Oct. 23, 1928. 1,688,993

E. B. SMITH

TELEPHONE SYSTEM

Filed Oct. 19, 1926 5 Sheets-Sheet 1

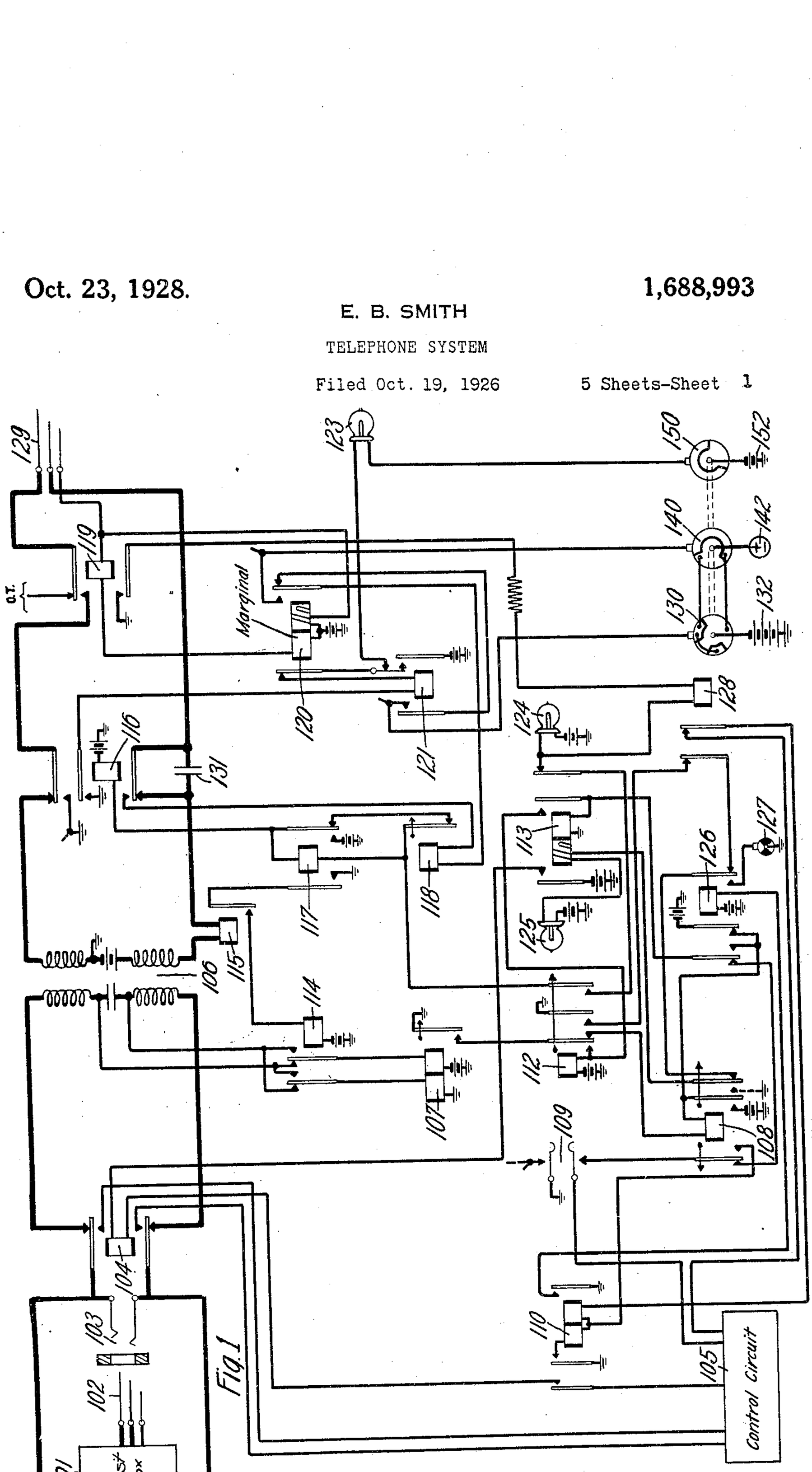

Fig. 1

Inventor:
Edmund B. Smith
by Jas. C. K. Holmes Att'y.

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E. B. SMITH

TELEPHONE SYSTEM

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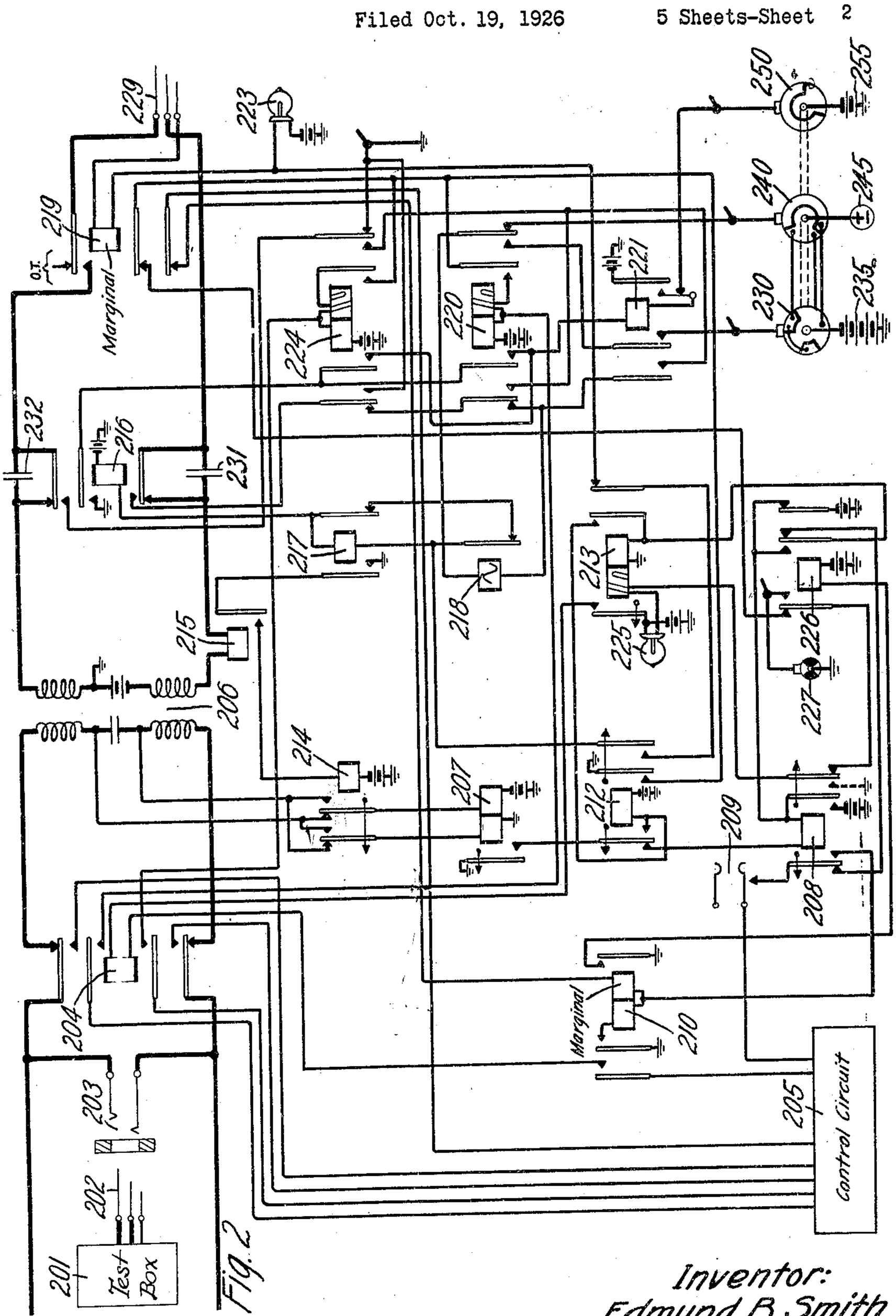

Fig. 2

Inventor:
Edmund B. Smith
by Joel Ch. Baines Att'y.

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E. B. SMITH

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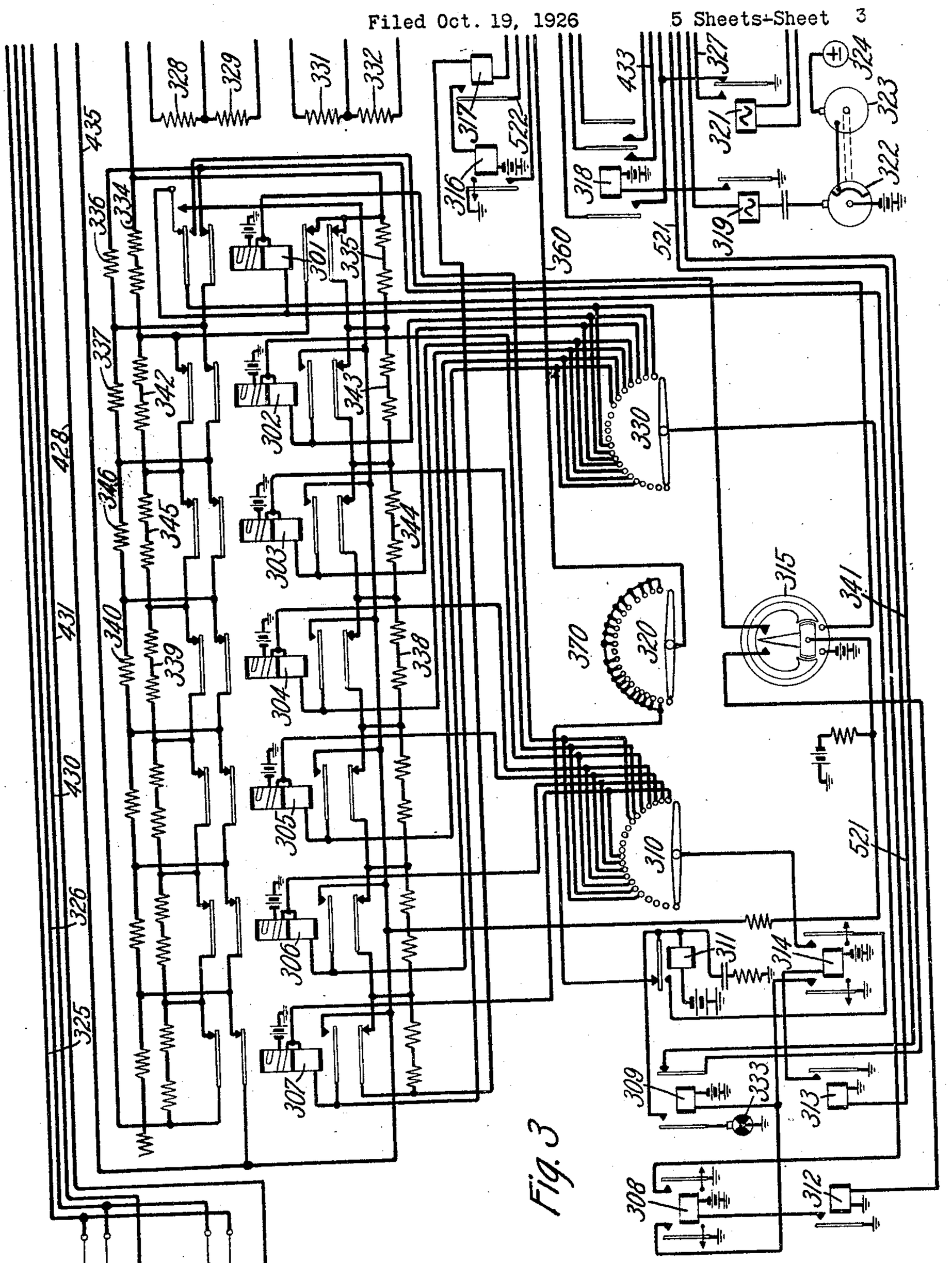

Fig. 3

Inventor:
Edmund B. Smith
by Joel R. Palmer Att'y.

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E. B. SMITH

TELEPHONE SYSTEM

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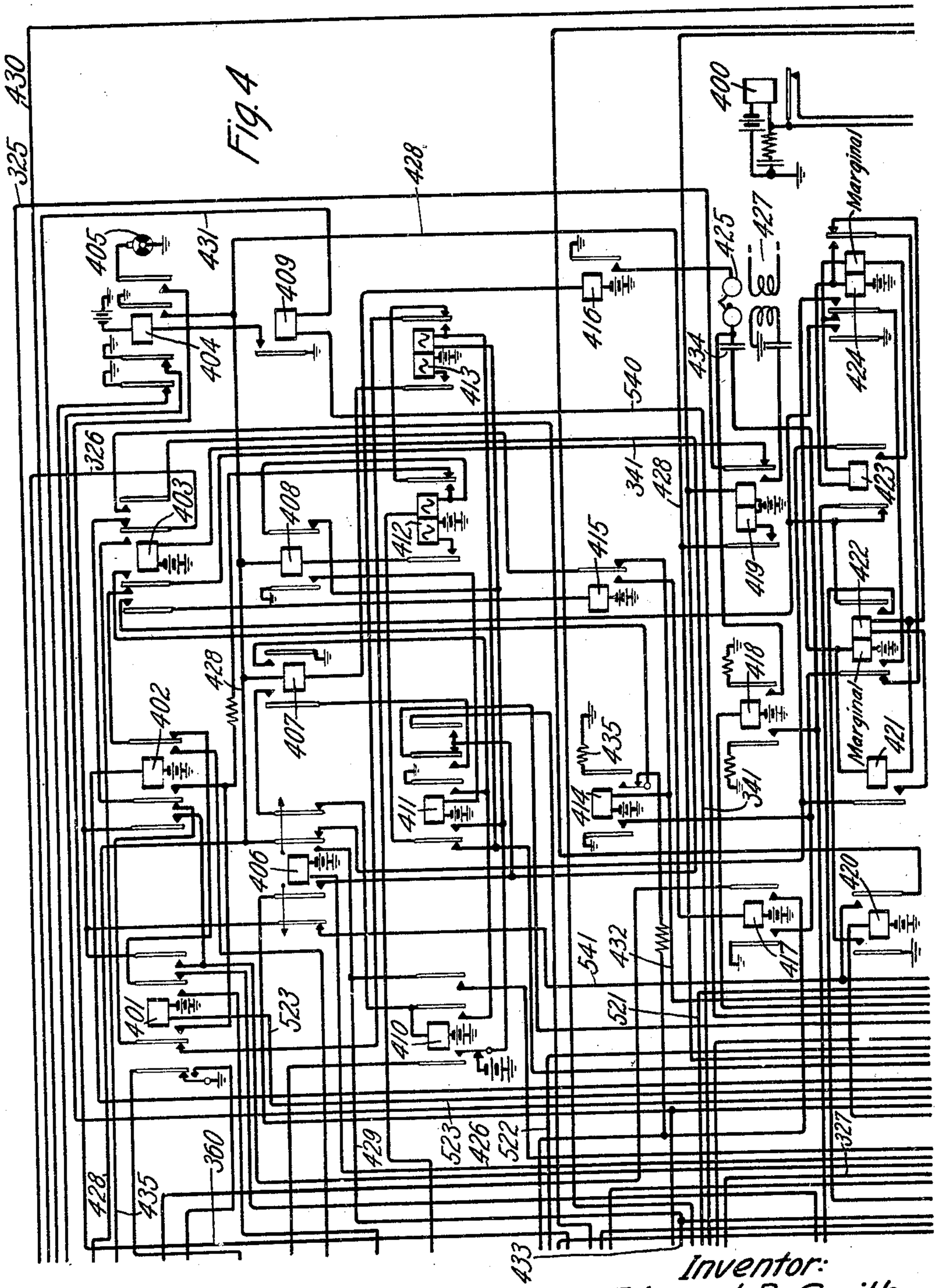
Fig. 4



Inventor:
Edmund B. Smith
by Joel C. Palmer Att'y.

Oct. 23, 1928. 1,688,993

E. B. SMITH

TELEPHONE SYSTEM

Filed Oct. 19, 1926 5 Sheets-Sheet 5

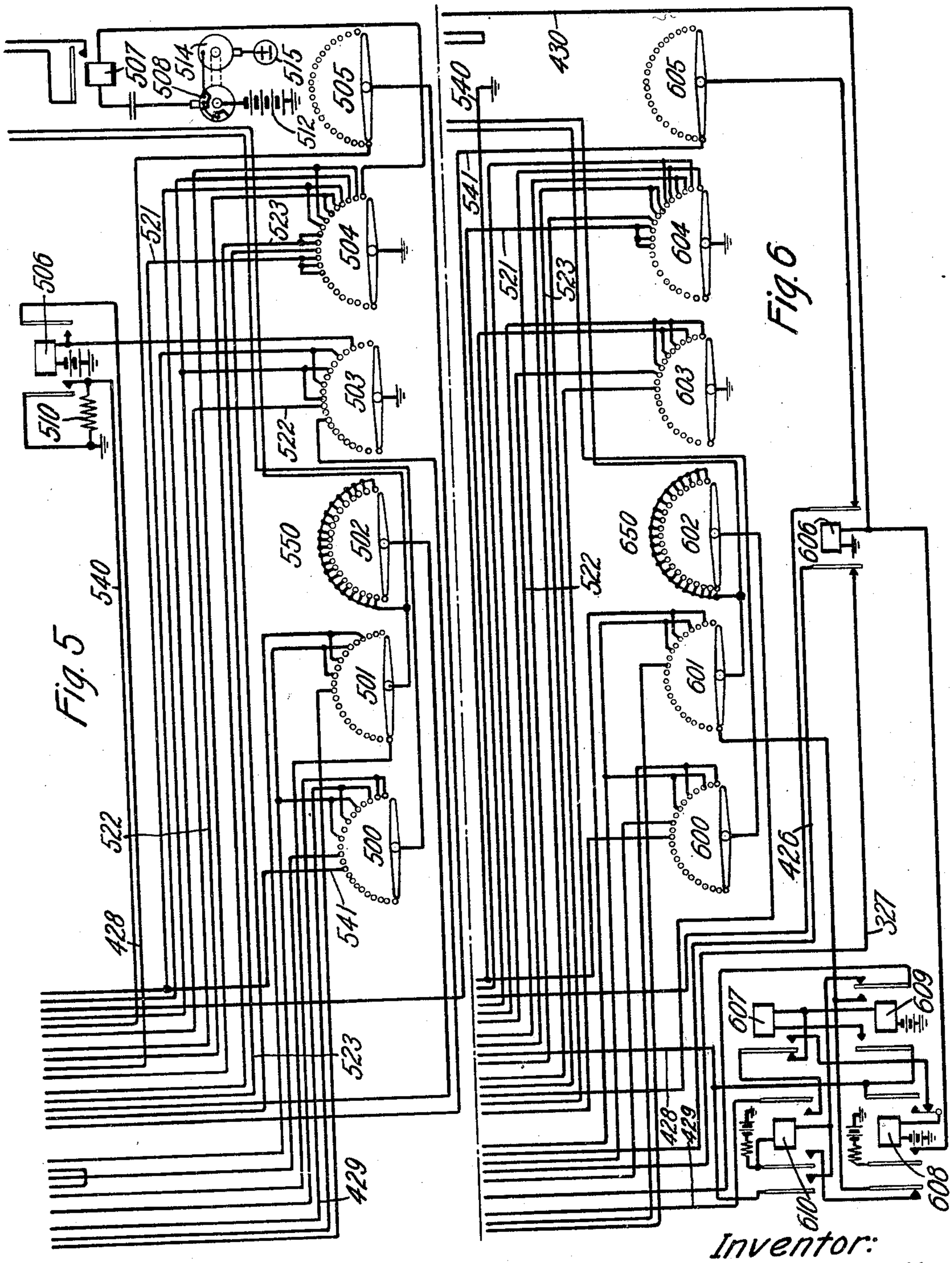


Fig. 5

Fig. 6

Inventor:
Edmund B. Smith
by Joel C. Palmer Att'y.

Patented Oct. 23, 1928. 1,688,993

UNITED STATES PATENT OFFICE.

EDMUND B. SMITH, OF NEW YORK, N. Y., ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TELEPHONE SYSTEM.

Application filed October 19, 1926. Serial No. 142,577.

This invention relates to telephone exchange systems and more particularly to the testing of equipment employed therein.

It is an object of the invention to provide automatically operable equipment for testing connecting circuits such as trunks and cord circuits, particularly those wherein ringing current is automatically applied to and disconnected from a called line.

In accordance with the present invention, an automatically operable circuit combination is provided for testing the ringing apparatus on trunks or other connecting circuits arranged for party line ringing wherein automatic control is employed to progressively change the ringing condition in the trunk in order to conduct a complete test of the trunk apparatus. The circuit is also arranged for testing the four combinations of ringing apparatus in trunks arranged for 4-party line ringing by means of separate tests together with means to distinguish a particular one of said tests in order that a complete progressive test of the trunk apparatus may follow said ringing tests. In addition the arrangement is made for the testing of supervisory relays with means to control the voltage at which current is supplied to the relay during tests.

For the purpose of establishing connections with called subscriber's lines, operators in telephone exchanges may be provided with plug ended trunks or with cord circuits depending upon the nature of the office and of the position. Called circuit trunks which originate at manual positions and cord circuits are equipped with ringing keys which control the application of machine ringing to the called line, while call indicator trunks originating at a machine switching office may be equipped either with keys or with automatically operable relays to control the application of ringing current.

Called subscriber's lines usually serve either 1, 2 or 4 parties and are represented either by a single jack or by a jack for each station in each outgoing multiple at the central office. In order to signal each party on a 4-line without serious interference with the other parties, ringing current for two parties is applied over the tip of the line and for two parties over the ring of the line. These parties are further distinguished by signaling one party with a single ring, and the other party with two rings grouped together. To accomplish this discrimination automatically in jack per station offices, the sleeve resistance of two parties is made lower than the others to operate a marginal relay in the trunk or cord circuit to discriminate between one or two rings while the connection of the tip and ring conductors of the line to the jacks is reversed to cause the application of ringing current to the tip or to the ring of the line as desired. In offices employing a single jack for each line the discrimination is within the trunk or cord circuit and is controlled either by the operator or by the indication set up on the relay call indicator.

In any one office all lines will be equipped either with a single jack or with a jack per station. Where 4-party lines are used, ringing on individual lines or two-party lines will be the same as the particular one or two parties on a 4-party line. In offices where only two parties are permitted to a line, the distinction is made by applying the ringing current either to the tip or to the ring conductor.

The testing device embodying the present invention has been arranged to test the ringing functions of any of the above mentioned types of connecting circuits and is arranged to be controlled by a step-by-step switch to progressively test the ringing current for application and duration, the tripping relay and the supervisory relay. In the case of offices using a jack per line it is necessary to set up in the trunk or cord circuit the condition determining the nature of the ringing current and the test circuit is therefore equipped with a step-by-step switch wired to permit the testing of each ringing function separately with means to prevent continuing the test except following the test of a particular ringing combination. In the case of jack per station offices, however, since the discrimination is brought about by the wiring of the jack, the testing device is

equipped with a step-by-step switch wired to first cause the trunk to apply two rings and then to alter the resistance attached to the sleeve of the trunk to cause the application of one ring. In jack per station offices employing two-party lines there will be no two-ring function to test, and the testing device will be equipped with a step-by-step switch wired like that for the 4-party jack per station office but omitting the test of the two-ring feature.

A clearer conception of the invention may be had from the following description in which:

Fig. 1 discloses a relay call indicator trunk circuit using 4-party jack per station ringing;

Fig. 2 shows a relay call indicator trunk circuit using 4-party jack per line ringing;

Fig. 3 discloses the current control circuit for testing supervisory relays;

Fig. 4 discloses the test relays;

Fig. 5 shows the control circuit for use with Fig. 4 when testing 4-party jack per station ringing; and

Fig. 6 shows the control circuit for use with Fig. 4 when testing 4-party jack per line ringing.

It is believed that the operation of the testing arrangement in connection with a relay call indicator trunk will sufficiently illustrate the invention, since as indicated above, the operation of the cord circuits and call circuit trunks differs from that of relay call indicator trunks chiefly in that keys are used to control the ringing combination. It is likewise believed to be unnecessary to show the wiring of a step-by-step switch for testing trunks employing 2-party jack per station ringing since it is very nearly a duplicate of that for testing trunks having 4-party jack per station ringing.

The test boxes 101 and 201 have been indicated merely by rectangles. These boxes are similar to the one disclosed in U. S. Patent 1,522,856, granted to A. S. Bertels, January 13, 1925, and comprise a relay call indicator impulse switch, such as used in panel machine switching senders. Such an impulse switch is shown in Fig. 6 of U. S. Patent 1,464,084 to Lundell et al. granted August 7, 1923. The switch is driven by a spring motor and a set of keys serves in place of the registers. Some additional apparatus for starting the switch and making trunk closure is also provided. Each trunk is provided with a test jack into which the plug attached to the test box is inserted, signalling the operator before whom the trunk appears as in the case of an ordinary incoming call. When the operator responds, the sequence switch is operated to set the indicator at her position. The number set up will be that of a jack leading to the testing device and she will insert the plug of the trunk in that jack, setting her master ringing keys for party discrimination where necessary.

When the test man inserts plug 102 of the test box in test jack 103 of the trunk to be tested, relay 107 operates in a circuit completed in the test box, to simulate that closed by the sender when the trunk is selected at the automatic office where it appears in the terminals of a selector. Relay 107 in turn operates relay 108 in a circuit which may be traced from battery at the inner left back contact of relay 126, winding of relay 108, back contact of relay 112 to ground at the front contact of relay 107. Relay 108 operated locks to battery on its inner right front contact and lights the assignment lamp 125 indicating to the operator at whose position it is located that a connection is desired over the corresponding trunk. The operator presses the display key 109 which completes a circuit for relay 110, extending from battery in the control circuit 105, back contact of relay 128, right winding of relay 110, left front contact of relay 108, contact of key 109, to ground in the control circuit. Relay 110 locks through both windings to ground on its inner left front contact and prepares a circuit for operating relay 104. It also closes an obvious circuit for relay 126. Relay 126 operated, closes a circuit from ground through the right winding of relay 113, left front contact of relay 126 to battery at the inner right front contact of relay 108. Relay 113 operated locks over its right front contact to battery through the winding of relay 112 to battery. At this time there is a shunt around relay 112 from battery on the inner right front contact of relay 108 and relay 112 does not operate. The operation of relay 113 also completes the circuit for relay 104, thereby closing the tip and ring conductors through to the control circuit 105 and releasing relay 107. The release of relay 107 releases relay 108 in turn removing the shunt from around relay 112 allowing it to operate. The release of relay 108 also closes a circuit from ground, through interrupter 127, right front contact of relay 126, right back contact of relay 108, non-inductive winding of relay 113 to lamp 125. The assignment lamp 125 flashes in this circuit as an indication to the operator that the control circuit has been connected and a number is being recorded.

When all of the code impulses sent from test box 101 have been received in the control circuit 105 and the number (which in this case is that of the test jack terminating in the testing apparatus of the present invention) has been displayed on the indicator, the circuit of relay 104 is opened in the control apparatus and that relay releases. The circuit for relay 107 is again closed in the test box, causing the re-operation of

that relay. Relay 107 short-circuits relay 113 and holds relay 112 operated. The operator tests the wanted line and inserts plug 129 of the trunk in the test jack 350, thereby closing a circuit through relays 120, 119, and 409, which may be traced from ground through resistance 510, conductor 540, winding of relay 409, conductor 431, sleeve of jack 350 and plug 129, winding of relay 119 and the left winding of relay 120 to battery. Relay 119 and the left winding of relay 120 are shunted by the right, non-inductive winding of relay 120 for operating reasons. As relay 120 is marginal it does not operate at this time due to the high resistance 510 in series with it. Relay 119 operates and closes a circuit for relay 128 to battery through lamp 124 and in parallel therewith to battery over the right back contact of relay 113, outer right front contact of relay 112, back contact of relay 118, back contact of relay 117, and the winding of relay 116. Relay 116 operates but lamp 124 is not lighted. Relay 119 also removes the busy test lead from the tip of the trunk and closes the tip through to the upper back contact of relay 116. Relay 128 operated opens the circuit through the right winding of relay 110, releasing that relay and the relays of the control circuit. Relay 116 operated removes the shunt around the condenser 131, and connects ground to the tip side of the trunk over its upper outer front contact. Relay 116 also closes a circuit for relay 121 from ground on the upper inner front contact of relay 116, winding of relay 121, left back contact of relay 120, right back contact of relay 121, lamp 123 to battery through interrupter 150, which forms a part of the ringing interrupter. The operation of relay 121 renders interrupter 130 effective to apply two impulses of ringing current to the line. Relay 121 operates when interrupter 150 closes its contact and locks up to battery on its right front contact. The operation of relay 121 connects ringing current to the ring side of the plug 129 through interrupter 130 which is arranged to give two separate and distinct impulses of ringing current.

When relay 409 operated it closed an obvious circuit for relay 404. The operation of relay 404 closes a circuit from ground through interrupter 405, outer right front contact of relay 404, outer left back contact of relay 406, conductor 541, normal contact of arc and brush 505, winding of relay 414 to battery. Relay 404 also disconnects ground at its inner left contact from conductor 360 and at its outer left contact from the brush of arc 502. Relay 414 operates at the first closure of interrupter 405 and closes a circuit from ground on its left front contact, outer left back contact of relay 422, right back contact of relay 424, winding of relay 421 to battery through the left winding of relay 422. Relay 421 operates and locks to ground through the right winding of relay 422, front contact of relay 421, inner right back contact of relay 406 to ground on the inner right front contact of relay 404. Relay 422 does not operate in the operating circuit of relay 421 being marginal, nor in the locking circuit, being shunted by the energizing ground. At the next open period of interrupter 405, relay 414 releases and removes the shunt from around the right winding of relay 422 and relay 422 operates. When the contacts of interrupter 405 again close, relay 414 reoperates and closes a circuit for operating relay 423 from battery through the left winding of relay 424, winding of relay 423, inner left back contact of relay 424, left front contact of relay 422 to ground on the left front contact of relay 414. Relay 423 operated locks over a circuit from battery through the left winding of relay 424, winding of relay 423, right winding of relay 424, right front contact of relay 423, inner right back contact of relay 406 to ground on the inner right front contact of relay 404. The left winding of relay 424 is shunted to ground on the left front contact of relay 414 and will not operate until the opening of the contacts of interrupter 405 releases relay 414, at which time relay 424 operates over the same circuit as traced above. The operation of relay 424 transfers the lead from ground on the front contact of relay 414 to the windings of relays 421 and 422. When the interrupter 405 again closes its contact, relay 422 is held operated and relay 421 is shunted out by the ground on the left front contact of relay 414. When the interrupter 405 again opens its contacts, relay 422 releases. Upon the next closure of interrupter 405, relay 424 is held operated and relay 423 is shunted down and a circuit is closed from ground on the outer left front contact of relay 424, left back contact of relay 423, normal contact and brush of arc 501, back contact and winding of magnet 400 to battery. The operation of magnet 400 moves the switch composed of brushes and arcs 500 to 505, inclusive, one step to position zero.

The operations described above are for the purpose of insuring that the ringing test is applied at the beginning of the ringing period. While ringing is in progress, relay 406 is operated as will be described hereinafter, preventing the operation of relay 414 as well as opening the locking circuit for relays 421 to 424. In the present disclosure the two-ring ringing interrupters 508 and 130 apply ringing current for one second, remove it for one second apply it for one second and remove it for three seconds. The interrupter 405 closes ground to the ar-

mature of relay 404 twice each second. It is therefore apparent that, if relay 404 operates while ringing current is being received, interrupter 405 is ineffective, while, if it operates during the one second interval between rings, the operation of the relay combination 421 to 424 will not progress to the point of advancing switch 550 before the second ring releases them. In the three second interval between the code rings there is time enough to advance switch 550 and the test is therefore begun at the beginning of the ringing period.

Ringing test.

The test circuit is now in condition for testing the ringing features of the trunk circuit. It will be remembered that when relay 116 in the trunk circuit operated, ground was connected to the tip of the trunk. This ground completes a circuit through the tip of plug 129, jack 350, conductor 326, inner right back contact of relay 403, inner left back contact of relay 402, inner left back contact of relay 401 to battery through the winding of relay 416 in which relay 416 operates. A circuit is now closed from ringing current source 142, through interrupter 130, left front contact of relay 121 (which was operated above), right back contact of relay 120, winding of relay 118, lower front contact of relay 116, over the ring of plug 129 and jack 350, conductor 325, right back contact of relay 419, inner left back contact of relay 403, right back contact of relay 402, inner right back contact of relay 401, winding of alternating current relay 321 to ground on the front contact of relay 416 through the subset 425. When now interrupter 130 applies the first impulse of ringing current to conductor 325 relay 321 and the ringer of subset 425 operate. The operation of relay 321, closes a circuit from ground on its front contact, over conductors 327 and 426 to battery through the winding of relay 406 opening the locking circuit of relays 421 to 424. At the same time ringing current from source 514 is connected through interrupter 508 (which is the same as interrupter 130 but shown separately for convenience) to the winding of relay 507, zero terminal of brush 504 to ground. Relay 507 operates, preparing a circuit for testing whether ringing current is being received from the trunk circuit. If the ringing current from the trunk is not being received by relay 321, that relay will not operate and ground from its back contact through the front contact of relay 507 will operate relay 419, through its right winding. Relay 419 operated locks through its left front contact to ground on the inner right front contact of relay 404. Relay 419 operated connects tone from source 427 to the ring side of the test circuit and trunk, through the right front contact of relay 419 as an indication to the test man that the ringing current is not being received. If the ringing current is being received by relay 321, its operation in turn operates relay 406 as described above and relay 406 closes a circuit from ground on the inner right front contact of relay 404, conductor 428, inner right front contact of relay 406, conductor 429, zero terminal of arc and brush 500 to battery, through the winding of the stepping magnet 400. During the open period of ringing interrupter 320, relay 321 releases in turn releasing relay 406 which releases magnet 400 thereby stepping the selector to position 1. When the interrupter 130 again closes its contact for the second impulse of ringing current, relay 321 again operates in turn operating relay 406 which again operates magnet 400 through terminal 1.

With the sequence switch in position 1, ground from arc 504 is connected through terminal 1, through the right winding of relay 413 to battery on the left back contact of relay 410 and also over a parallel circuit through the left back contact of relay 411, right winding of relay 412, back contact of relay 408 to battery over the left back contact of relay 410. Relays 412 and 413 operate and lock through the windings of relays 408 and 407 respectively to ground on the inner right front contacts of relay 404. Relay 408 in operating closes an obvious circuit for operating relay 411 and opens the circuit from battery on the left back contact of relay 410, through the winding of relay 412. When the second ringing period, which was started above, is completed, magnet 400 releases and moves the selector switch into position 2.

With the switch in position 2 which is an indication that the two rings have been received, a circuit is closed from ground on arc 503, terminal 2, to battery through the winding of relay 506. Relay 506 shunts the resistance 510 connected to conductor 540 which is in the operating circuit for relays 119 and 409. Relay 120 is also included in this circuit but as resistance 510 was too high, relay 120 did not operate. With resistance 510 shunted, relay 120 operates and opens the operating circuit for relay 121, closing a circuit from ringing commutator 140 and source 142, right front contact of relay 120, winding of relay 118, lower front contact of relay 116 to the ring side of the plug 129 and jack 350, conductor 325, right back contact of relay 419, inner left back contact of relay 403, right back contact of relay 402, inner right back contact of relay 401, through the winding of relay 321 to ground on the front contact of relay 416, through the subscriber's set 425. A circuit is also closed from ground on the brush of

arc 504 to the ringing commutator 322 and source 324 through the winding of relay 319. Commutators 322 and 140 also represent the same part of the office ringing machine and are shown separately merely for convenience. When the ringing commutator 322 closes its contact, relay 319 operates and relay 321 should operate as described above in turn operating relays 318 and 406.

If relay 321 does not receive ringing current from the trunk it will not operate and relay 406 will remain normal. With relay 319 operated and relay 321 normal, a circuit will be closed for relay 419 from ground at the back contact of relay 321, left front contact of relay 318, outer right front contact of relay 411, right winding of relay 419 to battery. Relay 419 operates and locks to ground on the permanent ground lead 428. Relay 419 operated transfers the ring conductor 325 to a circuit through the tone coil 427 thereby giving the test man a tone as an indication that ringing current is not being received by the test circuit. If the ringing current is being received, a circuit is closed from grounded conductor 428, inner right front contact of relay 406, conductors 429 and 433, inner right front contact of relay 318, second terminal and brush of arc 500 to battery through the winding of stepping magnet 400. At the end of the ringing interval, relay 319 releases in turn releasing relay 318 and relay 321 releases in turn releasing relay 406 which allows magnet 400 to release and step the switch to position 3.

Premature tripping test.

With switch 550 in position 3, a test is made of the operated condition of relays 412 and 413 since the release of these relays is employed to insure the application of the test resistance while the ringing current is passing through its maximum positive value. It may be noted that these relays are so designed that they operate through one winding on direct current but release as an alternating current applied to the other winding reaches a maximum value. In the present case the connections are such that relay 413 releases at the maximum of a negative half cycle while relay 412 releases at the maximum of a positive half cycle. The test circuit above mentioned may be traced from ground over terminal 3 of brush 504, middle front contact of relay 411 (which is operated if relay 408 remains operated in the locking circuit of relay 412), left front contact of relay 407 (which is included in the locking circuit of relay 413), right back contact of relay 406 to battery through the winding of relay 410. Relay 410 operates and disconnects battery from the right windings of relays 412 and 413 and transfers these windings to the left front contact of relay 410 through resistance 329, outer left back contact of relay 401 to ground. Relay 410 in operating locks to ground over a circuit through its inner right front contact to ground on the inner right front contact of relay 411. When relay 406 operates in response to the next impulse of ringing current, relay 410 closes a circuit from permanent ground conductor 428, inner right front contact of relay 406, outer right front contacts of relay 410, third terminal and brush of arc 501 to battery through the back contact and winding of magnet 400 thereby stepping the switch to position 4. In this position ground is connected through the brush and fifth terminal of arc 503 to battery through the winding of relay 418. Relay 418 connects ground through a resistance to the two sides of condenser 434, thereby discharging condenser 434 to prevent relay 321 from operating falsely on a condenser discharge. Relay 402 is operated at this time over a circuit from ground, brush and fourth terminal from arc 504 to battery through the winding of relay 402. In operating relay 402 opens the circuit through relay 321 and subset 425 and completes a circuit from ringing source 142, commutator 140, right front contact of relay 120, winding of relay 118, lower front contact of relay 116, ring of plug 129 and jack 350, conductor 325, right back contact of relay 419, inner left back contact of relay 403, right front contact of relay 402, through resistances 331 and 332, right front contact and right winding of relay 413, left front contact of relay 410, through resistance 329 to to ground on the outer left back contact of relay 401. Another circuit is closed from ground through interrupter 405, outer right front contact of relay 404, outer left front contact of relay 402, fourth terminal and brush of arc 500 to battery through the winding of magnet 400. When the interrupter 405 closes its contact, magnet 400 operates and steps the switch 550 to position 5. Relay 402 is held operated over a circuit to ground through the fifth terminal and brush of arc 504. As stated above the ring conductor 325 of the trunk is connected through the right winding of relay 413 and the winding of relay 118 in series. When the ringing current from source 142 reaches its maximum negative voltage through resistances 331, 332 and 329, relay 413 releases and connects relay 118 in a circuit from ground on the left back contact of relay 401 through resistance 329, left front contact of relay 410, left front contact of relay 411, right winding and right front contact of relay 412, right back contact of relay 413, resistances 331 and 332, right front contact of relay 402, inner left back contact of relay 403, right back contact of relay 419, conductor 325, ring contacts of jack 350 and plug 129, lower front contact

of relay 116, winding of relay 118, right front contact of relay 120 to ringing source 142, through interrupter 140. The release of relay 413, mentioned above, opens the circuit for relay 407. When the current from source 142 reaches its maximum point in the positive half cycle, the differential relay 412 releases and connects resistances 331 and 332 in series with resistance 490 across conductors 325 and 326 to the tripping relay 118. Relay 412 in releasing also opens the circuit for relay 408 allowing it to release in turn releasing relay 411. With relays 407 and 411 released relay 410 releases. Upon the next closure of interrupter 405, a circuit is closed from ground, through the interrupter, outer right front contact of relay 404, outer left front contact of relay 402, fifth terminal and brush of arc 501 to battery through the back contact and winding of magnet 400 thereby moving selector 550 into position 6. The use of two positions of switch 550 for this test is to insure the application of the test resistance for a minimum time of one second. When the switch moves out of position 5 the circuit for relay 402 is opened thereby releasing it. The release of relay 402 connects subset 425 to the ring conductor 325 in series with the winding of relay 321 over a circuit traced hereinbefore. Relay 321 operates and the bell of subset 425 rings providing the tripping relay 118 has not been prematurely tripped by resistances 490, 331 and 332.

With the selector in position 6, a circuit is closed from ground through the brush and sixth terminal of arc 504 to reoperate relays 412 and 413 over the same circuit described with the switch in position 3. Relays 407 408 and 411 are also reoperated. With relay 321 operated from current source 142, a circuit is closed for relay 406 which was traced above. Relays 318 and 319 will operate in the same manner as described. With relays 318 and 406 operated, a circuit is closed from permanent ground conductor 428, inner right front contact of relay 406, conductor 433, inner right front contact of relay 318 to the sixth terminal and brush of arc 500 to battery through the winding of magnet 400. At the end of the ringing interval relay 318 releases thereby opening the circuit for magnet 400 and moving selector switch 550 into position 7.

In position 7 a circuit is again closed for relay 410 from ground through the brush and seventh terminal of arc 504, middle front contact of relay 411, left front contact of relay 407, right back contact of relay 406 to battery through the winding of relay 410 to test whether relays 412 and 413 are properly operated. Relays 410 and 411 function as described above and at the next ringing period relay 321 operates in turn operating relay 406 over a circuit already traced above. With relay 406 operated a circuit is closed from permanent ground conductor 428, inner right front contact of relay 406, outer right front contact of relay 410, seventh terminal and brush of arc 501 to battery through the back contact and winding of magnet 400 thereby moving the switch 550 into position 8.

Had relay 118 been tripped prematurely by resistances 329, 331 and 332, relay 321 would not operate as described above and subset 425 would not ring. In this case with relays 318 and 319 operated a circuit will be closed from ground on the back contact of relay 321, left front contact of relay 318, outer right front contact of relay 411 to battery through the right winding of relay 419. Relay 419 operates and connects tone from source 427 to the ring conductor 325 as an indication to the test man that the ringing trip relay 118 has been prematurely operated. This tone will continue until the plug 129 is withdrawn from the jack and the test started again.

Tripping test.

With the selector in position 8, a circuit is closed from ground through the brush and eighth terminal of arc 504, conductor 523 to battery through the winding of relay 401. The operation of relay 401 connects resistance 328 in series with resistance 329 and resistance 322 to the ring of the trunk. Relay 401 is held operated while the selector switch 550 is in positions 8 and 9. Upon the next closure of interrupter 405, a circuit is closed over the outer right front contact of relay 401 and thence through the eighth terminal and brush of arc 500 over the same path as traced in position 4 thereby operating magnet 400 to step the selector switch to position 9.

With the switch in position 9 a circuit is again closed from ground through interrupter 405, arc 501 to magnet 400, thereby sending the selector 550 to position 10. When the switch is in positions 9 and 10 relays 412 and 413 are released under the same conditions as when the switch was in position 6, the only difference being that following the release of relays 412 and 413 resistances 332 and 490 alone are connected across the tip and ring conductors 325 and 326. These resistances should be sufficiently low to cause relay 118 to operate and open the shunt around relay 117 allowing it to operate. With relay 117 operated, relay 116 is shunted out by battery on the right front contact of relay 117 thereby removing ringing current from source 142 from the trunk. Relay 117 prepares an obvious circuit for relay 114 which is not completed at this time as supervisory relay 115 has not been operated.

In position 10 the circuit for relay 401 is

opened allowing it to release. The release of relay 401 connects subset 425 and relay 321 to conductor 325 and relay 416 to conductor 326. If the tripping relay 118 has failed to operate during the trip test ringing current will be applied from source 142, through the winding of relay 321 and subset 425 as an indication that the tripping relay has not operated. The operation of relay 321 will in turn operate relay 406 which closes a circuit over terminal 10 of brush 504 for relay 419. Relay 419 then connects tone from source 427 to the trunk as an indication to the test man that the trip relay has failed. A parallel circuit is also closed from ground through the brush and tenth terminal of arc 504, inner right front contact of relay 318, tenth terminal and brush of arc 500 to battery through the winding of magnet 400 thereby moving the selector switch to position 11.

Current control for supervisory relay test.

At this point the current control circuit for testing supervisory relays will be explained. This circuit is similar to those used in the voltage control of filaments in repeater circuits. When relay 404 has operated as described above and permanent ground is connected to conductor 428, the current control circuit is started over a circuit from battery through the winding of current control relay 315. This type of relay is so designed that when the battery voltage is below a given standard, one set of contacts is closed and if it is above it, the other set of contacts is closed. Whichever way these contacts are closed, a balancing network will be brought into play until the current from the office battery is of the correct potential. For example, if the office battery has a range from 20 to 28 volts, relay 315 may be adjusted to a normal position, that is, not touching either contact over a difference of one volt ±.2, that is the relay may be adjusted to be normal between 20.2 and 20.8 or between 21.2 and 21.8, etc. For example, if the relay is set for 24.5 volts, relay 315 will operate and close a circuit for operating relay 312 which in turn operates relay 308, should the voltage at any time go above 24.8. Relay 308 operated, operates relay 309 which opens a possible circuit for relay 403, thereby preventing the test of any supervisory relay during the changing of the resistances to adjust the testing current. Relay 309 also closes a circuit from ground through interrupter 333 to battery through the winding of stepping magnet 311. When the interrupter closes its contacts magnet 311 operates and steps the selector switch 370 one step. In this position ground from the right front contact of relay 308 through terminal 1 and brush of arc 330 operates relay 301 through its windings. Relay 301 operated locks over its uppermost front contact to conductor 428 and opens the shunt around resistances 334 and 335 thereby including these resistances in the test lead to the supervisory relay. The shunt around resistance 336 is also removed and it is connected in series with the winding of relay 315. Assuming that the current control relay 315 continues to keep its left-hand contact closed thereby holding relays 312, 308 and 309 operated, when interrupter 333 again closes its contact, magnet 311 is energized and upon the opening of the interrupter steps the selector 370 to position 2. Ground from the right front contact of relay 308 closes a circuit through the second terminal of arc 330 to battery through the windings of relay 302 in series. The operation of relay 302 is the same as that of relay 301, cutting in resistances 342 and 343 and connecting the resistance 337 in series with relay 315. Relays 303 and 304 may be operated in a like manner. After relay 304 has operated we will assume that the potential applied to the trunk has been adjusted to 24.5 volts. Relay 315 will now open its left contact and hold its armature at some point mid-way between its contacts, as long as the central office battery remains at a voltage of more than 24.2 volts or less than 24.8 volts.

If, for example, it should drop to something like 23.8 volts, relay 315 will close its right contact and a circuit will be closed from battery through the armature and right contact of relay 315, upper outer front contact of relay 301 to ground through the winding of relay 313. Relay 313 in operating closes an obvious circuit for relay 314 which also closes an obvious circuit for relay 309. When relay 315 opens its left-hand contact relay 312 releases in turn releasing relay 308. When interrupter 333 again closes its contacts magnet 311 operates closing a circuit from ground through the interrupter 333, left front contact of relay 309, front contact of magnet 311, right front contact of relay 314, brush and fourth terminal of arc 310, upper non-inductive winding of relay 304 to battery, thereby shunting relay 304. Relay 304 in releasing shunts out resistances 338, 339 and 340 and when interrupter 333 opens its contacts, magnet 311 steps the selector 370 one step. With resistance 340 shunted out of the circuit for relay 315, the potential will be increased and its armature may come to rest at some point mid-way between the two contacts, thereby releasing relays 309, 313 and 314. If the decrease in resistance is insufficient these relays will be held operated and selector 370 advanced another step to release relay 303 and shunt resistances 344, 345 and 346.

With the ringing current tripped and selector 550 in position 11, a circuit will be

closed from ground, brush and terminal 11 of arc 504, conductor 521, right back contact of relay 309, conductor 341 to battery through the winding of relay 403. Relay 403 operates and closes a circuit from ground through the upper right winding of repeating coil 106, upper outer back contact of relay 116, upper front contact of relay 119, tip of plug 129, jack 350, conductor 326, inner right front contact of relay 403, conductor 435, upper outer back contacts of relays 307, 306 and 305, (assuming relays 304, 303, 302 and 301 to be operated) through resistances 339, 345, 342, 334, 335, 343, 344 and 338, lower outer back contacts of relays 305, 306 and 307, winding of relay 317, right back contact of relay 414, inner left contact of relay 403, right back contact of relay 419, conductor 325, ring of jack 350 and plug 129, lower back contact of relay 116, winding of relay 115, lower right winding of repeat coil 106 to battery. Relay 317 operates in this circuit in turn operating relay 316 from battery through the winding of relay 316, front contact of relay 317, conductor 522 to ground through the eleventh terminal and brush of arc 503. The operation of relay 316 closes a circuit from ground on its front contact, eleventh terminal and brush of arc 501 to battery, through the back contact and winding of magnet 400 thereby causing the selector switch 550 to step to position 12. When the interrupter 405 next closes its contacts a circuit is closed from ground through the interrupter, outer right front contact of relay 404, outer left back contact of relay 406, conductor 541, twelfth terminal and brush of arc 500 to battery through the winding of magnet 400 thereby moving the selector to position 13.

With the selector in position 13 a circuit is closed from ground through the brush and thirteenth terminal of arc 503 to battery through the winding of relay 420 which operates. Ground from the interrupter 405 now operates relay 414 over a circuit from ground through the interrupter, outer right front contact of relay 404, outer left back contact of relay 406, conductor 541, and right front contact of relay 420, outer right front contact of relay 403, back contact of relay 415 to battery through the winding of relay 414. The operation of relay 414 supplies a "soak" current to the supervisory relay 515 in the trunk circuit. This "soak" current is one sufficient to operate and thoroughly saturate the core of the relay under test. The circuit for this purpose may be traced from battery through the lower right winding of repeat coil 106, winding of relay 115, lower back contact of relay 116, ring contacts of plug 129 and jack 350, conductor 325, right back contact of relay 419, inner left front contact of relay 403, right front contact of relay 414, to ground through resistance 435. Resistance 435 is sufficient to give the correct potential for soaking the core of supervisory relay 115. Interrupter 405 closes and opens its contact to operate the combination of relays 421, 422, 423 and 424 again as explained above to time the application of current to relay 115. When relay 422 operates, a circuit is closed from ground on the left front contact of relay 420, right front contact of relay 422, outer left front contact of relay 403 to battery through the winding of relay 415. Relay 415 operated closes a circuit from ground on interrupter 405, outer right front contact of relay 404, outer left back contact of relay 406, conductor 541, right front contact of relay 420, outer right front contact of relay 403, front contact of relay 415 to battery through the winding of relay 417. The operation of relay 415 opens the circuit of relay 414 permitting that relay to release. A circuit is now closed for providing the correct operating current for supervisory relay 115 which may be traced as before to conductor 325, right back contact of relay 419, inner left front contact of relay 403, right back contact of relay 414, right front contact of relay 417, resistances 334, 342, 345 and 339, upper outer back contacts of relays 305, 306 and 307, conductor 435, inner right front contact of relay 403, conductor 326, tip contacts of jack 350 and plug 129 to ground over the circuit mentioned above. With relay 415 operated, relay 417 alternately operates and releases under the control of interrupter 405. With relay 417 released the previously traced circuit through resistances 338, 344, 343, 335, 339, 345, 342 and 334 is restored thereby causing the supervisory relay to release. After three more closures of interrupter 405, relays 421 to 424 are released in turn releasing relay 415. When relay 415 releases relay 414 again operates under the control of the interrupter, connecting the soak current to the relay and a complete cycle of soak, operate and release current is continued until the plug 129 is removed from jack 350.

The operation of supervisory relay 115 closes an obvious circuit for relay 114. This relay reverses the connection of battery and ground to the incoming end of the trunk operating a relay in the test box, lighting a lamp therein. The lamp follows the operation and release of relay 115 and indicates to the testman whether the supervisory relay is responding properly to the current applied.

With the completion of this test, the testman removes the plug 102 of test box 101 from its jack 103 releasing relay 107. The release of relay 107 opens the locking circuit for relay 112 and that relay releases opening the shunt which has been closed around lamp 124 through the winding of relay 117. Lamp 124 now lights as a signal to the oper-

ator that the trunk is free. She then removes plug 129 from jack 350.

When the plug 129 is removed from jack 350 relays 119, 409 and 120 release. The release of relay 409 releases off-normal relay 404 thereby removing the ground from conductor 428, thus releasing relay 419 and any of relays 301 to 307 inclusive that are operated. The release of relay 404 also closes a circuit from ground on the outer left back contact of relay 404 over the strapped terminals and brush of arc 502 to battery through the back contact and winding of magnet 400 thereby restoring the selector 550 to normal. This relay performs this function with the switch 550 in any off-normal position. The release of relay 119 in turn releases relay 128 and extinguishes lamp 124.

Testing trunks having 4-party jack-per-line ringing.

A description will now be given of the testing operations for a trunk having four-party jack-per-line ringing. A trunk of this character is shown on Fig. 2 and is operated in a manner similar to the trunk already described on Fig. 1. As above indicated, Fig. 6 shows the control switch to be used for testing this type of trunk. The test operator inserts plug 202 of the test box 201 in jack 203 operating relay 207 which in turn operates relay 208. Relay 208 locks to battery on its inner right front contact and closes a circuit for lighting assignment lamp 225 through the non-inductive left winding of relay 213. The display key 209 is now operated, operating relay 210 from the control circuit 205. Relay 210 operated closes an obvious circuit for operating relay 226 and closes a locking circuit through its left winding to ground. Relay 226 now closes a circuit from battery over the inner right front contacts of relays 208 and 226 to ground through the right winding of relay 213 operating it. The operation of relay 213 operates relay 212 over a circuit from ground through its right winding, inner right front contact of relay 213 to battery through the winding of relay 212. Relay 212 does not operate at this time, however, as it is shunted by battery on the inner right front contact of relay 208. The operation of relay 213, however, closes a circuit for relay 204 from battery on the left front contact of relay 213, winding of relay 204, outer left front contact of relay 210 to ground in the control circuit 205. The operation of relay 204 opens the circuit for relay 207 and the tip and ring conductors are connected to the control circuit through the upper outer and lower outer front contacts of relay 204. Relays 220 and 224 are connected to the control circuit through the upper and lower inner front contacts of relay 204 respectively. The release of relay 207 opens a circuit for relay 208 thereby removing the shunt from around relay 212 which now operates. The release of relay 208 causes assignment lamp 225 to flash over a circuit from battery through the lamp and the left winding of relay 213, right outer back contact of relay 208, left front contact of relay 226 to ground through interrupter 227.

The circuit is now in condition for receiving impulses from the test box 201. After the station's digit has been registered in a manner well-known to the art, relays 220 and 224 are selectively operated in accordance with the type of ringing to be used. Either of these relays if operated locks to ground on the inner right front contact of relay 212. After all of the digits have been received in the control circuit and the number displayed on the indicator, relay 204 is released and the test box causes relay 207 to reoperate. The operation of relay 207 connects ground to the left armature of relay 212, holding that relay operated and shunting relay 213, which relay releases. The release of relay 213 opens the circuit for relay 204 thereby preventing its reoperation.

The circuit is now in condition for connection to the called station. As this trunk is to be tested, however, the number displayed will be that of a jack leading to the test circuit. For testing ringing over the tip of the line, the number set up will be that of jack 300 while for testing ringing over the ring of the line the number displayed will be that of jack 350. With plug 229 inserted in jack 300, a circuit is closed from ground through the winding of relay 606, conductor 430, sleeve of jack 300 and plug 229, winding of relay 219 to battery through lamp 223 and also over a circuit through the outer right back contact of relay 213, outer right front contact of relay 212, back contacts of relays 218 and 217 to battery through the winding of relay 216. Disconnect lamp 223 is kept from lighting at this time by the shunt formed by the winding of relay 216. Relay 219 operates and connects the tip of plug 229 through to the repeating coil 206 and opens the circuit of relay 210 thereby releasing the control circuit 205. The release of relay 210 releases relay 226 which extinguishes assignment lamp 225. Relay 216 operates in the above traced circuit and removes the short-circuit from around condensers 231 and 232.

For ringing over the tip of the trunk the control circuit operates relay 224 which closes a circuit from ground on the upper inner front contact of relay 216, left inner front contact of relay 224, winding of pick-up relay 221 to battery 255 through the interrupter 250. Relay 221 operates upon the

first closure of interrupter 250 and locks to battery on its right front contact. With relay 221 operated a circuit is closed for connecting ringing current to the tip of the line from ringing source 245 through two ring interrupter 230 or one ring interrupter 240 depending on whether or not relay 220 is operated.

When the plug 229 is inserted in jack 300 and the circuit closed through relay 606, that relay operates and opens the circuit from brush 605 thereby preventing switch 650 from being stepped off normal. A circuit is now closed from ground through the outer left front contact of relay 224, lower front contact of relay 216 over the ring of plug 229 and jack 300, conductor 326, inner right back contact of relay 403, inner left back contacts of relays 402 and 401 to battery through the winding of relay 416. Relay 416 operates and connects ground through the subset 425, winding of relay 321, inner right back contact of relay 401, right back contact of relay 402, inner left back contact of relay 403, right back contact of relay 419, conductor 325, over the tip of jack 300 and plug 229 to ringing source 245 as traced above. The subset 425 is used as an audible test for the ringing function of the trunk circuit. The subset bell will ring once or twice at each ringing period depending on relay 220, which will be operated or released according to the number set up by the test man. The other operations of the trunk circuit will not be tested at this time as the start lead is opened at the contacts of relay 606. In order to test the other functions it is necessary to plug into jack 350.

If the testman desires to test ringing over the ring side of the line, the number set up on the control circuit will be that of jack 350 and the operation will be slightly different. The insertion of plug 229 in jack 350 causes relays 404, 409, 421, 422, 423 and 424 to function the same as described for the test of the trunk shown in Fig. 1. The relay combination 421 to 424 furnishes ground for operating relay 610 over a circuit from battery, through the winding of relay 610, right back contact of relay 609, left back contact of relay 423 to ground on the outer left front contact of relay 424. Relay 610 operates and locks to off normal ground conductor 428 through its outer left front contact. At the first closed period of interrupter 240, relay 406 is operated from ground on the front contact of relay 321, conductor 327, left back contact of relay 606 (which is not operated with plug 229 in jack 350), conductor 426 to battery through the winding of relay 406. Relay 406 operated connects ground from the off-normal ground conductor 428 through its inner right front contact, and the right front contact of relay 610 back contact of relay 607 to battery through the winding of relay 609. The operation of relay 609 closes a circuit from ground on the off-normal ground conductor 428, left front contact of relay 609, through the winding of relay 607 to battery through the winding of relay 609. Relay 607 does not operate at this time being shunted by the energizing circuit of relay 609. At the completion of one ring relay 406 releases, opening the operating circuit of relay 609, permitting relay 607 to operate. With relay 406 released the relay combination 421 to 424 will again operate as described above and move selector 650 to position 0 over a circuit from ground on the outer left front contact of relay 424, left back contact of relay 423, right front contact of relay 609, normal contact and brush of arc 601 to battery through the back contact and winding of magnet 400, thereby moving the selector switch 650 to the position 0. At the same time the ground from the outer left front contact of relay 424 is connected over a circuit through the left back contact of relay 423, right front contact of relay 609, the outer left back contact of relay 608 inner left front contact of relay 610 to battery at one side of the winding of relay 610, thereby shunting out that relay.

If relay 220 had been operated to cause two rings to be sent by means of interrupter 230 in the trunk circuit, the relay combination 421 to 424 would not have had time to function before the second ring caused relay 406 to again operate. The operation of relay 406 closes a circuit from grounded conductor 428, right front contact of relay 406, conductor 429, front contact of relays 610 and 607, normal contact and winding of relay 608 to battery. Relay 608 operates and locks directly to conductor 428. Relay 608 in turn operates relay 606 from battery through the inner left front contact of relay 608 to ground through the winding of relay 606. Relay 606 operated, opens the circuit from the front contact of relay 321 for operating relay 406. Relay 606 likewise opens the circuit traced above through the outer left front contact of relay 424, preventing switch 650 from moving into position 0. Therefore the test circuit will not function further until the plug 229 is withdrawn from jack 350 and only the ringing is tested at this time.

With plug 229 inserted in jack 350, and the one-ring condition set up in the trunk, relay 416 will operate as described and connect the subset 425 and relay 321 across the tip and ring for testing the ringing in the trunk. Switch 650 will be advanced to position 0 as above described following the first ringing period. During the second ringing period a circuit is closed from ground on the off-normal ground conductor 428, inner right front contact of relay 406, conductor

433, inner right front contact of relay 318, 0 terminal and brush of arc 600 to battery through the stepping magnet 400. At the end of the ringing period when relays 406 and 418 release, the selector 650 is stepped into position 1.

With the switch in this position the test circuit is ready to carry out the test in the same manner as described above for the jack-per-station trunk under preliminary trip test, tripping test and supervisory relay test, the only difference being in the numbers of the positions of the sequence switch 650 employed for the tests. The position numbering used in the description for switch 550 is two positions ahead of that for switch 650, that is, the premature tripping test is started with switch 550 in position 3 while switch 650 is in position 1 for the same test. This is accounted for by the different functioning for the ringing test.

It will be apparent that cord circuits and call circuit trunks may be tested in the same manner, employing a simpler test box, since the instructions to the operator will be oral instead of visual.

What is claimed is:

1. In a telephone exchange system, machine ringing trunks having selectable apparatus to control the ringing of different party line bells, a device for testing said trunks, comprising means for selecting said apparatus and means responsive to ringing current to test the ability of said apparatus to control the ringing of party line bells, and means for rendering said selecting means and said responsive means effective during a single automatic progressive test to successively test the ability of said apparatus to cause the ringing of each of a plurality of party line bells.

2. In a telephone exchange system, machine ringing trunks having apparatus to control the ringing of different party line bells, such apparatus being selectable by means of conditions on a called line, and a device for testing said trunks comprising means to simulate different line conditions and means to automatically change from one condition to another to test the operation of said selectable apparatus.

3. In a telephone exchange system, machine ringing trunks having selectable apparatus to control the ringing of different party line bells, a testing device comprising means to make separate tests of the ringing apparatus on said trunk, and means effective in response to the completion of only a particular one of said tests to initiate a complete automatic test of the apparatus on said trunk.

4. In a telephone exchange system, machine ringing trunks having apparatus selectable in different combinations for ringing different party line bells, a testing device for progressively testing apparatus of said trunks comprising means for testing the ringing of each party, a switch for controlling the progressive test, and means to prevent the progression of said switch following the test of certain of said ringing combinations.

5. In a telephone exchange system machine ringing trunks having selectable apparatus to control the signaling of different subscribers on party lines, a device for testing said trunks, means in said device to successively select said apparatus and test its ability to cause the signaling of each of a plurality of subscribers in a single automatically progressive test of any one of said trunks, and means to arrest said test should said apparatus fail to function properly in the causing of said signaling.

6. In a telephone exchange system, machine ringing trunks having selectable apparatus to control the ringing of different party line bells, a device for testing said trunks, means in said device to cause said apparatus to apply the proper ringing current for ringing one of said plurality of party line bells, means responsive to the correct application of said ringing current to cause said apparatus to apply the proper ringing current for ringing a different party line bell, and means responsive to said second ringing current to initiate further tests of said trunk.

7. In a telephone exchange system, a trunk circuit, a plurality of relays in said circuit, a testing device, means to associate said trunk circuit and said relays with said testing device, said device comprising automatically progressive means for testing each of said relays for response to current of various strengths and means for automatically maintaining the current supply for one of said relays at a constant potential throughout tests thereof.

8. In a telephone exchange system, a trunk circuit, a plurality of relays in said trunk circuit, a testing device, means to associate said trunk circuit and said relays with said testing device, a source of current for each of said relays, means for automatically maintaining the current supply for one of said relays at a constant potential, means for testing each of said relays for response to current of various strengths, automatically progressive apparatus for rendering said tests successively effective and means controlled by said progressive apparatus for connecting said constant potential source to said one relay only during tests of said relay.

9. In a telephone exchange system, a trunk circuit, a plurality of relays in said trunk circuit, a testing device, means to associate said trunk circuit and said relays with said testing device, a source of current for each of said relays, means for automatically maintaining the current supply for one of said

relays at a constant potential, means for testing each of said relays for response to current of various strengths, an automatic switch for rendering said tests successively effective, means for advancing said switch responsive to the satisfactory completion of said tests, and means controlled by said switch for connecting said constant potential source to said one relay only during tests of said relay.

In witness whereof, I hereunto subscribe my name this 18th day of October, A. D. 1926.

EDMUND B. SMITH.