

March 8, 1927.

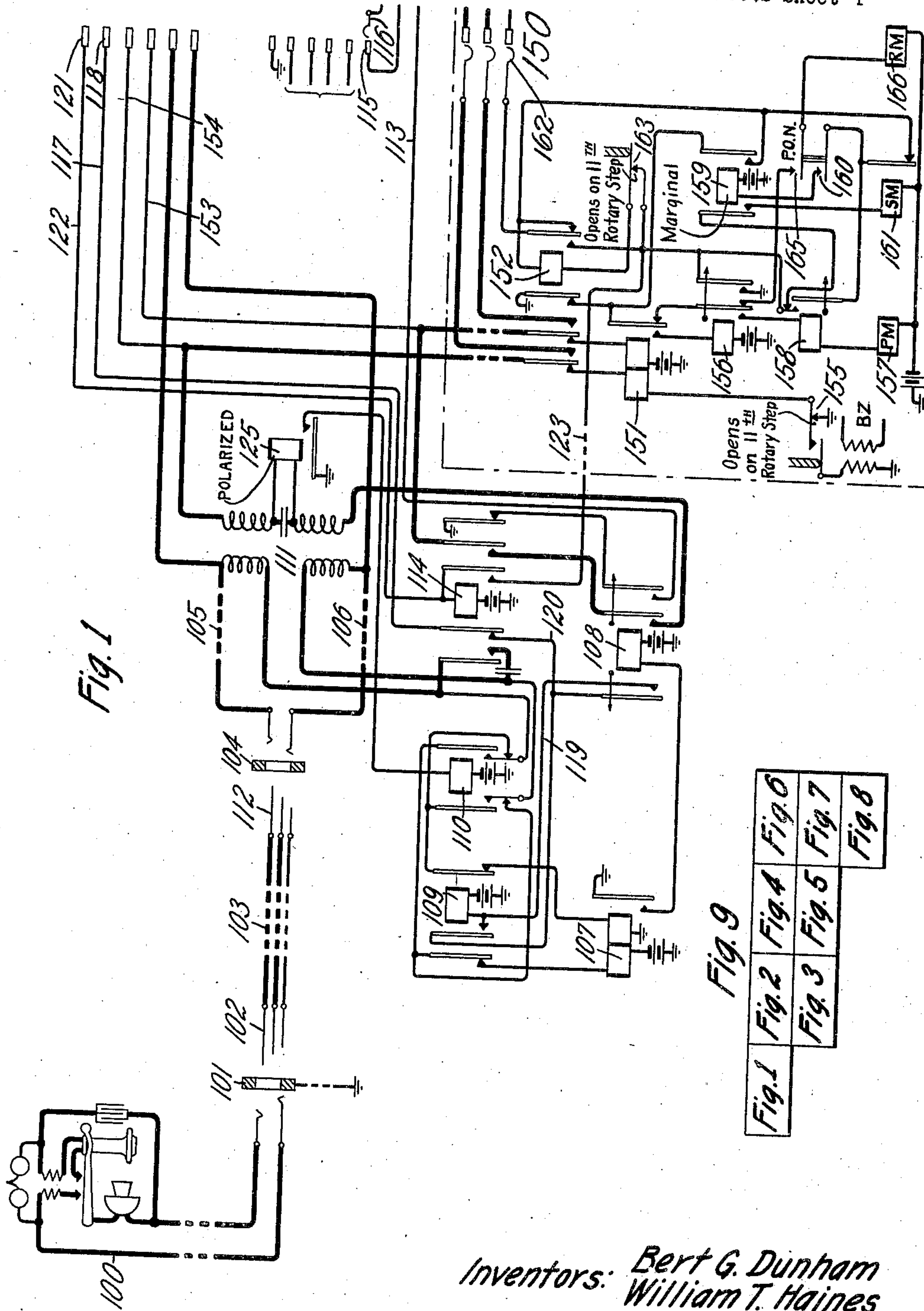
B. G. DUNHAM ET AL

1,620,012

TELEPHONE EXCHANGE SYSTEM

Filed Sept. 17, 1926

8 Sheets-Sheet 1



Inventors: Bert G. Dunham
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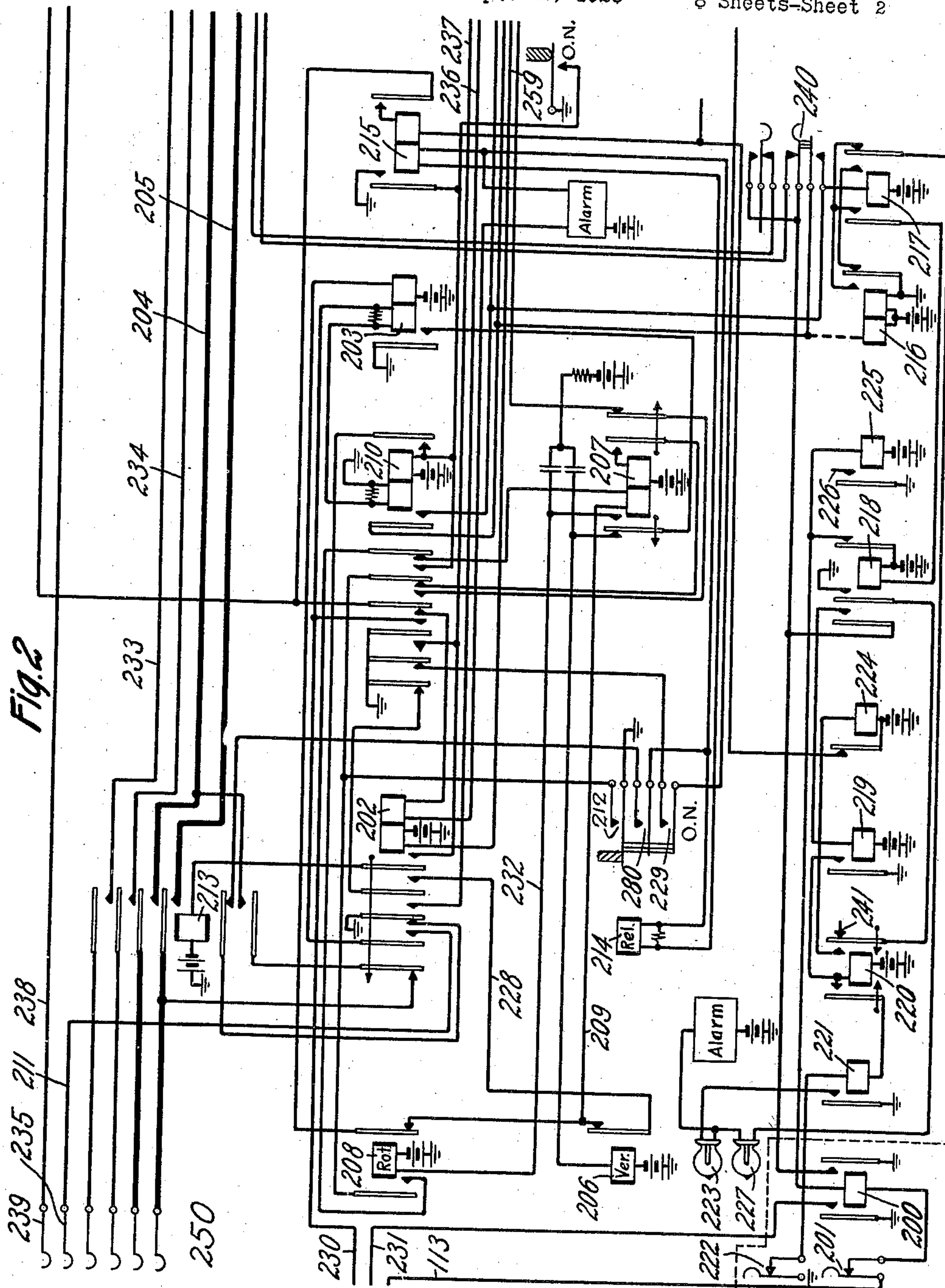
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TELEPHONE EXCHANGE SYSTEM

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8 Sheets-Sheet 2



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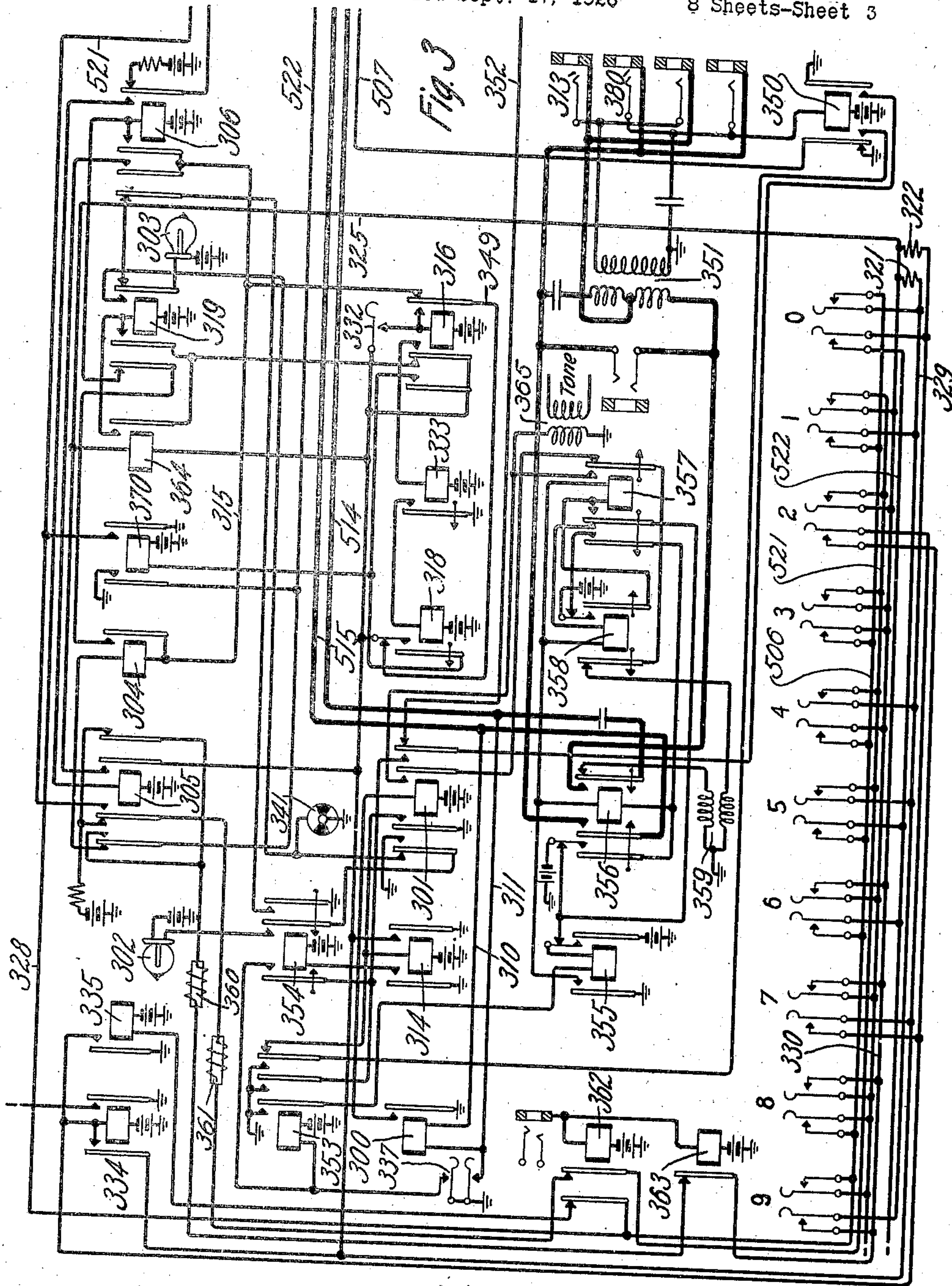
B. G. DUNHAM ET AL

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TELEPHONE EXCHANGE SYSTEM

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8 Sheets-Sheet 3



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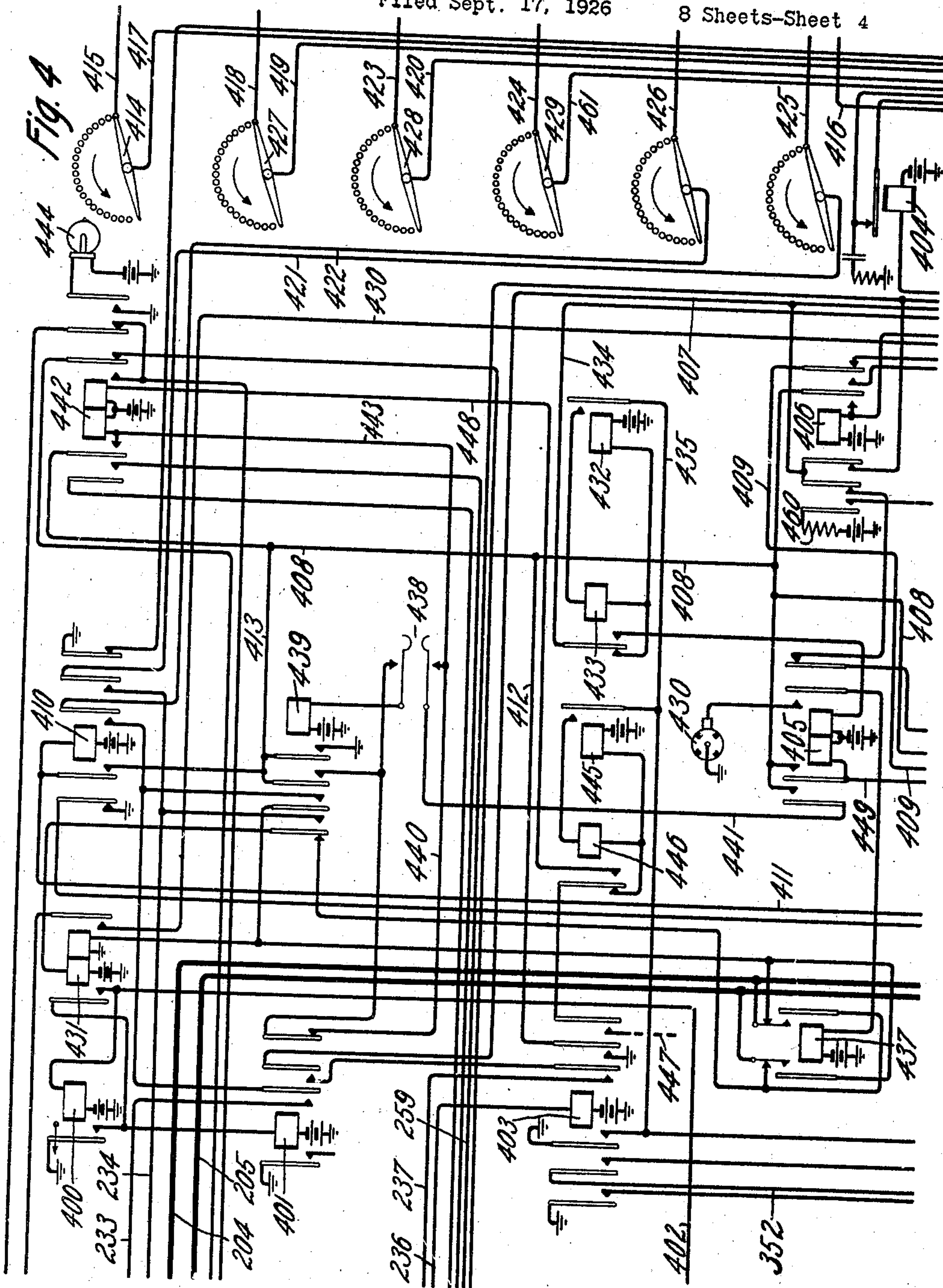
B. G. DUNHAM ET AL

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TELEPHONE EXCHANGE SYSTEM

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8 Sheets-Sheet 4



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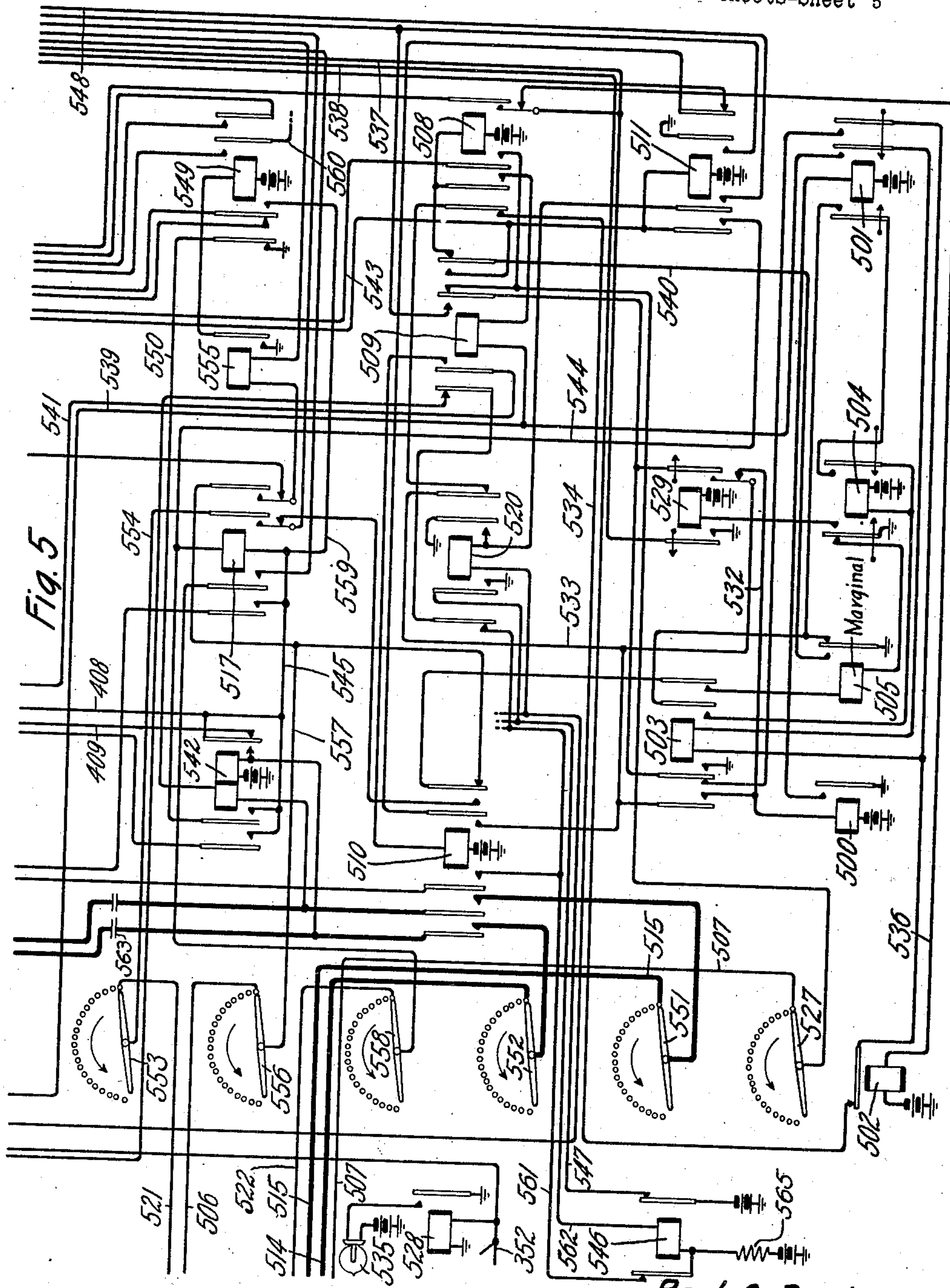
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B. G. DUNHAM ET AL
TELEPHONE EXCHANGE SYSTEM

1,620,012

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8 Sheets-Sheet 5



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March 8, 1927.

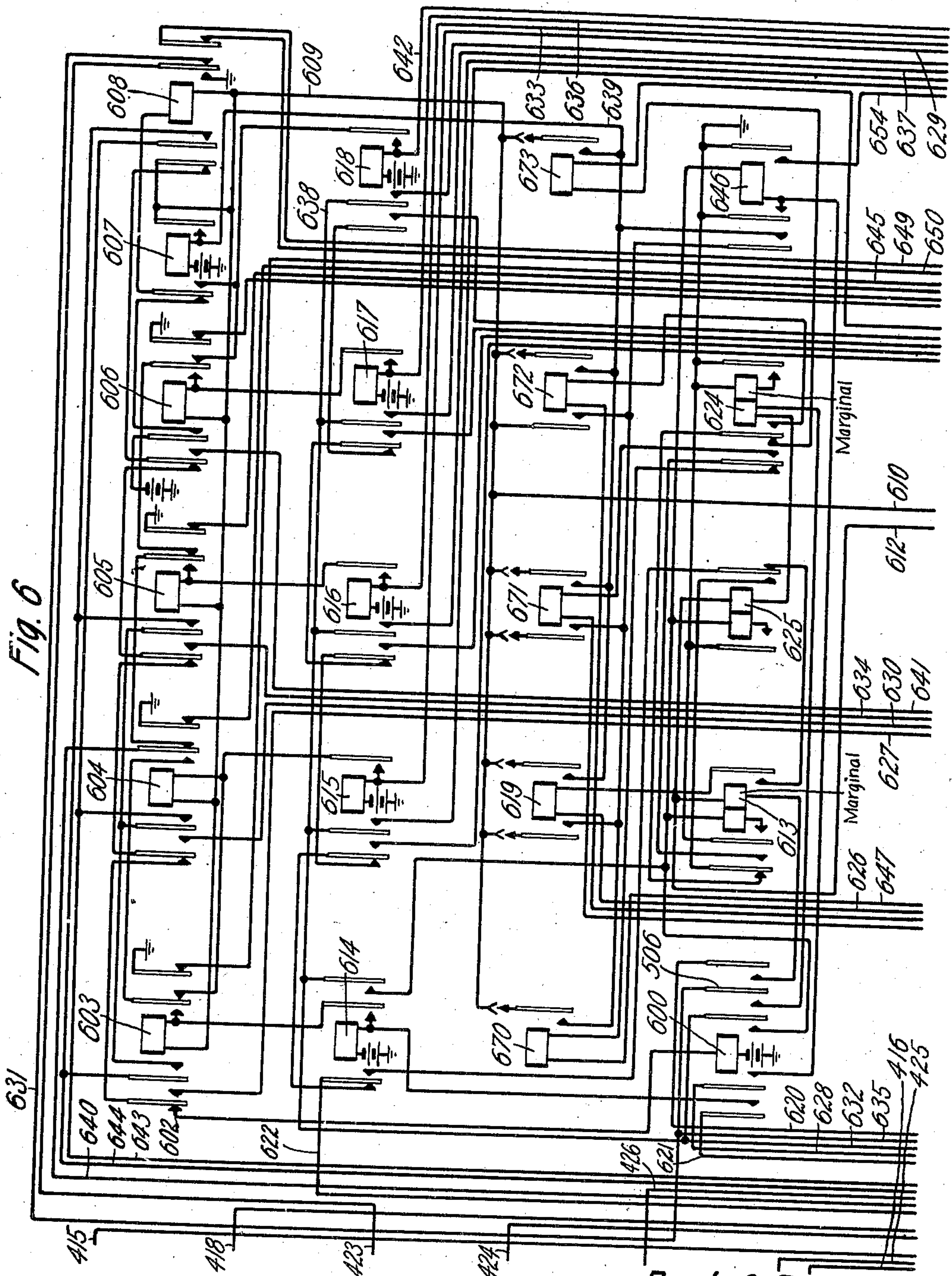
B. G. DUNHAM ET AL

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TELEPHONE EXCHANGE SYSTEM

Filed Sept. 17, 1926

8 Sheets-Sheet 6



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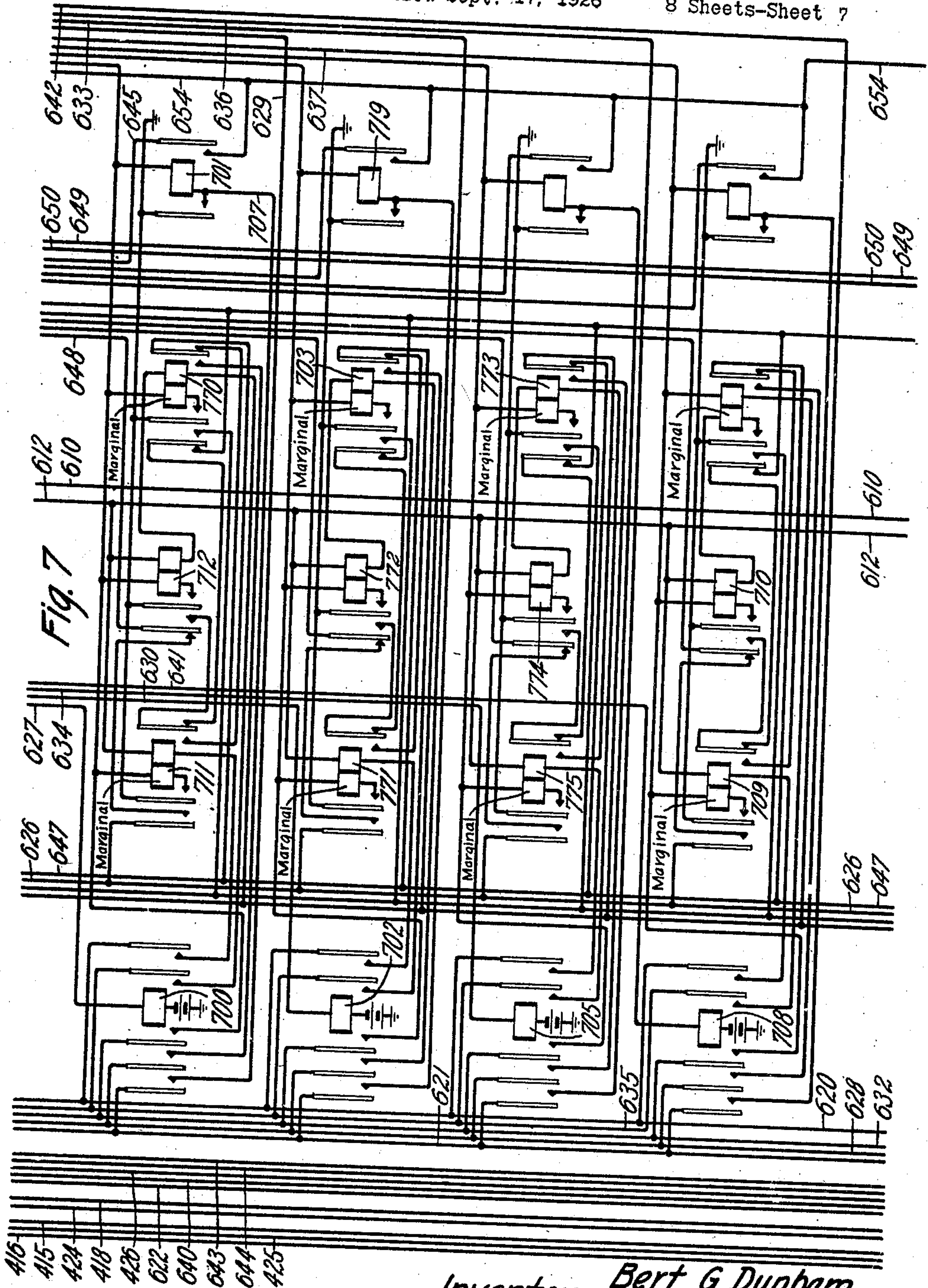
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B. G. DUNHAM ET AL
TELEPHONE EXCHANGE SYSTEM

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8 Sheets-Sheet 7



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B. G. DUNHAM ET AL
TELEPHONE EXCHANGE SYSTEM

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8 Sheets-Sheet 8

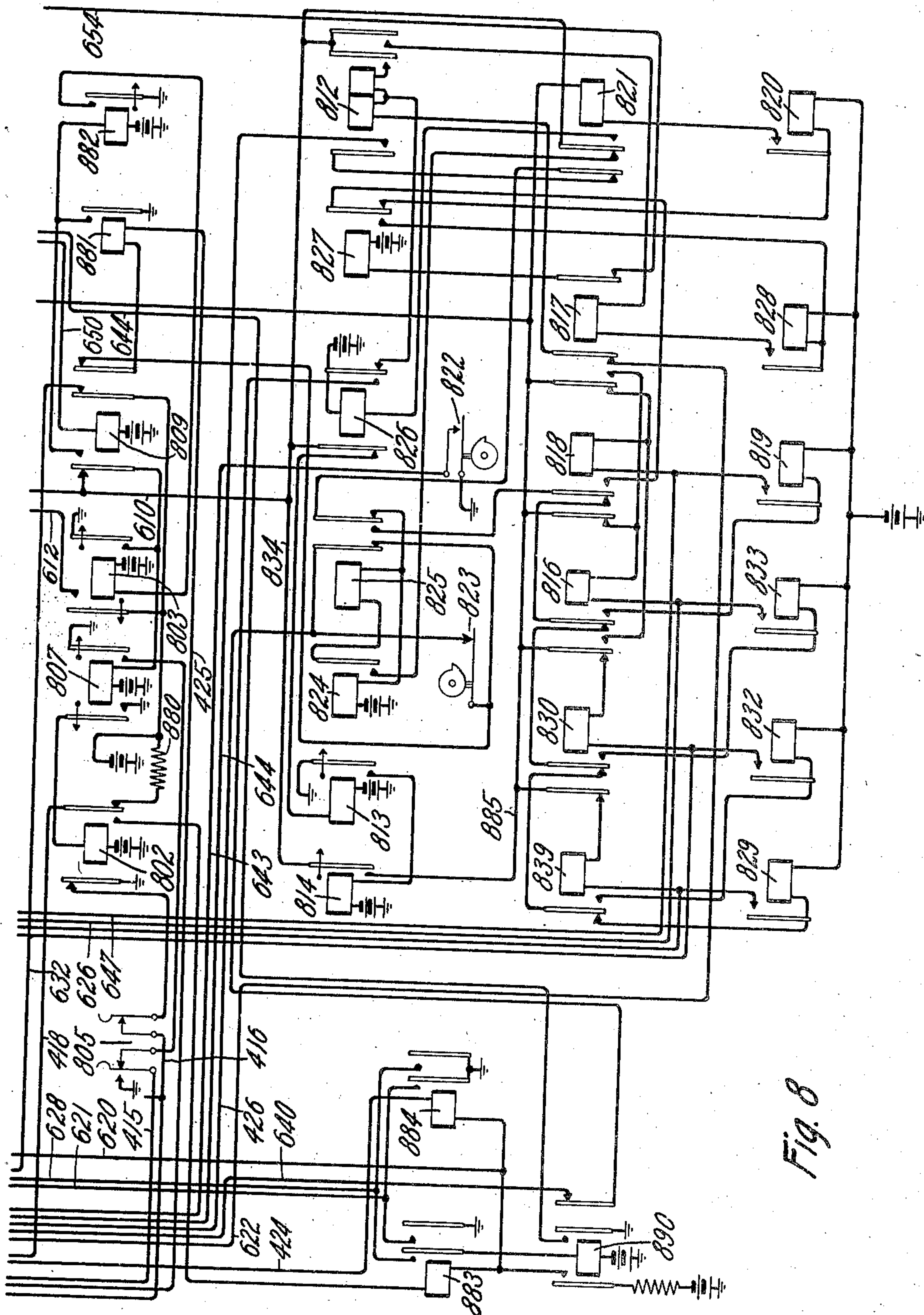


Fig. 8

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1,620,012

UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE SYSTEM.

Application filed September 17, 1926. Serial No. 136,033.

This invention relates to telephone exchange systems and more particularly to the establishment of connections between subscribers' lines in manual and machine switching offices.

In accordance with the present invention the interconnection of manual and machine switching offices is accomplished by trunks which appear at a manual operator's position and which when selected for use by that operator are automatically associated with an incoming operator's position at the machine switching office. The incoming operator's equipment is also automatically associated with a control device which may be set by such equipment to operate a train of switches connecting with the called subscriber's line and to connect such train when set with the trunk. According to another aspect of the invention, an erroneous partial setting of the control device may be corrected by the machine switching operator. According to an additional aspect of the invention the disconnection of the trunk by the manual operator prior to connection with the train of switches will also cause the release of the control apparatus and the train of switches.

The operation of a telephone system embodying the invention is briefly as follows: When a subscriber in a manual office wishes to converse with a subscriber in a machine switching office, he will communicate the number to his operator in the usual manner. The operator will then insert the calling plug of her cord circuit in the jack of an idle trunk leading to the machine switching office. The trunk circuit at the automatic office will function to close a start circuit for a link which includes a trunk finder, a position finder and a sender finder. The trunk finder and the position finder will be operated simultaneously to connect the trunk with an idle operator at the machine switching office. When an idle position and the trunk have both been found a talking circuit is completed between the two operators, and a momentary tone is connected thereto to inform the manual operator that she may give the wanted number. As soon as the position is found the sender selector is operated to find an idle sender and es-

tablish control circuits between the sender and the machine switching operator's key-board and between the sender and the first selector individual to the trunk circuit. When the sender is ready to receive the registration, a signal is given to the machine switching operator, who then writes up the called number on her keyset. The sender registers the number and starts the control of the first selector and subsequent selectors to select the called line as soon as the second digit is registered. When the last digit has been recorded an indication is transmitted to the link to dismiss the position. When selections have been completed the link dismisses the sender, causes the connection of the trunk to the train of switches and the release of the trunk finder.

The machine switching operator is provided with a key which permits cancelling a partial registration without disconnecting the position and sender. The completion of the established connection is under the control of the manual operator and may be prevented by disconnection by that operator at any point.

A clearer understanding of the invention may be obtained from the following detailed description and the attached drawings, in which:

Fig. 1 shows diagrammatically a calling subscriber's substation connected to an answering jack, and a cord circuit at an "A" operator's position in a manual office, and further shows in detail an outgoing trunk jack associated with a trunk circuit in the called office, also a first selector of the called office enclosed by the broken line.

Figs. 2, 4 and 5 show the link circuit comprising a trunk finder circuit (Fig. 2), a position selector (Fig. 5), and a sender selector (Fig. 4).

Fig. 3 shows a position circuit for a cordless "B" operator to enable such operator to talk with the manual "A" operator over a connection established through the link circuit, and to set the selected sender by means of a keyboard sender.

Figs. 6, 7 and 8 constitute the "B" operator's sender circuit, Fig. 6 showing the transfer relays, Fig. 7 the register relays, and Fig. 8 the counting relays. Fig. 9

shows the proper relative arrangement of Figs. 1 to 8.

Detailed description—Finding the trunk.

5 A subscriber at the manual substation 100, upon lifting the receiver from the hook, lights a line lamp at the "A" operator's position in the well known manner, where-
 10 upon the "A" operator inserts plug 102 into the answering jack 101 and receives the number of the wanted subscriber. The "A" operator by means of her cord circuit 103
 15 now connects with an idle trunk outgoing to the wanted office by inserting the calling plug 112 into an outgoing trunk jack such as jack 104. Jack 104 is connected by
 20 means of trunk conductors 105 and 106 with the called office, and when the manual operator inserts plug 112 in jack 104 relay 107
 25 operates over the trunk loop in a circuit which may be traced from ground through the right winding of relay 107, right back contact of relay 109, right normal contact of relay 110, upper left winding of repeat-
 30 ing coil 111 to the tip of jack 104, tip of plug 112, through the usual polarized relay (not shown) of the cord circuit 103, ring of plug 112 and jack 104, conductor 106, through the lower left winding of repeating
 35 coil 111, left normal contact of relay 110, left back contact of relay 109, left winding of relay 107 to battery. The operation of relay 107 in turn operates relay 108 in an obvious circuit.
 40 The operation of relay 108 closes the circuit for starting the trunk finder by connecting ground to group start lead 113. Relay 200 operates in a circuit which may be traced from ground at the right back con-
 45 tact of relay 114, outer right front contact of relay 108, conductor 113, through normally closed group start key 201; winding of relay 200, right back contact of relay 218 to battery. Relay 200 operated connects
 50 ground to commutator segment 115 corresponding to the level in which the trunk appears before trunk finder 250. (The apparatus within the dotted rectangle of Fig. 2 is common to a plurality of trunk cir-
 55 cuits appearing in the same level.) Relay 202 now operates in a circuit which may be traced from battery in the alarm circuit, right winding of relay 202, middle left back contact of relay 210, middle right back con-
 60 tact of relay 442, intermediate normal contact of key 240, to ground at the right contact of relay 200.
 65 Relay 202 operated closes an operating path for relay 203 which may be traced from battery, right winding of relay 203, armature and closed contact of rotary magnet 208, closed contact and armature of vertical magnet 206, conductor 228, contact of relay 202 to grounded contact of relay 210. Re-
 lay 202 operated also closes a start lead to the position finder at its middle front con-
 tact, and opens a short circuit between con-
 ductors 204 and 205 at its outermost left
 back contact. Relay 203 operated energizes
 the vertical magnet 206 in a circuit which may
 be traced from battery through the winding
 of vertical magnet 206, left back contact of
 relay 207 to grounded contact of relay 203.
 Vertical magnet 206 operates, thus break-
 ing the energizing path for relay 203. Re-
 lay 203 will accordingly release and allow
 vertical magnet 206 to release as well, caus-
 ing the trunk finder switch to take one ver-
 tical step. Magnet 206 having released, re-
 lay 203 will again energize and the trunk
 finder switch will take another vertical step.
 This action will continue until the commu-
 tator brush 116 engages grounded segment
 115. Relay 203 will be held operated and
 relay 207 will operate in a circuit which may
 be traced from battery through the right
 winding of relay 203, contact of rotary mag-
 net 208, conductor 209, left winding of re-
 lay 207, next to the innermost left back con-
 tact of relay 210, conductor 230, commutator
 brush 116, commutator segment 115, con-
 ductor 231 to ground at the left front con-
 tact of relay 200. The operation of relay
 207 opens the energizing circuit of vertical
 magnet 206 and closes a circuit for rotary
 magnet 208 which may be traced from bat-
 tery through the winding of magnet 208,
 conductor 232, left front contact of relay
 207 to grounded contact of relay 203. Ro-
 tary magnet 208 and relay 203 function the
 same as in the case of vertical stepping mag-
 net 206 and the switch will take rotary steps
 until the transfer conductor 211 is connected
 to contact 118. This contact is connected
 to battery through relay 109 of the trunk
 circuit, and relay 203 will be held energized
 in a circuit which may be traced from
 ground through the left winding of relay
 210, through the left winding of relay 203
 in series, outer front contact of relay 202,
 conductor 211, brush 235, contact 118, test
 conductor 117, left back contact of relay
 114, left contact of relay 108, winding of re-
 lay 109 to battery. Relay 210 will energize
 in this circuit and lock to ground through
 the off-normal contact 212 over its middle
 left front contact but relay 109 does not
 operate in series with relay 210. The opera-
 tion of relay 210 connects direct ground
 from the innermost grounded armature of
 relay 109, and opens the energizing circuit
 of relay 207 at its innermost back contact.
 Relay 207 releases and extends the start cir-
 cuit to the next idle trunk finder.
 This extended start circuit may be traced
 from ground at the right contact of relay
 200, intermediate normal contact of key 240,
 middle right back contact of relay 442, mid-
 dle left front contact of relay 210, right back

contact of relay 207, inner right back contact of relay 442, upper normal contact of key 240 thence to the out start wire connected to this contact of key 240.

5 Relay 210 operated closes a circuit for operating relay 213 which may be traced from battery through the winding of relay 213, innermost front contact of relay 202 to the intermediate grounded armature of relay 210. The operation of relay 210 also opens the commutator brush circuit traced hereinabove and closes a chain relay circuit at its left front innermost contact and armature which forms a part of an all-finders-
15 busy circuit. The operation of relay 213 at this time connects the talking leads of the trunk through to the link, closes the pulsing leads over which the switches are to be operated in reaching the wanted number, opens
20 the release magnet circuit and partially closes a short circuiting path across leads 204, 205 at its lowermost front contact.

The operation of relay 109 as above described causes the release of relays 107 and
25 108. Relay 109 operated, locks to test lead 117 in a circuit which may be traced from battery, winding of relay 109, left front contact of relay 109, conductor 120, left back contact of relay 114 to ground on test lead
30 117.

Finding a position.

As soon as the trunk finder switch took one step, relay 400 operated in a circuit
35 which may be traced from battery, winding of relay 400, conductor 402, off-normal contact 229 to ground at next to the outermost left back contact of relay 210. The operation of relay 400 causes relay 401 to operate
40 in an obvious circuit.

When relay 213 operates as above described, extending the talking conductors through to the link circuit, relay 431 operates in a circuit from battery, left winding
45 of relay 431, outer left back contact of relay 439, left normal contact of relay 437, conductor 205, innermost upper contact of relay 213 through the trunk finder, conductor 106, ring of jack 104 and plug 112, through the
50 usual polarized relay (not shown) of the "A" operator's cord circuit, tip of plug 112 and jack 104, conductor 105, through the trunk finder, next to the innermost upper contact of relay 213, conductor 204, right
55 normal contact of relay 437, right winding of relay 431 to ground. The operation of relay 210 opened the energizing circuit of relay 400, but relay 400, being slow-to-release, remains energized long enough for relay 431 to operate and close a locking circuit for relay 400 over its left front contact to ground at the front contact of relay 400. Relay 400 holds relay 401 operated. Since
60 the operation of relay 401 is necessary to close switch setting conductor 233, as will
65 be described hereinafter, the extension of the connection is now in part under the control of the "A" operator.

When relay 202 operated to start the trunk finder, relay 403 operated in a circuit
70 which may be traced from battery, through winding of relay 403, conductor 236, front contact and grounded armature of relay 202, closing the position finder start circuit. The operation of relay 403 closes a circuit for relay 500 which may be traced from battery,
75 winding of relay 500, conductor 532, normal contact of relay 529, conductor 533, right back contact of relay 520, outer left back contact of relay 508, conductor 534, left mid-
80 dle contact of relay 403, conductor 352 to ground in any idle position circuit to which the position finder has access. Relay 500 on operating connects ground from its right contact to the winding of relay 501 which
85 thereby energizes. Relay 501 operated closes an energizing circuit for operating stepping magnet 502 of the position finder which may be traced from grounded battery, winding of stepping magnet 502, conductor 536, normal contact of relay 508, conductor 537, contact of magnet 404, conductor 538, contact of stepping magnet 502, winding of relay 503, inner right contact of relay 501, conductor 539 to ground at the inner left con-
90 tact of relay 403. Relay 501 operated, thus closes a path for operating relay 503 and prepares a locking path for relay 504 over its left front contact to ground at the back contact of relay 505. If the terminal on
100 which the test brush 527 of the position finder is resting is grounded, indicating that the position is busy or vacant as will be described hereinafter, a shunt is closed around the winding of relay 503 extending over the
105 outer right contact of relay 501, left back contact of relay 503, inner right back contact of relay 509, brush 527, to grounded conductor 507. The stepping magnet 502 will operate its armature and interrupt its own
110 circuit causing the switch brushes to advance one step. This action will continue until an idle terminal is found. When an idle terminal is found, relay 503 will operate from battery through the stepping magnet
115 in the circuit hereinabove traced, preparing a circuit from ground at the back contact of relay 504, winding of relay 505, outer right front contact of relay 503, outer right back contact of relay 510, brush 556 to conductor
120 506. Relay 503 operated, also grounds test conductor 507 and closes a path for operating relay 504. If there is only one switch engaging the multiple terminals of the position at this time, relay 505 will operate in the
125 circuit traced from the battery connected to conductor 506 over the back contact of relay 306 and open the path for operating relay 504. If two position finders test the terminals of a position at the same time, neither
130

relay 505 will operate and the position
 finders will continue to operate until they
 test different positions, when each relay 505
 will operate. Relay 505 operated, operates
 relay 508 in a circuit which may be traced
 from battery, winding of relay 508, right
 outer back contact of relay 509, conductor
 540, front contact of relay 505 to ground.
 The operation of relay 508 opens the ener-
 gizing circuit for relay 500 which will re-
 store to normal, causing relays 501 and 503
 to release, thus opening the energizing cir-
 cuit for relay 505. The deenergization of
 relay 505 opens the circuit for energizing
 relay 508. Under this condition, relay 508
 will lock over its left middle contact, the
 winding of relay 509, conductor 539 to
 ground at the innermost left contact of relay
 403. Relay 509 is energized in this circuit
 and will in turn operate relay 510 in a cir-
 cuit which may be traced from battery,
 winding of relay 510 over the left front con-
 tact of relay 509, conductor 541, right back
 contact of relay 405, outer left back contact
 of relay 406, conductor 407, middle contact
 of relay 401, inner right contact of relay 403,
 conductor 237 to the middle grounded arma-
 ture of relay 210. Relay 508 operated, con-
 nects guarding ground to test brush 527 of
 the position finder in a circuit which may
 be traced from ground, right middle contact
 of relay 403, conductors 412 and 408; right
 back contact of relay 542, conductor 409,
 right back contact of relay 406, conductor
 543, inner left front contact of relay 508, to
 test brush 527. Relay 508 operated, con-
 nects, over its right front contact, stepping
 magnet 404 of the sender selector to the re-
 lays which control the operation thereof.
 Relay 509 operated, transfers the lead 540
 to relay 511 and connects the test brush 414
 through to the relays which control the
 operation of the sender selector. Relay 510
 operated, transfers the test circuit from lead
 506 of the position selector to lead 419 of
 the sender selector over its outer right front
 contact. It also closes the talking leads 514
 and 515 to the "B" operator's position (Fig.
 3) and closes the start lead 416 to relay 500.

Finding a sender.

This start circuit for relay 500 may be
 traced from battery through the winding of
 relay 500, right normal contact of relay 529,
 inner right front contact of relay 510, right
 back contact of relay 511, conductor 416,
 through the right contact of key 805, to
 ground at the left back contact of relay 802
 of any idle sender in the group. As before,
 relay 500 operates relay 501 and relay 501
 closes the circuit for the sender selector
 magnet 404.

The circuit of the sender selector stepping
 magnet 404 may be traced from battery
 through the winding of the magnet, right

alternate contact of relay 508, back contact
 of magnet 404, back contact of magnet 502,
 and thence in parallel through the winding
 of relay 503 to grounded conductor 539 and
 over the outer right front contact of relay
 501, left back contact of relay 503, inner
 right front contact of relay 509, to conductor
 417, brush 414, conductor 415, left contact
 of key 805, to the front contact of relay 807
 which will be operated if the sender is busy.
 In the case of a busy sender; therefore, relay
 503 is shunted as in the case of a busy posi-
 tion and magnet 404 operates, opening its
 own circuit and advancing the sender se-
 lector to the next sender. When an idle
 sender is found relay 807 will not be oper-
 ated and no shunt will be closed around the
 winding of relay 503. Relay 503 in operat-
 ing connects ground over its inner left front
 contact, to brush 414 to mark the sender busy
 to other sender selectors.

Relay 503 will also close a circuit from
 ground at the back contact of relay 504
 through the winding of relay 505, outer right
 front contact of relay 503, outer left front
 contact of relay 510, inner right normal con-
 tact of relay 517, conductor 419, brush 427,
 conductor 418, right back contact of relay
 802, resistance 880 to battery. Relay 505
 operates in this circuit and closes a circuit
 from battery through the winding of relay
 511, outer right front contact of relay 509 to
 ground at the front contact of relay 505.
 Relay 511 operates, connects ground to test
 conductor 417 and closes a locking circuit
 for itself over its outer left contact, winding
 of relay 517 to grounded conductor 408. As
 before the operation of relay 503 closed a cir-
 cuit for slow-to-operate relay 504 which
 when it operates opens the circuit of relay
 505, which when it operates in turn opens
 the circuit for relay 504. The operation of
 relay 511 as previously described opens the
 circuit of relay 500, restoring that relay and
 relays 501 and 503 to normal. The release
 of relay 505 when its circuit is opened by re-
 lay 504, opens the energizing circuit of relay
 511 permitting relay 517 to operate in the
 locking circuit of relay 511. Relay 511 op-
 erated also opens the start circuit from
 relay 500.

Relay 410 now operates in a circuit which
 may be traced from battery through winding
 of relay 410, conductor 411, outermost left
 armature and front contact of relay 517, con-
 ductors 545, 408 and 412, right middle front
 contact of relay 403 to ground. An addi-
 tional locking circuit for relays 511 and 517
 in series is now closed, which circuit may be
 traced from battery, through winding of re-
 lay 511, outer left front contact of relay 511,
 conductor 544, winding of relay 517, outer
 left front contact of relay 517; conductor 411,
 left front contact of relay 410, conductors
 413, 408 and 412 to ground at the middle

right front contact of relay 403. Relay 517 operated connects conductors 521, 506 and 522 from the position finder to the corresponding conductors 419, 420 and 461 from the sender selector. Relay 410 operated connects the pulsing leads 233 and 234 from the trunk finder (Fig. 2) to the sender selector pulsing leads 422 and 421. Relay 410 operated, also locks to the control ground supplied by relay 403.

Operation of position circuits.

The insertion of a "B" operator's headset plug into jacks 313 and 380 closes a circuit from battery through the winding of relay 350, tip of jack 380, through the telephone headset, (not shown) tip of jack 313, right winding of induction coil 351 to ground. The operation of relay 350 removes the ground at its left back contact, which marks the position vacant to the test lead 507 and extends conductor 507 over its left front contact and the right back contact of relay 354 to battery through the winding of relay 314, preparing a start circuit for the operation of the position equipment. It also connects ground over its right front contact, right back contact of relay 301 to conductor 352 for indicating to the position finder that an idle position is available.

When now the position finder connects with the position the battery connected to conductor 507 permits relay 503 to operate, and when relay 508 operates, connecting ground through brush 527 to conductor 507, the circuit of relay 314 is completed and that relay operates. Relay 314, in operating, supplies ground to the numerical keys and other parts of the circuit for controlling the position apparatus. It also closes an obvious circuit for operating relay 354. When relay 510 operates to initiate the operation of the sender selector, relay 300 will operate in a circuit which may be traced from ground at the outer left back contact of relay 549, conductor 550, left winding of relay 542, middle left front contact of relay 510, position finder brush and contact 551, conductors 515 and 310 through the winding of relay 300, conductors 311 and 514 to the contact and brush 552 of the position finder, outermost left front contact of relay 510, right winding of relay 542 to battery. Relay 300 operates and in turn operates relay 301 in a circuit which may be traced from battery through the winding of relay 301 to ground at the right front contact of relay 300.

With relays 301 and 354 operated, lamps 302 and 303 are lighted, lamp 302 over the inner right front contact of relay 354 and the outer left front contact of relay 301 to ground; lamp 303 over the right back contact of relay 319 and the left back contact of relay 306 to ground at the outer right contact of relay 354. The lighting of these

lamps indicates to the operator that her position has been selected to extend a call.

Relay 354 also closes an operating circuit for relay 353 extending through the winding of that relay, left front contact of relay 354, outer right front contact of relay 301 to ground at the right contact of relay 350. The operation of relay 353 disconnects relay 314 from the test lead 507 but relay 314 is held operated by ground over the inner left contact of relay 301. Relay 353 connects ground over its outer right front contact to test lead 507 to mark the position busy. It also closes a locking circuit for itself to ground over its middle right contact. At its inner left contact relay 353 connects ground through the winding of relay 355 to battery at the left normal contact of relay 356.

Position circuits of this type are arranged to transmit two short impulses of tone, usually called "zip tone," to the "A" operator to notify her when the "B" operator is ready to receive the number. The first tone is transmitted as soon as relay 301 operates due to the closure of a circuit from ground, through the secondary winding of tone coil 365, over the inner right front contact of relay 301, left back contact of relay 357, right back contact of relay 358, lower winding of repeating coil 359 to ground. This induces a tone in the upper winding of repeating coil 359 which is transmitted over the back contact of relay 356 to conductors 514 and 515, brushes 552 and 551, left front contacts of relay 510, condenser 563, conductor 205, lowermost contacts of relay 213, through the trunk finder, conductors 106 and 105, jack 104 and plug 112 to the "A" operator's telephone which she maintains connected to the cord circuit by the usual listening key (not shown). The operation of relay 355 in the circuit traced above, closes a locking circuit for that relay from battery over its right alternate contact and also closes a circuit from battery over the normal contact of relay 356, left back contact of relay 357, winding of relay 358 to ground at the left contact of relay 355. As soon as relay 358 operates it opens the tone circuit and the tone ceases in the "A" operator's headset. It also closes a circuit from battery over its right alternate contact through the winding of relay 357 to ground at the left contact of relay 355. Relay 357 locks over its inner left front contact, to battery at the normal contact of relay 356 and opens the circuit of relay 358. When relay 358 closes its back contact, a circuit is again closed through tone coil 365, this time over the right front contact of relay 357, left contact of relay 358, lower winding of repeating coil 359, to ground and a second tone is transmitted to the "A" operator.

The release of relay 358, with relay 357

operated, closes a circuit from battery over the right normal contact of relay 358, outer left front contact of relay 357, winding of relay 356 to ground at the left contact of relay 355. Relay 356 closes a locking circuit for itself over its left alternate contact and connects the talking conductors 515 and 514 through to the "B" operator's headset. Relay 356 is slow-to-operate and does not cut off the tone until after a measured interval. The slow release and slow operating character of relays 356, 357 and 358 serves the purpose of measuring the length of the tone and the interval between tones. As soon as the second tone ceases the "A" operator gives the number of the wanted subscriber to the "B" operator and then disconnects her headset from the cord 103.

20 *Connection of position to sender.*

The operation of relay 410 following the selection of an idle sender, as previously described, completes a circuit from battery through the winding of relay 151 in the first selector, inner left back contact of relay 152, conductor 153, through the trunk finder, next to the uppermost front contact of relay 213, conductor 234, middle right contact of relay 410, conductor 421, through the sender selector to conductor 425, winding of relay 881, outer right back contact of relay 809, in parallel with the contact of interrupter 823, inner right back contact of relay 825, conductor 426, through the sender selector, conductor 422, inner right front contact of relay 410, inner right front contact of relay 401, conductor 233, uppermost contact of relay 213, through the trunk finder, conductor 154, outer left back contact of relay 152, left winding of relay 151, contact 155 to ground. Relays 151 and 881 operate in this circuit, relay 151 closing a circuit from battery through the winding of relay 156, front contact of relay 151 to ground at the back contact of relay 152. No further operation of the first selector occurs at this time.

The operation of relay 881 prepares the sender to register the wanted number and closes an obvious circuit for relay 882. Relay 882 in turn operates and closes an obvious circuit for relay 803. Relay 803 in operating connects battery over its left front contact to the register relays, and connects ground over its right front contact and the back contact of relay 809, to conductor 610, to complete the holding circuits of certain relays as will hereinafter appear. It also closes an obvious circuit for operating relay 807. Relay 807 connects ground over its right front contact and the left contact of key 805 to test lead 415 marking the sender busy. It also closes an obvious circuit for relay 802 which disconnects ground from conductor 416 and disconnects battery

from conductor 418. At its right front contact relay 802 connects conductor 418 to the winding of relay 883.

As soon as relay 803 operates, connecting ground to conductor 610, relay 600 operates in a circuit from battery through its winding, outer left back contact of relays 603, 604, 605, 606 and 608, conductor 609 to grounded conductor 610. With relay 600 operated, a circuit is closed to indicate to the position that the sender is ready to register the number of the wanted subscriber. This circuit may be traced from battery over the left front contact of relay 803, conductor 612, through the right winding of relay 613, outer right front contact of relay 600, conductor 620, winding of relay 884, conductor 424, sender selector brush 429, conductor 461, inner left front contact of relay 517, position selector brush 558, conductor 522, outer left back contact of relay 305, winding of relay 304, conductor 315, right back contact of relay 316, normal contact of relay 318 to ground at the right front contact of relay 314.

Relay 304 operates in this circuit but relays 613 and 884 do not. Relay 304 closes a circuit from grounded conductor 315 over its front contact, left back contact of relay 319, winding of relay 306 to battery. Relay 306 operates and locks over its inner left contact to grounded conductor 315. The operation of relay 306 extends conductor 506 to the numerical keys. It also closes a circuit from battery through the winding of relay 305, middle left contact of relay 306 to grounded conductor 315. In addition it opens the circuit of the white lamp 303 indicating to the "B" operator that the sender is ready to receive registrations. The operation of relay 305 extends conductors 521 and 522 through to the numerical keys. It may be noted that conductors 522 and 521 are extended through resistance coils so as to compensate for the connection of relay 555 in series with conductor 506. The operation of relay 305 opens the circuit of relay 304 and that relay releases.

Registration of called number.

When the "B" operator observes that lamp 303 has been extinguished she will operate the keys of her keyset in accordance with the number given her by the "A" operator. The operation of each key connects direct ground or ground through a resistance such as resistance 321 or 322 to conductors 506, 521 and 522 in a combination determined by the key pressed. Following is a table indicating the relationship between the keys of the "B" operator's key set, the conductor to which ground is applied and the nature of that ground (whether direct or through a resistance), and the relay or relays operated thereby in the first register of the sender.

The relays of the various sender registers are similarly located, so that the correspondence between a key and the proper relays of other registers may easily be determined from the drawings.

Key.	Conductor.	Resistance.	Relay.
1	521	None.	613
2	506	321	625
3	521	None.	613
4	521	None.	613
5	506	None.	625
6	521	322	624
7	506	None.	625
8	521	322	624
9	506	321	625
0	522	321	613
	522	None.	646
	522	None.	613
	506	None.	646
	522	None.	625
	506	None.	624
	522	322	646
	506	321	625
	522	322	646

In the case of keys 4 and 5 the connection of ground to conductor 521 through resistance 322 serves to bring about the transfer from one register to the next as will be pointed out hereinafter.

Should the "B" operator press one or more of the numerical keys before the lamp 303 is extinguished (which indicates that the sender has not yet been attached, at which time relay 305 is not operated), relay 364 will operate in a circuit which may be traced from grounded battery over the inner left or outer right back contact of relay 305, through retardation coil 360 or 361 over the back contact of relay 362 or 363 over the contact of one or more of the numerical keys, through the winding of relay 364 to ground at the right front contact of relay 314. Relay 364 operated closes a circuit for relay 319 through its winding over the front contact of relay 364, left back contact of relay 316 to ground at the right front contact of relay 314. Relay 319 locks over its left front contact to its energizing circuit independent of relay 364 and closes a circuit for lamp 303 over its right front contact, to ground through interrupter 341. When the sender is attached the sender indicator lamp 303 will be extinguished as explained hereinabove.

Relay 803, when operated as previously described, closes a circuit extending from battery, through the winding of relay 813, left back contact of relay 826, conductor 834, to grounded conductor 610. Relay 813 operates and closes an obvious circuit for relay 814.

Assuming that the wanted number is 2603, the "B" operator will first press numerical key 2 representing the first digit of the

called number, whereupon relays 883 and 613 will operate in series in a circuit which may be traced from battery, conductor 612, through the right winding of relay 613, outer right front contact of relay 600, conductor 620, winding of relay 883, right front contact of relay 802, conductor 418, contact and brush 427 of the sender selector, conductor 419, inner right front contact of relay 517, conductor 554, brush and contact 553 of the position selector, to conductor 521, and thence over the inner left front contact of relay 305, retardation coil 361, back contact of relay 362, through the right closed contact of operated key 2, conductor 325, right front contact of relay 305, to ground at the right front contact of relay 314. Since direct ground is connected to the circuit of relay 613 by key 2, as described, relay 613 will operate and lock in a circuit from battery over the inner right back contact of relay 809, conductor 632, inner right front contact of relay 600, left winding and inner left front contact of relay 613 to ground. Relay 883 operated, operates relay 614 in a circuit which may be traced from battery through the winding of relay 614, outer left front contact of relay 600, conductor 621 to ground at the outer right front contact of relay 883. Relay 614 operated, locks over its inner right contact, winding of relay 603, conductor 609 and grounded conductor 610. Relay 603 does not operate, being shunted by the operating circuit for relay 614. Relay 614 also closes a circuit for operating relays 619, 812 and 816. This circuit may be traced from battery over the right back contact of relay 826, left winding of relay 812, inner left back contact of relay 817, conductor 622, left front contact of relay 614, conductor 623, right back contact of relay 625, right front contact of relay 613, winding of relay 619, conductor 626, through the winding of relay 816, outer left back contact of relay 818, conductor 885, front contact of relay 814, to ground over conductor 834. Relay 812 locks in a circuit from battery at the right back contact of relay 826, right winding and inner right armature of relay 812 to grounded conductor 834. Relays 619, 812 and 816 are employed in establishing the connection and will be discussed hereinafter.

When numerical key 2 is released by the "B" operator, relay 603 operates in the locking circuit of relay 614 since the release of key 2 permits relay 883 to release.

The operation of relay 603 opens the energizing circuit for relay 600 whereupon relay 600 releases. Relay 603 operated, operates relay 700 in a circuit which may be traced from battery through the winding of relay 700, conductor 627, outer left front contact of relay 603, outer left back contacts of relays 604, 605, 606 and 608 to grounded

conductor 609. The operation of relay 700 places the sender circuit in position to receive registration on the second set of register relays. It may be noted that with relay 614 operated the locking circuit of relay 613 extends from ground over the inner left front contact and left winding of relay 613, outer right front contact of relay 614 to battery over conductor 632, maintaining the locking circuit after relay 600 releases.

When numerical key 6 is depressed representing the second digit of the called number, relay 712 will energize in a circuit which may be traced from battery over conductor 612, through the right windings of relays 770 and 712, inner right contact of relay 700, contact of relay 608, conductor 423, brush 428 of the sender selector, conductor 420, through the winding of relay 555, outer right front contact of relay 517, through brush and contact 556 of the position selector to conductor 506, and thence, over the right front contact of relay 306, conductor 328, through the contact of operated key 6, conductor 329, through resistance 321, to ground on a conductor 325. Relay 770 does not operate in the circuit due to the presence of resistance 321 in the circuit. Relay 712 locks in a circuit from battery on conductor 632, through the inner left front contact of relay 700, left winding and inner left front contact of relay 712 to ground.

The operation of key 6 also closes a circuit from grounded conductor 325 over the right contact of key 6, back contact of relay 363, through retardation coil 360, outer left front contact of relay 305, conductor 522, brush 558 of the position selector, inner left front contact of relay 517, conductor 461, brush 429 of the sender selector, conductor 424, winding of relay 884, conductor 620, outer right front contact of relay 700, right winding of relay 711 to battery over conductor 612. Relays 884 and 711 both operate. Relay 711 locks in a circuit from battery on conductor 632, inner left front contact of relay 700, left winding and inner left front contact of relay 711 to ground. Relay 884 closes a circuit from battery on conductor 632, over the inner left front contact of relay 700, winding of relay 701, conductor 707, middle left front contact of relay 700, conductor 628, outer right front contact of relay 884 to ground. Relay 701 locks over its left front contact to ground. Relay 884 in operating also closes a circuit from battery through the winding of relay 615, conductor 629, outer left front contact of relay 700, inner right front contact of relay 884 to ground. Relay 615 locks in a circuit over its right contact, winding of relay 604, to grounded conductor 609. Relay 604 does not operate in this circuit being shunted by the operating ground for relay 615.

When numerical key 6 is released by the "B" operator relay 604 operates in series with relay 615. The operation of relay 604 opens the energizing circuit for relay 700 at its outer left back contact whereupon relay 700 releases. Relay 604 operated also closes an energizing circuit for relay 702 which may be traced from battery through the winding of relay 702, conductor 630, outer left front contact of relay 604, through the outer left back contacts of relays 605, 606 and 608 to grounded conductor 609. The operation of relay 702 places the sender circuit in position to receive registration upon the third set of register relays.

When the numerical key 0 is pressed by the "B" operator ground will be connected to conductor 506 through resistance 321 and to conductor 322 through resistance 322. The circuit of conductor 506 is extended as previously traced to conductor 631 and thence over the inner right front contact of relay 702 to battery through the right windings of relays 772 and 703. Relay 772 operates but relay 703 cannot operate in series with resistance 321. Relay 722 locks in a similar circuit to that of relay 613. Relay 884 operates in the circuit of conductor 522 which extends as previously traced through the winding of relay 884 to the outer right contact of relay 702 and through the right winding of relay 771 to battery on conductor 612. Relay 771 will not operate in this circuit due to the series resistance 322.

Relay 884 closes an operating circuit for relay 719 similar to that traced for relay 701. Relay 719 locks over its left armature to ground. Relay 616 operates in a circuit similar to that for relay 615 and locks through the winding of relay 605, to grounded conductor 609.

When the "B" operator releases numerical key 0, relay 605 operates in series with relay 616. The operation of relay 605 opens the energizing circuit of relay 702 and causes relay 705 to operate in a circuit over a front contact of relay 605, and back contacts of relays 606 and 608 similar to that traced for relays 700 and 702. The operation of relay 705 places the sender circuit in position to receive registration on the fourth set of register relays.

When the numerical key 3 representing the fourth and last digit of the called number is pressed by the "B" operator, relays 773 and 774 operate in series in a circuit extending to conductor 506, and through the contact of operated numerical key 3, to ground. Relays 773 and 774 lock in similar circuits to the locking circuit of relay 613.

A circuit is also closed from battery on conductor 612, through the right winding of relay 775, and the winding of relay 883, to conductor 521, and the right closed contact of numerical key 3 directly to ground

over conductor 325. Relays 775 and 883 both operate in this circuit, relay 775 locking to ground over its inner left front contact. Relay 617 operates over the contact of relay 883 and locks through the winding of relay 606 to grounded conductor 609.

When numerical key 3 is released by the "B" operator, relay 606 operates in series with relay 617, opening the circuit of relay 705 whereupon relay 705 releases. The operation of relay 606 closes a circuit for operating relay 608 which may be traced from battery, inner left front contact of relay 606, left back contact of relay 607, through the winding of relay 608 to grounded conductor 609. The operation of relay 608 connects ground to conductor 423 over its inner right front contact and disconnects the "B" operator from the link circuit as will be hereinafter described.

As has been explained, the setting up of the first digit by the "B" operator, operates one of the relays 670, 619, 671, 672 or 673. These relays operate individually when the register relays 613, 625 and 624 are operated in different combinations and either alone or in cooperation with the register relay 646 are effective to operate the relay 607 to indicate that a five digit number is to be recorded. For example, if the first digit registered is either two or seven, relay 619 is operated. If the digit is two, and it is desired to record five digits for connections to all substations designated by numbers whose first digit is two, then the right armature of relay 619 is connected to conductor 610 for operating relay 607 and all the other armatures of this group of relays would remain unconnected. If, however, the digit seven indicates the five digit group, the left armature of relay 619 is connected to conductor 610 and since, for recording the digit seven, relay 646 is also operated, the circuit of relay 607 will be prepared. Thus the right armatures of relays 619, 671, 672, 673, and 670, if connected, will cause the operation of relay 607, if the first digit recorded is either two, three, four, five or six respectively, and the left armatures of relays 619, 671 and 672, if connected, will cause the operation of relay 607, if the first digit recorded is either seven, eight or nine, respectively. In the drawing, it will be noted that the left armature only of relay 672 is shown connected and thus a five digit number is recorded only when the first digit recorded is nine.

The operation of relay 604 following the registration of the second digit closes a circuit for relay 824 which may be traced from battery through winding of relay 824, outer right back contact of relay 825, outer left back contact of relay 821, left front contact of relay 812, conductor 644, inner left front contacts of relays 603 and 604, con-

ductor 643, contact of interrupter 822 to ground. Relay 824 operated, closes an operating path for relay 825 and a locking path for itself which may be traced from battery through the windings of relays 824 and 825 in series, right front contact of relay 824 over the inner left back contact of relay 821 to grounded conductor 610. Relay 825 operated, removes the shunt which has been closed until this time around interrupter 823. Interrupters 823 and 822 are mechanically related so that the contact of interrupter 823 opens at the same time that interrupter 822 closes its contact. The operation of relays 824 and 825 thus insures against part of a pulse being sent out to the step-by-step switches over the leads 425 and 426. The removal of the shunt by the operation of relay 825 prepares for the operation of the switches in accordance with interruptions controlled by the counting relays.

The circuit for operating first selector 150 was completed when relay 410 operated and was traced from battery, through the right winding of relay 151, thence over the contact of interrupter 823, and the inner right back contact of relay 825 in parallel, and back to the left winding of relay 151, and ground at contact of relay 155 at the first selector. The operation of relay 825 as above described leaves this circuit dependent on the contact of interrupter 823. The operation of relay 156 under the control of relay 151 as previously described prepares an operating circuit for vertical magnet 157, which may be traced from battery through the winding of magnet 157, winding of relay 158, inner front contact of relay 156, to the back contact of relay 151, which circuit is completed when relay 151 releases on the first opening of the contact of interrupter 823.

The number of interruptions of the pulsing circuit is controlled by the operation of the counting relays of Fig. 8 as will hereinafter appear. In registering the digit 2, as the first digit of the wanted number, relay 613 was operated and locked in turn operating relays 816 and 812 as above described. As soon as relay 604 operates, indicating the completed registration of the second digit, relay 819 operates in a circuit which may be traced from grounded battery through the winding of relay 819, inner left front contact of relay 816, inner left back contact of relay 818, outer right contact of relay 825, outer left back contact 821, right front contact of relay 812, conductor 644, inner left front contacts of relays 604 and 603, conductor 643, contact of interrupter 822 to ground. Relay 819 operated, closes a locking circuit for itself in series with relay 818 which may be traced from battery through the winding of relay 819, front contact of relay 819, winding of relay 818, outer left

back contact of relay 817, conductor 885, front contact of relay 814 to grounded conductor 834. When interrupter 822 opens its contact relay 818 operates in this circuit and
 5 opens the energizing circuit for relays 816 which releases. Relay 812 does not release at this time as it is locked through its right winding and inner right front contact to grounded conductor 834. Since the contact
 10 of interrupter 822 is closed when the contact of interrupter 823 opens, the circuit of relay 151 is interrupted each time that a pair of counting relays is operated.

Upon the second closure of the contact of
 15 interrupter 822, counting relay 820 will operate in a circuit which may be traced from battery, through the winding of relay 820, right back contact of relay 827, inner left front contact of relay 818, outer right front
 20 contact of relay 825, and thence as traced for relay 819 to the closed contact of interrupter 822. Relay 820 operated, locks in a circuit from battery through the winding and front contact of relay 820, winding of
 25 relay 821 to grounded conductor 885. Relay 821 operated, releases relays 824 and 825 by opening its inner left back contact. The release of relay 825 will reclose the shunt around interrupter 823 and thus prevent the
 30 further interruption of the circuit of relay 151.

At the first opening of the contact of interrupter 823, relay 151 releases completing the circuit above traced for magnet 157, advancing the first selector one vertical step.
 35 The second interruption of the circuit of relay 151 by interrupter 823 causes the advance of the first selector in a second vertical step. Relay 158 operates in the circuit
 40 of magnet 157 and, being slow to release, remains operated as long as the circuit of relay 151 is being interrupted. The operation of relay 158 closes a circuit from battery through the winding of relay 159, off-normal
 45 contact 160, front contact of relay 158, outer front contact of relay 156 to ground. Relay 159 locks in a circuit from battery through its winding, off-normal contact 160, back contact of rotary magnet 161, right front
 50 contact of relay 159, inner left back contact of relay 152 to ground. When the release of relay 825 closes the shunt around interrupter 823, relay 151 remains operated long enough to permit relay 158 to release. The release
 55 of relay 158 closes a circuit from battery, through the winding of rotary magnet 161, left front contact of relay 159, normal contact of relay 158, outer front contact of relay 156 to ground. Magnet 161 operates, releasing relay 159 and advancing the switch one
 60 rotary step into engagement with the first outgoing trunk. If this trunk is busy, ground will appear on the sleeve terminal engaged by brush 162. As soon as magnet 161 closes its back contact relay 159 will be

reoperated in a circuit extending through its winding, off-normal contact 160, back contact of magnet 161, right back contact of relay 152, sleeve brush 162 to ground. The operation of relay 159 will reclose the operating circuit for rotary magnet 161 and the switch will take another rotary step. As long as sleeve brush 162 encounters ground, relay 159 will be reoperated after each rotary step and the switch advanced. A second circuit for relay 159 also exists which may be traced through its winding, off-normal contact 160, back contact of magnet 161, winding of relay 152, contact 163 to ground at the outer front contact of relay 156. As long as sleeve brush 162 encounters ground, relay 152 is shunted and does not operate. As soon as an idle trunk is found, characterized by the absence of ground, relay 152 operates. Relay 159 being marginal does not operate in this circuit. The operation of relay 152 extends the tip, ring and sleeve conductors through to the next selector. It also opens the circuit of line relay 151 which relay releases in turn releasing relay 156. However, relay 156 holds its armatures attracted for a time, thus maintaining ground on the sleeve conductor until the line relay and corresponding slow-to-release relay of the next selector have operated to render both selectors busy.

The ground over sleeve brush 162 completes a locking circuit for relay 152 which may be traced from battery, through the winding of relay 159, off-normal contact 160, back contact of magnet 161, winding of relay 152, contact 163 front contact of relay 152, brush 162 to ground.

The operation of relay 821, as previously described, closes the circuit of relay 826 which may be traced from battery, through the winding of that relay over the inner left front contact of relay 821 to grounded conductor 834. Relay 826 opens the energizing circuit for relay 813 at its left back contact. Relay 813 in turn releases relay 814. Relay 826 also removes battery from the energizing circuit of relay 812 which releases. The release of relay 814, releases counting relays 818 and 819, 820 and 821. Relays 603 and 614 release due to the operation of relay 826 which places battery on conductor 640 shunting these relays. The release of relay 821 opens the energizing circuit for relay 826 at its left front contact. Relay 613 releases when relay 614 releases due to the opening of the locking circuit of the latter relay at the outer right front contact of relay 614. At the close of any digit, therefore, the operation of relay 826 releases the various register relays, and relays 812 and 814 are released and again operated to provide an interval for the purpose of allowing time for the switches to trunk hunt. When relay 826 releases, relay 813 operates again in the

circuit previously traced. Relay 814 will accordingly reoperate.

It will be remembered that the second digit set up was 6. Under this condition register relays 701, 711 and 712 were operated. Relay 827 therefore energized as soon as relay 603 releases in a circuit which may be traced from battery, through the winding of that relay, back contact of relay 817, conductor 654, through the right front contact of relay 701, conductor 645 to ground at the outer right back contact of relay 603. The operation of relay 827, whenever the digit is greater than 5, alters the sequence of the counting relays to cause their repeated operations to count more than five interruptions of the switch control circuit. The counting for sending out the second digit (6) will start at counting relay 818 which operates in a circuit which may be traced from ground on conductor 834, front contact of relay 814, conductor 885, outer left back contact of relay 817, through the winding of relay 818, conductor 647, outer right back contact of relay 770, right front contact of relay 711, outer left front contact of relay 712, conductor 648, outer left front contact of relay 615, right back contact of relay 614, conductor 622, inner left back contact of relay 817, left winding of relay 812, to battery at the right back contact of relay 826. Upon the closure of the contact of interrupter 822 with relay 818 operated, an energizing circuit is closed for relay 828. At the same time the first opening of interrupter contact 823 causes the second selector (not shown) to take a vertical step. The energizing circuit for relay 828 may be traced from battery, through the winding of that relay, inner right front contact of relay 827, inner left front contact of relay 818, outer right front contact of operated relay 825 over the circuit previously traced to the closed contact of interrupter 822.

Relay 828 operated will lock through its left front contact in series with the winding of relay 817, outer right front contact of relay 812 to grounded conductor 834. Relay 817 will operate in this circuit when interrupter 822 opens its contact and opens the energizing circuit for relay 827 at its right back contact, whereupon relay 827 releases. The operation of relay 817 also opens the energizing circuit for relay 818 which releases. Relay 829 then operates in a circuit which may be traced from battery, through the winding of that relay, left back contact of relay 839, inner left back contacts of relays 830, 816 and 818, outer right front contact of relay 825 and thence to the closed contact of interrupter 822. Thus the second of the six pulses of the second digit will be counted.

Relay 829 operated, locks through its left

front contact in series with the winding of relay 829 in a circuit similar to that traced for relay 819, relay 839 operating when interrupter 822 removes the operating ground from relay 829. Upon the third closure of interrupter 822 with relay 839 operated, counting relay 832 will operate in a circuit similar to that traced for counting relay 819. This will complete the counting of the third pulse to the second selector.

Relay 832 operated, will close a locking circuit for itself through its left front contact in series with the winding of relay 830, which latter relay operates. The operation of relay 830 will open the energizing circuit for relay 839 and the locking circuit for relay 829, whereupon these two relays release. The operation of relay 830 closes an energizing path for relay 883 at its inner left front contact and relay 833 operates upon the fourth closure of the contact of interrupter 822, counting the fourth pulse of the second digit 6.

Relay 833 operated will close a locking circuit for itself through its left front contact in series with relay 816 which relay operates. The operation of relay 816 will open the energizing circuit of relay 830 and the locking circuit for relay 832, whereupon these two relays will release. Upon the fifth closure of the contact of interrupter 822, relay 819 will operate counting the fifth pulse to the switch.

Relay 819 operated, will close a locking path for itself through its front contact in series with the winding of relay 818 which later operates. The operation of relay 818 opens the energizing path for relay 816 and the locking path for relay 833, releasing these two last named relays. Upon the sixth closure of the contact of interrupter 822, counting relay 820 will operate and lock through its left front contact in series with the winding of relay 821 which relay operates. This will count the sixth and last pulse of the second digit set up.

The operation of relay 821 releases relays 824 and 825. The release of relay 825 replaces the shunt around interrupter 823 which prevents the further interruption of the switch control circuit. The operation of relay 821 operates relay 826, the operation of which releases relays 813 and 814. Relays 615 and 604 will also release.

The third digit zero will be marked on the counting relays to determine at which point the operation of the counting relays will begin in a manner similar to that described for the second digit. Relay 827 will at first be operated (the third digit also being a number above 5) whereupon the following pairs of counting relays will be operated to count 10 pulses: 829—839, 832—830, 833—816, 819—818, 828—817, 829—839 (operated for the second time), 832—830,

833—816, 819—818, 820—821. At the close of the digit the operation of relay 821 causes sending to cease by the operation of relay 826. The various register relays are caused to release as described.

The fourth digit 3 will be marked on the counting relays, the operation of the counting relays beginning at relay 830. Relays 833—816, 819—818, 820—821 are subsequently operated in the course of sending out three pulses. Following the completion of the last digit, relay 608 releases initiating the release of the sender as will be herein-after described.

The operation of the switches for extending the connection from the first selector to the called subscriber will take place in the usual way and the subscriber will be signaled.

Release of the position.

When the "B" operator releases the key corresponding to the last digit of the number received from the "A" operator, and relay 608 operates as previously described a circuit is closed from battery through the winding of relay 335, back contact of relay 362, conductor 328, right front contact of relay 306, conductor 506, brush and contact 556 of the position selector, outer right front contact of relay 517, winding of relay 555, conductor 420, brush and contact 428 of the sender selector, conductor 423, inner right front contact of relay 608 to ground. The current now flowing in this circuit permits relay 555 to operate in turn operating relay 549. Relay 549 operated, opens at its outer left back contact, the energizing circuit for relay 542 starting the release of the position. Relay 549 operated, also operates relay 406 in a circuit which may be traced from battery, through the winding of relay 406, inner left front contact of relay 549, conductors 559, 545, 408 and 412 to ground at the middle front contact of relay 403. Relay 406 operated, locks through its inner right front contact to conductor 408 and closes a shunt around the winding of relay 517, which circuit may be traced from battery through the winding of relay 511, outer right front contact of relay 406, right back contact of relay 542 to grounded conductor 408. This circuit holds relay 511 operated and releases relay 517. The release of relay 517 opens the conductors connecting the sender and the position. Relay 406 in operating removes ground from the test brush 527 of the position selector. It also opens the energizing circuit of relay 510, whereupon relay 510 releases to disconnect the position from the conductors incoming from the "A" operator. Relay 406 also closes a holding circuit for relay 555 at its outermost left front contact. In addition relay 406 opens the holding cir-

cuit of relay 202, but relay 549 has already closed a substitute holding circuit over its outer right front contact. The operation of relay 549 also opens the circuit of relay 300 so that relay releases in turn releasing relay 301. The release of relay 301 closes a circuit from battery through lamp 302, inner right front contact of relay 354, outer right back contact of relay 301, interrupter 341 to ground. Lamp 302 flashes in this circuit until the operation of relay 406 removes ground from conductor 507. The removal of ground from conductor 507 permits the release of relay 314 which removes ground from conductor 325; opens the locking circuit of relays 306 and 319; opens the holding circuit of relay 305; and opens the energizing circuit of relay 354. Relay 354 in turn releases relay 353 which opens the circuit of relay 355 and in turn the circuit of relay 356. The "B" operator's position is now free to care for calls incoming on other link circuits.

It will be clear from the foregoing description that as soon as the operator has finished setting up a number the sender will indicate to the link that the operation of the position has been completed and will bring about the disconnection of the link from the position after which the position is free to be seized by another link.

Release of the sender.

When the sender finishes controlling the establishment of the connection, relay 608 releases, opening the circuit of relay 555, which releases in turn and opens the energizing circuit for relay 549. Relay 549 releasing, connects ground from conductor 408, inner right front contact of relay 406, over the inner left back contact of relay 549, conductor 430, and the front contact of relay 431 to cut-through conductor 238 of the trunk. The release of relay 549 now opens the holding circuit of relay 202 and that relay releases disconnecting ground from conductor 236 and releasing relay 403. The release of relay 403 opens the locking circuit for relay 406 and the holding circuit of relay 511. The release of relay 202 also opens the circuit of relay 213 which in turn opens the pulsing leads connecting the sender and the switches. The opening of these conductors permits relay 881 to release. Relay 882 is thereupon released in turn releasing relay 803. The release of relay 803 removes battery and ground from the control conductors of the sender and in turn releases relay 807. Relay 807 releases relay 802 and the sender is now in condition to serve another call.

Cut through of connection.

The connection of ground to conductor 238 as above described completes a circuit

which extends from conductor 238 over brush 239, contact 121, conductor 122, through the winding of relay 114 to battery. Relay 114 operates and locks to ground on sleeve conductor 123 under the control of the train of switches and subsequently of the called subscriber. The operation of relay 114 connects the outgoing end of the trunk through the connecting switches to the called subscriber and opens test lead 117 to the trunk finder circuit. This permits relay 109 to release and reconnect the relay 107 to the incoming end of the trunk. Relay 107 operates and in turn operates relay 108 as before. The operation of relay 108 completes the closure of the loop of the called subscriber which was partially closed by the operation of relay 114. When the called subscriber answers, battery is reversed over the tip and ring conductors in the usual manner causing the operation of polarized relay 125. Relay 125 closes an obvious circuit for relay 110 which reverses the connection of battery to the "A" operator's position and reoperates a signal there.

Restoration of the link.

The release of relay 202 as above described opens the circuit of relay 213 and that relay releases. Relay 202 is slow to release and its contacts are so arranged that a shunting path is momentarily closed across conductors 204 and 205 to provide a path for quickly operating relay 107. The release of relay 213 opens the locking circuit of relay 210 of the link circuit. When both relays 213 and 202 release, a circuit is closed from battery through winding of release magnet 214, off-normal contact 280, lower back contact of relay 213, middle left back contact of relay 202 to ground. The operation of release magnet 214 restores the trunk finder to normal and the link is now ready to serve other calls.

Restoration of the trunk.

When the calling subscriber restores the receiver, the usual supervisory signal is given to the "A" operator. When the called subscriber hangs up, relay 125 is released, in turn releasing relay 110. The release of relay 110 again reverses the battery connected to the incoming end of the trunk, giving an indication to the "A" operator that the conversation is ended. The removal of plug 112 from jack 104 releases relay 107, in turn releasing relay 108. The release of relay 108 opens the tip and ring conductors, permitting the release of the connector, and in turn the switches of the train used in establishing the connection. The release of the connector removes ground from the release conductor, which is connected to terminal 150. Relay 152 thereupon releases and closes a circuit

from ground over its inner left back contact, back contact of relay 151, back contact of relay 156, off-normal contact 165, winding of release magnet 166 to battery. The operation of release magnet 166 restores the first selector to normal. The removal of ground from brush 162 also opens the locking circuit of relay 114 and that relay releases.

Use of sender with 5 digit numbers.

As was previously pointed out, the transformation of the sender from one handling four digits to one handling five digits is brought about by the operation of relay 607. The circuit of relay 607 in the present showing extends through the winding of that relay over the outer left front contact of relay 646, left front contact of relay 672 to grounded conductor 609. These two relays are operated when the first digit register is set. Accordingly whenever a five place number beginning with the digit 7 is set up by the "B" operator, relay 607 will be operated as soon as the first digit is registered. From the previous description of the operation of the sender it will be remembered that relay 603 operated after the registration of the first digit, relay 604 after the registration of the second digit, relay 605 after the registration of the third digit, and relay 606 after the registration of the fourth digit. With relay 607 normal, the operation of relay 606 closes a circuit for the operation of relay 608 which initiates the release of the position as previously described. With relay 607 operated this circuit is opened at the left armature of relay 607 and the connection between the position and the sender is maintained while a fifth digit is registered. During the registration of the fifth digit, relay 618 is operated through the front contact of relay 708 in a manner similar to relay 614 and others. Relay 618 locks over its right front contact, left front contact of relay 607, winding of relay 608 to grounded conductor 609 whereupon relay 608 causes the disconnection of the position as previously described. While controlling switches to establish a connection, relays 603, 604, 605, and 606 are released following the sending out of the corresponding sets of impulses as previously described. Due to the operated condition of relay 607 the release of relay 606 does not open the circuit of relay 608 but does extend the releasing circuit from battery over the front contact of relay 608 to the winding of relay 618 so that relay 608 which is operated in the locking circuit of relay 618 does not release until the fifth set of pulses have been sent out.

Sender reset.

If in setting up a series of digits, the "B" operator finds that she has made a mistake

but has not yet registered the last digit of the wanted number, she can press her sender reset key 332 which will operate relay 316 in a circuit which may be traced from battery, through the winding of relay 316, key 332 to ground at the right front contact of relay 314. Relay 316 operated, operates relays 333 and 318 in obvious circuits. Relay 318 operated, closes a circuit for relay 370 which in turn connects direct ground to conductors 522 and 521. Direct ground on conductor 521 causes the operation of relay 883 through the winding of relay 613, 711 or 771 and direct ground on conductor 522 causes the operation of relay 884 through the winding of one of the above mentioned relays. The operation of both relays 883 and 884 closes a circuit from ground at the outer right contact of relay 884, inner right contact of relay 883, through the winding of relay 890 to battery operating that relay. The operation of relay 890 connects battery directly to the windings of relays 883 and 884 in shunt of the register relays and connects ground over its inner right front contact and the outer right back contact of relay 608 to the winding of relay 809. Relay 809 opens the locking ground for all the register relays and the relays of Fig. 8 restoring these relays to normal. It will be remembered that relays 802, 807 and 803 depend upon relay 882. The operation of relay 809 closes an alternate holding circuit for relay 882 over its left front contact to the right front contact of relay 803 and hence relays 802, 807, 803 and 882 are held operated. However, the circuit of relay 881 and the pulsing circuit for controlling the switches is opened by the operation of relay 809 causing the restoration of any switches which may have been operated. Relays 333 and 318 in the "B" operator's position circuit are slow-to-release and accordingly hold relay 370 operated an appreciable length of time to ensure that the operation of relay 809 for a sufficient time to allow the relays in the sender circuit which had been operated under the control of the numerical keys to release. As soon as this time interval elapses, relay 809 will release and the sender will again be in position to register the digits set up by the operator.

It will be clear from the foregoing description that the operation of the sender reset key has no effect on the link circuit so that the position, link and sender remain engaged and the operator is free to set up the new number as though no registration had been attempted.

Disconnection by operator.

Under normal conditions the link, sender and position circuits are disconnected as previously described. However, it is possible

for either the "A" operator or the "B" operator to disconnect if she so desires. If the "A" operator desires to disconnect, she need only remove the plug of her cord circuit from the jack 104. This will release relay 431 which will in turn release relays 401 and 400. The further release of the apparatus awaits the completion of the operation of the sender. At that time relay 114 is operated to connect the right windings of repeating coil 111 through to the called subscriber's line. Immediately thereafter relay 213 releases. The operation of relay 114 releases relay 109, to permit the operation of relays 107 and 108 and the completion of the called subscriber's circuit. However, since plug 112 has been withdrawn from jack 104, these relays cannot operate and the connector releases as soon as relay 213 releases, in turn releasing the rest of the connection.

If the "B" operator wishes to disconnect she may do so as soon as she finishes recording the number by operating link disconnect key 337, in turn operating relay 353 to put ground on conductor 507 to mark the position circuit as busy during release. This will also close a circuit from battery through the right winding of relay 542, outer left front contact of relay 510 and brush 552 of the position finder, conductor 514 to ground over the contact of key 337. Relay 542 locks over its right contact to conductor 408 and connects ground to both terminals of relay 517 which releases, opening the conductors connecting the position circuit to the sender. It also closes a circuit from the battery through the left winding of relay 405, conductor 449, outer left front contact of relay 542 to grounded conductor 408. Relay 405 opens the holding circuit of relay 510 which disconnects the position from the trunk and opens the circuit of relay 300 to release the position apparatus. Relay 542 also disconnects ground from conductor 507, freeing the position for selection by other position finders. The operation of relay 405 will connect relay 437 to interrupter 430. Relay 437 reverses the connection of relay 431 to the "A" operator's position to flash a lamp at that position.

Stuck sender.

If the sender does not complete its operation and release the link within a predetermined interval, means are provided for signaling the "A" operator who may then release the link and the partially established connection.

When relay 549 operated on the completion of registration as previously described, a circuit was closed from battery, through the winding of relay 432, back contact of relay 433, inner right contact of relay 549,

closes a circuit over its inner left front contact, through the winding of relay 546 to battery through resistance 565. However, relay 510 was operated before relay 520 and therefore a circuit is closed from battery, through resistance 565, over the left back contact of relay 546, inner left front contact of relay 510, to ground at the left back contact of relay 410, in shunt of relay 546, until relay 410 operates to connect the pulsing leads to the sender at which time it also opens the energizing circuit of relay 520. If no other link circuit is waiting at this time, relay 546 operates, opening the locking circuit of relay 520.

If, however, the operation of another link circuit in the group has been started, the relay 403 of that link will have operated and a circuit will be closed from ground at the outer left front contact of that relay, over the left back contacts of the relays 509 and 520 of that link to the back link contact of relay 546 shunting that relay and preventing the release of relay 520 of the link shown. The presence of additional links awaiting an operator would prevent the release of the relays 520 of the remaining links that had been served.

When a locked-out link is selected a second time, the operated condition of relay 520 opens the circuit of the relay 500 and prevents the operation of the position finder. It also prevents the closure of the shunt around relay 546 by that link. When all the waiting links have found an operator, the shunts will be removed from relay 546 and the relays 520 will release. Immediately that they release, the corresponding shunt circuits from relay 403 will be extended to relay 546 to delay second calls on links already served once.

All "B" positions busy.

As each position is taken for use, the relay 301 of that position removes the ground from conductor 352 which is connected thereto over the right back contact of relay 301 when the position is idle. As mentioned before, when the position is vacated, the withdrawal of the headset plug releases relay 350 and disconnects ground from conductor 352. As long as an occupied position remains idle, the direct ground on conductor 352 shunts, and prevents the operation of, relay 528. When all occupied positions become busy, the shunt is removed from relay 528 and that relay operates when the next link circuit is taken for use, to light lamp 535, as an indication that a call is waiting.

What is claimed is:

1. In a telephone exchange trunking system whereby an incoming line is interconnected to one of a group of selectable out-

going trunks by a cord circuit for extending said incoming line to a distant office, operators' positions at said distant office, means operated by said interconnection to cause the selection of an idle operator's position and to associate said trunk therewith, automatic switches, means under the control of said idle operator's position to set a train of said automatic switches to select a wanted line, means to discharge said position, and automatic means to associate said trunk directly with the first switch of said train.

2. In a telephone exchange trunking system whereby an incoming line is interconnected to one of a group of selectable outgoing trunks by a cord circuit for extending said incoming line to a distant office, operators' positions at said distant office, means operated by said interconnection to cause the selection of an idle operator's position and to associate said trunk therewith, a first automatic switch associated with said outgoing trunk, other automatic switches, means under the control of said idle operator's position to set said automatic switches to select a wanted line, means to discharge said position, and automatic means to associate said trunk directly with said first switch of said train.

3. In a telephone exchange system, an operator's position, a switch control device, means for associating said position with said control device, means at said position for setting said control device, means in said control device operative when said setting is complete to disconnect said position from said control device, and means at said position effective prior to the completion of said setting to cancel said setting without disconnecting said position from said control device.

4. In a telephone exchange system, an operator's position, a key set thereat, a register sender, means for associating said key set with said sender, means under the control of said key set for setting the registers of said sender, means in said sender operative when said registration is completed to disconnect said sender from said key set, and means under the control of said operator effective prior to the completion of said registration to destroy said partial registration without disconnecting said key set from said sender.

5. In a telephone exchange trunking system, whereby an incoming line is interconnected to one of a group of selectable outgoing trunks by a cord circuit for extending said incoming line to a distant office, operators' positions at said distant office, means operated by said interconnection to cause the selection of an idle operator's position, and to associate said trunk therewith, automatic switches, means under the control of said

conductor 560 to the timing circuit where ground was momentarily connected to conductor 560. Relay 432 locks through winding of relay 433, contact of relay 432 to ground at the inner left contact of relay 403. Relay 433 operates when ground is disconnected from conductor 560. The operation of relay 433 closes a circuit from battery through the right winding of relay 405, front contact of relay 433, inner right contact of relay 549 to conductor 560. The timing circuit measures off an interval of several seconds predetermined in accordance with traffic conditions to allow complete establishment of a connection after which ground is again connected to conductor 560 and relay 405 operates and locks through its left winding and inner left front contact to conductor 408. The operation of relay 405 closes a circuit from battery, through winding of relay 437, inner right contact of relay 405, interrupter 430 to ground. Relay 437 is intermittently operated in this circuit to reverse battery over the trunk conductors to the "A" operator's position and flash her cord lamp, not shown, indicating to her that the sender is stuck. Under this condition the "A" operator will remove her cord from the jack 104 and relay 431 will release as previously described. The release of relay 401 opens the circuit of relay 202 and that relay releases disconnecting the link circuit from the trunk finder and restoring the trunk finder to normal. The release of relay 202 opens the circuit of relay 403 as previously described and that relay brings about the release of the rest of the link and the sender.

Stuck link.

If the link does not complete its operations and release within a predetermined interval, the "A" operator is signaled. The operation of relay 403 which initiates the operation of the position finder closes a circuit from battery through the winding of relay 445, back contact of relay 446, outer right front contact of relay 403, conductor 447 which also extends to the timing circuit where ground is momentarily connected to conductor 447. Relay 445 operates and locks through the winding of relay 446, front contact of relay 445 to ground at the inner left front contact of relay 403. Relay 446 closes a circuit from battery through the right winding of relay 442, front contact of relay 446, outer front contact of relay 403 to conductor 447. After an interval predetermined from traffic conditions to allow time for the operation of the link, ground is connected to conductor 447 a second time and the above circuit for relay 442 completed. Relay 442 locks through its left winding

and inner right front contact to grounded conductor 408. It operates stuck line pilot lamp 444 in an obvious circuit. This lamp appears at the "A" operator's position and that operator may release the link in the manner previously described.

Stuck link key.

If there have been complaints of stuck sender conditions or other reasons to suspect stuck link or stuck sender trouble, the operation of stuck link key 438 will prevent the release of the sender and link when the "A" operator disconnects and will enable the trouble man to locate the sender or link which has been giving trouble. With key 438 operated, when the "A" operator releases the link and sender after they have become stuck, relay 439 operates in a circuit from battery, through its winding, upper contact of key 438, back contact of relay 401, lower contact of key 438, outer left front contact of relay 405 to grounded conductor 408, if the sender has become stuck or over the inner left front contact of relay 442, to grounded conductor 408 provided it is the link circuit which failed to operate properly. Relay 439 closes a locking circuit for itself over the upper contact of key 438 and its two inner armatures to ground. This ground also serves as a locking circuit for relays 442 and 405 so that they do not release when relay 403 releases due to the opening of the holding circuit of relay 202. If relay 442 has not operated, relay 405 and key 438 operated will close a circuit from battery through the left winding of relay 442, lower contact of key 438, outer left front contact of relay 405 to grounded conductor 408, causing the operation of that relay. Relay 442 operated, lights stuck link pilot lamp 444. The locking of relays 442 and 405 prevents the release of the sender and link circuit until the attendant releases key 438 having identified the circuit and possibly having corrected the difficulty.

Lock-out circuit.

It will be remembered that when the relay 511 operated relay 520 was operated and locked. The purpose of relay 520 is to prevent a link from seizing an operator's position if it has once seized an operator and been released while other links are waiting to be served. Therefore, in a group of links as each link is served, it will be locked out providing a call is still waiting on another link. When all links have been served once, those links on which a second call is waiting will be free and may then select an operator. Relay 520 is individual to the link circuit while relay 546 is common to the group of link circuits. The operation of relay 520

idle operator's position to set a train of
said switches to select a wanted line, means
to discharge said position, automatic means
to associate said trunk directly with the first
5 switch of said train and means controllable
from said trunk prior to the association of
said trunk with said train of switches to re-
lease said switches.

In witness whereof, I hereunto subscribe
my name this 8th day of September, A. D., 10
1926.

BERT G. DUNHAM.

In witness whereof, I hereunto subscribe
my name this 15th day of September, A. D.,
1926.

WILLIAM T. HAINES.