June 25, 1946. S. B. WILLIAMS 2,402,700

TELEPHONE SYSTEM

Filed May 22, 1940 7 Sheets-Sheet 1

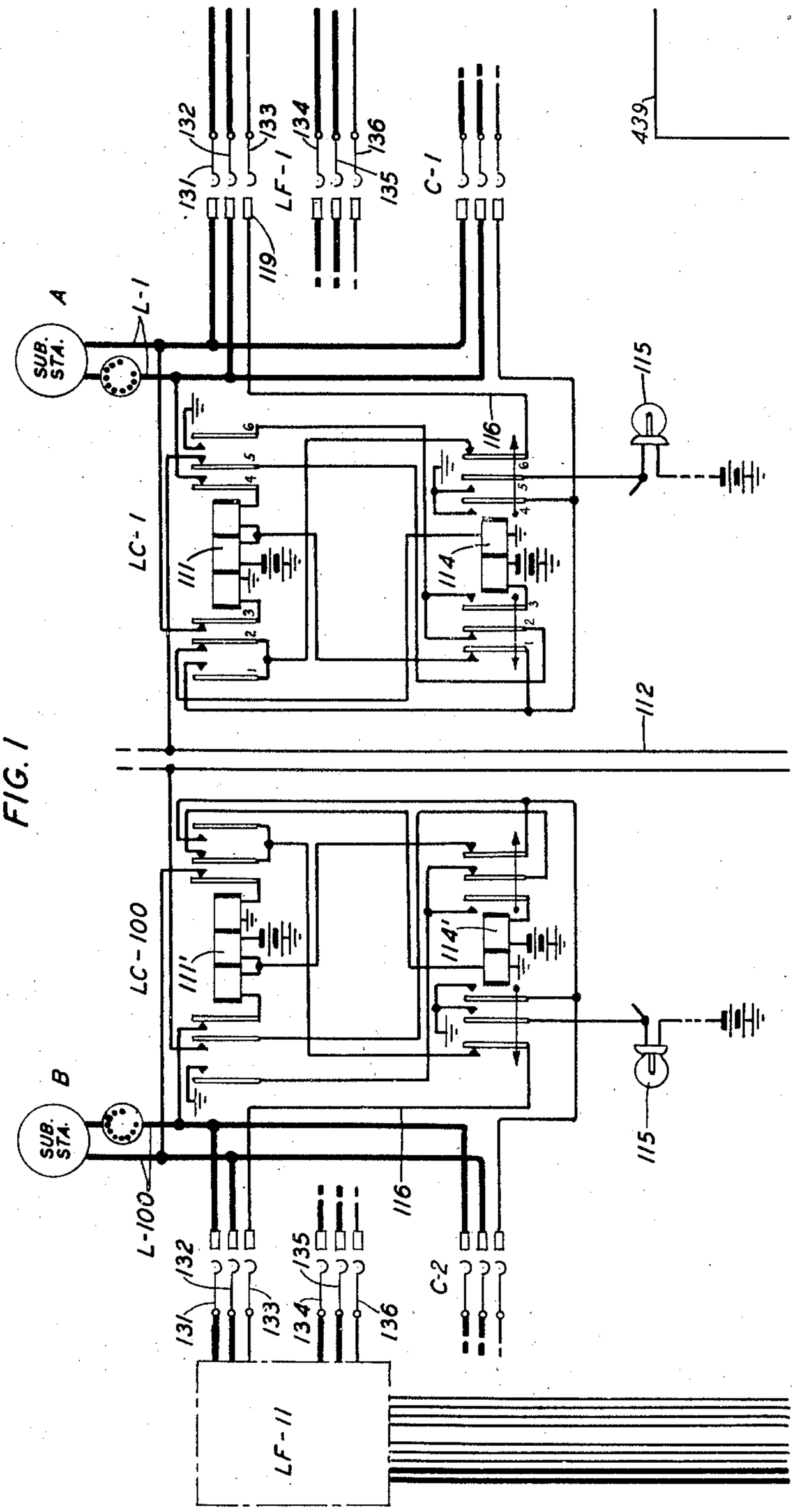

FIG. 1

FIG. 8

FIG. 1	FIG. 3	FIG. 5
FIG. 2	FIG. 4	FIG. 6
		FIG. 7

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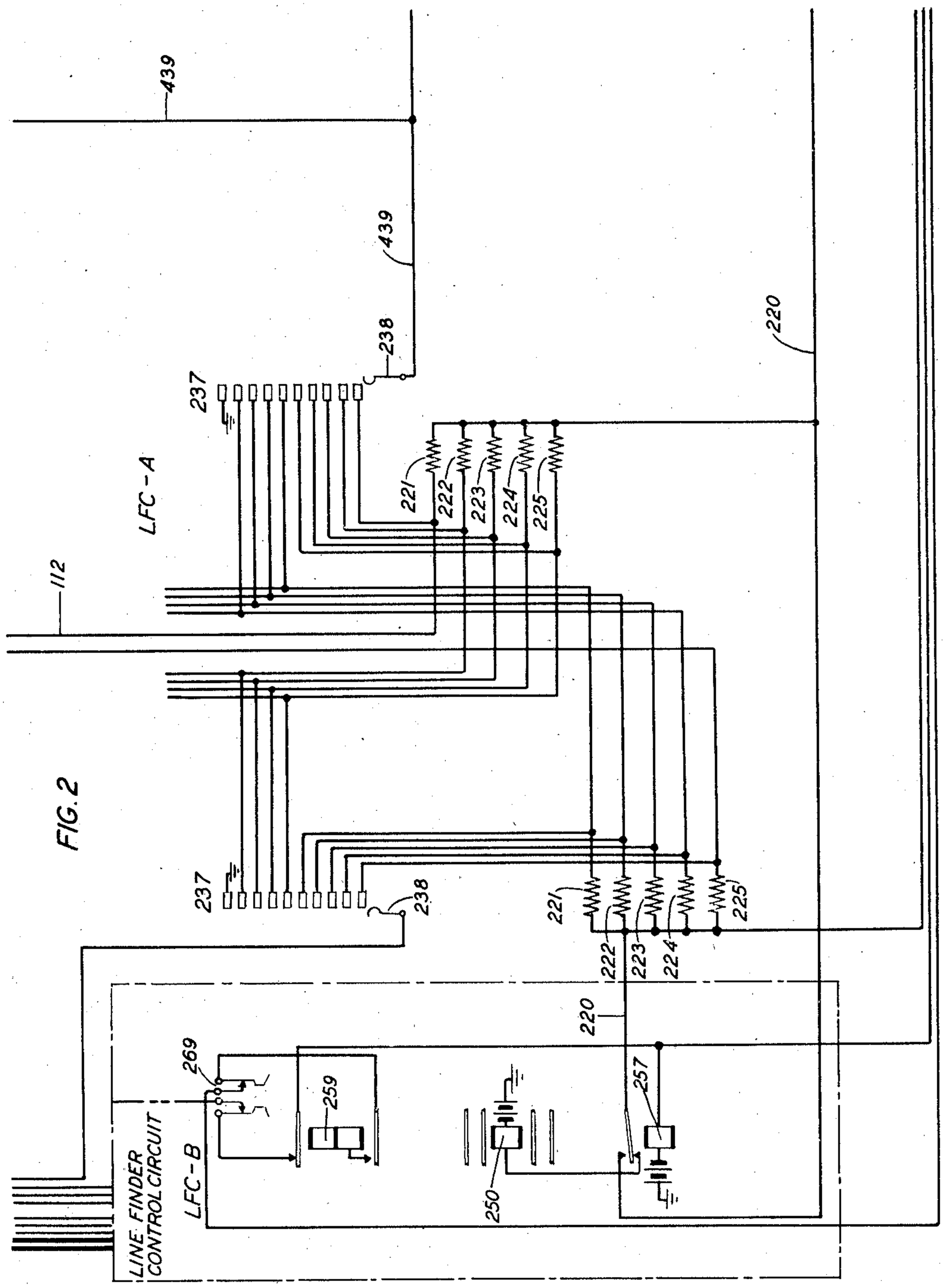

FIG. 2

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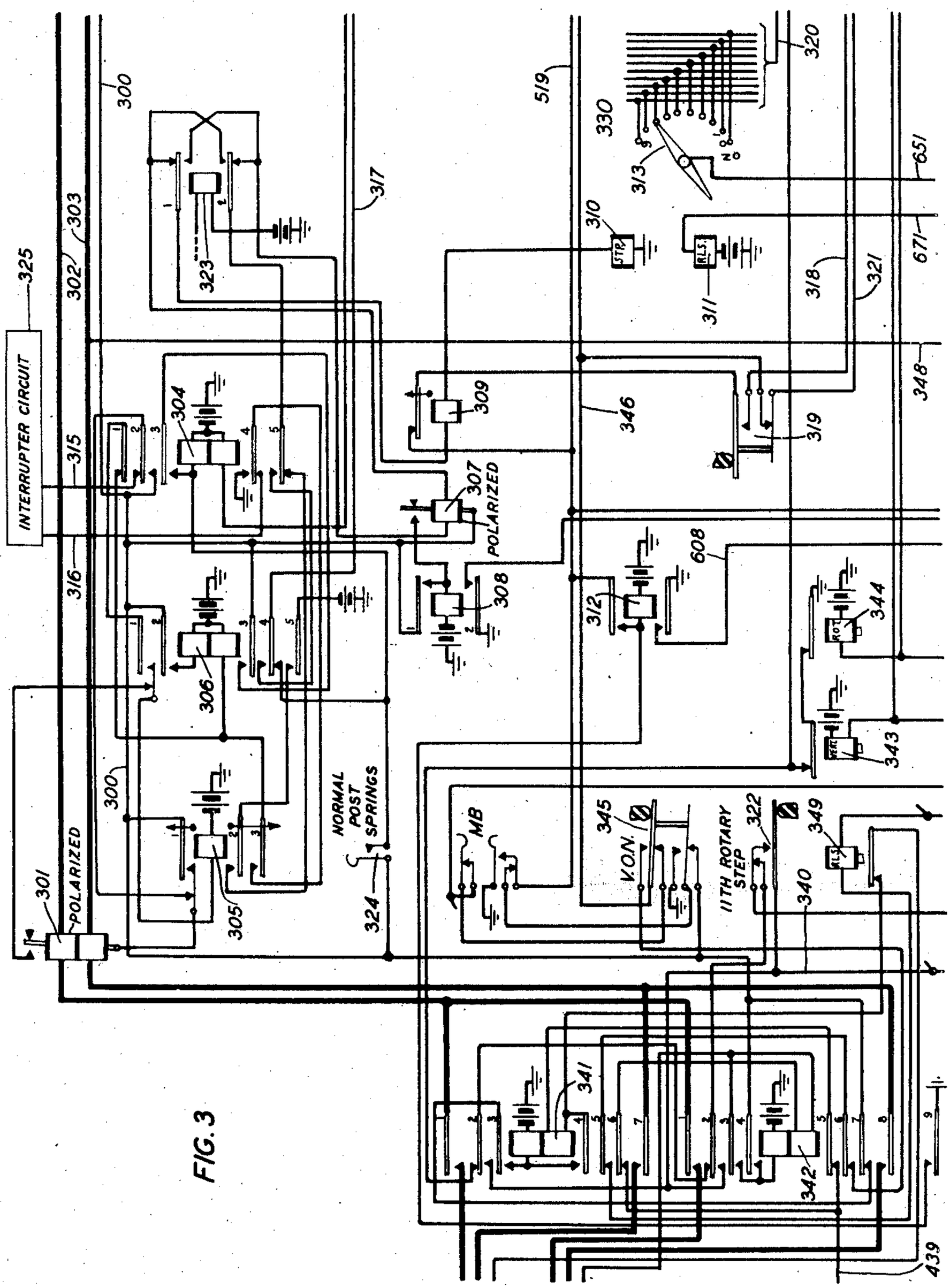

FIG. 3

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TELEPHONE SYSTEM

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FIG. 4

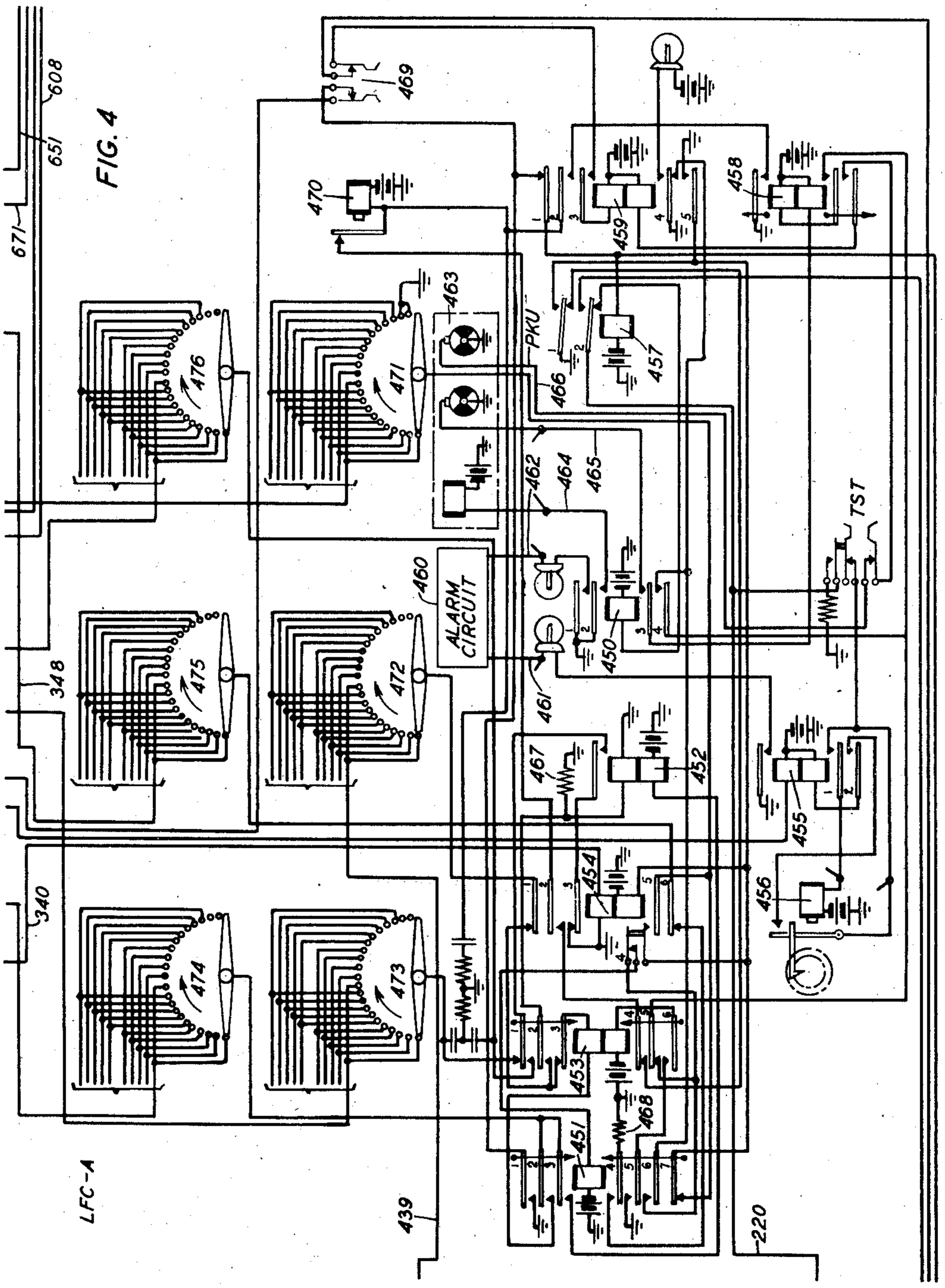

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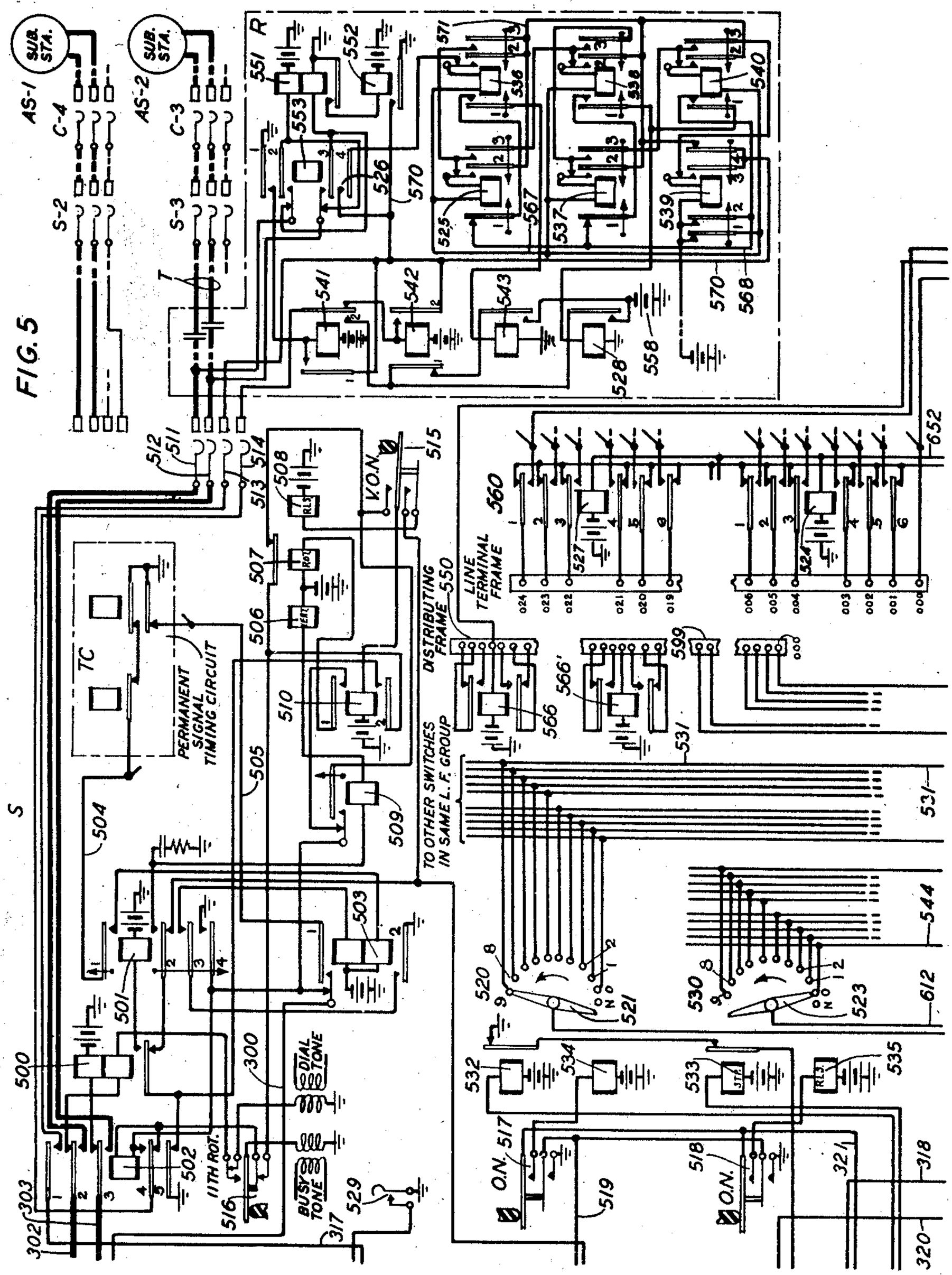
FIG. 5



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TELEPHONE SYSTEM

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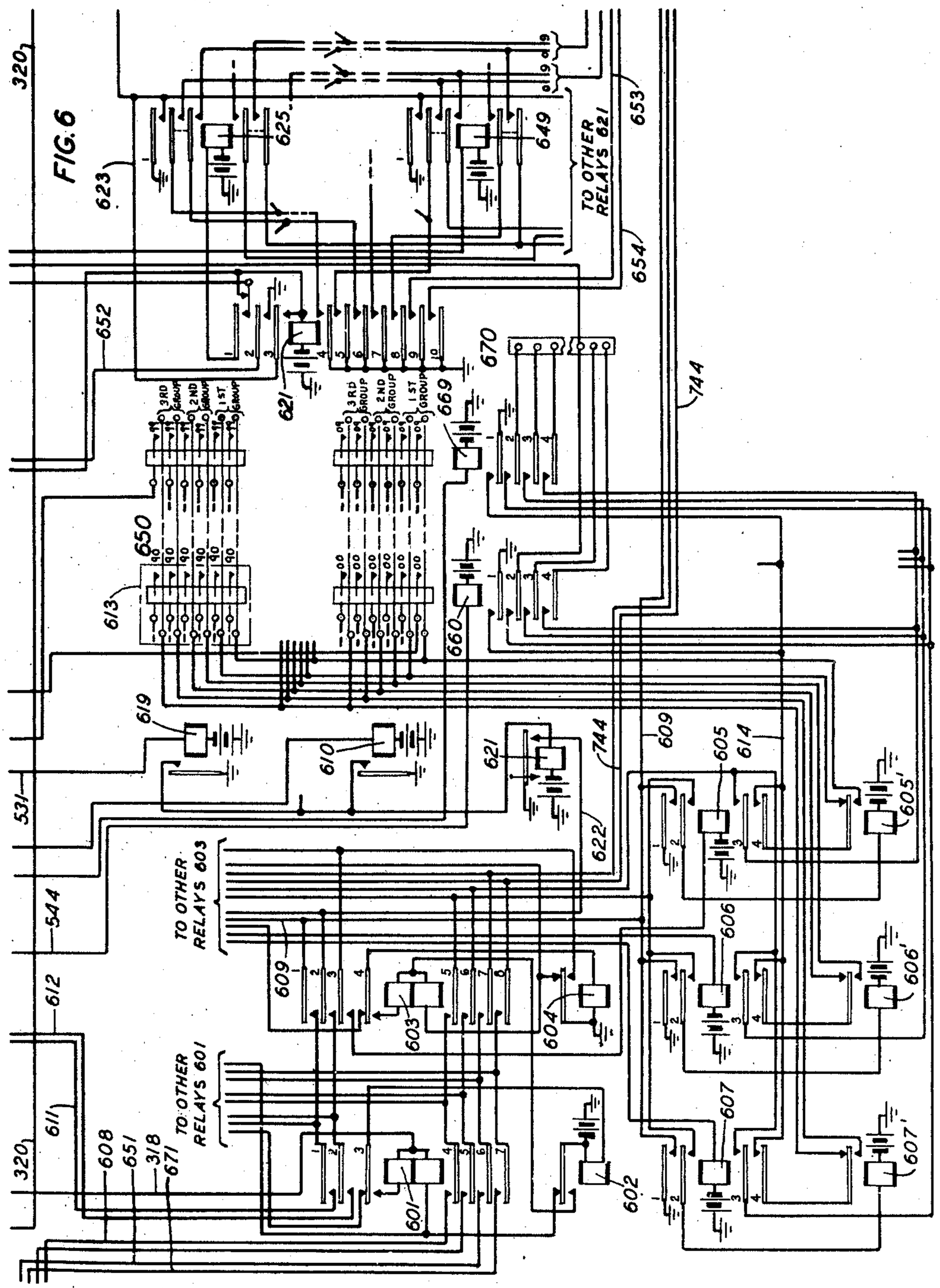
FIG. 6



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TELEPHONE SYSTEM

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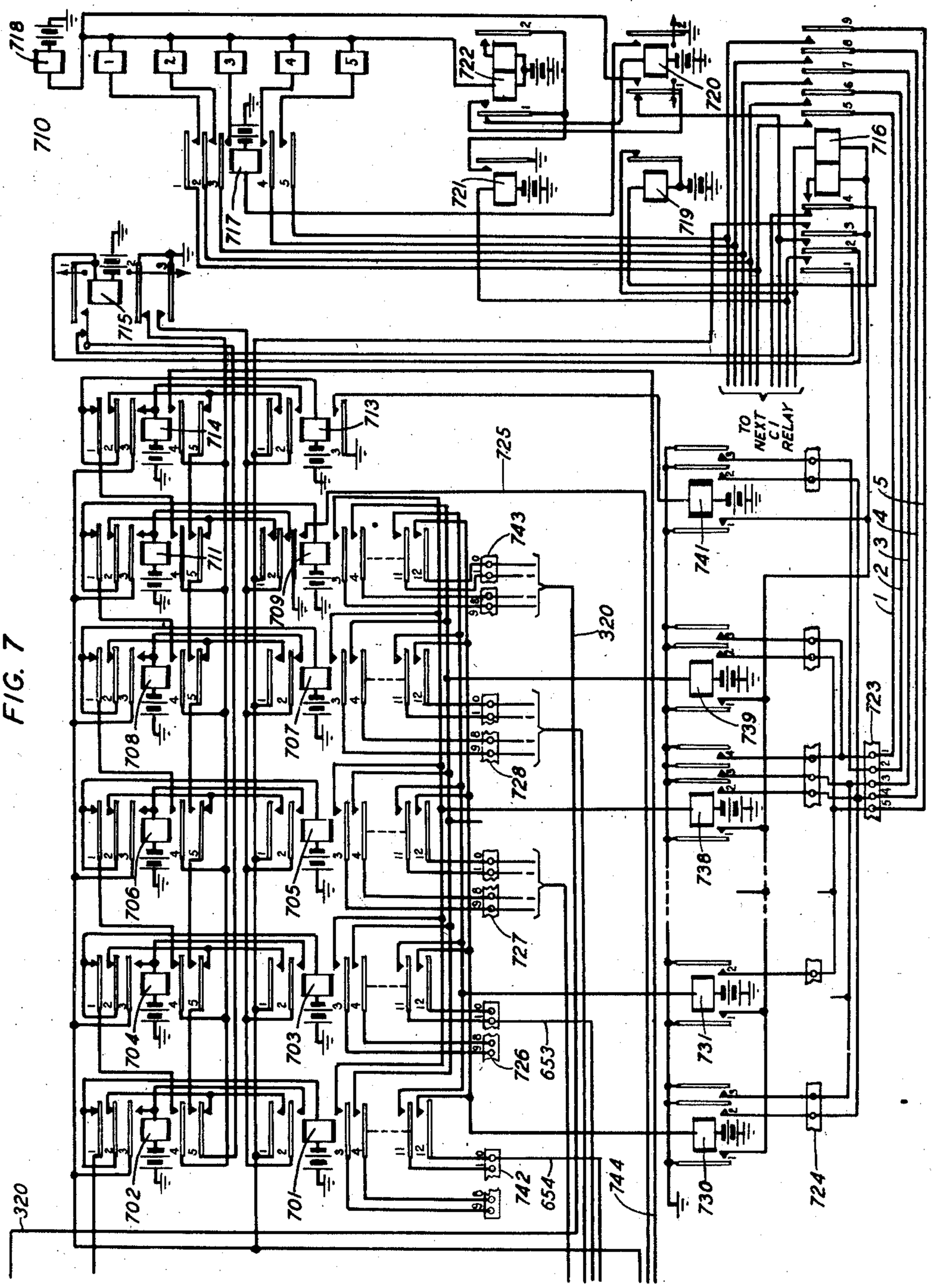

FIG. 7

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Patented June 25, 1946 2,402,700

UNITED STATES PATENT OFFICE

2,402,700

TELEPHONE SYSTEM

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Application May 22, 1940, Serial No. 336,494

28 Claims. (Cl. 179—7.1)

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This invention relates to measured service telephone systems in which a permanent record is made of the calling line identification and the charge units assessed for a connection between a calling line and a called line and in which the charge units are designated by one or more impulses depending upon the destination of the completed connection or the number of time intervals consumed after the connection is established. The object of the invention is to improve such systems by providing a recording mechanism available to said lines by which the number or other designation of the calling line and the number of charge units to be assessed for a call therefrom are permanently recorded.

It has been found desirable, for instance, and particularly in multioffice and suburban telephone systems, to provide two or more classes of service. In such systems the subscribers' stations may be classified as residence stations and business stations and the area itself divided into a plurality of zones. With such a classification, the residence subscribers will be given unlimited flat rate service for calls to stations within the same zone and will be charged one or more charge units for each call to stations in any of the other zones. The business subscribers, on the other hand, will be charged a rate of one charge unit for each call to stations within the same zone but, in addition, will also be charged additional charge units for each call to stations in the other zones. Again, in certain types of telephone systems and particularly in the local area of such systems, it is customary to assess charges for calls in terms of standard time units consumed during the conversation interval as, for instance, in so-called telechron charging systems wherein calling subscribers are charged a flat rate for each telechron unit consumed once the connection is established. In such systems, as well as in the multizone system above mentioned, it is believed to be more economical and efficient to eliminate individual station meters and institute in lieu thereof a central recording system which is adapted to produce a permanent record for each call which comprises the identity of the calling line and the number of charge units to be assessed for an established connection.

According to one embodiment of the present invention, the subscribers' lines of a telephone system are divided into a plurality of zones all of which, in establishing connections, have access to line finder switches capable of discriminating between one or more classes of lines, and furnished with a switch responsive to impulses that designate the number of charge units for a call. These impulses may, of course, be transmitted from a distant repeater which is adapted to produce a number of impulses indicative of a connection established thereover, or from a first selector adapted to produce a single impulse for a local call routed therethrough, or from a selector in a switching train wherein the call is "metered" purely on a time basis. The line finder switches have access, in turn, to common recording facilities that are adapted to produce a permanent identification of the calling line terminal number or the directory number, whichever is desired, and of the number of charges registered by the line finder register switch. Each of these records may be produced on a tape or other continuous impressible media by perforators, light valve apparatus or similar devices well known to the art.

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One feature of the invention, therefore, is a line finder switch that includes a register switch responsive to impulses from a trunk in the switching train, the circuit of said register switch including responsive means that indicate which of two parties of a two-party line is calling.

Another feature of the invention is a recording circuit accessible to all line finder groups which is provided with a novel means for identifying the calling line.

Yet another feature of the invention is a register in said recording circuit which is used in common by the line identifiyng means of the recording circuit and by the registering switch of the line finder to temporarily register, in succession, each of the digits of which the calling line number is composed and of the digit that designates the number of charge units registered in the stepping switch of the line finder taken into use, each of which temporary registrations is for the purpose of transferring them in succession to the magnets of a perforator or similar device which operate to make a permanent record of the same.

Yet another feature of the invention is a line identifying circuit of novel design that utilizes a cross-bar switch to mark a terminal individual to a calling line and a novel relay register cooperating therewith that "translates" the marked terminal into the directory number of the calling line.

A further feature of the invention lies in a guard circuit that keeps a line finder out of service after use in a connection until a charge for the call registered in the switch associated therewith is properly recorded by the recording circuit against the calling line notwithstanding the fact that said calling line may have restored and re-

leased the line finder before a record of the charge has been made.

A telephone system arranged in accordance with this invention is shown schematically in the drawings which form a part of this specification and in which:

Fig. 1 shows two subscribers' stations A and B, lines L—1 and L—100, line circuits LC—1 and LC—100, two sets of brushes and two sets of terminals of the bank of each of two line finder switches LF—1 and LF—11 and the brushes and a set of terminals of each of two connector switches C1 and C2;

Fig. 2 shows the vertical commutators 237 and the commutator brushes 238 of the line finders LF—1 and LF—11, resistors 221 to 225, inclusive (a set for each of the line finders) and a line finder control unit LFC—B;

Fig. 3 shows the circuit of the line finder switch LF—1 including the charging register 330;

Fig. 4 shows a line finder control unit LFC—A;

Fig. 5 shows a first selector switch S permanently associated with the line finder LF—1 of Fig. 3, a timing circuit TC, a repeater R, two other selectors S2 and S3 shown in schematic fashion, two connectors C4 and C3 accessible, respectively, from selectors S2 and S3; subscribers' stations AS1 and AS2, a part of the recording circuit and parts of the line finder switch LF—1;

Fig. 6 shows the line identifying portion of the recorder circuit;

Fig. 7 shows the common register and perforator of the recorder circuit; while

Fig. 8 shows the manner in which Figs. 1 to 7, inclusive, are to be arranged with respect to each other in order to show the invention completely.

The subscribers' stations are of the usual type employed in common battery automatic telephone systems and each includes a dial or other impulse sending device for controlling the numerical switches through which connections with other subscribers' lines are established. The line circuit LC—1 comprises a combined line and cut-off relay 111 and a permanent signal lock-out relay 114. The line circuit LC—1 comprises similar relays 111' and 114'.

The line finder switches LF—1 and LF—11, selector switches S, S2 and S3, and connectors C1, C2, C3 and C4 are of the well-known two-motion step-by-step type. A clear and complete description of the structure of such switches is to be found in "Automatic Telephony" by Smith and Campbell, 2nd edition, pages 53 to 67, inclusive. The bank of each of the line finder switches is represented in the drawing by two sets of terminals and the banks of the selector and connector switches are each represented by a single set of terminals. The line finder LF—1 and selector S are shown but the line finder LF—11, selector switches S2 and S3, and connector switches C1 to C4, inclusive, are represented by the brushes and the one or two sets of terminals.

The distribution of lines on the terminal banks of the line finder switches and the detailed operation of the control circuit shown in Fig. 4 are to be found in Patent 2,210,068 granted to T. L. Dimond on Aug. 6, 1940. Only such parts of these circuits are described in detail herein which are necessary to a complete understanding of the present invention, reference being made to the above-mentioned patent for a more detailed description thereof.

The line finder circuit, as said before, comprises a line finder switch of known structure which is adapted to step its brushes vertically and horizontally when seeking the terminals of a calling line. The brush shaft (not shown) of this switch is equipped with a pair of "normal post" springs 324 which can be adjusted to operate when the shaft has stepped vertically to any one of the ten horizontal levels of terminals reserved to the subscriber lines. By means of these springs, as it will be shown, discrimination may be made, say, between a group of lines which is entitled to flat rate service and another group entitled to individual message rate service. The trunk (that is, the combination of the line finder and first selector S) comprises a pair of charging relays 305 and 306 controlled by the polarized relay 307 by relay 304 and by a charging switch 330 so that when the line current is reversed, relays 305 and 306 will operate to record the charges on said switch. The operation of the relays 305 and 306 when relay 304 is not operated, is controlled from the interrupter circuit 325 and results in the count of one on the charging switch 330.

Associated with each line finder switch LF—1 are two stepping switches of known structure, namely, switches 520 and 530. As the line finder brushes are raised vertically and turned horizontally, the switch 520 is operated each time the vertical magnet 343 of the line finder is operated and switch 530 is operated each time the horizontal magnet 344 is operated. It will be noted that the operation is synchronized by the back contacts of stepping magnets 532 and 533 of switches 520 and 530, respectively, which are in parallel with the back contacts of the vertical and rotary magnets 343 and 344, respectively, of the line finder. The number of vertical steps taken by the line finder is registered on switch 520, the number of rotary steps taken is registered on switch 530 and the particular set of terminals belonging to the calling line is determined by the operation or non-operation of relay 342 and registered on relay 312 of the trunk.

The identification circuit shown in Fig. 6 and the recording circuit shown in Fig. 7 are adapted to be connected to a calling line finder when ground is connected by said finder to conductor 318. A relay 601 is provided for each trunk and this, together with relay 602, provides for non-interference in case two trunks are calling for the recording circuit at the same time. A relay 603 is provided for each group of trunks serving the same line finder group. These relays 603 together with relay 604 provide for non-interference between line finder groups. Thus the common identification and recording circuit can be connected to one trunk at a time. When so connected, one of the relays 605, 606 or 607 is operated depending upon whether or not relay 312 in the line finder is operated, to distinguish between the upper and lower terminal sets at the brushes of the line finder switch.

The positions assumed by the switches 520 and 530, respectively, indicate the terminal identity of the calling line on the line finder terminal bank, and circuits completed over the terminal arc of each of these switches result in the operation of a vertical and horizontal magnet of the cross-bar switch 650 which is effective in closing a cross-point on the switch that includes a grounded conductor that marks the calling line. The cross-bar switch shown is assumed to be a six-wire switch, thus providing for six hundred terminals, one for each line of three line finder

groups of two hundred lines each. The vertical rows on the switch represent line finder level positions while the horizontal rows represent the line finder terminal positions. The cross-bar switch **650** is of the type disclosed in Patent 2,021,329, issued to J. N. Reynolds on November 19, 1935, and reference is made thereto for a complete disclosure of its construction and operation.

The marking conductors from the various cross-points of the switch **650** which indicate the terminal numbers of the lines on the banks of the line finder frame, extend to the distributing frame **550** where, by cross-connection to the line terminal frame **560**, the line finder terminal number may be translated into a line directory number through the operation of a translating circuit which consists of four relays **524—527** and a relay **621** per group of twenty-five lines, and a group of twenty-five relays **625—649** for the entire office. The contacts on relay **621** and the relays **625—649** provide for the tens and units digit designations while other contacts on relay **621** alone provide for the thousands and hundreds digit designations as will be subsequently set forth.

The recording circuit shown in Fig. 7 includes a perforator **710** which comprises a punching magnet **718** and five recording magnets **1—5**, six pairs of progress relays **701—702** . . . **713—714**, and a register comprising ten relays **730—739** and relay **741**. Each pair of progress relays is operated for the registration of a particular digit of the directory number and, also, for the digit which represents the number of charge units for the call. When so operated, the lower of the two progress relays connects the register with a group of ten conductors extending between each of the first four pairs of progress relays **701—708** and the line translating circuit. One conductor in each group is grounded to indicate the digits involved, thereby causing the operation of one of the register relays. The perforator is then tied in with the operated register relay to punch the digit registered. These operations are repeated for each digit of the calling line number and each pair of progress relays is, in turn, operated and released.

When making the record of the number of charge units, the progress relays **709** and **711** connect the register relays with the group of conductors which extend to the terminals of the charging switch **330**, and the particular conductor grounded by the brush **313** will cause the operation of a register relay whose connection with the perforator will result in the punching of the digit that corresponds to the terminal to which brush **313** is engaged.

The repeater R to which the selector S may have access is of a conventional design well known to the telephone art and comprises a group of relays which, upon response of the called subscriber AS2, operate to produce a number of pulses which are transmitted over conductor **317** to effect the operation of the magnet **310** of charging switch **330**. The number of pulses produced by the repeater indicates the number of charge units to be assessed for a call routed thereover and it is easily seen that the number of impulses may be different with groups of repeaters that give access to different zones for which the charges are different. Provision is made to cancel one of the charge units in the repeater on signal from the line finder normal post springs **324** that the call is from a line entitled to flat rate service, in which event, since the subscriber is entitled to one charge unit for the call, the same must be

subtracted from the total charge units assessed for a call routed through the repeater.

The selector S has access, of course, to second selectors such as S2, for example, in which no impulse producing facilities are required. This selector gives access to a local zone where one charge is provided upon the reversal of the loop on the response of the called line. There are other selectors to which selector S has access which are designed to time the call for charging on a telechron unit basis. These types of selectors as well as the manner of charge control exercised thereby are so well known in the art that their conventional representation as shown in Fig. 5 is thought to be sufficient to indicate that the scope of the invention is intended to cover all known types of telephone switching facilities adapted, upon battery reversal in response to the answer of the called line, to produce one or more charging impulses for a completed connection, irrespective of whether such charges are for the area to which a calling line is extended or for the number of units of conversation time or both.

To more completely describe the operation of the system shown, assume that the subscriber at station A removes the receiver to originate a call, thereby closing a circuit for operating line relay **111** which extends from battery through the middle and right windings of said relay, No. 4 contacts of said relay, over line L—1 and through station A, through the No. 3 contacts and left winding of relay **111** to ground. The right winding of relay **111** has a high resistance and, therefore, said relay is only partially energized by the current in this circuit. Relay **111** closes its No. 6 contacts thereby connecting ground to conductor **112** to mark the commutator segments of the level in which the line terminates in the banks of the finders of both subgroups. (Ground is permanently connected to the top commutator segment of each line finder so that a finder will always stop on the top level, if not before.) The ground connected to conductor **112** is further extended through resistor **221** (which is common to the twenty lines connected to the first level of the finders in subgroup A) to start conductor **220**.

As long as there is an idle finder in subgroup A, relay **457** is held operated in a circuit which includes the No. 1 contacts of relay **459**, left contact of make-busy key **469**, upper contacts of the make-busy key MB of each finder in subgroup A, upper back contact of the vertical off-normal springs **345** of each idle finder in the subgroup, thence over conductors **346**, through the No. 2 back contacts of relay **501**, back contacts of relay **500**, and No. 5 back contacts of relay **502** of each associated idle first selector, to ground. Assuming that there is an idle finder in subgroup A so that relay **457** is operated, the connection of ground to conductor **220** causes the operation of start relay **450** over the No. 2 front contacts of relay **457**, winding of relay **450** to battery.

Relay **450**, in operating, connects ground over its No. 2 contacts to conductor **464** to start the ringing interrupter **463**, and connects ground over its No. 1 contacts to conductor **462** leading to the alarm circuit **460** for the purpose of effecting an alarm in case relay **450** remains unduly operated. Relay **450** further closes a circuit for operating relay **451** which extends from battery through the winding of relay **451**, No. 4 contacts of relay **454**, No. 5 contacts of relay **453**, No. 4 contacts of relay **450**, to ground at No. 4 back contacts of relay **459**. Relay **451** locks through its No. 6 contacts under the control of relays **454** and **459**

and closes a circuit for operating the line relay of the selector associated with the allotted line finder.

As shown in the drawings, the brushes **471** to **476** of the line finder allotter switch are in engagement with the first set of terminals, which terminals are connected to the line finder whose circuit is shown in Fig. 3. The circuit closed by relay **451** for operating the line relay **500** of the associated selector S of Fig. 5 is traced from ground through resistor **468**, No. 4 contacts of relay **451**, No. 6 contacts of relay **454**, through brush **475** and terminal **1**, conductors **348** and **303**, No. 3 back contacts of relay **502** of selector S, through the upper winding of relay **500** to battery. In operating, relay **500** closes a circuit for operating the slow-to-release relay **501**. Relay **501** connects the lower winding of relay **503** through its No. 1 contacts to conductor **504** which extends to ground in the permanent signal timing circuit TC and connects ground through its No. 4 contacts to the winding of relay **502** and the No. 1 normal contacts of relay **503** to conductor **300**. Relay **503** operates, locks through its upper winding and the No. 3 contacts of relay **501**, and connects conductor **300** to conductor **505** via its No. 1 contacts to ground in the timing circuit TC.

The connection of ground to conductor **300**, due to operations consequent to the operation of relay **500**, is in preparation for the finding of the calling line as hereinafter described. Relay **451** connects ground through its No. 1 contacts to hold relay **457** operated during the operation of the allotted finder to find the calling line in case this line finder is the only available one in the group. Relay **451** also closes a circuit for operating the stepping relay **452** which extends from battery through the lower winding of said relay, No. 3 contacts of relay **451**, brush and terminal **1** of bank **474** of the allotter switch, back contact of the 11th rotary step springs **322**, No. 2 back contacts of relay **342**, No. 2 back contact of relay **341**, the back contacts of the vertical stepping magnet **343** and the rotary stepping magnet **344** to ground. The stepping relay **452** operates and closes a circuit from ground at the No. 3 back contacts of relay **454**, front contacts of relay **452**, No. 1 back contacts of relay **453**, brush and terminal **1** of bank **473** of the allotter switch through the winding of the vertical stepping magnet **343** to battery. Magnet **343** operates, stepping the brushes of the finder up to the first level. The vertical off-normal springs **345** are actuated when the shaft on which the brushes are mounted moves out of normal position. The operation of magnet **343** opens the operating circuit of relay **452**, but if the calling line is connected to terminals in the first level of the line finder bank, relay **452** is held operated to prevent reoperation of magnet **343**. The circuit for holding relay **452** operated is traced from battery through the lower winding of said relay, No. 3 and No. 2 contacts of relay **451**, upper winding and No. 3 contacts of relay **453**, No. 1 contacts of relay **454**, brush **472** and terminal **1** of the allotter switch, conductor **439**, commutator brush **238** and first segment of commutator **237**, through conductor **112** to ground in the line circuit LC—**1**. If, however, the calling line is connected to terminals in some other level of the bank, relay **453** does not operate when brush **238** engages the first commutator segment and, in this case, relay **452** releases when magnet **343** operates. The release of relay **452** causes the release of magnet **343**, and the release of magnet **343** again closes the circuit for operating relay **452**. The described cycle of operations between relay **452** and magnet **343** is repeated to raise the brushes step by step until the brushes of the finder reach the level of the terminals of the calling line, at which time relay **452** is held in the circuit through commutator brush **238** as already described.

In parallel with the winding of vertical magnet **343** is the winding of magnet **532** of rotary stepping switch **520** whose terminal arc comprises ten terminals and a normal terminal N with which the brush **521** of the switch is in normal engagement. The ten terminals are multipled to conductors which extend to the windings of the ten select magnets **610**—**619** of the cross-bar switch **650** in the same order as the numerical designation of each of the terminals, that is, the conductor connected with terminal **0** being connected to the conductor which extends to the winding of select magnet **610** and so on up to and including the conductor connected with terminal **9** which extends to select magnet **619**.

When the circuit is completed for the vertical magnet **343** as above described, a parallel circuit is completed to the winding of magnet **532** and the two magnets, operating together, cause the brush shaft of the line finder (not shown) and the brush **521** of the switch **520** to step in synchronism so that when vertical stepping is completed, the brush **521** will be engaged to a terminal of its arc that corresponds to the terminal level to which the line finder brushes have been raised. The off-normal springs **517** of the switch **520** aré closed on the first step, the lower contacts connecting ground to conductor **519** and the upper connecting the winding of release magnet **534** to conductor **321**.

In the present embodiment of the invention, it is assumed that lines entitled to two different classes of service will terminate on terminal banks accessible to the same group of line finders of which, say, line finder LF—**1** is representative. Thus it may be assumed that lines entitled to flat rate service will appear on certain upper terminal levels and lines entitled to individual message rates will appear on lower terminal levels. To discriminate between the two classes of service, therefore, normal post springs **324** are provided in each line finder, which springs may be adjusted to close at the first terminal level in which the flat rate lines are located, it being further assumed that the individual message rate lines appear below this level and that the normal post springs are not closed therefor. Hence, under the above assumption, if line A is a flat rate line then, when the vertical magnet **343** has raised the brush shaft to the terminal level in which line A is located, normal post spring **324** operate to perform functions noted hereinafter. One the other hand, if the line A should be an individual message rate line, then the normal post springs will not operate and these subsequently to be described functions will not be performed.

Relay **453** is partially operated by the energization of its upper winding in the circuit above described to close its No. 6 contacts and thereby operatively energize its lower, locking winding under control of the No. 5 contacts of relay **451**. The complete operation of relay **453**, due to the energization of its locking winding, opens the circuit through its upper winding, opens the operating circuit of vertical stepping magnet **343** and closes the circuit for operating the rotary stepping magnet **344**. Relay **453** is slow in operat-

ing so that the brushes of the line finder will stop vibrating before the circuit is closed for operating the rotary stepping magnet. The circuit for operating the rotary stepping magnet **344** is traced from battery through its winding, terminal **1** and brush **476** of the alotter switch, No. 1 front contacts of relay **453**, contacts of relay **452** to ground at the No. 4 back contacts of relay **454**. The operation of magnet **344** steps the brushes of the line finder switch into engagement with the first set of terminals in the level to which the brushes were advanced by the operation of magnet **343**, and its operation opens the operating circuit through the lower winding of relay **452**, causing its release unless the calling line is connected to the terminals engaged by the upper set of brushes **131**, **132** and **133** or to the terminals engaged by the lower set of brushes **134**, **135** and **136**. If neither of the lines connected to the terminals engaged by the brushes of the line finder is a calling line awaiting connection to a first selector, relay **452** releases when the circuit through its lower winding is opened by the operation of magnet **344**. The release of relay **452** causes the release of rotary magnet **344** and the release of said magnet again closes the operating circuit for relay **452**. Relay **452** and rotary magnet **344** are thus alternately operated and released to advance the brushes of the line finder step by step until the one or the other of the two sets of brushes engages the terminals of the calling line, whereupon relay **452** is held operated and one or the other of relays **341** or **342** is operated as hereinafter described.

In parallel with the winding of rotary magnet **344** is the winding of magnet **533** of rotary stepping switch **530** whose terminal arc comprises ten terminals and a normal terminal N with which the brush **523** of the switch is in normal engagement. The ten terminals are multipled to conductors which extend to the windings of the ten hold magnets **660—669** of the cross-bar switch **650** in the same order as the numerical designation of each of the terminals; that is, the conductor connected with terminal **0** being connected to the conductor which extends to the winding of hold magnet **660** and so on up to and including the conductor connected with terminal **9** which extends to hold magnet **669**.

When the circuit is completed for the rotary magnet **344** as above described, a parallel circuit is completed to the winding of magnet **533** and the two magnets, operating together, cause the brush shaft of the finder and brush **523** of the switch **530** to step in synchronism so that when rotary stepping is complete and the brushes of the finder are engaging the terminals of the calling line, brush **523** will be engaged to a terminal of its arc which corresponds to the numerical designation of the line terminal in the horizontal level in which it is located. The off-normal springs **518** of the switch **530** are closed on the first step, the lower contacts connecting ground to conductor **519** and the upper connecting the winding of release magnet **535** to conductor **321**.

If the calling line is found by brushes **131**, **132** and **133**, a circuit is closed for holding the stepping relay **452** operated and for operating relay **341**. This circuit is traced from ground through the upper winding of relay **452**, No. 2 front contacts of relay **453**, No. 1 contacts of relay **454**, brush **472** and terminal **1** of the allotter switch, conductor **439**, No. 5 contacts of relay **342**, lower winding of relay **341**, contacts

of release magnet **349**, test brush **133** and terminal **119**, conductor **116**, No. 6 contacts of relay **114**, No. 1 contacts of relay **111**, No. 1 contacts of relay **114**, through the middle winding of relay **111** to battery. The non-inductive resistor **467** connected across the upper winding of relay **452** makes this relay somewhat slow in releasing so as to prevent its release if the brushes are momentarily advanced beyond the terminals of the calling line; it also prevents the release of relay **452** while the current is building up in the circuit through the test brush and terminal of the calling line. In addition to holding relay **452** operated, the current in this circuit is effective to complete the operation of relay **111** and to energize the lower winding of relay **341** and thereby partially operating said relay to the extent of closing its No. 3 contacts and completing a circuit from battery through said upper winding and No. 3 contacts, No. 7 contacts of relay **342**, to ground on conductor **300** as already traced thereto. With relay **341** completely operated by its upper winding, the line L—**1** is connected through brushes **131** and **132**, the Nos. 1 and 7 contacts, respectively, of relay **341**, upper and lower windings of polarized relay **301**, conductors **302** and **303**, Nos. 2 and 3 back contacts of relay **502**, to the windings of the line relay **500** of selector S. The complete operation of relays **341** also disconnects the lower winding of relay **342** from conductor **439**, disconnects the release magnet **349** from conductor **346**, disconnects the lower winding of relay **452** from the contacts of magnets **343** and **344**, and closes a circuit for holding relay **452** and operating relay **454**. This circuit is traced from battery through the lower winding of relay **452**, No. 3 contacts of relay **451**, brush **474** and terminal **1**, back contact of the 11th rotary step springs **322**, No. 2 back contacts of relay **342**, No. 2 front contact of relay **341**, conductor **340**, upper winding of relay **454** to ground. With relay **341** operated, the complete operation of the line and cut-off relay **111** through its middle winding is assured by its connection through conductor **116**, terminal **119**, brush **133**, contacts of magnet **349**, Nos. 4 and 3 contacts of relay **341**, No. 7 back contact of relay **342**, conductor **300** to holding ground potential already connected to this conductor as above described.

If the calling line is connected to the set of terminals engaged by the brushes **134**, **135** and **136**, a circuit is closed from ground through the upper winding of relay **452**, No. 2 contacts of relay **453**, No. 1 contacts of relay **454**, brush **472** and No. 1 terminal, conductor **439**, No. 6 back contacts of relay **341**, the lower winding of relay **342**, brush **136**, to the winding of the line relay of the calling line (not shown). Relay **452** is held operated by its upper winding and relay **342** is partially operated by its lower winding. Relay **342** closes its No. 4 front contact thereby completing a circuit through its upper winding to ground on conductor **300**. Relay **342** is thereby completely operated, connecting the calling line to selector S. Relay **342** also disconnects the lower winding of relay **341** from conductor **439** and disconnects the locking contact of relay **341** from conductor **300** so that, if relay **341** has also operated due to brushes **131**, **132** and **133** engaging the terminals of a calling line, relay **341** will release and the line engaged by brushes **134**, **135** and **136** will be the only one connected to selector S. Relay **342** also disconnects the winding of release magnet **349** from conductor **346**, discon-

nects the lower winding of relay 452 from the contacts of magnets 343 and 344, and closes a circuit for holding relay 452 and for operating relay 454. This circuit is traced from battery through the lower winding of relay 452, No. 3 contacts of relay 451, brush 474, and terminal 1, normally closed contact of the 11th rotary step springs 322, No. 2 front contacts of relay 342, conductor 340, the upper winding of relay 454 to ground. Relay 342 also connects the test brush 136 directly to conductor 300 to insure the complete operation of the line and cut-off relay of the calling line and completes an obvious circuit for relay 312 which operates and locks to ground on conductor 519.

It is particularly to be noted that further rotary stepping of the line finder is prevented due to stepping relay 452 holding energized through its upper winding in the circuit for operating the switching relay 341 or 342 of said line finder and completing the operation of the line and cut-off relay of the subscriber's line circuit. It is also to be particularly noted that the switching relays 341 and 342 do not need to be fast operating to prevent advance beyond the terminals of a calling line because the stepping relay 452 is held operated. Relay 452, being held to prevent further stepping, no further action can take place until the lower operating winding of relay 341 or 342 has become sufficiently energized to close the locking circuit through its upper winding.

With relay 454 operated, due either to the operation of relay 341 or to the operation of relay 342, a circuit is closed through the lower winding and No. 5 front contacts of relay 454, through brush 471 of the allotter switch, lower back contact of the make-busy key MB, to ground at the lower front contact of the vertical off-normal springs 345. In operating, relay 454 disconnects ground from the contact of the stepping relay 452 to prevent further operation of the rotary stepping magnet 344; opens the circuit path through brush 475 and conductor 348 to the upper winding of the line relay 500 of selector S; opens the circuit through the upper winding of relay 452 and brush 472 of the allotter switch, and causes the release of relay 451. The release of relay 451 opens the circuit through the lower winding of relay 452, brush 474 and the upper winding of relay 454, thereby causing the release of relay 452. The release of relay 451 also opens the circuit for holding relay 457 operated which, however, will not release if there is an idle line finder supplying ground over conductor 346 through the left contacts of key 469, and causes the release of relay 453. In releasing, relay 453 closes a circuit for operating the stepping magnet 470 of the allotter switch that extends from battery through the winding and interrupter contact of said stepping magnet, No. 2 contacts of relay 454, No. 4 contacts of relay 453 to ground on the No. 1 front contacts of relay 457. The operation and release of magnet 470 steps the brushes of the allotter switch to the next set of terminals. If the line finder connected to this set of terminals is busy, relay 454 is held operated by its lower winding in a circuit through brush 471 of the allotter switch to ground at the vertical off-normal springs 345 of the busy finder. Since brush 471 makes contact with each terminal before it breaks contact with the circuit for the preceding terminal, relay 454 is held operated and the stepping magnet 470 is alternately operated and released to advance the brushes of the allotter switch step by step until brush 471 encounters a terminal connected to an idle line finder. When an idle finder is encountered, relay 454 releases and stops the allotter. The control circuit LFC—A is then ready to operate in response to another call.

Returning now, to the selector S, the extension of the calling line through conductors 302 and 303 to the winding of relay 500 is effective in operating said relay. Relay 500 completes a circuit for relay 501 extending from battery through the winding of said relay, front contacts of relay 500, No. 5 contacts of relay 502 to ground. Relay 501 operates and, among other functions, applies ground to its No. 4 contacts which, through the No. 1 normally made contacts of relay 503, is applied to conductor 300. If, now, the normal post springs 324 of the line finder switch are operated, due to the fact that the call comes from a line entitled to flat rate service, said ground will complete a circuit through the upper winding of relay 304 via the normal post springs, causing said relay to operate and causing ground to be applied to conductor 317 via the No. 4 back contacts of relay 306. The function of relay 306 and the significance of the ground on conductor 317 will be taken up in their respective sequence in the operation of the circuit.

Dial tone is transmitted to the calling subscriber in the usual manner and, when the subscriber dials the first digit of the called subscriber's number, relay 500 is alternately released and reoperated by each of the impulses in the train. The release of relay 500, in response to the first impulse, closes a circuit from battery through the winding of the vertical stepping magnet 506, winding of change-over relay 509, No. 2 front contacts of relay 501, through back contacts of relay 500, No. 5 back contacts of relay 502 to ground. The operation of magnet 506 raises the brushes 511, 512, 513 and 514 to the first level of the bank. As soon as the shaft and brushes of the switch are moved out of normal position, the vertical off-normal springs 515 are actuated, closing thereby a circuit for operating relay 510. This circuit includes the upper set of contacts of springs 515, the front contact of relay 509 and the No. 4 contacts of relay 501. Relay 510 locks in a circuit which includes the contacts of the rotary stepping magnet 507, the No. 2 contacts of relay 510, the No. 5 contacts of relay 502 to ground. When relay 500 reoperates at the end of the first impulse, the vertical stepping magnet 506 releases. Relay 501 is slow in releasing and remains operated while relay 500 is responding to dial impulses. Relay 509 is also slow in releasing and remains operated until all of the impulses in the series have been received by relay 500. The vertical stepping magnet 506 is reoperated by the release of relay 500 in response to each of the succeeding impulses of the train, thereby stepping the brushes up to the level corresponding to the digit dialed.

The first digit dialed by the subscriber may act to discriminate between an unlimited service area and one in which the charge for the call is a function of its destination. For this purpose, a set of "normal post" springs 529 is provided in the first selector which may be adjusted to close at any desired level. If, for instance, multiple charging is reserved for trunk outlets located on the fifth level and over the terminal banks accessible to brushes 511—514 of the switch, springs 529 are adjusted to close when the brush shaft is raised five steps in response to the five impulses of the first digit. When

these springs close, an obvious circuit is completed for relay **304** over its lower winding, causing said relay to operate and perform functions noted hereinafter. For all trunk levels below the fifth, that is, for all outlets provided by digits 1 to 4 inclusive, springs **529** do not close, relay **304** is not operated and selector S moves vertically to engage a second selector S2 which is adapted to reverse the direction of current flow over the talking circuit upon the response of the called subscriber AS1 but is not adapted to transmit pulses to operate the charging equipment more than once.

When relay **509** releases after the last impulse of the train has been received (assuming that the switch S has been advanced to the fifth or higher terminal level), it closes a circuit from battery through the winding of the rotary stepping magnet **507**, No. 1 contacts of relay **510**, back contacts of relay **509** to ground at the No. 4 contacts of relay **501**. The operation of magnet **507** advances the brushes into engagement with the first set of the terminals in the selected level and it also causes the release of relay **510** which, in turn, causes the release of magnet **507**. If the repeater R connected to the first set of terminals is busy, the test brush **513** encounters a ground potential thereon which is effective to cause the reoperation of relay **510** over a path that extends from battery to the winding of said relay, the upper contacts of springs **515**, contacts of magnet **507**, lower back contact of the 11th rotary step springs **516**, the No. 4 back contacts of relay **502**, brush **513** to the ground potential (not shown) on the sleeve terminal of the busy repeater. Relay **510** recloses the circuit for operating the rotary stepping magnet **507** and the brushes are thereby advanced to the next set of terminals. Relay **510** and magnet **507**, in operating and releasing in the manner described, thus cooperate to advance the brushes of the selector step by step until an idle set of terminals is encountered as determined by the absence of ground on the test terminal of the set engaged by brush **513**, whereupon relay **502** is operated in a circuit traced from battery through the winding of relay **510**, upper set of contacts of springs **515**, contacts of magnet **507**, lower back contacts of the 11th rotary step springs **516**, winding of relay **502** to ground on the No. 4 contacts of relay **501**. Relay **502** operates in this circuit but relay **510**, being marginal, does not. Relay **502** operates and disconnects the windings of relay **500** from conductors **302** and **303** and connects these conductors through its Nos. 2 and 3 front contacts, respectively, and brushes **511** and **512**, respectively, to the terminals of the selected repeater. The release of relay **500** causes, in turn, the release of relay **501** which, in turn, causes the release of relay **503**. Ground is momentarily extended from the No. 4 contacts of relay **501** through the No. 4 front contacts of relay **502** and brush **513** to the test terminal of the selected set of terminals to mark the trunk connected thereto busy until holding ground potential is connected to the test terminal thereof in the usual manner.

The impulses produced by the dialing of the succeeding digits of the called subscriber's number effect the operation of the outgoing trunk repeater R associated with an interoffice trunk over which the desired connection may be completed and which determines not only the route of the call but also the number of charges to be made therefor. Upon extension of the calling line to the repeater R, therefore, the line relay **551** of said repeater is operated, the operating circuit being traced from battery through the upper winding of relay **511**, No. 3 normal contacts of reversing relay **553**, through brush **512** of selector S, No. 3 front contacts of relay **502**, conductor **303**, lower winding of polarized relay **301**, No. 7 contacts of relay **341**, brush **132** and terminal, subscriber's loop, brush **131** and terminal, No. 1 contacts of relay **341**, upper winding of polarized relay **301**, conductor **302**, No. 2 front contacts of relay **502**, brush **511** and terminal No. 2, normal contacts of relay **553**, lower winding of relay **551** to ground. The current in this circuit is not effective to operate the polarized supervisory relay **301**. In operating, relay **551** closes a circuit for operating relay **552** and relay **552** connects ground over conductor **570** and to the sleeve terminal of the repeater to hold the first selector switch S in usual manner and to hold relay **502** operated.

Before proceeding with the description of the manner in which the repeater R produces the number of impulses which designates the charge units for a call established therethrough, it will be recalled that when the line finder LF—1 operates to engage the terminals of the calling line, the normal post springs **324** are closed if the calling line happens to be one entitled to flat rate service. Now, when brushes **511—514** of the selector S engage the terminals of the repeater and relay **502** operates in the manner described, ground on conductor **300** is applied through the normal post springs **324**, No. 4 back contacts of relay **306**, conductor **317**, No. 1 contacts of relay **502**, brush **514**, No. 2 back contacts of relay **541**, winding of relay **542** to battery. Relay **542** operates, locks over its No. 2 contacts to ground on conductor **570** and performs functions noted hereinafter. On the other hand, if the calling line is entitled to individual message rate service, the normal post springs **324** will not be closed upon the operation of the line finder and relay **542** will not operate.

The line relay **551** of repeater R responds to the impulses produced by the dialing of the second and succeeding digits of the called number to repeat each train of impulses over trunk T, the first repeated train of impulses being effective to control the selective operation of the incoming selector switch S3 and the last two repeated trains of impulses being effective to control the selective operation of the connector switch C3 to establish connection with the line leading to the called station AS2. The called line is tested and, if idle, ringing current is transmitted thereover to operate the ringer at station AS2, all in the well-known manner.

The removal of the receiver at station AS2 to answer the call causes the operation of the reversing relay **553** of repeater R in usual manner, thereby reversing the current through the windings of polarized relay **301** and causing said relay to operate and complete a circuit for relay **305** which extends from battery through the winding of said relay, No. 1 normal contacts of relay **306**, contacts of relay **301**, No. 1 normal contacts of relay **305**, No. 2 front contacts of relay **304**, conductor **300** to ground. Relay **305** operates and closes a circuit for relay **306** which extends from ground through the No. 4 front contacts of relay **304**, No. 3 contacts of relay **305**, lower winding of relay **306** to battery. Relay **306** operates, opens the circuit of relay **305** which thereupon releases, locks over its upper winding and No. 2 contacts to ground on conductor **300** and extends con-

ductor 317 over its No. 4 front contacts, No. 5 front contacts of relay 304, No. 2 back contacts of relay 323, winding of polarized relay 307, No. 1 back contacts of relay 323, winding of slow-release relay 309, magnet 310 of charging switch 330 to ground. The line finder circuit, over conductor 317, is now ready to receive impulses indicating intervals of chargeable elapsed time for the connection or the initial number of charges for a conversation depending upon the zone in which the connection is completed or both types of charges depending upon the charging rates used in any particular telephone system. In what follows, the principle of the invention is illustrated in connection with the charges made for a given zone, but this is not to be understood as a limitation of the invention but only as one of the many expressions thereof, it being evident that for local calls in which charges are made strictly in accordance with the number of elapsed time units, said charges will be rendered in the same manner since the charging impulses that activate the switch 330 (as will be presently shown) may be produced either by zone charging equipment or by time charging equipment.

The operation of relay 553 also closes a circuit from ground through the front contacts of relay 552, conductor 570, No. 4 contacts of relay 553, No. 2 normal contacts and winding of relay 536, conductor 567, through the No. 1 contacts of relay 539 to battery. Relay 536 operates and locks over conductor 571, No. 4 contacts of relay 539 to ground on conductor 570. From this point on, the operation of the repeater depends upon whether or not a signal has been received from the normal post springs 324 of the line finder that the calling line is entitled to flat rate service. If such a signal has been received, then, as already described, relay 542 will have been operated and locked. If no signal has been received, indicating thereby that the calling line is entitled to individual message rate service, then relay 542 will be normal.

Assume, first, that no signal has been received and that relay 542 is normal. Relay 536, in operating, closes a circuit for operating relay 543 which extends from battery through the No. 2 contacts of relay 539, conductor 568, the No. 1 contacts of relay 525, No. 1 contacts of relay 536, winding of relay 543 to ground. Relay 543, in operating, closes a circuit from battery 558, contacts of relay 543, No. 1 contacts of relay 542, No. 2 front contacts of relay 541, brush 514 of the selector S, No. 1 contacts of relay 502, conductor 317 and thence as traced to ground through the windings of relays 307 and 309 and the winding of magnet 310. This magnet operates and causes brush 313 to advance one terminal on its terminal arc. Relay 309 also operates in the above circuit. When relay 536 operated, it also closed a circuit for operating relay 525 which extends from ground over conductor 570, the No. 4 contacts of relay 539, conductor 571, the No. 3 contacts of relay 536, the No. 2 normal contacts and winding of relay 525, conductor 567, the No. 1 contacts of relay 539 to battery. Relay 525, in operating, opens the operating circuit for relay 543. Relay 543 accordingly releases, disconnects battery 558 from brush 514 and thereby opens the circuit of magnet 310 and that of relay 309. The magnet releases but relay 309, being slow release, does not. Relay 525 locks through its No. 2 contact over conductor 571 and, through the No. 4 contacts of relay 539, to ground on conductor 570. Relay 525, in operating, also closes a

circuit for operating relay 538 which extends from battery through the No. 1 contacts of relay 539, conductor 567, through the winding and No. 2 normal contacts of relay 538, No. 3 contacts of relays 525 and 536, conductor 571, No. 4 contacts of relay 539, over conductor 570 to ground. Relay 538, in operating, locks to conductor 571 and closes a circuit for operating relay 528; this circuit including the No. 2 contacts of relay 539, conductor 568, No. 1 contacts of relay 537, and the No. 1 contacts of relay 538, winding of relay 528 to ground. Relay 528, in operating, reconnects battery 558 to brush 514 via the No. 2 front contacts of relay 541 thereby again completing the charging circuit of magnet 310 which now operates and advances brush 313 another terminal. Relay 538, in operating, also closes a circuit for operating relay 537; this circuit includes the No. 1 contacts of relay 539, conductor 567, the winding and No. 2 normal contacts of relay 537, the No. 3 contacts of relays 538, 525 and 536, conductor 571, and the No. 4 contacts of relay 539. Relay 537, in operating, locks through its No. 2 front contacts and opens the operating circuit for relay 528 at its No. 1 contacts which now releases and opens the impulse circuit to magnet 310. Relay 537, in operating, also closes a circuit for operating relay 540; this circuit including conductor 567, the winding and No. 2 normal contacts of relay 540, the No. 3 contacts of relays 537, 538, 525 and 536, conductor 571, No. 4 contacts of relay 539 to ground on conductor 570. Relay 540, in operating, locks through its No. 2 front contacts over conductors 571 and 570, and closes a circuit for again operating relay 528; this circuit including conductor 568 and the No. 1 contacts of relay 540. Relay 528, in operating, reconnects battery 558 to brush 514 to cause the reoperation of magnet 310 and the advancement of brush 313 to another terminal. Relay 540 also closes a circuit for operating relay 539 which is traced from battery through the winding and No. 3 normal contacts of relay 539, No. 3 contacts of relays 540, 537, 538, 525 and 536, over conductor 571, the No. 4 contacts of relay 539, to ground on conductor 570. Relay 539 operates and locks through its No. 3 front contact to ground on conductor 570. The locking contacts of relay 539 close before the operating circuit is opened. The operation of relay 539 causes the release of relays 528, 525, 536, 537, 538 and 540. The release of relay 528 disconnects battery 558 from brush 514 to cause the release of magnet 310. Each of the relays 525 and 536 to 540, inclusive, is slow in operating to insure that the operation of relay 542 and each operation and release of relay 528 will effect a corresponding operation and release of the charging switch 330.

The aforementioned three successive operations of the charging switch 330, effected under the control of the zone relays of repeater R, indicate to the line finder that the called subscriber's station is located in a zone for which three charges are to be made for the call. Assume, now, that the call was initiated by a line entitled to a flat rate service, in which event and as already noted, the normal post springs 324 will have been operated and a ground will have been transmitted over brush 514 to operate relay 542 which locks under the control of relay 552. Therefore, when relay 536 operates to close the circuit of relay 543 which transmits the first charging pulse, the connection of battery 558 to brush 514 is interrupted at the No. 1 contacts of relay 542 which are opened in consequence of the operation of this

relay. The number of pulses transmitted to the charging switch **330** in this case is, therefore, one less than the number transmitted when relay **542** is not operated, that is, in the case of a calling line entitled to individual message rate service.

In the event that the repeater R is equipped with overtime registering apparatus wherein overtime intervals for the connection are charged for at the rate of a definite number of charge units, say the same number which is initially charged when the connection is answered by the called subscriber, battery at the winding of relay **539** and the Nos. 1 and 2 contacts thereof may be placed under the control of said registering apparatus which, operating at the beginning of the overtime interval, opens said battery to cause relay **539** to release. Since relay **552** would still be operated, then, when the battery is reconnected to the winding of relay **539** and the Nos. 1 and 2 contacts thereof by said registering apparatus, the repeater would then operate as before to produce four charging pulses which are transmitted to the charging switch **330**. The locked relay **539** is released again at the beginning of the next overtime interval and the operation is then repeated to produce another set of four pulses.

It will be noted that the polarized relay **307** is included in the circuit of the magnet **310** of the charging switch **330**. In accordance with well-known practice, in the event that the invention is utilized in telephone systems involving two stations per line in which, say, the party on the tip side of the line connects ground to the tip conductor upon initiating a call, the first selector is provided with a relay **323** that, over a circuit (not shown), responds to this ground on the tip conductor and, upon so operating, reverses the direction of current through polarized relay **307**. Now when the charge impulses are transmitted from the repeater or from any circuit adapted to transmit charge impulses in accordance with zone calling or in accordance with elapsed time intervals, not only will magnet **310** and relay **309** operate but polarized relay **307** will operate also, in which event a path is completed for relay **308** which extends from battery through the winding of said relay, contacts of relay **307**, to ground on conductor **300**. Relay **308** operates and locks over its No. 1 contacts to ground on conductor **300** to perform functions noted hereinafter.

The charges for the call are thus made over conductor **317**, each pulse for a charge operating step magnet **310** thus causing the brush **313** of the switch **330** to advance one terminal for each pulse and causing relay **309** to operate and hold between pulses. When charging is completed, relay **309** releases and ground is connected to conductor **318** via ground on conductor **519** from the lower contacts of off-normal springs **517**, **518** of switches **520** and **530**, contacts of relay **309**, upper contacts of off-normal springs **319** of switch **330** to conductor **318**.

In the event that the call is completed through a selector in a local zone for which but one charge is made for the call, relay **304** will not be operated and, upon the operation of relay **301** in response to a current reversal consequent to the called line answering, relay **305** operates from a ground closure on conductor **315** of the interrupter circuit **325** which is only shown schematically. Relay **305** operates and locks under the control of the operated contacts of relay **301** and its own No. 1 contacts. After an interval, ground is applied to conductor **316** and a circuit is thereby completed for relay **306** extending over the No. 4 back contacts of relay **304**, No. 3 contacts of relay **305**, lower winding of relay **306** to battery. Relay **306** operates, locks over its upper winding and No. 2 contacts to ground on conductor **300**, and completes a charging circuit for relay magnet **310** which extends from battery through the No. 5 contacts of relay **306**, No. 2 contacts of relay **305**, No. 5 back contacts of relay **304**, No. 2 back contacts of relay **323**, winding of relay **307**, No. 1 back contacts of relay **323**, winding of relay **309**, winding of magnet **310** to ground. Magnet **310** operates to advance brush **313** one terminal to register the one charge for the call.

When relay **306** operates, the locking circuit of relay **305** is transferred to interrupter lead **316** via the No. 1 front contacts of relay **306**, No. 1 contacts of relay **304**, No. 3 contacts of relay **305**, No. 4 back contacts of relay **304**, to interrupter ground on conductor **315**. When the ground is removed from conductor **316**, relay **305** releases and the charging circuit is opened thereby causing the release of magnet **310**.

The connection of ground to conductor **318** causes the operation of relay **601** in a circuit that extends from ground on said conductor, lower winding of said relay, back contacts of relay **602** to battery. There is one relay **601** for each trunk and this, together with relay **602** which is common to all relays **601**, provides for non-interference in case two or more trunks are simultaneously calling for the recording circuit shown in Figs. 6 and 7. For, with the operation of relay **601** of any trunk over a circuit identical to the one above described, said relay locks over its upper winding and No. 3 front contacts, winding of relay **602** to battery, causing the latter relay to operate and disconnect battery through its back contacts, which battery extends to the lower winding of all relays **601**. Now if another trunk connects ground to its own start conductor **318** and, therefore, to its associated relay **601**, the fact that one relay **601** is already locked in series with relay **602** means that operating battery is disconnected from the lower (operating) winding of all relays **601** until relay **602** releases. This insures that only one trunk at a time can be connected to the recording circuit.

A circuit is now completed for relay **603** which extends from battery through the front contacts of relay **602**, lower winding of relay **603**, back contacts of relay **604** to ground. Relay **603** operates and locks over its upper winding and No. 4 front contacts, winding of relay **604** to ground, thereby causing relay **604** to operate in said locking circuit.

One relay **603** is provided for each group of trunks that serve the same line finder group. These relays, together with relay **604** provide for non-interference between line finder groups inasmuch as the operation of relay **604** in the locking circuit of any one of the relays **603** cuts off the ground required to complete the circuit of any of the remaining relays **603**, thereby effectively locking out all other line finder groups from access to the recording circuit once any particular trunk in a group is locked in with it. When relay **603** is operated, relay **605** operates in a circuit which is completed from ground through the front contacts of relay **604**, No. 3 contacts of relay **603**, winding of relay **605** to battery. Relay **605** operates to mark the line finder group with which the calling trunk is associated, there being other relays such as, for example, relays **606** and **607** designating other and separate groups

that are connected to the contacts of appropriate relays **603** in said different groups for the purpose.

Upon the operation of relay **605** a circuit is completed for relay **605'** which is traced from battery through the winding of said relay, the No. 2 contacts of relay **605**, No. 5 contacts of relay **603**, No. 4 contacts of relay **601**, conductor **608**, to ground on the No. 2 contacts of relay **312**, which latter relay operates or not depending upon whether or not relay **312** has operated to indicate that the calling line is located in the lower terminal bank of the line finder frame. In a similar manner, relay **606'** or relay **607'** will or will not operate in response to the operation of relay **606** or **607**, respectively, to indicate that the call has originated in a line located in the lower terminal bank of the appropriate line finder frame.

When relay **605** operates, ground on its No. 1 contacts is applied to conductor **609** and a circuit is thereupon completed over the No. 1 contacts of relay **603**, No. 1 contacts of relay **601**, conductor **611**, brush **521** of switch **520**, a conductor **531** depending upon the terminal engaged by the brush **521**. Since this brush was stepped in synchronism with the brushes **131**, **132** and **133** in rotary movement when the line finder switch was seeking the vertical level of the calling line, the terminal engaged by brush **521** marks the numerical designation of the particular level of terminals in which the calling line is located. If, for instance, the calling line had been located in the ninth vertical level, causing vertical magnet **343** to take nine steps to reach said level, then brush **521** would be engaging its ninth terminal and grounding conductor **531** as shown. The ground on conductor **531** completes an obvious circuit for vertical select magnet **619** of the crossbar switch **650** which is a structure of the type disclosed in Patent 2,021,329 granted to J. N. Reynolds on November 19, 1935. The operation of select magnet **619** closes an obvious circuit for relay **621** causing said relay to operate. Now, depending upon the terminal set in the level of the line finder bank in which the calling line is located and, therefore, the number of rotary steps taken by brushes **131**, **132** and **133** to reach the terminal set, will determine the terminal engaged by brush **523** of switch **530** since magnet **533** of this switch operated in unison with rotary magnet **344** at the time said last-mentioned magnet operated to step the line finder brushes rotatively to the terminal set of calling line. If, for instance, it is assumed that the calling line is located in the first terminal set, requiring but one step of rotary magnet **344** to rotate the switch brushes to said terminal set, then brush **523** will have likewise taken one step and engaged terminal zero, in which event the operation of relay **621** causes a circuit to be completed extending from ground on the contacts of said relay, No. 2 contacts of relay **603**, No. 2 contacts of relay **601**, conductor **612**, brush **523** and terminal engaged thereby, conductor **544**, winding of hold magnet **660** of crossbar switch **650** to battery. Since select magnet **619** is already operated, the operation of hold magnet **660** is effective in holding closed the cross-point indicated by the dotted box **613** in accordance with the teaching of the above-mentioned patent to J. N. Reynolds.

Calling lines in other levels and other terminals of the line finder frame other than the ones above illustrated will cause the operation of corresponding select and hold magnets as an inspection of the cross-bar switch **630** in Fig. 6 clearly shows. The cross-bar switch **630** is a six-wire switch which thus provides for six hundred terminals, one for each line of three line finder groups of two hundred lines each, which is the grouping ordinarily used with line finder switches equipped with two sets of terminal banks of one hundred terminals each. The vertical columns of these switches represent, as said before, line finder level positions, while the horizontal rows represent the line finder terminal positions. Each of the six contacts of each cross-point of the switch **630** is reserved for a line whose line finder terminal designation corresponds to the numerical designation of the cross-point, and the distinction between a line in the upper bank and a corresponding line in the lower bank is made at the cross-point itself by reserving the upper of two consecutive sets of contacts for the line in the upper bank and the lower set to the line in the lower bank. Since, for three groups of two hundred lines each, there would thus be two lines in each group having the same line finder terminal designation, one in the upper bank and one in the lower bank of each group, it is apparent that all the contact pairs in each of the cross-points of the switch will bear identical numerical designations, the lowest cross-point, closed by select magnet **610** and held by hold magnet **660**, having all its contact sets identified by the number **00** while the highest cross-point closed by select magnet **619** and held by hold magnet **669**, having all its contact sets identified by the number **99**.

Each contact of each contact pair in the cross-bar switch is extended to a terminal in the distributing frame **550** there being, for the switch, six hundred terminals in all and these, in turn, are cross-connected to terminals in the line finder frame **560** in accordance with the directory number of the several lines as shortly to be described. In the event that the cross-point represents a party line, such fact will be known from the operated hold magnet which has a group of additional sets of contacts reserved for this purpose. The armatures of these contacts are connected to block **670** and the contacts of a hold magnet whose cross-points represent the party lines are cross-connected to a relay **566** having two transfer contacts the armatures of which are cross-connected to the appropriate terminals on distributing frame **550** and the back and front contacts to the appropriate directory numbers on terminal frame **560**. The operation of the hold magnet will close an obvious circuit for relay **566** which, upon operating, transfers the ground on the cross-point at terminal on frame **550** to the proper "party" terminal on frame **560**. Hence when the horizontal hold magnet **660** operates, ground is applied over its No. 1 contacts, conductor **614**, No. 4 contacts of relay **605** (or front contact if calling line is in the lower bank), back contacts of relay **605'** to the vertical contact in cross-point **613** thence over a conductor to the terminal of the distributing frame and over to a terminal on the line terminal frame **560**.

The decoding of the line terminal number into the directory number of the line is accomplished through a group of four relays **524**—**527** and one relay **621** for each of twenty-five lines and one group of twenty-five relays **625**—**649** for the whole office which, in the case illustrated, is limited to six hundred lines although the decoding principle is workable for a ten thousand line office. Each relay in the group of twenty-five relays **625**—**649** is assigned to one of the numbers from zero to

twenty-four with relay 625 assigned to zero and relay 649 to twenty-four, the remaining intermediate relays being assigned to corresponding intermediate numbers in consecutive numerical order.

Each relay in each group of four relays 524—527 is equipped with six sets of transfer springs, the back contacts of which are all commoned and connected to the winding of relay 621 associated with one particular group of four relays. The transfer contacts are all connected to individual terminals on the line terminal frame 560, each of said terminals being reserved to one line in the group. Since a group of relays 524—527 and the associated relay 621 are intended to serve a group of twenty-five lines and only twenty-four transfer contacts are provided by the four relays 524—527 of a group, the remaining terminal is provided by the No. 1 continuity set of contacts of the associated group relay 621, the moving contact of which is wired to the line terminal frame 560. Remembering that the twenty-five relays 625—649 are to serve all groups of twenty-five lines, since they are common to the office, each of these relays is wired to a front contact in a corresponding relay in each group of relays 524—527. Thus, if we consider that the relays 524—527 and relay 621 shown in Figs. 5 and 6, respectively, are reserved to the first group of twenty-five lines of the office, namely, lines 000 to 024, inclusive, relay 625 is extended, through the No. 1 front contact of relay 621, to the 000 terminal on frame 560; relay 626 (not shown) to the No. 6 front contact of relay 524 the transfer contact of which is connected to terminal 001 of the frame 560; relay 627 (not shown) to the No. 5 front contacts of relay 524 the transfer contact of which is connected to terminal 002 on frame 560. In the same manner each of the other relays is connected to one of the remaining front contacts in the order indicated up to and including relay 649 which is connected to the No. 1 front contact of relay 527, the cooperating transfer spring of which is reserved to line No. 024 on line terminal frame 560. The twenty-five relays (625—649) are, of course, multiplied to corresponding contacts in each of the groups of four relays (524—527) reserved to each of the other twenty-five line groups in the office whose transfer contacts are wired, in turn, to the line terminal frame 560.

Now in decoding the terminal number of a line into its corresponding directory number, it is necessary to cross-connect the terminal on the distributing frame 550 bearing the line number on the line finder frame with the terminal on the line terminal frame 560 designating the hundreds, tens and units digits of the wanted directory number. Since the present invention is being disclosed with respect to an office limited to six hundred lines, all thousands digits of directory numbers will be zeros and the highest directory number in the office (exclusive of party numbers) will be 0599. Hence when the particular cross-point on switch 650 operates and grounds the conductor individual to the calling line from the front or back contacts of relay 605' (or 606' or 607'), the cross-connection between the terminal on the distributing frame to which the individual conductor is connected and the terminal on the line terminal frame 560 which designates the desired number for directory listing purposes, the ground on the individual line conductor will be applied to one of the back contacts of one of the relays in the group of relays 524—527 involved which, in turn, will complete the circuit of the associated relay 621.

If the individual conductor is connected to terminal 000 in the line terminal frame 560, the ground on said conductor is applied to the winding of relay 621 via its own No. 1 continuity contacts, and when relay 621 has operated, said ground is similarly applied to relay 625 via the No. 1 front contacts of relay 621 causing said relay to operate. On the other hand, if the individual conductor is cross-connected to any terminal other than terminal 000 (or its equivalent in groups of twenty-five) on the line terminal frame 560, relay 621 will operate as before described but relay 625 will not operate. When relay 621 operates, however, ground is applied to conductor 652 which extends to the winding of each of the relays in the group of relays 524—527 associated with the particular relay 621 that operated, causing said relays to operate and close their respective transfer contacts to each of the relays in the group of twenty-five relays 625—649, except relay 625. Now the relay in this group which will be operated will depend, of course, upon which of the twenty-four terminals on frame 560 the individual line conductor is cross-connected, and the operation of relay 621 in any one group of twenty-five lines combined with the operation of a relay in the group of relays 625—649 will ground four conductors that will operate, in succession, four relays in the group of ten relays 730—739 in the register of Fig. 7 that will cause the punching of appropriate respective codes for the thousands, hundreds, tens and units designations of the directory number. The manner in which this is achieved through relay 621 and relays 625—649 is as follows:

Each relay 621 has as many lower contact pairs as will be required to give the thousands, hundreds, and tens and units designation, the last two in accordance with the particular relay in the group of relays 625—649 that was operated from frame 560.

The object in decoding is to operate, in succession, one relay in the group of ten relays 730—739 for each of the digits of the number, depending upon the value of the digit itself. The numerical designation of each of said relays 730—739 is chosen to indicate each one of the ten digits with relay 730 indicating the first or zero digit and relay 739 indicating the last or ninth digit. This group of relays is wired to the contacts of pairs of progress relays in Fig. 7 which, operating and releasing progressively in the manner to be hereinafter described, connect these relays to conductors which extend to the contacts of the relays 621 and/or those of the one relay in the group of relays 625—649 which is operated.

In decoding the thousands and hundreds digits, it will be remembered that each relay 621 represents twenty-five numbers. It is obvious, therefore, that each of said relays may be made to mark arbitrarily the particular thousands and hundreds digit which includes the group of twenty-five lines represented by the relay. Each of these digits may, of course, be anything from 0 to 9 for the thousands depending upon the maximum line number capacity. Hence in order to mark the particular thousands digit of the thousands group that includes the twenty-five numbers designated by any relay 621, a conductor is extended from one of a pair of contacts on said relay 621 to that terminal on block 742 which connects with the armature of that pair of con-

tacts on relay 701, the make contact of which extends to the winding of the one relay in the group of relays 730—739 whose units digit designation corresponds to the particular thousands digit to be designated. Since it has been assumed that, in the specific embodiment of the invention herein disclosed, the exchange is limited to six hundred lines and it may be further assumed, but not as a limitation, that the directory numbers will be no higher than 0599, it is obvious that all relays 621 must be wired to provide a 0-thousands indication. Accordingly, the lowest make contact on relay 621 is connected by a conductor 652 with terminal zero on block 742 which, in turn, extends to the armature of the No. 12 contact set of relay 701, the make of which is connected to the winding of relay 730. For any other thousands digit, of course, said conductor would be connected to the appropriately numbered terminal on block 742 and would lead, through the operated contacts of relay 701, to the appropriately numbered relay in the group of ten relays 730—739.

The hundreds digit is indicated in a similar way. Since each relay 621 marks a group of twenty-five lines, four such relays will control one hundred lines, and it is obvious that each relay, thus belonging to a particular hundred, may be made to indicate the fact by a conductor which connects through the progress relay 703, one of a pair of contacts on said relay 621 with the winding of the particular relay in the group of ten relays 730—739 whose units digit designation corresponds with the hundreds digit of the hundreds group in which said relay 621 belongs. Thus if the relay 621 shown in Fig. 6 is one of four such relays which makes up the one hundred group, the make contact on the next to the lowest contact pair is connected by conductor 653 to the No. 1 terminal on block 726 which terminal, in turn, is connected with the armature of the No. 11 contact set of relay 703, the make of which extends to the winding of relay 731. It will be shown that when a permanent record is to be made of the hundreds digit, assuming it to be the digit 1, relay 731 will be operated to perform this function.

To decode the tens and units number, further consideration has to be given to the fact that the lines are grouped in units of twenty-five each. If we assume any group of one hundred numbers and remember that this group of numbers is represented by four relays like relay 621, the distribution of the lines among the four relays with respect to their tens and units designation is as follows:

Relay	Tens and units line number	Relays
621 (1)	00—09	625—634
	10—19	635—644
	20—24	645—649
621 (2) (not shown)	25—29	625—634
	30—39	635—644
	40—49	645—649
621 (3) (not shown)	50—59	625—634
	60—69	635—644
	70—74	645—649
621 (4) (not shown)	75—79	625—634
	80—89	635—644
	90—99	645—649

Now when a line calls, it will cause the operation of the relay 621 of its own twenty-five line group and one of the twenty-five relays in the group of relays 625—649, and the combination of both of these two operated relays will ground two conductors, one for the tens digit and one for the

units digit which, in the proper succession, and through the progress relays 705 and 707 respectively, will cause, again in succession, the operation of two relays in the group of ten relays 730—739 whose units designations correspond with the tens and units digit to be recorded.

The make contacts of the contact sets 4 to 8, inclusive, in each of the four relays 621 in each group of one hundred lines are wired to the armatures of the relays 625—649 in accordance with the above distribution of numbers and when relay 621 operates, ground is applied to two of the armatures of the relay in the group of twenty-five relays 625—649 which has been operated from the terminal of frame 560. As an example, consider the wiring of relay 621 (1) which is the group relay for the line numbers 00–24, inclusive, that is, operates with the appropriate relay in the group of relays 625—649 when any line in said group of numbers initiates a call. For the first ten numbers (00–09) the zero tens digit must be designated in the order in which relays 625—634 are operated. Consequently, the make of its No. 6 contact set is connected to an upper armature of each relay 625—634, inclusive, the corresponding makes of which are all wired to the zero terminal on block 727 which, in turn, is connected to the armature of the No. 12 contact set of relay 705, its make contact extending to the winding of relay 730. It is obvious, therefore, that when relay 621 operates, and any one of the relays 625—634 operates which fact indicates that the tens digit of the calling line number is zero, relay 730 will operate (through the contacts of relay 705) to designate the tens zero digit. Line numbers from 10–19, inclusive, have a 1 for the tens digit; hence the make contact of the No. 7 contact set of relay 621 is connected to corresponding armatures in each of the relays 635—644 whose make contacts on the other hand are all multipled and connected (connecting conductor omitted) to the No. 1 terminal on block 727 which, in turn, is connected to the No. 11 armature of relay 705, its make contact extending to the winding of relay 731. Line numbers 20–24, inclusive, have a 2 for the tens digit; hence the make contact of the No. 8 contact set is connected to corresponding armatures in each of the relays 645—649 whose cooperating make contacts are all multipled and connected (connecting conductor not shown in the drawing) to the No. 2 terminal on block 727 which, in turn, is connected to the No. 10 armature (not shown) of relay 705, its make contact extending to the winding of relay 732.

The wiring for the units digits designation is similarly carried out in accordance with the above table. It will be observed from said table that relays 625–634 operate consecutively for each of the units digits 0–9, inclusive. Since relay 621 (1) marks the group of lines 00—24, the make contact of the No. 4 contact set of said relay is connected to corresponding armatures in each of the relays 625–634, inclusive. In this case, however, and in contrast with the wiring of this group of relays for the designation of the zero digit, each cooperating make contact on each of said relays is connected to a different terminal on block 728, the cooperating make contact of relay 625 which operates for the line 00 being connected to terminal 0 and thereby causing the operation of relay 730 through the No. 12 contacts of relay 707 as will be shown; the cooperating make contact of relay 626 which operates for the line 01, being connected to terminal 1 and thereby causing the operation of relay 731

through the No. 11 contacts of relay **707** and so on up to and including the cooperating make contact of relay **634** which operates for the line **09** being connected to terminal **9** and thereby causing the operation of relay **739** through the No. 3 contacts of relay **707**. Relays **635—644** operate consecutively for each of the units digits 10–19. Since relay **621** (1) marks the group of twenty-five lines including these numbers, the make contact of the No. 4 contact sets is further connected to corresponding armatures of each of said relays **635—644** and the corresponding cooperating make contacts are each connected to terminals 0–9 respectively on block **728**.

The last four relays **645—649** operate consecutively for each of the last four numbers of the group **20—24** involving units digits 0–4 inclusive. Hence the make contact of the No. 5 contact set of relay **621** (1) is connected to corresponding armatures in each of the relays **645–649**, inclusive, and their respective cooperating make contacts are each connected to terminals 0–4, inclusive, on block **728**, resulting in the operation, as will be shown, of relays **730–734**, inclusive, to designate the respective units digits of the last four line numbers in the group of **00—24** lines.

In the same way, by following the above table, the Nos. 4–8 contact sets of each of the separate relays **621** (2), **621** (3) and **621** (4) are connected to the various relays **625–649**, inclusive, to ground terminals on blocks **727** and **728** to cause the operation of the appropriate relays **730—739** to indicate the tens and units digits.

When, therefore, relay **621** operates, its No. 1 contacts are closed to extend ground on the No. 1 contacts of hold magnet **660** previously traced to a terminal on the "line terminal frame **560**" to the winding of some relay in the group of relays **625—649** causing said relay to operate. The relay which is operated in the group is the one that marks the tens and units number of the calling line, and since the proper relay **621** is likewise operated to mark the thousands and hundreds, the identity of the calling line is ready for recording the same on tape.

The recording circuit shown in Fig. 7 comprises six pairs of progress relays **701—713**, the recording relays **730—739**, relay **741**, and a perforator **710** of known construction having the five punch magnets **1** to **5** and a punch magnet **718**. It is also provided with a relay **716** in the event that a plurality of recording circuits all use the same perforator. When, therefore, a relay in the group of relays **625—649** is operated, as for instance, relay **625**, a circuit is completed for relay **701** which traces from battery through the winding of said relay, No. 1 contacts of relay **702**, No. 1 contacts of relay **625** to ground. Relay **701** operates and connects the windings of relays **730—739** to block **742**. Inasmuch as one of the terminals on this block is grounded by conductor **654** extending to the No. 10 contacts of relay **621** of the group of twenty-five lines containing the calling line and, therefore, marks the thousands digit of the line number in the manner already described, a circuit is thereby completed for one of the relays **730—739**. Since it has been assumed that the number of lines in the exchange is less than a thousand, conductor **654** will be connected to terminal **0** on block **732** whereupon a circuit is completed for relay **730** extending from ground on said terminal, No. 12 contacts of relay **701**, winding of relay **730** to battery. Relay **730** operates to ground conductors which

complete circuits to certain of the magnets of the perforator to operate in the combination required to punch the code of the digit 0 according to the following code:

No.	Punch positions				
	1	2	3	4	5
1	−	−	−	−	+
2	−	−	−	+	+
3	−	−	+	−	+
4	−	−	+	+	+
5	+	−	−	−	−
6	+	−	−	+	−
7	+	−	+	−	−
8	+	−	+	+	−
9	+	−	−	−	+
0	−	−	+	+	−
Period	−	+	−	+	−

The connecting wires to the magnets extend to the right contacts of relay **716** whence they extend to the terminal block **723**. There is further provided another block **724** to which are connected the make contacts in each of the ten relays **730—739** that denote, according to the above code, the digit to be indicated by each of said relays. For instance, relay **730** marks the zero digit and when operated to cause the punching of said digit upon the tape must, according to the above code, produce the operation of punch magnets **3** and **4**. Hence the relay is provided with two sets of contacts that extend to the block **724** from which they are cross-connected to conductors **3** and **4** on block **723** and are grounded when the relay operates. Similarly, relay **739** which marks the ninth digit should cause the operation of magnets **1** and **5**. Hence it is provided with two contact sets, the makes of which extend to the terminals of block **724** from which they are cross-connected to conductors **1** and **5** on terminal block **723** to close partial circuits thereover for punch magnets **1** and **5** when the relay operates. In the same way, each of the intermediate relays is furnished with a number of contact sets appropriate to the respective digital value that each of the relays is to designate.

Now when relay **701** operates, ground is applied over conductor **654**, No. 12 contacts of relay **701**, winding of relay **730** to battery. Relay **730** operates and closes a circuit for relay **716** extending from ground on the No. 1 contacts of relay **730**, right winding of relay **716**, contacts of relay **719** to battery. Relay **716** operates and locks over its left winding and No. 4 front contact, winding of relay **719** to battery. Relay **719** operates and disconnects battery from the operating winding of relay **716** and all other relays **716**, if any, are provided for connecting the perforator with more than one recording circuit. If, however, but one recording circuit is to be used, relays **716** and **719** may be omitted and the conductors extending between the make contacts of the relays **730—739** and **741** and the right armatures of relay **716** may then be directly connected to the armatures of relay **717** and thence to the windings of the perforator magnets.

When relay **716** operates, a circuit is completed for relay **721** which extends from ground on the No. 1 contacts of relay **605**, conductor **609**, through the Nos. 2 and 5 contacts of relay **702**, No. 1 normal contacts of relay **715**, No. 1 contacts of relay **716**, winding of relay **721** to battery. Relay **721** operates and closes a circuit for slow-to-release relay **720** via the No. 1 back contacts of relay **722**, which relay **720** operating, in turn operates relay

717 over an obvious circuit completed through the No. 2 contacts of relay 720, to connect the punch magnets 1 to 5 to the signaling conductors 1 to 5.

With the operation of relay 717, the operated condition of relay 730, causes ground to be applied to conductors 3 and 4, thereby completing two circuits as follows: (1) ground through the No. 3 contacts of relay 730, terminal blocks 724 and 723, terminal 3 on said latter block, conductor 3, No. 7 contacts of relay 716, No. 3 contacts of relay 717, recording magnet 3, left winding of relay 722 to battery; (2) ground through the No. 2 contacts of relay 730, terminal blocks 724 and 723, terminal 4 on said latter block, conductor 4, No. 4 contacts of relay 717, winding of recording magnet 4, left winding of relay 722 to battery. Recording magnets 3 and 4 operate as well as relay 722 which latter locks over its right winding and No. 2 contacts to the contacts of relay 721 and opens the circuit of relay 720. The operated position of relays 721, 722 and 720, however, completes the circuit of the punch magnet 718 over a path that traces from battery through the winding of said punch magnet, No. 2 front contacts of relay 720, No. 1 front contacts of relay 722, to ground on the contact of relay 721. The magnet operates to perforate holes in positions 3 and 4 of the tape which is the code of the digit 0, which is the digit assumed to represent the thousands directory number of all the lines in the exchange.

When relay 720 releases, relay 717 is released also and ground through the No. 1 front contacts of relay 722 (which is locked) is applied over the No. 2 back contacts of relay 720, No. 2 contacts of relay 716, winding of slow-release relay 715 to battery. Relay 715 operates, locks through its No. 1 operated contacts, No. 5 back contacts of relay 702, No. 1 contacts of relay 701, to ground on conductor 609, releases relay 721 and, through its No. 3 front contacts, completes a circuit for relay 702 which extends from ground on said contacts, No. 2 contacts of relay 701, winding of relay 702 to battery. Relay 702 operates and locks over its No. 3 contacts to ground on conductor 609, releases relays 701 and 715, and completes a circuit for relay 703 which traces from battery through the winding of said relay, No. 1 contacts of relay 704, No. 4 contacts of relay 702 to ground on the No. 2 contacts of relay 715. Upon the release of relay 701, relay 730 also releases which, in turn, opens the circuits of the recording magnets 3 and 4 and releases relays 716 and 719, thereby disconnecting the signaling conductors 1, 2, 3, 4 and 5 from the armatures of relay 717. Relay 703 operates and connects the windings of relays 730—739 to the terminals of block 726 to which a conductor 653, grounded by a relay 621, of a group of twenty-five lines that includes the calling line, causes the operation of one of said relays, the relay operated indicating the hundreds digit of the calling lines as already described. As already described, it also causes the reoperation of relays 716 and 719 whereby the signaling conductors are closed through to the armatures of relay 717. The relay in the group of relays 730—739 that operates in response to the ground on conductor 653, grounds the appropriate number of signaling conductors and, in the manner already described, results in the operation of the corresponding number of recording magnets and the punch magnet 715 to punch the code of the hundreds digit.

Relays 705 and 707 are subsequently operated in a similar manner to cause the reoperation of

a relay in the group of relays 730—739 in response to a ground on one of the conductors on block 727 coming from one of the lower contact sets of relay 621 (1) [or 621 (2) or 621 (3) or 621 (4)] and one of the contacts of a relay in the group of relays 730—739 which was operated from block 560, and then the same or different relay in the group of relays 730—739 in response to a ground on block 728 coming from the No. 4 or 5 contact sets of relay 621 (1) [or 621 (2) or 621 (3) or 621 (4)] and one of the contacts of a relay in the group of relays 730—739. Each operation of a relay in the group of relays 730—739 results in the operation of the appropriate number of recording magnets and punch magnet 718 of perforator 710 to punch a series of holes on the tape to represent the code of the tens and units digit respectively.

When relay 708 operates subsequent to the punching of the units code, a circuit is completed for relay 709 which extends from battery through the winding of said relay, No. 1 contacts of relay 711, No. 4 contacts of relay 708, to ground on the No. 2 contacts of relay 715. Relay 709 operates and applies ground through its No. 3 contacts, conductor 725, No. 7 contacts of relay 603, No. 6 contacts of relay 601, conductor 651, to brush 313 of the charging switch 330. Depending upon the terminal to which the brush is engaged, which denotes the number of charges to be made for the call, this ground is applied to one of the ten conductors included in the bracket line 320 and which, in turn, are fanned out among the terminals 0—9 of block 743 in the same numerical order as they are distributed among the terminals of switch 330. The conductor grounded will, of course, cause the operation of a relay in the group of relays 730—739 which, in turn, marks the digit that indicates the number of charges. If, for instance, brush 313 is on terminal 5, relay 735 will be operated and punch magnet 1 will then be operated to punch the code of that digit upon the tape to indicate the number of charges for the call.

The operation of relay 715 following the release of relay 720 completes a circuit for relay 711 which extends from battery through the winding of said relay, No. 2 contacts of relay 709 to ground on the No. 3 front contacts of relay 715. The operation of relay 711 opens the circuit of relay 709 which releases and completes that of relay 713 over a path which traces from battery through the winding of said relay, No. 1 contacts of relay 714, No. 4 contacts of relay 711 to ground on the No. 2 contacts of relay 715. Relay 713 operates and closes an obvious circuit for relay 741 which grounds signaling conductors 2 and 4 to cause the punching of a period code on the tape, which period code will be used for sorting operations as described in the invention covered by my copending application Ser. No. 351,661, filed August 7, 1940.

When the period code is punched and relay 715 operates in the manner above described, relay 714 operates over a circuit which extends from battery through the winding of said relay, No. 2 contacts of relay 713 to ground on the No. 3 front contact of relay 715. Relay 714 operates, releases relay 713, and when relay 715 releases in the manner described, a circuit is completed for release magnet 311, which circuit extends from ground on the No. 2 back contact of relay 715, No. 4 contacts of relay 714, conductor 744, No. 8 contacts of relay 603, No. 7 contacts of relay 601, conductor 671, winding of magnet 311 to battery.

Magnet 311 operates and restores the charging switch 330 to normal.

It should be noted that as long as the charging switch 330 is off-normal, its off-normal contacts 319 are operated and, therefore, the release magnets 534 and 535 of switches 520 and 530, respectively, are open at conductor 321. With this arrangement, when switch 330 is off-normal, switches 520 and 530 cannot release. If they cannot release, ground will be held on conductor 519 of the allotter circuit, thus preventing the reseizure of the off-normal line finder by the allotter circuit until the switches 330, 520 and 530 are restored to normal. By this arrangement the charge will be recorded even though the line finder and first selector may be released, a desirable feature especially in the event that one recording circuit is to be used with a large number of lines. When the switch 330 has been released in the manner described, ground on conductor 346 is applied through the normal contacts of off-normal springs 319, conductor 321, through off-normal contacts 517 and 518 of switches 520 and 530, respectively, to the windings of release magnets 534 and 533 respectively of said switches. When these switches have restored to normal, ground is disconnected from conductor 519 by the opening of the lower contacts of off-normal springs 517 and 518, thereby removing the guard in the connector against the reseizure of the line finder.

The opening of the upper set of contacts on off-normal springs 319 of switch 330 disconnects ground from conductor 318 which serves to release relays 601 and 602. The release of the latter, in turn, releasing relays 603 and 604, thereby disconnects the recording circuit from the message rate trunk. The release of relay 603 causes the release of relays 605 and 605', the removal of ground from conductor 624 thereby, and the restoration of all relays to normal.

When the calling subscriber replaces the receiver, the release of the line relay (not shown) of the connector C2 causes the disconnection of the holding ground potential, thereby causing the release of relay 502 of the selector S, the release of the cut-through relay 341 or 342 of the line finder, and the release of the line and cut-off relay 111 of the calling line. The release of relay 502 closes a circuit for operating the release magnet 508 of selector S, thereby effecting the return of selector S to normal. The release of relay 502 and the release of the cut-through relay 341 or 342 close a circuit for operating the release magnet 349 of the line finder LF—1. This circuit is traced from battery through the upper winding of relay 455 of control circuit LFC—A, through the winding of release magnet 349 of line finder LF—1, No. 5 contacts of relay 341, No. 6 contacts of relay 342, upper front contact of the VON springs 345, conductor 346, through back contacts of relays 501, 500 and 502 of selector S, to ground. Relay 455 operates and then locks through its lower winding and No. 2 contacts under control of the peg count register 456. Relay 455 also connects ground through lamp RLS and conductor 462 to the alarm circuit 460 to cause an alarm in usual manner in case the line finder fails to release within a predetermined interval of time. When the shaft of the line finder reaches normal, the VON springs 345 are restored to normal, releasing magnet 349 and relay 455. The release of relay 455 releases the register 456.

While I have described my invention in connection with its specific application in an automatic telephone system to an exchange involving less than a thousand lines and utilizing specific switch structures, it is to be understood that various other applications and embodiments thereof may be made by those skilled in the art without departing from the spirit of the invention as defined within the scope of the appended claims.

What is claimed is:

1. In a telephone system in combination, a calling line disposed on the terminals of a line finder switch terminal bank, a called line, means for identifying the terminal number of said calling line, means for translating the terminal number of said calling line into an arbitrary directory number, means for establishing a talking connection between said calling line and said called line, a charging switch, impulse means responsive directly upon the answer of the called line for setting said switch in accordance with the charge for said connection, and means for permanently recording said calling line directory number and the setting of said charging switch.

2. In a telephone system, a calling line and a called line, means for establishing a connection between said lines, means operatively responsive to the answer of said called line for producing a number of impulses indicative of a predetermined conversation interval over the connection, means for identifying said calling line, and a recording circuit for permanently recording the identity of said calling line and said number of impulses.

3. In a telephone system, a plurality of offices divided into a number of zones, subscribers' lines in each of said offices, means for establishing a connection between a calling line in an office of one zone and a called line in an office of another zone, means operatively responsive to the answer of the called subscriber and dependent upon the zone within which the office containing the called line is located and the duration of said connection for producing a number of impulses indicative of a predetermined conversation time interval over said connection, means for transmitting said impulses over said connection and means for permanently recording said impulses.

4. In a telephone system, a plurality of offices divided into a number of zones, subscribers' lines in each of said offices, means for establishing a connection between a calling line in an office of one zone and a called line in an office of another zone, means operatively responsive to the answer of the called subscriber and dependent upon the zone within which the office containing the called line is located for producing a number of impulses indicative of the charge to be made for a connection extended to the zone including the called office, means responsive to an overtime interval in the duration of said connection for producing a number of impulses indicative of the charge to be made for said overtime interval, means for transmitting all said impulses over said connection and means for permanently recording all of said impulses.

5. In a telephone system, a plurality of offices divided into a number of zones, subscribers' lines in each of said offices, means for establishing a connection between a calling line in an office of one zone and a called line in an office of another zone, a charging switch in said connection, means operatively responsive to the answer of the called subscriber and dependent upon the zone within which the office containing the called line is lo-

cated for producing a number of impulses indicative of the charge to be made for a connection extended to the zone including the called office, means responsive to an overtime interval in the duration of said connection for producing a number of impulses indicative of the charge to be made for said overtime interval, means for transmitting all of said impulses over said connection to set said charging switch in accordance with the impulses transmitted and means for permanently recording the setting of said switch.

6. In a telephone system, a plurality of offices divided into a number of zones, a calling line in an office of one zone disposed on the terminals of a line finder switch terminal bank, a called line in an office of another zone, means for establishing a connection between said calling line and said called line, means for identifying the terminal number of said calling line, means for translating said terminal number into an arbitary directory number, a charging switch, means operatively responsive to the answer of said called subscriber for producing a number of impulses indicative of the charge to be made for a connection extended to the zone of the office containing called subscriber's line, means responsive to an overtime interval in the duration of said connection for producing a number of impulses indicative of the charge to be made for said overtime interval, means for transmitting all of said impulses over said connection to set said charging switch in accordance with the impulses transmitted, and means for permanently recording said calling line directory number and the setting of said charging switch.

7. In a telephone system, calling subscribers' lines in a first zone arranged for two different classes of service, called subscribers' lines in a second zone, means including a trunk for establishing a connection between a calling line in the first zone and a called line in the second zone, means in said trunk operatively responsive directly upon the answer of the called subscriber for producing a plurality of impulses for transmission over said connection to indicate the charges for the connection, means in said connection responsive to said calling line if it is entitled to one class of service for causing one of said impulses to be canceled, and means for permanently recording the remainder of said impulses to indicate the charge for the connection from said line.

8. In a telephone system, calling subscribers' lines in one zone arranged for two different classes of service, called subscribers' lines in a second zone, means including a trunk for establishing a connection between a calling line in the first zone and a called line in the second zone, means in said trunk operatively responsive to the answer of the called subscriber for producing a plurality of impulses to indicate the charge for the connection, means in said connection dependent upon which of said two classes of service said callling line is entitled for canceling one of said impulses, means for automatically determining the numerical designation of said calling line, and means for permanently recording said numerical designation and the number of impulses which designate the charge.

9. In an automatic telephone system comprising two-motion line finder switches, two auxiliary switches for each of said line finder switches each of which is automatically and sequentially operated in unison with its associated line finder switch when actuated to find the terminals of a

calling line in establishing a talking connection therefrom, another switch operated in response to the establishment of said talking connection to indicate the charge for said connection, a recording device available to all of said line finder switches, means responsive to the establishment of said talking connection for operatively connecting said recording device to the line finder switch used in said connection, and means in said recording device for permanently recording the operated position of each of said auxiliary switches and the adjusted position of said other switch.

10. A telephone number recording system for telephone exchanges in which connections are established between calling and called subscribers' lines by automatic switches including a two-motion finder switch that automatically hunts for the terminals of a line on which a call originates, comprising two rotary switches one for each direction of motion of said finder switch, means for setting each of said rotary switches in unison successively with the operation of said finder switch in selecting the terminals of the calling line to indicate the number of said line, a register settable in accordance with the position assumed by each of said rotary switches, and means for permanently recording the setting of said register upon the response of the called subscriber.

11. In an automatic telephone system comprising in combination, line finder switches adapted for a plurality of different movements to reach the terminals of a calling line, a plurality of settable switches for each line finder, each of said settable switches being operated automatically in unison with its associated line finder switch as it is successively actuated to find the terminals of said calling line, a cross-bar switch having select and hold magnets, means responsive to the setting of each of said settable switches for operating a select magnet and a hold magnet in said cross-bar switch to close a particular cross-point therein, and means responsive to the closing of said cross-point for providing a designation individual to the calling line.

12. In an automatic telephone system comprising in combination, line finder switches adapted for a plurality of different movements to reach the terminals of a calling line, a plurality of settable switches for each line finder, each of said settable switches being operated automatically in unison with its associated line finder switch as it is successively actuated to find the terminals of said calling line, a cross-bar switch having select and hold magnets to each of whose cross-points is connected a conductor individual to a line, means responsive to the setting of each of said settable switches for operating the select magnet and the hold magnet in said cross-bar switch to close the cross-point of the line making the call, means for applying a potential to the conductor at the operated cross-point, and means responsive to said potential on said conductor for producing a designation that identifies said calling line.

13. In an automatic telephone system comprising in combination, line finder switches adapted for two different movements to reach the terminals of a calling line, two settable switches for each line finder, each of said settable switches being operated automatically in unison with its associated line finder as it is successively actuated to find the terminals of said calling line, a cross-bar switch having as many select magnets

as there are terminals of one of said settable switches and as many hold magnets as there are terminals of the other of said settable switches, conductors extending between the terminals of said settable switches and the respective select and hold magnets of said cross-bar switch in the order of their correspondence, a conductor connected to each cross-point of said cross-bar switch, means responsive to the setting of each of said settable switches for operating the select and hold magnets connected to the respective terminals of said settable switches as determined by their unison automatic operation with the associated line finder switch whereby the cross-point fixed by said operated select and hold magnets is closed, means for applying a potential to the conductor at the operated cross-point, and means responsive to said potential for producing a designation that identifies the calling line marked by said cross-point.

14. In a telephone system, in combination with means adapted to register calling line identification and the number of charge units for an established connection from a calling telephone line by marking one and only one conductor in each group of a plurality of groups of conductors, a recording circuit for making a permanent record of the calling line identification and said number of charge units comprising recording means, a group of registers each connectable to said recording means, and means for connecting in succession each of said marked conductors to one of said registers for operating said recording means.

15. In a telephone system, in combination with circuits adapted to register calling line identification and the number of charge units for an established telephone connection by marking one and only one conductor for each digit of the line identification and one and only one conductor for the digit designating the number of charge units, a recording circuit for making a permanent record of the calling line identification and said number of charge units comprising a plurality of recording magnets, a group of registers each of which designates a particular digit, circuits completed from each of said registers when operated for operating some of said magnets in combinations to record the digit characterized by the operated register, and means for connecting said marked conductors in succession to the appropriate ones of said registers for operating said registers.

16. In a telephone system, in combination with circuits adapted to register the digits of a calling line number and the number of charge units for an established telephone connection by marking one and only one conductor in each of a plurality of groups of conductors reserved for the several digits of the calling line number and one and only one conductor in a group of conductors reserved for the number of charge units, a recording circuit for making a permanent record of the digits of said calling line number and the number of charge units comprising a group of relays for each of said groups of conductors, a group of registers operatively connectable to each of said groups of relays whereby the marked conductor in said group completes an operating circuit for one of said registers, a settable perforator adapted to produce a punched tape in response to a definite setting, means for connecting said perforator to an operated register whereby a setting of said perforator is produced in response to the operated condition of said register, means for operating each of said groups of relays in succession for connecting the associated group of conductors to said group of registers whereby one of said registers is caused to be operated by the marked conductor in the group of conductors, and means for successively connecting said perforator to each of said operated registers.

17. In a telephone system, in combination with circuits adapted to register the digits of a called line number and the number of charge units for an established connection by marking one and only one conductor in each of a plurality of groups of conductors reserved for the several digits of the calling line number and one and only one conductor in a group of conductors reserved for the number of charge units, a recording circuit for making a permanent record of the digits of said calling line number and the number of charge units comprising a group of two relays for each group of conductors to the contacts of one of which relays said conductors are connected, a group of ten digit registers connectable with each of said group of conductors through the contacts of each of the relays to which a particular group of conductors is connected when each of said relays is operated, whereby the marked conductor in the group completes an operating circuit for the register to which it is connected, a perforator comprising five recording magnets and a punch magnet for producing a punched tape, a group of conductors connected to each of said registers and means for completing a partial circuit path over each of said conductors upon the operation of each of said registers, means for operating the first relay in a group of two relays for connecting the associated group of conductors to said group of digit registers and for operating the register connected to the marked conductor in the group, means responsive to the operation of a register for connecting the conductors thereof to the recording magnets of the perforator in the code combination required to record the digit designated by the operated register whereby said partial circuits are completed through the recording magnets to operate the same, means responsive to the operation of said recording magnets for operating said punch magnet, means responsive to the operation of said punch magnet for operating the second relay in a group of two relays whereby said first relay is released to disconnect one group of conductors from said digit registers and the first relay of a succeeding group of two relays is operated to connect the associated group of conductors to said group of digit registers for a register therein.

18. In a telephone system, in combination with circuits adapted to register the digits of a called line number and the number of charge units for an established connection by marking one and only one conductor in each of a plurality of groups of conductors reserved for the several digits of the calling line number and one and only one conductor in a group of conductors reserved for the number of charge units, a recording circuit for making a permanent record of the digits of said calling line number and the number of charge units, comprising a group of two relays for each group of conductors to the contacts of one of which relays said conductors are connected, a group of ten digit registers connectable with each of said group of conductors through the contacts of each of the relays to which a particular group of conductors is connected when each of said relays is operated, whereby the marked conductor in the group completes an op-

erating circuit for the register to which it is connected, a perforator comprising five recording magnets and a punch magnet for producing a punched tape, a group of conductors connected to each of said registers and means for completing a partial circuit path over each of said conductors upon the operation of each of said registers, means for operating the first relay in a group of two relays for connecting the associated group of conductors to said group of digit registers and for operating the register connected to the marked conductor in the group, means responsive to the operation of a register for connecting the conductors thereof to the recording magnets of the perforator in the code combination required to record the digit designated by the operated register whereby said partial circuits are completed through the recording magnets to operate the same, means responsive to the operation of said recording magnets for operating said punch magnet, means responsive to the operation of said punch magnet for operating the second relay in a group of two relays whereby said first relay is released to disconnect one group of conductors from said digit registers and the first relay of a succeeding group of two relays is operated to connect the associated group of conductors to said group of digit registers for operating a register therein, and means responsive to the operation of all of said groups of two relays for operating the recording magnets and the punch magnet of said perforator for punching an arbitrary designation on the tape following the punching of the digit designating the number of charge units.

19. In a telephone system adapted for the automatic recording of connections including the identification of a calling line number and in which the lines are divided into groups, a translating circuit for said lines comprising a group of relays for each line group and a common group of relays for all lines, means responsive to a line making a call for operating a relay in the associated line group to designate the thousands and hundreds digits of the calling line number, means for operating the remaining relays in the line group, and means responsive over one of said operated relays of the line group for operating a relay in said common group of relays for designating the tens and units digits of the calling line number.

20. In a telephone system adapted for the automatic recording of connections including the identification of a calling line number and in which the lines of the system are divided into groups, a translating circuit for said lines comprising a group of relays for each line group and a common group of relays for all lines, four groups of marking conductors, means responsive to a line making a call for operating a relay in the associated relay group to mark a conductor in each of two groups of said four groups of conductors to designate the thousands and hundreds digits, respectively, of the calling line number, means responsive to the operation of said relay for operating the remainder of the relays in said line group of relays, means responsive to the operation of one of said relays in said line group of relays for operating a relay in said common group of relays, and means jointly controlled by the operated relay in the common group and by the first operated relay in the line group for marking a conductor in each of the two remaining groups of said four groups of conductors to

designate the tens and units digits, respectively, of the calling line number.

21. In a telephone system adapted for the automatic recording of connections including the identification of a calling line number and in which the lines of the system are divided into groups, a translating circuit for said lines comprising a conductor for each line, a group of relays for each line group and a common group of relays for all lines, four groups of marking conductors, means responsive to a line making a call applying a potential to the conductor associated with the calling line for operating a relay in the associated relay group, means controlled by said relay for marking a conductor in each of two groups of said four groups of marking conductors to designate the thousands and hundreds digits, respectively, of said calling line number, means controlled by said operated relay for operating the remaining relays in the relay group, whereby the potential on said line conductor is effective over one of said last operated relays to operate a relay in the common group of relays, and means jointly controlled by said first operated relay in the line relay group and said operated relay in the common relay group for marking a conductor in each of said remaining two groups of four marking conductors for designating the tens and units digits, respectively, of the calling line number.

22. In a telephone system adapted for the automatic recording of connections including the identification of a calling line number and in which the lines of the system are divided into groups of twenty-five lines each, a translating circuit for said lines comprising a conductor for each line, a group of five relays for each line group and a common group of twenty-five relays for all lines, four groups of marking conductors, means responsive to a line making a call for applying a potential to the conductor associated with the calling line for operating a relay in the associated relay group, means controlled by said relay for marking a conductor in each of two groups of said four groups of marking conductors to designate the thousands and hundreds digits, respectively, of said calling line number, means controlled by said operated relay for operating the remaining four relays in the line relay group whereby the potential on said line conductor is effective over one of said four operated relays to operate a relay in said common group of relays, and means jointly controlled by said first operated relays and said common relay group for marking a conductor in each of said remaining two groups of four marking conductors for designating the tens and units digits, respectively, of the calling line number.

23. In a measured service telephone system wherein a group of subscribers' lines receive different classes of charge service in terms of charge units for different connections, means for charging some of said lines one charge unit for every completed connection, means for charging other of said lines the prescribed charge unit rates for calls to other zones, means for charging yet other lines a flat rate for a prescribed number of completed connections, means for charging said other lines one charge unit less than the prescribed rate for a connection involving a rate of more than one charge unit, and means for making a permanent record of the charges for the different connections from all of said lines.

24. In a measured service telephone system wherein a group of subscribers' lines receive dif-

ferent classes of charge service in terms of charge units for different connections, means for extending connections from said lines, a charging switch in said connection extending means, means for operating said switch directly in response to the called party answering on a completed call to a called line, the number of times said switch is operated being dependent upon the location of the called line and the class of service said calling line receives, and means for making a permanent record for each connection in which said connection extending means are used of the number of times said switch therein is operated for each connection.

25. In a measured service telephone system wherein a single group of subscribers' lines receive different classes of charge service in terms of charge units for different connections, there being both individual and two-party lines in said group of lines, means for extending connections from said lines, a charging switch in said connection extending means including other means for discriminating between which of the parties of a two-party line initiates a call, means for operating said switch directly upon the called party answering on a completed call to a called line and for operating said other means in the event that a party of a two-party line has initiated a call, the number of times said switch is operated being dependent upon the location of the called line and the class of service said calling line receives, means for identifying the designation of the calling line, and means for making a permanent record for each connection of the calling line identity including the party line indication if said other means has operated and the number of times said charging switch has operated.

26. In a measured service telephone system, a group of subscribers' lines, means for extending a connection from a calling line in said group to a called line, a charging switch in said connection extending means, a plurality of conductors extending to said charging switch, means directly responsive to the response of a called line for operating said charging switch to engage a particular one of said conductors in accordance with the location of the called line, means controlled over said engaged conductor for registering the digital designation of said conductor and means for making a permanent record of said digital designation.

27. In an automatic telephone system, a group of subscribers' lines, means for extending a connection from one of said lines to a called line, and a recording circuit for said lines operably connectable to said connection extending means comprising means for identifying said calling line, means for registering the charge for said connection directly upon the answer of the called line, means for initiating the making of a permanent record of said calling line identity and the charge for said connection pending the duration of said connection, and means for precluding the seizure of said connection extending means and said recording circuit operatively connected thereto by another calling line until said permanent record is made.

28. In an automatic telephone system, a group of subscribers' lines, means for extending a connection from one of said lines to a called line, and a recording circuit for said lines operably connectable to said connection extending means comprising means for identifying said calling line, means for registering the charge for said connection directly upon the answer of the called line, means for initiating the making of a permanent record of said calling line identity and the charge for said connection pending the duration of said connection, and means responsive to said calling line restoring for rendering said connection extending means and said recording circuit operably connected thereto non-connectable to other calling lines until said permanent record for said calling line is made.

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