

June 17, 1930.

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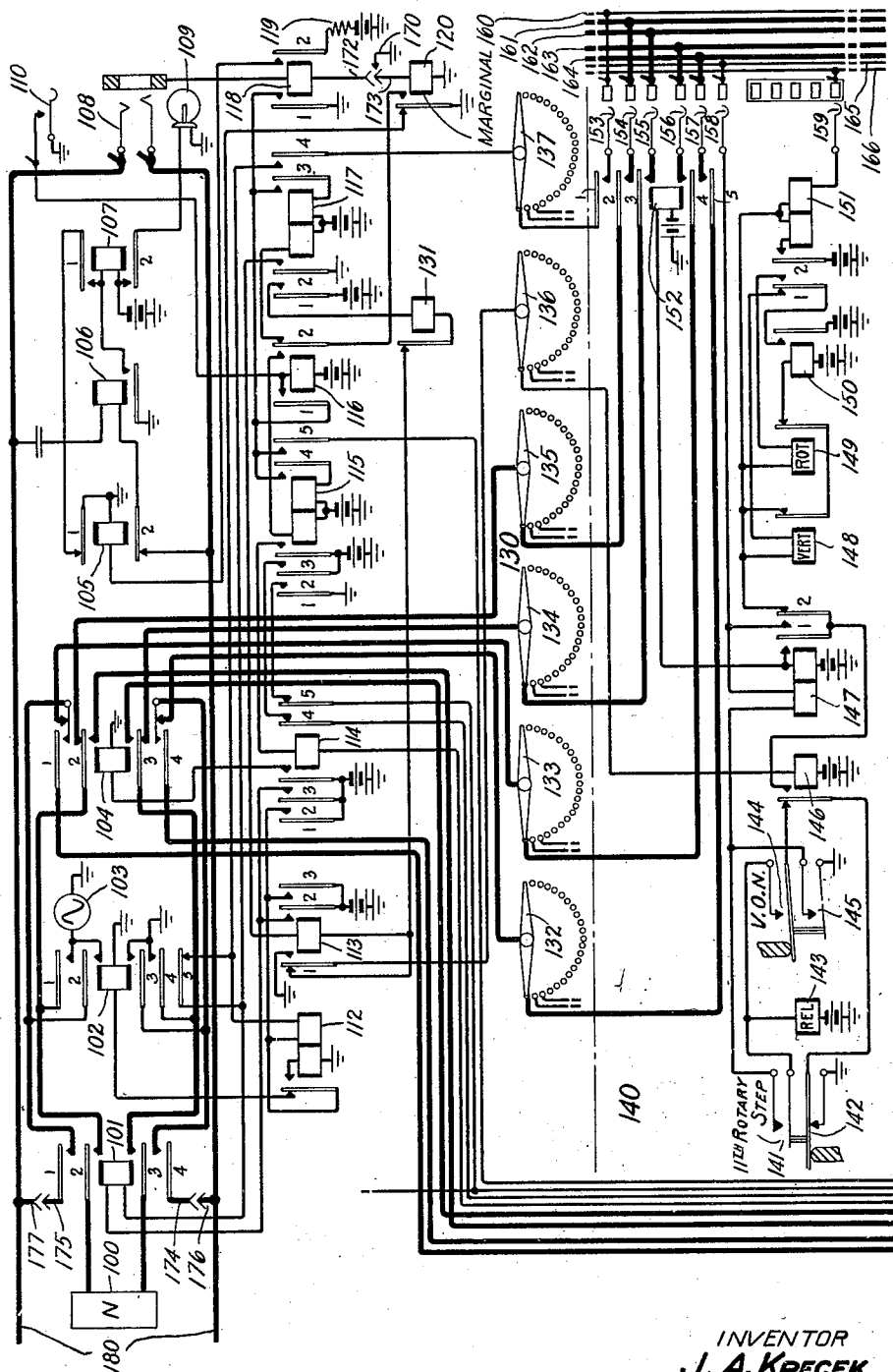
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TELEPHONE SYSTEM

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6 Sheets-Sheet 1

Fig. 1



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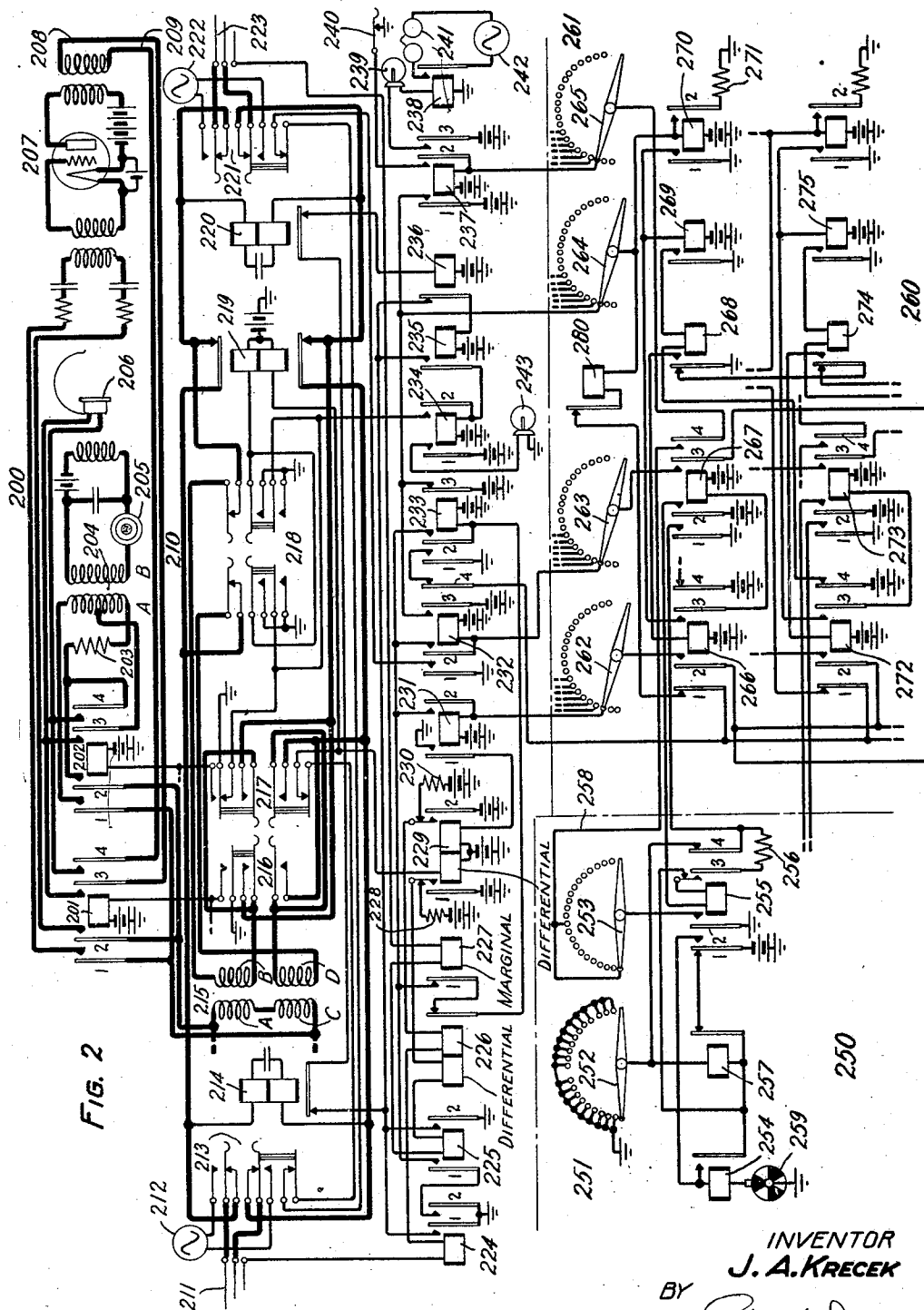
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TELEPHONE SYSTEM

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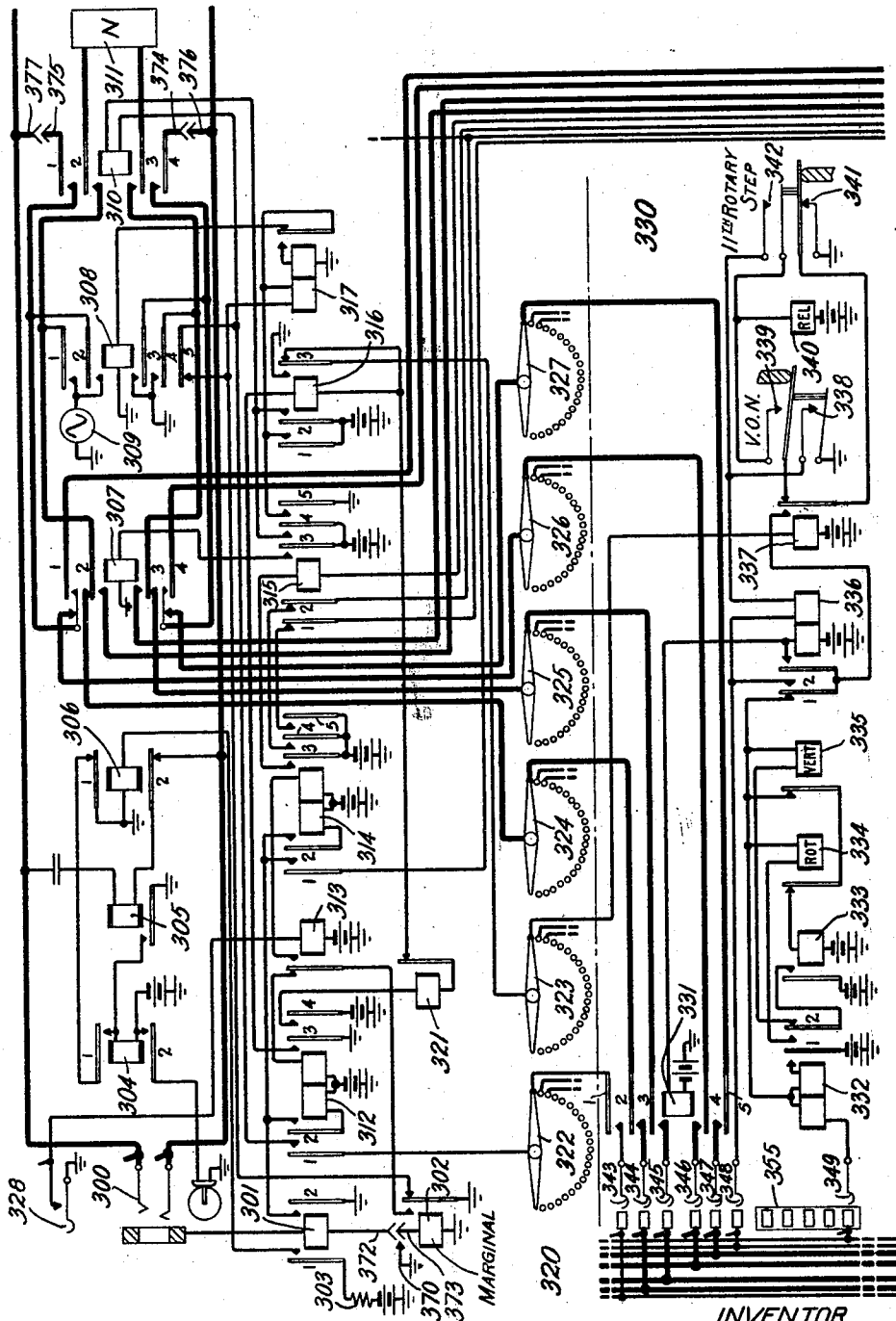
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FIG. 3



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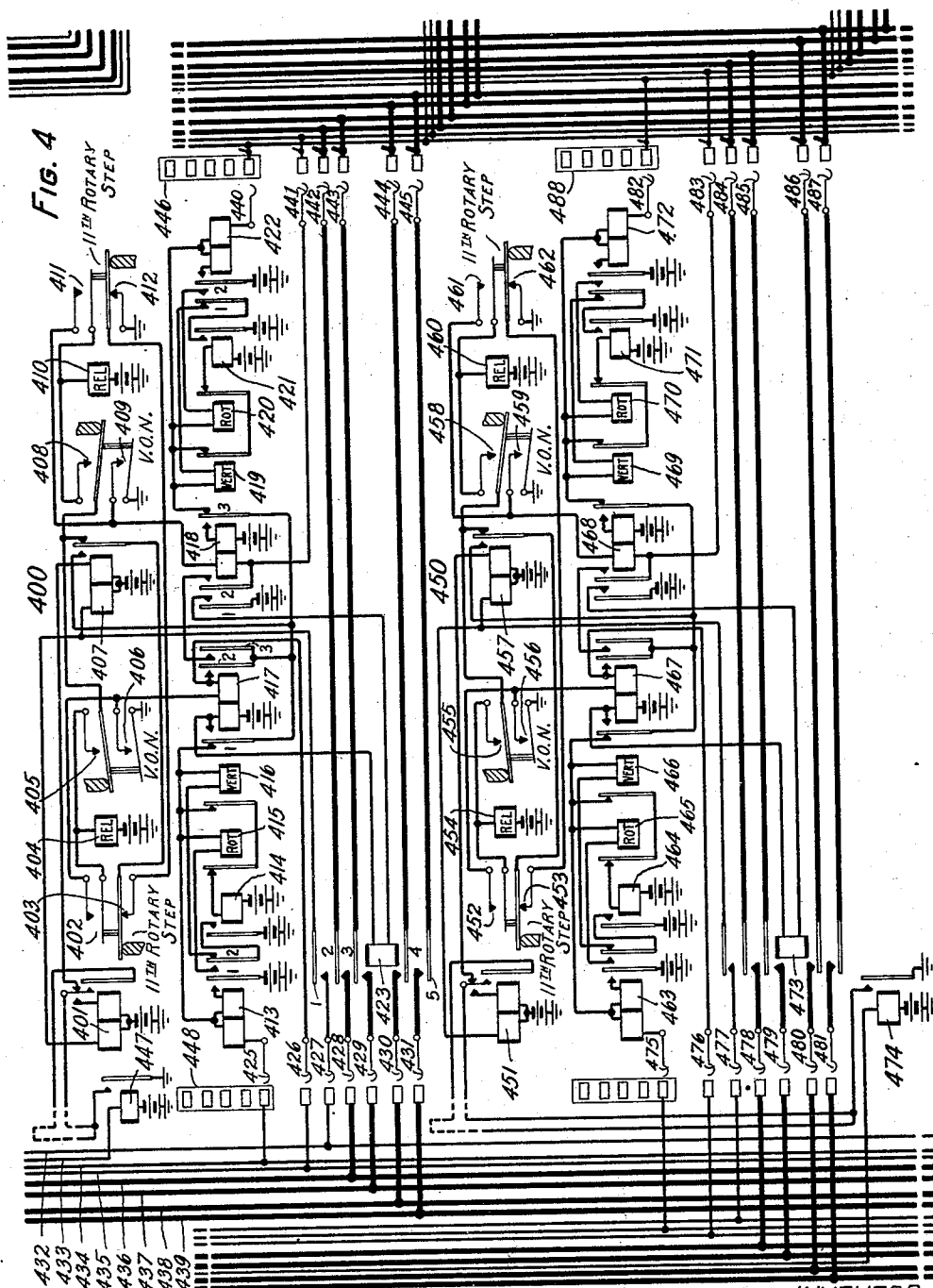
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TELEPHONE SYSTEM

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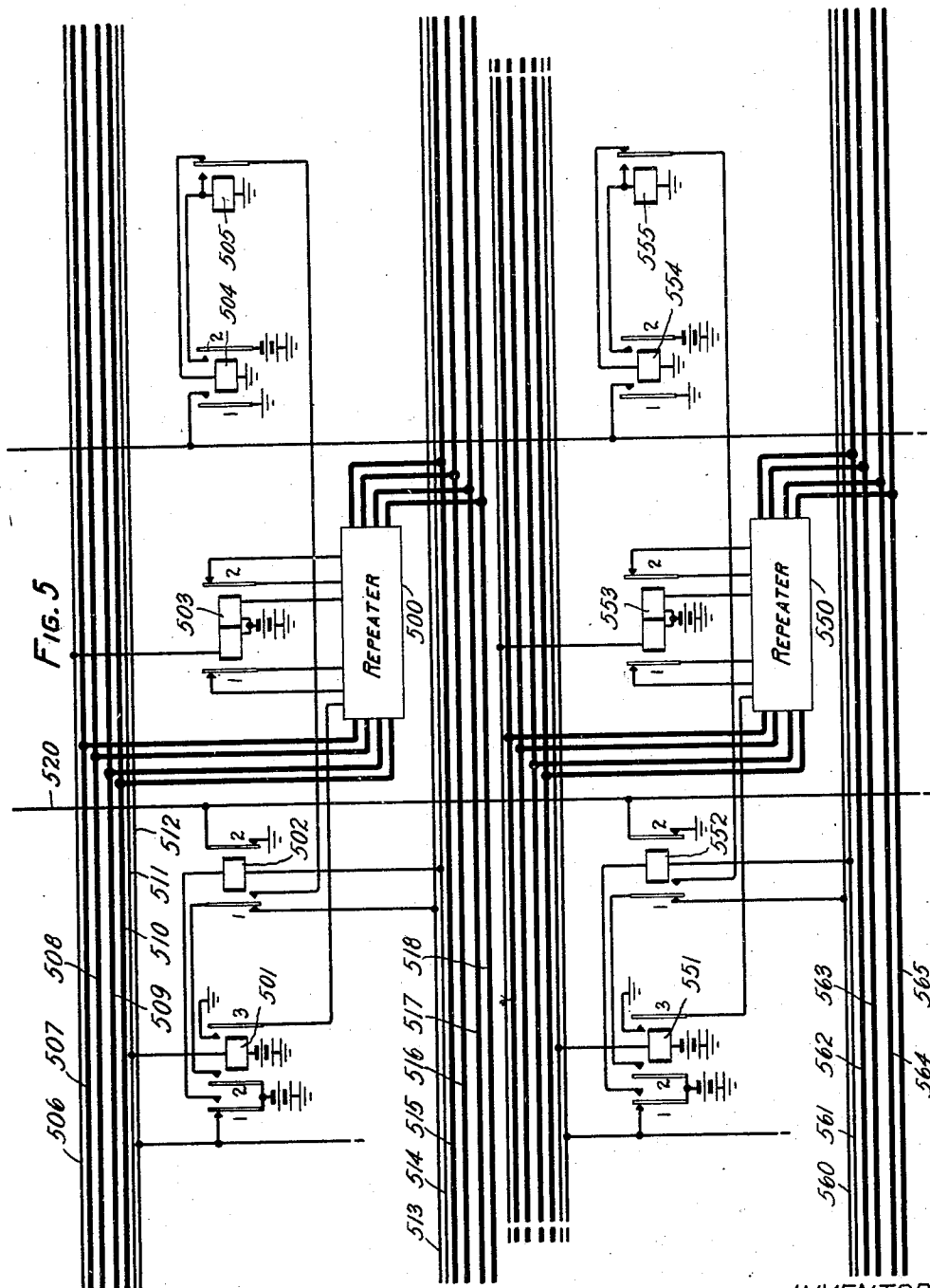
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TELEPHONE SYSTEM

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TELEPHONE SYSTEM

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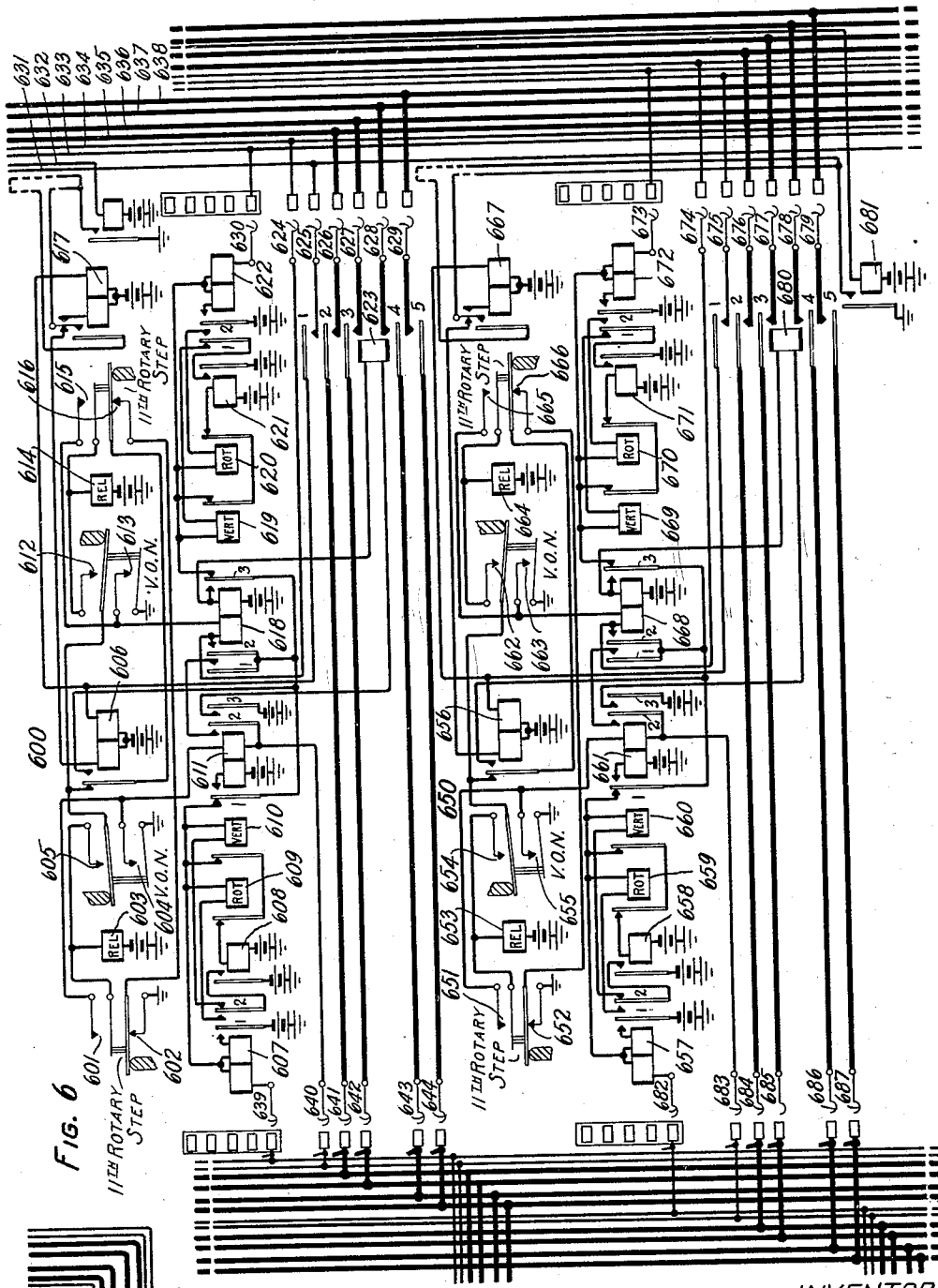


Fig. 6

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TELEPHONE SYSTEM

Application filed October 20, 1928. Serial No. 313,665.

This invention relates to telephone exchange systems. More specifically it relates to the automatic selection of speech amplifying apparatus and the insertion of this apparatus between toll lines.

Systems such as those disclosed in Patents No. 1,647,796 issued to L. L. Glezen—S. P. Shackleton—E. Vroom, November 1, 1927; No. 1,708,982 issued to E. Vroom—J. A. Krecek, April 16, 1929; No. 1,708,983 issued to E. Vroom—F. S. Entz, April 16, 1929; No. 1,725,323 issued to E. Vroom—F. S. Entz, August 20, 1929 and No. 1,738,302 issued to J. A. Krecek, December 3, 1929 have been devised for automatically inserting repeating amplifiers in line connections. In these applications toll cord circuits are arranged for discriminating between toll lines that require the addition of repeaters and toll lines that do not require such an addition. In general, the arrangement is such that an automatic discrimination is made between the two kinds of toll lines, when a cord circuit is employed to interconnect the lines. When a repeater is required this discriminating arrangement functions to start the automatic selection and connection of the repeater between two lines. A selecting mechanism or repeater selector is associated with each cord circuit so arranged as to be automatically started by the discriminating means to search for and seize an idle repeater, a plurality of repeaters being provided for the common use of said cord circuits. The repeater selected by the cord circuit is marked thereby, in order that the selected repeater may be identified by the lines to be connected therewith. Apparatus in the line circuits connected to the cord circuit is operated in response to the action of the cord circuit discriminating apparatus. The operation of this line apparatus actuates selecting switches for the selection of the idle repeater as identified by the cord circuit markings.

One embodiment of this invention comprises, means in a cord circuit interconnected between two lines for identifying lines that require the addition of a repeater and means in lines of a particular character operable

in response to a certain operation of this identifying means for actuating line apparatus to search for and seize an idle repeater and interconnect the seized repeaters between the lines.

In accordance with this invention the operation of differentially connected and marginal relays in a cord circuit is controlled by the line circuit apparatus with which the cord circuit is connected. When a cord circuit is connected to the lines that require a repeater the differential and marginal relays are operated and released to form a circuit combination that simultaneously actuates the apparatus of the connected line circuits to search for and connect therewith an idle repeater. A common group of repeaters is provided for the lines. Switching apparatus in the outgoing line searches through the group of repeaters for an idle repeater which is seized when found. Apparatus in the repeater is operated in response to this seizure for marking a set of terminals for the repeater finder of the incoming line. An idle finder in a group of finders associated with each line is actuated by the incoming line to find said incoming line and find the seized repeater. In response to the foregoing seizure and selection, apparatus in each line is operated to direct the transmission circuit of the lines through the repeater.

Fig. 1 in its upper portion illustrates two toll line circuits, one requiring the addition of a repeater and one not requiring such addition. A repeater selecting switch is shown in the lower portion of Fig. 1;

Fig. 2 illustrates a toll cord circuit with an associated telephone circuit and an amplifying circuit for monitoring purposes. In the lower left portion of Fig. 2 a timing circuit is shown for use in connection with the position finder circuit shown in the right lower portion of this figure.

Fig. 3 illustrates optional line circuits the same as shown in Fig. 1;

Fig. 4 illustrates two groups of repeater and line finding links, one in the upper portion of the drawing and one in the lower portion;

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Fig. 5 illustrates the repeater circuits of a common group for selection by the lines;

Fig. 6 illustrates link circuits the same as shown in Fig. 4.

5 The switches 130, 251, 261 and 320 are of a self-interrupting type well known in the art. The switches 140, 400, 450, 330, 600 and 650 are shown as the Strowger type step-by-step switch well known in the art. Switches
10 of any type, however, may be used in place of the switches shown.

General description

15 Considerable apparatus is required in a toll exchange for automatically interconnecting repeaters between toll lines. For this reason economy has been effected in the circuit arrangement disclosed herein by dividing the lines into groups for incoming service and
20 permitting the same lines to be in a common group for outgoing service. This may be explained in detail as follows: When a line is associated with a cord circuit as an outgoing line, a step-by-step switch such as 320 is actuated which has access to trunks extending
25 to the movable brushes of step-by-step Strowger type switches. The terminals of the Strowger switches are connected to repeaters in a common group serving the lines of the office. The foregoing switches of the outgoing line can therefore be operated to search for and seize any idle repeater in the office. Each toll line also has associated there-
30 with a group of double ended link circuits, one end of which finds the repeater seized by the outgoing line and the other end of which finds the incoming line. A large group of lines is associated with a comparatively smaller group of link circuits. Links 400,
35 450, 600 and 650 each represent a group. The switching apparatus of a line over which a call is incoming is operated to select an idle link in the group of links serving this group of lines. One end of the link has access to
40 all of the repeaters whereas the alternate end of the link only has access to a divisional group of lines. By the use of this circuit arrangement which pyramids the selecting circuits, a smaller number of repeaters is re-
45 quired for a large number of lines than would be required with other systems known in the art. The speed with which repeaters may be selected is not reduced by this circuit arrange-
50 ment since both the incoming and outgoing lines are simultaneously actuated for selecting the required repeater. If a link steps beyond the level in which a repeater has been selected by an outgoing line and therefore does not find the selected repeater, it will re-
55 store to normal in the well known manner and find the selected repeater upon a second attempt. The circuit is, however, arranged so that the probability of a second operation of the link switch is quite remote.

65 The lines incoming to a toll office vary in

characteristics, some of which require the insertion of a repeater for speech application and others of which do not. The lines that require the addition of a repeater must be characterized differently from the lines that do not require this addition in order that automatically operable apparatus in the cord circuit can distinguish the character of the lines interconnected by a cord circuit. A repeater is only required when two lines of the same particular characteristic are connected together. When lines having different characteristics are connected together no repeater is required. All of the cord circuits in a switchboard position are arranged as shown
70 in Fig. 2. The apparatus of the lines, however, is quite different since lines not requiring the addition of a repeated are not equipped with repeater selecting apparatus.

Optional line circuits are shown in Figs. 1 and 3. The line circuits not requiring the addition of a repeater have the windings of relays 118 and 301 connected directly to ground through conductors 170 and 370 respectively. All other apparatus not permanently connected to the line conductors is omitted. The line circuits requiring the addition of repeaters have the windings of relays 118 and 301 connected to the windings of relays 120 and 302 through conductors 173 and 373 and have conductors 174, 175, 374 and 375 connected to conductors 176, 177, 376 and 377 respectively.

A call may enter a toll switchboard position over line conductors 180 or may be transferred to the position over a multiple of these conductors. Assuming then that a call enters a position over line 180, relay 106 is operated from ringing current applied thereto. The operation of relay 106 operates relay 107 which locks through its contact 1 to ground at contact 1 of relay 105. Line lamp 109 is lighted over a circuit extending through contact 2 of relay 107. The switchboard operator observes the call signal and inserts plug 211 or a plug associated with a similar cord circuit into jack 108. A circuit is thus established for operating the relays 118, 224 and 226. The circuit for these relays may be traced from ground through the winding of marginal relay 120, winding of relay 118, sleeve of jack 108, and plug 211, winding of relay 224, right winding of relay 226, normal contact 2 of relay 229, resistance 230, to battery. The marginal relay 120 does not operate in the circuit traced. The operation of relay 118 establishes a circuit for operating relay 105 from battery through resistance 119, contact 2 of relay 118, winding of relay 105 to ground. The operation of relay 105 opens the locking circuit for relay 107 which releases and also opens the circuit extending through the winding of relay 106. The release of relay 107 opens the circuit for lamp 109 which is extinguished. The operation of
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relay 224 establishes an energizing path for relay 236 from ground through contact 1 of relay 224, normal contact of relay 214, normal contact of relay 220, winding of relay 236 to battery. Relay 236 controls supervisory lamp 243 and its function will be hereinafter described. The operation of relay 226 opens the circuit extending to relay 233 in order to place the latter relay under the joint control of both interconnected lines.

At this time the switchboard operator actuates key 217 for associating the telephone set with the incoming line. The actuation of key 217 establishes an obvious energizing circuit for relay 202. The operation of relay 202 associates the telephone set transmitter and receiver, through high impedance coil 215, with the incoming line. The operator obtains the wanted line designation from the calling party and inserts plug 223 into jack 300 of a line such as shown in Fig. 3.

Key 110 is individual to the line and is operated if the line is used for an incoming call but is not operated if the line is used for an outgoing call. This key may be operated by a transfer operator or by the operator completing the connection. The operation of key 110 in Fig. 1 establishes an obvious circuit for operating relay 116, which locks through its contact 1 to ground at contact 1 of relay 118. A circuit is thus prepared for the operation of relay 115 which is effective upon a circuit change in the cord circuit when it has found that a repeater is required. If a repeater is not required, this circuit change is not made and the line apparatus remains positioned as previously described until the connection is terminated.

The insertion of plug 223 into jack 300 establishes a circuit for the operation of relays 301 and 225. This circuit may be traced from ground through the winding of marginal relay 302, winding of relay 301, sleeve of jack 300 and plug 223, winding of relay 227, winding of relay 225, left winding of relay 226, contact 1 of relay 229, to battery through resistance 228. Relays 302 and 227 are marginal and do not operate in the circuit traced. The operation of relay 301 does not establish any circuit at this time. Relay 226 has its windings differentially connected so that the circuit established through its right winding nullifies the effect of the circuit through its left winding. This relay therefore releases.

When a cord circuit is connected with lines of different character the current through the windings of relay 226 is not equalized and this relay remains operated. If the outgoing line has a low resistance sleeve circuit with relay 302 omitted, an operating circuit is established for relay 227. In either case a repeater is not selected. Therefore relays 226 and 227 distinguish between lines requiring a repeater and those that do not, and thus control circuit changes for either causing a

repeater to be selected and inserted between the toll line or for preventing the selection of a repeater.

Let it be assumed that a repeater is required between the lines of Figs. 1 and 3. Relay 227 remains normal and relay 226 is released. A circuit is thus established for operating relay 233 from battery through its winding, normal contact of relay 226, normal contact of relay 227, contact 1 of relay 225, contact 2 of relay 224 to ground. Relay 233 in operating establishes a locking circuit for itself through its contact 2, to ground through contact 1 of relay 225 and contact 2 of relay 224. The operation of relay 233 removes battery from a particular terminal associated with brush 264 of switch 261. The cord finder circuit 260 and timing circuit 250 are used to prevent a cord circuit from being connected to lines longer than an allotted time when an idle repeater cannot be found. Circuits are also established from the repeater to the cord finder for releasing the cord circuit apparatus when a telephone conversation is terminated. This apparatus does not, however, serve in locating an idle repeater since the selection of an idle repeater is made by the line apparatus.

The operation of relay 233 further establishes a circuit for operating magnet 280 which may be traced from ground through contact 1 of said relay, normal contact 4 of relay 232, normal contact 1 of relay 266, contact and winding of stepping magnet 280, brush 264 to battery connected to all the terminals excepting the terminal associated with the cord circuit desiring a connection. When brush 264 reaches a terminal not connected to battery, the circuit for magnet 280 is opened and relay 270 which has heretofore been shunted by battery on the busy terminals is now permitted to operate. The stepping magnet 280 does not receive sufficient current when in series with relay 270 to cause its operation. Relay 270 in operating establishes a locking circuit for itself through its contact 2 and resistance 271. Relay 270 also establishes an obvious operating circuit for relay 269. Relay 269 establishes a circuit for operating relay 268 from ground through its contact, winding of relay 268, to battery through normal contact 4 of relay 272. The operation of relay 268 establishes an obvious operating circuit for relay 266. Relay 266 establishes an obvious operating circuit for relay 267. At contact 1 of relay 266 the circuit for magnet 280 is opened. At contact 2 of relay 266 a circuit is established for relay 231, from ground through contact 2 of relay 502, and relay 552, or any idle repeater, extending through brush 262 and the winding of relay 231 to battery.

The timing circuit 250 is operated by the association of ground through contact 1 of relay 267, contact 4 of relay 255, winding and contact of stepping magnet 257 to battery

through contact 1 of relay 255. When the magnet 257 attracts its armature, relay 255 is permitted to operate for establishing interrupter control for the timing circuit. The circuit for relay 255 may be traced from battery through contact 2 of relay 267, winding of relay 255, normal contacts 3 of relay 255, winding of magnet 257, normal contacts 4 of relay 255, to ground through contact 1 of relay 267. Relay 255 in operating establishes a locking circuit for itself through its contact 3 and resistance 256. The brush assembly is advanced one step and a circuit is established through contact 1 of relay 255, winding of relay 254 and the associated constantly rotating interrupter 259 which is intermittently connected to ground. Ground is connected to brush 253 through contact 2 of relay 255, for the purpose of sounding an alarm after a predetermined time interval. Upon each association of a grounded segment of interrupter 259 with the winding of relay 254, a circuit is established for operating the latter relay, since its winding is now connected to battery at contact 1 of relay 255. The operation of relay 254 connects battery through its contact and the winding of stepping magnet 257 to ground through brush 252 and its associated contact. The switch 251 thus continues to rotate until brush 253 is associated with conductor 258 which will occur unless relay 255 is previously released.

Let it be assumed that no idle repeater is available and that brush 253 is connected with conductor 258. A circuit is thus established from ground at contact 2 of relay 255, through brush 253, conductor 258, contact 4 of relay 267, brush 265 and its associated contact, winding of relay 237 to battery. Relay 237 establishes a locking circuit through its contact 2 to ground at key 240. Relay 237 further establishes a circuit through its contact 3 to operate relay 238 and light lamp 239. The operation of relay 238 establishes a circuit from alternating source 242 through bell 241 for sounding an alarm. Battery is connected through contact 1 of relay 237, brush 264 and its associated contact to the winding of relay 270 for releasing relay 270 by the shunt method. The apparatus of the cord finder circuit and timing circuit is released in consequence of the release of relay 270. Two sets of relays individual to cord circuits are shown in the cord finder 260.

As previously explained when a repeater is available ground is connected through brush 262 for operating relay 231, and the timing circuit slowly advances. Relay 231 in operating establishes a locking circuit for itself through its contact 2 to ground through contact 1 of relay 225 and contact 2 of relay 224. Relay 231 also establishes an obvious circuit through the right winding of relay 229, for operating the latter relay. The operation of

relay 229 eliminates resistances 228 and 230 from the circuits previously traced through the sleeve relays of the lines in Figs. 1 and 3. The current flow through the sleeve relays is thus sufficiently increased to cause the operation of relay 120 of Fig. 1 and relay 302 of Fig. 3 for operating the repeater selecting apparatus of each line.

The incoming and outgoing lines are now simultaneously actuated for the selection of an idle repeater. The line circuit apparatus may be arranged so that either the incoming or the outgoing line may be actuated to search for and seize one end of an idle repeater and mark the other end of said repeater for selection by the alternate line apparatus. In order to economically group the lines and repeaters, it is preferable to operate the outgoing line apparatus to search for and seize an idle repeater as disclosed herein. The selection of an idle repeater by the outgoing line of Fig. 3 will therefore be first described.

It will be remembered that in the outgoing line the switching relay 313 is not operated. Therefore the operation of relay 302 establishes an energizing circuit for relay 312 from ground at the contact of relay 302 to battery through the normal contact of relay 313 and the right winding of relay 312. Relay 312 in operating establishes a locking circuit for itself through its left winding and contact 2 to ground at contact 2 of relay 301. A circuit is now established for energizing the stepping magnet 321 from battery at contact 4 of relay 312, winding and contact of the stepping magnet, normal contact 3 of relay 316 to busy ground or battery connected to the contact associated with brush 323. If the terminals associated with brush 323 are busy the magnet 321 is energized and deenergized for stepping the brushes until brush 323 is associated with a non-grounded terminal. Let it be assumed that the first terminal is non-grounded. A circuit is thus immediately established for the operation of relay 316, which may be traced from battery at contact 4 of relay 312, through the winding and contact of magnet 321, winding of relay 316, to ground at contact 3 of relay 312. Relay 316 is shunted by busy grounds and is thus maintained normal until an idle trunk is found. This busy ground is supplied by relays similar to 316 in other lines. The operation of relay 316 associates busy ground through its contact 3 with brush 323 for maintaining the associated terminal busy.

The brushes of switch 320 are rotated according to the foregoing description to find an idle trunk, extending between the line and a switch such as 330. As many switches 330 are provided as are necessary for the maximum number of simultaneous calls. The number of such switches may be considerably

less than the number of lines and is proportioned according to the number of repeaters required in the common group. When an idle trunk is found, a circuit is established for the operation of relay 337 which may be traced from battery through its winding, brush 323 and associate contact to ground at contact 3 of relay 316. The operation of relay 337 establishes an energizing circuit for the relay 333 which may be traced from ground through contact 341, contact of relay 337, normal contact 1 of relay 336, contact of vertical magnet 335, contact of the rotary magnet 334 to battery through the winding of relay 333. The operation of relay 333 connects battery through its contact and the normal contact 2 of relay 332 to the winding of vertical magnet 335. The energization of the vertical magnet causes the attraction of its armature which maintains the circuit for relay 333 opened until the armature again releases. Relay 333 is released and the switch brushes 343 to 348 are advanced one step. The vertical magnet armature is released which again causes the energization of relay 333. The operation of relay 333 again energizes the vertical magnet which procedure continues until a terminal level is found which has an idle repeater connected to a set of terminals in said level. Upon the first vertical step the vertical off normal contacts 338 and 339 are closed.

The terminals associated with brushes 343 to 348 are divided into levels, 10 terminals in each level, each terminal of the level being connected to a repeater. If an idle repeater is connected to any terminal of the level, the segment of commutator 355 associated with that level is characterized by battery from normal contact 1 of relay 501 connected to conductor 512. This conductor is extended to the 10 repeaters of the level. If all of the repeaters in a level are busy, battery is removed from conductor 512 upon the operation of relay 501 in each repeater. When brush 349 is associated with a battery segment of commutator 355, a circuit is established for operating relay 332, from battery extending over conductor 512, to brush 349, through the left winding of relay 332, normal contact 1 of relay 336, contact of relay 337 to ground at contact 341. The operation of relay 332 opens at its contact 2 a circuit for energizing the vertical magnet and establishes a circuit for energizing the rotary magnet 334. Relay 332 also establishes a locking circuit for itself through its right winding and contact 1. The rotary magnet 334 now advances the brushes 343 to 348 step-by-step in search of the first idle repeater appearing in the level. An idle repeater is characterized by the absence of ground on conductor 511. When an idle repeater is found a circuit is thus established for operating relays 336 and 501. This circuit may be traced from ground

at contact 338 through the right winding of relay 336, brush 348 and its associate contact, conductor 511, winding of relay 501 to battery. Battery is removed from conductor 512 by the opening of contact 1 of relay 501. This conductor is however extended to the relays of 9 other repeaters connected to the same terminal level. The segments of commutator 355 thus indicate the presence of idle repeaters in the levels. Relay 336 in operating establishes a locking circuit for itself through its left winding and contact 2, contact of relay 337 to ground at contact 341. The operation of relay 336 further opens the circuit for the rotary magnet to arrest the brushes 343 to 348 upon the terminals connected to the idle repeater and connects a busy ground through its contact 1 with brush 348. The locking circuit for relay 336 furnishes ground for operating relay 331, which connects the conductors from one end of the idle repeater to the outgoing line apparatus.

The operation of relay 501 in the selected repeater establishes a circuit through its contact 3 for lighting the filaments of the electron tubes in the repeater. The non-selected end of the repeater is now designated for selection by the association of battery through contact 1 of relay 501, winding of relay 502 to conductor 514. A segment of commutator 446 is also characterized by battery through contact 2 of relay 501, normal contact 1 of relay 502, and thence over conductor 513 to the lower segment of commutator 446.

It will be remembered that the line apparatus of Figs. 1 and 3 were simultaneously actuated. The operation of the selecting apparatus associated with the line in Fig. 1 will now be described. The incoming line because of the operation of relay 116 associates itself with a link such as 400 or 450 instead of associating itself with a trunk hunting switch as shown at 140. The operation of relay 120 establishes a circuit from ground through its contact and contact 2 of relay 116 to battery through the left winding of relay 115 for operating the latter relay. Relay 115 establishes a locking circuit for itself through its right winding and contact 4 to ground through contact 1 of relay 118. The operation of relay 115 initiates the actuation of the apparatus in an idle link circuit in a group of links serving the incoming line. Relay 401 in Fig. 4 is one of a chain of relays in a link circuit of a given group. When a link has been taken for use, the operation of relay 401 extends the link starting circuit along to another idle link in the group. Such arrangements are well known in the art and therefore only one link in each of two groups has been shown, links 400 and 450 being in different link groups. Relay 447 is energized from battery through its winding, normal contact 5 of relay 114, to ground at contact 1 of relay 115. The operation of relay 115 further extends

battery through its contact 2, normal contact 4 of relay 114 to characterize a segment of commutator 448 as associated with the line taken for use. Battery is further connected at contact 3 of relay 115 through the winding of relay 114, to conductor 435 associated with brush 426 for operating line and link apparatus when the line is found by the link. A ground is extended from contact 1 of relay 118 to contact 5 of relay 115, for conductor 432, associated with brush 427, for further operation of the link apparatus as explained hereinafter.

The operation of relay 447 extends ground through a chain of relays to battery through the winding of relay 407 of the first idle link. The operation of relay 407 initiates the operation of the switching apparatus at both ends of the link for selecting the idle repeater taken for use and the line taken for use. Relay 421 is operated for initiating the selection of the seized repeater. The circuit for operating relay 421 may be traced from battery through its winding, normal contact of rotary magnet 420, normal contact of vertical magnet 419, normal contact 3 of relay 418, contact of relay 407, contact 403, to ground through contact 412. An energizing circuit is also established for relay 414 for initiating the selection of the incoming line. This circuit may be traced from battery through its winding, normal contact of rotary magnet 415, normal contact of vertical magnet 416, normal contact 1 of relay 417, contact of relay 407, contact 403, to ground through contact 412. The operation of relays 421 and 414 establishes operating circuits for the respective vertical magnets. The circuit for vertical magnet 419 may be traced from battery through the contact of relay 421, normal contact 1 of relay 422, winding of vertical magnet 419, to ground as traced for the operation of relay 421. The energizing circuit for vertical magnet 416 may be traced from battery through the contact of relay 414, normal contact 2 of relay 413, winding of vertical magnet 416, normal contact 1 of relay 417, to ground as traced for the operation of relay 414. The brushes associated with both terminal banks and commutators are now stepped vertically for hunting the repeater and line taken for use. Relays 421 and 414 release upon each operation of the vertical magnets and are reoperated after each step is taken. When the terminal level is found which includes the repeater taken for use, a circuit is established for relay 422, which may be traced from ground at contact 412, through contact 403, contact of relay 407, normal contact 3 of relay 418, right winding of relay 422, brush 440 and the associated segment of commutator 446, conductor 513, normal contact 1 of relay 502, to battery through contact 2 of relay 501. When the level of terminals is found which includes the line taken for use, a circuit is

established for the operation of relay 413, which may be traced from ground at contact 412, through contact 403, contact of relay 407, normal contact 1 of relay 417, left winding of relay 413, brush 425, and the segment of commutator 448 associated therewith, conductor 434, normal contact 4 of relay 114, to battery through contact 2 of relay 115.

The operation of relay 422 opens the circuit through the winding of the vertical magnet and establishes a circuit for the rotary magnet 420, which may be traced from battery through the contact of relay 421, contact 1 of relay 422, winding of rotary magnet 420 to ground at contact 412 as previously traced. Relay 413 also opens the circuit for vertical magnet 416 and establishes a circuit for rotary magnet 415 which may be traced from battery through the contact of relay 414, contact 2 of relay 413, winding of the rotary magnet 415, to ground at contact 412 as previously traced. Relays 422 and 413 establish obvious locking circuits for themselves through secondary windings. The brushes 441 to 445 are now driven in a step-by-step rotary motion to find the terminals associated with the selected repeater. Upon each energization of the rotary magnet, relay 421 is released and again energizes upon the deenergization of the rotary magnet. Upon the association of brushes 441 to 445 with the selected repeater, a circuit is established for relay 418 in the link and relay 502 in the repeater. This circuit may be traced from battery through contact 1 of relay 501, winding of relay 502, conductor 514, brush 441, left winding of relay 418, to ground through contact 409, which contact was closed after the first vertical step of the switch. The operation of relay 418 opens the circuit for rotary magnet 420 and establishes a locking circuit for itself through its right winding and contact 3 to ground at contact 412 as previously traced. The operation of relay 502 establishes an energizing circuit for relay 504 which may be traced from battery at contact 2 of relay 501, through contact 1 of relay 502, normal contact of relay 505, to ground through the winding of relay 504. The operation of relay 502 also opens the ground circuit extended over conductor 520 to the cord circuit. The operation of relay 504 establishes an obvious operating circuit for relay 505 which locks to battery at contact 2 of relay 501 and opens the circuit for relay 504. Ground is connected from contact 1 of relay 504 through contact 3 of relay 267, brush 263 and its associated contact, winding of relay 232 to battery. Relay 232 operates and locks to ground through contact 1 of relay 225 and contact 2 of relay 224. The purpose of operating relay 232 at this time is for indicating to the cord circuit that the repeater has been selected by the lines. The

function of relay 232 will be hereinafter described in detail.

The line selecting switch brushes 426 to 431 are driven in a step-by-step rotary motion to find the line taken for use, the rotary magnet and relay 414 being alternately operated and released upon each step of the brushes. When the terminals connected to this line are found, a circuit is established for relay 417 in the link and relay 114 in the line. The circuit for energizing these relays may be traced from ground at contact 406 of the vertical off-normal contact, which contact was closed on the first vertical step of the switch, through the right winding of relay 417, brush 426 and its associate contact, conductor 435, winding of relay 114, to battery through contact 3 of relay 115. Relay 417 opens the circuit for the rotary magnet and establishes a locking circuit for itself which may be traced from ground at the vertical off-normal contact 406, through the left winding contacts 1 and 2 and the right winding of relay 417 to battery. The operation of relays 417 and 418 establishes an energizing circuit for relay 423 which may be traced from battery at contact 1 of relay 418, winding of relay 423, contact 1 of relay 417, contact of relay 407, contact 403 to ground through contact 412. The operation of relay 423 connects the seized repeater to the incoming line, establishes a circuit for operating relay 401 and establishes a secondary holding circuit for relay 407. The circuit for relay 401 may be traced from battery through its left winding, contact 1 of relay 423, brush 427 and its associated contact, conductor 432, contact 5 of relay 115, to ground at the contact 1 of relay 118. The holding circuit for relay 407 may be traced from battery through its left winding to ground over the circuit traced for relay 401. The operation of relay 401 extends the link chain circuit to a link of the group which may be seized for a subsequent telephone connection. It will be seen that the operation of relay 401 opens the energizing circuit extending through the right winding of relay 407. The latter relay, however, remains operated by the establishment of the holding circuit traced through its left winding.

A circuit is established in each line for applying alternating current through the switch contacts for a predetermined period of time in order to preclude the possibility of contact resistance from oxidation or a film of dirt. This alternating current is applied to the switch contacts after the brushes have been positioned. Relay 102 is operated in the line circuit shown in Fig. 1 from ground through its winding, normal contact of relay 112, to battery through contact 1 of relay 114. An obvious circuit is established for operating relay 104 at the same time that relay 102 is operated. Relay 308 is also

operated in Fig. 3 from ground through its winding, normal contact of relay 317 to battery through contact 1 of relay 316. The contact cleaning circuit may be traced from alternating current source 103 through contacts 1 and 2 of relay 102, contacts 1 and 2 of relay 104, thence over conductors 439 and 437, brushes 431 and 429, contacts 5 and 3 of relay 423, brushes 445 and 443 and associated contacts, conductors 518 and 516, extending through the repeater 500 to conductors 510, and 508, thence through brushes 347 and 345, contacts 5 and 3 of relay 331, brushes 327 and 325 and their associated contacts, normal contacts 4 and 3 of relay 307 to ground through contacts 3 and 4 of relay 308. A second pair of circuits may be traced from ground at contacts 3 and 4 of relay 102, through contacts 3 and 4 of relay 104, thence over conductors 436 and 438, brushes 430 and 428, contacts 4 and 2 of relay 423, brushes 444 and 442 and the associated contacts, conductors 517 and 515 through repeater 500, thence over conductors 509 and 507 to brushes 346 and 344 and associated contacts, contacts 4 and 2 of relay 331, brushes 326 and 324 and associated contacts, normal contacts 1 and 2 of relay 307, to alternating current source 309 through contacts 1 and 2 of relay 308. The alternating current flows over the talking conductors and the switching and relay contacts until the repeater is connected between the incoming and outgoing lines.

The outgoing line has now selected and seized an idle repeater through switch 320 and switch 330, and the incoming line has actuated an idle link 400 which has found the repeater seized by the outgoing line and has found the incoming line. It will be remembered that when the seized repeater was found by the link, that a circuit was established for operating relay 232, which locked to ground at contact 2 of relay 224. Assuming that the keys in the cord circuit are at this time in their normal position, a circuit is established for differentially releasing relay 229. This circuit may be traced from ground at contact 1 of relay 232, lowermost normal contact of key 221, lowermost normal contact of key 213, lowermost normal contact of key 217, to battery through the left winding of relay 229. It will be remembered that a circuit was established through the right winding of relay 229 from ground at contact 1 of relay 231. Since the windings of relay 229 are differentially connected, this relay now releases. The operation of relay 232 also establishes a circuit for relay 219 which may be traced from battery through the lower winding of relay 219, lowermost contact of key 217, lowermost contact of key 213, lowermost contact of key 221 to ground at contact 1 of relay 232. The operation of relay 219 opens the talking conductors between the incoming and outgoing lines.

The release of relay 229 again inserts resistances 228 and 230 in series with sleeve relays 120 and 302 to cause the release of the latter relays. The release of relay 120 establishes a circuit for relay 112 which may be traced from ground through the normal contact of relay 120, right winding of relay 112, to battery through contact 1 of relay 114. Relay 112 in operating establishes a locking circuit for itself through its left winding and contact to battery at contact 1 of relay 114. The operation of this relay releases relay 102 to disestablish the alternating current cleaning circuit extending through the switch contacts. The release of relay 102 also establishes a circuit for relay 101 which may be traced from battery at contact 2 of relay 114 through the winding of relay 101, normal contact 5 of relay 102, to ground at the normal contact of relay 120. One end of the repeater and the network 100 is thus connected to line 180.

In the outgoing line, the release of relay 302 establishes a circuit for relay 317 which may be traced from ground through normal contact of relay 302, left winding of relay 317 to battery at contact 5 of relay 315. Relay 317 in operating establishes a locking circuit for itself from ground through its right winding and contact to battery at contact 1 of relay 316 and also opens the energizing circuit for relay 308. The release of relay 308 disestablishes the alternating current cleaning circuit traced through its contacts. The release of relay 308 also establishes a circuit for relay 310 which may be traced from ground at the normal contact of relay 302, normal contact 5 of relay 308, winding of relay 310, to battery at contact 2 of relay 316. The operation of relay 310 connects the alternate end of the repeater and network 311 to the outgoing line.

The operation of the talking key 217 or ringing keys 213 or 221 opens the circuit through the winding of relay 229 and through the winding of relay 219. The operation of any of these keys thus causes the operation of relay 229 for opening the circuit between the repeaters and the lines, and also causes the release of relay 219 in order that talking may take place between the toll operator and either subscriber.

It will be noted that battery is connected through contact 3 of relay 232 to brush 264 and its associate contact, winding of relay 270, for maintaining the switch point busy and for permanently shunting relay 270. The release of relay 270 causes the release of relays 269, 268, 267 and 266 which arrest the movement of the time alarm circuit 250 and causes the alarm circuit switch to restore to its normal position. The restoring circuit may be traced from battery through the normal contact 1 of relay 255, contact and wind-

ing of the stepping magnet 257 to ground associated with brush 252.

The supervising of the toll lines is accomplished in approximately the same manner as in toll cord circuits well known in the art. Relay 236 is maintained operated from battery through its winding, normal contact of alternating current relay 220, normal contact of alternating current relay 214 to ground at contact 1 of relay 224. Lamp 243 therefore remains extinguished unless a signal is transmitted over the incoming or outgoing toll lines. A signal transmitted over the incoming line operates relay 214 and a signal transmitted over the outgoing toll line operates relay 220. The operation of either one of these relays causes the release of relay 236, which provides an operating circuit for relay 235. This circuit may be traced from battery through the winding of relay 235, normal contact of relay 236 to ground at contact 1 of relay 224. The operation of relay 235 provides a circuit from battery through the winding of relay 234 to ground at contact 1 of relay 224. An obvious circuit is thus established to light lamp 243. Relay 234 in operating establishes a locking circuit for itself through its contact 2 to ground at the uppermost contact of the talking key 217. The switchboard operator upon noting the signal operates the talking key for associating her telephone set with either line. It will be remembered that relay 219 releases when a talking key is operated. The operation of the talking key opens the locking circuit for relay 234 which releases and extinguishes lamp 243.

Upon the termination of a conversation the operator presiding over the cord circuit, Fig. 2, is given a disconnect signal by the toll operator who originated the call. This operator applies ringing current to the line conductors for operating relay 214 for lighting lamp 243 as previously described. At this time plugs 211 and 223 are removed from jacks 108 and 300 respectively. The relays of the cord circuit and the incoming and outgoing line circuits are thus restored to normal. Switches 261 and 320 are not restored to normal and are advanced from the position in which they are resting when used for a subsequent telephone connection. Upon the release of relay 316 the circuit for relay 337 is opened which causes the release of the latter relay. The release of relay 337 establishes a circuit for the release magnet 340 which may be traced from ground at contact 341, through the normal contact of relay 337, vertical off-normal contact 339, winding of release magnet 340, to battery. Switch 330 is thus caused to restore brushes 343 to 349 to their normal position. The circuit for maintaining relay 501 of the repeater is thus opened which relay releases causing the release of the remaining relays of the repeater.

The apparatus of link 400 is released at approximately the same time as the apparatus of switch 330. It will be remembered that relay 407 was maintained in operation over a circuit extending through its left winding to ground at contact 1 of relay 118. This circuit is opened by the release of relay 118 causing the release of relay 407. Circuits are thus simultaneously established for the release magnets 404 and 410. The circuit for energizing magnet 404 may be traced from battery through its winding, vertical off-normal contact 405, normal contact of relay 407, contact 403 to ground at contact 412. The circuit for magnet 410 may be traced from battery through its winding, vertical off-normal contact 408, normal contact of relay 407, contact 403 to ground at contact 412. The brushes 425 to 431 and 440 to 445 are thus restored to their normal position and the remaining relays of the link are released.

What is claimed is:

1. In a telephone exchange system, lines of different characteristics, a link, means in said link for interconnecting said lines, a group of repeaters, automatically operable means in said link for determining the character of the lines with which it is connected, switching means in interconnected lines of a particular character operable in response to the said determining means to search for and seize an idle repeater and means in said lines for directing the transmission circuit of said lines through said seized repeater.

2. In a telephone exchange system, lines having switching apparatus associable therewith, a link, means in said link for interconnecting said lines, a group of repeaters, means in said link operable in response to the interconnection of two of said lines to cause the apparatus of one line to search for and seize an idle repeater and cause the apparatus of the alternate line to select said seized repeater, and means in said lines operable in response to said seizure and selection for directing the transmission circuit of said lines through said seized repeater.

3. In a telephone exchange system, lines having switching apparatus associable therewith, a link, means in said link for interconnecting said lines, a group of repeaters, means in said link operable in response to the interconnection of two of said lines to simultaneously actuate the apparatus of both lines to cause the apparatus of one line to search for and seize an idle repeater, and cause the apparatus of the alternate line to select said seized repeater, and means in said lines operable in response to said seizure and selection for directing the transmission circuit of said lines through said seized repeater.

4. In a telephone exchange system, lines of different characteristics, a link, means in said

link for interconnecting any two of said lines, a group of repeaters, means in said link operable in response to an interconnection of lines of a particular character to cause the apparatus of one of said lines to search for and seize an idle repeater and cause the apparatus of the alternate line so connected to select said seized repeater and means in said lines responsive to said seizure and selection for directing the transmission circuit of said lines through said seized repeater.

5. In a telephone exchange system, lines of different characteristics, switching apparatus associable with lines of certain characteristics, a link, means in said link for interconnecting any two of said lines, a group of repeaters, means in said link operable in response to an interconnection of two lines of said certain characteristic, to simultaneously actuate the switching apparatus of said interconnected lines to cause the switching apparatus of one line to search for and seize an idle repeater and the switching apparatus of the alternate line to select said seized repeater, and means in said lines responsive to said seizure and selection for directing the transmission circuit of said lines through said seized repeater.

6. In a telephone exchange system, lines having a hunting switch and a group of finders associable therewith, a link, means in said link for interconnecting two of said lines, a group of repeaters, means in said link operable in response to the interconnection of said lines to simultaneously actuate the apparatus of said two lines to cause the hunting switch in one line to search for and seize an idle repeater and cause an idle finder in said group to associate itself with the alternate line and connect said alternate line with the seized repeater and means in said lines responsive to the connection of said lines to said repeater for directing the transmission circuit of said lines through said seized repeater.

7. In a telephone exchange system, lines of different characteristics, a cord circuit for interconnecting said lines, repeaters, automatically operable means in said cord circuit for determining the character of the lines with which it is connected, means associable with one of two interconnected lines of a particular character operable in response to said first means and independent of further cord circuit control for selecting and seizing an idle repeater, means associated with a second one of two interconnected lines of a particular character responsive to said first means and independent of further cord circuit control for selecting said seized repeater, and means for including said seized repeater in series with the talking conductors of said two lines.

8. In a telephone exchange system, an office, a plurality of two-way trunk lines ex-

tending between said office and a plurality of other offices, means for interconnecting said trunks, repeaters, means for searching for and seizing an idle repeater, means for selecting said seized repeater, and means in each trunk responsive to a said interconnection for connecting with said searching means or said selecting means according as said trunk is used as an incoming trunk or an outgoing trunk.

9. In a telephone exchange system, an office, a plurality of two-way trunk lines extending between said office and a plurality of other offices, means for interconnecting said trunks, repeaters, means for searching for and seizing an idle repeater, means for selecting said seized repeater, means in each trunk responsive to a said interconnection for connecting with said searching means or said selecting means according as said trunk is used as an incoming trunk or an outgoing trunk, and means for indicating to said connecting means whether said trunk is used as an incoming trunk or an outgoing trunk.

10. In a telephone exchange system, an office, a plurality of trunks extending between said office and a plurality of other offices, said trunks being arranged for use either as incoming trunks or outgoing trunks, means for interconnecting said trunks, repeaters, means for searching for and seizing an idle repeater, means for selecting a said seized repeater, connecting means in each trunk responsive to a said interconnection for connecting with said searching means, other connecting means in each trunk for connecting with said selecting means, and means for operating said first connecting means if said trunk is employed as an outgoing trunk and for operating said other connecting means if said trunk is employed as an incoming trunk.

11. In a telephone exchange system, an office, a plurality of trunks extending between said office and a plurality of other offices, said trunks being arranged for use either as incoming trunks or outgoing trunks, means for interconnecting said trunks, repeaters, means for searching for and seizing an idle repeater, means for selecting a said seized repeater, means in each trunk responsive to said interconnection for connecting with said searching means, other means in each trunk for connecting with said selecting means, and means to determine which connecting means shall be effective.

12. In a telephone exchange system, an office, a plurality of trunks extending between said office and a plurality of other offices, said trunks being arranged for use either as incoming trunks or outgoing trunks, means for interconnecting said trunks, repeaters, means for searching for and seizing an idle repeater, means for selecting a said seized repeater, means in each trunk responsive to said interconnection for connecting with said search-

ing means, other means in each trunk for connecting with said selecting means, and operator controlled means to determine which connecting means shall be effective.

In witness whereof, I hereunto subscribe my name this 9th day of October, 1928.

JOSEPH A. KRECEK.

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