

Sept. 11, 1945.

R. E. HERSEY

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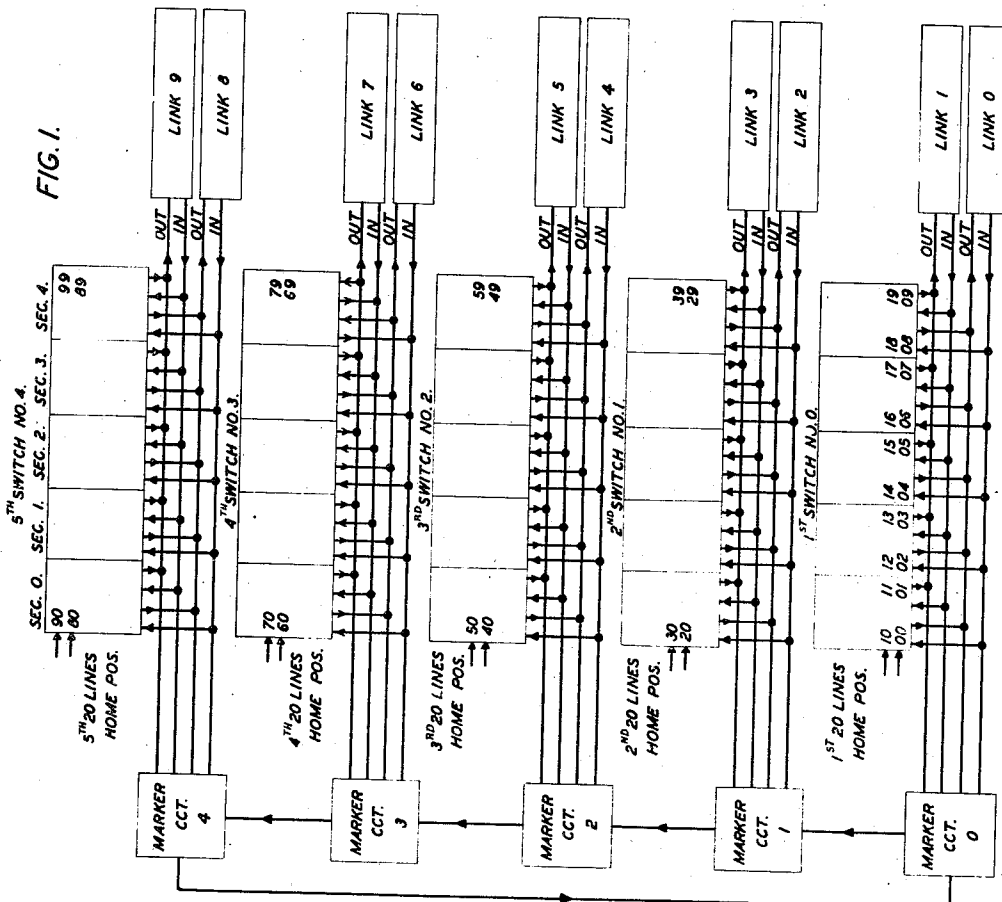
TELEPHONE SYSTEM

Filed Nov. 9, 1944

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FIG. 10.

FIG. 2.	FIG. 6.
FIG. 3.	FIG. 7.
FIG. 4.	FIG. 8.
FIG. 5.	FIG. 9.



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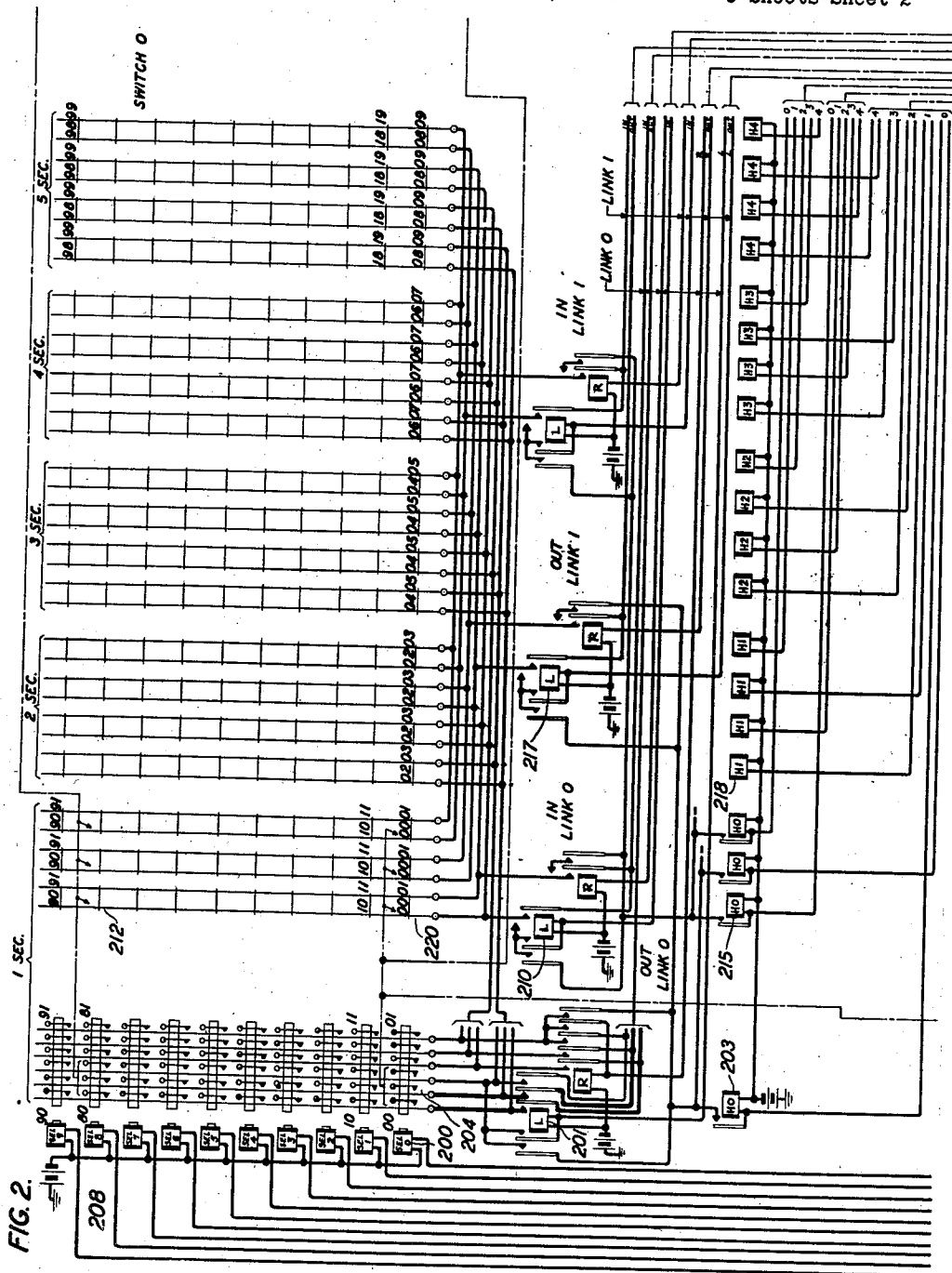
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TELEPHONE SYSTEM

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9 Sheets-Sheet 2



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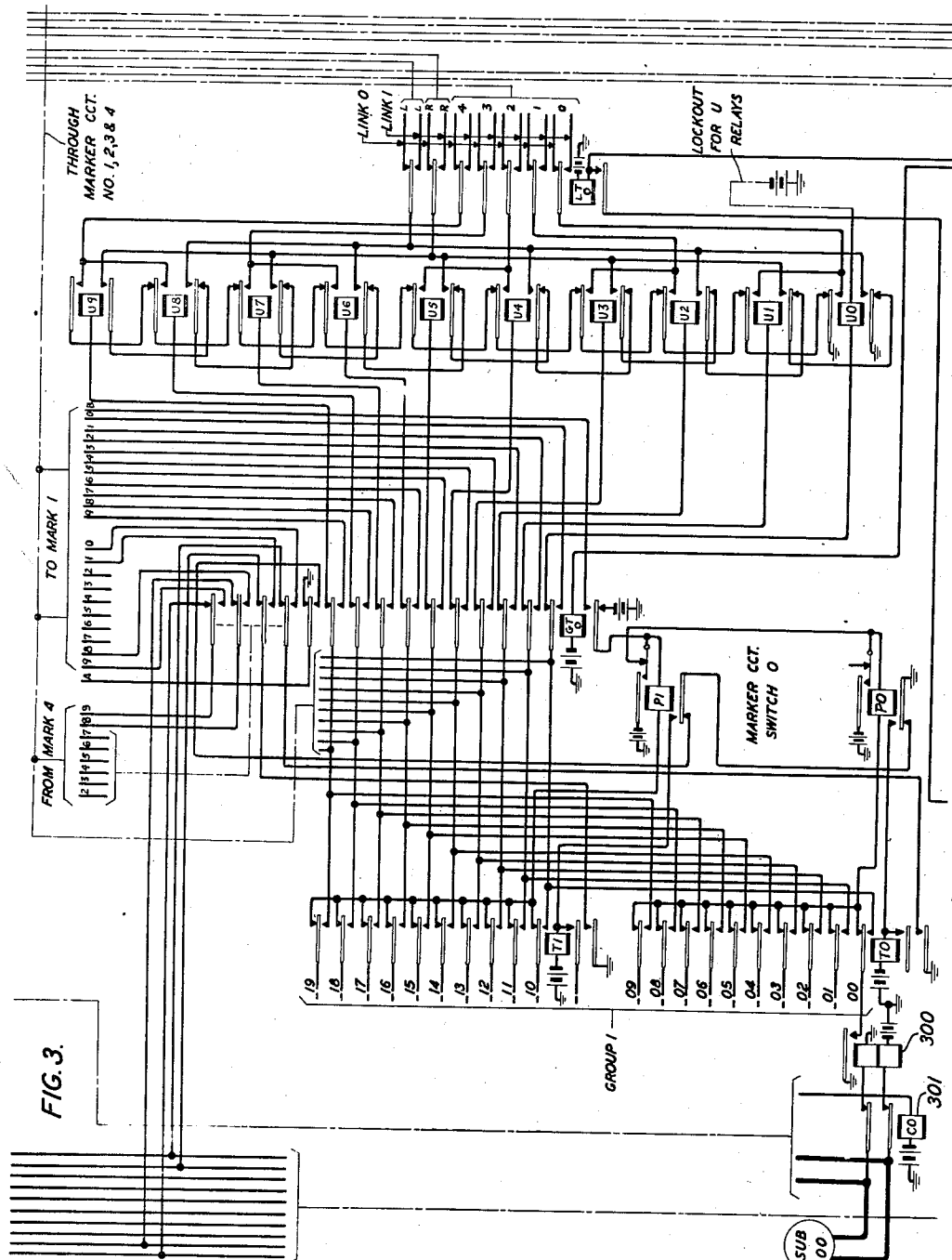
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TELEPHONE SYSTEM

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9 Sheets-Sheet 3



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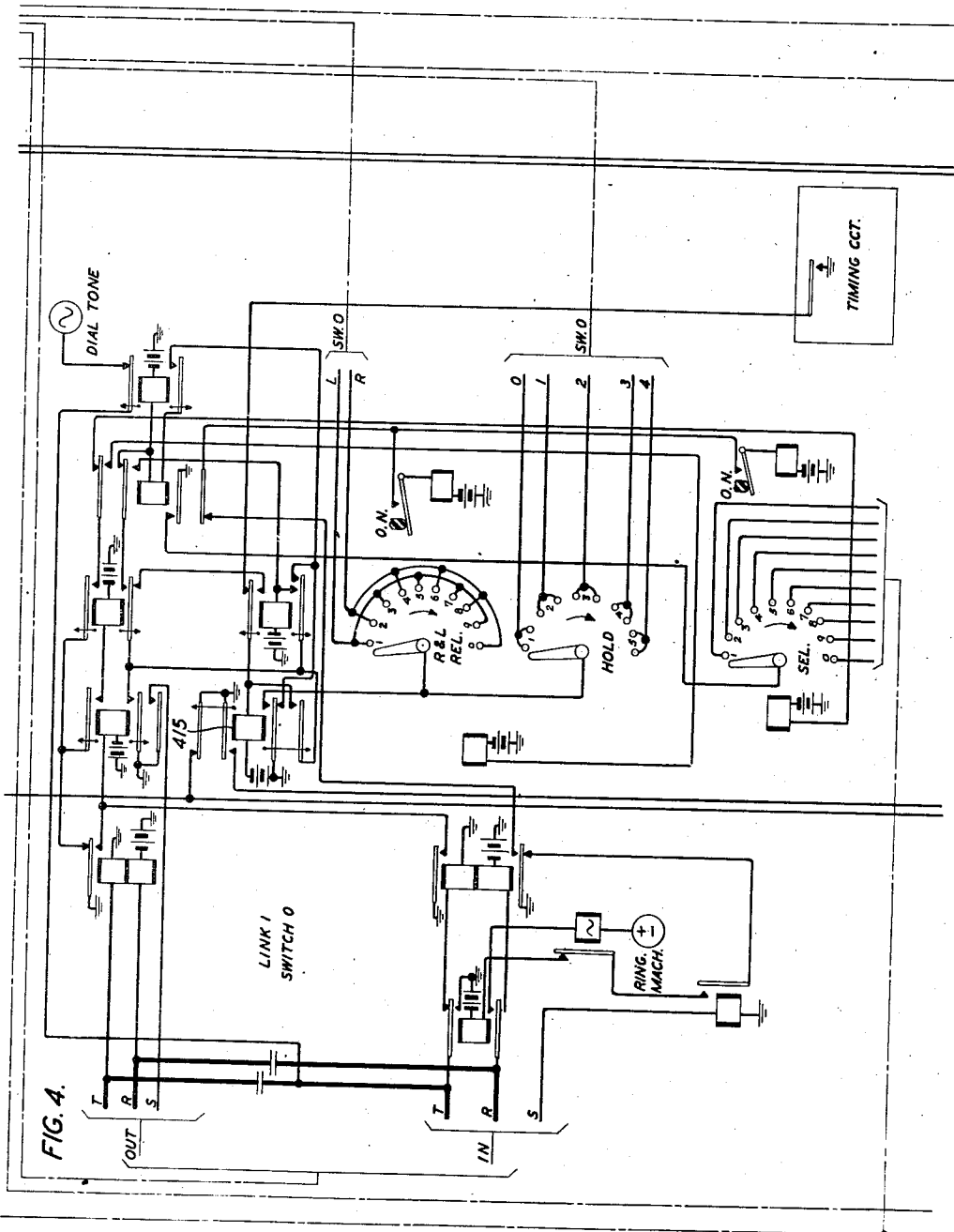
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TELEPHONE SYSTEM

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9 Sheets-Sheet 4



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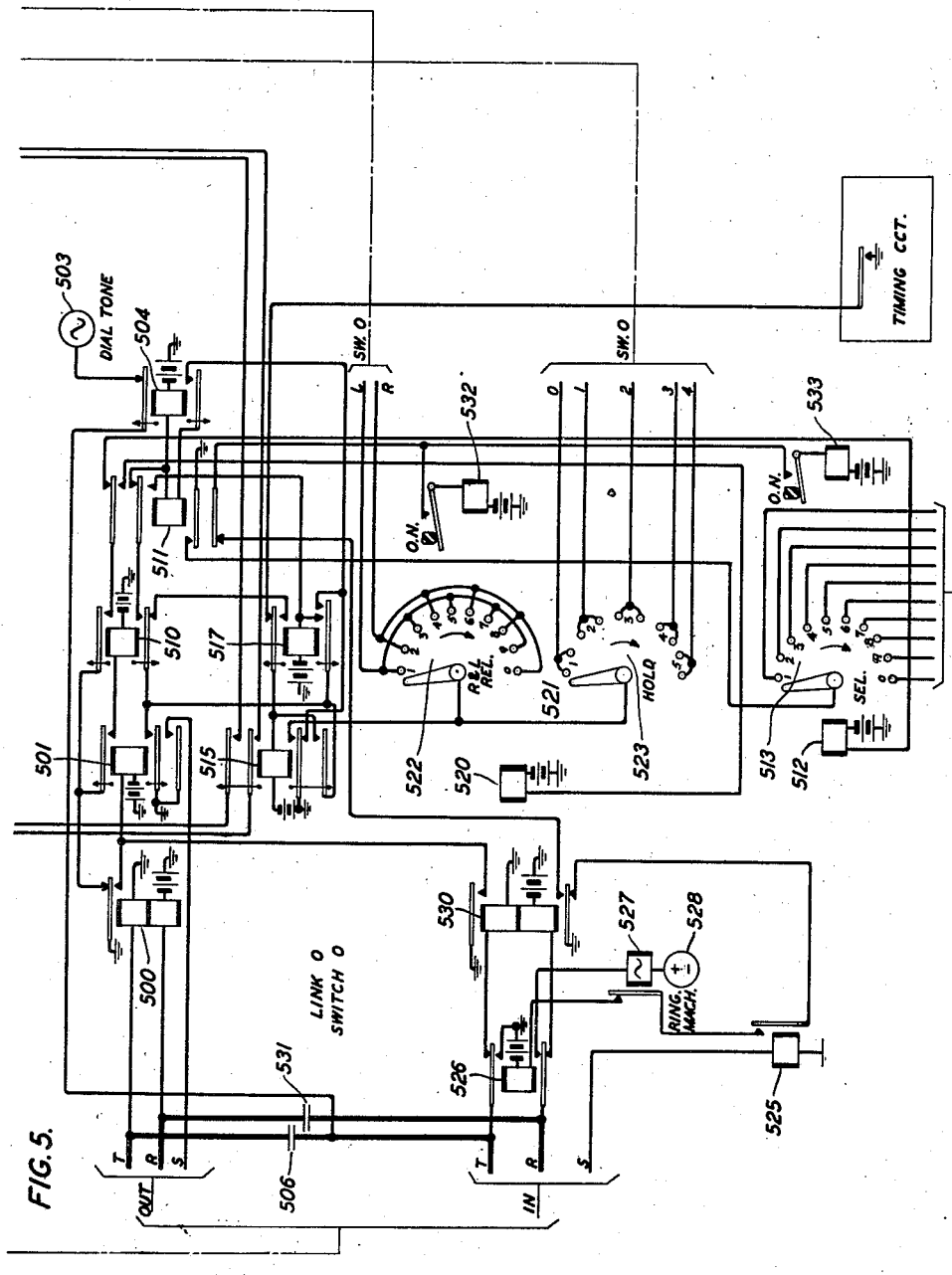


FIG. 5.

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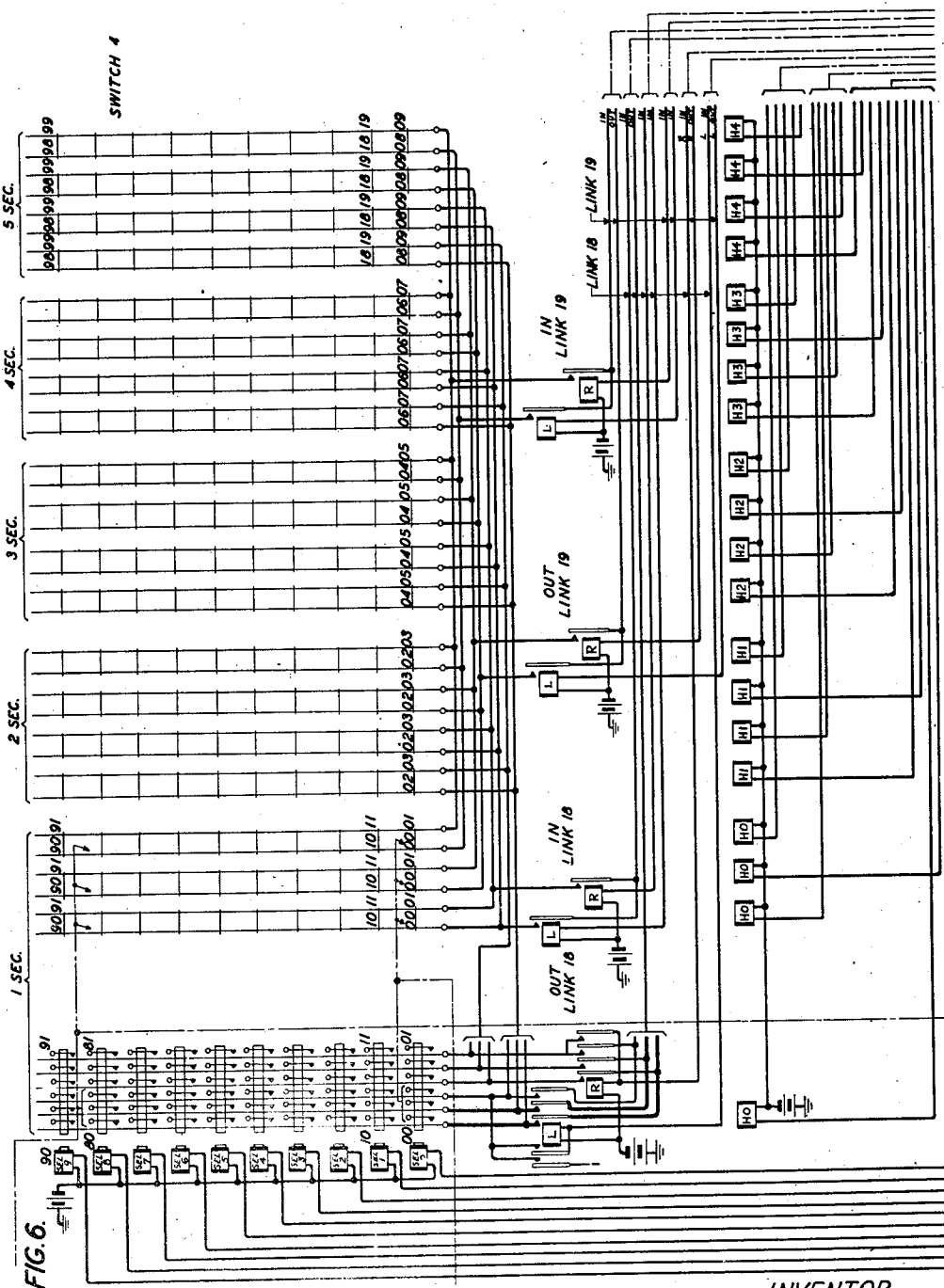
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TELEPHONE SYSTEM

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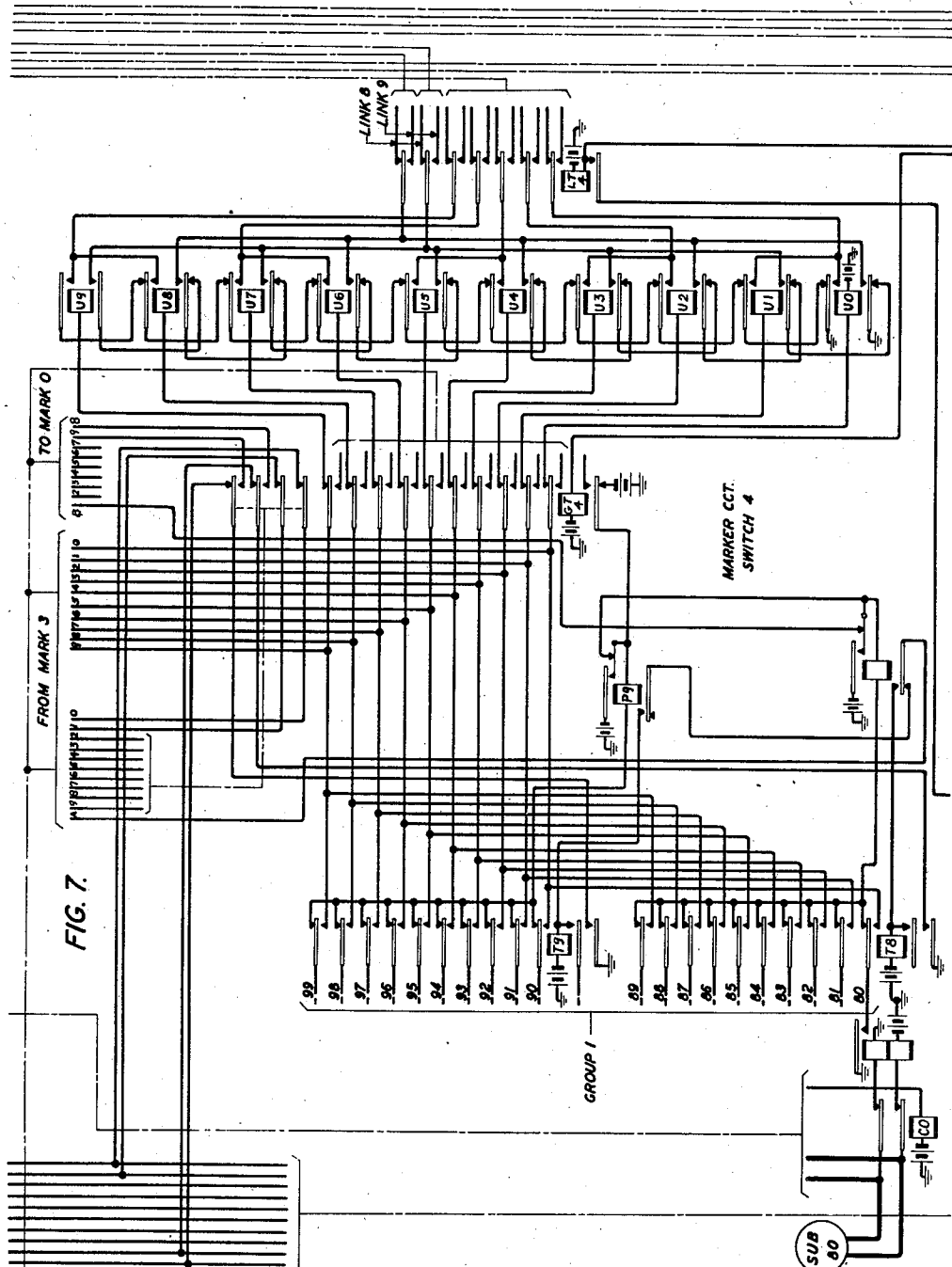
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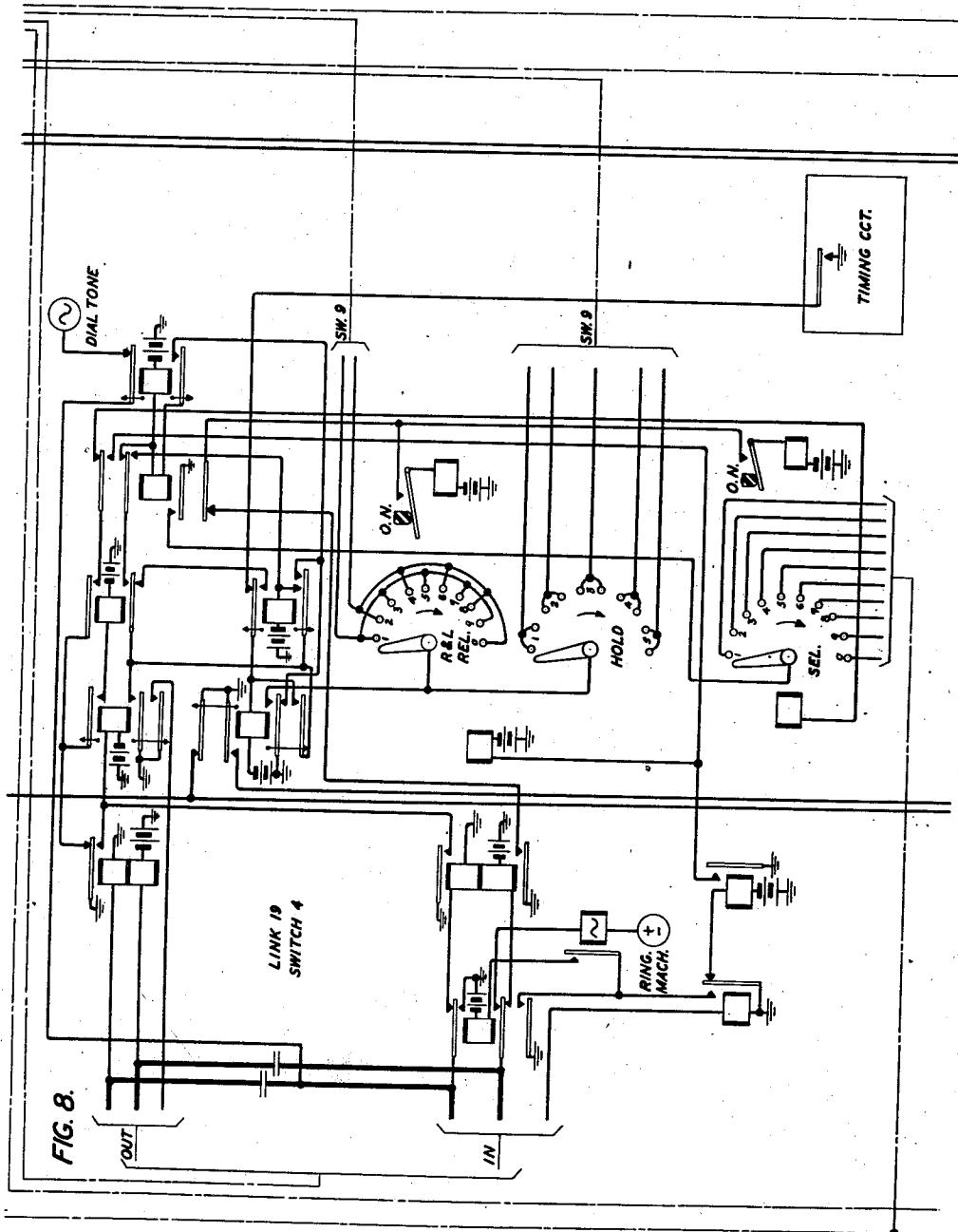


FIG. 8.

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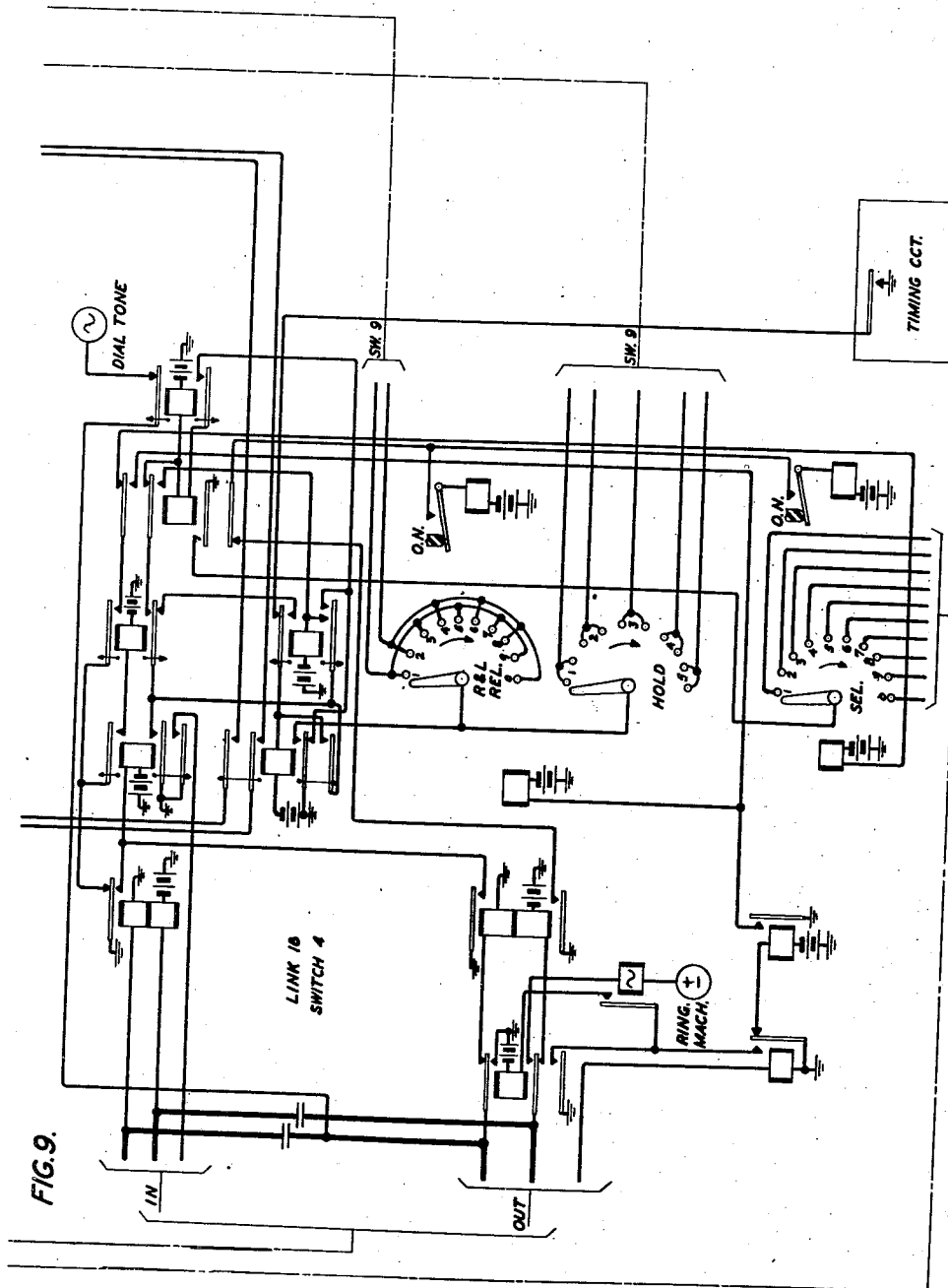
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9 Sheets-Sheet 9



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UNITED STATES PATENT OFFICE

2,384,620

TELEPHONE SYSTEM

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Application November 9, 1944, Serial No. 562,599

5 Claims. (Cl. 179-22)

This invention relates to telephone systems and particularly to systems in which cross bar switches are employed to automatically extend connections between subscribers' lines.

An object is to simplify and improve the operating characteristics of systems of this kind and to increase the number of simultaneous subscribers' connections that may be maintained through such switches without materially increasing the common control circuit equipment for the establishing of such connections.

Heretofore cross bar switches have been used in small capacity systems for establishing connections between subscribers over interconnecting links. In such prior systems the subscribers' lines were multiplied to a number of switches or sections of switches provided with its own links and in which an idle link in any switch was used to connect a calling subscriber's line with a called subscriber's line in the switch in which the link used appears. In some systems connections between subscribers' lines over interconnecting links were controlled by the aid of control relay groups or marker circuits and minor step-by-step switches which selected and operated the usual individual select and hold magnets of the cross bar switches.

The present invention relates to small capacity systems of these general types and an inventive feature thereof relates to the grouping of the subscribers' lines in the switches and the arrangement of the links and the control marker circuits and minor switches. If these features are applied in one hundred line capacity systems the arrangement would consist of five cross bar switches with all subscribers' lines multiplied to all five switches and with two so-called "home" links individual to each switch, each link including minor switches for the selection of the called line in the corresponding switch. The lines would be divided into five groups or sections in each switch and an individual marked circuit provided for each section but with each marker circuit more or less associated with a particular pair of home links and the corresponding switch. With this arrangement when a subscriber in such a group calls the associated marker circuit controls the associated cross bar switch to establish a connection between this calling line and the outgoing branch of a first idle one of said home links, then when the calling subscriber dials a desired subscriber's number the minor switches associated with this link operate to actuate this associated switch to connect the incoming branch

of said link to the called subscriber's line in whatever group it may be found.

Another feature of this invention is an additional circuit arrangement in the marker circuit whereby when the two home links are busy and the subscriber in the associated section calls, switching operations take place to employ part of this associated marker circuit and part of the marker circuit of the succeeding switch to establish a connection between the calling line and the associated outgoing branch of the first idle one of the home link in said latter switch; that is, the connections will be established through a first idle home link in a first succeeding switch in which an idle link may be found.

Referring to the drawings, Fig. 1 shows the general plan of five switches and five pairs of home links in a one hundred line system embodying the applicant's invention;

Figs. 2 to 9 arranged in accordance with Fig. 10 show this system in sufficient detail for the establishing of a connection between a calling subscriber's line and a called subscriber's line by the aid of the associated marker circuits and home links.

If reference is not made particularly to Fig. 1 and partly to Figs. 2 and 6, it should be noted that the five switches are numbered switch 0 to switch 4, respectively, and that the switches are each divided into five sections. The subscribers are grouped to appear and be multiplied in the same manner in all of the switches and in the five sections as follows: In the first horizontal level subscribers 00 and 01 appear each at four vertical positions in the first section No. 0 and subscribers 02 and 03 appear at four vertical positions in the second section No. 1, etc., until the subscribers' numbers 08 and 09 appear in the section No. 4. Similarly, subscribers' Nos. 10 to 19 appear in the same manner in the second horizontal level, while similarly succeeding subscribers' groups of ten appear in the succeeding eight horizontal levels making a total of 100 subscribers' lines appearing each four times in the same positions in all five switches. With reference to the home links, two links appear for connection to all the verticals in each switch, for example, links 0 and 1 appear as the home links in switch 0 in all five sections and as the lines in each section appear four times and each link has an outgoing branch and an incoming branch in each section four sets of left and right relays are provided for the connection of each line to either link to either the outgoing or the incoming branch. If, for example, the available con-

nections for the subscribers over the four verticals in section 0 to the links 0 and 1 are considered, the first vertical is connectable through the first left or right relay to the outgoing branch of link 0; the second vertical through the second left or right relay to the incoming branch of link 0; the third vertical through the third left or right relay to the outgoing branch of link 1 and the fourth vertical through the fourth left or right relay to the incoming branch of link 1. Similarly the other four groups of four verticals each in the other four sections 1 to 4 of switch 0 are connectable through the same four groups or left or right relay to links 0 and 1 in the same manner. The arrangement is such that these two home links 0 and 1 are home links for lines 00 to 19 in this switch No. 0 and similarly the succeeding four pair of links are home links respectively, for the succeeding four groups of twenty lines each in the remaining four switches. This is clearly indicated in Figs. 2 and 6 in particular. The hold magnets in each switch are arranged so that each hold magnet controls the connection for two lines at each cross-point, that is, one hold magnet for each vertical, but the associated left or right relay will extend a connection to a link for the corresponding left or right subscribers' lines. Thus each switch is provided with twenty hold magnets while there will, of course, be only ten select magnets for selecting the ten horizontal levels in each switch.

In general, to establish a connection from a calling subscriber's line to a called subscriber's line when the calling subscriber lifts his receiver, the associated marker circuit is controlled to operate the select magnet for the level in which the calling subscriber's line is located in the switch where the associated home link is located and also the associated left or right relay and the hold magnet in the section where the calling line is located in said switch for connecting the calling subscriber's line to the outgoing branch of the first idle link of the two home links. The subscriber then, after receiving his dial tone, dials the chosen subscriber's number and the minor switches in the chosen link operate the select magnet representing the level in which the called subscriber's line is located as well as the associated left or right relay and the associated hold magnet in the section in this switch where the called line is located to connect the called line to the incoming branch of the chosen link. The called subscriber is then rung from the chosen link and when the called subscriber answers the connection is completed between the subscribers through this link. If the home links are busy certain special relays are operated to connect the calling subscriber by the aid of the associated marker circuit to the next switch in which an idle link is available and the called subscriber is then connected by the minor switches in the chosen link and by the aid of the marker circuit associated with the chosen link due to the operation of said special relays.

With this preliminary description of the arrangement of the subscribers' lines, switches and marker circuits, the establishing of a connection will now be traced in detail from a calling subscriber No. 00 to a calling subscriber No. 80 by the aid of the arrangement shown in Figs. 2 to 9. Fig. 2 shows the switch No. 0, Fig. 3 the associated marker circuit, and Figs. 4 and 5 the home links 1 and 0, respectively, for lines 00 to 19 in this switch, while Figs. 6 to 9 show the

switch No. 4 with the associated marker circuit and home links.

If then the subscriber No. 00 lifts his receiver his line relay 300 will operate from battery and ground through the winding of this relay over the calling subscriber's loop and contacts of the associated cut-off relay 301. Relay 300 closes the circuit for the relay P0 from battery, contacts of the GT0 and P1 relays, winding of this P0 relay, contacts of relay T0 to ground at contacts of relay 300. Relay P0 closes an obvious circuit for the operation of relay T0. It should be noted that in this marker circuit for switch No. 0 there would be two relays of the type T and two of the type P, that is, T0 and T1 and P0 and P1, or a total of ten of these two types of relays for the five marker circuits. It should be noted that ten subscribers' lines have access to each of these two types of relays. The operation of the T0 relay marks the level in which the calling subscriber's line is located, that is, the first or lower levels in these switches while T1 marks the second level. It should now be noted that on the operation of this relay T0, therefore, the select magnet 200 will be operated from battery, winding of this magnet, contacts of the GT0 relay associated with this marker, contacts of relays T0 and 300 to ground. This select magnet, therefore, marks the level in which the calling line is located in switch 0 provided the two home links for switch 0 are idle as indicated by the released condition of the GT0 relay. It should also be noted that one of the ten U relays in this marker is now operated which in this case will indicate that the calling subscriber's line is located in the first section of switch 0. In this case, therefore, U0 will operate from battery, winding of this relay, contacts of relays GT0, T0 and 300 to ground. There is also one relay LT0 in this marker circuit which is normally released if the home link No. 0 is idle so that now on the operation of relay U0 the left relay 201 for this first section of switch 0 will operate from battery, winding of relay 201, contacts of relays LT0 and U0 to ground, indicating that the calling subscriber is located in the first vertical of the first section of switch 0. The hold magnet for this first section will also operate from battery through the winding of hold magnet 203, contacts of relays LT0 and U0 to ground. The operation of the left relay 201 and the hold magnet 203 after the operation of select magnet 200 now, therefore, establishes a connection at the cross-point 204 between the calling subscriber's line 00 and the outgoing branch of link 0 to the tip and ring leads through the windings of relay 500 to battery and ground. The sleeve lead is also connected as noted to contacts of relay 501 in link 0. As the result of this connection relay 500 operates. Relay 500 in turn closes an obvious circuit for the operation of relay 501. This relay in operating closes a circuit for the operation of cut-off relay 301 of the subscriber 00 over the sleeve lead. Cut-off relay 301 releases relay 300, relays P0, T0 and U0 in the marker circuit. This causes the release of the select magnet 200 in the switch No. 0, while the hold magnet and the left relay 201 are maintained operated over their own armatures and front contacts and the sleeve connection to ground at relay 501. Dial tone is now transmitted from the dial tone source 503 over contact of relay 504, condenser 506 and the tip lead to the calling subscriber No. 00 indicating that the circuits are ready for dialing.

If now the subscriber No. 00 desires to establish a connection to subscriber No. 80, he will dial the first digit 8. The first impulse of this digit will release relay 500 in the link 0. This causes the operation of relay 510 from battery, winding of this relay, contacts of relays 501 and 500 to ground. Relay 510 operates relay 504 from battery, winding of this relay, contacts of relays 511, 510 and 501 to ground. Relay 504 in operating removes the dial tone from the subscriber's line. Relay 510 also closes a circuit for the operation of the stepping magnet 512 for the minor switch 513 to make this switch take one step. At the end of this first impulse relay 500 releases and the stepping magnet 512 also releases. Relays 504 and 510 remain operated due to their slow to release characteristic during the pulsing. On each succeeding impulse from the calling subscriber's line on the release of relay 500 the stepping magnet 512 takes an additional step until eight steps have been taken when relay 500 finally remains operated. This causes the release of relay 510 which now causes the operation of relay 511 due to the removal of ground at the armature and back contact of relay 500. This circuit for relay 511 may be traced from battery, windings of relays 504 and 511, contacts of relays 504 and 515 to ground. The select magnet 208 in switch 0 is now operated from battery, winding of this magnet, the eighth contact and the brush of switch 513 to ground at contacts of relay 511. This indicates that the called subscriber's line is located in the eighth horizontal level. If now the calling subscriber dials the second digit 1, that is to say, one impulse only, the release of relay 500 in response to this digit causes the reoperation of relay 510 which causes the operation of relay 517 from battery, winding of this relay, contacts of relays 511, 510 and 501 to ground. Relay 517 in operating closes a locking circuit for relays 504 and 511 at its lower armature and front contact to ground and contacts of relay 501. The stepping magnet 520 for the switch 521 is now also operated from battery, winding of this magnet, contacts of relays 511, 510 and 500 to ground. The operation of this magnet causes the brushes of switch 521 to take one step. At the end of this impulse when relay 500 again operates the circuit for the stepping magnet 520 is opened at the contacts of relay 500 and releases. As no other succeeding impulses are received, relay 510 releases and causes the operation of relay 515 from battery, winding of this relay, contacts of relays 517, 510 and 501 to ground. Relay 515 in operating closes a locking circuit for itself through contacts of relay 501. As the result of the switch 521 taking one step, the left relay 210 in the first section of the switch 0 operates from battery, winding of this relay, the first contacts of the switch bank 522 over the brush thereof to ground at contacts of relay 515. This determines that the called line is located at the cross-point 212 in the first section of switch 0 for the vertical leading to the link 0. The hold magnet for this section for establishing a connection at point 212 is now operated from battery, winding of this hold magnet 215, the first contact of bank 523 and the brush thereof to ground at relay 515. This establishes the connection at cross-point 212 between the called subscriber 80 over the associated verticals and through contacts of the left relay 210 to the incoming branch of link 0 and the sleeve connection to ground through relay 525 through the cross-point 212, locks the hold magnet 215 and the left relay 210, the same as the

hold magnet 203 and left relay 201 were locked over the sleeve to the outgoing end of the link 0, and causes the operation of this relay 525. Relay 525, in operating, closes a circuit for the operation of the relay 526 from battery, winding of this relay, contacts of the ringing relays 527 and 525 to ground at relay 530. Relay 526 now applies intermittent ringing current from the source 528 through the ringing relay 527. This ringing source does not operate relay 527 until the called subscriber removes his receiver. The operation of relay 527 releases relay 526 and causes the operation of the line relay 530. Relay 530 closes an obvious holding circuit for relay 501 and the calling and called subscribers' lines are now connected through condensers 506 and 531 in the zero link of switch 0.

When the calling and called subscriber release the connection, relays 500 and 530 are released. This causes the release of relay 510 which causes the release of relays 504, 511, 517, 515 and the release of relay 511 closes the circuit for the release magnets 532 and 533 of the switches 524 and 513 to cause them to return to normal and the left relays 201 and 210 and the hold magnets 203 and 215 are released causing the release of the connection through link 0 for the subscribers as well as the relay 525 and the circuits are now in condition for the establishing of other calls.

If link 0 had been busy when the subscriber 00 called, it should be noted that the relay 515 in link 0 would have been operated. The circuit for relay LT0 would then extend from battery through the winding of this relay, contacts of relay 515 and the corresponding relay 415 in link No. 1 to ground. Relay LT0 then locks to this ground at relay 516 through its lower armature and front contact. Relay LT0 transfers the leads in the marker circuit to make a selection to connect the calling subscriber to link No. 1 and the selection of this link proceeds as in the selection of link 0 except that in this case the left relay 217 and the hold magnets 218 are operated to establish the connection to link No. 1 from the calling subscriber at the cross-point 220.

Should both home links for switch 0 be busy, the GT0 relay in the marker circuit for switch 0 would operate from battery, winding of this relay, contacts of relays 515 and 415 to ground. The relay GT0 in operating transfers leads from the T0 and T1 relays through contacts of this relay GT0 to corresponding U relays of the marker for the second switch and, if the links for this second switch are idle, the second switch would be actuated to establish the connection from the calling subscriber through this switch to the first idle home link associated with this switch in the same manner as the connection was establishing through switch No. 0. That is to say the marker circuit for switch 0 will employ the P0, T0 and GT0 relays but the U relays in the marker for switch No. 1 will be employed for this connection. Should the home links in the second switch No. 1 also be busy, the corresponding GT1 relay for the marker for switch No. 1 will be operated and the home links for the third switch No. 2 would be available for establishing the connections through switch No. 2. These GT relays will operate as soon as the home links are all busy and transfer to the home links of succeeding switches. Thus normally a first section of a switch 0 would employ the home links Nos. 0 and 1 for establishing connections to the calling and the called subscribers and similarly the succeeding switches would employ their home links, but if the home

links in any switches are busy when the corresponding subscribers in the corresponding switch call, the first idle home link of a succeeding switch would be employed for establishing the connection.

What is claimed is:

1. In a telephone system, a plurality of cross bar switches, links individual to each switch, each link having an outgoing and an incoming branch, groups of subscribers' lines multiplied to all the switches, a marker circuit for each switch, each marker circuit arranged to serve an individual group of lines when calling and being responsive to a call from any one of said lines for actuating the associated switch to connect the calling line with the outgoing branch of an idle link individual to said switch and thereafter releasing for service with other lines when calling, means responsive to dial pulses received from said calling line for actuating said switch to connect any called line in any group to the incoming branch of said link, means thereafter responsive in said link for ringing the called line and for disconnecting the ringing when the called subscriber answers.

2. In a telephone system, a plurality of cross bar switches, links individual to each switch, each link having an outgoing and an incoming branch, groups of subscribers' lines multiplied to all the switches, a marker circuit for each switch, each marker circuit arranged to normally serve a particular group of lines when calling and being responsive to a call from any one of said lines for actuating the associated switch to connect the outgoing branch of an idle associated link to said calling line, means operative if all the links of a switch are busy and a call originates from the group of lines normally served by the associated marker circuit for changing the functions of this marker circuit and the marker circuit of an adjacent switch so that said adjacent switch is actuated to connect the outgoing branch of an idle link individual to said adjacent switch to said calling line, and means responsive to dial pulses received from the calling line for actuating this latter switch to connect any called line to the incoming branch of said last-mentioned link.

3. In a telephone system, a plurality of cross bar switches, links individual to each switch, each link having an outgoing and an incoming branch, groups of subscribers' lines multiplied to all the switches, a marker circuit for each switch, each marker circuit arranged to normally serve an individual group of lines when calling and being responsive to calls from any one of said lines for actuating the associated switch to connect the calling line to the outgoing branch of an idle link individual to said switch, means operated if all links of a switch are busy and a call originates from the group of lines normally served by the associated marker circuit for utilizing a part only of this marker circuit and a part of the marker circuit of an adjacent switch to actuate said adjacent switch and connect the calling line to the

outgoing branch of an idle link individual to said adjacent switch, means operative when the calling line is connected to said link for releasing said parts of the two marker circuits to normal condition, and means responsive to dial pulses received from the calling line for actuating this latter switch to connect any called line to the incoming branch of said link.

4. In a telephone system, a plurality of cross bar switches, two links individual to each switch, each link having an outgoing branch and an incoming branch, groups of subscribers' lines multiplied to appear in all switches, each line appearing in each switch at four cross-points, one point serving to connect the line with the outgoing branch of one link, a second point serving to connect the line with the outgoing branch of the second link, a third point serving to connect the line with the incoming branch of the first link and for the fourth point serving to connect the line with the incoming branch of the second link, a marker circuit for each switch, each marker circuit arranged to serve an individual group of lines when calling and responsive to a call from any one of said lines for actuating the associated switch to connect the calling line with the outgoing branch of a first idle link individual to said group and at the corresponding cross-point in said switch, means responsive to dial pulses incoming over said calling line over the connected outgoing branch of said link for actuating said switch to connect any called line from any group to the incoming branch of said link at the corresponding cross-point.

5. In a telephone system, a plurality of cross bar switches arranged in a certain order, links individual to each switch, each link having an outgoing and an incoming branch, groups of subscribers' lines multiplied to all the switches, a marker circuit for each switch, each marker circuit arranged to normally serve an individual group of lines when calling and being responsive to calls from any one of said lines for actuating the associated switch to connect the calling line to the outgoing branch of an idle link individual to said switch, means operative if all links of a switch are busy and a call originates from the group of lines normally served by the associated marker circuit for utilizing a part only of this marker circuit and a part of the marker circuit of another switch to connect the calling line to the outgoing branch of an idle individual link in said other switch, this connection being established through the next succeeding of the remaining switches arranged in said order in which an idle link is available, means operative when the calling line is connected to said idle link for releasing said parts of the two marker circuits used to normal condition and means responsive to dial pulses received from the calling line for actuating the switch used to connect any called line to the incoming branch of said idle link.

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