Feb. 9, 1943. L. A. MEACHAM ET AL 2,310,452

SWITCHING SYSTEM

Filed June 5, 1941 6 Sheets-Sheet 1

FIG. 1

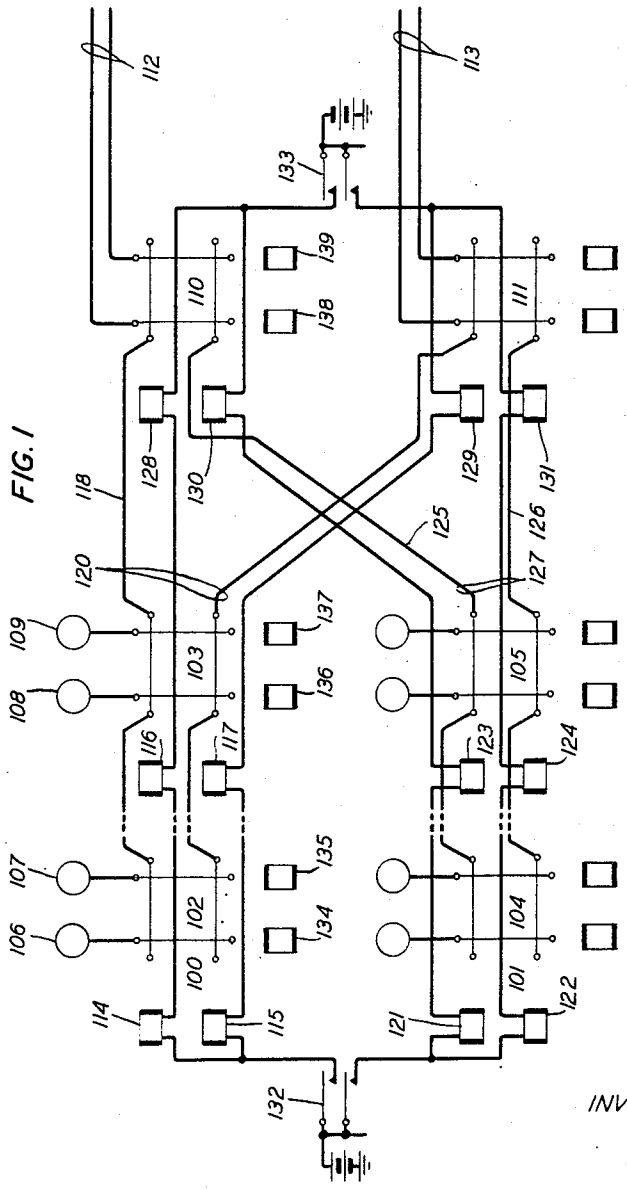


FIG. 7

| | |
|---|---|
| FIG. 6 | |
| FIG. 4 | FIG. 5 |
| FIG. 2 | FIG. 3 |

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SWITCHING SYSTEM

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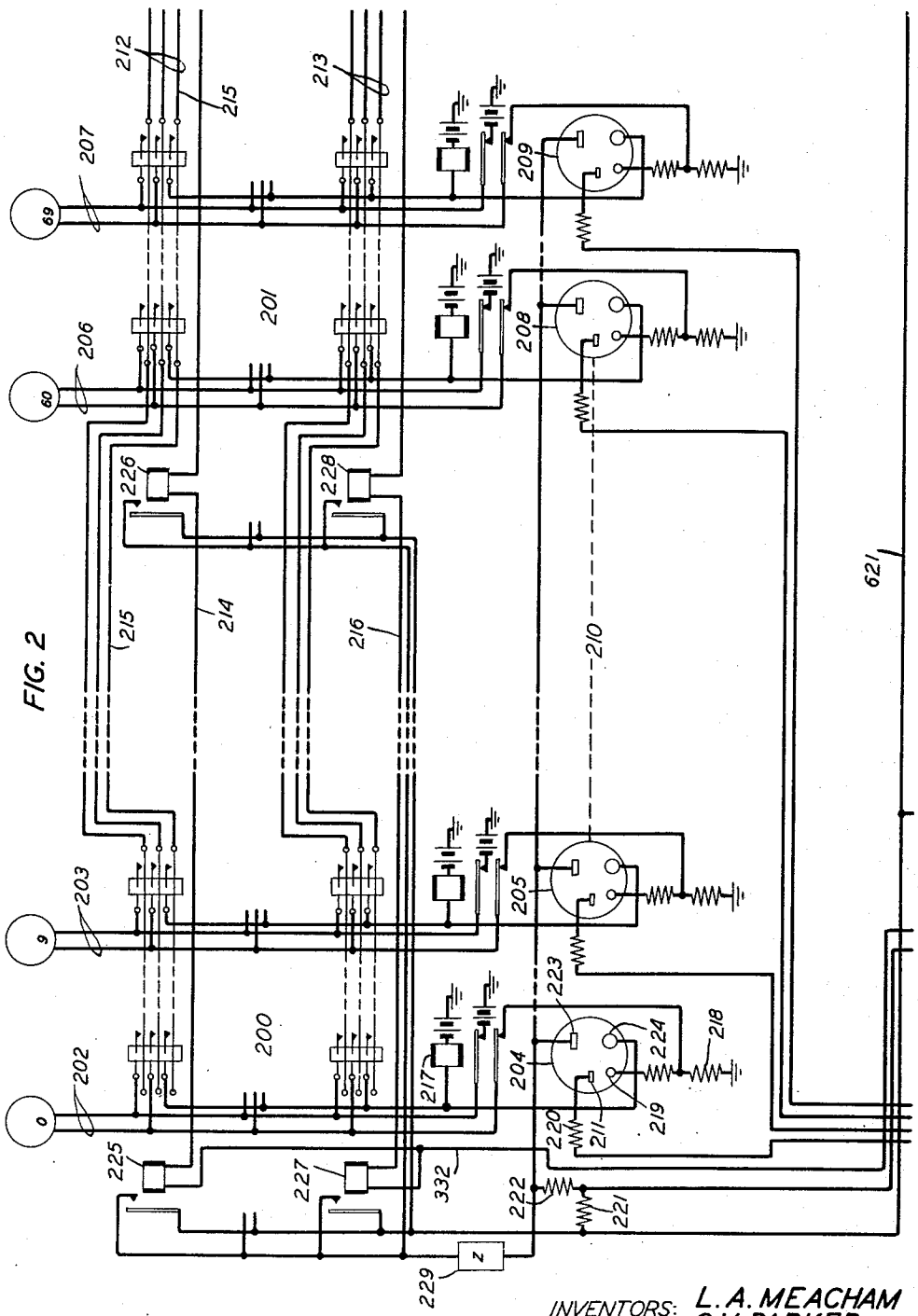


FIG. 2

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SWITCHING SYSTEM

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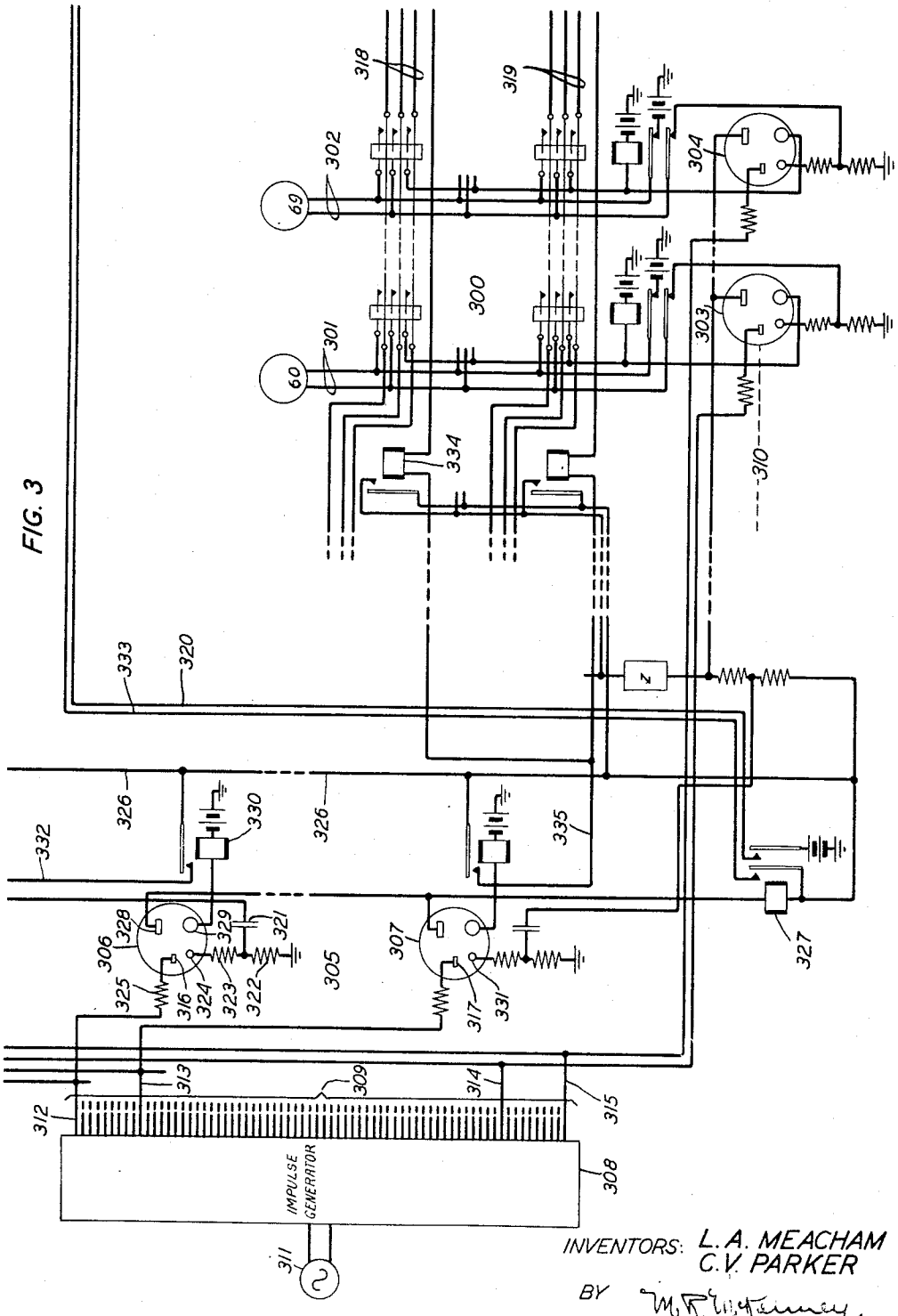


FIG. 3

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SWITCHING SYSTEM

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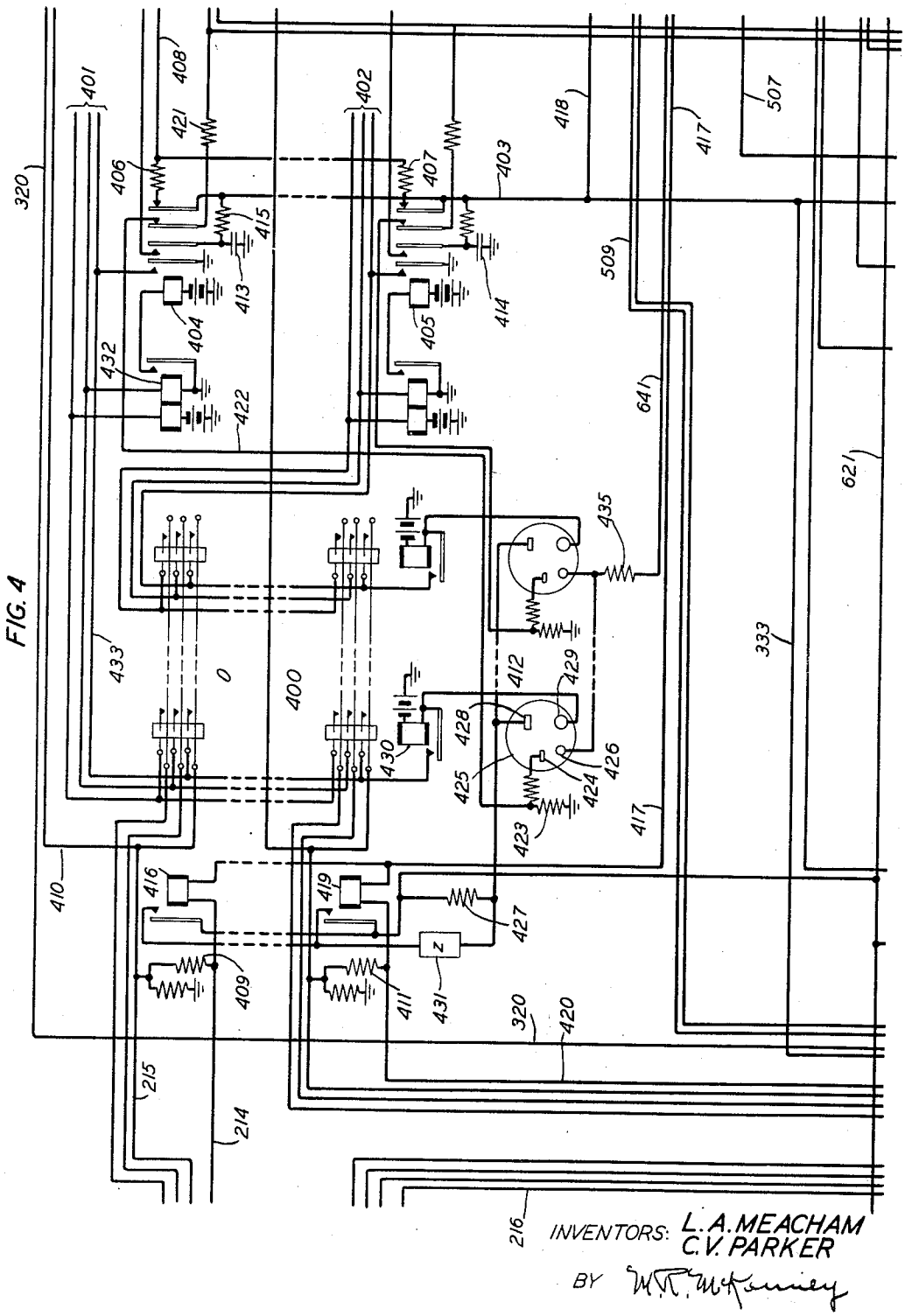


FIG. 4

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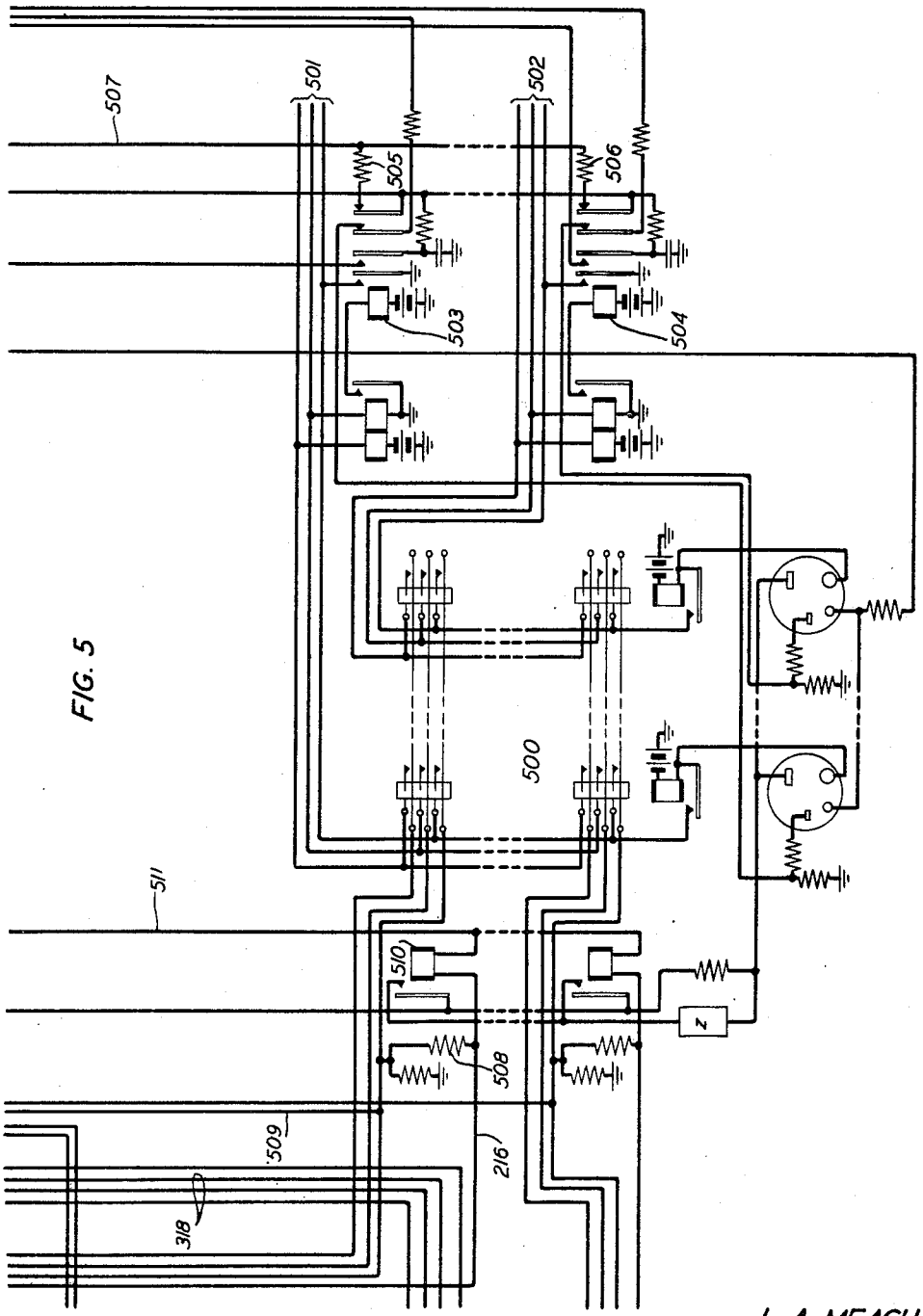


FIG. 5

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SWITCHING SYSTEM

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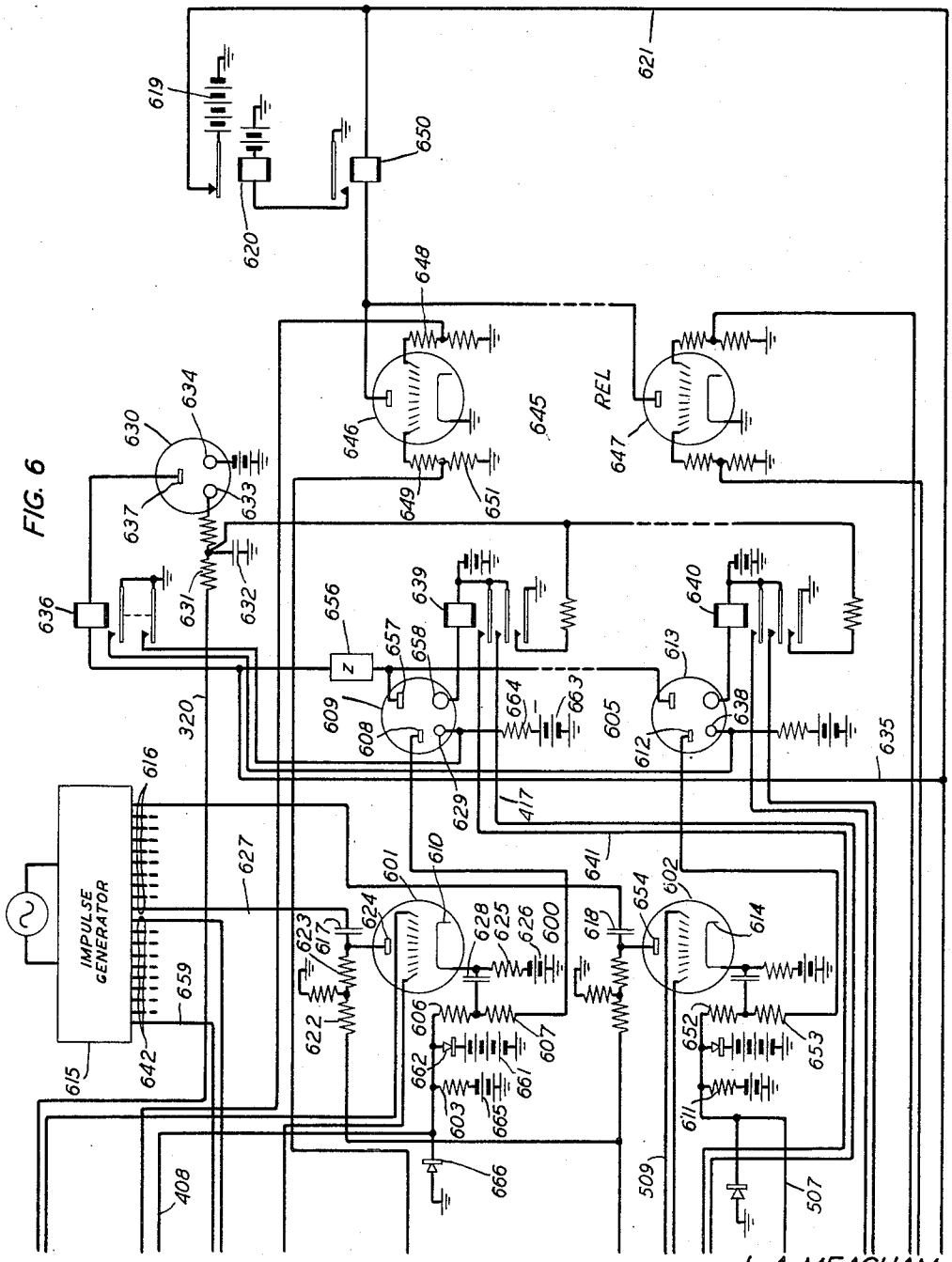
FIG. 6

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Patented Feb. 9, 1943

2,310,452

# UNITED STATES PATENT OFFICE

2,310,452

## SWITCHING SYSTEM

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Application June 5, 1941, Serial No. 396,687

7 Claims. (Cl. 179—18)

This invention relates to switching systems and particularly to such systems when used for establishing telephone or other communication connections.

The objects of the invention are to simplify these switching systems, to minimize the use of common controlling equipment, to increase the speed of operation, and to obtain other improvements therein.

In automatic telephone systems where large groups of lines have access through switches, such as line finders or line switches, to trunk groups it has been proposed heretofore to arrange these switches in primary and secondary formation with links for extending the lines to the trunks and also to arrange the switches and lines in coordinate rows or groups, such as horizontal and vertical groups, for the purpose of obtaining an orderly interconnection of the lines with the trunks. In such a switching system, and particularly when crossbar switches are used, it has usually been necessary to provide relay chains and rather involved control circuits for serving the lines having calls thereon, for preventing interference between simultaneous calls in the different groups, for insuring selection in preferred horizontal and vertical groups, for selecting idle groups of trunks, and for selecting idle links having access to these trunk groups. Also in these prior systems it has been necessary to provide each group of primary and secondary switches, such as those occupying a frame, with a considerable amount of equipment that is used in common by all switches on the frame.

Accordingly a feature of the present invention is a system in which the relay selecting and testing mechanisms are replaced by electronic discharge devices which perform the testing, selecting, and other controlling functions with greater speed, and in which much of the common controlling circuits and equipment have been eliminated. More specifically a calling line in one of the primary switches is extended over a link to a secondary switch and thence to an idle trunk in the group accessible to such secondary switch by selectively operating with impulses of different phases one of a series of discharge tubes to select the horizontal group of primary switches containing the calling line; by utilizing this tube to apply potential to the switch magnet operating circuits of all links extending from the chosen horizontal group to the respective secondary switches, each operating circuit including the operating magnets associated with a given link on all primary switches in the group and the magnet of the secondary switch to which the corresponding link extends; by operating by means of phase impulses one of a series of tubes representing a trunk group having idle trunks therein and an idle link extending from the calling horizontal group of primary switches to the secondary switch having access to such trunk group; and by utilizing the operated tube to apply potential at the chosen secondary switch to the magnet operating circuits of all links extending to said secondary switch from each of the several primary switch groups. Thus at the primary switches the magnet operating circuits are prepared for all links extending from the chosen horizontal group to the several secondary switches, and at the chosen secondary switch the magnet operating circuits are prepared for all links extending thereto from the several primary horizontal groups; and the result is that one and only one of these circuits is completed to effect the desired connection, the choice of the idle link and trunk group from other links and groups, which may be busy or idle at the time, being made by applying phase impulses to the selecting tubes.

Another feature of the invention is a system of this kind in which the extension of a calling line to an idle trunk results in the discharge of a tube common to the trunk group to cause the release of the operated tubes and circuits associated with the frame, whereby the switches and links of the frame become available to other calling lines.

These and other features of the invention will be described more fully in the following detailed specification.

In the drawings accompanying the specification:

Fig. 1 is a diagram of a frame of primary and secondary switches, illustrating in particular the energizing circuits of the switch operating magnets;

Figs. 2 to 6 when arranged as indicated in Fig. 7 disclose the detailed circuits and equipment for a portion of one of the line switch frames illustrated in Fig. 1;

Fig. 2 shows a horizontal row or group of primary line switches;

Fig. 3 illustrates another horizontal row of primary switches and also shows the horizontal group selecting equipment for choosing the horizontal group to be served;

Figs. 4 and 5 show two of the secondary line switches to which the links incoming from the several horizontal primary groups have access and which have access to respective outgoing groups of trunks; and

Fig. 6 shows the common controlling mechanism for performing the link and trunk testing operations and for releasing the circuits after use.

Referring first to Fig. 1, the frame of crossbar line switches illustrated therein comprises ten horizontal groups or rows of primary line switches, of which two are shown, the No. 0 group 100 and the No. 9 group 101. Each horizontal group may have any desired number of primary switches therein, it being assumed in the present case that seven primary switches are provided in each of the ten horizontal groups. Two of the seven primary switches 102 and 103 are shown in the horizontal group 100, and two primary switches 104 and 105 are shown in the group 101. Each of these primary line switches serves ten subscribers' lines, the lines appearing in the vertical rows of contacts of the switches. For example, lines 106 and 107 appear in the primary line switch 102, and lines 108 and 109 appear in the primary line switch 103.

The line links which interconnect the primary line switches and the secondary line switches appear in the horizontal rows of contacts in the switches of the different primary horizontal groups. There are ten of these links for each horizontal group, and all ten links are multipled to appear in the horizontal rows of contacts of all of the seven primary switches.

Ten secondary switches are also provided on the line switch frame, there being one of these secondary switches for each horizontal group of primary switches. Two of these secondary switches are shown, the No. 0 switch 110 and the No. 9 switch 111. The primary and secondary switches are interconnected by the line links in such a manner that all ten primary groups have access to all ten secondary switches. This is accomplished by extending the ten line links from each horizontal group respectively to the ten secondary switches. Stated in another way, each secondary switch receives a single link from each of the ten primary groups.

The ten secondary switches have access respectively to ten outgoing groups of trunks, to which the calling lines are connected through the joint operation of the primary and secondary switches. For example, the trunk group 112 appears in and is accessible to the secondary line switch 110, and the trunk group 113 appears in the secondary line switch 111. Eight other trunk groups appear respectively in the remaining eight secondary switches not shown in the drawings.

Each of the primary and secondary switches on the frame is provided with ten select magnets, one for each horizontal row of contacts, for preparing the switch for operation and with ten hold magnets individual respectively to the vertical rows of contacts for holding the contacts in their operated condition after the select magnets have been released. For example, the select magnets 114 and 115 are individual respectively to the No. 0 and No. 9 horizontal rows in the switch 102. Similarly the select magnets 116 and 117 serve the No. 0 and No. 9 horizontal rows of contacts in the switch 103. The two line links 118 and 119 of the horizontal group 120 appear respectively in the No. 0 and No. 9 horizontal rows of switches 102, 103, etc., of the horizontal group 100. Similarly the select magnets 121, 122 of switch 104, and 123, 124 of switch 105 control the No. 0 and No. 9 horizontal rows of contacts in these switches, in which the line links 125 and 126 of the group 127 appear. The links of the group 120 appear respectively in the No. 0 horizontal rows of contacts in the ten secondary switches, the link 118 in the No. 0 row of switch 110 and the link 119 in the No. 0 row of switch 111. These horizontal rows in switches 110 and 111 are controlled by the select magnets 128 and 129. The links of the group 127 appear in the No. 9 horizontal rows of contacts in the respective secondary switches and are controlled by the select magnets thereof, such as the magnets 130 and 131 of switches 110 and 111, respectively.

As will be described more fully hereinafter, the select magnets of the primary and secondary switches are operated in series circuits. For example, the select magnets 114, 116, etc., of all primary switches and the select magnet 128 of the secondary switch pertaining to the No. 0 line link 118 are included in a series circuit. One end of this circuit is closed through contacts 132 to the positive pole of battery, and the other end of this circuit is closed through contacts 133 to the negative pole of battery. Likewise the select magnets of the primary switches and secondary switches pertaining to each of the remaining links are included in series circuits. All of the select magnet operating circuits for a horizontal group of links, such as the group 120, are connected in series parallel relation through the contact 132 to the positive pole of battery. Similarly all of the select magnet operating circuits incoming to any particular secondary switch, such as the switch 110, are connected in series parallel relation through the contact 133 to the negative pole of battery. By closing the contact 132 at the primary switches and the contact 133 at the secondary switches a single circuit is completed through the windings of magnets 114, 116, etc., of the primary switches and the magnet 128 of the secondary switch 110. In this manner the select magnets of the primary switches and the secondary switch having access to the calling line and to an idle trunk respectively are energized simultaneously to prepare these switches for operation.

The hold magnets 134, 135, 136, 137, etc., of the primary switches serve to hold these switches in their operated condition after the select magnets have been released. Similarly the hold magnets 138, 139, etc., of the secondary switch 110 (and the same is true of the other secondary switches) serve to hold the operated contacts in their closed condition after the release of the select magnets.

The primary and secondary line switches disclosed herein may be of any well-known type of crossbar construction, one suitable type being disclosed in the patent to Reynolds, No. 2,021,329 of November 19, 1935.

A general description will now be given of the circuits and equipment shown in detail in Figs. 2 to 6. The No. 0 horizontal group of primary switches on the frame includes the No. 0 switch 200 and the No. 6 switch 201, there being, as above explained, five similar intermediate primary switches. Ten subscribers' lines, including lines 202 and 203, appear in the vertical rows of contacts of switch 200 and are provided with individual line discharge tubes, including the No. 0 and No. 9 tubes 204 and 205. Similarly the No. 60 and No. 69 lines 206 and 207 appear in the last switch 201 in the group and are provided with corresponding line tubes 208 and 209. There are, therefore, seventy subscribers' lines appearing in the horizontal group and seventy individual line tubes comprising the group 210.

In like manner each of the remaining nine

horizontal groups on the frame includes seven primary switches and seventy line tubes serving the corresponding group of seventy subscribers' lines. The last or No. 9 horizontal group is partially illustrated in Fig. 3 and includes the No. 6 primary switch **300**. Subscribers' lines **301** and **302** appear in this switch. These and other subscribers' lines not shown in this horizontal group are provided with a group of line tubes **310** of which tubes **303** and **304** are individual to lines **301** and **302** respectively.

The ten horizontal groups of primary line switches are provided with a group of ten space discharge tubes **305**, one for each of the horizontal groups. These tubes serve to select one of the horizontal groups for service to the exclusion of other groups having calling lines therein. The tube **306**, for example, is individual to the No. 0 horizontal group shown in Fig. 2 and when operated renders this group effective and excludes the remaining groups. The other tube shown, tube **307**, is individual to the last or No. 9 horizontal group shown in Fig. 3.

The tubes of each of the line groups **210**, **310**, etc., are operated selectively by means of multiplex signal impulses. These impulses are produced by the impulse generator **308** which has seventy output circuits **309**. The generator **308** is energized by a source of alternating current **311** of any suitable frequency and serves to produce momentary impulses of seventy different phases during each successive cycle of the source **311**. The impulses of the different phases, which are referred to herein as phase impulses, appear successively in the impulse circuits of the group **309** and are applied to the control electrodes of the respective tubes of the group **210** and similarly to the electrodes of the respective tubes in each of the other groups. For example, impulses of the No. 0 phase appear in the conductor **312**, which is connected to the starting anode **211** of the No. 0 tube **204** and in multiple to the starting anodes of the corresponding tubes in the other nine groups. Impulses of phase No. 9 appear in impulse conductor **313**, which is connected to the starting anode of the No. 9 tube **205** in group **210** and to the corresponding tube in the other groups. Impulses of phases No. 60 and No. 69 appear respectively in impulse conductors **314** and **315**, these conductors being connected to the starting anodes of tubes **208** and **209** and tubes **303** and **304** and to corresponding tubes in other groups. When two or more lines in any one of the horizontal groups initiate calls the line tube corresponding to one of these lines operates depending upon the phase of the impulses at the time the calls are originated and excludes or locks out all of the other tubes in the group. Thus only one line tube in any horizontal group is permitted to operate at a time. This will be explained more fully hereinafter.

The horizontal group tubes **305** are also operated selectively by phase impulse delivered by the generator **308**. Since there are only ten of these horizontal group tubes only ten of the group of impulse generator leads **309** are required. Any ten of the seventy leads may be used depending upon the phases desired. As shown in the drawing, however, the first ten impulse conductors are connected to the starting electrodes of the ten tubes of the group **305**. For example, the No. 0 impulse conductor **312** is connected to the starting anode **316** and the No. 0 horizontal group tube **306**, the No. 9 impulse conductor **313** is connected to the starting anode **317** of the No. 9 horizontal group tube **307**, and the eight intermediate phase impulse conductors are connected to the corresponding intermediate tubes of the group **305**. When two or more horizontal groups are calling at the same time, one of the tubes **305** operates to prefer its horizontal group and to exclude the others.

The currents of the different phases may be obtained from the source **311** in any suitable manner, and the momentary impulses delivered to the circuits **309** for operating the tubes may also be produced by suitable impulse generating means. For example, impulse generators designed to produce momentary impulses of either positive or negative polarity are disclosed in the application of W. H. T. Holden, Serial No. 361,536, filed October 17, 1940; and W. H. T. Holden Patents 2,288,815, of June 9, 1942; and 2,252,766, of August 19, 1941.

The ten links outgoing from the horizontal group shown in Fig. 2 extend respectively to the ten secondary line switches. For example, the link **212** appears in the secondary line switch **400**, and link **213** appears in the secondary line switch **500**. The other eight links not shown in this group appear in the corresponding secondary line switches. In like manner the remaining groups of link circuits are distributed among the secondary line switches **400**, **500**, etc., the links **318** and **319** shown in the last horizontal group appearing respectively in the secondary switches **400** and **500**.

The No. 0 secondary line switch **400** has access to a group of ten trunks, including trunks **401** and **402**, outgoing to some selective switching stage beyond. The No. 9 secondary switch **500** has access to a similar group of trunks which includes the trunks **501** and **502**, and the same is true of the eight intermediate secondary switches. Thus the subscribers' lines appearing in the ten different horizontal groups of primary switches have access through these switches and intermediate links and the secondary switches to any one of ten groups of outgoing trunk circuits.

The secondary switches of the frame are provided with a common group of testing tubes **600**, there being one of these tubes for each of the outgoing trunk groups. The first of these tubes, tube **601**, is individual to the group of trunks outgoing from the switch **400** and serves simultaneously to test these trunks for an idle one and to test the link incoming to the switch **400** from the calling group of primary switches. The last tube of the group **600**, tube **602**, is individual to the group of trunks outgoing from the last secondary switch **500** and serves simultaneously to test these trunks and to test the link incoming to the switch **500** from the calling group of primary switches. The matching test made by the tubes of the group **600** is registered on the tubes of group **605**. There is one of these tubes in the group **605** for each of the ten groups of outgoing trunks, and the tube that is finally operated as a result of the matching test by the group **600** indicates that there is an idle trunk in the associated group and that there is an idle link having access to this trunk from the primary switches in which the calling line appears.

The test of the trunk group is made by a circuit extending through the contacts of the sleeve relays individual to the trunks of the group. Considering the trunk group appearing in the switch **400**, the test circuit for this group extends from the battery lead **403** through the normal contacts in parallel of the sleeve relays **404**, **405**,

of all idle trunks, thence through parallel resistances 406, 407, conductor 408, resistor 603 to battery and ground. If all trunks are busy, this circuit is open, and no current flows through the resistor 603. Therefore, no potential is applied through resistors 606 and 607 to the starting anode 608 of the corresponding tube 609. However, if two or more of the trunks are idle, the amount of current flowing through resistor 603 results in the application of a potential of a predetermined value to the anode of the tube 609. This potential alone, however, is not sufficient to ionize the control gap of the tube. Simultaneously with the foregoing test of the trunk group a test is also being made of the particular one of the ten links 212, 318, etc., which extends to switch 400 from the calling group of primary switches. If the group of Fig. 2 is calling, for example, the link 212 is tested by means of a circuit extending over the conductor 214 through resistor 409, conductor 410 to one of the multiple starting anodes of the tube 601. If the link 212 is idle, positive potential appears on this anode, and the gap including the anode and the cathode 610 is ionized. If, however, the link 212 is busy, the usual ground potential on the sleeve conductor 215 is applied over conductor 410 to the starting anode of the tube 601, and the control gap is not ionized. The test of the other nine groups of trunks and the simultaneous test of the respective links having access to these trunks are made in a similar manner by means of the corresponding tubes of the groups 600 and 605. For example, the last group of trunks, including trunks 501 and 502, are tested by means of a circuit extending from the battery supply conductor 403 through the back contacts in parallel of the sleeve relays 503, 504, of all idle trunks, through the parallel resistors 505, 506, conductor 507 through resistor 611 to battery and ground 610. If two or more trunks are idle, the amount of current flowing through resistor 611 results in the application of a potential of a predetermined value to the anode 612 of the tube 613. At the same time the link having access to this trunk group, such as the link 213, is tested by means of a circuit extending over conductor 216, through resistor 508, conductor 509 to one of the multiple starting anodes of tube 602. If the link 213 is idle, positive potential appears on this anode and the gap including the anode and the cathode 614 is ionized.

As a result of these tests, therefore, each tube of the group 600 corresponding to a trunk group which is reached by an idle link has its control gap ionized; and each tube of the group 605 corresponding to a trunk group having two or more idle trunks therein has a positive potential applied to its starting anode. Since one trunk group and its matching idle link should be selected to the exclusion of other groups, the operation of tubes 605 is controlled by phase impulses delivered from the impulse generator 615. The ten impulse conductors 616 to which the generator 615 delivers impulses of ten different phases, are connected through condensers 617, 618 to the main anodes of the ten tubes of the group 600. The first one of the tubes 600 to receive an impulse from the generator 615 after the foregoing test has been made causes the operation of the corresponding tube of the group 605. Assume for instance that the control gap of tube 601 is ionized because the associated trung group contains two or more idle trunks. As soon as the control gap ionizes, the main gap discharges in a circuit traceable from the battery supply conductor 403, resistors 622 and 623, anode 624, cathode 610, resistor 625 to the negative pole of battery 626. Assume also that a moment later an impulse of the corresponding phase is applied by the generator 615 to the impulse conductor 627. This impulse passes through the discharged tube 601, and current flows through the resistor 625. This added flow of current as a result of the impulse causes the application of an increased positive potential through condenser 628, resistor 607 to the starting anode 608 of the tube 609. This increased potential applied to the anode 608 is sufficient to ionize the control gap formed by the anode 608 and the starting cathode 629. Thereupon the tube 609 discharges and signifies the selection of the associated trunk group and its matching idle link. The operated tube 609, as will be explained more fully hereinafter, also locks out the remaining tubes of the group 605 to prevent the selection of another group of trunks for serving this particular call. As the generator 615 proceeds to transmit impulses of succeeding phases to the remaining conductors of the group 616, corresponding impulses are applied to the cathodes of all tubes of the group 600 that are in a discharged condition because they represent qualified trunk groups that are reached by idle links from the calling primary group. However, these impulses are ineffective to cause the operation of a second one of the tubes 605, in case the associated trunk groups have idle trunks therein, for the reason stated, namely that the operation of the first tube 609 to select the associated group and link automatically renders the remaining tubes of the group 605 ineffective.

Since the positive potential applied to anode 608 must be enough to operate the tube if two trunks are idle and must not be enough to operate the tube falsely if several trunks are idle, the potential on conductor 408 is held below a predetermined value by means of the battery 661, which has its positive pole connected through the varistor 662 to conductor 408. Thus, no matter how many trunks are idle, the potential of anode 608 is held to such a value that the phase impulse delivered to the tube 601 is needed to operate tube 609, having in mind the positive potential applied to cathode 629 from battery 663 through resistor 664.

When all trunks are busy, battery 619 is disconnected from conductor 408. To avoid the possibility, under this condition, of tube 609 ionizing on the combined voltage of batteries 663 and 665 a varistor 666 is connected between conductor 408 and ground.

It was mentioned above that the trunk groups are first tested to determine whether they have two or more idle trunks. In case no trunk group is found having as many as two idle trunks a reserve test is then made to determine whether any group has a single idle trunk. This test is made by the tube 630 and the associated circuits. At the time the matching test is started battery potential is applied to conductor 320, and current flows through the resistor 631 to charge the condenser 632. After an interval of time has expired the condenser 632 reaches a predetermined charge, and the control gap of the tube 630 formed by the electrodes 633 and 634 ionizes. Current now flows in the main discharge circuit of the tube traceable from battery supply conductor 621, conductor 635, winding of relay 636,

anode 637, cathode 634 to battery and ground. Relay 636 operates and applies direct ground potential to the starting cathodes 629, 638, etc., of the tubes of the group 605. With direct ground potential on the starting cathodes of these tubes the control gap of any tube will ionize if a single trunk in the group is idle. In other words, a single idle trunk results in current flow over conductor 403 through the closed contact of a single one of the sleeve relays, such as relay 404, resistor 406, conductor 408, resistor 603 to battery. The intensity of this current flow through resistor 603 causes the application of a potential to anode 608 which is somewhat less than the potential applied thereto when two trunks are idle. However, the voltage produced across the gap 608—629, when the generator 615 delivers its phase impulse to the tube 601, and with electrode 629 at ground potential, is sufficient to ionize the gap. Thus the reserve test results in the selection of any group having a single idle trunk matching with an idle link.

When one of the tubes 605 operates to indicate the selection of the trunk group, an associated relay 639, 640, operates to prepare for the selection of an idle one of the trunks in the group. Relay 639, for example, closes a circuit from negative pole of battery through its contacts, conductor 641, resistor 435 to the starting cathodes of the tubes of group 412, there being one of these tubes for each of the ten trunks 401, 402. The starting anodes of the tubes 412 are connected through the normal contacts of the sleeve relays 404, 405 to the ten phase impulse leads 642 outgoing from the impulse generator 615. Therefore, as soon after one of the relays 639, 640 operates as the generator 615 delivers an impulse of the phase corresponding to the first idle trunk the corresponding tube 412 ionizes and prepares for the operation of the associated hold magnet of the switch 400. The selection of an idle trunk in any one of the other groups, such as the group outgoing from the secondary switch 500, proceeds in the same manner under the control of the associated relay, such as the relay 640 individual to the tube 613.

The impulse generator 615 may be similar to the generator 308; or, if desirable, the impulse leads 616 and 642 may be connected directly to the output leads of generator 308 for obtaining pulses of the required phases for application to tubes 600, 605 and 412.

The common matching and testing mechanism shown in Fig. 6 is released, as soon as it has performed its functions, under the control of a group of release tubes 645. There are ten of these tubes 646, 647, etc., one for each of the ten trunk groups. The starting anodes of these tubes are connected through resistors and the front contacts of the sleeve relays of the trunks to condensers. For example, the anodes of tube 646 are connected through resistors 648, 649 through the contacts of relays 404 and 405 to condensers 413 and 414. When the testing operation commences, battery potential is applied to conductor 403, and condensers 413 and 414 assume a charged condition. Later when the trunk is selected and the sleeve relay operates, the potential of the associated condenser is applied to the starting anode of the tube 646, and this tube ionizes its control gap. The main discharge gap of the tube 646 is then ionized, and current flows through the release relay 650. Relay 650 brings about the release of the common equipment as will be described hereinafter. The condenser 413 discharges through the relatively low resistance 651 and cannot assume a sufficient charge to cause the reionization of the tube 646 for the reason that the resistor 415, through which the condenser charges, is considerably higher in value than the resistor 615, through which it is constantly discharging while the trunk 401 is in use. Therefore, other trunks in the same group may be selected subsequently, and the tube 646 operates as soon as each trunk is selected in turn to cause the release of the common mechanism.

A description will now be given of the detailed operation of the system, assuming for this purpose that the subscribers of lines 202 and 301 initiate calls at about the same time. When the subscriber of line 202 removes his receiver from the switchhook, thus connecting a low resistance across his line, an obvious circuit is closed through the back contacts of the hold magnet 217 including the resistor 218. The current flowing through the resistor 218 places a negative potential on the starting cathode 219 of the associated tube 204, and this tube ionizes as soon as a positive impulse is delivered by the generator 308 over conductor 312, resistor 220 to the starting anode 211. As soon as the tube ionizes, current flows from the positive pole of battery 619, conductor 621, resistors 221 and 222, anode 223, cathode 224, winding of the hold magnet 217 to the negative pole of battery. The current flowing in this circuit is not enough to cause the operation of the hold magnet 217. The voltage drop, however, produced by the current flowing in resistors 221 and 222 lowers the potential of the anodes of the remaining tubes in the group 210 to a point where no other one of these tubes can operate. Prior to the operation of the tube 204 the condenser 321 associated with the horizontal group tube 306 is in a charged condition. The charging circuit for this condenser may be traced from the positive pole of battery over conductor 621, resistor 221, condenser 321, resistor 322 to ground. At the instant the tube 204 discharges sudden current flow through the resistor 621 lowers the positive potential applied to the condenser 321, resulting in the application of a negative potential through the resistor 323 to the starting cathode 324 of the tube 306. This negative potential is applied to the cathode 324 until the condenser 321 has time to adjust its charge in the circuit including the resistors 322 and 221. This interval is sufficiently long to permit the impulse generator 308 to apply a positive impulse over conductor 312 and resistor 325 to the starting anode 316 of the tube 306.

In a similar manner the initiation of a call on line 301 causes the operation of the associated line tube 303. Tube 303 causes the application of a negative impulse to the starting cathode 331 of the horizontal group tube 307, and this potential remains on the electrode 331 sufficiently long to permit the generator 308 to deliver a positive impulse of the corresponding phase to the starting anode 317.

Depending upon the phase of the generator 308 at the time the cathodes 324 and 331 are rendered negative in potential, an impulse of positive potential will be applied first to the anode 316 of the tube 306 or to the anode 317 of the tube 307. Assuming that the phase is such that the next impulse is delivered over the conductor 312 to the anode 316, the tube 306

ionizes its control gap 316—324, and current now flows from the positive pole of battery 619, conductor 621, conductor 326, winding of the common relay 327, anode 328, cathode 329, group relay 330 to the negative pole of battery. Relay 330 operates to indicate the selection of the No. 0 group of primary switches 200, 201 for service; and the flow of current through the common impedance 327 lowers the potential on the anodes of the remaining tubes of the group 305 to a value such that no one of these tubes can operate. Therefore, the tube 307 representing calling line 301 fails to operate when the generator 308 delivers the corresponding impulse to the anode 317, and the subscriber's line 301 must wait until the other line has been served.

When the horizontal group relay 330 operates, circuits are prepared for the select magnets associated with the ten link 212, 213 outgoing from the primary group serving the calling line 202 to each of the ten secondary switches 400, 500 on the frame. The preparation of these select magnet circuits consists in connecting the positive pole of battery to them. The circuit for the select magnets associated with the first link 212 may be traced from the positive pole of battery 619, conductor 621, conductor 326, contacts of relay 330, conductor 332, through the winding of select magnet 225, thence over conductor 214 through the windings of the corresponding select magnets, including magnet 226, of the other six primary switches, thence through the select magnet 416 associated with the link 212 in the secondary switch 400 to the common conductor 417. The circuit for the select magnets of the link 213 may be traced as before over the common conductors 621, 326, contacts of relay 330, common conductor 332 thence through the windings of select magnets 227, 228 and over conductor 216 through the select magnet 510 associated with the link 213 in the secondary switch 500 to the common conductor 511. Likewise parallel circuits may be traced from the positive pole of battery 619 through the select magnets of all of the remaining eight links outgoing from the primary group to the remaining eight secondary switches not shown. These circuits, however, are not yet effective to cause the operation of any of these select magnets since the common conductors 417, 511, etc., at the secondary switches are open and will remain open until it is determined which trunk group is to serve the calling line 202.

When the common relay 327 operates, it also extends the positive pole of battery 619 by way of conductor 621 through the contacts of relay 327, conductor 333, conductor 403, thence through the back contacts of the sleeve relays of all idle trunks in all of the ten trunk groups outgoing from the secondary switches 400, 500. As hereinbefore explained, these parallel circuits through the back contacts of the sleeve relays extend through the resistors 606, 607 and 652, 653, etc., to the starting anodes of the test tubes 605. Battery potential on the conductor 333 is also extended over conductor 418 to the main anode 624, 654, etc., of the ten tubes 600. Each one of the tubes 600 representing a trunk group that is reached by an idle link extending from the calling group is ionized as above explained; and, when the generator 615 applies a positive impulse through the discharged tube 600 to the anode of the associated tube 605, the latter tube operates to indicate the selection of a trunk group having an idle trunk therein and accessible to an idle link from the calling primary group. Assume that the tube 609 is the one operated, indicating that the trunk group including trunks 401 and 402 has been selected, the operation of tube 609 results in the closure of a circuit from the positive pole of battery 619, conductor 621, conductor 635, impedance element 656, anode 657, cathode 658, winding of relay 639 to the negative pole of battery.

When relay 639 operates it connects the negative pole of battery to the select magnet operating circuits of all ten links incoming to the switch 400 from the ten different primary groups of switches. It will be noted that only one of these select magnet operating circuits has been prepared by the connection of positive battery thereto, namely, the select magnet operating circuit for the link 212 coming from the calling primary group containing the subscriber's line 202. Hence this one select magnet circuit is closed while the remaining circuits remain ineffective. This circuit may be traced from the negative pole of battery through the middle contacts of relay 639 to the conductor 417 thence as previously traced through magnet 416, conductor 214, magnets 226, 225, conductor 332 to the positive pole of battery 619. Similarly relay 639 partially completes parallel circuits for the remaining nine links incoming to the secondary switch 400. One of these may be traced over the common conductor 417 through the winding of select magnet 419, conductor 420 through the select magnet 334 and other select magnets of the primary switches to the common conductor 335. These circuits, however, are open at the primary switches, and none of them is fully closed. Primary select magnets 205, 226, etc., and secondary select magnet 416, however, are energized in the circuit above traced to prepare for the establishment of the connection over the selected link 212 to one of the ten trunks in the group outgoing from the switch 400.

The operation of relay 639 also prepares for the test of the ten trunks in the selected group to choose an idle one thereof for use. Relay 639 at its inner contacts closes a circuit over conductor 641 through the resistor 435 to the starting cathodes of the tubes 412. Assume that the first trunk 401 in the group is idle and that the phase of the impulse generator 615 is such that the next impulse is delivered to the impulse conductor 659. This impulse is applied through the resistor 421 through the back contacts of the sleeve relay 404 of the idle trunk 401, conductor 422 through resistor 423 to ground. This impulse causes the application of positive potential to the starting anode 424 of the tube 425, which is individual to the trunk 401. Since the starting cathode 426 is at negative potential, the gap 424—426 ionizes when the impulse is delivered, and the main discharge gap ionizes resulting in the flow of current in the following circuit: positive pole of battery 619, conductor 621, resistor 427, anode 428, cathode 429, winding of the hold magnet 430 to the negative pole of battery. Current flowing in this circuit alone is not sufficient to energize the magnet 430. However, as soon as the select magnet 416 has been operated as above described, a parallel circuit is traceable from conductor 621 through the closed contacts of magnet 416, common impedance 431 thence through the tube 425 and the magnet 430 to battery. The magnet 430 operates in this circuit and closes the contacts of the switch to complete the connection from the

incoming link 215 to the selected outgoing trunk 401. The flow of current through the common impedance element 431 lowers the potential of the anodes of the remaining tubes of the group 412 to prevent another one from operating in response to the succeeding phase impulses delivered thereto by the impulse generator 615.

At the time the primary select magnet 225 operates as above described a parallel circuit is closed from the battery supply conductor 621 through the closed contacts of magnet 225, common impedance element 229, anode 223, cathode 224 of the tube 204 and winding of the hold magnet 217 to battery. The added current flowing through the parallel circuit just traced causes the energization of the hold magnet 227. Magnet 227 closes the contacts of the switch 200 to complete the connection from the calling line 202 to the selected link 212.

Thus the calling subscriber's line 202 is extended through the switch 200 over the link 215 through the switch 400 to the idle trunk 401. The relay 432 operates in an obvious circuit in series with the loop of the subscriber's line 202 and closes an operating circuit for the sleeve relay 404. Relay 404 operates and applies ground potential to the sleeve conductor 433. The hold magnet 217 of the primary switch is now maintained energized in a circuit traceable from battery through the winding of the magnet contacts of the switch 200, sleeve conductor 215, contacts of switch 400 to the grounded conductor 433. The hold magnet 430 of the secondary switch 400 is maintained energized in a circuit from battery through the windings of said magnet through the grounded conductor 433. The grounded conductor 433 is extended through contacts of the switch 400 thence over conductor 410 to the start anode of the test tube 601, thus identifying the link 215 as busy when the next test is made.

The operation of the sleeve relay 404, indicating that the connection has been completed to the trunk 401, causes the connection of the charged condenser 413 to the starting anode of the release tube 646. The tube 646 discharges and release relay 650 operates in the main discharge circuit thereof. Relay 650 operates the relay 620, which in turn disconnects the main battery supply from the conductor 621. The operated tubes and relays of the common control mechanism are now released to restore this mechanism to the common use of the switch frame. The release of tube 306 and relay 330 reconditions the tubes 305 for subsequent operation and causes the release of the operated select magnets 225, 226 and 416. The release of tube 609 and relay 639 causes the restoration of the tubes 605.

As soon as the horizontal group tubes 305 are released and the common mechanism is restored to the common use of the frame, the calling subscriber's line 301 becomes effective in competition with other lines that may be calling in the meantime to seize a horizontal group of primary switches and to initiate the testing operations above described for extending a call to an idle trunk in one of the groups.

It will be obvious that numerous modifications may be made in the details of the system herein disclosed. It may also be noted that the discharge tubes illustrated may be of any suitable types such as those commonly known as gas-filled cold cathode tubes.

What is claimed is:

1. In combination, primary switches, secondary switches, lines appearing in said primary switches, trunk groups appearing in said secondary switches, groups of links interconnecting the primary and secondary switches, operating magnets for said switches, a magnet operating circuit for each link including in series a primary switch magnet and a secondary switch magnet, electronic devices for said primary switches, means for operating one of said devices to select a group of links for serving one of said lines, electronic devices for said trunk groups, means for operating one of said trunk group devices to select a group of trunks to serve said line, means controlled by the operated electronic devices for applying potential to the magnet circuits of the links of the selected group outgoing from the primary switches and to the magnet circuits of the links incoming to the selected trunk group to effect the energization of the magnets of a single link interconnecting a primary switch in which said line appears and a secondary switch in which the selected trunk group appears, and means controlled by the energization of said magnets for establishing a connection from said line over the selected link to an idle trunk in said group.

2. In combination, primary switches, secondary switches, lines appearing in said primary switches, trunk groups appearing in said secondary switches, groups of links interconnecting the primary and secondary switches, operating magnets for said switches, a magnet operating circuit for each link including in series a primary switch magnet and a secondary switch magnet, a plurality of discharge tubes individual respectively to said link groups, means for applying impulses of different characters to said tubes for selectively operating one of them to determine the link group to serve a calling one of said lines, a plurality of discharge tubes individual respectively to said trunk groups, means for applying impulses of different characters to said latter tubes for selectively operating one which represents a group having an idle trunk and accessible to an idle link in the selected group, means controlled by the operated tubes for applying potential to the magnet circuits of all links of the selected group outgoing from the primary switches and to the magnet circuits of all links incoming from the several primary groups to the secondary switch having access to the selected idle group of trunks to cause the energization of the magnets of a single link interconnecting a primary switch in which said calling line appears and a secondary switch in which the selected trunk group appears, and means controlled by the energization of said magnets for establishing a connection from said line over the selected link to an idle trunk in said group.

3. In combination, primary switches, secondary switches, lines appearing in said primary switches, trunk groups appearing in said secondary switches, groups of links interconnecting the primary and secondary switches, operating magnets for said switches, a magnet operating circuit for each link including in series a primary switch magnet and a secondary switch magnet, a plurality of discharge tubes individual respectively to said link groups, means for applying impulses of different phases to said tubes for selectively operating one of them to determine the link group to serve a calling one of said lines, a plurality of discharge tubes individual respec-

tively to said trunk groups, means for applying impulses of different phases to said trunk group tubes for selectively operating one of said tubes representing a group having an idle trunk and accessible to an idle link in the selected group of links, means controlled by the operated tubes for applying potential to the magnet circuits of the links of the selected group outgoing from the primary switches and to the magnet circuits of the links incoming from the several primary groups to the secondary switch having access to the selected idle group of trunks to cause the energization of the primary and secondary switch magnets of a single link in the selected link group, and means controlled by the energized magnets for establishing a connection from the calling line to an idle trunk in the selected group.

4. In combination, primary switches, secondary switches, lines appearing in said primary switches, trunk groups appearing in said secondary switches, groups of links interconnecting the primary and secondary switches, operating magnets for said switches, a magnet operating conductor for each link extending from a primary switch to a secondary switch, said conductor including in series a primary switch magnet and a secondary switch magnet, a plurality of electronic tubes serving respectively said groups of links, means for operating one of said tubes selectively to choose the corresponding link group to serve one of said lines, a plurality of electronic tubes serving respectively said groups of trunks, means for operating selectively one of said trunk group tubes representing a group having an idle trunk and accessible to an idle link in the selected link group, means controlled by the operated link group tube for connecting at the primary switches battery potential to the magnet operating conductors of all links in the selected link group, means controlled by the operated trunk group tube for connecting at the secondary switches battery potential to the magnet operating conductors of all links incoming from the several link groups to the secondary switch having access to the selected idle trunk group, thereby causing the energization of the primary and secondary switch magnets for a single one of the links in the selected group, and means controlled by the operation of said magnets for extending a connection to an idle one of the trunks in the selected group.

5. In combination, primary switches arranged in groups, secondary switches, each group of primary switches having a plurality of links outgoing therefrom, the links of each primary group appearing in all primary switches of the group and appearing respectively in said secondary switches, each primary and secondary switch having an operating magnet for each link appearing therein, a magnet operating circuit for each link including in series the operating magnet of each primary switch and the operating magnet of the secondary switch, trunk groups accessible respectively to said secondary switches, electronic devices serving respectively said primary switch groups, means for selectively operating one of said primary group devices to select the associated primary switch group for extending a connection, electronic devices serving respectively said trunk groups, means for selectively operating one of said trunk group devices to select a trunk group which has an idle trunk and which is reached through the secondary switch by an idle link in the selected primary group, means responsive to the operated primary group electronic device for applying a potential to the magnet circuits of the links of the selected primary switch group, means responsive to the operated trunk group electronic device for applying potential to the magnet circuits of the links incoming to the corresponding secondary switch from the primary groups for effecting the operation of the primary and secondary switch magnets for the single link extending from the selected primary group to the selected trunk group, and means controlled by the operated magnets for completing a connection to an idle trunk in the selected group.

6. In combination, primary switches arranged in groups, lines appearing in said primary switches, secondary switches, each group of primary switches having a group of links outgoing to all of said secondary switches, trunk groups accessible respectively to said secondary switches, a plurality of line discharge tubes, means for operating said tubes selectively by phase impulses to determine the particular calling line in a group of primary switches to be served, link group tubes individual respectively to said groups of links, means for operating one of said link group tubes selectively to determine the group of primary switches to serve one of its calling lines to the exclusion of other primary switch groups, trunk group tubes individual respectively to said groups of trunks, means for operating one of said trunk group tubes selectively to determine the trunk group to serve the calling line, operating magnets for said primary and secondary switches, a magnet operating circuit for each link including in series the operating magnet of each primary switch in which said link appears and the operating magnet of said secondary switch in which said link appears, means controlled by the operated link group tube for applying potential to the magnet operating circuits of all links of the group selected to serve a calling line, means controlled by the operated trunk group tube for applying potential to the magnet operating circuits of all links incoming to the secondary switch having access to the selected trunk group, thereby energizing an operating magnet for a single link in each of the primary switches in which said link appears and the operating magnet of the secondary switch in which said link appears, and means controlled by one of the operated primary switch magnets and by the operated secondary switch magnet for establishing a connection from the calling line chosen for service over the selected link to an idle trunk in the selected trunk group.

7. In combination, primary switches, secondary switches, lines appearing in said primary switches, trunk groups appearing in said secondary switches, groups of links interconnecting the primary and secondary switches, operating magnets for said switches, a magnet operating circuit for each link including in series a primary switch magnet and a secondary switch magnet, a plurality of discharge tubes individual respectively to said link groups, means for applying impulses of different characters to said tubes for selectively operating one of them to determine the link group to serve a calling one of said lines, a plurality of discharge tubes individual respectively to said trunk groups, means for applying impulses of different characters to said latter tubes for selectively operating one which represents a group having an idle trunk and accessible to an idle link in the selected group means controlled by the operated tubes for ap-

plying potential to the magnet circuits of all links of the selected group outgoing from the primary switches and to the magnet circuits of all links incoming from the several primary groups to the secondary switch having access to the selected idle group of trunks to cause the energization of the magnets of a single link interconnecting a primary switch in which said line appears and a secondary switch in which the selected trunk group appears, means controlled by the energization of said magnets for establishing a connection from said line over the selected link to an idle trunk in said group, release discharge tubes serving respectively said trunk groups, means responsive to the completion of a connection to a trunk in any one of said trunk groups for operating the associated release tube, and means controlled by the operated release tube for restoring the previously operated link group and trunk group tubes to their normal condition.

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