April 18, 1944. F. A. HUBBARD 2,347,107

SWITCHING SYSTEM

Filed Aug. 22, 1942 6 Sheets-Sheet 1

FIG. 1.

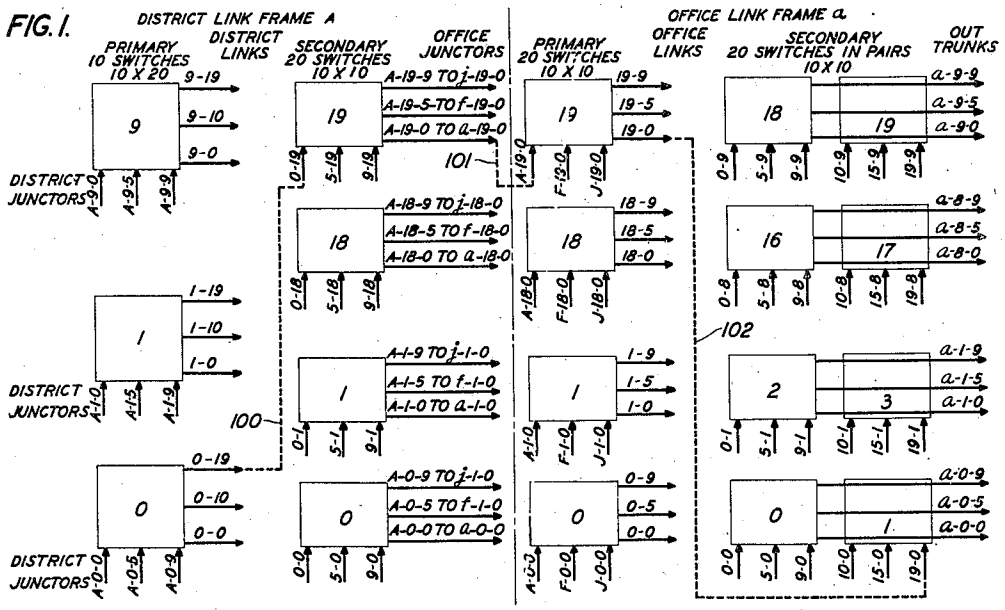
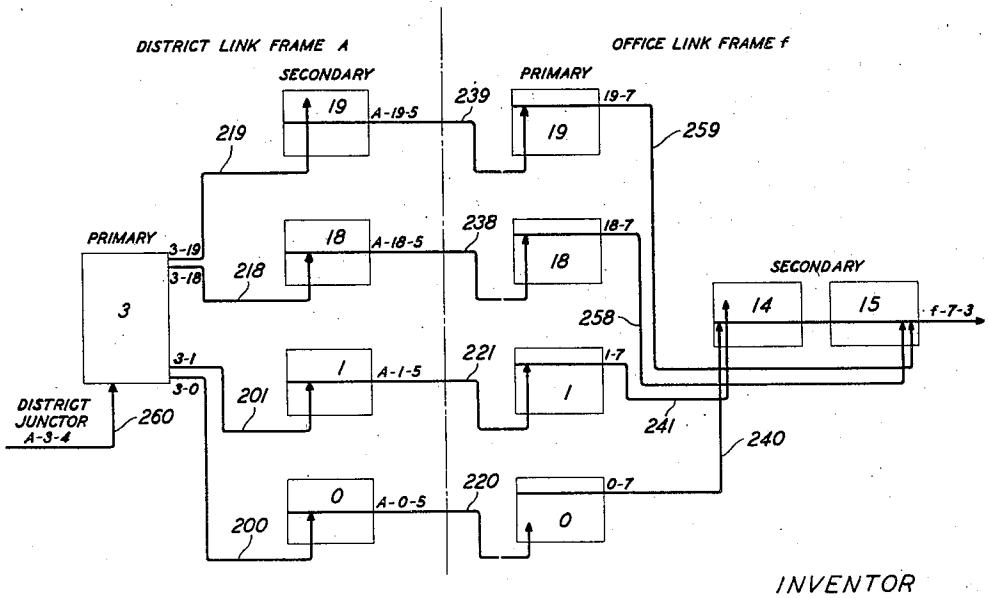


FIG. 2.



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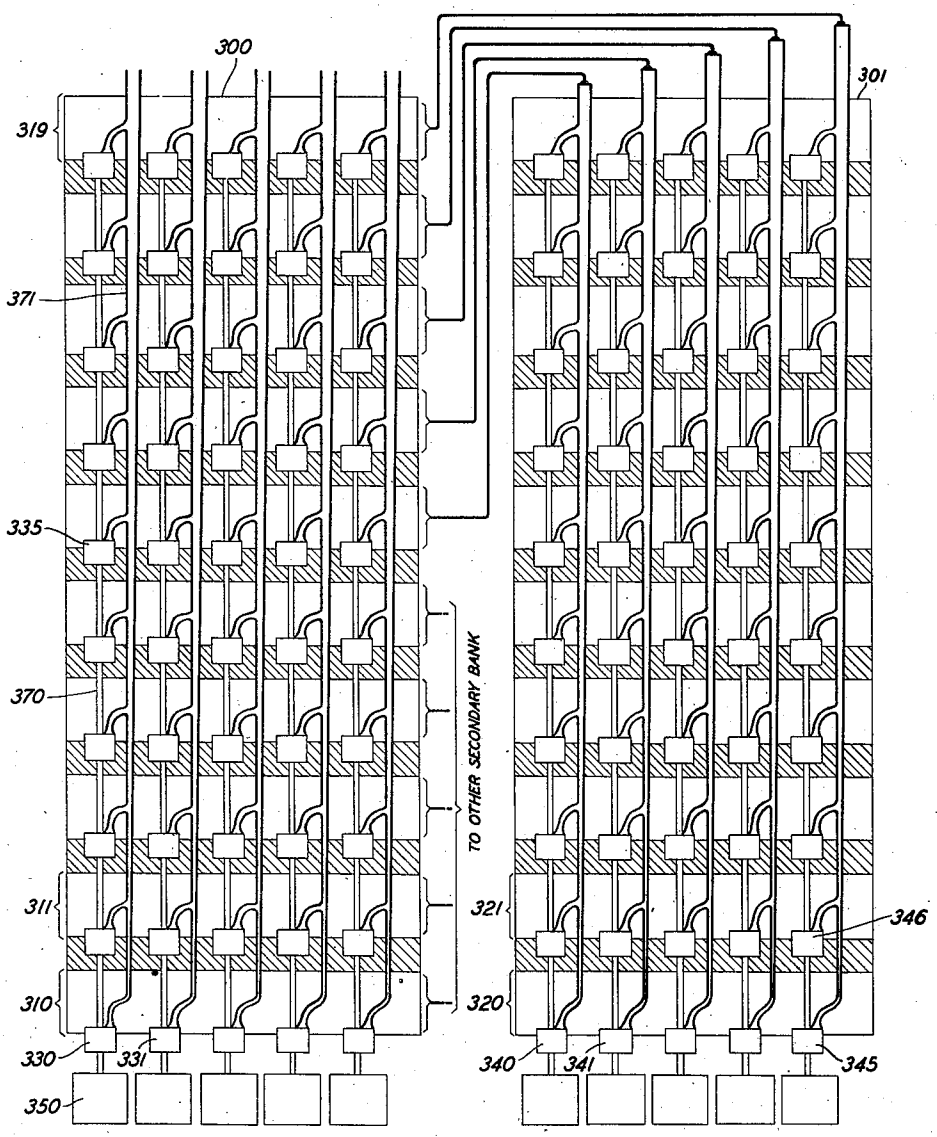
April 18, 1944. F. A. HUBBARD 2,347,107

SWITCHING SYSTEM

Filed Aug. 22, 1942 6 Sheets-Sheet 2

FIG. 3.



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April 18, 1944. F. A. HUBBARD 2,347,107

SWITCHING SYSTEM

Filed Aug. 22, 1942 6 Sheets-Sheet 3

FIG. 4.

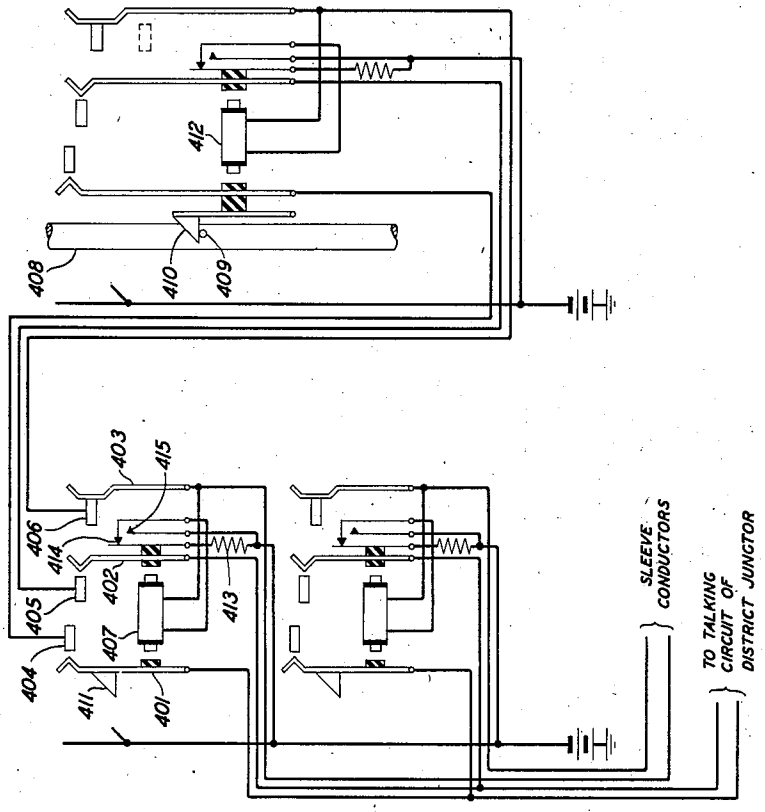
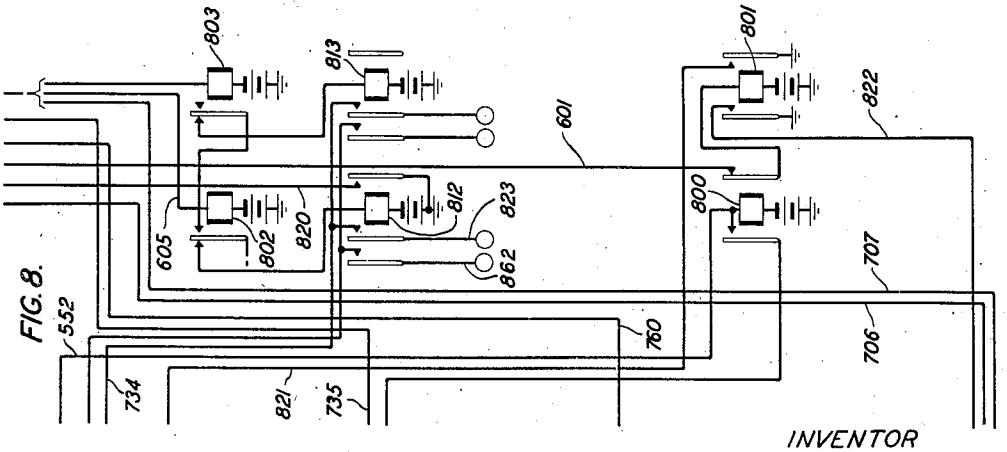


FIG. 8.



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April 18, 1944. F. A. HUBBARD 2,347,107

SWITCHING SYSTEM

Filed Aug. 22, 1942 6 Sheets-Sheet 4

FIG. 5.

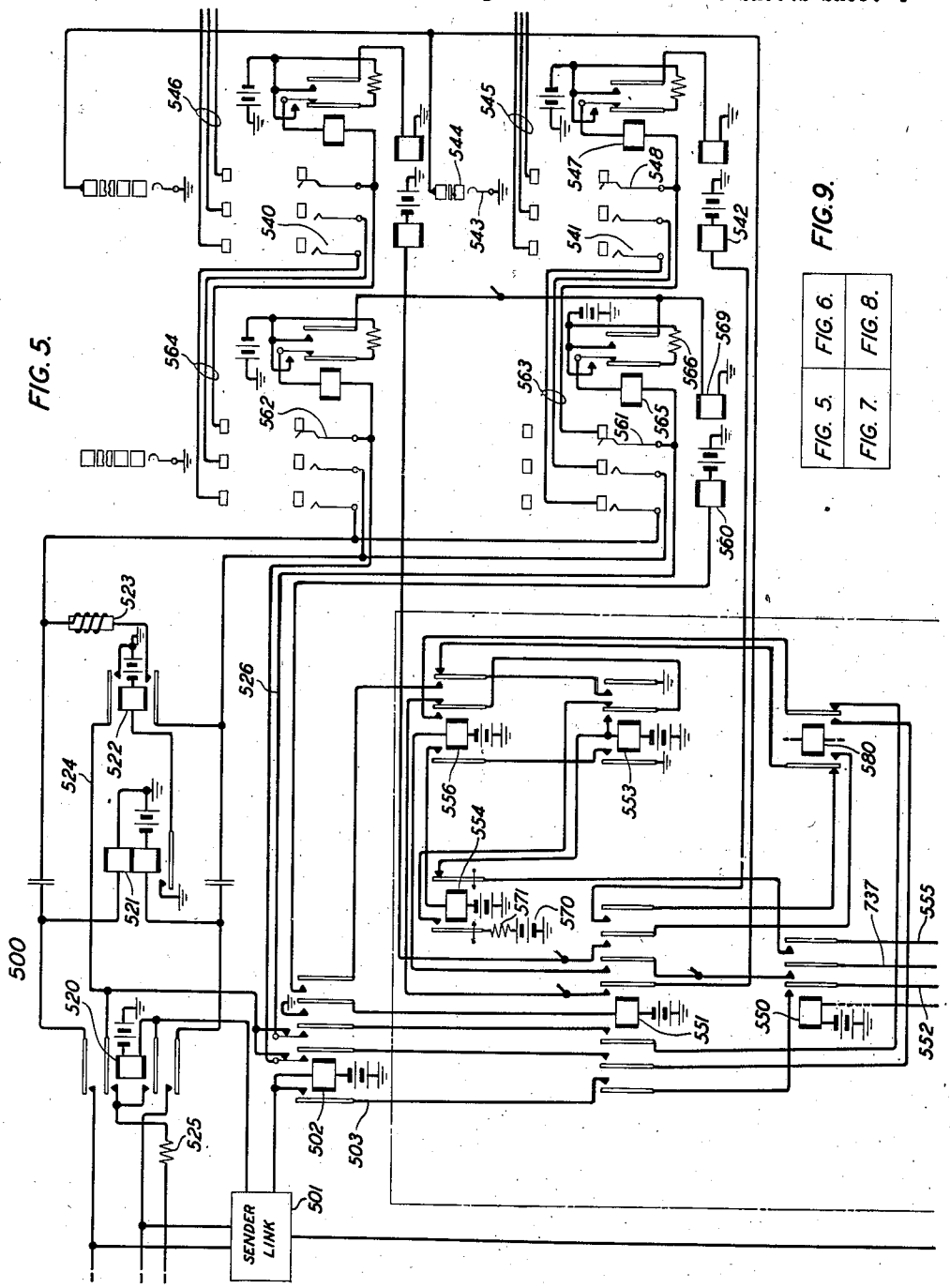

FIG. 9.

FIG. 5.	FIG. 6.
FIG. 7.	FIG. 8.

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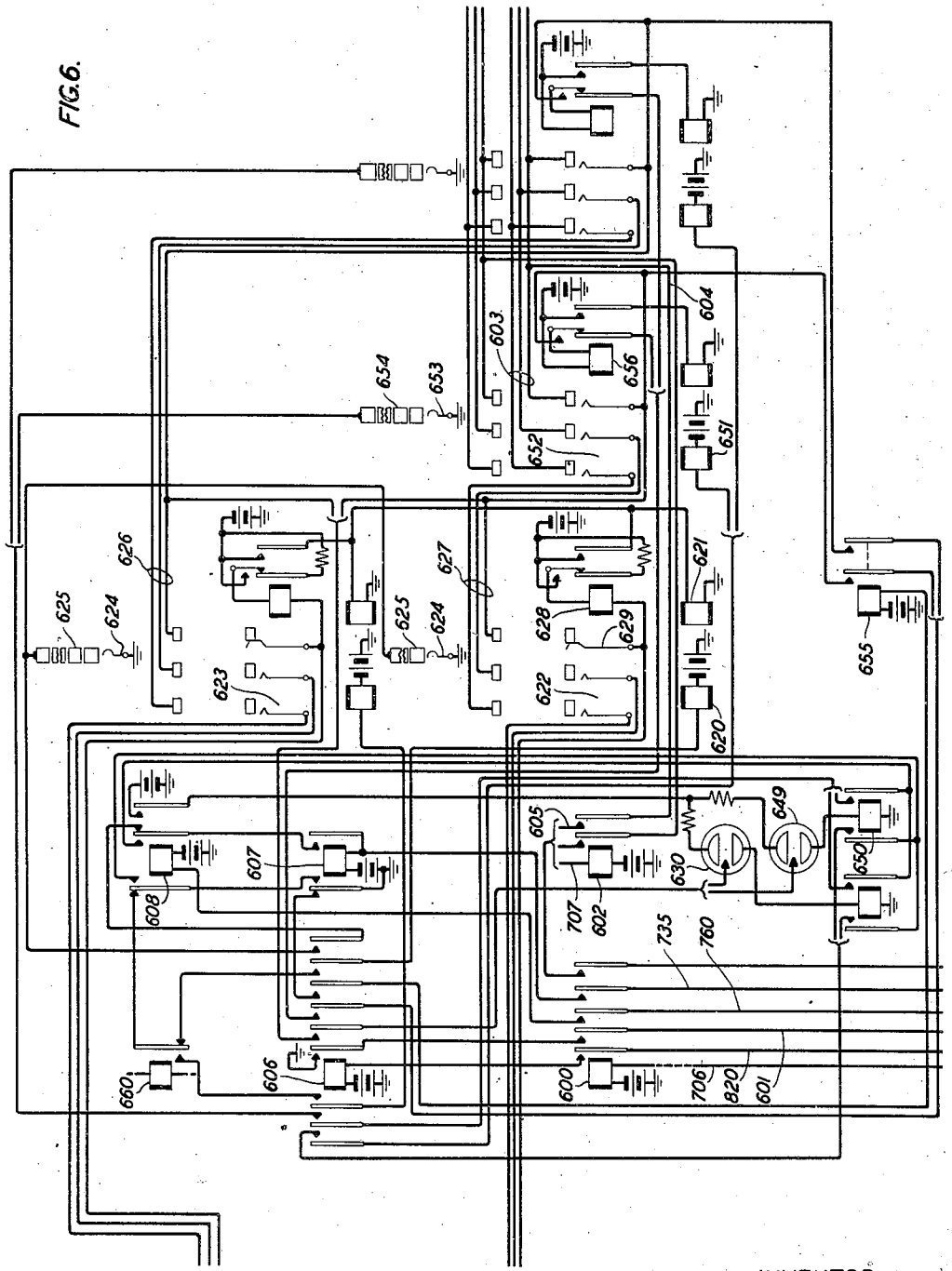
April 18, 1944. F. A. HUBBARD 2,347,107

SWITCHING SYSTEM

Filed Aug. 22, 1942 6 Sheets-Sheet 5

FIG. 6.



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April 18, 1944. F. A. HUBBARD 2,347,107

SWITCHING SYSTEM

Filed Aug. 22, 1942 6 Sheets-Sheet 6

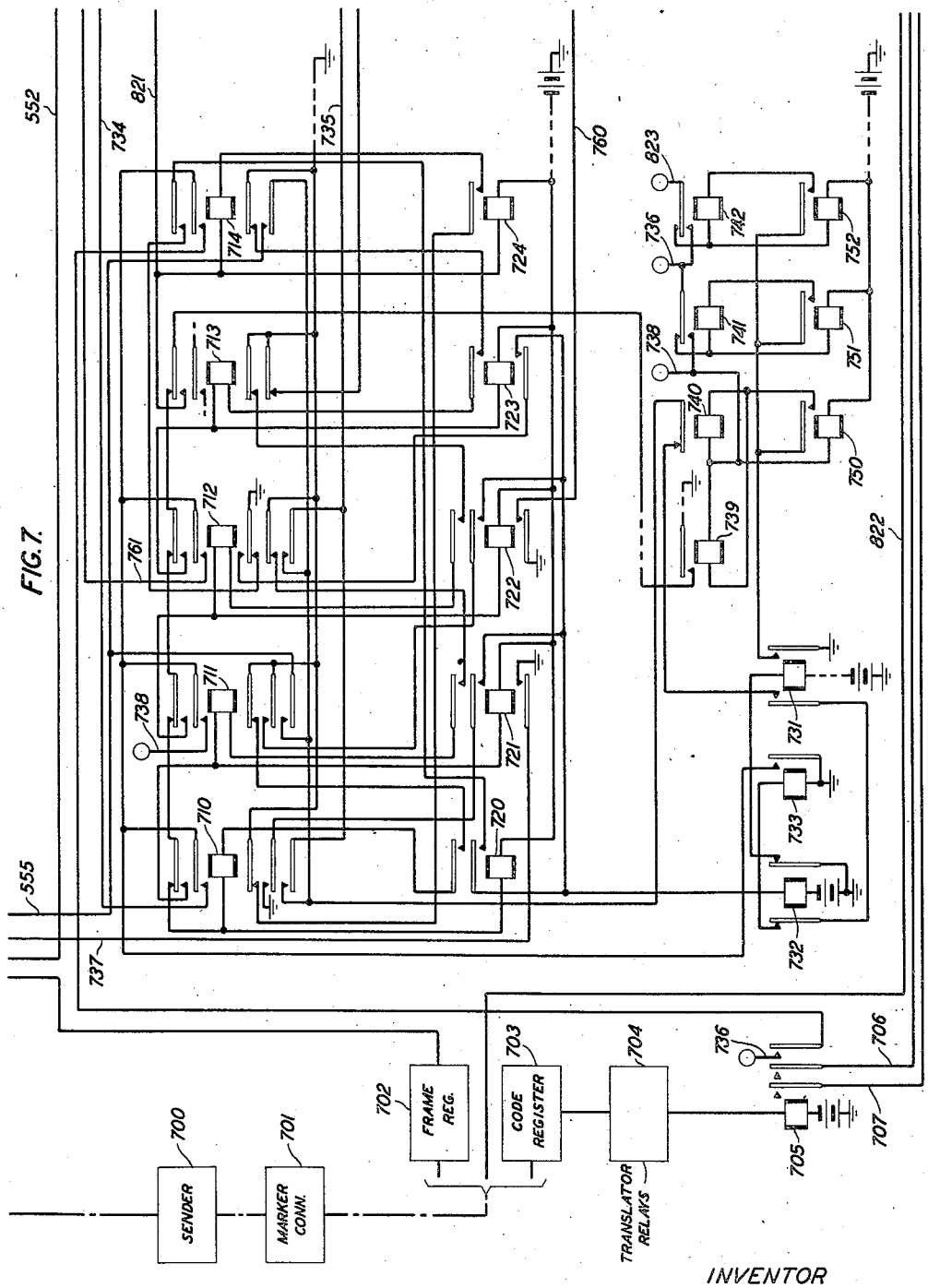

FIG. 7.

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Patented Apr. 18, 1944 2,347,107

UNITED STATES PATENT OFFICE

2,347,107

SWITCHING SYSTEM

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Application August 22, 1942, Serial No. 455,739

13 Claims. (Cl. 179—18)

This invention relates to telephone systems and has for its object to provide novel means for establishing telephone connections.

Because of the high degree of symmetry employed in the telephone system known as the crossbar system, only a small number of choices is required at each switch and the time consumed in establishing a connection is considerably reduced over the time required when hunting switches are used.

By applying such a symmetrical arrangement to movable switches, such as panel type switches, smaller trunk and link groups may be used, thus reducing the travel of the switches, and trunk hunting may be largely eliminated.

The present invention provides a multistage, marker controlled telephone system in which a multistage busy test can be made at a single point by means of a moving switch. More specifically, after the identity of a calling line and a called line has been determined, a series of traveling switches are arbitrarily positioned to select a plurality of links by which the calling line and the called line may be interconnected, after which the switch to which the calling line has been extended hunts for an idle channel made up of a set of idle links.

The invention will be more clearly understood from a consideration of the following description in connection with the drawings in which:

Fig. 1 shows a typical symmetrical arrangement suitable for the crossbar system;

Fig. 2 shows a similar arrangement applied to panel type switches;

Fig. 3 is a diagrammatic showing of details of a primary and a secondary panel switch frame;

Fig. 4 shows a suitable arrangement for brushes to be used on the frames of Fig. 3;

Figs. 5 to 8 show parts of the circuits of a marker and district junctor circuit suitable for controlling the switches shown in Figs. 3 and 4; and

Fig. 9 indicates the proper arrangement of Figs. 5 to 8.

For a description of a complete marker, employed for controlling crossbar switches and forming the basis for the circuits shown, reference is made to Patent 2,235,803 to W. W. Carpenter, granted March 18, 1941.

Referring first to Fig. 1, there is shown a typical layout for a theoretical four-stage marker control system which is approximately the arrangement used in the crossbar system for the district and office frames and employs the designations generally used in such a system. The switches of the four stages are shown as conventional line grids each grid having the dimensions indicated at the top of each stage where the horizontal dimension is given first, followed by the vertical dimension. The grids of the primary district stage have ten inlets and twenty outlets, while the grids of the other stages each have ten inlets and ten outlets, there being ten grids in the first stage and twenty grids in each of the remaining stages. In this figure the inlets are shown along the bottom of each grid, the outlets along the vertical side, with the direction of traffic indicated by the arrows. This figure, therefore, represents an idealized pattern for an office having a capacity of one thousand district junctors and one thousand outgoing trunks.

It is impossible in limited space to show individually all of the grids of a stage or all of the inlets and outlets of any one grid. However, in each case the grids are numbered from 0 to 9 or from 0 to 19 and the outlets of each grid are similarly numbered. Each outlet is marked with two fingers, the first the number of the grid and the second the number of the terminal. For example, the nineteenth terminal of district primary grid No. 0 is designated 0—19. On the secondary grid the outlet numbers are preceded by a letter representing the frame on which the grid is located. Therefore, the office junctor connected to the ninth terminal of secondary grid No. 19 on district frame A is designated A—19—9.

The designation on the inlet terminal along the horizontal side of each grid indicates the output terminal of the preceding stage to which the input terminal is connected. Thus the No. 0 vertical on the nineteenth district secondary grid is marked 0—19 to show that it is connected to the nineteenth terminal of primary grid No. 0. This particular connection is indicated by the dotted line 100 but no attempt has been made to show the interconnections completely since this would lead to very complicated drawings. Examination of the designations will show, however, that the basic pattern of the link is extremely simple. The twenty outlets from any given primary grid go to twenty different secondary grids and on this secondary grid they all appear in the same position, such position being determined by the number of the primary grid from which they come. Thus the twenty outlets from primary grid No. 0 go to vertical No. 0 on each of the secondary grids, primary outlet 0—0 to vertical No. 0 on secondary grid No. 0, primary outlet

No. 19 to vertical No. 0 on secondary grid No. 19, etc. Similarly, primary outlet 9—0 goes to vertical No. 9 on secondary grid No. 0, etc.

To follow the pattern of the office junctors on the outlets of the district secondary grids is somewhat more difficult because the ten outlets of each grid are connected to ten different office link frames. For this reason there is marked on each of these junctors the destination to which it is routed. Thus it will be seen that office junctor A—0—0 goes to primary vertical 0—0 on office frame *a* while junctor A—0—5 goes to the corresponding point on office frame *f*, and junctor A—0—9 to office frame *j*. Similarly, the junctors on grid No. 1 go to vertical 1—0 on the ten different office frames. The effect can be seen on the vertical of the office primary grids which are marked to indicate the district secondary outlets from which they come. Thus it will be observed that all the first verticals of the office primary come from district frame A, all of the verticals No. 5 from district frame F, and all verticals No. 9 from district frame J. The dotted line **101** indicates one such connection.

The office link pattern is practically the same as that of the district links except that in this case the primary-secondary conditions are reversed, the outlets from the secondary grids being multipled together so that the grids, in effect, have twenty inlets and ten outlets as already noted. The connections may be followed on the basis of the numbering as before. The designations on the secondary verticals correspond to the primary outlets to which they are connected. The dotted line **102** shows one of these connections. If the dotted lines **100** to **102** are traced through, they will be found to provide a path from any one of the ten district junctors (A—0—0 to A—0—9) to any of the ten outgoing trunks (A—0—0 to A—0—9). There are twenty such paths that could be traced, all completely independent, each using a different district secondary grid and a different office primary grid.

From the foregoing, it will be apparent that all of the district links, such as link **100**, from a particular primary grid, appear in the same position on the district secondary grids, that is, they occupy the same vertical row. Further, all of the office junctors, such as junctor **101** from a particular district frame appear in the same vertical row on the office primary grid. On the other hand, all of the office junctors of a particular office frame appear on the same levels of the district secondary grid and all of the office links, such as link **102**, leading to a particular office secondary grid, appear in the same level of all office primary grids.

In place of the crossbar switch assumed to form the grids of Fig. 1, there may be substituted switches having a horizontal fixed multiple with vertical moving switches similar to the well-known panel type switch but having access to only ten sets of multiples. Such an arrangement is indicated in Fig. 2. In this figure it has been assumed that a call is incoming on district junctor A—3—4 and that outgoing trunk *f*—7—3 has been chosen to serve it. Since the call is on district primary grid No. 3 it must be routed over secondary verticals No. 3 any one of which, if not already busy, may be able to serve it. Since the chosen outgoing trunk is on office frame *f* the district secondary vertical which is to route the call must be moved to level No. 5, hence all idle verticals No. 3 are driven to level No. 5. They will represent all the available district links. In Fig. 2 it has been assumed that district link **219** is busy with another call, which will have been directed to it from some other district junctor on district primary grid No. 3. District links **200**, **201** and **218** are represented as idle and have been driven to level No. 5.

Similarly, since the call originates on district frame A, it must be served by one of the office primary verticals in row No. 0, and, since the chosen outgoing trunk is on secondary grids **14**, **15** which constitute pair No. 7, the primary office switches must go to level No. 7. In Fig. 2 it has been assumed that the office junctor **220** is busy on another call from district frame A but office junctors **221**, **238** and **239** have been driven to level No. 7. Also the office link **241** is represented as busy on another call while the verticals, to which the office links **240**, **258** and **259**, etc., are connected, have been driven to level No. 3 and rest on the chosen outgoing trunk.

If, now, a hunting operation is instituted by the district junctor **260**, as the vertical starts upward it first encounters district link **200** which is idle. However, the secondary vertical on the secondary grid No. 0, to which this link **200** is connected, is resting on office junctor **220** which is busy on the office primary grid No. 0. Hence there is a busy condition on office junctor **220** which will be extended over the district secondary switch and appear on the test terminal of the district primary. The primary switch recognizes this busy condition when it tests district link **200** and passes on. District link **201** is idle and office junctor **221** to which it is connected is idle also, but the office secondary vertical to which connection is made over office link **241** is shown as busy on the office secondary so that a busy condition will appear from this point on district link **201** at the district primary switch where the district junctor switch will test it and pass on. At level No. 18 it encounters district link **218** which is connected to office junctor **238** and in turn to office link **258**, all of which are idle so that the path is idle throughout and the district junctor switch may stop thereon and establish the connection over this path.

Figs. 3 and 4, in a diagrammatic way, show a possible type of switch which could be used to realize the system above described. Fundamentally, the switch is of the panel type such as is disclosed in Patent 1,103,623 to J. N. Reynolds, July 14, 1914. The basic unit **310**, **311**, etc., is of the panel multiple type comprising thirty multiple strips each with side projections on front and rear accommodating a total of ten switch units, **330**, **331**, **340**, **341**, etc. Fig. 3 shows a primary frame **300** and a secondary frame **301** each including ten such basic units **310**, **311**, **320**, **321**, etc. Such a unit would be approximately 1¼ inches high and each unit is independently secured to the frame so that variations in terminal positions are not cumulative. The equipment shown in Fig. 3 represents half of a frame, a second similar unit being mounted above or beside it. Since the contact terminals project on the front and rear of the terminal strips, a second set of switches, such as **330**, **331**, etc., serves the rear of the frame, and one terminal unit with the ten switches corresponds to one 10 x 10 grid of Figs. 1 and 2. Switches **330** and **335** are connected in multiple to the district junctor so that the frame has ten groups of ten district junctors, each of which has access to

twenty district links and thereby to twenty district secondary switches. The terminal groups of the primary unit **300** are cabled to the switches of the secondary unit **301** as indicated in Fig. 3, these connections being district links. For example, the terminals of block **319** will be wired to the switches **345**, **346**, etc. The terminal group of the secondary unit **301** representing the office junctors are cabled to the primary switches of the office link frame. For convenience, a cross-connection frame would probably be interposed between the district link frame and the office link frame.

The switch unit comprises a vertical drive rod **370**, driving means **350** arranged to raise the rod **370** through ten vertical steps, and ten brush carriages **330**, **335**, etc., one for each terminal unit. Electrical connections to the brush carriages **330**, **335**, etc., are made by flexible leads from the vertical cable **371**. The use of such flexible leads is possible because of the limited travel of the brush carriages. In the circuit shown in Figs. 5 to 8, it has been assumed that the driving means **350**, **351**, etc., is of the power drive type controlled by revertive pulses from a commutator. Only a slow up-drive is necessary, since both rod and brush carriage may be returned by gravity. It is, of course, obvious that a suitable step-by-step mechanism controlled by directive pulses could readily be designed.

Fig. 4 is a diagrammatic showing of a suitable form of brush carriage. It consists of three principal brushes **401**, **402** and **403** mounted in any convenient manner to be movable before the multiple terminal bank. The sleeve brush **403** is of the bridging type and is always in contact with a sleeve terminal such as terminal **406**. The tip and ring brushes **401** and **402** are normally spaced away from the bank terminals to which they have access, such as terminals **404** and **405**, and are brought into contact with them by means of an operating magnet **407**. The brush carriage is moved upwards by means of a driving rod like rod **408** to which is fixed a pin **409** which engages a latch **411** on the brush carriage. This latch may be fastened directly to the tip brush as at **411** or may be separately mounted as at **410** but in either case is movable with the brush so that, when magnet **407** or magnet **412** is operated, the latch is withdrawn from the pin permitting the driving rod **408** to be withdrawn and later to operate again without disturbing the established connection. With the magnet operated, the tip and ring brushes hold the brush carriage in position. The circuit of magnet **407**, for example, extends from battery, through resistance **413** over a normal contact **414** controlled by ring brush **402** through the winding of magnet **407** to the sleeve brush **403**. Resistance **413** is sufficient to prevent the operation of magnet **407** when brush **403** passes over or rests on a grounded terminal. When magnet **407** is operated drawing the ring brush **402** to the left, contact **414** is opened and contact **415** closed, short-circuiting resistance **413**. With resistance **413** short-circuited magnet **407** will remain operated with brush **403** connected to ground.

It will be noted that the primary tip and ring brushes are connected in pairs, each pair extending to a district junctor while the secondary switches are connected individually to different district links. This is in agreement with the arrangement of Figs. 1 and 2, since each district junctor is given access to twenty district links, while each district link has access to ten office junctors. At the same time this arrangement permits the use of the same multiple units and brush structures on all frames and limits the switch movement to a distance of 1¼ inches in all cases. The twenty district links which are accessible to the group of district junctors all appear as secondary switches in the same vertical row, ten on each half of the secondary frame. Thus each of these twenty district links can reach ten different office junctors so that every district junctor can reach all of the two hundred office junctors.

In general, the operation of such a system takes place as follows: when the marker has chosen an outgoing trunk on a particular office frame it seizes the driving means of one of the two vertical units of the district secondary switches which are accessible to the district junctor that is being used and operates this driving means by a number of pulses corresponding to the office frame on which the chosen trunk is located. All idle brush carriages in this vertical row are engaged by their drive rods and are driven upwards to the level on which the office junctors of the chosen office frame appear. The sleeve brushes rest on sleeve terminals but the tip and ring circuits remain open, even if the office junctor is busy since the holding magnet will not operate to ground. These office junctors appear on the office frame primary as brush carriages all in the same vertical row corresponding to the district frame from which they come. The marker seizes the drive elements belonging to this vertical row and applies a number of pulses corresponding to the secondary bank on which the chosen trunk is located. Thus all available paths will be extended from the primary bank of the district frame to the brushes of the office secondary bank where the trunk is located. Those paths which are busy at any point produce ground on the corresponding sleeve terminals of the district primary bank.

The marker then operates the drive mechanism of the district primary, making a busy test of a sleeve terminal at each step. As soon as a non-grounded sleeve is found the drive is stopped, thus selecting a path which is idle throughout. Reverse battery is now applied to the sleeve circuit at the district junctor to operate the hold magnets of the brush units which are in contact with the sleeve conductor thus cutting through the tip and ring conductors to the office link and short-circuiting the resistance such as resistance **413** on each brush carriage and identifying that link to the marker or office frame connector. The office secondary brush which forms the final step in this path is now driven to the chosen trunk completing the sleeve circuit from the district junctor to the trunk. Ground from the supervisory relay is now applied to the sleeve, operating the magnet of the office secondary switch and the connection will remain held until the supervisory ground is removed. Operation of the magnets disengages the latches from the driving rods and returns the latter to normal.

Figs. 5 to 8 show circuits, for performing these operations, in more detail. However, only such circuits as are necessary to understand the present invention have been shown, reference being hereby made to the above-identified Carpenter patent for a complete disclosure of a marker for use in the crossbar system, many of the functions of which would be incorporated in a system embodying the present invention. In addition,

reference is made to Patent No. 1,862,549 to R. Raymond et al., June 14, 1932, for a complete telephone system employing panel type switches.

A call incoming to district junctor 500 will be extended in the manner described in the above-identified Carpenter patent through sender link 501 to an idle subscriber sender 700 where the designation of the wanted line will be recorded. As soon as the designation of the office in which the wanted line is located has been recorded, the sender operates the marker connector 701 to seize an idle marker which includes the equipment shown in Figs. 7 and 8. The number of the frame on which the district junctor 500 is located is recorded on the frame register 702 which operates the district frame connector to associate the marker with the district frame of Fig. 5 by closing a circuit for operating multicontact relay 550.

The designation of the wanted office is transferred to the code registers 703 which in turn operate translator relays 704 to bring about the operation of a route relay 705. Route relay 705 identifies the group of trunks leading to the wanted office and closes a circuit over conductor 706 for operating the multicontact relay 600 which completes a connection between the marker and the office frame of Fig. 6 on which the trunks leading to the wanted office are located. Both relays 550 and 600 are controlled through a preference circuit by which it is determined that one and only one marker can be connected with a frame at a time.

With relay 600 operated the route relay 705 closes a circuit over conductor 707 to the winding of trunk group relay 602 which operates to extend the sleeve conductors of the selected group of trunks to the chain of test relays 802, 803, etc. Busy trunks are characterized by ground on the sleeve conductor and the corresponding relays 802, 803, operate. Thereupon a circuit is closed over the contacts of relays 802, 803, etc., which extends over the back contact of the first non-operated test relay to the corresponding trunk selecting relay. Assuming that trunk 603, whose sleeve conductor 604 extends over the contacts of relay 602 to conductor 605 and the winding of relay 802, is idle, relay 802 is not operated and the trunk selecting circuit above mentioned is extended over the back contact of relay 802, through the winding of relay 812 and battery. Relay 812 operates and closes a circuit from ground over its contact, conductor 820, contact of relay 600 to the winding of relay 606 and battery. Since the identification of the trunk also identifies the group of office links having access thereto and thereby the set of switches and the driving elevator controlling them, relay 606 prepares the circuits for controlling the selection of the primary office switch but these circuits are not effective at this time.

However, relay 606 in operating closes a circuit from ground over its inner right contacts and a contact of relay 600 to conductor 601, back contact of relay 800, through the winding of relay 801 and battery to indicate that the office frame connector is ready for selections. Relay 801 closes a circuit from ground over its left contact, conductor 822 through the marker connector, sender and sender link, through the winding of relay 502 to battery. Relay 502 operates and closes an obvious circuit for relay 551 in the district frame connector to identify the group of district links which serve district junctor 500. With relay 551 operated, relay 502 extends its operating ground over conductor 503, contact of relay 551, contact of relay 550, conductor 552 through the winding of relay 800 to battery. Relay 800 locks to ground over the back contact of relay 713. This ground also serves to hold relay 502 operated when relay 801 releases due to the opening of its circuit by the operation of relay 800. These circuits lock the marker to the district junctor by way of the district frame connector.

When relay 801 operated, it also closed a circuit from ground to conductor 821, winding of relay 724 to battery. Relay 724 operates and locks through the winding of relay 714, upper front contact of relay 724, lower back contact of relay 710 to ground but relay 714 cannot operate, being shunted by the operating circuit of relay 724 until relay 801 releases.

Relay 551 is individual to the group of district junctors including the junctor 500 and therefore identifies the group of district links and the switches in which they terminate. Relay 551 therefore associates these switches with the control equipment in the district frame connector and in the marker. When relay 714 operates, it closes a circuit for controlling the operation of the district secondary switches. This circuit is closed from battery through the winding of relay 553, back contact of relay 554, contact of relay 550, conductor 555, front contact of relay 714, back contact of relay 740, front contact of normally operated relay 731, back contact of relay 732 and the winding of stepping relay 733 to ground. Relays 553 and 733 operate in this circuit. Relay 733 closes a circuit from ground at its front contact, inner upper contact of relay 714, contact of relay 705 to conductor 736. Since route relay 705 identifies the frame on which the trunk 603 is located it therefore identifies the level to which the district secondary switch must be advanced. Therefore conductor 736 is cross-connected to one of the counting relays of Fig. 7 to control the operation of magnet 542.

Relay 553 in operating closes a circuit from ground at its outer right front contact, back contact of relay 556, back contact of relay 580, front contact of relay 551 and the winding of magnet 542 to battery. Relay 580, included in this circuit, and relay 660 of the office link connector would be controlled by the marker to route approximately half of the calls through one panel of the frame and the other half through the other panel, with means for directing a second trial to the other panel in either case.

Magnet 542 drives switches 541, etc., upward and at the same time carries brush 543 over commutator 544. As the switches approach each set of trunk terminals, brush 543 makes contact with a segment of commutator 544 thereby closing a circuit over the contact of relay 551, inner back contact of relay 556 to the front contact and winding of relay 553 and battery. Relay 553 is held operated but the stepping relay 733 is released. Assuming that conductor 736 was connected as shown, the circuit closed by relay 733 above traced to conductor 736 extends over the back contact of relay 741, winding of relay 751 to battery. Relay 751 operates and closes a locking circuit for itself through the winding of relay 741 and the front contact of relay 751 to ground at the contact of normally operated relay 731. However, relay 741 cannot operate

as long as the operating circuit of relay 751 remains closed.

When now relay 733 is released by the action of the commutator, relay 741 operates and extends the conductor 736 over the front contact of relay 741 to the winding of relay 750 and battery. When the brush 543 moves off the first conducting segment of commutator 544, relay 733 reoperates in turn operating relay 750 which locks through the windings of relays 739, and 740, the latter relays remaining unoperated. Contact with the second conducting segment by brush 543 again releases relay 733 permitting relays 739 and 740 to operate. Relay 740 in operating opens the circuit of relay 553 which now releases, in turn releasing magnet 542, and leaving the brush rod elevated to hold switches 541, etc., opposite the second office junctor in each case. At this time the brush rod is maintained in its elevated position by means of a latching mechanism of the type shown in the above-identified Reynolds patent.

Relay 739 in operating closes a circuit from ground at its contact, over the back contact of relays 713, 712, 711 and 710 to the winding of relay 720 and battery. Relay 720 closes a locking circuit for itself through the winding of relay 710, upper front contact of relay 720, lower back contact of relay 711 to ground. Relay 720 also closes a circuit from ground at the back contact of relay 712, front contact of relay 714, front contact of relay 720 to battery through the winding of relay 732. Relay 732 opens the circuit of relays 733 and 553 at another point and also opens the circuit of relay 731 causing that relay to release, further opening the circuit of relay 733 and also releasing the counting relays. The release of the counting relays opens the operating circuit for relay 720 and permits relay 710 to operate. The operation of relay 710 releases relays 714 and 724. The release of relay 714 opens the circuit of relay 732 and that relay releases, restoring the circuit of relay 731 which reoperates.

With relays 710 and 720 operated, the circuits for operating the primary office switches are established. The circuit of stepping relay 733 may be traced from ground through the winding of relay 733, back contact of relay 732, front contact of relay 731, back contact of relay 740, lower front contact of relay 710, conductor 735, contact of relay 600, winding of relay 607 to battery. Relay 607 closes a circuit from ground at its front contact, over the back contact of relay 608, back contact of relay 660, front contact of relay 606 through the winding of magnet 620 to battery. Magnet 620 advances switches 622, etc. in the manner previously described. Brush 624 moving over commutator 625 completes an intermittent holding circuit for relay 607 over a front contact of relay 606 and back contact of relay 608, which circuit shunts relay 733 as in the case of the district secondary switch. With relay 710 operated, the counting relay circuit is controlled by relay 812 which, in identifying the position of the idle trunk, also identifies the position to which the primary office switches must be advanced. The counting relay circuit may be traced from the front contact of relay 733, inner upper contact of relay 710, conductor 734, front contact of relay 812, conductor 823 which is cross-connected to the counting relays, for example as shown, so that the circuit extends over the back contact of relay 742, winding of relay 752 to battery. Therefore, three reverting pulses from commutator brush 624 terminate the operation of the office primary switches. As before, relay 740 opens the circuit of relay 733, releasing that relay and relay 607, relay 607 in turn releasing magnet 620. Relay 739 operates relay 721 which locks through the winding of relay 711 to ground over the back contact of relay 712, but relay 711 does not operate at this time being shunted by the operating circuit for relay 721. Relay 721 closes a circuit for relay 732 over its lower front contact to ground at the lower front contact of relay 710, operating relay 732 to release the counting relays and prepare for the next operation. The release of the counting relays opens the operating circuit of relay 721 permitting relay 711 to operate. Relay 711 opens the locking circuit for relays 710 and 720 and these relays release, thereby releasing relay 732 to reclose the pulsing circuit.

When relay 721 operates, it closes a circuit from ground at its contact over conductor 737, contacts of relays 550, 551, winding of relay 556 and battery. Relay 556 transfers the control of relay 553 from the secondary district switch to the primary district switch.

When relay 711 operates, the circuit of relay 553 is closed and relay 553 operates and establishes a holding circuit for itself over its front contact and the front contact of relay 556, back contact of relay 580, contact of relay 551, contact of relay 502, conductor 526 to sleeve brush 561. Since only the district secondary switches associated with drive magnet 542 have been positioned, only those district links which terminate therein need be tested. At its left contact relay 553 closes a circuit for relay 554 which operates, opening the operating circuit for relay 553, leaving that relay dependent upon its holding circuit. Relay 553 also closes a circuit over its front contact, front contact of relay 556, front contact of relay 502 through the winding of up-drive magnet 560 and battery. As brush 561 moves upward it tests not only the condition of the district links 563, etc., but over these links the condition of the office junctors 545, etc., and the office links 627, etc., that is, it tests for an idle channel by which the connection may be extended to the selected trunk.

When brush 561 reaches an idle channel, relay 553 releases to stop the up-drive magnet 560 and bring the brush carriage to rest. Relay 553, in releasing, opens the circuit of relay 554 but relay 554 is slow to release and a circuit is closed during the releasing time of that relay from high potential positive battery 570, through resistance 571, front contact of relay 554, back contact of relay 553, front contact of relay 556, back contact of relay 580, front contact of relay 551, front contact of relay 502, conductor 526, through the winding of hold magnet 565, normal contact of magnet 565, resistance 566 to the negative central office battery and ground. Magnet 565 operates, drawing the tip and ring brushes into contact with the tip and ring multiple terminals, disconnecting resistance 566 at its front contact and connecting battery to release magnet 569 to restore the brush rod of the selector to normal. The high potential battery extends over brush 561 to the sleeve conductor of district link 563 and thence to magnet 547 which functions in a manner similar to magnet 565. The positive battery also extends over the sleeve brush 548 and the sleeve conductor of office junctor 545 to magnet 628. Magnet 628

operates, drawing up the tip and ring brushes to hold the switch 622 in position and operating release magnet 621 to restore the drive rod. The high potential battery also extends over brush 629 to the sleeve conductor of the associated office link 627, and thence over front contact of relay 606 to the control anode of the trigger tube 649.

Twenty trigger tubes are provided, one for each of the office links included in a group serving a trunk and, when the relay corresponding to relay 606 is operated to identify the group of office links, the tubes are connected to the sleeve conductors of the group of office links.

When relay 733 operated in series with relay 553, prior to the operation of the district primary switch, a counting relay circuit was closed over the front contact of relay 711 to conductor 738 and thence through the winding of the No. 0 counting relay 750 to battery. Relay 750 locks through the windings of relays 739 and 740 as before but the latter relays do not operate. When relay 533 established the holding circuit above described, ground over this holding circuit completed a shunt around the winding of relay 733 and that relay released so that relays 739 and 740 operated. Relay 740 opened the pulsing circuit as before. Relay 739 closed a circuit over the back contacts of relay 713 and 712, front contact of relay 711, winding of relay 722 and battery. Relay 722 locked through the winding of relay 712 which did not operate at that time. Relay 722 operated relay 732 to bring about the release of the counting relays and to permit relay 712 to operate. Relay 722 also connected ground to conductor 760 which completed a circuit over the front contact of relay 600, winding of relay 608 to battery. Relay 608 transferred the driving and revertive pulse circuits from the office primary switch to the office secondary switch. In addition it prepared an operating circuit for the trigger tubes 630 to 649. Relay 712 closed a circuit from battery through the winding of relay 607, front contact of relay 600, conductor 735, front contact of relay 712, back contact of relay 740, front contact of relay 731, back contact of relay 732 through the winding of relay 733 and ground. Relay 607 prepared an operating circuit for the up-drive magnet of one of the office secondary switches and a revertive pulse circuit to the commutator of that switch. However, these circuits do not become effective until the positive battery applied to the selected channel causes the operation of one of the trigger tubes 630 to 649. Since battery was connected as above described to the sleeve of office link 627, tube 649 will become conducting, causing the operation of relay 650. With relay 650 operated, the circuit of up-drive magnet 651 is closed, advancing brush carriage 652. A circuit is also closed from ground on brush 653, commutator 654, over a front contact of relay 606, contact of relay 650, front contact of relay 608 to the front contact and winding of relay 607 and battery, thereby transmitting revertive pulses to shunt relay 733 in the marker.

With relay 712 operated, stepping relay 733 closes a circuit from ground at its front contact, front contact of relay 712, conductor 761, front contact of trunk relay 812 to conductor 862 which will be cross-connected to the counting relays in accordance with the position of the trunk in the secondary office switch. The counting relays will be operated under the control of the revertive pulses, resulting in the operation of relays 739 and 740 to open the circuit of relay 607 to bring the switch to rest. Relay 607 in releasing closes a circuit over its back contact, front contact of relay 606, winding of relay 655 to battery. Relay 655 closes the sleeve conductors of the office links having access to the group of trunks to which relay 606 is individual to the normal contacts and windings of magnets 656, etc., preparatory to operating magnet 656. Relay 739 operates relay 723 which in turn operates relay 732 to release the counting relays. Relay 723 locks through the winding of relay 713 which operates when the counting relays have been released. Relay 713 at its outer lower contact disconnects ground from the holding circuit of relay 800 which in turn permits relay 502 to release. Relay 713 also initiates the further operation of the marker.

With relay 502 released the district junctor is disconnected from the district frame connector. In response to the release of the marker the sender 501 operates relay 520 which connects the incoming tip and ring conductors through to the windings of relay 521. If the receiver is still off the hook at the calling substation, relay 521 operates in turn operating relay 522. Relay 522 connects a bridge through retard coil 523 across the tip and ring conductors leading toward the wanted office to initiate the operation of the equipment at that office to complete the call. Relay 522 also connects ground to conductor 524 thereby providing a holding circuit for relay 520 and transmitting a signal over the operating circuit of relay 520 to the sender 501 which causes the sender to send a release signal to the marker. Ground on conductor 524 through resistance 525 holds the line switches operated. Conductor 524 is also connected over the normal contact of relay 502 to the sleeve conductor 526 and brush 561 of the district primary switch. Magnet 565 is held operated as are magnets 547 and 628 under the control of relay 521 and thereby of the calling subscriber. This ground extends over the sleeve of office link 627, front contacts of relays 655 and 606, normal contact and winding of magnets 656 to battery. Magnet 656 operates, locking over its alternate contact directly to the sleeve conductor of office link 627. The circuits of office secondary magnet 656, etc., do not include the resistances included in the circuits of the other switches so that they will operate from ground. However, since the magnets are disconnected from the sleeve brush until the switch is in position, the magnets cannot operate falsely in passing over busy terminals.

It is to be understood that these circuits are illustrative only and that other circuits might be substituted for those shown without departing from the spirit of the invention. One modification contemplated is to terminate the outgoing trunk before the office primary switches thereby eliminating the last selection and permitting the district junctor to select an idle trunk as well as an idle channel.

What is claimed is:

1. In a telephone system, a district junctor, a plurality of trunk circuits, a plurality of channels, each comprising a plurality of switch-ended links by which said junctor may be connected to said trunk circuit, means for identifying an idle trunk, means under the control of said identifying means to position the switches of idle links included in the channels having access to said trunk, and means in said district junctor for selecting an idle channel.

2. In a telephone system, a district junctor, a

plurality of trunk circuits, a plurality of serially related switch-ended links for connecting said junctor with one of said trunk circuits, means for positioning said switches to prepare a plurality of connections, and means in said district junctor for selecting an idle series of links and an idle trunk.

3. In a telephone system, a switch-ended district junctor, a plurality of trunk circuits, a plurality of serially related switch-ended links for connecting said junctor with one of said trunk circuits, means for positioning said link switches to prepare a plurality of connections, and means to operate said district junctor switch to simultaneously select an idle series of links and an idle trunk.

4. In a telephone system, a district junctor, a plurality of trunk circuits, a plurality of serially related switch-ended links for connecting said junctor with one of said trunk circuits, means for positioning said switches to prepare a plurality of connections, and means in said district junctor for selecting an idle series of links leading to an idle trunk.

5. In a telephone system, a switch-ended incoming circuit, outgoing circuits, a plurality of channels for connecting said incoming circuit to said outgoing circuits comprising a plurality of serially related switch-ended links, and means for establishing a connection between said incoming circuit and one of said outgoing circuits comprising means for positioning idle ones of said switches, and means for operating said incoming circuit switch to select a channel in which all of the links are idle.

6. In a telephone system, an incoming circuit, outgoing circuits, a plurality of channels for connecting said incoming circuit to said outgoing circuits comprising a plurality of serially related switch-ended links, and means for establishing a connection between said incoming circuit and one of said outgoing circuits comprising means for positioning idle ones of said switches, and means for testing sets of said links in series for selecting an idle channel.

7. In a telephone system, an incoming circuit, a plurality of outgoing circuits, a plurality of serially related switch-ended links for connecting said incoming circuit with one of said outgoing circuits, means for positioning said switches to prepare a plurality of links, and means in said incoming circuit for selecting an idle series of links leading to an idle outgoing circuit.

8. In a telephone system, a switch-ended incoming circuit, a plurality of outgoing circuits, a plurality of serially related switch-ended links for connecting said incoming circuit with one of said outgoing circuits, common control means, means in said control means for identifying a wanted outgoing circuit, means under the control of said identifying means for positioning idle ones of said link switches to prepare a plurality of connections between said incoming circuit and said wanted outgoing circuit, means to operate the switch of said incoming circuit to select an idle connection between said incoming circuit and said outgoing circuit, means in said control means for completing said connection, and means in said incoming circuit for maintaining said connection independent of said control means.

9. In a telephone system, a switch-ended incoming circuit, a plurality of outgoing circuits, a plurality of channels comprising primary, secondary and tertiary switch-ended links for connecting said incoming circuit with said outgoing circuits, common control means, means in said control means for identifying an idle wanted outgoing circuit, means under the control of said identifying means for positioning the switches of the idle ones of said primary and secondary links, means to operate said incoming circuit switch to select a channel the primary, secondary and tertiary links of which are all idle, and means to operate the switch of the tertiary link of said selected channel to complete the connection between said incoming circuit and said outgoing circuit.

10. In a telephone system, a switch-ended incoming circuit, a plurality of outgoing circuits, a plurality of channels comprising primary, secondary and tertiary switch-ended links for connecting said incoming circuit with said outgoing circuits, common control means, means in said control means for identifying an idle wanted outgoing circuit, means under the control of said identifying means for positioning the switches of the idle ones of said primary and secondary links, means to operate said incoming circuit switch to select a channel the primary, secondary and tertiary links of which are all idle, means to identify the selected channel, and means under the control of said channel identifying means to operate the switch of the associated tertiary link to complete the connection between said incoming circuit and said outgoing circuit.

11. In a telephone system, an incoming frame, a switch-ended incoming circuit on said incoming frame, an outgoing circuit on said outgoing frame, a plurality of channels for connecting said incoming circuit with said outgoing circuit comprising a plurality of switch-ended primary links on said incoming frame to which said incoming circuit switch has access and all of which have access to the same outgoing frame in the same position, a plurality of switch-ended secondary links and a plurality of switch-ended tertiary links on said outgoing frame, said tertiary link switches all having access to the same trunk in the same position, and said secondary link switches having access to said plurality of tertiary links in the same position, a common control circuit, means for connecting said control circuit with said incoming frame, means for connecting said control circuit with said outgoing frame, means in said control circuit for identifying said outgoing circuit, means under the control of said identifying means for positioning said primary link switches and said secondary link switches, means for operating said incoming circuit switch to select an idle channel, means for identifying said selected channel at said outgoing frame, means in said control circuit to prepare the operating circuit for a tertiary link switch, and means under the control of said channel identifying means for extending said prepared circuit to the tertiary link of said selected channel.

12. In a telephone system, an incoming frame, a switch-ended incoming circuit on said incoming frame, an outgoing frame, an outgoing circuit on said outgoing frame, a plurality of channels for connecting said incoming circuit with said outgoing circuit comprising a plurality of switch-ended primary links on said incoming frame to which said incoming circuit switch has access and all of which have access to the same outgoing frame in the same position, a plurality of switch-ended secondary links and a plurality of switch-ended tertiary links on said outgoing frame, said tertiary link switches all having access to the same trunk in the same position, and

said secondary link switches having access to said plurality of tertiary links in the same position, a common control circuit, means for connecting said control circuit with said incoming frame, means for connecting said control circuit with said outgoing frame, means in said control circuit for identifying said outgoing circuit, means under the control of said identifying means for positioning said primary link switches and said secondary link switches, means for operating said incoming circuit switch to select an idle channel, vacuum tube means for identifying said selected channel at said outgoing frame, means in said control circuit to prepare the operating circuit for a tertiary link switch, and means under the control of said vacuum tube means for extending said prepared circuit to the tertiary link of said selected channel.

13. In a telephone system, an incoming frame, a switch-ended incoming circuit on said incoming frame, an outgoing circuit on said outgoing frame, a plurality of channels for connecting said incoming circuit with said outgoing circuit comprising a plurality of switch-ended primary links on said incoming frame to which said incoming circuit switch has access and all of which have access to the same outgoing frame in the same position, a plurality of switch-ended secondary links and a plurality of switch-ended tertiary links on said outgoing frame, said tertiary links all having access to the same trunk in the same position, and said secondary links having access to said plurality of tertiary links in the same position, a common control circuit, means for connecting said control circuit with said outgoing frame, means in said control circuit for identifying said outgoing circuit, means under the control of said identifying means for positioning said primary link switches and said secondary link switches, means for operating said incoming circuit switch to select an idle channel, means for identifying said selected channel at said outgoing frame, means in said control circuit to prepare the operating circuit for a tertiary link switch, means under the control of said channel identifying means for extending said prepared circuit to the tertiary link of said selected channel, and means under the control of said incoming circuit for holding the switches of said selected channel operated and for restoring the remaining switches and said control circuit to normal.

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