April 12, 1932. W. W. CARPENTER 1,854,106

AUTOMATIC TELEPHONE SYSTEM

Filed Dec. 22, 1922 7 Sheets-Sheet 1

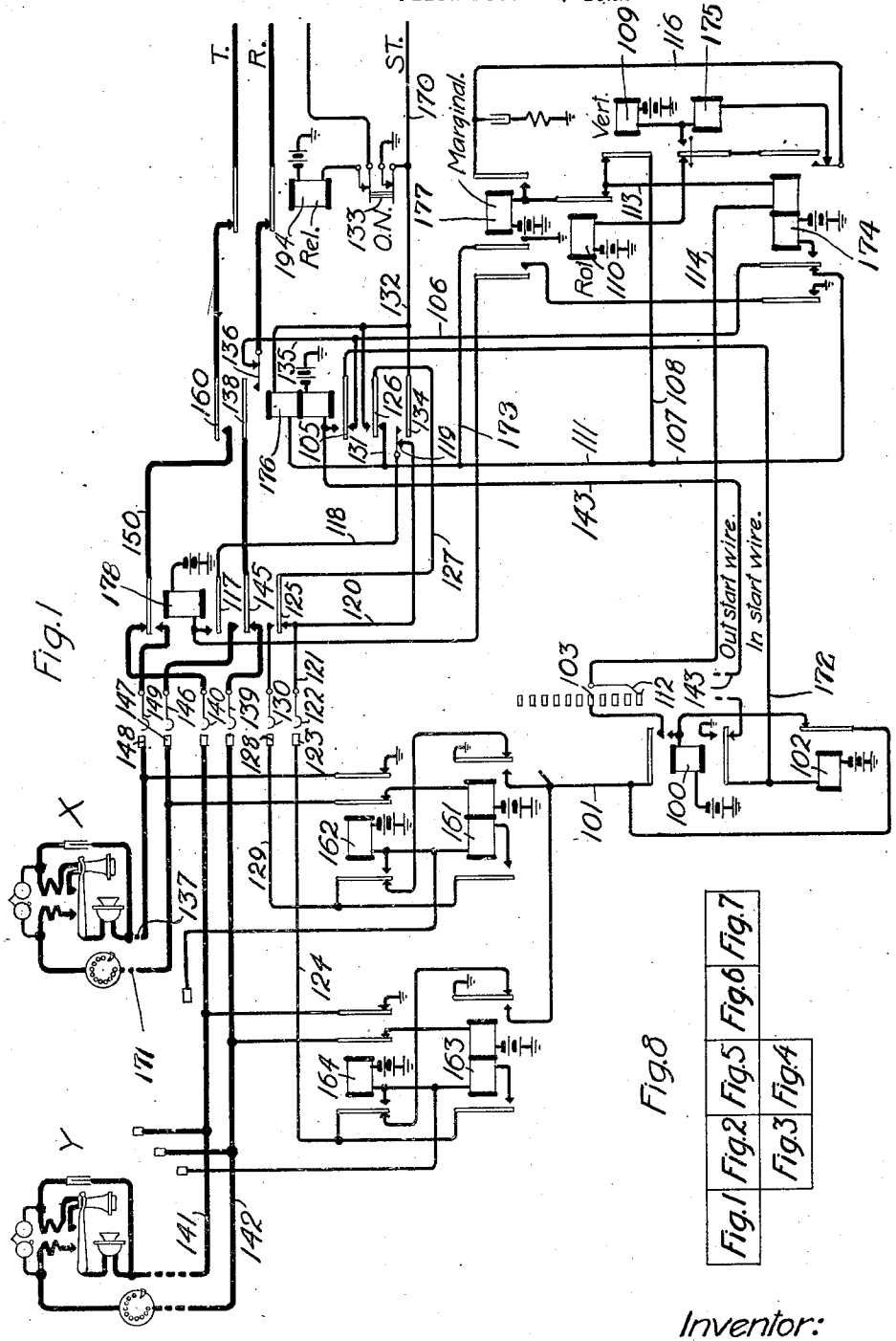


Fig. 1

Fig. 8

Inventor:
Warren W. Carpenter.
by W. E. Beatty. Atty.

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AUTOMATIC TELEPHONE SYSTEM

Filed Dec. 22, 1922 7 Sheets-Sheet 2

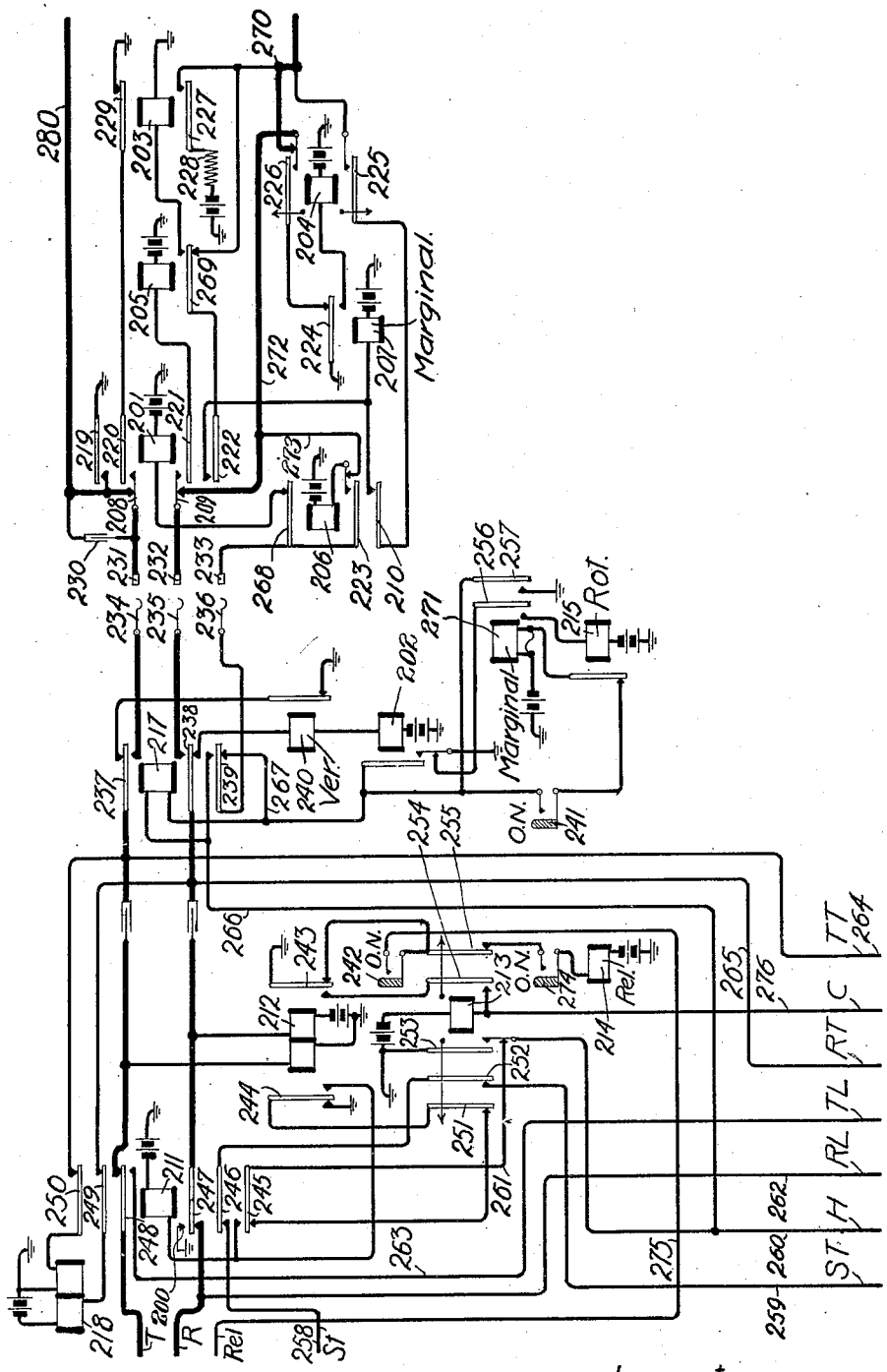


Fig.2

Inventor:
Warren W. Carpenter.
by W. W. Beatty Atty.

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AUTOMATIC TELEPHONE SYSTEM

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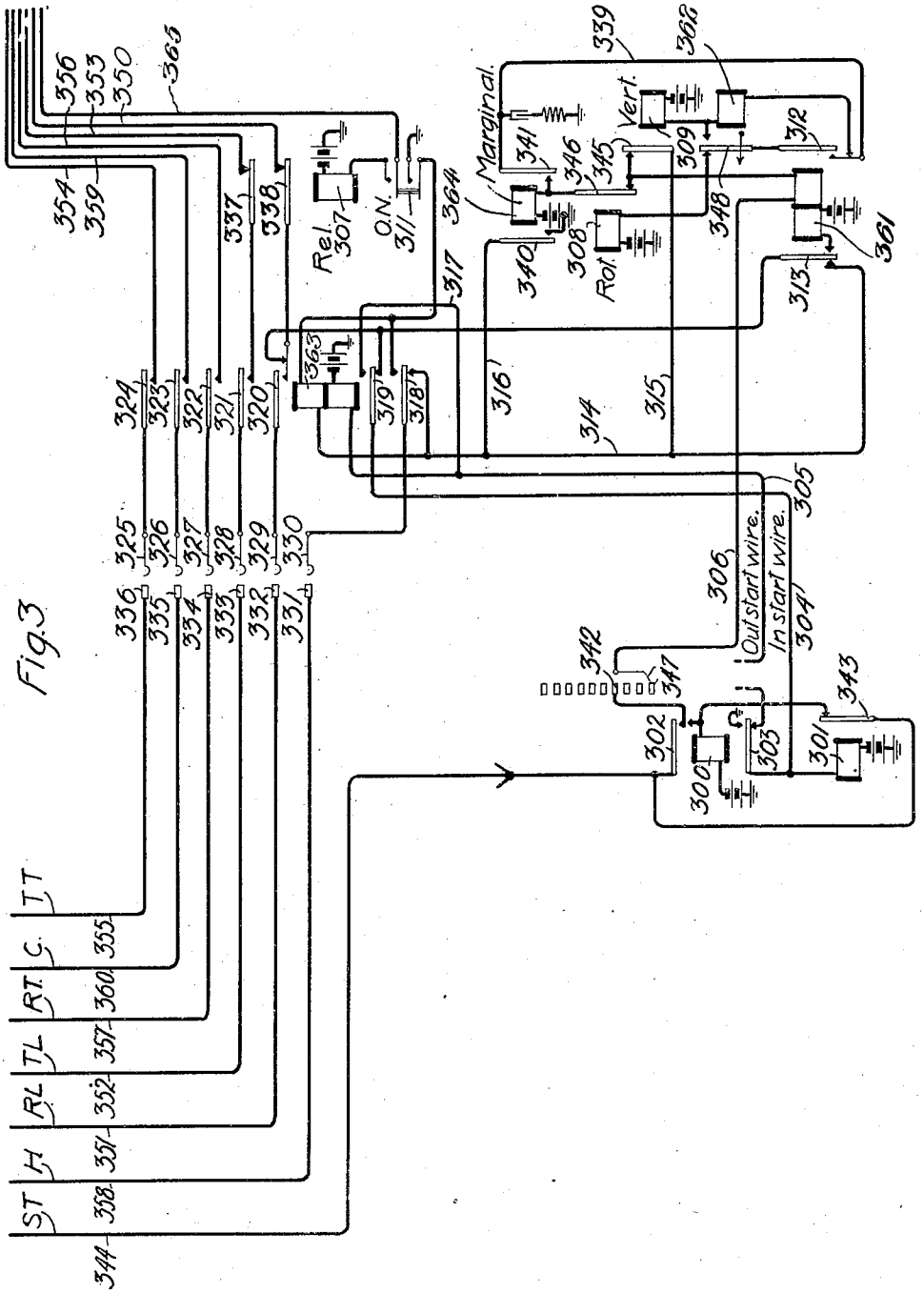


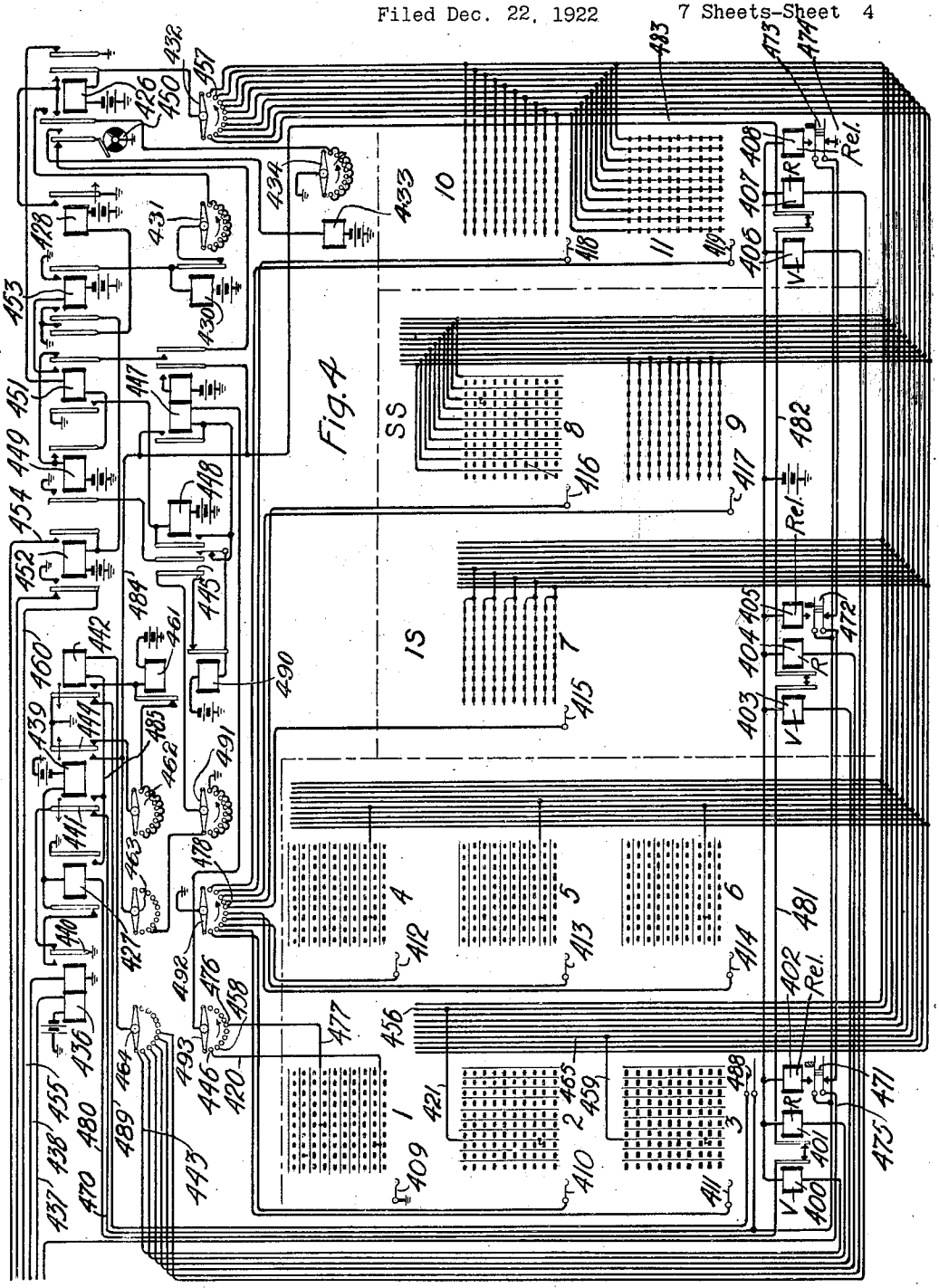
Fig. 3

Inventor:
Warren W. Carpenter.
by W. E. Beatty. Atty.

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AUTOMATIC TELEPHONE SYSTEM

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Inventor:
Warren W. Carpenter
by W. W. Beatty. Atty

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AUTOMATIC TELEPHONE SYSTEM

Filed Dec. 22, 1922 7 Sheets-Sheet 5

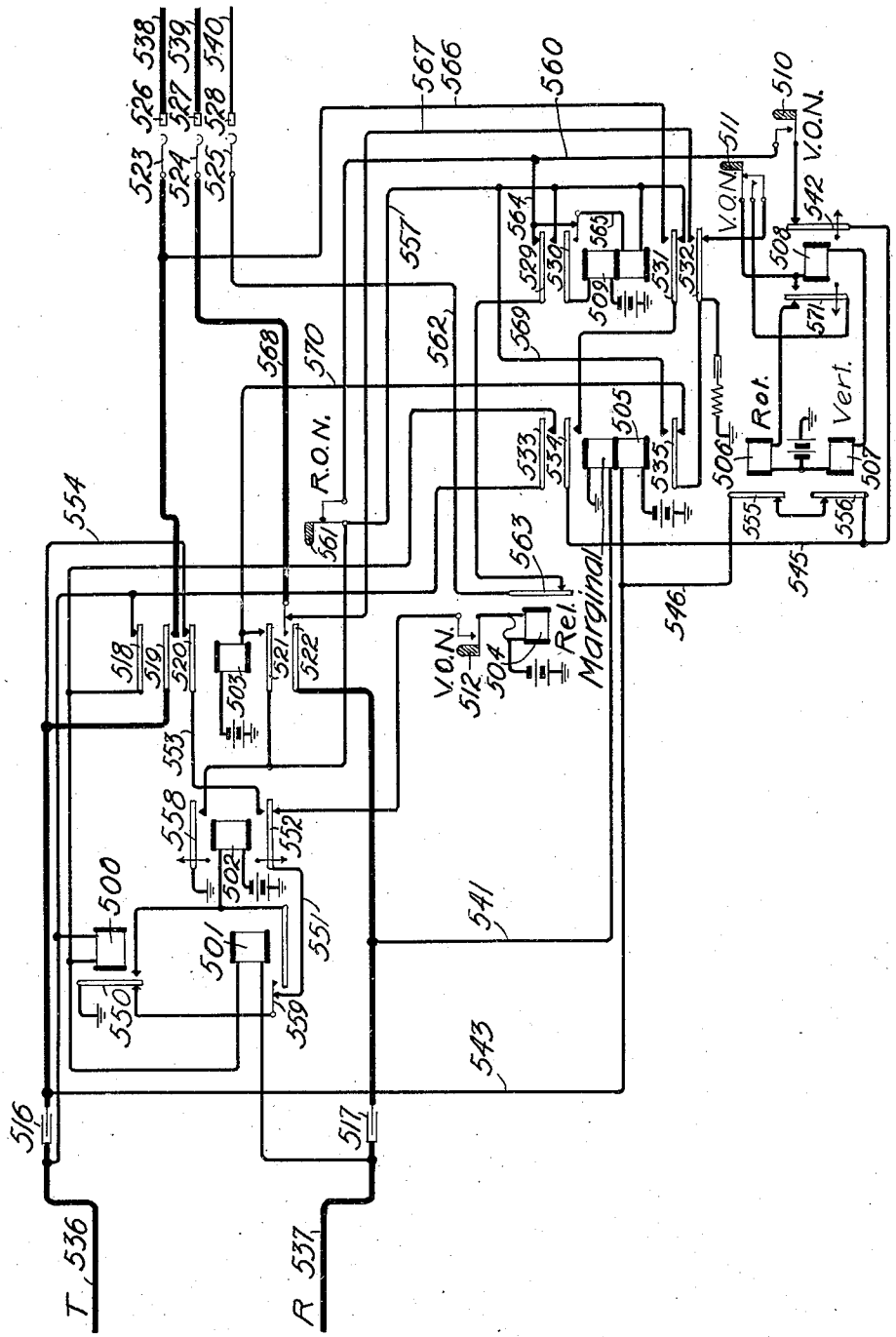


Fig. 5

Inventor:
Warren W. Carpenter.
by W. E. Beatty. Atty.

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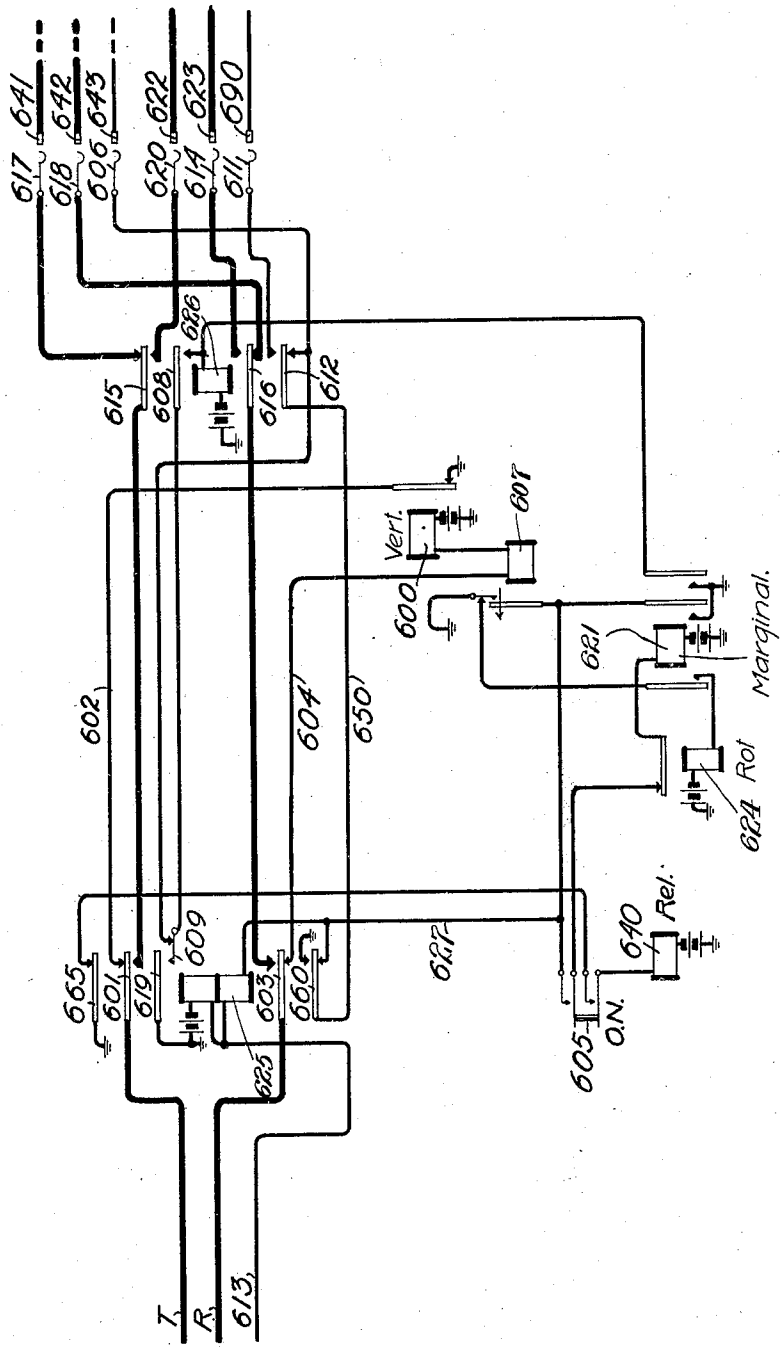


Fig. 6

Inventor:
Warren W. Carpenter.
by W. W. Beatty. Atty.

April 12, 1932. W. W. CARPENTER 1,854,106

AUTOMATIC TELEPHONE SYSTEM

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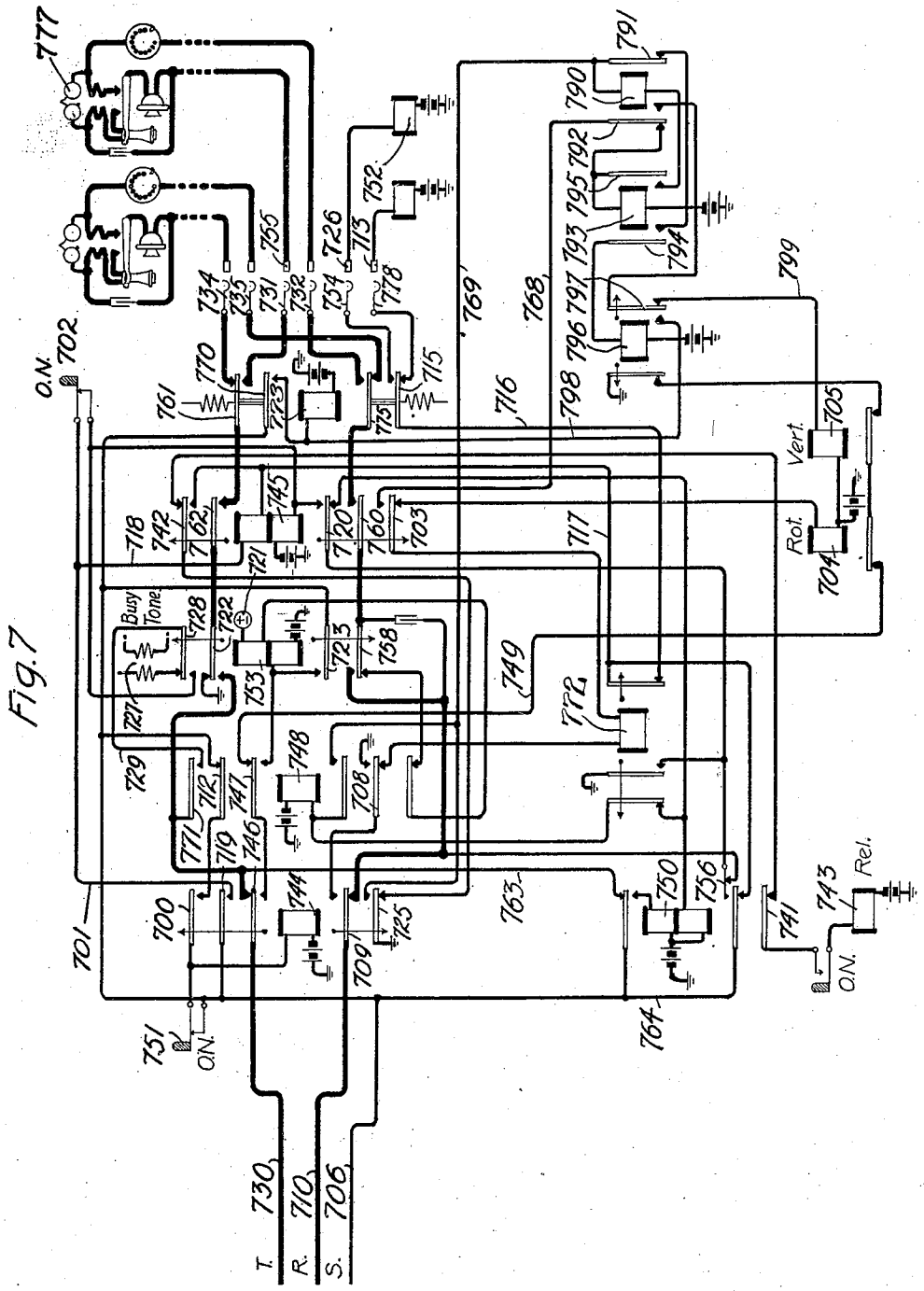


Fig. 7

Inventor:
Warren W. Carpenter.
by W. E. Beatty. Atty.

Patented Apr. 12, 1932 1,854,106

UNITED STATES PATENT OFFICE

WARREN W. CARPENTER, OF BROOKLYN, NEW YORK, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

AUTOMATIC TELEPHONE SYSTEM

Application filed December 22, 1922. Serial No. 608,470.

This invention relates to automatic telephone systems.

Its object is to provide a system using step-by-step switches which shall be suitable for telephone exchange areas having a very large number of offices.

In accordance with this invention register senders are provided at the central offices, and upon the initiation of a call, an idle one of the register senders of the office to which the calling line belongs is automatically connected to such line and receives and registers the desired line number under control of the calling subscriber's dial. The set position of the switches making up the register sender then determines the routing of the call through the telephone network and the register sender transmits impulses to the proper automatic step-by-step switches to select the desired line.

One of the switches of the register sender which may be called a code translating switch, by its set position after the receipt of the office code of impulses, determines in what office the called line is located and controls the register sender to transmit sets of impulses to cause the proper automatic selectors in the telephone network to be set to properly route the call; that is, if the called line is located in a distant office, the code switch controls the register sender to transmit a greater number of sets of impulses than received from the dial, and if the called line is located in the originating office controls the register sender to transmit only the numerical impulses, entirely nullifying the sets of impulses transmitted by the calling party and representing the office code.

Preferably the step-by-step switches have a capacity of two hundred instead of one hundred lines, which gives better trunking efficiency, and the register sender transmits to the switches in the final office translated sets of impulses to enable selection to take place according to the grouping of the lines on the switches.

These and other features of the invention will be more fully described hereinafter.

The invention will be most readily understood from a description of the operation of the system, during which enough description of the apparatus and its location will be interposed to make the invention comprehensible.

Referring to the drawings, Fig. 1 shows the subscribers' line circuits and an automatic line finder switch; Fig. 2 shows a first selector and reperater; Fig. 3 shows a cord finder; Fig. 4 shows a sender; Fig. 5 shows a selector which may be either an office selector or an incoming selector; Fig. 6 shows a second selector, and Fig. 7 shows a connector. Fig. 8 shows the arrangement of Figs. 1 to 7.

Initiation of call

Upon the removal of the receiver at substation X, the line relay 161 operates over the following circuit, free pole of battery, right winding of relay 161, inner right armature and back contact of the cut-off relay 162, line conductor 171, through the substation loop at X, returning to ground over the line conductor 137 and outer right-hand armature and back contact of relay 162. The line relay 161 operates the group relay 100 over the following path: grounded right armature and front contact of relay 161, conductor 101, armature and back contact of relay 102, relay 100, free pole of battery. Relay 100, in attracting its upper armature, locks itself to the grounded right-hand armature of the line relay 161 and also applies ground to the contact 103 which is common to the group to which substations X and Y belong. In attracting its lower armature, relay 100 operates relay 102 which temporarily removes relay 100 from the control of the other subscribers to prevent interference, and grounds the in-start wire 172 to cause the finder to move in a vertical direction to pick out the calling line group. The circuit for initiating this vertical movement of the finder is as follows: ground, lower armature of relay 100 and its front contact, in-start wire 172, armature 105 of relay 176 and its back contact, conductor 106, inner left armature and back contact of relay 174, conductors 107, 108, armature and back contact of the vertical magnet 109, armature and back contact of rotary magnet 110, relay 177, free pole of battery.

Relay 177 in attracting its right armature extends this ground to the slow relay 175 and vertical magnet 109 in series, by way of the right normal contact of relay 174, whereupon the magnet 109 steps the finder one step in its vertical movement. Relay 177 upon energizing, locks itself over the following circuit: free pole of battery, relay 177, armatures and back contacts of magnets 110, 109, conductors 108, 111, 173, inner left armature and front contact of relay 177 to ground. The vertical magnet 109 at the end of its stroke, opens the locking circuit of relay 177 as well as the original energizing circuit of said relay, whereupon the relay 177 releases and opens the circuit of the vertical magnet 109. The vertical magnet thereupon releases, and in closing its back contact again energizes the relay 177 over its original energizing circuit, whereupon it locks up over its locking circuit, the operation of relay 177 transmitting another impulse to the vertical magnet 109. This interaction of the relay 177 and the vertical magnet continues until the group brush 112 of the finder reaches the grounded segment 103 of the calling group, whereupon the relay 174 operates over the following circuit: free pole of battery, relay 177, armature and back contact of magnet 110, conductor 113, right winding of relay 174, conductor 114 to ground on the group segment 103. Relay 174 at its right armature opens the vertical stepping circuit, and at its inner left armature closes a locking circuit for itself over conductor 106, armature 105, conductor 172 to ground at the lower armature of relay 100. At the moment that the group brush engages this grounded segment, the relay 177 is still locked up, since its locking circuit is only opened at the extreme limit of the stroke of the vertical magnet 109. When this occurs the relay 177 does not release because it has a circuit including the right winding of relay 174 to ground on the group segment 103. When the slow relay 175 releases, which occurs shortly after relay 174 operates, the following circuit is closed to operate the rotary magnet 110 to rotate the brushes over the calling line group: free pole of battery, magnet 110, armature and back contact of relay 175, right armature and front contact of relay 174, conductor 116, right armature and front contact of relay 177, armatures and back contacts of magnets 110 and 109, conductors 108, 111, 173, to ground at the inner left armature and front contact of relay 177. Magnet 110 rotates the brushes one step and at the end of its stroke opens the locking circuit of the relay 177 and also moves the group brush 112 off the grounded group contact 103. If the first two sets of terminals encountered by the brushes are terminals of non-calling lines, the brush shifting relay 178 which was operated when relay 174 operated at the end of the vertical movement over a circuit including the outer left armatures and front contacts of relays 177 and 174, remains operated over the following circuit: free pole of battery, relay 178, its armature 117 and front contact, conductor 118, contact 119 of relay 176, conductors 120, 121 brush 122, test multiple 123, conductor 124, left armature and back contact of the cut-off relay 164 and right armature and back contact of line relay 163 of line Y to ground, and armature 125, of the relay 178 transmits an impulse over the following circuit to again pull up the relay 177 to transmit another impulse to the rotary magnet to advance the finder from the terminals of these two lines which are non-calling to the next two lines: free pole of battery, relay 177, armatures and back contacts of magnets 110, 109, conductors 108, 111, 131, armature 126 of relay 176, conductor 127, armature 125 and front contact of relay 178, test brush 130, test terminal 128, conductor 129, left armature and back contact of the cut-off relay 162, right armature and back contact of the line relay 161 to ground. Relay 177 in operating again locks up over the circuit heretofore traced, including its inner left armature and front contact and again operates the rotary magnet 110, over the following circuit: grounded test multiple 128, brush 130, armature 125 and front contact of relay 178, conductor 127, armature 126 and back contact of relay 176, conductors 131, 111, 108, armatures and back contacts of the magnet 109, 110, right armature and front contact of relay 177, conductor 116, right armature and front contact of relay 174, armature and back contact of relay 175, magnet 110, free pole of battery. The rotary magnet at the end of its stroke opens the locking circuit traced for the relay 177, which in releasing its right armature opens the circuit of the rotary magnet. This interaction of the relay 177 and the rotary magnet 110 continues until one of the sets of brushes encounters a calling line, which is indicated by the absence of ground at its test terminal. It having been assumed that the calling line is substation X, no ground is present at its terminal 128, but ground is present on test terminal 123 of the non-calling substation Y. Consequently, relay 178 is held up from the ground on test multiple 123. There being no ground, however, at test terminal 128, relay 177 cannot again energize to transmit another impulse to the rotary magnet. The switch thus comes to rest on the calling line multiples. During the movement of the finder over the non-calling line terminals, the relay 176 is not operated since its upper winding is short-circuited over the following path: conductor 131, armature 126 and back contact of relay 176, conductor 127, armature 125 and front contact of relay 178, brush 130 to grounded test terminals 128 of non-calling lines. When the brush 130 reaches test terminal 128

of the substation X which is calling and therefore is not grounded, relay 176 energizes over the following circuit: free pole of battery, relay 177, armatures and back contacts of magnets 110, 109, conductors 108, 111, upper winding of relay 176, conductor 132, off-normal switch 133, now closed, to ground. Relay 176 in attracting its armature 134 maintains the relay 178 energized from the ground on the off-normal switch 133. Relays 178 and 176 will therefore remain energized until release takes place. In attracting its armature 126, relay 176 applies a direct ground from the off-normal switch 133 to the cut-off relay 162 of the calling line X to operate the same. This circuit is as follows: free pole of battery, relay 162, left winding of relay 161, its left armature and front contact, conductor 129, terminal 128, brush 130, armature 125 and front contact of relay 178, conductor 127, armature 126 and front contact of relay 176, conductor 132 to ground at the off-normal switch 133. This ground also renders line X non-calling in the other finders in which it appears. The cut-off relay 162, in attracting its right armatures opens the original circuit for line relay 161 and in attracting its left armature short-circuits the left winding of said line relay whereupon it releases. The right armature of line relay 161 in retracting releases the group relay 100, which in turn, releases group relay 102 to restore the starting circuit to the control of the other lines of this group. The cut-off relay 162 is now locked over its left armature to ground on the off-normal switch 133. Relay 176 in attracting its armatures 160 and 138 operates relay 212 over the subscriber's line X.

Assuming now that the call has been initiated by substation Y and substation X is non-calling. In that event, ground would be present on the multiple 128 of substation X and the multiple 123 of substation Y would be ungrounded due to the attraction of the right armature of the line relay 163 of substation Y. The operation would be the same as just traced up to the time the test brushes 130 and 122 reach the terminals 128 and 123 respectively. No ground being present on the test terminal 123 of line Y, relay 178 would release when relay 177 released due to the opening of its locking circuit by the rotary magnet. Relay 178 in releasing connects the trunk talking conductors to the brushes 139 and 140 and consequently to the talking conductors 141 and 142 of substation Y, disconnecting such trunk from the brushes 146 and 149. Although in the case assumed, ground is present on the test multiple 128 and the armature 125 of the relay 178 is attracted when the brush 130 reaches such contact, the relay 178 releases its armature 125 before this ground is applied long enough to permit the relay 177 to again attract its armature. The relay 176 operates in this case exactly as it did in the other; that is to say, due to the removal of the shunt about its upper winding, caused by the brush 122 engaging the open terminal 123. In attracting its armature 126, relay 176 operates the cut-off relay 164 of substation Y.

The armature 105 of the relay 176 extends the in-start wire 172 to the out-start wire 143 and thence to the next idle finder. The function of the lower winding of the relay 176 is to prevent the replacement of the receivers by the parties to a connection and the consequent release of the finder from deenergizing the relay 176 and thus interfering with a circuit extending over the armature 105 to the out-start wire 143, which circuit at this particular time, may be setting the next finder. The lower locking winding of relay 176 will hold this relay energized as long as ground is present on the start wire 172, which will be until the finder beyond which is being set has reached the calling line.

Assuming that substation X is calling, the operation of relay 212 removes ground at its armature 244 from terminal 331 of the used trunk (Fig. 2) at the cord finders (Fig. 3).

Connection of idle sender

Relay 300 corresponds to relay 100 and the operation of the cord finder in picking out the trunk used is very similar to the operation of the finder in seeking the calling line, as will appear.

The off-normal switch 133 in operating on the first step of the line finder (Fig. 1) operates start relay 300 of the cord finder as follows: battery 300, 343, 344, 259, 252, 246, 258, 170, 133 to ground. Relay 300, at its armature 302, locks itself to the grounded conductor 344 and also applies ground to the group contact 342 which is common to the level of trunks in which the first selector shown in Fig. 2 and which has been taken for use is located. In attracting its armature 303, relay 300 operates relay 301 which temporarily removes relay 300 from the control of the other trunks, preventing interference, and grounds the in-start wire 304 to cause the cord finder to move in a vertical direction to pick out the group containing the trunk taken for use. The circuit for initiating this vertical movement of the finder is as follows: ground, 303, 304, 319, 313, 315, 345, 346, 364, to battery. Relay 364 which is similar to 177 (Fig. 1), in attracting its armature 341, extends this ground to the slow relay 362 and vertical magnet 309 in series, whereupon the vertical magnet elevates the cord finder one step. Relay 364, upon energizing, locks itself over the following circuit: battery, 364, 346, 345, 315, 314, 316, 340 to ground. The vertical magnet 309, at the end of its stroke, opens this locking circuit as well as the original energizing circuit of said relay, whereupon relay 364 releases and opens the cir-

cuit of the vertical magnet. The vertical magnet thereupon releases and in closing its back contact energizes relay 364 over its original energizing circuit. Relay 364 thereupon locks up over the circuit previously traced and transmits another impulse to the vertical magnet 309. This interaction of the relay 364 and the vertical magnet continues until the group brush 347 of the cord finder reaches the grounded group segment 342, whereupon the relay 361 operates over the following circuit: battery, relay 364, 346, right winding of 361, 306, 347, 342 to ground on conductor 344. Relay 361, at its right armature, opens the vertical stepping circuit and at 313, 319 and 303 closes a locking circuit for itself. At the moment the group brush 347 engages the grounded segment 342, relay 364 is still locked up since its locking circuit is only opened at the extreme limit of the stroke of the vertical magnet 309. When this occurs relay 364 does not release because it finds a circuit including the right winding of relay 361 to ground on the segment 342. When the slow relay 362 releases, which occurs shortly after relay 361 operates, the following circuit is closed to operate the rotary magnet 308 to rotate the brushes over the group containing the used trunk: battery, 308, 348, 312, 339, 341, 346, 345, 315, 314, 316, 340 to ground. Magnet 308 rotates the brushes one step and at the end of its stroke opens the circuit of relay 364 and also moves the group brush 347 off the grounded group segment 342. The brushes of the cord finder are now in engagement with the terminals of the first trunk, and assuming this is not the calling trunk, the following circuit is closed to again operate relay 364 to rotate the brushes another step: battery, 364, 346, 345, 315, 314, 318, 330, 331, 358, 260, 261, 245, 251, 244 to ground. Relay 364 again locks up in the circuit heretofore traced including its left armature and again operates the rotary magnet 308 over the following circuit: battery, 308, 348, 312, 339, 341, 346, 345, 315 to ground over the path traced for locking relay 364. This interaction of the relay 364 and magnet 308 continues until brush 330 in the cord finder encounters the calling trunk, which is indicated by the absence of ground on multiple 331. During the movement of the cord finder brushes over the non-calling trunk terminals, relay 363 is not operated since its upper winding is short-circuited over the following path: armature 318 and brush 330 to ground on the non-calling trunk terminal 331. When, however, the brush 330 encounters the ungrounded test terminal 331 of the calling trunk, relay 363 operates over the following circuit: battery, 364, 346, 345, 315, 314, upper winding of relay 363 to ground at the off-normal contact 311. In attracting its armature 318, relay 363 applies direct ground from the off-normal switch 311 to the multiples 331 of the calling trunk to render it non-calling in the other cord finders. In attracting its armature 319 relay 363 connects the in-start wire 304 to the out-start wire 317, 305, which leads to the next idle cord finder. In attracting its armature 318 relay 363 operates relay 211 as follows: ground, 311, 318, 330, 331, 358, 260, 261, 245, 251, 244, relay 211 to battery and relay 211 at its armature 245 locks to said ground. Relay 211 at its armature 246 disconnects grounded start wire 258 from conductor 344 thus unlocking the common start relay 300 which releases relay 301 thus restoring the starting circuit to the control of the other subscribers of the group. Relay 212 holds to ground controlled by the lower inner armature and front contact of relay 211.

Although it has taken considerable time to trace the operations which result from the removal of the receiver, it will be understood that these operations take place in an extremely short interval of time and ordinarily these operations have taken place by the time the subscriber starts turning the dial for the first digit of the wanted number.

Registering the office designation of wanted line

Assuming that the call has been initiated at the substation X first considered, the impulse circuit for setting the translator switch and registers shown in Fig. 4 and now associated with line X, is as follows: battery, 436, 437, 350, 338, 320, 329, 332, 351, 262, ring or lower talking conductor through the dial at substation X, returning over the upper or tip talking conductor, armature 248, conductor 263, 352, 333, 328, 321, 337, 353, 438, 436 to ground. The impulse relay 436, in operating, energizes slow to release relay 439 which remains operated during the breaks in the circuit of relay 436. Assume the called number to be BC–8888, that B of the office code BC represents two impulses, and that C represents three impulses. Upon the first retraction of the armature of relay 436, a circuit for slow relay 442 and the vertical magnet 400 of the office code switch having six blanks 1, 2, 3, 4, 5, 6, is closed as follows: ground, 440, 441, 485, 442, brush 464 and its first terminal, 443, 400, to battery. As soon as the impulse relay armature 440 leaves its front contact, it removes a short circuit about relay 427 which short circuit includes the left armature and normal contact of relay 427 and the armature 440 and front contact of the impulse relay 436. Relay 427 thereupon operates over the following circuit: battery, 439, 427, 480, 481, 482, 483, 484, to ground at 444. This circuit, it will be noted, includes the armature and normal contact of the vertical magnet 400 which is arranged to open this circuit at the end of its stroke to release relay 427. Relay 427, in closing its

right contact provides a substitute ground to conductor 485 connected to slow relay 442 and the vertical magnet and since the circuit of relay 427 is only broken, as stated, when the vertical magnet 400 reaches the end of its stroke, a full stroke of the magnet 400 is insured, even though the ground applied to conductor 485 at the armature 440 and back contact of the impulse relay 436 is so momentary as not to operate said magnet 400. It is only necessary for the impulse relay armature 440 to leave its front contact long enough to allow relay 427 to operate and this relay at its right armature closes a circuit for the vertical magnet which will be closed until such magnet completes its stroke at which time relay 427 releases, and the impulse relay having by this time again attracted its armature 440, the short circuit about relay 427 is again closed, and the circuit is ready for the next impulse. This series of impulses causes magnet 400 to elevate the six brushes 409, 410, 411, 412, 413 and 414 two steps. Upon the return of the dial to normal position the slow relay 442 releases and opens the circuit of the magnet 461 which was closed when 442 operated. This magnet 461 is a back stroke magnet and upon its demagnetization upon the cessation of the impulses advances its arms 462, 463 and 464 one step, whereupon the arm 464 substitutes the rotary magnet 401 of the translator switch for the vertical magnet 400. Upon the transmission of the next set consisting of three impulses, rotary magnet 401 rotates the brushes of the office code switch into engagement with the third set of terminals of the second level in each bank, and upon the release of the slow relay 442 the back stroke magnet 461 advances the brushes 462, 463 and 464 another step. The vertical magnet 403, of the thousands and hundreds register switch having three terminal banks 7, 8 and 9, is operated by the next set of impulses, and this set of impulses being assumed to consist of 8 impulses, magnet 403 elevates the brushes 415, 416 and 417 to the eighth vertical level and then the magnet 461 advances the arms 462, 463 and 464 a step, whereupon the next set of 8 impulses operate magnet 404 which rotates the brushes to the eighth set of terminals. Similarly, the next two sets of impulses operate the vertical and rotary magnets 406 and 407 of the tens and units register switch having banks 10 and 11 and brushes 418 and 419, so that at the end of these two sets of impulses each of which is assumed to be eight, the brushes 418 and 419 are in engagement with the eighth set of terminals in the eighth level.

Setting selectors to select office of wanted line

Upon the termination of the impulses for the second digit of the office code, the brush 463 passes on to its third contact which results in the closing of a circuit for starting the transmission of the office impulses to the first selector (Fig. 2). This circuit is as follows: ground, 444, 463, 491, 445, 490, to battery. The magnet 490 interrupts its own circuit advancing the brushes 491, 492 and 493 over their terminals until brush 493 reaches the terminal in its bank connected to the third terminal in the second level which is grounded by translator brush 409, this, as shown, being the first terminal 446 encountered by brush 493. The connections between the terminals of bank 1 and those engaged by brush 493 are purely arbitrary as will later appear. In the present case the office code BC indicates an interoffice connection: that is to say, the office code BC will be translated into five sets of impulses, one set operating a first selector in the originating office and an incoming selector in each of the four intermediate offices. The operation of the magnet 490 is stopped by the brush 493 engaging terminal 446 which results in the closure of the following circuit: grounded brush 409, conductor 420, terminal 446, 493, left winding of relay 447 normal contact of relay 448, magnet 490 to battery. Relay 447 locks itself by its right winding to the grounded right armature 444 and front contact of the slow relay 439 and at its left armature it closes a holding circuit for magnet 490 to ground at armature 444. At its outer right armature relay 447 prepares a circuit to operate relay 449 which is closed when the interrupter 450 reaches the next metallic segment. Relay 449 then operates and locks through relay 451 to ground at the outer right armature and back contact of relay 426. Relay 451, however, is short-circuited as long as the interrupter 450 is riding on a metallic segment. As soon as this short circuit is opened relay 451 operates and at its left armature operates relay 448, which, in attracting its middle left armature, closes a new holding circuit for magnet 490 to ground at the left armature of relay 449. Relay 451, in attracting its right armature, connects relay 453 to the interrupter 450 and when the interrupter brush reaches the next metallic segment relay 453 operates, closing at its inner left armature, a circuit for the relay 452 and at its right armature closes a circuit for the magnet 430. The interrupter now transmits impulses to relay 453, which, in turn, transmits impulses to relay 452 and magnet 430. Relay 452, in attracting its right armature when first energized locks over the following circuit: battery, 452, 454, 354, 324, 325, 336, 355, 264, 237 to ground at the armature and normal contact of the vertical magnet 240 of the first selector. In attracting its left armature relay 452 closes a circuit for the vertical magnet 240 of the first selector as follows: ground, 460, 455, 356, 322, 327, 334, 357, 265, 238, 240, slow re-

lay 202 to battery. Magnet 240 steps the first selector up a step and at the end of its stroke breaks the locking circuit traced for relay 452. Relay 452 thereupon retracts its left armature thereby opening the circuit of the vertical magnet 240. Relay 453 is then operated from the interrupter to again close the original energizing circuit of relay 452 and the circuit of magnet 430, and relay 452 again locks up to the back contact of the vertical magnet 240. Its left armature closes a circuit for this magnet whereupon the magnet steps the brushes of the first selector up another step. The slow relay 202 of the first selector remains operated during the transmission of these impulses. This operation continues until the brush 432, advanced by the magnet 430, encounters a grounded contact in its path, and in the present case assuming the brush 410 is engaging the third terminal in the second level, of bank 2 which terminal is at this time grounded by brush 492, resting on its first terminal, the relay 426 operates after nine impulses have been transmitted due to wire 421 being connected from said terminal to the conductor 456 which is connected to the ninth contact 457 in the path of brush 432. Relay 426 in attracting its outer left armature disconnects the interrupter from the relay 453, stopping the transmission of impulses to said relay and therefore to relay 452, and magnet 430. Relay 426, in attracting its inner right armature, locks up to ground at the front contact of slow release relay 428, which relay was operated upon the first energization of relay 453 and being slow remains operated during the transmission of the impulses. Relay 426, in attracting its outer left armature, connects interrupter 450 to the timing magnet 433 and since relay 426 locks up upon its energization over its innermost right armature and brush 434 of the timing switch, impulses are transmitted to the timing magnet 433 until brush 434 reaches normal when relay 426 is unlocked and the interrupter 450 is disconnected from the magnet 433 of the timing switch. This is for the purpose of measuring off a definite predetermined interval of time between the transmission of the last impulse to the first selector and the transmission of the next set of impulses, in order to allow the first selector time to seize an idle trunk in the selected ninth level in which terminate trunks leading to the desired office through which the call is to be extended. As soon as relay 426 operates, it closes a self-interrupting circuit for magnet 430 including brush 431, inner left armature and alternate contact of relay 426, brush 434 to ground. This circuit is effective to step brushes 431 and 432 to normal before brush 434 reaches normal. Referring now to Fig. 2, upon the operation of the slow relay 202 on the transmission of the first impulse, relay 271 operated over the off-normal contact 241 and the armature and front contact of relay 202 and locked up to ground at its own armature 257. At its inner armature 256, relay 271 prepares a circuit for rotary magnet 215 of the first selector, which circuit is closed upon release of the slow relay 202. The rotary magnet thereupon takes its first step rotating the first selector brushes 234, 235 and 236 into engagement with the first trunk 231, 232 and 233. At the end of its stroke, magnet 215 opens the locking circuit of relay 271 which releases opening the energizing circuit of the rotary magnet. If this trunk is busy its test multiple 233 will be grounded resulting in the transmission of an impulse to relay 271 through the following path: battery, 271, 241, 267, 239, 236, 233 to ground, and relay 271 in operating locks up as before and transmits an impulse to the rotary magnet 215 which steps the brushes on to the next trunk and at the end of its stroke opens the locking circuit of relay 271, which releases the rotary magnet. This interaction of the relay 271 and the rotary magnet 215 continues until an ungrounded test terminal 233 is reached when relay 271 remains inert stopping the switch. Relay 217 then operates as follows: battery, 271, 241, 217, 266, 260, 358, 331, 330, 318, 311 to ground. This relay was shunted as long as busy trunks were encountered, the shunt including conductor 267, armature 239, brush 236 to grounded multiples of busy trunks. Relay 217 disconnects the tip and ring conductors from the vertical magnet 240 and its armature and extends them through to the repeater shown at the right of Fig. 2, the function of which is to repeat impulses to the switches beyond. Ground at off-normal contact 311 is extended by armature 239 of relay 217 to the test multiple 233 of the seized trunk to render the same busy. This ground also operates relay 201 over the armature 268 of relay 206. Relay 201 closes a loop circuit to the distant office wherein the selector (Fig. 5) is located, as follows: battery, 207, 222, 269, 270, 537, 501, 518, 536, 280, 219 to ground. The impulse relay 501 of the incoming selector of the distant office, in operating, energizes slow relay 502 which prepares the stepping circuit. A short interval after this trunk has been seized, timing brush 434 reaches its normal position as described, unlocking relay 426 preparatory to transmitting the second set of impulses. When the relay 426 operated, it released relays 449 and 451. Relay 449 opened the circuit of the magnet 490, which being a back stroke magnet, advanced the arm 491, 492 and 493 another step upon its deenergization. The next time the interrupter reaches a metallic segment relay 449 again operates, again preparing a circuit for relay 451 which is closed as soon as the interrupter moves off the metallic segment. Relay 451 again connects relay 453

to the interrupter and the next metallic segment transmits an impulse to relay 453. Relay 453 in turn operates relay 452 and magnet 430. Brush 492 in position 2, connects ground to brush 411 and this brush is now resting on a terminal connected by a wire 459 to the fourth terminal in the bank over which the brush 432 passes so that when the brush 432 reaches this grounded terminal relay 426 is again operated to terminate the transmission of this set of impulses which in the present instance is four. Relay 452 operates as before described but transmits impulses to relay 205 of the repeater. The circuit for relay 205 is as follows: ground, left armature of relay 452, 460, 455, 356, 322, 327, 334, 357, 265, 238, 235, 232, 221, 205, battery. The locking circuit for relay 452 is as follows: battery 452, its right armature, 454, 354, 324, 325, 336, 355, 264, 237, 234, 231, 220, 229 to ground. Relay 205 at its armature 269 opens the loop to the distant office containing the relay 501 four times. Upon the first retraction of the armature of the impulse relay 501 as the circuit is broken by the relay 205 in the repeater, it closes the following circuit for relay 505: ground, 550, 559, 551, 552, 553, 520, 554, 543, 505 to battery. Relay 505 upon energizing locks up as follows: battery, 505, 546, 555, 556, 545, 534, 531, 557, 558 to ground. Relay 505, in attracting its armature 535, closes the following circuit for vertical magnet 507: battery, 507, 508, 511, 532, 535, 569, 557, 558 to ground. Magnet 507, at the end of its stroke, opens the locking circuit of relay 505 which releases, releasing the vertical magnet. When the contact 559 of the impulse relay 501 is again closed, relay 505 again operates and locks up to transmit an impulse to magnet 507 which at the end of its stroke opens the locking circuit of relay 505 as described which releases the vertical magnet. These operations are repeated for each impulse, and assuming four impulses have been transmitted, the incoming, selector is raised to the fourth level. Upon the termination of the impulses, slow relay 508 in the vertical magnet circuit releases, closing the circuit for relay 505 as follows: battery, 505, 546, 555, 556, 542, 510, 560, 561, 558 to ground. Relay 505, in attracting its armature 534 locks over 546, 555, 556, 545, 534, 531, 557, 558 to ground and at its armature 535 closes the following circuit for the rotary magnet: battery, 506, 571, 511, 532, 535, 569, 557 to ground at the armature 558 of the relay 502. Magnet 506, steps brushes 523, 524 and 525 to the terminals 526, 527 and 528 of the first trunk and at the end of the stroke, opens at 555 the locking circuit of relay 505 which releases in turn opening the circuit of the rotary magnet. On the first rotary step, contact 561 opens. If the first trunk is busy, its test multiple 528 will be grounded resulting in the transmission of an impulse over brush 525, 562, 563, 529, 564, 560, 510, 542, 556, 555, 546, 505 to battery. Relay 505 will again operate and lock as follows: battery, 505, 546, 555, 556, 545, 534, 531, 557, 558 to ground. At its armature 535, relay 505 transmits another impulse to the rotary magnet to step the brushes on to the terminals of the next trunk and at the end of its stroke opens the locking circuit for relay 505 traced. If its trunk is idle, this terminal 528 will be ungrounded and relay 505 will not again operate, thus stopping the switch. Due to the absence of this ground, relay 509 now operates as follows: battery, 505, 546, 555, 556, 542, 510, 560, 564, 565, 509, 557, 558 to ground. Relay 505 is marginal and does not operate in the circuit. While the switch was passing over grounded terminals 528, relay 509 was shunted over conductor 564, armature 529, armature 563 of magnet 504, conductor 562, brush 525 to the grounded multiples 528. Relay 509, in attracting its armature 530, includes its upper winding in series with its lower winding in a locking circuit to ground at armature 558. Relay 509, at its armature 531, prepares a circuit for relay 505 to cooperate in setting the next selector. A short interval after the trunk has been seized as described, the brush 434 of the timing switch TM reaches its normal position unlocking relay 426 preparatory to transmitting the third set of impulses. When relay 426 operated it released relays 449 and 451. Relay 449 opened the circuit of magnet 490 which released and advanced brushes 491, 492 and 493 to their third positions in which brush 492 connects ground to brush 412 of bank 4.

To avoid unnecessary duplication, only one repeater and incoming selector circuit, Figs. 2 and 5, are shown. Since in the present instance three more office sets of impulses are to be transmitted from the sender, it will be assumed that the incoming selector has picked out another repeater at a distant office similar to that shown in Fig. 2, and terminating in another incoming selector similar to that shown in Fig. 5. This incoming selector is now elevated five steps under the control of brushes 492, 412 and 432, and then rotates and seizes a trunk leading to the next office. The selector in which the trunk terminates is then elevated six steps under control of brushes 492, 413 and 432 and seizes an idle trunk to the succeeding office. The selector in which this trunk terminates is then elevated five steps under control of brushes 492, 414 and 432, whereupon it rotates and seizes a trunk leading to the terminating office, terminating in an incoming selector such as shown on Fig. 5.

Setting the incoming or first selector of wanted line office

At the end of this selecting operation brush 492 is in engagement with the terminal 478

which is connected to register brush 415. This selector must pick a group of 2,000 out of a group of 10,000 lines. Since the called number is assumed to be BO–8888 or 23–8888, this particular 2000 will be located in the fourth level, since the thousands digit is 8. Consequently, four impulses are transmitted to the incoming selector at the terminating office from the sender and when brush 432 reaches the fourth terminal, and relay 426 unlocks, this selector rotates and seizes an idle trunk terminating in a second selector such as shown in Fig. 6 which will pick a trunk to a group of 200 lines out of the selected 2,000.

Setting second selector of wanted line office

Assuming that the selector shown in Fig. 6 has been seized by the incoming selector and that the brush 492 has advanced into engagement with the terminal terminating in the brush 416, eight impulses will be transmitted to the vertical magnet 600 of the second selector. The impulse relay 501 is used in transmitting impulses to this selector and upon the first closure of its contact 559, relay 505 operates as follows: ground, 550, 559, 551, 552, 553, 520, 554, 543, 505 to battery. Relay 505 locks as follows: battery 505, 546, 555, 556, 545, 534, 531, 566, 523, 526, 538, 601, 602 to the grounded back contact of the vertical magnet 600. Relay 505, in attracting its armature 535, operates magnet 600 as follows: ground, 558, 557, 569, 535, 532, 567, 568, 524, 527, 539, 603, 604, slow release relay 607, Fig. 6, magnet 600 to battery. Magnet 600, at the end of its stroke opens the locking circuit for relay 505, and relay 505, in releasing, opens the circuit of the vertical magnet 600. This operation continues for each closure of the contact 559 of relay 501. The operations just traced continue until eight vertical impulses are transmitted, which positions the brushes 617, 618, 606, 620, 614, 611 opposite the desired level having trunks terminating in connectors upon which terminate the desired line multiples. The relay 607 is similar to the relay 202 (Fig. 2) and remains energized during the transmission of the vertical impulses. When the O. N. contacts 605 closed during the first vertical step relay 621 which corresponds to relay 271 (Fig. 2) operates over the following circuit: free pole of battery, relay 621, armature and back contact of the rotary magnet 624, off-normal switch 605, armature and front contact of relay 607 to ground. Relay 621 in attracting its inner right armature locks itself up and at its left armature transmits an impulse to the rotary magnet 624 when the slow relay 607 releases a short interval after the transmission of the vertical impulses, the circuit for the magnet 624 including the left armature and front contact of the relay 621 and the normal contact of the slow relay 607. The set of brushes are now in engagement with the first trunks of equivalent groups and the relay 626 is operated at this time. Its original energizing circuit was closed when the relay 621 closed its outer right armature and if both trunks are busy, that is to say, test multiples 643 and 690 are grounded, relay 626 holds up over the ground on multiple 643 and the ground on multiple 690 again operates relay 621 to transmit another impulse to the rotary magnet 624 to step the brushes on to the next two trunks. The circuit for holding relay 626 operated leads over its armature 608, normal contact 609 of relay 625, test brush 606 to the grounded multiple 643. The circuit for again operating relay 621 leads over grounded multiple 690, test brush 611, armature 612 and front contact of relay 626, conductor 650, armature 660 and back contact of relay 625, conductor 627, switch 605, relay 621, free pole of battery. Relay 621 locks up in the circuit previously traced and transmits an impulse to the rotary magnet 624 over the circuit previously traced. If the upper trunk is busy and the lower trunk idle, the ground on the upper trunk test multiple 643 holds the relay 626 energized, and the absence of ground on the test multiple 690 of the lower trunk causes the relay 621 to remain inert. The absence of ground on the lower trunk removes the shunt from about the switching relay 625 which now receives enough current through its lower winding to operate over the following circuit: free pole of battery, relay 621, armature and back contact of the rotary magnet, switch 605, conductor 627, lower winding of relay 625, release conductor 613, conductor 540, test multiple 528, brush 525, armature 563 and its back contact 530, armature 529 and front contact of relay 509, conductor 557, armature 558 and front contact of relay 502. Relay 621 is marginal and does not operate in this circuit. Relay 625 in attracting its armature 619 provides a substitute circuit for relay 626 independent of the original energizing circuit including the grounded multiple 690, the ground from which may be removed at any time by the release of this trunk by the selector that seized it. Relay 625 in attracting its lower armature 660 applies ground to the test multiple 690 to cause the seized trunk to test busy to other switches. In attracting its armatures 601 and 603, relay 625 extends the calling line to the talking brushes 620 and 614, and cuts off the bridge containing the vertical magnet 600 and its armature. If, on the other hand, the upper trunk was idle and the lower trunk busy, the test brush 606 finding no ground on the test multiple 643 of the upper trunk causes the release of the relay 626. In this latter event, relay 626 in releasing its armatures 615, 616, extends the calling line to the upper talking brushes 617, 618. The absence of ground on the upper test multiple 643 removes the shunt from about the relay 625 which operates to effect the results

described. The attraction of the armature 660 of the relay 625 grounds the test multiple 643 of the upper trunk to cause the same to test busy to other selectors.

Connector brush or hundreds selection—hundreds digit even

When the calling line is extended to the connector, Fig. 7, ground is supplied to the test wire 706 from armature 660 of relay 625. Relay 744, Fig. 7, operates from this ground, which in turn causes relay 745 to operate from ground on sleeve wire 706 through armature 719 and front contact of relay 744, conductor 701, off-normal switch 702 now closed, lower winding of relay 745 to battery. A short interval after the connector has been seized, the brush 434 of the timing switch (Fig. 4) reaches its normal position unlocking relay 426 preparatory to transmitting the next set of impulses. When relay 426 operated it released relays 449 and 451, the former opening the circuit of magnet 490 which released and advanced brushes 491, 492 and 493 to position 8 in which position brush 492 connects ground to brush 417. The hundreds digit involved being even, the sender now transmits two impulses by means of brushes 432 and 417, since the terminal on which brush 417 is resting is connected to the second terminal in the terminal arc over which brush 432 travels. These impulses follow the path traced in operating the vertical magnet 600 of the second selector up to the armature 603 of relay 625 and due to this armature being attracted, the new path leads over armature 616, 614, 623, 710, 709, 708 772, 703, 768, 792, 793, battery. Relay 793 in attracting its right armature on receipt of the first impulse operates slow relay 796 as follows: battery 796, 794, 791, 769, 725, to ground. Relay 793 in attracting its armature 795 locks to said ground in series with relay 790. Relay 790 in attracting its left armature 792 connects conductor 768 to armature 797 which is now extended, due to the energized condition of relay 796, to conductor 798 and thence to shifting relay 773. The second impulse operates this shifting relay which in attracting its armature 770 locks to grounded sleeve wire 706. Its armatures 775 and 761 connect the tip and ring conductors to the brushes 731, 732, disconnecting brushes 734 and 735. Thus hundreds selection is accomplished.

Setting connector for tens digit

A short interval after the connector shifting relay 773 has operated to select the hundreds, the brush 434 of the timing switch (Fig. 4) reaches its normal position, unlocking relay 426 preparatory to transmitting the tens set of impulses. When relay 426 operates it released relays 449 and 451, the former opening the circuit of magnet 490 which released and advanced brushes 491, 492 and 493 to position 9 in which brush 492 connects ground to brush 418. The sender now transmits eight impulses by means of brushes 492, 432 and 418, since the contact on which brush 418 is resting is connected to the eighth terminal in the terminal arc over which brush 432 travels. These impulses follow the path traced for operating relay 793 up to the armature 792 of relay 790 but since relay 790 is now locked up, these impulses pass by way of the front contact of said armature, the back contact of slow relay 796, now inert, to the vertical magnet 705.

The locking circuit for relay 505 leads over its armature 534, armature 531 and front contact of relay 509, conductor 566, the upper talking conductor, Figs. 5, 6 and 7, armature 746 and front contact of relay 744, armature 747 and back contact of relay 748, conductor 749 to ground at the armature and back contact of the relay 796. The stepping circuit for said magnet leads from grounded armature 558 of relay 502 (Fig. 5), conductor 557, 569, 535 of relay 505, armature 532, conductor 567, lower talking conductors (Figs. 5, 6 and 7), armature 709 and front contact of relay 744, armature 708 and back contact of relay 748, slow relay 772, armature 703 and front contact of relay 745, 768, 792, 797, to battery through the magnet 705. The connector is thus stepped up the number of steps corresponding to the tens digit involved, which in the present case, is presumed to be 8. Slow relay 772 is operated in this circuit and being slow holds up over the breaks in its circuit. In attracting its inner left armature, relay 772 holds up the relay 745 after the off-normal switch 702 opens on the first step of the connector. When the impulses cease relay 772 releases, releasing relay 745 which in retracting its armature 703 transfers the impulse circuit to the rotary magnet 704.

Setting connector for units digit

A short interval after the connector is set vertically, the brush 432 of the timing switch (Fig. 4) reaches normal, unlocking relay 426 preparatory to transmitting the units set of impulses. When relay 426 operated it released relays 449 and 451, the former opening the circuit of magnet 490 which released and advanced brushes 491, 492 and 493 to position 10, in which brush 492 connects ground to brush 419. The sender now transmits eight impulses by means of brushes 492, 432 and 419 since the contact on which brush 419 is resting is connected to the eighth terminal in the terminal arc over which the brush 432 travels. These impulses pass along the path traced for the tens impulses to armature 703 of relay 745 which relay being now inert, the path leads over the bank contact of armature 703 to the rotary magnet 704, to battery. During the transmission of the rotary im-

pulses, relay 772 is operated as in the case of the vertical impulses, and in attracting its inner left armature operates relay 750 over a circuit including the armature 720 and back contact of relay 745 which released on the termination of the tens impulses. Relay 750 locks up to the grounded sleeve wire 706.

Release of sender

When relay 772 releases at the end of the series of units pulses, relay 748 is operated over the outer left armature and back contact of relay 772, the ground being supplied from sleeve wire 706 over the front contact 756 of relay 750 and armature 720 of relay 745. Ground is now connected through armature 708 of relay 748, armature 709 of relay 744 over the ring conductors 710, terminal 623, brush 614, armature 616 and front contact of relay 626, armature 603 and front contact of relay 625, 539, 527, 524, 568, 567, 532, 535, 570, 503 to battery. This ground is removed when slow relay 744 releases which occurs shortly after its locking circuit is opened by the attraction of the armature 712 of relay 748. Off-normal contact 751 is at this time open. Relay 503 in attracting its armature 520 disconnects relay 505 from the lower front contact of the slow relay 502, thus permanently opening the impulse circuit. Relay 503 in operating locks up to ground on the upper armature of slow relay 502. In attracting its armature 522 it disconnects conductor 567 from the lower talking conductor. In attracting its armatures 519 and 522, it prepares a circuit for supplying talking battery to the called line. Relay 503 at its armature 518 removes a short circuit from about high resistance relay 500 which operates and provides a new circuit for slow relay 502. Due to the removal of this short circuit relay 207, which is marginal, releases, opening the circuit of slow relay 204, but before this relay retracts its upper armature 226, a circuit is closed from grounded armature 224 of relay 207, armature 226 and front contact of relay 204, conductors 272, 273, relay 206 to battery. Relay 206 operates and locks over 233, 236, 239, 266, 260, 358, 331, 330, 318 to ground at 311. Relay 206 in attracting its armature 268 releases relay 201 disconnecting the repeater relays and reestablishing the continuity of the talking conductors. The ground applied to conductor 272 to operate relay 206 also operates relay 213 as follows: 272, 209, 232, 235, 238, 265, 357, 334, 327, 322, 356, 455, 460, 359, 323, 326, 335, 360, 276, 213 to battery. Relay 213 operates to release the cord finder and sender for the use of other calls and releases relay 211 whereupon relay 212 holds in circuit with the calling line. At its armature 254 relay 213 locks to ground at the right armature of relay 212. At its armatures 249 and 250, relay 211 connects coil 218 in the loop containing relay 501 in place of repeater relay 207. Relay 213 in attracting its armature 253 applies a substitute ground for holding relay 217 operated after its operating ground is removed by the release of the cord finder. The cord finder, Fig. 3, and sender, Fig. 4, are released as follows upon the operation of relay 213. The operation of relay 213 released relay 211 as described and the release of this relay disconnected the impulse relay 436 of the sender (Fig. 4) from the calling line. This relay in retracting its armature 440 opened the circuit of the slow relay 439. These relays in their inert condition at their armatures 440 and 441 apply ground to conductor 470 to which the release magnets 402, 405 and 408 are connected in parallel through their off-normal switches 471, 472 and 473, respectively. These magnets restore the sender brushes 409 to 419 inclusive to normal and when said off-normal switches restore, a circuit is closed from ground 474, through normal contacts on said off-normal switches in series, conductor 475, 365, off-normal switch 311 of the cord finder, release magnet 307 of the cord finder to battery which circuit is opened when the switch 311 opens as the cord finder is completely restored. The opening of this off-normal switch also unlocks relay 363. The cord finder and sender are now ready to be used to build up another connection.

Ringing called line

Relay 745 (Fig. 7) is connected to the sleeve conductor of the called line over brush 754, armature 715 of relay 773 and its front contact, conductor 716, right armature and back contact of relay 772, conductor 717, upper winding of relay 745, conductors 718, 701, armature 719 and front contact of slow to release relay 744 which is still operated at this time, to the grounded sleeve wire, causing relay 745 to operate from full potential through the cut-off relay 752 in case the called line is idle. Relay 745 then locks through its lower winding and its armature 720 and front contact, contact 756 to ground on the sleeve wire 706. The attraction of armature 742 of relay 745 applies a direct ground from the armature 725 and back contact of relay 744, which is now inert, to the test multiple 726 to reduce the potential thereon and thus cause the seized line to test busy. The circuit of relay 748 is opened by the operation of relay 745 at the back contact and armature 720. Relay 748 in releasing connects ringing current from the generator 721 to the called line bell ground return being supplied over the armature 722 of the ringing cut-off relay 753. When the called party answers, relay 753 is operated and locks over its lower winding and armature 723 to ground on the sleeve wire 706 and connects the talking circuit through. Upon the operation of the relay 753 and the extension of the calling

line to the called line, the battery feed relay 505 operates over the called line. The subscribers may now converse, talking current being fed to the calling line through the windings of relay 212 and to the called line over the relay 505.

Called line busy

Assuming now that the line desired had been busy, due to the ground on the multiple 726, the upper winding of the relay 745 is shunted by the path at the other switch and this relay fails to operate. Due to the non-operation of relay 745 relay 753 applies busy tone to the calling subscriber from the busy tone source 727, armature 728 and back contact of relay 753, conductor 729, armature 771 and front contact of relay 748 to the tip conductor 730 and thence to the calling line. Relay 748 is at this time operated due to the failure of the test relay 745 to operate.

Connector brush or hundreds selection—hundreds digit odd

Assuming now that the hundreds digit of the desired number had been odd instead of even, that is to say, assuming it to be BC 8988 instead of BC 8888. In that event the brush 417 would be resting on a terminal which is connected to the first terminal in the terminal arc over which the brush 432 passes and only one impulse would be sent to the relay 793 (Fig. 7) instead of two as described. This impulse is used to operate relay 793, which locks in series with 790, and although relay 790 by its armature 792 connects impulse lead 768 to armature 797, no impulse follows to operate relay 773. Therefore, when the hundreds digit is odd, the brush shifting relay 773 remains inert allowing incoming talking conductors to remain connected to the brushes 734 and 735 which serve the odd hundred lines in the connector, the other brushes 731, 732, serving the even hundreds, being disconnected from the trunk. The test brush 754 serving the even hundreds is also disconnected from the test wire 716 and the test brush 778 adapted to engage the test multiples 713 serving the odd hundreds is substituted. After the setting of the connector, therefore, if the relay 773 is inert, the calling line is connected to a line in the odd hundreds, whereas, if the relay 773 is operated it is connected to the corresponding line in the even hundred.

Restoration of connection

Upon the conclusion of the conversation and the replacement of the receiver by the calling party relay 212 is deenergized, releasing relay 213. Relays 212 and 213 released close at armatures 243 and 255 and off-normal contact 274, the circuit of first selector release magnet 214. Relay 212 released also closes by way of armature 243 off-normal contact 242, release conductor 275, and off-normal contact 133 the circuit of finder release magnet 194. The release of the first selector opens the loop containing retardation coil 218 and relays 500 and 501, relay 500 in releasing, opening the circuit of slow release relay 502. The circuit of release magnet 504 of the incoming selector is thus closed as follows: battery, 504, 512, 552, 559, 550 to ground. Relay 502 in releasing its upper armature 558 removes the ground from the sleeve conductor which is holding relay 625, Fig. 6, energized. Relay 625 in restoring its armature 665 closes the circuit of the release magnet 640 of the second selector, and in retracting its armature 660, removes ground from the sleeve wire leading to the connector which causes the unlocking of relay 750. Assuming that the called party has not yet replaced the receiver on the hook, the release of the connector is prevented by slow relay 745 which holds up by its lower winding, in series with the line loop of the called party, the circuit being as follows: battery, lower winding and armature 720 of relay 745, contact 756 and back contact of relay 750, armature 758 and front contact of relay 753, now operated, armature 760 and front contact of slow relay 745, armature 775, and front contact of relay 773, through the substation loop returning over armature 761 and front contact of relay 773, armature 762 and front contact of slow relay 745, armature 722 and front contact of relay 753, conductor 763, upper armature and back contact of relay 750, conductor 764, armature and back contact of relay 750, conductor 717, armature 742 and front contact of relay 745 to ground at the armature 725 and back contact of relay 744. Relay 753 is also locked over the following circuit: battery, lower winding of relay 753, armature 723, 764, 717, armatures 742 and 725, to ground.

When the called party replaces the receiver on the hook, relay 745 is released, and in turn releases relay 753. The release of relay 745 connects ground through the armature 725 and back contact of relay 744, armature and back contact 742 of relay 745, armature 741 and back contact of relay 750, causing the release magnet 743 to restore the connector.

In case of a busy line, or if the called subscriber is the first to hang up, the releasing operations are the same as those described, except that the removal of ground from the sleeve wire 706 causes the release of relays 750 and 745 which results in the closure of the circuit of release magnet 743.

In order to prevent accidental movement of the switchhook at the calling station, or fluttering of the switchhook, as it is called, from causing a wrong connection by transmitting a false preliminary impulse previous to the first set of impulses, the number 1 is

not used and when one impulse is transmitted the release magnet 402 of the code sender is operated as follows: When upon receipt of the first impulse the brushes 409 to 414 are elevated one step, a contact 488 is closed. When the line circuit remains closed after the transmission of this impulse slow relay 442 releases after a slight interval whereupon release magnet 402 operates as follows: battery, 402, 471, 488, 489, left armature of 442 to ground. Contact 488 is only closed when the switch is resting opposite the first level and is open at all other times.

Referring now to Fig. 4, it will be remembered that when office code BC was transmitted, the brushes 409 to 414, inclusive, were driven to the third terminal in the second level of their respective banks, and that due to this terminal in bank 1 being connected by conductor 420 to the first working terminal of the arc over which brush 493 wipes, the brushes 491, 492 and 493 were stopped in position 1.

Registration of office codes having a small number of letters

In office code GE, G representing seven impulses and E five impulses, is dialed by the calling subscriber the brush 409 is set on the fifth terminal in the seventh horizontal row and the brushes 491, 492 and 493 would be stepped until brush 493 engages terminal 476 connected by conductor 477 to the terminal in the bank grounded by brush 409. Brush 492 would then be connected to brush 415 and only five sets of impulses would be transmitted to the switches instead of ten; in other words the office code would thus be entirely cut out. This code GE or 75 would represent an intraoffice call; that is a call from a subscriber in one office to another subscriber in the same office instead of a call leading through a number of offices as described in detail. The first of these five sets of impulses would set a selector like that shown in Fig. 2, to pick out a trunk leading to the desired 2000 group. The second set would set a selector like that shown in Fig. 6 to pick out a trunk leading to the particular 200 group in that 2000. The third set of impulses would operate to determine which hundred of the two the called line is in, and the last two sets would cause the connector to select the tens and units in the selected hundred. Similarly any number of sets of impulses between 5 and 10 sets each set consisting of any number of impulses from 1 to 10 can be transmitted, depending on the wiring between the terminals of bank 1 and those of the arc associated with brush 493 and the wiring between banks 2 to 6 and the terminals of the arc associated with brush 432.

In other words, the brushes 409 to 414 and their banks make up a two-digit office code translating register sender which according to the setting of the brush 409 and the wiring between bank 1 and the arc of brush 493 and between banks 2 to 6, inclusive, and the arc of brush 432 and its bank determine the routing of the call through the telephone network to the desired office after which the brushes 415 to 419 and their banks cooperate with brush 432 and its bank to set the switches in said office to select the desired line.

What is claimed is:

1. In a telephone system, a telephone line, automatic switches for extending said line, a plurality of selective switches each having a plurality of separate directive movements, means controlled over said line for setting said selective switches in accordance with the designation of the desired line, means actuated by the setting of the first selective switch for transmitting impulses to said automatic switches in accordance with the setting of said switch, and means for thereupon transmitting impulses to the remaining automatic switches in accordance with the setting of the other selective switches.

2. In a telephone system, a telephone line, automatic switches for extending said line, a plurality of selective switches each having a plurality of separate directive movements, means controlled over said line for setting the first selective switch in accordance with the office code of the desired number and the remaining selective switches in accordance with the numerical designation of the desired line, means actuated by the completion of the setting of the first selective switch for transmitting impulses according to the office code to said automatic switches, and means for thereupon transmitting impulses to the remaining automatic switches in accordance with the setting of the other selective switches.

3. In a telephone system, a telephone line, automatic switches for extending said line, a plurality of selective switches each having a plurality of separate directed movements, means controlled over said line for setting said selective switches in accordance with the designation of the desired line, a counting device, means for associating the same successively with said selective switches to transmit impulses to said automatic switches as determined by the setting of the selective switches, and means for successively associating said counting device with said selective switches.

4. In an automatic telephone system, telephone lines, a plurality of offices wherein said lines terminate, automatic step-by-step switches, translating register senders at each office, means for automatically associating a calling line with an idle register sender, an impulse sender associated with said line for setting said register sender according to a given number of sets of impulses, and means for causing said register sender to transmit a modified number of sets of impulses to the

switches in the proper offices in tandem to route the call to the office wherein the desired line terminates and for thereupon causing said register sender to transmit a number of additional sets of impulses, the impulses of certain sets being translated to properly set the switches of the terminating office to select the desired line.

5. In an automatic telephone system, telephone lines, a plurality of offices wherein said lines terminate, automatic step-by-step switches, translating register senders at each office, means for automatically associating a calling line with an idle register sender, an impulse sender associated with said line for setting said register sender according to a given number of sets of impulses, and means for causing said register sender to transmit a greater number of sets of impulses to the switches in the proper offices in tandem to route the call to the office wherein the desired line terminates and for thereupon causing said register sender to transmit a number of additional sets of impulses, the impulses of certain sets being translated to properly set the switches at the terminating office to select the desired line.

6. In an automatic telephone system, telephone lines, a plurality of offices wherein said lines terminate, automatic step-by-step switches, translating register senders at each office, each register sender comprising a number of two movement step-by-step switches, means for automatically associating a calling line with an idle register sender, an impulse sender associated with said line for setting said register sender according to a given number of sets of impulses, and means for causing said register senders to transmit a different number of sets of impulses to the switches in the proper offices in tandem to route the call to the office wherein the desired line terminates and for thereupon causing said register sender to transmit a number of additional sets of impulses, the impulses of the first three sets of said additional impulses operable to control switches in the terminating office being translated by said register and the last two being untranslated to effect the proper setting of the switches at the terminating office to select the desired line.

7. In an automatic telephone system, telephone lines, a plurality of offices wherein said lines terminate, automatic step-by-step switches, register senders at each office, each register sender comprising plurality of registers each having a number of banks of terminals and brush sets and primary and secondary stepping magnets, means for automatically associating a calling line with an idle register sender, and impulse sender associated with said calling line for setting said registers in succession according to a given number of sets of impulses, means for causing said register sender to transmit a modified number of sets of impulses to switches in the proper offices in tandem to route the call to the office wherein the called line terminates, and to transmit additional sets of impulses to the switches at said office to properly set the same to select the desired line.

8. In an automatic telephone system, telephone lines, a plurality of offices wherein said lines terminate, automatic step-by-step switches, register senders at each office, each register sender comprising a plurality of registers each having a number of banks of terminals and brush sets and primary and secondary stepping magnets, means for automatically associating a calling line with an idle register sender, an impulse sender associated with said calling line for setting said registers in succession according to a given number of sets of impulses, means for causing said register sender to transmit a greater number of sets of impulses to switches in the proper offices in tandem to route the call to the office wherein the called line terminates, and to transmit additional sets of impulses to the switches at said office to properly set the same to select the desired line.

9. In an automatic telephone system, telephone lines, a plurality of offices wherein said lines terminate, automatic step-by-step switches, register senders at each office, each register sender comprising a plurality of registers each having a number of banks of terminals and brush sets and primary and secondary stepping magnets, means for automatically associating a calling line with an idle register sender, an impulse sender associated with said calling line for setting said registers in succession according to a given number of sets of impulses, means for causing said register sender to transmit a less number of sets of impulses to route the call over switches in the originating office and to transmit additional sets of impulses to switches thereat to properly set the same to select the desired line.

10. In an automatic telephone system, telephone lines, a plurality of offices wherein said lines terminate, automatic step-by-step switches, register senders at each office, each register sender comprising a plurality of senders each having a number of banks of terminals and brush sets and primary and secondary stepping magnets, means for automatically associating a calling line with an idle register sender, an impulse sender associated with said calling line for setting said registers in succession according to a given number of sets of impulses, means for causing said register sender to transmit a greater or less number of sets of impulses to the switches to properly route the call to the office wherein the called line terminates, and to transmit additional sets of impulses to switches at said office to properly set the same to select the desired line.

11. In an automatic telephone system, telephone lines, a plurality of offices wherein said lines terminate, automatic step-by-step switches, register senders at each office, each register sender having a class switch and a number of translating registers, means for automatically associating a calling line with an idle register sender, an impulse sender associated with said calling line for setting said register sender according to a given number of sets of impulses, and means controlled by the setting of said class switch for causing said translating register sender to transmit an office code of impulse sets to switches in the proper offices in tandem to route the call to the desired office, or for nullifying the office code of impulses and for causing said register sender to transmit sets of impulses to switches in the originating office to select the desired line.

12. In a telephone system, a train of automatic switches for connecting a calling and a called line, a director comprising registering apparatus and sending apparatus controlled by said registering apparatus to produce series of impulses for operating said switches, two sets of wipers in one of said switches, and means in said director for controlling the selection of either set of wipers.

13. In a telephone system, a train of automatic switches for connecting a calling and a called line, a director comprising registering apparatus and sending apparatus controlled by said registering apparatus to produce series of impulses for operating said switches, two sets of wipers in one of said switches, means in said director for controlling the selection of either set of wipers, and circuit arrangements in said director such that the set selected is made dependent upon the setting of said registering apparatus.

14. In a telephone system, a train of automatic switches for connecting a calling and a called line, a director comprising registering and sending apparatus for operating said switches for transmitting series of digit impulses, said registering apparatus comprising an office register and a plurality of digit registers, two sets of wipers in one of said switches, and means in said director for controlling wiper selection in accordance with the setting of one of the digit registers.

15. In a telephone system, a train of automatic switches for connecting a calling and a called line, a director comprising registering and sending apparatus for operating said switches for transmitting series of digit impulses, said registering apparatus comprising an office register and a plurality of digit registers, two sets of wipers in one of said switches, and means in said director for controlling wiper selection in accordance with the setting of the thousands digit register.

16. In a telephone system, a register sender including registering apparatus set under the control of a calling line to record a called telephone number, a sending device in said register sender controlled in accordance with the instant position of the registering apparatus to transmit a translated number represented by series of switch control impulses, and means in said register sender also controlled in accordance with the position of the registering apparatus for transmitting switching currents in addition to said series of impulses.

17. In a multi-office telephone system employing register translators for translating the portions of telephone numbers indicative of the called offices, means in the register translators for translating the portion of telephone numbers indicative of the subscribers' lines in the called offices into combinations of impulse series and switching currents.

18. In a multi-office telephone system employing register translators for translating series of stepping impulses corresponding to the office designations of called lines into series of similar impulses which may differ in number and value from the original impulses, means in the register translators whereby the series of stepping impulses representing the numerical designation of the called line are translated into a combination of stepping impulses and switching currents.

In witness whereof, I hereunto subscribe my name this 20th day of December A. D., 1922.

WARREN W. CARPENTER.