact of relay 1406 to conductor 966 through the decoder connector to conductor 2166 and the winding of relay 2531 to battery.

Circuits have now been closed for operating all of the relays shown in Fig. 25 including all of the incoming code relays as well as the service class relays and the permanent signal relay. With all of these relays operated indicating that all of the receiving circuits connecting the sender with the decoder are closed, a circuit is completed from battery through the lower winding of relay 3108, outer right front contact of relay 2501,

outer left front contact of relay 2502, outer right contacts of relays 2503 and 2504, left front contact of relay 2541, outer left front contacts of relays 2511 and 2512, right front contacts of relays 2513 and 2514, left contacts of relay 2521 and 2522, right contacts of relays 2523 and 2524, left front contact of relay 2542, right front contact of relay 2531, left front contacts of relays 2532 and 2533, conductor 2151 to ground at the contact of relay 2104. This circuit is, therefore, a test of the continuity of the incoming circuits to the decoder. If the circuit is completed, relay 3108 is operated, disconnecting ground from conductor 2150 and thereby from conductor 950 resulting in the release of all of the relays of Fig. 25 except those held by the operated relays of the sender. Relay 3108 locks through its upper winding and upper contact to grounded conductor 2151. It also closes a circuit from battery through its lower winding and lower front contact, through the upper winding of relay 3107 to conductor 2151. The winding of relay 3107 is shunted by ground over the chain circuit above traced until one or more relays release. If any of the unused receiving circuits is falsely grounded, this ground extends over the back contact of the corresponding relay to conductor 950, so that the operation of relay 3108 is ineffective to open the chain circuit.

When the chain circuit is opened relay 3107 operates, supplying ground for the establishment of the decoding circuits. One of these circuits may be traced from ground over the inner upper contact of relay 3107, left back contact of relay 2514, right back contact of relay 2513, inner right front contact of relay 2512, left back contact of relay 2511, windings of relays 3002 and 3012 to battery. A second circuit may be traced from ground over the outer upper front contact of relay 3107, right back contact of relay 2541, right back contact of relay 2504, right front contact of relay 2503, winding of relay 2904 to battery. Relay 2904 closes the contacts controlled by it. A third circuit extends from ground at the lower front contact of relay 3107, back contact of relay 2531, front contact of relay 2532 and back contact of relay 2533, windings of relays 3303 and 3305 to battery. A fourth circuit may be traced from ground at the lower front contact of relay 3107, left front contact of relay 2524, outer right back contact of relay 2521, left back contact of relay 2523, outer right back contact of relay 2522, over the innermost front contact of relay 3002, contact of relay 2904, conductor 2920, cross-connecting rack 3211 through the winding of routing relay 3205, cross-connecting racks 3211 and 3215, lowermost front contact of relay 3303, winding of relay 3401, winding of relay 2867 to battery. Relay 3204 in operating closes a plurality of circuits for transmitting information to the sender for controlling the establishment of the connection. Relay 3401 operates to indicate that the office called lies in the first or local zone to the particular class of subscriber calling. Relay 2867 connects ground to conductor 2870 and thence to the winding of relay 3105 to prepare for operating an alarm if the decoder is not released in the proper length of time.

Assuming that the cross-connections are as shown, the operation of relay 3205 closes six circuits: The first circuit extends from ground over the lowermost contact of relay 3205, cross-connection racks 3211 and 3214, lower winding of relay 2801, winding of relay 2810, winding of relay 2812 to battery. A second circuit is closed from ground over the next to lower contact of relay 3205, cross-connecting racks 3211 and 3214, upper winding of relay 2858, winding of relay 2861, winding of relay 2866 to battery. The third circuit is closed from ground over the third from the bottom contact of relay 3205, cross-connecting racks 3211 and 3213, upper winding of relay 2753, winding of relay 2756, winding of relay 2760 to battery. An additional circuit is closed over the fourth from the bottom contact of relay 3205, cross-connecting racks 3211 and 3213, upper winding of relay 2704, winding of relay 2711, winding of relay 2716 to battery. The fifth circuit is closed over the next to the innermost contact of relay 3205, over cross-connecting racks 3211 to 3212, upper winding of relay 2604, winding of relay 2607, winding of relay 2608 to battery and the sixth circuit is closed over the innermost contact of relay 3205, cross-connecting racks 3211 and 3212, upper winding of relay 2656, winding of relay 2661, winding of relay 2668 to battery.

Relays 2608, 2668, 2716, 2760, 2812 and 2866 are for the purpose of determining that no more than one of the transmitting register relays is operated in any one register. Each relay is marginal so that with only one circuit closed through its winding, it does not operate; but if more than one circuit is closed it will operate, connect ground to conductor 2880, operate relay 3101 and thereby prevent the regular release of the sender and cause a trouble release signal to be transmitted to the sender.

Relays 2801, 2858, 2753, 2704, 2656 and 2604 close one or more circuits for the purpose of setting the selector control registers in the sender. Relay 2801 closes no circuits leading to the sender but does close at its contact a link in a chain circuit which will be traced hereinafter. Relay 2858 closes a circuit from ground through the winding of relay 2864, outer lower front contact of relay 2858, inner lower back contacts of relays 2859 and 2860, conductor 2174, through the decoder connector to conductor 974, right winding of

relay 1924 to battery. Relay 2753 closes a circuit from ground through the winding of relay 2759, lower front contact of relay 2753, upper back contact of relay 2755, conductor 2642, through the decoder connector to conductor 1042, right winding of relay 1812 to battery. Relay 2704 closes a circuit from ground through the winding of relay 2713, lower front contact of relay 2704, lower back contacts of relays 2707 and 2709, conductor 2681 through the decoder connector to conductor 1081 through the right winding of relay 1901 to battery. Relay 2704 also closes a circuit from ground through the winding of relay 2712, outer upper front contact of relay 2704, back contacts of relays 2708 and 2715, conductor 2682 through the decoder connector to conductor 1082, right winding of relay 1902 to battery. Relay 2656 closes a circuit from ground through the winding of relay 2664, lower front contact of relay 2656, upper back contacts of relays 2657, 2658, 2667 and 2660, conductor 2693 through the decoder connector to conductor 1093, left winding of relay 1120 to battery. Relay 2604 closes a circuit from ground through the winding of relay 2612, upper front contact of relay 2604, conductor 2622 through the decoder connector to conductor 1052, right winding of relay 1912 to battery. In addition certain of the relays which are operated in series with the register relays also close circuits. Relay 2861 closes a circuit from ground through the winding of relay 2863, front contact of relay 2861, conductor 2175 through the decoder connector to conductor 975, winding of relay 1925 to battery. Relay 2756 closes a circuit from ground through the winding of relay 2757, front contact of relay 2756, conductor 2625, through the decoder connector to conductor 1055, right winding of relay 1310 to battery. Relay 2661 closes a circuit from ground through the winding of relay 2663, front contact of relay 2661, conductor 2694, through the decoder connector to conductor 1094, right winding of relay 1121 to battery. Relay 2607 closes a circuit from ground through the winding of relay 2611, front contact of relay 2607, conductor 2624, through the decoder connector to conductor 1054, right winding of relay 1914 to battery. It will also be remembered that relay 3400 was operated in series with relay 3205. Relay 3400 closes a circuit from ground over its contact through the upper winding of relay 3410, winding of relay 3416, winding of relay 3417 to battery. Relay 3417 serves the same purpose as relay 2866 etc. that is, acts as a check against the operation of more than one of the zone relays at a time. Since relay 3400 corresponds to the local zone, a circuit is closed from ground through the winding of relay 3414, front contact of relay 3415, conductor 2176, through the decoder connector to conductor 976, left winding of relay 1321 to battery.

With all of the above traced circuits completed a chain circuit is established to indicate that the circuits employed in setting the selection control registers of the sender are properly closed. This chain circuit includes contacts of the relays operated from the routing relay, such as relay 3205 and contacts of all relays included in the operating circuits of the sender register relays. The circuit may be traced as follows: from ground over the inner lower front contact of relay 2858, front contact of relays 2864, 2863, 2801, 2810, 3410 and 3414, upper contact of relay 2753, contacts of relays 2759 and 2757, inner upper front contact of relay 2704, contacts of relays 2713, 2712 and 2711, upper contact of relay 2656, contacts of relays 2664 and 2663, 2610, 2612 and 2611 through the winding of relay 3102 to battery. The operation of relay 3102 is an indication that all the circuits indicated by the routing relay have been completed.

At the same time that this test circuit is completed, circuits are prepared to test whether or not any of the conductors not employed are either grounded or crossed with any of the above traced circuits. Taking the class register 2800, for an example, it will be remembered that the operation of relay 2801 connected ground to none of the conductors extending to the class register of the sender but that relay 2807 connected ground through relay 2808 to conductor 2674. Class information is transmitted to the sender over conductors 2671, 2672, 2673 and 2674. Conductor 2674 has been grounded as above described. Conductor 2671 extends over the back contacts of relays 2804, 2802 and the lowermost contact of relay 2813 to conductor 2880 and the winding of relay 3101. Conductor 2672 extends over the back contacts of relays 2806, 2804, 2803 and the inner lower contact of relay 2813 to conductor 2880. Conductor 2673 extends over the back contacts of relay 2806, 2805 and the inner upper contact of relay 2813 to conductor 2880. Similar circuits are closed over the back contacts of the relays of the other outgoing registers so that if any of the transmitting conductors between the decoder and the sender are falsely grounded or crossed with any of the conductors used in transmitting the necessary information to the sender, relay 3101 is operated.

If relay 3101 is not operated and relay 3102 is, as should be the case, a circuit is closed from ground over the back contact of relay 3101, inner front contact of relay 3102 to conductor 2158, through the decoder connector to conductor 958, upper winding of relay 722 to battery. Relay 722 closes a locking circuit for itself from battery over its inner lower front contact and lower wind-

ing to grounded conductor 1238. Relay 722 also connects relay 723 to battery in parallel with its lower winding. Relay 723 at its upper contact prepares the fundamental circuit and at its lower contact connects ground to conductor 737 to provide a locking circuit for the stations delay relays 1120 and 1121, talking selection relays 1310 and 1321, two-wire office relay 1322, class register relays 1801, 1802 and 1803 and the compensating resistance register relays 1921 to 1925. In addition, this ground extends over the left contacts of cam 1704 in positions 2 to 3 of sequence switch 1700 to form the locking circuit for the district brush register relays 1811 to 1813 and the district group register relays 1901 to 1910 and the zone relays 1504 and 1505, while it extends over the lower contacts of cam 1704 in positions 2 to 7 of sequence switch 1700 to form the locking circuit for the office brush register relays 1821 to 1823, office group register relays 1911 to 1914 and the skip office relay 1123.

In addition, relay 723 disconnects battery from the start conductor 930. The removal of battery from conductor 930 releases sender relay 2331 and decoder relay 2301 in the decoder connector. These relays in turn release multi-contact relays 2104 and 2101 thereby in turn releasing relays 2201 and 2204 and completely disconnecting the sender from the decoder. The release of relay 2301 also reoperates relays 2303 and 2304 to remove the busy condition from the decoder in other channels while the release of relay 2331 restores the circuit for operating other sender relays in this channel

Returning to the decoder, it will be remembered that the operation of the multi-contact relay 2201 connected ground to conductor 2210, operating relay 3106. Relay 3106 operates relay 3105 which in turn operates relay 3104. Relay 3104 extends ground from the front contact of relay 3106, over the upper front contact of relay 3104 to interrupter 3109. This ground is maintained as long as the decoder is busy, but is removed as soon as the decoder is released. The interrupter is also grounded over conductor 2695 and the back contact of relay 3104 when the decoder is in trouble. If either the busy or trouble ground continues for an unreasonable time, the following operations take place. Under the control of interrupter 3109, relays 3110 and 3111 are operated. Relay 3111 operates relay 3114 which in turn operates relay 3116 and relay 3115. Relay 3115 connects ground over its inner front contact, lower front contact of relay 3104, conductor 2695 to the windings of relays 2305, 2425 and other similar relays to hold the decoder busy.

Interrupter 3109 continues to function and operates relays 3112 and 3113. Relay 3113 lights lamp 3118 to indicate that the decoder has not functioned properly and also connects ground to conductor 3132 in case the trouble recorder should be busy. Relay 3115 also connects battery to the trouble recorder which, if idle, returns ground to conductor 3132. If relay 3106 is still operated, a circuit is closed from conductor 3132, over the front contacts of relays 3116, and 3106 to the windings of relays 2613, 2669, 2718, 2761, 2813, 2868 and 3306 to disconnect the transmitting conductors from the decoder connector.

The operation of relay 3306 connects ground over conductor 2634 to the winding of relay 3103 and through the decoder connector to conductor 1034, outer left back contact of relay 838, winding of relay 836, resistance 837 to battery. Relay 836 at its left back contact opens the start circuit of the decoder connector permitting the decoder and connector to be released as will be described hereinafter. Relay 836 locks through the left winding of relay 838, left front contact of relay 837 to grounded conductor 1238, but relay 838 cannot operate, being shunted over the operating circuit of relay 836. When the decoder releases, relay 838 operates, locking in a circuit from ground through its right winding to battery over conductor 839. The start circuit is now reclosed over the inner right front contacts of relays 836 and 838. Relay 838 also connects battery from conductor 839 over conductor 948 through the decoder connector to conductor 2148, through the lower winding of relay 3107 to ground. Relay 3107 therefore operates immediately without waiting for the test of the receiving conductors. If the second attempt at completing the call fails so that the second decoder connects ground to conductor 2634 and thence to conductor 1034, since relay 838 is now locked up, this ground is connected over the outer left front contact of relay 838 to resistance 837 in shunt to the winding of relay 836. Relay 836 releases again removing battery from the start conductor 930. Both circuits above traced for starting the decoder are now open, and since relay 838 is locked up no further attempt can be made to establish the connection but the call awaits the action of the timing circuit of Fig. 8 in causing the release of the sender.

Relays 3119 and 3129 constitute a group of relays for recording the number of times that the decoder is used. The use of the decoder is so frequent and so short that instead of operating a meter each time that the decoder is employed, the meter is operated once for every ten times that the decoder is used. Briefly, the operation of these relays is as follows: The first operation of relay 3102 to release the decoder, closes a circuit from ground over conductor 3130 supplied from this meter circuit through the winding of relay 3124. Relay 3124 locks through the upper winding of relay 3119, which does not

operate until relay 3102 releases. The second operation of relay 3102 operates relay 3126 and its release operates relay 3120. The third operation of relay 3102 operates relay 3128 followed by relay 3121. The fourth operation shunts down relay 3124 followed by relay 3119. The fifth operation shunts down relay 3125 followed by relay 3120. With relay 3102 released at this time, relay 3122 is operated and locks to conductor 3130. The sixth operation releases relay 3128 followed by relay 3121. The seventh, eighth and ninth operations reoperate relays 3124, 3119, 3125, 3120, 3128 and 3121. The tenth operation releases relay 3124 followed by relay 3119. At this time relay 3129 operates over the front contact of relay 3122, back contact of relay 3124, front contact of relay 3125, back contact of relay 3102 to conductor 3130. Relay 3129 locks over the back contact of relay 3102 to conductor 3130, connecting ground from conductor 3130 to the conductor 3131 which extends to the meter, indicating that the decoder has been used ten times. Relay 3129 opens the locking circuits of all the counting relays permitting them to restore to normal. When the decoder is used the next time relay 3102 operates releasing relay 3129 starting the counting operation over again.

It may be assumed for the purpose of this description that there are four classes of subscribers including two groups of flat rate subscribers, one having a more extended calling area than the other and two groups of message rate subscribers, one having a more extended calling area than the other. It may also be assumed that the telephone area is divided into five zones in accordance with the charge to be made for calls to those zones from the central office at which the sender is located. Zone relays 3400 to 3405 correspond to these zones and when operated transmit to the sender a setting for the zone class relays in the sender which in turn transmit an indication to the district selector of the charge to be made. The no-charge area for flat rate subscribers may include several local offices for those having the limited service or may include a large number of offices for those having extended service while it includes only official calls for message register subscribers. For offices outside of these local areas the flat rate subscriber must have the assistance of an operator in order that a proper charge should be made while the message rate subscribers may dial such offices directly and have their message registers operated a number of times determined by the zone in which the office lies. Still other more distant offices may be denied to some message rate subscribers and allowed to other subscribers. To take care of these varying conditions the routing relays connected to the contacts of the decoding relays have their opposite terminals cross-connected to the armatures of the class of service relays 3301 to 3304. The front contacts of these relays are connected to the proper zone relays 3400 to 3405 according to whether or not service in that zone is permitted and the charge to be made. If service to a particular zone is denied to a class of subscribers, the contact of the service relay is connected to the winding of relay 3207. The original routing relay cannot operate in series with relay 3207 but relay 3207 does and operates relay 3206 which causes the call to be directed to an operator's position. Since calls to operators are free, the circuit of relay 3206 extends through the zero zone relay 3400.

It is, of course, understood that the classification of the subscribers and the zone may be varied to suit the local conditions. Relay 2533 which is operated and released ineffectively in the present case, may be wired to permit the use of eight classes of subscribers. If the senders of an office serve only a single class of subscribers, the class-of-service relays may be omitted and the routing relays connected directly to the zone relays. If zone charging is not used, the zone relays will be omitted and a resistance substituted between the routing relay and relay 2867.

Under the assumption that the call is to a panel type office in the local zone, the following relays have been operated from the routing relay 3205; relay 1924 to indicate that a short trunk needs considerable compensating resistance; relay 1925 to indicate that marginal trunk guard relay 1314 is to be used; none of the relays of class register 1800 to indicate a full mechanical type call; relay 1812 indicating that the third district brush is to be selected; relays 1310 and 1321 indicating that the district selector is to be advanced to the second talking position; relays 1901 and 1902 to select the fourth group of office selectors, none of the relays of the office brush register 1820 to cause the selection of the first or zero brush; relays 1912 and 1914 to cause the selection of the eighth group of trunks outgoing from the office selector; and relays 1120 and 1121 to indicate that the call is to an office employing neither stations digits nor five digit numbers.

When relay 723 operates to release the decoder, the fundamental circuit is completed for making district brush selection. The circuit for this purpose may be traced as follows: from battery through the upper winding of relay 225, upper right contact of cam 210, lower right contact of cam 213, conductor 248 through the link circuit to conductor 748, upper front contact of relay 723, lower contacts of cam 1722, winding of relay 1300, back contact of relay 1220, inner left contact of relay 1226, right winding of re-

lay 1225, resistance 1230, left back contact of relay 1506, conductor 1514, upper left contact of cam 1709, lower left contact of relay 1708 to ground. Relay 225 operates in this circuit locking over its inner upper front contact and the lower left contact of cam 210 to the fundamental circuit as traced. Relay 225 closes a circuit from battery through the winding of sequence switch magnet 200, upper right contact of cam 224, lower front contact of relay 225, lower back contact of relay 226, upper right contact of cam 209 to ground, advancing sequence switch 200 to position 4. In this position the operating circuit of relay 225 is opened but the relay remains operated in its locking circuit. It also closes a circuit from battery through the winding of up-drive magnet 154, of district selector 150, upper contacts of cam 215, lower front contact of relay 225 to ground as above traced. Magnet 154 causes the district selector to move upward in a brush selecting operation. In this movement, it closes a circuit from ground over the lower contacts of cam 212, brush 158, commutator strip 162, lower contacts of cam 213, to the fundamental circuit, closing a substitute locking circuit for relay 225 and shunting relay 1300. This circuit is closed each time the brush 158 encounters a conducting segment of the commutator strip and is opened each time that it passes over an insulating segment.

Relay 1300 also operates in the fundamental circuit, but the direction of current flow is such that relay 1225 does not. The operation of relay 1300 closes a circuit from ground over the left contacts of cam 1708, conductor 1320, front contact of relay 1300, conductor 1730, left contacts of cam 1707, conductor 1735, upper right contact of cam 1720, lower right contact of cam 1719, left back contact of relay 1813, outer left front contact of relay 1812, conductor 1842, back contact of relay 1216, winding of relay 1215, inner lower front contact of relay 722, to battery. Relay 1215 operates in this circuit and locks through the winding of relay 1216, front contact of relay 1215, outer left contact of relay 1226, upper right contact of cam 1709, lower left contact of cam 1708 to ground. Relay 1216 cannot operate because its winding is shunted by the operating circuit of relay 1215. When commutator brush 158 makes contact with the first conducting segment of strip 162, closing the shunt around the winding of relay 1300, that relay releases permitting relay 1216 to operate. When brush 158 reaches an insulating segment, relay 1300 reoperates and the circuit closed over its contact is extended over the front contact of relay 1216, back contact of relay 1218, winding of relay 1217 to battery. Relay 1217 operates and locks through the winding of relay 1218, back contact of relay 1228, lower left and upper right contacts of cam 1705 to ground, but relay 1218 does not operate until brush 158 reaches the next conducting segment. When brush 158 leaves this segment, relay 1300 reoperates and the circuit is extended over the front contact of relay 1218, lower left and upper right contacts of cam 1713 to the winding of relay 1219 and battery. When brush 158 reaches the third conducting segment, shunting relay 1300 for the third time, relays 1220 and 1229 operate in the locking circuit of relay 1219.

The operation of relay 1220 opens the fundamental circuit releasing both relays 1300 and 225. The release of relay 225 opens the circuit of magnet 154 and brings the selector to rest in position to select the third set of brushes. It also closes a circuit from battery through the winding of sequence switch magnet 200, lower contacts of cam 219, lower back contact of relay 225, back contact of relay 226, upper right contact of cam 209 to ground, advancing sequence switch 200 to position 5. In this position a circuit is closed from battery through the winding of trip magnet 156, upper right contact of cam 214, to ground, rotating the trip rod to trip the selected set of brushes when the selector next moves upward.

The operation of relay 1229 closes a circuit from battery through the winding of relay 1228, lower contacts of cam 1718, right back contact of relay 1235, front contact of relay 1229 to ground. Relay 1228 locks over its inner right contact to ground over the lower left and upper right contacts of cam 1705. Relay 1228 also closes an obvious circuit for relay 1227. When both relays 1228 and 1227 operate, the circuit of relay 1226 is opened and that relay releases. The operation of relay 1228 opens the locking circuit for the odd numbered counting relays, while the release of relay 1226 opens the locking circuit for the even numbered counting relays including relays 1219, 1220 and 1229. The release of relay 1229 closes the circuit from ground over its back contact, outer right front contact of relay 1228, upper left contact of cam 1701, winding of sequence switch magnet 1700 to battery, advancing sequence switch 1700 to position 3. As soon as sequence switch 1700 leaves position 2, the locking circuit of relay 1228 is opened and that relay releases. When relay 1228 recloses its back contact, relay 1226 reoperates over the back contact of relay 1228, upper left contact of cam 1716 and the lower left contact of cam 1708 to ground.

The release of relay 1220, the reoperation of relay 1226 and the advance of sequence switch 1700 reclose the fundamental circuit. Relays 225 and 1300 again operate, relay 225 locking as before and advancing sequence switch 200 to position 6 in which position the up-drive magnet is again operated under the

control of relay 225 and an intermittent circuit prepared from ground as above traced over brush 159, commutator strip 163, lower contacts of cam 210 to the winding of relay 225 and in shunt of the winding of relay 1300. As the district selector moves upward in its group selecting operation, this circuit is intermittently closed, releasing relay 1300 in the manner above described. With sequence switch 1700 in position 3, the counting relay circuit extends from ground over the contact of relay 1300 to conductor 1735 as above traced and thence over the upper right contact of cam 1720, the upper left contact of cam 1719, right front contact of relay 1901, right front contact of relay 1902, conductor 1843, back contact of relay 1214, winding of relay 1213 to battery. The counting relays function to count four closures of the intermittent circuit and then the operation of relay 1220 opens the fundamental circuit. Relay 225 releases bringing the district selector to rest with the brushes engaging the first trunk in the fourth group. It also advances sequence switch 200 to position 7 in the manner above described.

With sequence switch 200 in position 7, relay 225 is reoperated in the circuit which may be traced through the lower winding of relay 225, upper left contact of cam 220, right contact of cam 222, lower contacts of cam 217, front contact of relay 229, lower left contact of cam 214, to ground. Relay 225 advances sequence switch 200 out of position 7 and into position 8. When sequence switch 200 reaches position 7½, the testing circuit for the first outgoing trunk is closed over the sleeve of that trunk, sleeve brush 153 of the district selector, lower contacts of cam 221, inner upper front contact and winding of relay 225 to battery. Therefore, if the first outgoing trunk is busy, as indicated by ground connected to its sleeve terminal, relay 225 is held operated. Another holding circuit is closed over the outer upper front contact of relay 225, and the right contacts of cam 203, to the sleeve brush. If relay 225 remains operated in position 8, updrive magnet 154 is again operated and the selector moves upward in search of an idle trunk. Relay 225 is held operated between trunks in a circuit through its lower winding, upper left and lower right contacts of cam 220, centering commutator strip 161, brush 157, left contacts of cam 215, lower front contact of relay 225, back contact of relay 226, upper right contact of cam 209 to ground.

When an idle trunk is found and the brushes are properly centered, relay 225 releases, advancing sequence switch 200 to position 9. In position 9 relay 225 is operated through its lower winding, upper right and lower left contacts of cam 217, front contact of relay 229, lower left contact of cam 214, to ground. Relay 225 advances sequence switch 200 to position 10 where relay 225 is held operated under the control of relay 229. In this position the tip of the fundamental circuit is extended from conductor 248, upper back contact of relay 237, lower contacts of cam 204 to brush 151 and thence to the tip conductor of the office selector, and the ring of the fundamental circuit is extended from conductor 247, over the lower right and upper left contacts of cam 205 and brush 152 to the ring conductor of the office selector. At the office selector, the tip and ring conductors extend to battery and ground respectively.

In the sender the operation of relays 1220 and 1229 performs the same function as above described, advancing sequence switch 1700 to position 4. With sequence switch 1700 in position 4, a circuit is closed from battery through the winding of relay 1602, upper right and lower left contacts of cam 1710 to grounded conductor 1319. Relay 1602 in operating, with neither relay 1504 nor relay 1505 operated, closes a circuit from battery through resistance 1603, inner left front contact of relay 1602, right back contacts of relays 1504 and 1505, right winding of relay 1506 to ground. With relay 1506 operated, the circuit for testing the office selector is closed. This circuit extends from the office selector over the fundamental circuit to conductor 748, upper front contact of relay 723, left back contact of relay 1804, through resistance 1725, lower left and upper right contacts of cam 1703, conductor 1731, right front contact of relay 1506, conductor 1510, right front contact of relay 1925, winding of relay 1314, back contact of relay 1220, inner left contact of relay 1226, right winding of relay 1225, left contacts of cam 1717, back contact of relay 1921, through resistances 1927 and 1926, back contact of relay 1922, upper right and lower left contacts of cam 1714, back contact of relay 1231 to conductor 747 and thence to the office selector. If the circuit is properly completed at that point, relay 1314 operates, but relay 1225 does not. The presence of resistance 1725 also prevents the premature operation of the control relay of the office selector. Relay 1314 closes an obvious circuit for relay 1307 which locks to ground over conductor 1734 and the lower right contact of cam 1709. Relay 1307 closes a circuit from ground at its left front contact, left contacts of cam 1706, through the winding of sequence switch magnet 1700 advancing the switch to position 5. As soon as the switch leaves position 4, the locking circuit of relay 1307 is opened. The advance from position 4 also opens the testing circuit and as soon as position 5 is reached, the fundamental circuit is closed from conductor 748 to the lower right contact of cam 1722, lower left contact of that cam, through the

winding of relay 1300 to the back contact of relay 1220 and thence as traced for the testing circuit to the fundamental ring conductor 747.

The operations in making office selections are very much the same as those described for making district selections. The counting relay circuit for making office brush selection may be traced from ground over the front contact of relay 1300 to conductor 1735, upper right contact of cam 1720, upper right contact of cam 1719, back contact of relay 1821, left back contact of relay 1822, right back contact of relay 1823 to conductor 1840, lower left and upper right contacts of cam 1713 to the winding of relay 1219 and battery. Therefore, a single revertive impulse from the office selector satisfies the recorded condition in the sender and the first set of office brushes is selected. Relays 1220, 1229, 1228, 1227 and 1226 operate as previously described to advance sequence switch 1700 to position 6 where office group selections are made. In this position the reoperation of relay 1226 awaits the release of relay 1227 which is slow to release. The fundamental circuit is the same as that for office brush selection but the counting relay circuit extends over the upper contacts of cam 1720, right back contact of relay 1911, outer left front contact of relay 1912 to conductor 1842. Two reverted impulses therefor cause the operation of relay 1215 to 1218. With relay 1218 operated, the circuit now extends over the left contacts of cam 1713, right front contact of relay 1914, conductor 1845 to the back contact of relay 1202, winding of relay 1201 and battery. The following five revertive impulses cause the operation of relays 1201 to 1210, inclusive, and the operation of relay 1210 extends the counting circuit to the winding of relay 1219 so that the eight revertive impulse causes the operation of relays 1220 and 1229 resulting in the opening of the fundamental circuit and the advance of sequence switch 1700 to position 7 where a test is made of the trunk outgoing to the incoming selector at the wanted office. As in position 6, the fundamental circuit is not reclosed until relay 1227 has released.

As soon as sequence switch 1700 leaves position 3, the locking circuit for the relays of registers 1900 and 1810 is opened, and relays 1901, 1902 and 1812 release. When sequence switch 1700 reaches position 7, a circuit is closed from battery over the inner left back contact of relay 1804, conductor 1850, through the winding of relay 1501, conductor 1511, upper contacts of cam 1715, conductor 1732 and thence over the inner left front contact of relay 1001 to grounded conductor 1317. Therefore, relay 1501 cannot operate until the thousands digit has been recorded as indicated by the operation of relay 1001. Relay 1501 in operating connects the thousands register 1000 to the district brush register 1810 which now becomes the incoming brush register. Relay 1830 is now included in this register. Since the number of the called subscriber was assumed to be 3678, relays 1004 and 1005 of register 1000 will be operated and a circuit will be closed from ground over the middle right contact of relay 1004, outer right front contact of relay 1501, winding of relay 1830 to battery. A second circuit is closed from conductor 1732 which is grounded by the operation of relay 1001, inner right contact of relay 1005, middle right contact of relay 1501, conductor 1041, winding of relay 1811 to battery.

In position 7 of sequence switch 1700 the trunk testing circuit extends as traced in position 4, except that the amount of compensating resistance is now controlled by relays 1923 and 1924 and the circuit therefore extends from the lower left contact of cam 1714 to the lower left contact of cam 1717 by way of the right front contact of relay 1924, resistance 1926 and the right back contact of relay 1923 so as to include only resistance 1926 instead of both resistances 1927 and 1926. Relay 1602 and relay 1506 are again operated in positions 6 and 7 to complete the testing circuit as previously traced. As before, the completion of the circuit at the selector permits the operation of relay 1314, in turn operating relay 1307 which locks as long as sequence switch 1700 is in position 7. It closes a circuit from ground over its outer left contact and the lower contacts of cam 1706, right back contact of relay 1804 to the winding of sequence switch 1700 advancing the sequence switch from position 7 to position 8. The advance of sequence switch 1700 opens the locking circuit of relay 1307 which releases. It also opens the locking circuit for the relays of registers 1820 and 1910.

In position 8 incoming brush selection takes place in a manner similar to the other selections, the fundamental circuit extending as for office selection except that resistance 1926 is included alone as in the test circuit. The counting relay circuit for this selection extends from ground over the contact of relay 1300 to conductor 1735, inner left back contact of relay 1236, lower contacts of cam 1719, left back contact of relay 1813, left back contact of relay 1812, right front contact of relay 1811 to conductor 1841 and thence to the winding of relay 1217 so that two revertive pulses are received and the second brush set of the incoming selector is chosen.

The operation of relay 1229 closes a circuit from ground over its front contact, right back contact of relay 1235, lower left and upper right contacts of cam 1718, winding of sequence switch magnet 1700 to battery, advancing the sequence switch to position 9.

In position 9 a circuit is closed from bat-

tery over the back contact of relay 1804, conductor 1850, winding of relay 1502, conductor 1512, upper contacts of cam 1721, conductor 1742, inner left front contact of relay 1011, to ground at the front contact of relay 1030. Incoming group selection is under the joint control of the thousands and hundreds registers, and therefore can be made only after the hundreds digit has been recorded as indicated by the operation of relay 1011. With relay 1502 operated, a circuit is closed from ground over the middle right front contact of relay 1502, upper right contact of cam 1701 to the winding of sequence switch magnet 1700, advancing the sequence switch to position 10 in preparation for making incoming group selection. Relay 1502 also connects the hundreds register 1010 with office brush register 1820 which now becomes the final brush register and with relay 1901 of the district group register 1900 which now becomes the incoming group register. Under the assumption made, relays 1014 and 1017 are operated. A circuit is closed from ground at the right contact of relay 1014, outer right front contact of relay 1502, conductor 1031, right winding of relay 1821, to battery. Another circuit is closed from ground over the inner right contact of relay 1017, inner right contact of relay 1502, conductor 1081, right winding of relay 1901 to battery. Since relay 1830 was operated, a circuit is closed from ground over the upper front contact of relay 722, conductor 750, outer left contact of relay 1501, right front contact of relay 1830, right back contact of relay 1813 to the winding of relay 1902 and battery.

With sequence switch 1700 in position 10, the fundamental circuit is established for incoming group selection and is the same as that for incoming brush selection. The counting relay circuit extends as for incoming brush selection to the lower left contact of cam 1719, and thence over the upper left contact of cam 1719, front contact of relay 1901, front contact of relay 1902, conductor 1843, back contact of relay 1214 to the winding of relay 1213 and battery. Therefore, four revertive impulses are required to satisfy the sender and the fourth group of final selectors is selected. The incoming selector hunts for an idle final selector in the usual manner and extends the fundamental circuit to it when found. The operation of relay 1229 advances sequence switch 1700 to position 11. When sequence switch 1700 leaves position 10 relay 1501 releases in turn releasing the relays of register 1810. In this position the fundamental tip is connected to the fundamental ring to discharge any charge which may have accumulated thereon before starting final selection. The circuit extends for this purpose from conductor 748 to the back contact of relay 1804, through resistance 1725, left contacts of cam 1703, resistance 1726, right back contact of relay 1231 to conductor 747. Since relay 1502 is operated, sequence switch 1700 is immediately advanced to position 12 where the fundamental circuit is reclosed for final brush selection.

The counting relay circuit for final brush selection extends from ground over the lower left and upper right contacts of cam 1708, conductor 1730, front contact of relay 1300, conductor 1320, upper contacts of cam 1707, conductor 1735, inner left contact of relay 1236, lower left and upper right contacts of cam 1719, front contact of relay 1821, back contact of relay 1822, conductor 1841 to the winding of relay 1217 so that the second brush set of the final selector is taken for use. As before, the operation of relay 1229 advances sequence switch 1700 to position 13. The advance of the sequence switch releases relay 1502 and the relays of registers 1820 and 1900.

In position 13 a circuit is closed from battery over the back contact of relay 1804, conductor 1850, through the winding of relay 1503, conductor 1513, lower contacts of cam 1715, conductor 1743, inner front contact of relay 1021 to ground at the front contact of relay 1030. Relay 1503 connects the tens register 1020 with the relays of register 1910 which now becomes the final tens register. Since relays 1025 and 1027 were operated, circuits are closed from ground over the right contact of relay 1025, inner left contact of relay 1503, conductor 1052, winding of relay 1912 to battery and from ground over the inner right contact of relay 1027, outer right contact of relay 1503, conductor 1054, winding of relay 1914 to battery. Relay 1503 also connects ground to the winding of magnet 1700 advancing the sequence switch to position 14 in which position final tens selection is made. The counting relay circuit for final tens selection may be traced over the contact of relay 1300 to conductor 1735, inner left back contact of relay 1236, lower left contact of cam 1719, upper left contact of cam 1720, back contacts of relay 1911, front contact of relay 1912, conductor 1842, back contact of relay 1216, winding of relay 1215 to battery. Two revertive impulses operate relays 1215 to 1218, when the circuit is extended over the front contact of relay 1218, left contacts of cam 1713, front contact of relay 1914 to conductor 1845, back contact of relay 1202, winding of relay 1201 to battery. Five more impulses operate relays 1201 to 1210, when the circuit is extended to relay 1219. Therefore, eight revertive impulses are necessary to satisfy the setting of the sender. The operation of relay 1229 advances sequence switch 1700 to position 15, releasing relay 1503 and the relays of register 1910.

In position 15 a circuit is closed from battery over conductor 1850 through the winding of relay 1601, conductor 1604, lower contacts of cam 1721, conductor 1744, inner right front contact of relay 1101 to ground at the front contact of relay 1030. Therefore, relay 1601 can only operate after the units digit has been completely recorded. Relay 1601 connects the units register 1100 with the relays of registers 1900, which now serves as the final units register. Since relays 1104, 1105 and 1107 are operated, circuits are closed from ground over the right contact of relay 1104, inner left contact of relay 1601, conductor 1081, winding of relay 1901 to battery, from ground over the right contact of relay 1105, outer left contact of relay 1601, conductor 1082, winding of relay 1902 to battery, and from ground over the outer right front contact of relay 1107, middle right contact of relay 1601, conductor 1084, right winding of relay 1904 to battery. Relay 1601 also closes a circuit from ground at its outer right contact over the upper right contact of cam 1701, through the winding of sequence switch magnet 1700 advancing the sequence switch to position 16 in which position the fundamental circuit is reestablished for making final units selection. With relays 1901 and 1902 operated, the counting relay circuit extends over the left contacts of cam 1719, front contact of relay 1901, front contact of relay 1902, conductor 1843, back contact of relay 1214, winding of relay 1213 to battery. Three revertive impulses operate relays 1213 to 1218, when the circuit is extended over the lower contacts of cam 1713, front contact of relay 1904 to conductor 1845 and the winding of relay 1201. Five more revertive impulses result in the operation of relays 1201 to 1210 inclusive while the ninth revertive impulse operates relays 1219, 1220 and 1229. In this position of sequence switch 1700, the operation of relay 1229 causes the operation of relay 1228 in turn operating relay 1227 and releasing relay 1226 to release the counting relays in the manner previously described. With relay 1229 released, and relay 1228 operated, sequence switch 1700 is advanced to position 17 releasing relay 1601 and the relays of register 1900. In position 17 the fundamental circuit is reestablished for receiving reversed battery from the incoming selector, as soon as relay 1226 reoperates following the reclosure of the back contact of relay 1227.

After the wanted line has been found, the incoming selector is advanced to a position in which reversed battery is connected to the fundamental circuit. Therefore, relays 1300 and 1225 are both operated. Relay 1225, in operating, closes a circuit from ground at its contact over the left contacts of cam 1711, through the left winding of relay 1225 to battery holding the relay operated. It also closes a circuit over the upper left and lower right contacts of cam 1711, winding of relay 1235 to battery. With relay 1235 operated, the operation of relay 1300 closes a circuit from ground over its front contact to conductor 1735 as previously traced, inner left front contact of relay 1235, winding of relay 1219 to battery. Relay 1219 operates and locks as before described. A relay in the incoming selector also operates over the fundamental circuit and advances the incoming selector to a position where the reversed battery is removed. Relay 1300, therefore, releases, but relay 1225 is locked holding relay 1235 operated. The release of relay 1300 removes the shunt from relays 1220 and 1229 and these relays now operate. Relay 1229 closes a circuit from ground over its front contact, right front contact of relay 1235, winding of relay 1231 to battery. Relay 1231 operates, locking over its inner left contact to grounded conductor 1238. Relay 1231 opens the fundamental ring conductor at its right contact. Relay 1229 also closes a circuit from ground at its front contact over the right front contact of relay 1235, lower contacts of cam 1712, right contacts of cam 812 through the winding of relay 1232 to battery. Relay 1232 in operating closes a circuit from battery through the winding of relay 1228, right front contact of relay 1232, upper right contact of relay 1716 to ground. Relay 1228 locks over cam 1705, operates relay 1227, releases relay 1226, and relays 1219, 1220 and 1229. When relay 1229 releases, it closes a circuit over the back contact of relay 1229, front contact of relay 1228, cam 1701, to magnet 1700 advancing the sequence switch to position 18. Relays 1225 and 1235 release. Relay 1231 remains locked and holds relay 1232 operated. Relay 1228 also releases, reclosing the circuit of relay 1226 over the upper left contact of cam 1716 to ground.

The operation of relay 1232 opens the shunt around the high resistance winding of relay 1306, including this resistance in the circuit of relay 229 at the district selector. Relay 229 cannot remain operated in series with this resistance and, therefore, releases, in turn releasing relay 225 which advances sequence switch 200 from position 10 to position 11. With sequence switch 200 in position 11, ground is connected to conductor 245 over the lower right contact of cam 214. This ground is connected to conductor 245 before relay 229 is disconnected therefrom and, therefore, reoperates that relay. If the calling subscriber still has the receiver off the switchhook, relay 231 is held operated in the dialing circuit previously traced and a second circuit is closed for relay 229 through resistance 239, front contact of relay 231, upper left contact of cam 214 to ground in which it is held operated through position 17 of the sequence switch under the control of the calling subscriber. Sequence switch 200 is

advanced from position 11 to position 12 over the upper right contact of cam 224, right contacts of cam 215 and the lower contacts of cam 212. When sequence switch 200 leaves position 11, relay 229 is disconnected from conductor 245.

In the sender, the disconnection of battery from conductor 245 opens the circuit of relay 1306 which releases, in turn releasing relay 1234. With relay 1234 released, a circuit is closed from ground over its outer right back contact, left contact of relay 1233, winding of relay 1305, to battery. Relay 1305 locks over its outer right front contact to conductor 745. It also connects ground in shunt of battery through resistance 1304 so that relay 1233 also releases.

With relay 1234 released, the circuit for making talking selection is completed as follows: battery through the upper winding of relay 225, upper right contact of cam 210, lower right contact of cam 213, conductor 248 through the link circuit to conductor 748, front contact of relay 723, lower contacts of cam 1722, winding of relay 1300, back contacts of relay 1220, front contact of relay 1226, right winding of relay 1225, resistance 1230, inner right back contact of relay 1234 to ground. Relay 1300 closes a counting relay circuit from ground as previously traced to the upper right contact of cam 1720, lower left contact of that cam, back contact of relay 1224, front contact of relay 1310, front contact of relay 1321, conductor 1841, lower back contact of relay 1218, winding of relay 1217 to battery. Relay 225 in operating closes a circuit from battery through the winding of sequence switch magnet 200, upper right contact of cam 224, lower front contact of relay 225, upper left contact of cam 209 to ground. As sequence switch 200 advances out of position 21 through positions 12⅜ and 13⅜, ground is connected over the left contacts of cam 221 and the lower left contact of cam 210, lower right contact of cam 213, to conductor 248 in shunt of the winding of relay 1300. Relay 1300 releases twice, permitting relays 1217, 1218, 1219, 1220 and 1229 to operate. Relay 1220 opens the holding circuit for relay 225 which now releases holding sequence switch 200 in position 14 in which a charge is made.

When sequence switch 200 advances to position 11¼ the dialing circuit is opened and in position 11½ the calling subscriber's talking circuit is completed from ground over the upper left winding of repeating coil 234, upper contacts of cam 201, inner back contact of relay 125, brush 111 of the line finder 110 through the subscriber's substation back to brush 112, middle back contact of relay 125, winding of relay 231, lower contacts of cam 202, lower left winding of repeating coil 232 to battery. The cuttings of cam 202 overlap sufficiently to prevent the release of relay 231. The opening of the dialing circuit releases relay 724 which in turn releases relays 716, 713, 714 and 715.

The operation of relay 1229 closes a circuit from ground over the front contact of relay 1229, back contact of relay 1235, left contacts of cam 1718, winding of relay 1237 to battery. It also connects ground over the left back contact of relay 1234 and the left contacts of cam 1723 to the winding of relay 1237 to insure its operation. The release of relay 225 also connects ground over the upper left contact of cam 209, lower back contact of relay 225, right contacts of cam 219, conductor 247 through the link to conductor 747. The operation of relay 1237 opens the circuit of relay 1301, connects battery through the resistance 1302 over the outer left front contact of relay 1237 and the inner right front contact of relay 1305 to conductor 745.

The connection of battery to conductor 745 reverses the direction of current flow through the upper winding of relay 424 so that the relay now operates, closing a circuit from ground over its lower front contact, lower contacts of cam 624, upper winding of relay 422 to battery. Relay 422 locks in a circuit from battery through its upper winding and upper front contact to ground over the lower contacts of cam 625. Relay 422 closes a circuit from ground at the lower back contact of relay 420, inner lower front contact of relay 422, right contacts of cam 623 to the winding of sequence switch magnet 600 and battery, advancing sequence switch 600 to position 6. In this position, conductors 743, 744, 746, 747 and 748 are all disconnected from the corresponding conductors of the district selector, the connection of conductor 745 being maintained until the sequence switch moves out of position 5½, at which time relay 424 releases.

In position 6, the locking circuit of relay 422 is held closed, if the sender selector is within predetermined distance of the top of its bank. This is determined by the use of commutator segments 463 and 464. Segment 464 extends over the top ten terminals and segment 463 over the next ten terminals, so that, according as segment 463 alone or both 463 and 464 are used, the locking circuit of relay 422 over the right contacts of cam 615 is held closed, if the sender selector is engaging one of the top ten or one of the top twenty terminals. With relay 422 held operated in position 6, a circuit is closed from battery through resistance 421, winding of relay 420, upper left and lower right contacts of cam 619, outer lower front contact of relay 422, lower left and upper right contacts of cam 618 to ground. Relay 420 closes a circuit from battery through the winding of down-drive magnet 466, lower left and upper right contacts of cam 611, lowermost front contact of relay 420 to ground. The sender se-

lector is thereby driven to its lowermost position, where a circuit is closed from ground over strip 460, brushes 459 and 458, commutator segment 461, lower contacts of cam 616, to resistance 421 in shunt of the winding of relay 420, releasing that relay and opening the circuit of the down-drive magnet 466, leaving the sender selector in its lowermost position ready to hunt for another sender. As soon as brush 458 leaves segments 464 and 463, relay 422 releases. If the sender selector is engaging any set of terminals below the eightieth, relay 422 releases when sequence switch 600 leaves position 5½ and the sender selector remains in engagement with the set of terminals last used.

When relay 422 falls back, sequence switch 600 is energized over the upper left contact of cam 613, lower back contact of relay 422, lower left and upper right contacts of cam 618 to ground, advancing sequence switch 600 to position 7. In this position, the link is ready to associate itself with another idle district. When a district is ready for association with a link circuit, its sequence switch is advanced to position 1 and a circuit is closed similar to that traceable from ground over the lower right contact of cam 212, lower right contact of cam 214, lower left and upper right contacts of cam 211, contact of jack 230, conductor 249, contact of jack 622, contact of jack 614, lower contacts of cam 618, upper back contact of relay 424, lower left and upper right contacts of cam 619 to the winding of relay 423 and battery. Relay 423 closes a circuit from battery through the middle winding of relay 424, left contacts of cam 624, lower winding of relay 424, to ground at the front contact of relay 423. At the same time, a circuit is closed from ground at the inner upper front contact of relay 423, through the lower winding of relay 424, lower left and upper right contacts of cam 624, upper winding of relay 424, back contact of relay 420, upper left and lower right contacts of cam 626, contact of jack 614 to brush 404 to test for a district selector in the awaiting link condition. In position 1 of the district selector sequence switch, battery through a predetermined resistance is connected to the terminal to which brush 404 has access over a circuit similar to that traceable from battery through resistance 241, lower left and upper right contacts of cam 216, contact of jack 230 and conductor 246. When district finder reaches a set of terminals marked in this manner, relay 424 operates.

If the district finder 400 reaches the top of its bank without finding a district ready for association with the link, a circuit is closed from ground over commutator strip 410, brushes 409 and 408, commutator segment 415, lower left and upper right contacts of cam 610, winding of relay 420, resistance 421 to battery. Relay 420 locks over its inner lower contact and the upper left and lower right contacts of cam 625. It also opens the circuit of up-drive magnet 413 and closes a circuit from ground over its lowermost front contact, upper contacts of cam 611, winding of down-drive magnet 414 to battery. The district finder is restored to normal in this circuit. Relay 420 also opens the testing circuit leading to brush 404 to prevent the false operation of relay 424. When the finder has reached normal, ground is connected over segments 410 and 411 and brushes 408 and 409, upper right and lower left contacts of cam 616 to resistance 421, shunting and releasing relay 420 which restores the testing circuit as well as the circuit of up-drive magnet 413 and the hunting continues.

When a district is found standing in position 1, relay 424 operates opening the circuit of relay 423 which now releases closing a circuit from battery, through sequence switch magnet 600, lower left contact of cam 613, contact of jack 607, lower back contact of relay 423, upper front contact of relay 424, lower contacts of cam 618, contact of jack 614, contact of jack 622 to ground over conductor 249. Sequence switch 600 is advanced to position 8 in this circuit. In this position relay 424 remains locked under the control of battery from the district selector. In position 8 a circuit is closed from ground over the upper right and lower left contacts of cam 618, upper front contact of relay 424, left contacts of cam 608, brush 401, to the tip conductor of the district selector engaged by finder 400 whence the circuit is similar to that traceable over conductor 243, upper left contact of cam 213, upper right contact of cam 210, upper winding of relay 225 to battery. This relay locks over its inner upper front contact and the left contacts of cam 221 and advances sequence switch 200 to position 2. As the sequence switch leaves position 1, relay 225 releases and the sequence switch comes to rest in position 2. The advance from position 1 disconnects battery from conductor 246 thus permitting relay 424 to release and close a circuit from battery through sequence switch magnet 600, upper right contact of cam 613, back contact of relay 424, lower left and upper right contacts of cam 618 to ground, advancing the sequence switch to position 9. The link remains in this position until the link next to it in the chain has been taken for use and advanced to position 2. Assuming that the link represented by cams 631 to 636 inclusive is the next link, when this link reaches position 2, a circuit is closed from ground over the left contacts of cam 635, right contacts of cam 636, contact of jack 607, left contacts of cam 606, right contacts of cam 605, to the winding of sequence switch magnet 600 advancing the

sequence switch to position 10 which is the equivalent of position 1 and making this link ready for use in connection with the next incoming call in this group of lines.

Returning now to the sender, the disconnection by the link of the conductors extending to the district selector results in the release of relay 1305. With relay 1305 released, as well as the relay 714 as above described, a circuit is closed from battery through the winding of sequence switch magnet 1700, lower right contact of cam 1701, lower contact of relay 714, back contact of relay 1233, back contact of relay 1305 to ground. Sequence switch 1700 advances in this circuit to position 1 thereby disconnecting battery at cam 1724 from the various conductors associated therewith and ground at cam 1716 from conductor 1238, which in turn releases relay 1303. With sequence switch 1700 in position 1, a circuit is closed for returning sequence switch 2000 to position 1, if it should be off normal. The disconnection of ground from conductor 1238 releases relay 826 which controls the time measure switch thereby closing a circuit from ground at its back contact, lower left contact of cam 808, upper right contact of cam 801, left winding of relay 827 to battery. Relay 827 closes a circuit for advancing sequence switch 800 which is maintained until sequence switch 800 reaches position 1 at which time relay 827 also releases and brings the time measure switch to rest.

In the district selector when the sequence switch comes to rest in the talking position selected, i. e. position 14, the outgoing end of the talking circuit is established from tip brush 151, left contacts of cam 204, upper right winding of repeating coil 232, left contacts of cam 203, winding of relay 233, lower right winding of repeating coil 232, left contacts of cam 205 to ring brush 152.

In the meantime the incoming selector connects ringing current to the called subscriber's line and when that subscriber responds, the current flow through relay 233 is reversed so that relay 233 operates, closing a circuit from ground over the lower right contact of cam 209, front contact of relay 233, lower left and upper right contacts of cam 220, left contact of interrupter 235, the winding of relay 226 to battery. Relay 226 locks over its inner upper front contact, right contact of cam 222, lower left contact of cam 220 to ground under the control of relay 233. When interrupter 235 closes its right contact, a circuit is closed over the outer lower front contact of relay 226, upper right and lower left contacts of cam 218 to the winding of relay 237 and battery. Relay 237 locks to ground over the upper left contact of cam 209.

At the end of the conversation, when the called subscriber restores his receiver to the switchhook, the direction of current flow through relay 233 is restored and that relay releases in turn releasing relay 226. When the calling subscriber restores his receiver, relay 231 releases in turn releasing relay 229. With relay 229 released, a circuit is closed from ground over interrupter 236, back contact of relay 229, lower left contact of cam 208, lower right contact of cam 211, upper winding of relay 125 to battery. Relay 125 locks through its lower winding and inner front contact to ground over the upper left and lower right contacts of cam 212. It also disconnects the tip and ring conductors from the tip and ring brushes, and disconnects ground through resistance 126 from brush 113. Ground from the upper middle contact of relay 237 is still connected through resistance 126 to that terminal. Relay 125 also connects ground over its lowermost front contact, lower right contact of cam 216, upper left contact of cam 223, through the winding of sequence switch magnet 200 to battery, advancing the sequence switch to position 17. As the sequence switch passes through positions 15 to 17, the locking circuit of relay 237 is held closed and battery is connected through resistance 238, outer lower contact of relay 237, lower contacts of cam 206, brush 114, back contact of relay 101, winding of message register 103 to ground, registering a single call. In position 17 a circuit is closed from ground over the interrupter 236, back contact of relay 229, lower left contact of cam 208, lower right contact of cam 211, upper left contact of cam 216, upper right contact of cam 223, winding of relay 226 to battery. Relay 226 locks over its inner upper front contact, upper right and lower left contacts of cam 222 to off-normal commutator strip 141 and ground over brush 118. With relay 226 operated, magnet 200 is energized over the lower right contact of cam 207, upper right contact of cam 218, lower front contact of relay 226, upper right contact of cam 209 to ground. Sequence switch 200 is thereby advanced to position 18. As sequence switch 200 leaves position 17¼ the locking circuit of relay 237 is opened. With relay 237 released, ground is disconnected from brush 112 and cut-off relay 102 releases restoring the subscriber's line circuit to normal. In this position down-drive magnet 155 of the district selector is energized in a circuit from battery through the winding of magnet 155, left contacts of cam 210, left contacts of cam 221 to ground. At the same time a circuit is closed from battery through the winding of down-drive magnet 116 of the line finder, upper contacts of cam 218, front contact of relay 226, upper right contact of cam 209 to ground. When the line finder reaches normal, the locking circuit of relay 226 over commutator strip 141 is opened and that relay releases. When the district selector reaches normal, a circuit is closed from

battery through the winding of sequence switch magnet 200, upper left contact of cam 224, normal commutator segment 160, brush 157, lower contacts of cam 212 to ground advancing sequence switch 200 to position 1, where it awaits selection by another link in the manner above described.

Call to two-digit office reached through full mechanical tandem office

Assume now that a call is originated by a subscriber whose line is equipped with a message register and who is entitled to extended service. The district selector of Figs. 1 and 2 would not serve such a subscriber since it is equipped for making only a single charge, but the district selector which is disclosed and described in detail in the application of R. E. Collis, Serial No. 463,945, filed June 26, 1930, would be used. Assume also that the subscriber wishes to call a manual office located in a distant zone, for example, zone 5, and reached through a full mechanical tandem office and that the called subscriber's number is Chelsea 10459. Since the first code digit is "C" which is the equivalent of the digit 2, which is one of the digits identifying a two digit code, only the first two digits of the office name will be dialed, i. e., digits 2 and 4.

The initiation of the call and the connection of the subscriber's line with the sender will proceed as above described except that ground will be connected over the lower right and upper left contacts of cam 617 to brush 455, conductor 747, back contact of relay 1303, conductor 1315, through the right winding of relay 1407 to battery. Ground will also be connected over the upper right and lower left contacts of cam 612 to brush 456, conductor 748, back contact of relay 723, right winding of relay 1406 to battery. Relays 1406 and 1407 lock in a circuit from battery over cam 1724, conductor 1729, left windings and left front contacts of relays 1407 and 1406 to grounded conductor 1238.

The first digit 2 will be recorded on register 900 and, since relay 905 is operated, relay 1402 will be operated and relay 1401 over cross-connecting rack 1400, back contact of relay 1403, front contact of relay 1402, back contact of relay 904 to grounded conductor 1317. With relay 1401 operated, the operation of relay 901 closes a circuit from battery through the winding of relay 922, back contact of relay 921, front contact of relay 1401 to grounded conductor 1239 which is grounded over the inner front contact of relay 901. The second digit is, therefore, recorded on register 920 operating relay 926. The remaining digits will be recorded on registers 1000, 1010, 1020, 1100, 1110, in the usual manner, relays 1004, 1013, 1026, 1107, 1116 and 1117 being operated.

As previously described, the operation of relay 921 causes the operation of relay 721 and the connection of battery to conductor 930 to initiate the association of the decoder with the sender. With relay 905 operated, ground is connected directly to conductor 935 and with relay 926 operated, ground is connected directly to conductor 956. Since none of the relays of register 910 are operated, none of the conductors 944 to 947 are grounded. Since relays 1406 and 1407 are operated, conductors 966 and 967 are also grounded. Therefore, after the conductors have been tested in the manner previously described relays 2502, 2523, 2531 and 2532 remain operated. Relay 2502 causes the operation of relay 2902 and relay 2523 grounds the outermost contacts of relays 3010 to 3019. None of the relays of register 2510 is operated. Since zero is not used for office codes, it is assumed that zero is dialed falsely for the letter O and the circuits are arranged to operate relays 3006 and 3016, whether register 2510 is set for 6 or zero. Therefore, relays 3006 and 3016 are operated and the ground supplied by relay 2523 is extended over the outermost contact of relay 3016 to a contact of relay 2902 which is cross-connected over conductor 2930 to routing relay 3202, the other terminal of which is connected to the next to innermost armatures of the service group relays 3301 to 3304. Since relays 2531 and 2532 were operated, a circuit is closed from ground at the lower contact of relay 3107 over the front contact of relay 2531, front contact of relay 2532, back contact of relay 2533, winding of relay 3304, through the winding of relay 3305 to battery. With relay 3304 operated, the circuit of relay 3202 extends over the next to the innermost contact of relay 3304 through the winding of relay 3405, winding of relay 2867 to battery. Relay 3405 closes a circuit from ground over its contact through the lower winding of relay 3412, winding of relay 3415, winding of relay 3417 to battery. Relay 3412 closes a circuit from ground through the winding of relay 3413, upper front contact of relay 3412, conductor 2692, through the decoder connector to conductor 1092, right winding of relay 1505 to battery. It also closes a circuit from ground over its lower front contact to conductor 2870 to hold relay 3105 operated. Relay 3415 closes a circuit from ground through the winding of relay 3414, front contact of relay 3415, conductor 2176, through the decoder connector to conductor 976, left winding of relay 1321 to battery. Relay 3202 in operating closes circuits for operating the following transmitting register relays in the manner previously described; relays 2803, 2810, 2859, 2862, 2753, 2756, 2707, 2717, 2656, 2662, 2606 and 2609.

Relay 2859 in operating connects ground through the winding of relay 2864 to conductor 2174 and ground through the winding of relay 2865 to conductor 2171. Relay

2803 in operating connects ground through the winding of relay 2811 to conductor 2672. Relay 2753 in operating closes a circuit from ground through the winding of relay 2759 to conductor 2642 while relay 2756 which operated in series with relay 2759 connects ground through the winding of relay 2757 to conductor 2625. Relay 2707 in operating connects ground through the winding of relay 2712 to conductor 2684 and through the winding of relay 2713 to conductor 2681, while relay 2717 which was energized in series with relay 2707, connects ground through the winding of relay 2719 to conductor 2685. Relay 2656 in operating connects ground through the winding of relay 2664 to conductor 2693. Relay 2606 in operating connects ground through the winding of relay 2612 to conductor 2644. The chain circuit is closed over the contacts of the relays operated from the routing relay and the relays in series with the transmitting conductors in a manner similar to that described in the previous operation of the decoder. If the circuit is completed, relay 3102 operates, causing the operation of relays 722 and 723 as previously described.

In the sender, the grounding of the above enumerated conductors results in the operation of relays 1921 and 1924 in compensating resistance register, relay 1802 in the class register, relay 1812 in the district brush register, relays 1901 and 1904 in the district group register, and no relays in the office brush register or the office group register. At the same time, talking selection relay 1310, relay 1120 and skip office relay 1123 are operated, as well as relay 1322 which indicates that a full mechanical tandem office is to be included in the circuit. It will be remembered that relays 1505 and 1321 are operated from the zone relays. In addition, relay 1802 closes a circuit from battery through the winding of relay 1804, middle left front contact of relay 1802 to grounded conductor 750. Relay 1804 disconnects battery from the windings of relays 1501, 1502 and 1503 and 1601 to prevent their operation on this class of call and to perform other functions, as described hereinafter.

As above described, the operation of relay 722 permits the release of the decoder connector and the decoder and establishes the fundamental circuit for making district selections. These selections take place in the manner above described except that the seventh group of outgoing trunks is selected under the control of relays 1901 and 1904.

It will be remembered that in making district selections, only the tip side of the fundamental circuit is employed. During this time a signal is transmitted over the fundamental ring to the district selector of the zone in which the called line lies. Since relay 1505 is operated from the zone relays of the decoder, a circuit is closed from battery over the right contacts of cam 1724 through low resistance 1727, conductor 1736, front contact of relay 1505, back contact of relay 1504, inner left back contact of relay 1602, right front contact of relay 1226, left contacts of cam 1714, back contact of relay 1231 to the fundamental ring conductor 747 and thence to the district selector where both the sensitive and the marginal relays are operated which in combination with the advance of the district selector sequence switch to position 14, as described hereinafter, is an indication that the subscriber is to be charged for a call to zone 5. For a detailed description of this operation, reference is made to the above identified Collis application.

Since relay 1123 was operated to indicate that no office selector was included in the connection, when relay 1228 operates in position 3 of sequence switch 1700 following district group selection, it is locked over the lower contacts of cam 1705, conductor 1733, outer right contact of relay 1123, conductor 1124, lower contacts of cam 1708, to ground through positions 3 to 6. Relay 1228 as usual operates relay 1227, opening the circuit of relay 1226, which releases in turn releasing relays 1219, 1220 and 1229. With relay 1229 released and relay 1228 operated, sequence switch 1700 is advanced out of position 3 and is advanced from position 4 over the lower left contact of cam 1701, conductor 1125, inner right contact of relay 1123, conductor 1124, to ground. Since relay 1228 is held operated, sequence switch 1700 is advanced through positions 5 and 6 to position 7 where relay 1228 releases. Relay 1123 supplies ground from the lower right contact of cam 1709, conductor 1734, left contact of relay 1123, conductor 1126 to the armature of relay 1228, permitting relay 1226 to immediately reoperate without waiting for the release of relay 1227.

When sequence switch 1700 left position 3, the locking circuit of relay 1505 was opened and that relay released, so that, in position 6 relays 1602 and 1506 are operated as before. Therefore, when sequence switch 1700 reaches position 7, the trunk outgoing to the distant office is tested in the usual manner except that the fundamental circuit now extends from conductor 748, over the front contact of relay 723, left front contact of relay 1804, right contacts of cam 1703, conductor 1731, front contact of relay 1506, conductor 1510, back contact of relay 1925, winding of relay 1309, back contact of relay 1220, inner left front contact of relay 1226, right winding of relay 1225, lower left and upper right contacts of cam 1717, back contact of relay 1923, resistance 1926, front contact of relay 1924, lower contacts of cam 1714, back contact of relay 1231 to conductor 747. Resistance 1725 is not included in this testing circuit, and relay 1309 is used in place of relay 1314.

If this circuit is properly closed, relay 1309

operates, operating relay 1308, which in turn operates relay 1307. Relay 1307 closes a circuit from ground at its left front contact, lower contacts of cam 1706, right front contact of relay 1804, front contact of relay 1802, back contact of relay 1224, winding of relay 1223 to battery. Relay 1307 locks over conductor 1734 as long as sequence switch 1700 remains in position 7. In combination with relay 1223 it also closes a holding circuit for relay 1309 in parallel with the contact of relay 1506 and the contacts of cam 1703 which remains closed after sequence switch 1700 leaves position 7 and thereby also holds relay 1307 operated under the control of the distant office. Relay 1223 in operating closes a circuit from ground at its outer right contact over the lower left contact of cam 1701 to the winding of sequence switch magnet 1700 and battery, advancing the sequence switch to position 15. Relay 1223 also closes a locking circuit for itself over the back contact of relay 1224, middle left contact of relay 1223 to grounded conductor 1238. Since class relay 1802 was operated, indicating that the call was to be completed through a tandem call indicator office, when relay 722 operated, a circuit was closed from battery through the winding of relay 1311, back contact of relay 1801, lowermost front contact of relay 722, outer left front contact of relay 1802, lower left contact of cam 1709 to ground. Relay 1311 prepares a locking circuit for itself over its inner right contact, lower right and upper left contacts of cam 2022 of the call indicator impulser switch, lower left contact of cam 1716 to ground. With relay 1311 operated, a circuit is closed from battery through the windings of relays 1312 and 1313 in series to ground at the outer right front contact of relay 1311. Relay 1313 locks over its inner left contact, left contacts of cam 2022 to ground over the lower left contact of cam 1715.

With relay 1311 operated, a circuit is closed for advancing sequence switch 2000 to the position for starting the transmission of the office code digits. This circuit may be traced from battery through the winding of magnet 2000, upper left contact of cam 2023, middle right contact of relay 1311, lower left contacts of cams 2002 and 2003 to ground. Sequence switch 2000 is advanced to position 5 in this circuit, completing the locking circuit of relay 1311.

When a district selector at the tandem office has been associated with a tandem sender and that sender is ready to receive the designation, a loop circuit is substituted for the battery and ground previously connected to the fundamental circuit. Relay 1309, therefore, releases in turn releasing relay 1307. The release of relay 1307 places the fundamental circuit under the control of the impulser sequence switch 2000. The release of relay 1307 also closes a circuit from ground at the left back contact of relay 1307, outer left front contact of relay 1223, through the winding of relay 1222 and battery. Relay 1222 closes a circuit from ground at its left contact, upper contact of cam 2024, winding of sequence switch 2000 to battery advancing sequence switch 2000 in its first revolution.

It is well known in the art that the call indicator code consists of light positive pulses and light or heavy negative pulses under control of the registered designation. The light positive pulses are generated by connecting ground to the ring conductor and battery through a high resistance to the tip conductor while the light negative pulses are generated by connecting ground to the tip conductor and battery to a high resistance to the ring conductor, the heavy negative impulses being generated by connecting battery through a low resistance in parallel with the battery to a high resistance to the ring conductor.

The fundamental circuit for the first impulse of the first office code digit extends from conductor 747, back contact of relay 1231, lower contacts of cam 1714, front contact of relay 1924, through resistance 1926, back contact of relay 1923, inner right front contact of relay 1223, outer right back contact of relay 1307, left contacts of cam 2014, upper left and lower right contacts of cam 2019 to ground, and from conductor 748, front contact of relay 723, inner left contact of relay 1223, inner right back contact of relay 1307, left front contact of relay 1312, inner left front contact of relay 1311 to the lower left contact of cam 2005. With sequence switch 2000 in position 5, this circuit extends over the upper left contact of cam 2005, to the outer left armature of relay 906 of the first office code register 900, over the back contact of that relay, back contact of relay 904, which is also not operated, upper left contact of cam 2002, lower contacts of cam 2003 to ground. While this circuit is not actually closed in position 5, it overlaps the position slightly to insure the discharge of the cable and prevents the false registration of a pulse when none is to be transmitted. When sequence switch 2000 reaches position 6, ground is disconnected from conductor 747 and connected over the right contacts of cam 2019, left contacts of cam 2018 to the inner right back contact of relay 1307 and thence to conductor 748. In this position battery is connected through resistances 1508 and 1507, upper contacts of cam 2014 to the outer right contact of relay 1307 and conductor 747. A branch of this circuit extends over conductor 2025, outer left front contact of relay 1311, lower left and upper right contacts of cam 2004, inner right front contact of relay 905 which is operated, to conductor 2032, upper right and lower left contacts of cam

2009, front contact of relay 1222, outer left back contact of relay 1236, right contacts of cam 2008, conductor 1736, low resistance 1727, right contacts of cam 1724 to battery. Therefore, a heavy negative impulse is transmitted in this position. In position 7 the same circuits are closed as in position 5, while in position 8, the circuit for generating the light negative impulse is closed, but the circuit used for the first heavy negative impulse is opened at the upper right contact of cam 2009 and the circuit prepared over the right contacts of cam 2001, middle right front contact of relay 1311, right contacts of cam 2021 to the front contact of relay 907 is opened at the contact of relay 907. Therefore, the first digit transmitted corresponding to the registered code letter C consists of a heavy negative impulse followed by a light negative impulse.

It will be remembered that no digit was recorded on the second register. Therefore, none of the relays of register 910 are closed. The circuits for the two light negative impulses are completed as above traced since these are independent of the registers. At the beginning of positions 9 and 11, tip conductor 748 is extended over the upper right contact of cam 2005, and the back contacts of relays 916, 914, and 913 to ground over cam 2003 in the manner described for the first pulse. It may be noted that the circuit extends over the back contact of relay 913 as well as the contacts of relays 914 and 916. Since none of the office codes employs zero for the second or third digit, it is assumed that if zero is dialed for such a digit it has been dialed in error for the letter O and the zero relay in the second and third office code registers close the same circuits to the impulsing switch as would be closed by relays 914 and 917, jointly, which would be operated if the letter O had been dialed correctly. In the present case, since no digit was recorded on the register 910, zero will be transmitted correctly. In positions 10 and 12, the branch for transmitting the heavy negative impulses is opened at the contacts of relays 913, 915 and 917. Therefore, only light negative impulses are transmitted.

In positions 13 to 16 the second office code digit H, as recorded on register 920, is transmitted, the register control being exercised over cams 2004 and 2005. The code for this digit consists of a light negative pulse, a positive pulse and a second light negative pulse. The negative pulses are generated as previously described. In position 15 the fundamental tip is extended over the left front contact of relay 1312, inner left front contact of relay 1311, lower contacts of cam 2005, front contact of relay 926, conductor 2034, right contacts of cam 2007, resistance 1831, left back contact of relay 1237 to battery, thereby generating the positive pulse.

Having transmitted the last of the office code digits, it becomes necessary to determine in what order the remaining digits are to be transmitted. Some offices have five digit numbers lying between 10,000 and 10,499; some offices have party lines and party line designations, while other offices may have both or neither. In addition the number recorded may or may not lie in this five digit range and may or may not have a party letter. A five digit number will be transmitted in the order recorded, that is, ten thousands, thousands, hundreds, tens, units which are recorded on the thousands, hundreds, tens, units and stations registers, respectively; while for all other numbers, the stations digits or a zero, if no stations digit was recorded, will be transmitted before the thousands digit.

It has been assumed that the wanted office has five digit numbers and this fact is indicated by the non-operation of relay 1121. Relay 1122 is operated over the back contact of relay 1405, right contact of relay 1013 which is operated because the hundreds digit is zero, and the middle right front contact of relay 1004 which is operated because the thousands digit is one. Relay 1405 is operated whenever either relay 1005 or 1007 is operated to prevent the operation of relay 1122 when relay 1004 is operated in recording digits other than 1.

Relay 1404 is operated following the reception of the last digit in a circuit over the right front contact of relay 1111, normal contact of relay 1027, left front contact of relay 1122, left back contact of relay 1121 to grounded conductor 750. The circuits for transmitting the called subscriber's number are carried over contacts of relay 1404 so that, since relay 1404 is operated, the digits are transmitted in the order ten thousands, thousands, hundreds, tens and units. These digits are transmitted in substantially the same manner as the code digits.

When sequence switch 2000 leaves position 17, the locking circuit of relay 1311 is opened and that relay releases. When sequence switch 2000 reaches position 1, the circuit closed by relay 1222 is opened. However, the locking circuit of relay 1313 is closed in this position and a circuit is completed from battery through the winding of sequence switch magnet 2000, lower right contact of cam 2023, right front contact of relay 1313 to ground at the left contact of relay 1222, so that sequence switch 2000 continues to advance into its second revolution. When sequence switch 2000 leaves position 10 of the second revolution, the locking circuit of relays 1312 and 1313 is opened and these relays release. At the end of the last pulse, ground to the tip conductor is extended in position 16½ of sequence switch 2000 over the back contact of relay 1312, upper contact of cam 2022 and the lower

left contact of cam 1716. In passing through positon 17, an open pulse is transmitted. In positions 17¾ to 18¼ the heavy positive pulse is transmitted. For this purpose, the tip conductor is extended over the left back contact of relay 1312, left contacts of cam 2008 to battery over conductor 1736; while the ring conductor is extended over the right back contact of relay 1312 and the left contacts of cam 2003 to ground. This heavy pulse is used for controlling a two-wire office selector, if such a selector is included in the connection.

As sequence switch 2000 passes through positions 18¾ to 20, a circuit is closed from ground over the left contact of relay 1222, back contact of relay 1313, contacts of cam 2006, winding of relay 1231 to battery. Relay 1231 locks over its inner left contact to grounded conductor 1238. The operation of relay 1231 further opens the fundamental circuit which is opened by sequence switch 2000 in passing through positions 19 and 20. When sequence switch 2000 again reaches position 1, no circuit is closed for operating the magnet and the sequence switch comes to rest. Relay 1231 closes a circuit from ground over its left front contact, upper right contact of cam 1702 to the winding of sequence switch magnet 1700 and battery, advancing the sequence switch to position 17. In this position a circuit is closed from battery through the winding of relay 1232, right contacts of cam 812, lower contacts of cam 1712, front contact of relay 1231 to grounded conductor 1238. Relay 1232 closes a circuit from battery, through the winding of the relay 1228, right front contact of relay 1232, upper right contact of cam 1716 to ground. Relay 1228 in operating closes a circuit from ground over the back contact of relay 1229, front contact of relay 1228, upper left contact of cam 1701, to the winding of sequence switch magnet 1700 and battery, advancing the sequence switch to position 18. In this position the circuit for talking selection is established as previously described. Relay 1300 closes a circuit from ground to conductor 1735 as previously traced, upper right and lower left contacts of cam 1720, back contact of relay 1224, front contact of relay 1310, front contact of relay 1321, conductor 1841, back contact of relay 1218, winding of relay 1217, to battery. As the district selector advances to position 12, the pulse in position 12⅜ operates relays 1217 and 1218 and the pulse in position 13⅜ operates relays 1219, 1220 and 1229, bringing the district selector to rest in position 14. The use of this talking position, in combination with the zone indication given by relay 1505, prepares the district selector for making the proper charge. The operations following talking selection are the same as for the call previously described.

Calls to other offices

In the case of direct calls to manual offices equipped with relay call indicators, class relays 1801 and 1802 are both operated, in turn operating relay 1804. Therefore, relay 1311 cannot be operated. When relay 722 operates, a circuit is closed from battery through the winding of sequence switch magnet 2000, lower left contact of cam 2023, outer left front contact of relay 1801, lower front contact of relay 722, outer left front contact of relay 1802, lower left contact of cam 1709 to ground. Sequence switch 2000 is advanced to position 17 in this circuit, i. e., to the position for starting the transmission of the called line number. As soon as sequence switch 2000 reaches position 11, ground from cam 1709 is extended over the left contacts of cam 2021, to the winding of relays 1313 and 1312 and these relays operate and lock as before.

There are two classes of calls for operators over direct trunks, one class for a call which was made for an unused or a restricted code which the decoder reroutes to an operator. In this class the decoder operates and locks relay 1801, the only object of which is to operate relay 1804; the other class includes the zero operator, three digit operator or permanent signal operator. For this class the decoder causes the operation of relay 1803 which also operates relay 1804. With relay 1804 operated the fundamental circuit for trunk test is the same as traced in connection with the call indicator call.

On the first of the above classes of call, it is to be expected that the subscriber will dial a number and it is necessary to delay the trunk test until he has done so to prevent the dial pulses from falsely releasing the supervisory relay in the district selector. This function is performed by the time measure switch 800 as will be described.

On the second class of call, no number will be dialed and the operation of relay 1803 permits the trunk test to take place immediately. The trunk test causes the operation of relays 1309, 1308 and 1307 in the same manner as in connection with other calls. However, relay 1307 now closes a circuit from ground at its left front contact, lower contacts of cam 1706, right front contact of relay 1804, back contact of relay 1802, winding of relay 1221 to battery. Relay 1221 locks to grounded conductor 1238 and extends ground over its inner left contact, upper left contact of cam 1702 to the winding of sequence switch magnet 1700 and battery, advancing the sequence switch to position 10. As the sequence switch passes through position 9¾, a circuit is closed from battery through the winding of relay 1231, left contacts of cam 1712, outer left front contact of relay 1221

to grounded conductor 1238 operating relay 1231 which also locks to conductor 1238. Relay 1231 advances sequence switch 1700 to position 17 where relay 1232 is operated as previously described, in turn operating relay 1228 and advancing sequence switch 1700 to position 18. In this position talking selection takes place. Since this call is for an operator, neither relay 1310 nor 1321 will be operated and the circuit controlled by relay 1300 at this time will extend as previously traced to the lower left contact of cam 1720, back contact of relay 1224, back contact of relay 1310, back contact of relay 1216, to the winding of relay 1215 and battery. Sequence switch 200 in advancing from position 12, closes ground in shunt of the winding of relay 1300 in positions 12 3/8, 13 3/8 and 14 3/8, whereupon the circuit of relays 1300 and 225 is opened and sequence switch 200 is brought to rest in position 15. In position 15, the incoming and outgoing ends of the talking circuit extend as previously described to repeating coil 232, the outgoing end including the winding of polarized supervisory relay 233. When the operator answers, relay 233 operates, closing a circuit from ground over the lower right contact of cam 209, front contact of relay 233, left contacts of cam 220, lower winding of relay 225 to battery. Relay 225 operates, closing a circuit from battery through the winding of sequence switch magnet 200, upper right contact of cam 224, lower front contact of relay 225, upper left contact of cam 209 to ground. Sequence switch 200 is advanced to position 16 in this circuit where relay 225 releases. In position 16, the talking circuit extends from tip brush 111 of the line finder 110, inner back contact of relay 125, upper left and lower right contacts of cam 201 to the tip brush 151 of the district selector, and from the ring brush 112 of the line finder 110, middle back contact of relay 125, winding of relay 231, lower left and upper right contacts of cam 202, to the ring brush 152 of the district selector 150. Battery and ground are supplied from the operator's position so that relay 231 is held operated, in turn holding relay 229 operated. The release of the sender takes place as for other calls. Since relay 233 is not operated in positions 13 or 14, relay 237 cannot operate and no charge is made.

If the call is to an operator reached through a tandem office, only the three digits of the official code will be registered and the decoder will cause the operation of relays 1802 and 1803. The operation of relay 1802 brings the call indicator impulser into action, while relay 1803 prevents the delay for the dialing of additional digits and relay 1804 which is operated from either relay 1802 or 1803 transforms the fundamental circuit.

Time measure switch

Sequence switch 800 and the apparatus of Fig. 8 serve to time the various stages of the operation of the sender and to control the restoration thereof if it fails to function properly. It will be remembered that when ground was connected to conductor 1238, relay 826 operated over contacts of cam 812, locking to conductor 1238 independent of that of cam 812. Relay 826 closes a circuit from grounded conductor 1238 over the middle contact of relay 826, lower right contact of cam 808, upper right contact of cam 801, to the left winding of relay 827 and battery. Relay 827 operates, connecting ground to the winding of sequence switch magnet 800, advancing the sequence switch from position 1. In position 2, relay 827 releases and the sequence switch comes to rest. In position 2 the timing operation is started. Ground is connected over the lower right and upper left contacts of cam 803 through interrupter 821, left contacts of cam 815, back contact of relay 827 to the normal contact and winding of relay 831, resistance 832 and battery. Relay 832 locks to ground over the upper left and lower right contacts of cam 803, independent of interrupter 821 and closes a circuit from battery through resistance 834, winding of relay 833, front contact of relay 831, to this same ground, but relay 833 is shunted by ground over the interrupter and the back contact of relay 833. When the interrupter opens, relay 833 operates. At the next closure of the interrupter, about 10 seconds later, ground is connected through the interrupter over the outer left contact of relay 833 to resistance 832 in shunt of the winding of relay 831 which releases. Relay 833 is held operated over the normal contact of relay 831 to ground over the interrupter until the interrupter opens its contact, whereupon relay 833 also releases. This cycle of operations may occur any desired number of times.

If a call progresses normally, the operation of relay 902 to indicate that the first digit has been dialed, closes a circuit from battery, through the left winding of relay 827, upper right and lower left contacts of cam 801, right front contact of relay 901 to grounded conductor 1238. Relay 827 advances sequence switch 800 to position 4 and releases. When the units digit has been recorded, a circuit is closed from battery through the left winding of relay 827, right contacts of cam 802, left front contact of relay 1101, inner left front contact of relay 1021 to ground at the left contact of relay 1030. If the call has been for an operator reached by dialing either zero or a three digit code, relay 1803 will be operated from the decoder and the circuit above traced will extend from the lower right contact of cam 802, over the inner left contact of relay 1803 to grounded conductor 750.

Switch 800 is advanced to position 6 when either of these circuits is closed.

Sequence switch 800 is advanced through positions 6 and 7 to allow for the dialing of a stations digit under the control of interrupter 820 which is a fast interrupter pulsing at about half-second intervals. In these positions relays 831 and 833 are under the control of interrupter 820. Relays 831 and 833 are operated by the first cycle of interrupter 820 and relay 831 releases at the second closure of that interrupter. At this time a circuit is closed from battery through the winding of relay 828, left contacts of cam 805, front contact of relay 833, back contact of relay 831 to ground over the right contacts of cam 803. Relay 828 locks through the right winding of relay 827, contact of relay 828 to ground at the right contacts of cam 803. Relay 827 cannot operate, being shunted by the operating circuit of relay 828. When relay 833 releases at the second opening of the interrupter contact, relay 827 operates and advances sequence switch 800 to position 7. In passing from position 6 to position 7, relays 831 and 833 release. In position 7 the same cycle of operations is performed and sequence switch 800 is advanced to position 8.

If the stations digit is dialed during this time, a circuit is closed from battery through the left winding of relay 827, upper right contact of cam 801, upper left contact of cam 808, inner left front contact of relay 1111, inner right front contact of relay 1101 to ground at the front contact of relay 1030. Relay 827 immediately advances sequence switch 800 to position 8 without waiting for the interrupter. If both relays 1120 and 1121 are operated indicating that neither a stations letter nor a five digit number is to be expected, the circuit of relay 827 extends over the outer left front contacts of these relays to grounded conductor 750.

With relay 1120 operated and relays 1121 and 1122 not operated, the indication is that the five digit numbers are used in the called office, but the failure to operate relay 1122 indicates that the thousands and hundreds digits were not one and zero, respectively, so that a five digit number will not be received. In this case the circuit extends over the front contact of relay 1120, back contacts of relays 1122 and 1121, to grounded conductor 750. If relay 1122 is operated indicating that the thousands and hundreds digits dialed were one and zero, respectively, relay 1027 is operated indicating that the tens digit was greater than five, but relay 1121 is not operated indicating that stations letters are not used and, therefore, the number will be a four digit number since the numbers above ten thousand five hundred are not used, the circuit for relay 827 extends from the upper left contact of cam 808 over the outer right front contact of relay 1027, left front contact of relay 1122, left back contact of relay 1121 to grounded conductor 750.

When sequence switch 800 reaches position 8, it is immediately advanced to position 11, since relay 827 is operated locally over the left contact of cam 804 and the lower right contact of cam 803. In position 11, 20 to 30 seconds is measured off for the release of the sender. When the sender releases, relay 826 also releases closing a circuit for relay 827 over the upper right contact of cam 801, lower left contact of cam 808 to ground at the back contact of relay 826. Relay 827 now advances sequence switch 800 into position 1 releasing relay 827.

With sequence switch 800 in position 2 and awaiting receipt of the first digit, relay 825 is operated when relay 831 is released by the second closure of interrupter 821 and relay 828 is operated when relay 831 operates at the third closure of interrupter 821, locking through the winding of relay 827, which operates when relay 833 also operates at the opening of the interrupter. Relay 827 advances sequence switch 800 to position 3 where the timing relays release, in turn releasing relay 825. In position 3 a circuit is closed from battery, through the upper winding of relay 725, upper contacts of cam 813 to ground at the back contact of relay 827. Relay 725 locks over its second lower contact to grounded conductor 1317, operates relay 721 over its inner lower contact and connects ground over its upper front contact to conductor 949. Relay 721 in operating initiates the operation of the decoder connector and decoder as previously described. The grounding of conductor 949 causes the operation of relay 2541 directly, which in turn, as soon as the checking operation is completed connects ground from the contact of relay 3107 to the winding of relay 3204, winding of relay 3400, winding of relay 2867 to battery. Relay 3204 determines the setting for the selection-control registers of the sender which will connect the subscriber with a permanent signal trunk and an operator's position.

Relay 725 also connects ground over its lower front contact, lower front contact of relay 721, upper contacts of cam 801 to the left winding of relay 827 advancing sequence switch 800 to position 14. In position 14 a ten second interval is measured for the release of the sender, interrupter 821 operating relay 831 which in turn operates relay 828 which locks in series with relay 827, and the operation of relay 833 following the opening of the interrupter permitting the operation of relay 827 to advance sequence switch 800 to position 15. If the sender is released, sequence switch 800 is restored to position 1 as above described. If the sender is not released, relay 725 is still operated and relay

827 is operated in position 15, advancing sequence switch 800 to position 18.

In position 18 ground is connected over the back contact of relay 827, upper right and lower left contacts of cam 813 to conductor 843 which operates a stuck-sender signal at the sender make-busy frame. Likewise as sequence switch 800 passes through positions 14¾ to 15¼, ground is connected from conductor 1238, over the right contacts of cam 814 to conductor 842 to make a record of the sender on a stuck-sender recorder.

With sequence switch 800 in position 4 following the timely reception of the first digit, relays 831 and 833 are operated under the control of interrupter 821 as before. Relays 825, 828 and 827 function as before to advance sequence switch 800 to position 5. As before described if the units digit or in the case of an official call the three office code digits have not been dialed before the sequence switch reaches position 5 the sequence switch will not be advanced directly into position 6 but will be arrested in position 5.

In position 5 relay 827 releases and a circuit is closed from battery through the winding of relay 829, right contacts of cam 813 to ground at the back contact of relay 827. Relay 829 in operating closes a circuit from tone source through interrupter 830, outer right front contact of relay 829, condenser 730, upper winding of relay 724, inner upper front contact of relay 715 to ground. This tone is induced into the lower winding of relay 724 and thence to the subscriber's telephone, informing him that the call cannot be completed and that he should restore his receiver to the switchhook. If he does so, relay 724 releases and subsequently relay 715 which opens the tone circuit and releases the sender. In the meantime with sequence switch 800 in position 5, relays 831 and 833 are operated under the control of interrupter 821. At the next closure of the interrupter 821, relay 831 releases, closes a circuit for relay 828 which locks as before through the winding of relay 827 which operates when the interrupter opens its contact to release relay 833. The operation of relay 827 advances sequence switch 800 to position 6 and releases. Relay 829 in operating locks over the lower contacts of cam 803 to ground in positions 5 to 10 of the sequence switch. Therefore, relay 829 now closes a circuit from battery through the left winding of relay 827, inner right front contact of relay 829, lower right contacts of cams 804 and 803 to ground. Relay 827 advances sequence switch 800 to position 11 where relays 829 and 827 both release. As sequence switch 800 passes through positions 5¾ to 6¼ with relay 829 operated, a circuit is closed from ground over the lower right contact of cam 803, upper right contact of cam 804, outer left front contact of relay 829, left contacts of cam 814, windings of relay 822 and meter 823 to battery. Meter 823 operates each time that a sender fails because the called number was only partially dialed.

As sequence switch 800 passes through positions 6 and 7 with relays 829 and 721 operated, ground is connected over the left front contact of relay 826, middle left contact of relay 829, left contacts of cam 807, upper front contact of relay 721, back contact of relay 725, upper right and lower left contacts of cam 810 to the middle winding of relay 1306. This reduces the resistance in series with relay 125 so that relay 125 operates, dismissing the district and sender. If relay 721 has not been operated, the circuit above traced is extended to the winding of relay 725 which functions as above described.

If the calling subscriber fails to hang up after receiving the tone signal and the district selector and sender have been released by the timing mechanism, a new sender is seized in the manner previously described and if the calling subscriber does not redial, the timing device of this sender operates the routing relay of the decoder associated therewith to route the connection to a permanent signal trunk terminating at an operator's position.

In positions 11 and 12, if three digits have been dialed and the decoding operation causes the operation of relay 1322 to indicate that a two-wire office selector or full mechanical tandem office is to be included in the connection, seventy seconds are measured off, while if neither relay 1322 nor relay 1223 is operated, only thirty seconds are measured. In position 11 relays 831 and 833 are operated as previously described. When relay 831 is released after the second closure of interrupter 821, relay 825 is operated and when relay 831 operates at the third closure of interrupter 821, relay 828 is operated followed by relay 827 when the interrupter opens. Relay 827 advances sequence switch 800 to position 12 where relays 825, 827 and 828 release but relays 831 and 833 do not. In position 12 if neither relay 1322 nor relay 1223 is operated, a circuit is closed from ground over the right back contact of relay 1223, left back contact of relay 1322, upper right contacts of cams 808 and 801 to the winding of relay 827 advancing the sequence switch to position 13. If either of these relays is operated, relays 831 and 833 are released at the fourth closure and opening of the interrupter and are reoperated at the fifth closure and opening of the interrupter. When relay 831 operates, relay 825 is again operated; when both relays 831 and 833 have released, relay 828 is operated; and when relay 831 reoperates, relay 827 operates to advance switch 800 to position 13. The advance of sequence switch 800 releases relays 825, 827 and 828 but relay 831 remains locked to the contact of cam 803. In posi-

tion 13 relay 829 operates over the right contacts of cam 813 to the back contact of relay 827. Relay 829 performs the same functions as described in position 5 except, that since relay 831 is already operated, the intervals for operating relay 825 and therefore relays 827 and 828 are slightly shorter. The operation of relay 827 advances sequence switch 800 to position 14. Relay 829 is locked through positions 13 to 16 and advances sequence switch 800 to position 15 whence it is advanced to position 16 by the operation of relay 827 in a local circuit. As it passes through positions 14¾ to 15¼, the stuck-sender recorder functions and in positions 14 to 15¼ ground is connected to the left winding of relay 1306.

In position 16, ten seconds is measured for the release of the sender at the end of which a circuit is closed from battery through the right winding of relay 835, upper contacts of cam 810, back contact of relay 725, front contact of relay 721, key 824, upper left and lower right contacts of cam 819, inner left front contact of relay 833, right front contact of relay 831 to ground at the right contacts of cam 803. Relay 835 locks over its middle left contact to ground conductor 1238. It also connects ground to the winding of relay 1306 and operates relay 827 to advance sequence switch 800 to position 17. Relay 835 also closes a circuit from grounded conductor 1238 over the outer right contact of relay 835, lower left contact of cam 1702 to the winding of sequence switch magnet 1700, advancing that sequence switch to position 18.

In position 17 an interval of ten seconds is measured for the sender to release, after which sequence switch 800 is advanced to position 18 where the stuck-sender signal is given. Relay 835 also operates relay 1237 which functions to dismiss the sender as in the case of an abandoned call if the subscriber hangs up in response to the tone.

When it is desired to hold a stuck-sender for maintenance or other purposes, key 824 is operated thus opening the operating path for relay 835, therefore, an interval of twenty seconds is measured in position 16 and sequence switch 800 advances to position 17. In position 17 ten seconds are measured and the sequence switch advanced to position 18. In position 18 the stuck-sender signal is given. With key 824 operated, the sender cannot return to normal unless the off-normal ground is opened.

What is claimed is:

1. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, a decoder associable with said sender, a dial associated with the calling line for setting the registers of said sender in accordance with the designation of a desired connection, routing relays in said decoder controllable in accordance with the setting of certain of the registers of said sender for controlling said sender to route connections, a trunk circuit terminating in an operator's position, a time measuring device in said sender, and means controlled thereby for operating one of said routing relays to cause said sender to route a connection from said calling line to said trunk circuit.

2. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, a decoder associable with said sender, a dial associated with the calling line for setting the registers of said sender in accordance with the designation of a desired connection, a trunk circuit terminating in an operator's position, a routing relay in said decoder for controlling said sender to route a connection from said calling line over certain of said selector switches to said trunk circuit, a time measuring device in said sender, a relay in said sender controlled thereby if said calling subscriber fails to dial within a predetermined interval, and a circuit for said routing relay controlled by said sender relay.

3. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, a decoder associable with said sender, a dial associated with the calling line for setting the registers of said sender in accordance with the designation of a desired connection, a trunk circuit terminating in an operator's position, a routing relay in said decoder for controlling said sender to route a connection from said calling line over certain of said selector switches to said trunk circuit, a time measuring device in said sender, a relay controlled thereby if said calling subscriber fails to dial within a predetermined interval, a circuit for said routing relay controlled by said sender relay, and means controlled by said sender relay for releasing said sender.

4. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, a decoder associable with said sender, a dial associated with the calling line for setting the registers of said sender in accordance with the designation of the desired connection, a trunk circuit terminating in an operator's position, a routing relay in said decoder for controlling said sender to route a connection from said calling line over certain of said selector switches to said trunk circuit, a time measuring device in said sender, a relay controlled thereby if said calling subscriber fails to dial within a predetermined interval, a circuit for said routing relay controlled by said sender relay, means

controlled by said sender relay for releasing said sender, a lamp signal, and means controlled by said time measuring device for operating said signal if said sender fails to release within a predetermined interval.

5. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, a dial associated with the calling line for setting the registers of said sender in accordance with the designation of a desired line, a time measuring device and a source of tone current in said sender, and means in said sender controlled by said time measuring device for transmitting a tone signal to said calling line if said calling subscriber fails to complete dialing within a predetermined interval.

6. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, a dial associated with the calling line for setting the registers of said sender in accordance with the designation of a desired line, a time measuring device and a source of tone current in said sender, means in said sender controlled by said time measuring device for transmitting a tone signal to said calling line if said calling subscriber fails to complete dialing within a predetermined interval, and means controlled by said time measuring device to thereafter restore said sender and to cause an operation in the selector switches seized in response to the initiation of the call simulating the restoration of the calling subscriber's receiver to the switchhook.

7. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, a dial associated with the calling line for setting the registers of said sender in accordance with the designation of a desired line, a time measuring device and a source of tone current in said sender, means in said sender controlled by said time measuring device for transmitting a tone signal to said calling line if said calling subscriber fails to complete dialing within a predetermined interval to release said sender and to thereafter cause an operation in the selector switches seized in response to the initiation of a call simulating the restoration of the calling subscriber's receiver to the switchhook, means thereafter responsive for seizing a second sender if said calling subscriber has not restored his receiver to the switchhook, a trunk circuit terminating in an operator's position, a time measuring device in said second sender and means controlled thereby if after a predetermined interval said calling subscriber has not started to redial for setting said selector switches to extend a connection from said calling line to said trunk circuit.

8. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a sender for controlling said switches, a decoder associable with said sender, a dial associated with the calling line for setting the registers of said sender in accordance with the designation of a desired connection, routing relays in said decoder controllable in accordance with the setting of certain of the registers of said sender for controlling said sender to route connections, a time measuring device in said sender, means in said sender controlled by said time measuring device for transmitting a tone signal to said calling line if said calling subscriber fails to complete dialing within a predetermined interval, to release said sender and to thereafter cause an operation in the selector switches seized in response to the initiation of the call simulating the restoration of the calling subscriber's receiver to the switchhook, means thereafter responsive for seizing a second sender if said calling subscriber has not restored his receiver to the switchhook, a trunk circuit terminating in an operator's position, a time measuring device in said second sender, and means controlled thereby if after a predetermined interval said subscriber has not started to redial for operating one of said routing relays to cause said second sender to route a connection from said calling line to said trunk circuit.

9. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, a dial associated with the calling line for setting the registers of said sender in accordance with the designation of a desired line, a time measuring device, a source of tone current and a meter in said sender, and means in said sender controlled by said time measuring device for transmitting a tone signal to said calling line from said source and for operating said meter if said calling subscriber fails to complete dialing within a predetermined interval.

10. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, a dial associated with the calling line for setting the registers of said sender in accordance with the designation of a desired line, a time measuring device and a source of tone current in said sender, means in said sender controlled by said time measuring device for transmitting a tone signal to said calling line if the calling subscriber fails to complete dialing within a predetermined interval and for releasing said sender, a lamp signal, and means controlled by said time measuring

device for operating said signal after a predetermined interval if said sender fails to release.

11. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, a dial associated with the calling line for setting the registers of said sender in accordance with the designation of a desired line, a time measuring device in said sender, means in said sender controlled by said time measuring device for causing the release of said sender if the calling subscriber fails to complete dialing within a predetermined interval, and means for canceling the control of the release of said sender by said time measuring device.

12. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, a dial associated with the calling line for setting the registers of said sender in accordance with the designation of a desired line, a time measuring device in said sender, a relay in said sender operable by said time measuring device for causing the release of said sender if the calling subscriber fails to complete dialing within a predetermined interval, a key for canceling the control of said relay by said time measuring device, a lamp signal, and means controlled by said time measuring device with said relay unoperated for operating said signal.

13. In a telephone exchange system, a calling subscriber's line, selector switches for extending a connection from said line, a register sender for controlling said switches, a dial associated with the calling line for setting the registers of said sender in accordance with the designation of a desired line, a time measuring device in said sender, a relay in said sender operable by said time measuring device for causing the release of said sender if the calling subscriber fails to complete dialing within a predetermined interval, and a key which, when operated, cancels the control of said relay by said timing device, said sender being then held from releasing until said relay operates upon the release of said key.

In witness whereof, I hereunto subscribe my name, this 29th day of October, 1931.

WALTER B. STRICKLER.