Dec. 10, 1935. N. H. SAUNDERS 2,023,702

AUTOMATIC TELEPHONE SYSTEM

Filed May 19, 1934 6 Sheets-Sheet 1

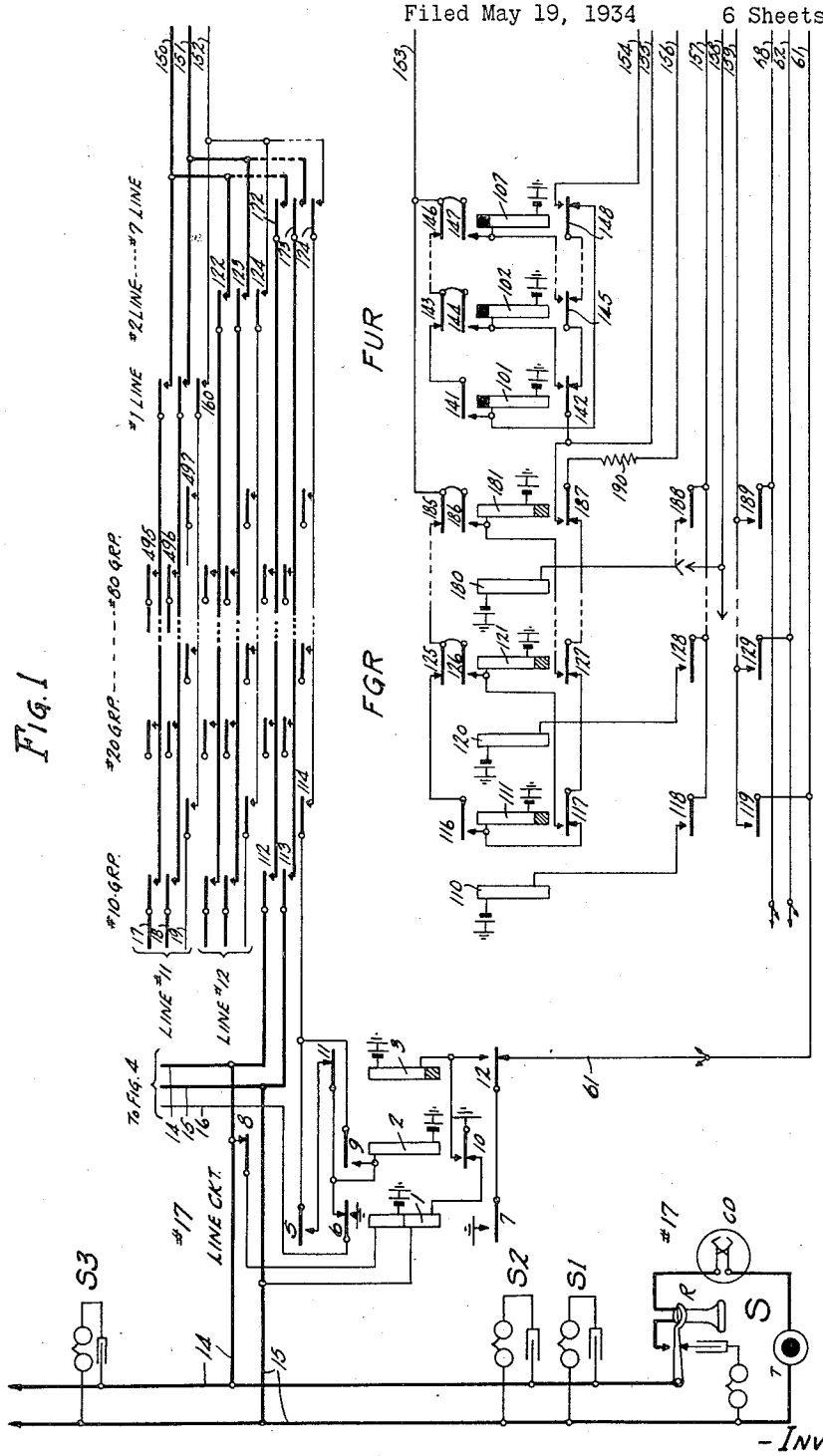


FIG. 1

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AUTOMATIC TELEPHONE SYSTEM

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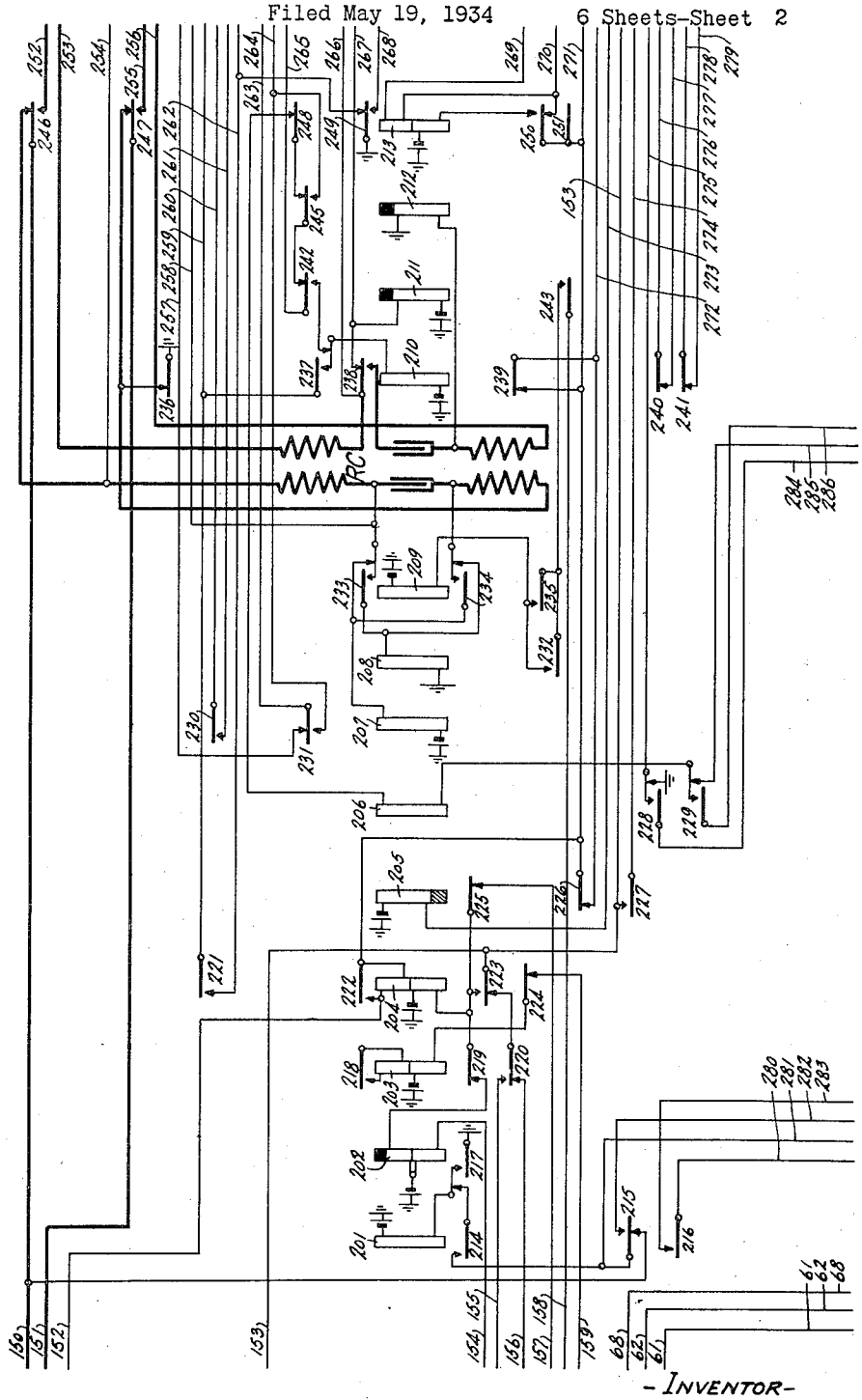


FIG. 2

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AUTOMATIC TELEPHONE SYSTEM

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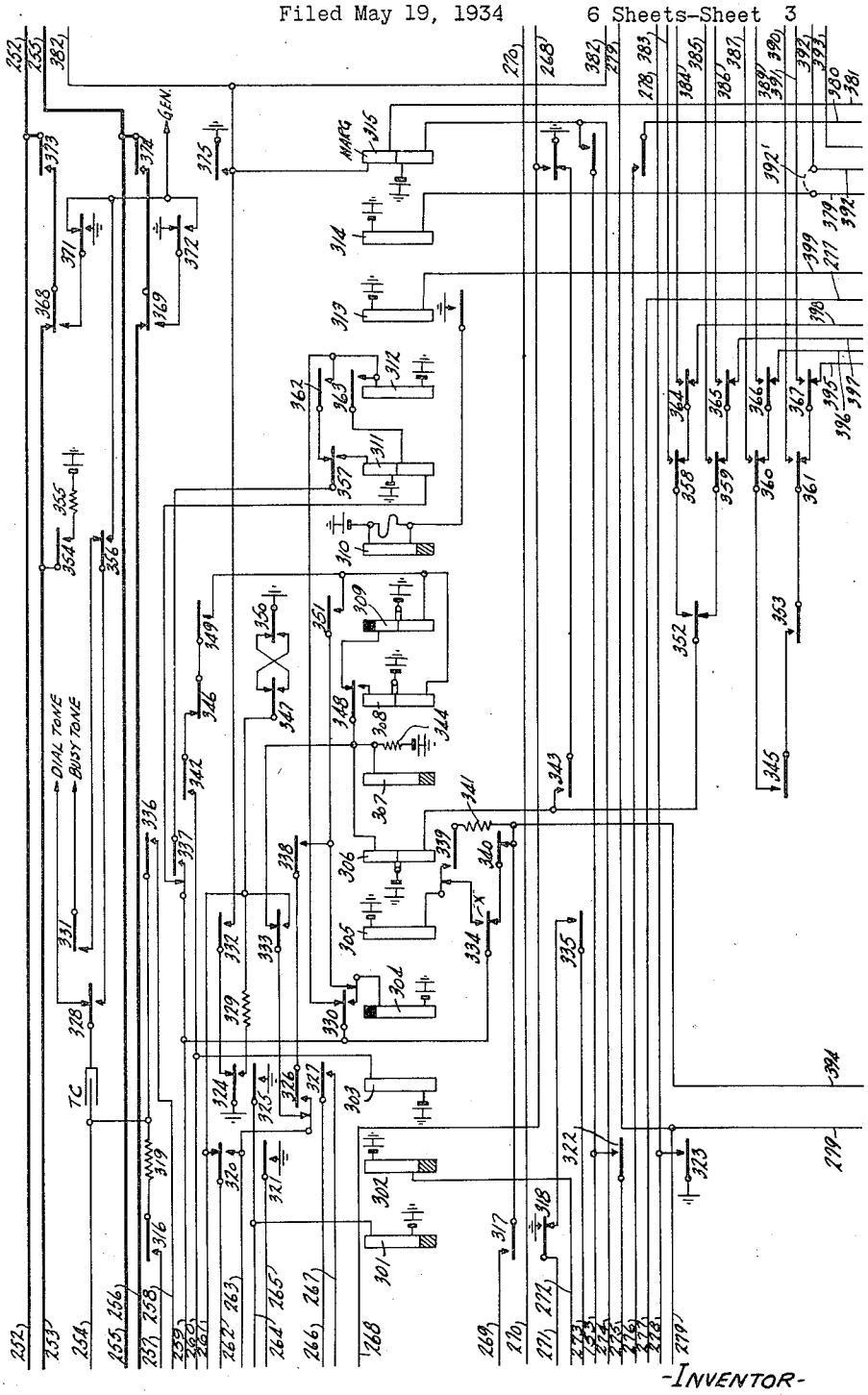


FIG. 3

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AUTOMATIC TELEPHONE SYSTEM

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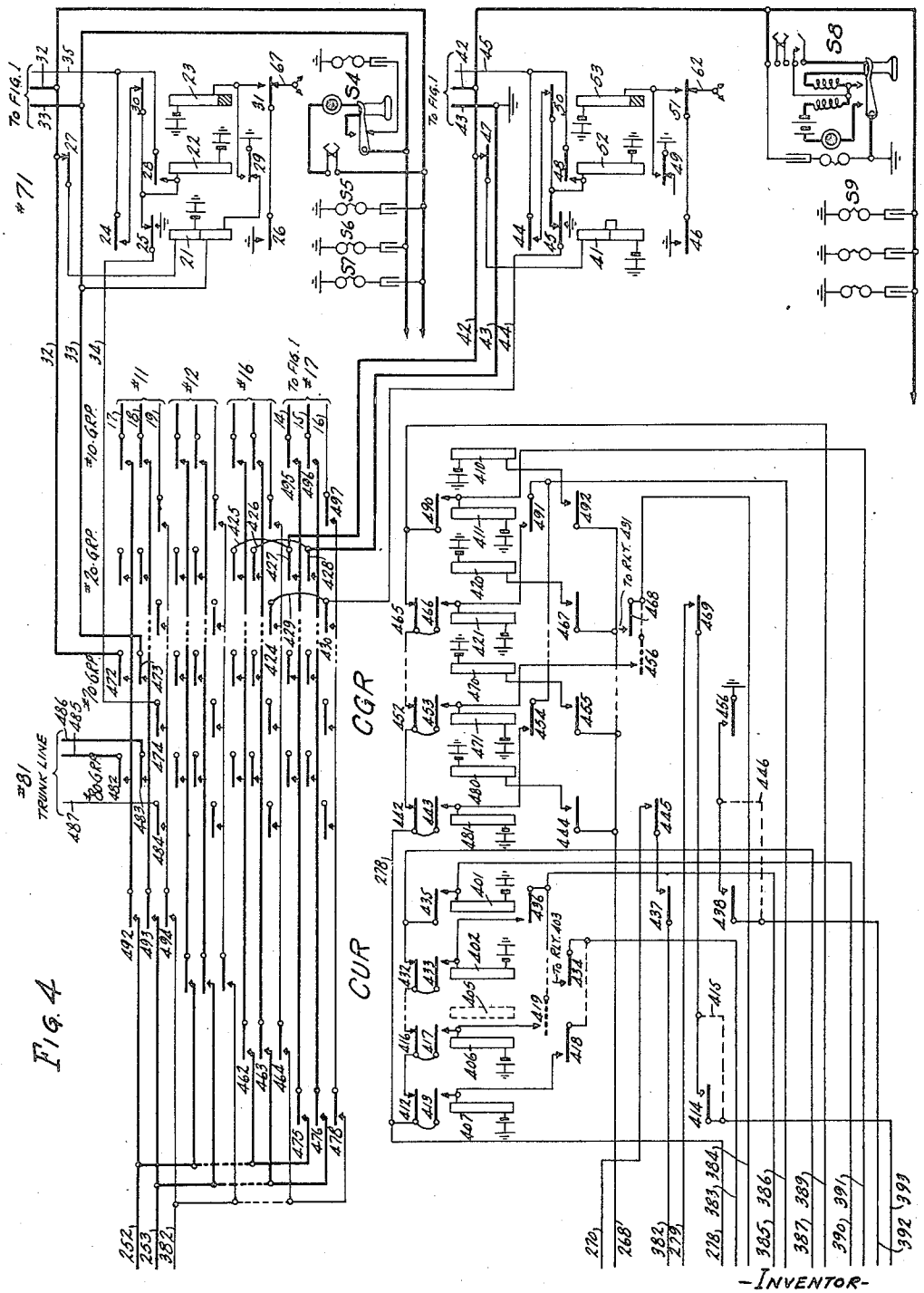


FIG. 4

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AUTOMATIC TELEPHONE SYSTEM

Filed May 19, 1934 6 Sheets-Sheet 5

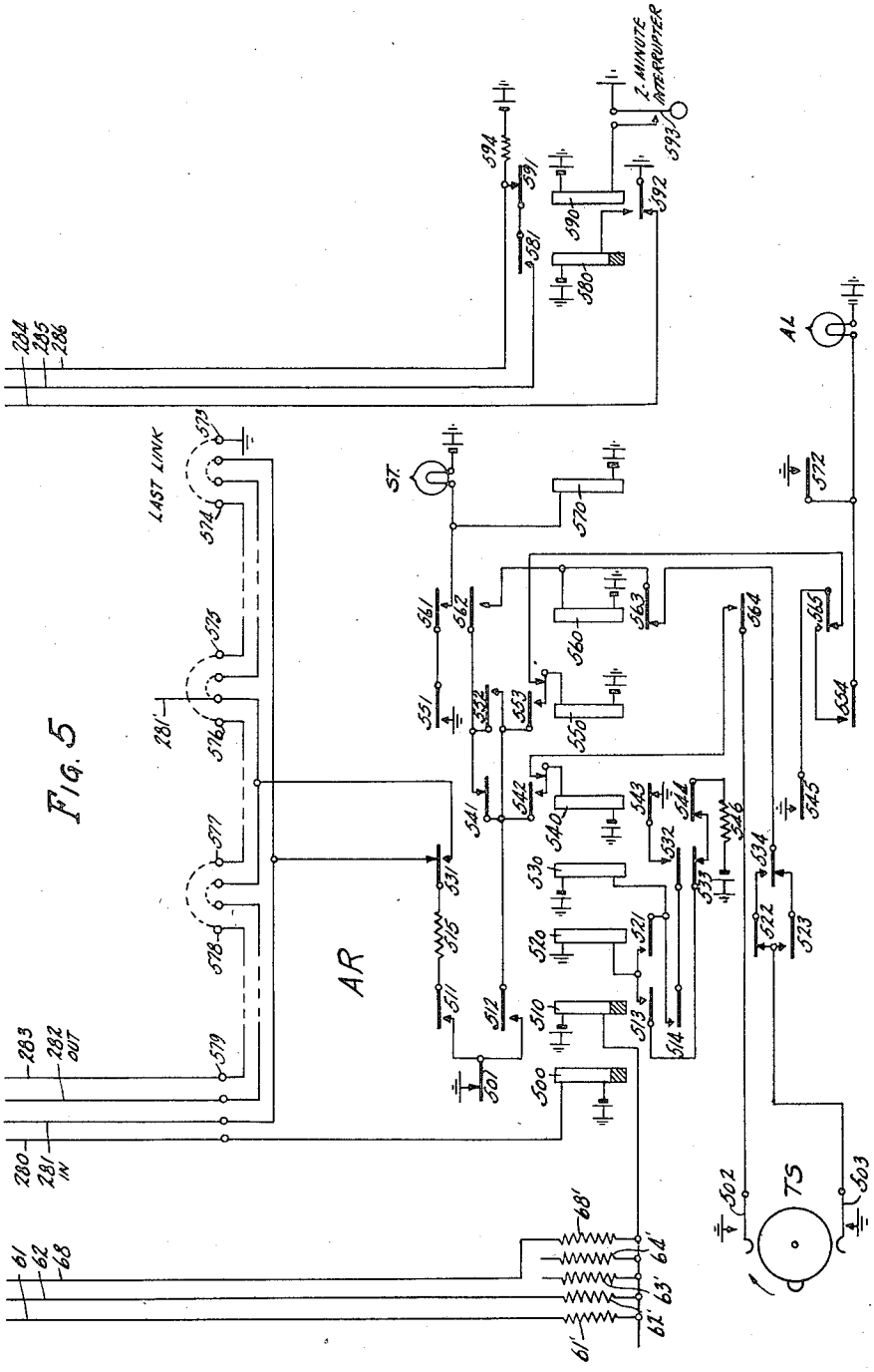


FIG. 5

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AUTOMATIC TELEPHONE SYSTEM

Filed May 19, 1934 6 Sheets-Sheet 6

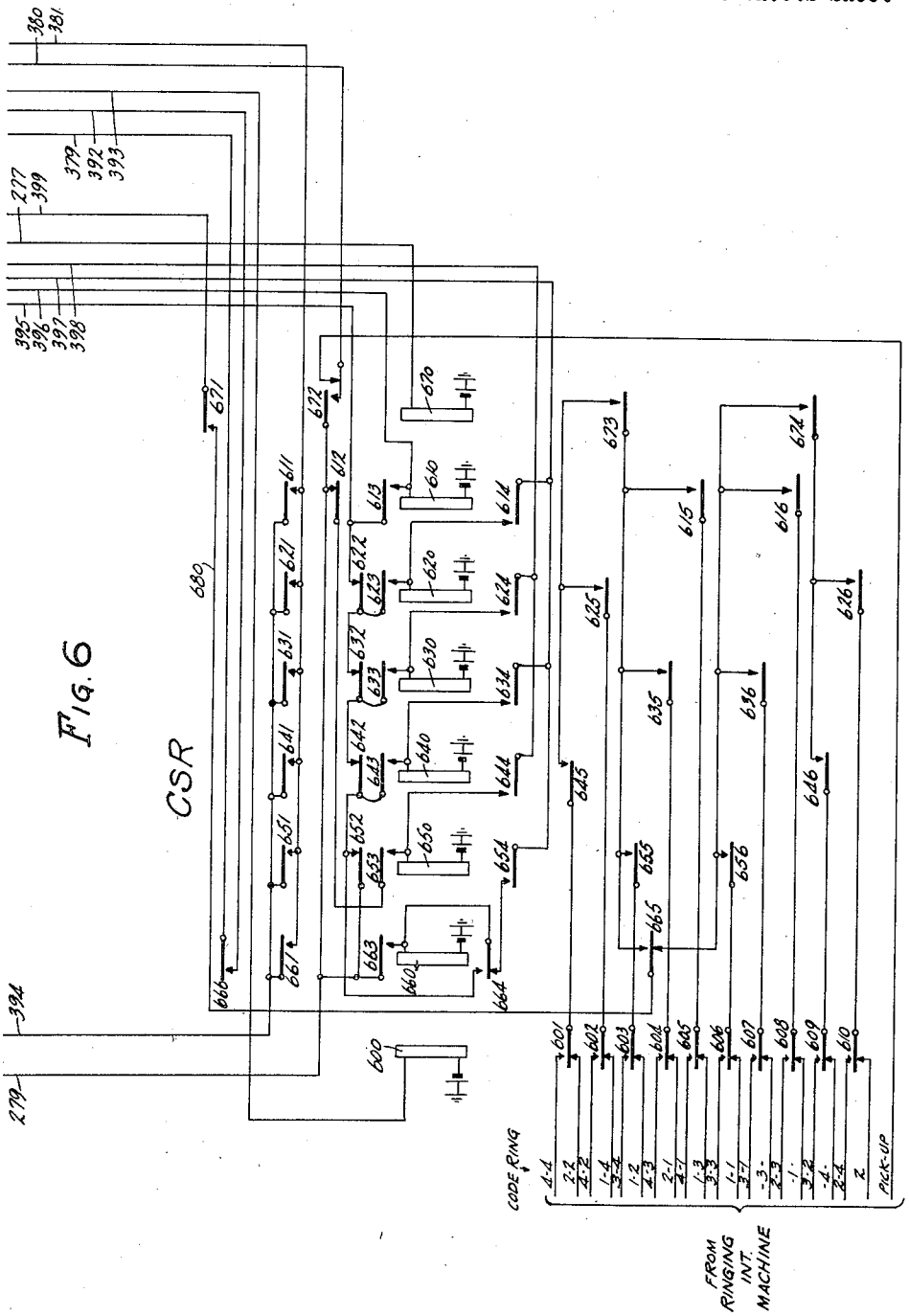


FIG. 6

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Patented Dec. 10, 1935 2,023,702

UNITED STATES PATENT OFFICE

2,023,702

AUTOMATIC TELEPHONE SYSTEM

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Application May 19, 1934, Serial No. 726,501

20 Claims. (Cl. 179—17)

This invention relates in general to automatic telephone systems, but more in particular to small systems suited for installations in towns or villages. An automatic telephone system of this type is generally known as a community automatic exchange or C. A. X., and may have a capacity of fifty lines, more or less. Usually the lines are party lines having either bridged or grounded ringing circuits over which the subscribers are signalled by means of code ringing. Provision is made also for trunking calls to and from distant exchanges.

The object of the present invention is to provide a novel and improved all relay community automatic exchange of the foregoing character.

One of the features of the invention relates to the novel circuit arrangement in the all-relay finder connector link for interconnecting the various lines in this system.

Another feature of invention relates to an improved lock-pulse arrangement for repeating impulses.

Another feature of the invention relates to the circuit arrangements for selecting and connecting various code rings to called subscribers' lines to signal a particular subscriber thereon dependent on both the line and code selecting digits dialled.

Another feature relates to the novel start and transfer circuit arrangement for allotting the various links for use, for transferring a call from one line to another in case the finder-unit relays of the first link fails to find the calling line, and for preventing a link, just released, from stealing a call away from another link.

These and other features of the invention will be apparent from the following detailed description of the invention.

Referring now to the drawings, comprising Figs. 1 to 6, inclusive, there is shown by means of the usual circuit diagram one of the all-relay finder connector links, the different line circuits and substation circuits by means of which the invention may be described and understood.

Fig. 1 shows a party line, in this case line 17 and its associated line circuit. The line conductors 14 and 15 and the incoming test conductor 16 of this line, shown bracketed, extend to the connecting end of the finder connector link in Fig. 4 where the conductors connect with correspondingly numbered conductors. The remainder of Fig. 1 shows the finding end of the finder connector link comprising a set of finder group relays FGR and finder unit relays FUR. Each group of lines, such as the ten group has two finder group relays, such as relay 110 for connecting only the line conductors of line group 10 to the link, and relay 111 which connects only the test conductors of line group 10 to the link. It is assumed in this case that there are eight groups of lines, each comprising seven lines each. In order to simplify the drawings, only three groups of lines, namely the 10-group, 20-group, and 80-group have been shown. Each of the lines are connected to a line circuit in the same manner as illustrated for line 17. The finder unit relays FUR correspond in number to the number of lines in each group, in this case, since there are seven lines in each group there are seven finder unit relays. Only three of the finder unit relays, however, have been shown in order to simplify the drawings.

Figs. 2 and 3 show the control relays of this finder connector link.

Fig. 4 shows the connecting end of this finder connector link and two line circuits. In the same manner as described for the finder group relays the connecting end of the link includes two relays for each group of lines. The connector group relay 410 for the first or tens group connects only the line conductors of the lines in the 10-group to the link while the relay 411 connects only the test conductors of the line in the 10-group to the link. Since there are eight groups of lines then there are eight sets of connector group relays provided, but only four of such sets have been shown. The connector unit relays comprise a group of seven relays, one relay for each corresponding line in a group. In this case only four of the connector unit relays are shown in order to reduce the drawing. Each odd connector unit relay prepares a circuit for the succeeding even connector unit relay, and each even connector unit relay prepares a circuit for the succeeding odd connector unit relay, as diagrammatically illustrated by the dotted lines. In a similar manner each off connector group test relay, such as relay 411, prepares a circuit for the succeeding even connector group test relay, such as relay 421. In a similar manner each even connector

group test relay such as relay 421 prepares a circuit for the succeeding odd connector group test relay, such as relay 431, not shown. In the upper right-hand corner is shown the line circuit for party line 71. The subscriber's ringers on this line are connected to both the negative and positive line conductors to provide the so-called divided ringing. In the lower right-hand corner of Fig. 4 is shown the line circuit of a grounded twenty-party party line.

Fig. 5 in its upper portion diagrammatically illustrates the chain circuit arrangement between the various finder connector links in this system while relays 500 to 570, inclusive, comprise the allotting and alarm relays. TS diagrammatically illustrates a time switch which is started in response to the operation of start relay 510 to close springs 502 and 503 at predetermined time intervals. Relays 580 and 590 and interrupter 593 comprise a timing device for freeing a finder connector link in case the same is held by a permanent line.

Fig. 6 shows the code selecting relays CSR which are controlled by the impulse repeating relay in the link to selectively connect one of the code ringing conductors extending to a ringing interrupter, not shown. The ringing machine, not shown, is started in operation in response to the operation of a switching relay in any link circuit and periodically grounds the code ring conductors shown to produce codes indicated by the numerals associated with such conductors.

Briefly, the operation of this system is as follows: When a calling subscriber initiates a call the test conductor of the calling line is marked with calling potential and the calling group is marked in all the finder group relays in all the links. The start conductor is grounded and the finder group relays in the first idle link operate in sequence to find the calling group. When the calling group is found the last operated finder group relay connects the test conductor of all the lines in the calling group to the finder units relay, which now operates in sequence until the marked calling line is found.

When the calling line is found the transfer relay in the link is operated to prepare another idle link for use and the calling line is connected to the control circuit of the link in use. The first digit transmitted by the calling subscriber operates an impulse repeating relay to successively operate the connector group relays. Only the last operated connector group relay is maintained energized to connect the test conductor of the called group to the connector units relays of the link. The second digit reoperates the impulse repeating relay to successively operate the corresponding connector unit relays. Only the last operated connector unit relay is maintained energized to connect the test conductor of the called line to the link control circuit. The third digit reoperates the impulse repeating relay to select the ringing code. If the called line is idle the ringing interrupter, not shown, grounds the selected code ringing conductor to cause the bells on the called line to be rung in accordance with the code selected.

In outgoing trunk calls the calling line is found in the same manner as just described and in response to dialling the two digits designating a trunk call the corresponding connector group and unit relays operate as before to connect with the trunk line. In this case the code selecting digit is not dialled as none is needed.

Local calls

It will now be assumed that subscriber S in Fig. 1 desires to call subscriber S4 shown in Fig. 4. When subscriber S removes his receiver a circuit is completed for energizing line relay 1 over the following circuit: from ground by way of armature 10 and resting contact, lower winding of line relay 1, line conductor 15, through the substation loop over line conductor 14, armature 8 and through the upper winding of relay 1 to battery; at armature 5, relay 1 connects calling potential to the test conductor by way of armature 11 and the winding of cut-off relay 2; at armature 6 and resting contact disconnects the cut-off relay 2 from the incoming test conductor 16, and at its make contact grounds the test conductor 16 to make this line busy to other subscribers attempting to call the same. At armature 7 relay 1 grounds the start lead 61 common to the 10-line group to complete a circuit for energizing the common start relay 510 as follows: from ground by way of armature 7, armature 12 and resting contact, common start lead 61, resistance 61' and through the winding of start relay 510 to battery. At armature 511 relay 510 completes a circuit for energizing line relay 207; at armature 512 prepares the locking circuit for relays 540, 550 and 560; at armature 513 completes the circuit for energizing relay 520, and at armature 514 prepares a circuit for shunting relay 520 and for energizing relay 530. The circuit for energizing relay 520 extends from ground through winding of relay 520, armatures 513, 533, and 544, resistance 546 to battery. Relay 520, upon energizing, at armature 521 prepares a circuit for energizing relay 530 and at armature 523 connects the winding of relay 560 to the time switch TS. Relay 530 is not energized at this time because this relay is shunted over the following circuit: from battery through the resistance 546, armatures 544, 533, 513, and 521 to the winding of relay 530 and battery.

Line relay 207 energizes over the following circuit; ground by way of armature 501, armature 511, resistance 515, armature 531 and resting contact, IN start lead 281, armature 215 and resting contact, conductor 150, armature 246 and resting contact, upper left-hand winding of repeating coil RC, normally closed springs controlled by armature 233 and through the winding of line relay 207 to battery. At armature 230 relay 207 completes the circuit for energizing impulse repeating relay 303, and at armature 231 prepares the circuit for energizing relay 301. The circuit for energizing impulse repeating relay 303 may be traced as follows: from ground by way of armature 249 and resting contact, conductor 262, armature 320 and resting contact, conductor 261, armature 230, conductor 260, and through the winding of impulse repeating relay 303 to battery. At armature 324 and working contact relay 303 completes a holding circuit for itself by way of resistance 329 and conductor 261; at armature 325 completes an obvious circuit for energizing relay 301 and grounds conductor 264; at armature 326 opens a point in the circuit to relays 306, 307 and 309, and at armature 327 shunts armature 238. At armature 316 relay 301 prepares a high resistance circuit for line relay 207, at armature 317 prepares a circuit for switch-through relay 213, and at armature 318 grounds conductor 271 to complete a circuit for energizing slow to release relay 302, as follows: from ground by way of armature 318, conductor 271,

through armatures 239 and 226 in multiple to conductor 272 and through the winding of relay 302 to battery.

At armature 320 and resting contact relay 302 opens the original energizing circuit of relay 303 which is now held energized over its locking circuit from ground at armature 324. At armature 320 and working contact relay 302 grounds conductor 263 and closes a multiple ground circuit though relay 301 by way of armature 231 and working contact and conductor 264. At armature 321 relay 302 grounds conductor 265 to prepare a circuit for the disconnect relay 206, at armature 322 connects grounded conductor 275 to finder lock conductor 153 and completes a circuit for energizing the first finder group relay 111, and at armature 323 grounds the connector lock conductor 278 as well as lock conductor 279 by way of armature 241.

The circuit for energizing the first finder group relay 111 extends from grounded conductor 153, armature 223 and resting contact, armature 220 and resting contact, conductor 156, resistance 190, armature 187 and resting contact, through the armatures and resting contacts of the finder group relays, not shown, to armature 127, resting contact of armature 127, armature 117 and resting contact, through the winding of relay 111 to battery. At armature 116, relay 111 completes its own locking circuit through the resting contacts of armatures, such as armatures 125 and 185, on the finder group relays to grounded conductor 153; at armature 118 prepares the circuit for relay 119; at armature 119 connects the grounded start lead 61 to the group test relay 203 by way of conductor 159 and armature 224; at armature 117 and resting contact opens its original energizing circuit and at its working contact closes the circuit for the second finder group relay 121. Relay such as relays 111, 121 and 181 are slightly slow to operate on account of their slugs and the resistance 190. At the upper armatures of relay 111 the test conductors of the 10-line group are connected to the test armatures of the finder units relay.

In order to describe the operation of the finder group relays it will be assumed for the time being that the calling line is not in the first or the 10-line group. In this case, after an interval relay 121 energizes over the following circuit: from grounded lock conductor 153, by way of armatures 223 and 220 and their resting contacts, conductor 156, resistance 190, armatures and resting contacts of the finder group relays to armature 117 and its working contact and through the winding of relay 121 to battery. In a manner similar to that described for relay 111 relay 121 energizes and at armature 126 locks itself to grounded conductor 153. At armature 125 relay 121 opens the locking circuit of relay 111 whereupon the latter relay deenergizes after an interval, and at armature 127 opens a point in its original energizing circuit and at the working contact of armature 127 completes the circuit for the succeeding finder group relay associated with the 30-line group, not shown. At armature 128 relay 121 prepares the circuit for relay 129, at armature 129 connects the start lead 62 of the 20-line group to the group test relay 203, and at its upper armatures connects the test conductors of the 20-line group to the finder units relay. Relay 111, upon deenergizing at its upper armatures disconnects the test conductors of the 10-line group, at armature 118 opens the prepared circuit to relay 119 and at armature 119 disconnects the start lead 61 from the group test relay 203. Finder group relays 131 to 171, inclusive (not shown) and relay 181 operate in the manner just described, each succeeding relay opening the locking circuit to the preceding relay to deenergize the same, connecting the corresponding group start lead to the group test relay 203, preparing a circuit to its associated line connecting relay, completing its own locking circuit, and connecting the test conductors of its associated group to the finder units relay.

When the finder group relay corresponding to the group in which the calling line is located is operated ground on the start lead completes the circuit for energizing the group test relay 203. For example, relay 111 at armature 119 completes the circuit for energizing group test relay 203 in case a line in the 10-line group is calling as follows: from grounded start lead 61, armature 119, conductor 159, armature 224 and through the lower winding of group test relay 203 to battery. At armature 218 relay 203 completes a short circuit around its upper winding to make this relay slow to release, at armature 219 opens a point in the circuit to relay 202, at armature 220 disconnects grounded conductor 153 from conductor 156 to open the circuit to the succeeding finder group relay before the same can energize and close its locking circuit, and at armature 220 and working contact connects the grounded conductor 153 to conductor 155 for energizing the first finder unit relay 101 as follows: from grounded conductor 153, armature 223 and resting contact, armature 220 and working contact, conductor 155, armature 142 and resting contact, armature 145 and resting contact, through similar armatures on the finder unit relays (not shown) to armature 148 and resting contact and through the winding of relay 101 to battery. At armature 141 relay 101 completes a locking circuit for itself by way of armatures on the other finder unit relays (not shown) to grounded conductor 153. At armature 142 relay 101 opens its original energizing circuit and completes the circuit for relay 102 and at its upper armatures connects the link line conductors 150 and 151 to contacts on the finder group relay and at armature 160 connects the test lead 152 to the test lead 19 of line 11 to prepare a circuit for the line test relay 204.

The finder unit relays, due to the copper slug on their upper ends, are fairly slow to operate, and therefore the second finder unit relay only operates after a time sufficient to permit the energization of the line test relay 204 in case a calling line is connected with. In case line 11 is not a calling line, then relay 102 energizes after an interval by way of grounded conductor 155, armature 142 and working contact. At armature 143 relay 102 opens the locking circuit of relay 101 which accordingly deenergizes after an interval, at armature 144 completes a locking circuit for itself from grounded conductor 153, at armature 145 and working contact prepares the circuit for the third finder unit relay (not shown) and at its upper armatures connect the line conductors 150 and 151 to the line finder group contacts and at armature 124 connects the test conductor of line 12, since relay 111 associated with the 10-line group is energized, to the test conductor 152.

Relay 101, upon deenergizing, at its upper armatures disconnects the test and line conductors at armature 141 opens a point in its own locking circuit, at armature 142 and working con-

tact opens the original energizing circuit of relay 102, and at the resting contact of armature 142 connects the third finder unit relay (not shown) to grounded conductor 155, by way of armature 145 and its working contact. Finder unit relays 103 to 105, inclusive (not shown) and relay 107 operate in the manner just described, each relay at its upper armature connecting the test conductor of its corresponding line to line test relay 204, opening the locking circuit of the preceding operated relay, closing its own locking circuit, and preparing the energizing circuit to the succeeding relay which is completed when the preceding relay deenergizes.

In this case, since line 17 is calling, then when finder unit relay 107 energizes this relay at armature 174 completes the circuit for energizing the line test relay 204 in series with the cut-off relay 2 as follows: from ground at armature 318, conductor 271, upper winding of line test relay 204, conductor 152, armature 174, armature 114, armature 5, armature 11 and through the winding of cut-off relay 2 to battery. At armature 221 relay 204, upon energizing, completes a circuit for energizing relay 312 and for grounding conductor 259, at armature 222 short circuits its upper winding to render the relay slow to release and to connect direct ground to the test conductor, at armature 223 disconnects grounded conductor 153 from conductor 155 to open the circuit to the succeeding finder unit relay before the same can fully energize, at armature 223 and working contact completes a locking circuit to its lower winding and a circuit for energizing relay 110, and at armature 224 opens the circuit to group test relay 203 to cause this relay to deenergize.

Cut-off relay 2, upon energizing, at armatures 8 and 10 and opens the circuit of line relay 1, at armature 9 completes a locking circuit for itself to grounded test conductor 142, and at armature 10 and its working contact completes the circuit for energizing lockout relay 3. Relay 110 is energized over the following circuit: from grounded conductor 153 by way of armature 223 and working contact, armature 225, conductor 157, armature 118 and through the winding of relay 110 to battery. At its upper armatures relay 110 connects the line conductors of the lines in the 10-line group to the contacts of the finder unit relays and in the case of armatures 112 and 113 connects the calling line or line 17, to conductors 150 and 151 by way of armatures 172 and 173 thereby completing a new energizing circuit for line relay 207 and for connecting dial tone to the calling subscriber's line to notify such subscriber that he may now dial the called subscriber's number. Lockout relay 3, upon energizing, at armature 11 opens the original energizing circuit of cut-off relay 2, at armature 12 and resting contact disconnects ground from the start conductor 61 to deenergize start relay 510 if no other line is calling, and at armature 12 and its working contact completes a locking circuit for itself from grounded armature 7. Line relay 1, upon deenergizing, at armature 6 disconnects direct ground from incoming test conductor 16 at its working contact and at its resting contact connects ground by way of armature 318, conductor 271, armature 222, conductor 142, armatures 164 and 114, and armature 9 to the incoming test conductor 16 to maintain this line busy at the called end of the link. At armature 7 relay 1 opens the locking circuit of lock-out relay 3.

Group test relay 203, upon deenergizing when its circuit is opened at armature 224, at armature 219 completes a circuit for energizing relay 202 through its upper winding by way of working contact of armature 223 and grounded conductor 153. At armature 217 relay 202 completes an obvious circuit for the transfer relay 201. At armature 214 relay 201 prepares a locking circuit for itself, at armature 215 opens the original energizing circuit of line relay 207 now held energized over the calling subscriber's loop, and at the working contacts of armature 215 connects the IN start conductor 281 with the out conductor 282 so that a succeeding call may seize the next idle finder connector link. At armature 216 relay 201 completes one point in the all link busy chain by connecting conductor 280 to conductor 283.

The circuit for energizing relay 312 may be traced as follows: from grounded armature 249 and resting contact, conductor 262, armature 221, conductor 259, armature 330 and resting contact, and through the winding of relay 312 to battery. At armature 362 relay 312 prepares a locking circuit for itself, at armature 363 prepares a circuit through the lower winding of relay 311, which relay does not energize at this time because the lower winding is short circuited by way of armature 363, armature 330 and resting contact, and the normally closed spring controlled by armature 337. At armatures 364 to 367, inclusive, relay 312 prepares the pulsing circuit to the connector group relay.

Relay 510 deenergizes in case no other line is calling at this time, and at armature 511 disconnects ground from the start IN lead 281. At armature 513 relay 510 opens the shunt circuit of relay 530 which relay now energizes in series with relay 520 by way of armature 521. Relay 530, upon energizing, at armatures 531 transfers the start circuit from the beginning of the chain to the middle of the chain; at armature 532 prepares a short circuit for relay 520 and a circuit for relay 530, at armature 533 opens a point in the low resistance shunt of relay 530, and at armature 543 disconnects the time switch from relay 560 before the time switch has had sufficient time to energize relay 560.

At this point it may be advisable to consider the operation of the allotter relays in response to a second call when relay 530 is energized. In this case start relay 510 is energized over the common start lead as before, and at armature 511 completes the start circuit and grounds the IN start lead 281' as follows: ground by way of armature 501, armature 511, resistance 515, armature 531 and working contact to IN start lead 281', extending to the finder connector link near the middle of the chain. At armature 514 relay 510 connects grounded armature 543 by way of armature 532 to the winding of relays 520 and 530 with the result that relay 520 is short circuited and deenergizes, while relay 530 is maintained energized over this circuit. Relay 520, upon deenergizing, at armature 522 connects springs 503 of the time switch TS to the winding of relay 560. Relay 510 is deenergized and ground is removed from the IN start lead 281' at armature 511. At armature 514 relay 510 opens the circuit of relay 530 which accordingly deenergizes. At armature 531 relay 530 transfers the start circuit back to the beginning of the chain and at armature 534 disconnects the time switch TS from the winding of relay 560.

The circuit for maintaining line relay 207 energized over the calling subscriber's loop may be traced as follows: from ground by way of armature 236, resting contact and armature 247, con-

ductor 161, armatures 173 and 113, positive line conductor 15 through the substation loop to negative line conductor 14, armatures 112 and 172, conductor 150, armature 246 and resting contact, upper left hand winding of repeating coil RC, normally closed spring controlled by armature 233, and through the winding of line relay 207 to battery. Dial tone is also connected to the calling line at this time over the following circuit: from dial tone in Fig. 3, resting contact and armature 328, tone condenser TC, conductor 254, resting contact and armature 246, thence over the calling loop circuit just traced. The calling subscriber, after listening to the dial tone, dials the group and line digits followed by the code selecting digit. Line relay 207 deenergizes in response to each impulse. In response to the first pulse relay 207 at armature 230 opens the circuit of impulse repeating relay 303 which accordingly deenergizes. At armature 231 and its resting contact relay 207 closes a high resistance priming circuit for itself which may be traced as follows: from grounded conductor 262, armature 326 and working contact, conductor 263, armature 231 and resting contact, conductor 257, armature 316, resistance 219, conductor 254, upper left hand winding of repeating coil RC, normally closed switch springs controlled by armature 233, and through the winding of line relay 207 to battery. This priming circuit while sufficient to energize line relay 207 due to resistance 319 greatly assists the energization of line relay 207 when the same is connected to a "leaky" calling line. At armature 231 and its make contact one of the multiple ground connections to relay 301 is opened but this relay, due to its slow releasing characteristics, remains energized during the impulsing period.

Impulse repeating relay 303, upon deenergizing, at armature 324 opens a point in its own holding circuit, at armature 325 opens a further circuit to slow to release relay 301, and at armature 326 completes a circuit for energizing relays 306, 307 and 309. The circuit for energizing relay 306 and relay 307 extends from grounded conductor 262, armature 329 and working contact, normally closed springs controlled by armature 326, armature 333 and resting contact, and through the upper winding of relay 306 and the winding of relay 307 to battery. A branch of this circuit extends by way of armature 348 and resting contact, through the upper winding of relay 309 for energizing the latter relay. At armature 336 relay 308 short circuits the upper left-hand winding of repeating coil RC in order to improve the impulsing circuit, at armature 337 completes a holding circuit for relay 312 by way of grounded conductor 259 and armatures 357 and 362, at armature 333 prepares an energizing circuit for relay 304 and the holding circuit extending to the lower windings of relays 308 and 309, at armature 339 prepares a point in the circuit for the busy relay 305, and at armature 343 disconnects grounded conductors 259 from conductors 269 and 394.

Slow to release relay 307, upon energizing, at armature 342 prepares a holding circuit for relay 309, at armature 343 completes a locking circuit from grounded armature 376 through the lower windings of relay 308, and at armature 345 prepares a point in the circuit for the first connector group relay 411. Relay 307, due to its slow release characteristics, is maintained energized during the impulsing period and therefore deenergizes shortly after each series of impulses.

Impulse repeating relay 309, upon energizing, at armature 349 prepares a point in the energizing circuit of relay 308 and in the holding circuit of relay 309, at armature 350 prepares a new energizing circuit for impulse repeating relay 303 and the circuit through the lower winding of relays 308 and 309, at armature 351 prepares a holding circuit for the lower windings of relays 308 and 309, at armature 352 disconnects ground at armature 376 from the even pulse conductor 336 and connects ground to the odd pulse conductor 384, and at armature 353 completes a circuit for energizing connector group relay 411 as follows: from grounded lock conductor 278, through armatures 442, 452 and 465 of the connector group relays to conductor 389, working contact and armature 366, resting contact and armature 369, armatures 345 and 353, armature 391 and resting contact, armature 367 and working contact, conductor 391, and through the winding of relay 411 to battery. Relay 411 at its upper armature connects the test conductors of the lines in the 10-group to the connector unit relays; at armature 490 completes a locking circuit for itself to grounded lock conductor 278 by way of armatures 465, 452 and 442; and at armature 492 prepares the circuit for relay 410.

At the termination of the first impulse line relay 207 again energizes over the subscriber's loop to complete a circuit at armature 230 for energizing impulse repeating relay 303 and a circuit through the lower winding of relays 309 and 308. At armature 231 relay 207 opens its priming circuit and recloses the circuit for slow release relay 301 to maintain the same in energized position. The circuit for energizing relay 303 may be traced as follows: from ground at armature 350 on the energized repeating relay 309, resting contact and armature 347, conductor 261, armature 230, conductor 260, and through the winding of relay 303 to battery. A branch of this circuit extends by way of conductor 260, armatures 342, 346 and 349, through the lower windings of relays 306 and 309 and by way of armature 351 to relay 304. At armature 324 relay 303 again completes its holding circuit, at armature 325 again closes a multiple circuit for relay 301, and at the normally closed spring controlled by armature 326 opens the original energizing circuit of relays 306, 307 and 309, while at armature 326 and its working contact completes a circuit from grounded conductor 263 by way of armatures 338 for energizing relay 304 and for completing a circuit by way of armature 351 through the lower windings of relays 308 and 309. Relay 309 is maintained energized over this circuit while relay 308 is energized. At armature 346 relay 308 opens a point in one of its energizing circuits, at armature 347 opens the original energizing circuit of relay 303 which is now maintained energized over its own locking circuit, at armature 348 and resting contact opens the original energizing circuit of relay 309 and at its working contact prepares a locking circuit for itself. Relays 308 and 309 at this time are maintained energized from ground by way of conductor 263, working contact and armature 326, armature 338, armature 351 and through the lower windings of relays 308 and 309 to battery. Relay 304, upon energizing, at armature 328 disconnects dial tone and prepares a circuit for connecting ring back tone to the calling subscriber, at armature 330 and its resting contact opens the original energizing circuit of relay 312 and at its working con-

tact closes a locking circuit for itself from grounded conductor 259 as well as opening its original energizing circuit. At this time relay 312 is maintained energized over the following circuit: from grounded conductor 259, working contact and armature 337, armature 357 and resting contact, armature 362 and the winding of relay 312 to battery.

In response to the second pulse of the first series, line relay 207 again deenergizes and at armature 230 opens the circuit to the impulse repeating relay 303, while at armature 231 the multiple circuit to slow to release relay 301 is opened and the priming circuit for the line relay is again closed. Relay 303, upon deenergizing, at armature 324 again closes its own holding circuit, at armature 325 again opens the circuit to slow to release relay 301, at armature 326 recloses the circuit to slow to release relay 307 before such relay deenergizes, at armature 326 opens the holding circuit extending through the lower windings of relays 308 and 309, and at the normally closed springs controlled by armature 326 completes a locking circuit through the upper winding of relay 308 by way of armatures 333 and 348. Relay 309, upon deenergizing, at armature 350 prepares a circuit for reenergizing relay 303, at armature 351 opens a further point in the holding circuit through the lower windings of relays 308 and 309, at armature 352 connects ground at armature 376 to the even conductor 386 to complete an energizing circuit for the next connector group relay, in this case relay 421, and at armature 353 opens the original energizing circuit of relay 411. The circuit for energizing relay 421 may be traced as follows: from grounded armature 376 and resting contact, armature 343, armature 352 and resting contact, armature 359 and resting contact, armature 365 and working contact, conductor 386, armature 491, and through the winding of relay 421 to battery. Relay 421, upon energizing, at its upper armatures connects the test conductors of the lines in the 20-group to the connector unit relays, at armature 465 opens the locking circuit of relay 411 which accordingly deenergizes, at armature 466 completes a locking circuit for itself from grounded lock conductor 278 by way of armatures, such as armature 442 and 452, at armature 467 prepares a circuit for relay 420, at armature 468 connects the succeeding connector group relay 431 (not shown) to the odd pulse conductor 384, and at armature 469 prepares a point in the circuit for code switching relay 600. Relay 411, upon deenergizing, at its upper armatures opens the circuit to the test conductors of the line in the 10-group, at armature 490 opens its own locking circuit, at armature 491 opens the circuit to relay 421 now locked energized, and at armature 492 opens the prepared circuit to relay 410.

Line relay 207 reenergizes over the calling subscriber's loop at the end of the second pulse, and at armature 230 closes a circuit for energizing relay 303 by way of resting contact of armature 350 and working contact of armature 347, while at armature 231 the circuit to slow release relay 301 is again reclosed. Relay 303, upon energizing, at armature 324 again closes its locking circuit, at armature 325 again closes the circuit for relay 301, and at armature 326 opens the holding circuit through the upper winding of relay 308 which accordingly deenergizes. Relay 308, upon deenergizing at armature 346 prepares a point in the original energizing circuit of relay 308, at armature 347 opens the energizing circuit of relay 303 which is now held energized over its locking circuit, and at armature 348 opens a point in its own locking circuit and prepares a circuit for relay 309. From the foregoing it will be seen that relay 303 follows the pulses of line 207; that relays 308 and 309 are energized on the first pulse, and for each off pulse; that relays 309 and 308 are deenergized on the second pulse or on each even pulse; that relay 309 grounds the odd pulse conductor 384 on energization and grounds the even pulse conductor 386 on deenergization to successively operate the connector group relay such as relays 411, 421, etc. The circuit for reoperating impulse repeating relay 303 is taken through armatures 347 and 350 so that the circuit to relay 303 cannot be closed until relays 308 and 309 have operated or released.

As is well known, the line relay, such as relay 207, may be sluggish in its deenergization due to the leaky or heavily loaded condition of the line connected with. In order to insure correct pulsing a so-called lock-pulse arrangement is provided. In this arrangement the armatures or springs operated by line relay 207 have a strong adjustment or tension and the springs or armatures operates by pulse repeating relay 303 also have a very stiff adjustment so that this relay will very quickly fall back when its circuit is momentarily opened by line relay 207 at armature 230. When relay 303 is deenergized such relay cannot again energize until the repeating relays 308 or 309 have operated or released to close the circuit for relay 303, even though the line relay is immediately reoperated. Relays 308 and 309 need not necessarily be fast operating relays in order to repeat the impulses received. In addition a priming circuit or artificial leak is provided through resting contacts on the line relay 207 for facilitating its reoperation over long, clear lines. This impulsing circuit in combination with the odd and even pulsing circuits has proven to be a very satisfactory circuit arrangement on lines of varying electrical characteristics which heretofore have prevented automatic working.

In response to the third pulse relays 207 and 303 deenergize and relay 303 causes the energization of relay 309 as previously described for the first pulse. When relay 309 grounds the odd conductor 384 the third connector group relay 431 (not shown) is energized over the odd pulse conductor 384 at armature 468. In the same manner as described for relay 421, relay 431 (not shown) closes its upper armatures to connect the test leads of the 30-line group; opens the locking circuit of relay 421 which deenergizes; closes its own locking circuit; prepares the circuit through its associated line connecting relay (not shown) similar to relay 420; and connects the connector group test relay of the 40-line group (not shown) to the even conductor 386. At the end of the third pulse relays 207, 303 and 308 energize as previously described for the end of the first pulse.

In response to the fourth impulse relays 207, 303 and 309 deenergize as described for the second pulse. When relay 309 grounds the even conductor 386 the connector group test relay (not shown) for the 40-line group is energized in a manner similar to that previously described. This connector group relay closes the test leads of the 40-line group; opens the locking circuit of the connector group relay of the 30-line group which deenergizes; closes its own locking circuit; prepares a circuit through its own associated line

connecting relay (not shown), and connects the connector group test relay of the fifth line group (not shown) to the odd conductor 384.

In the same manner as just described, each odd pulse grounds the odd conductor 384 to energize the corresponding connector group relay, and each even pulse grounds the even conductor 386 to energize the corresponding connector group test relay. The connector group test relays 431 to 461 and the associated connector group line connecting relays 430 to 460 are not shown because their circuit operations are identical with the connector group relays shown. In response to the seventh pulse odd conductor 384 is grounded by relay 309 to energize the connector group test relay 471 of the 70-line group by way of armature 456 on the connector group test relay of the 60-line group. Relay 471 at its upper armatures connects the test leads of the lines in the 70-group to the connector unit relays, at armature 452 opens the locking circuit of the last operated connector group test relay, at armature 453 closes its own locking circuit, at armature 454 connects the connector group test relay 481 of the 80-line group to even conductor 386, at armature 455 prepares the circuit to line connecting relay 470 of the 70-line group, and at armature 456 prepares a circuit for the ring reversing relay 314.

Relays 207 and 303 remain energized after the last impulse of the series and after an interval slow to release relay 307 deenergizes. At armature 343 relay 307 opens a point in the pulsing circuit as well as the holding circuit of relay 306 which accordingly deenergizes, and at armature 345 opens a point in the original energizing circuit of relay 411. Relay 306, upon deenergizing, at armature 336 removes the short circuit from the repeating coil RC, at armature 337 opens the locking circuit of relay 312 and substitutes the circuit through the lower winding of relay 311 in series with the winding of relay 312, whereby relay 312 is maintained energized and relay 311 is energized over the circuit from grounded conductor 259 in series with the winding of relay 312. At armature 338 relay 306 opens the circuit to relays 308 and 309 to deenergize the same if they should be energized at this time, at armature 339 opens a point in the circuit to the busy relay 305, and at armature 340 reconnects grounded conductor 259 to conductors 389 and 394. Relay 311, upon energizing in series with relay 312, at armature 357 prepares a locking circuit for itself, at armatures 358 and 359 prepares the pulsing circuit over the odd and even conductors 383 and 385 to the connector unit relays and at armatures 360 and 361 prepares a circuit for connecting the grounded lock conductor 278 to conductor 390.

The calling subscriber may now dial the second digit of the desired called subscriber's number. In the same manner as previously described, line relay 207 and repeating relay 303 deenergize for each impulse and in response to the first impulse completes the circuit for energizing relays 306, 307, and 309. Relay 306, upon energizing, at armature 337 opens the holding circuit of relay 312 to cause this relay to deenergize and likewise completes a locking circuit through the upper winding of relay 311 for maintaining this relay in energized position. In response to the energization of relays 307 and 309 a circuit is completed for energizing the first connector unit relay 401. Relay 312, upon deenergizing at armatures 364 to 367 prepares the pulsing circuit for the code selecting relay CSR.

Relay 401 energizes over the following circuit: from grounded lock conductor 278, armatures 412, 415, 432 and similar armatures on the connector unit relays (not shown), conductor 337, working contact and armature 360, armatures 345 and 353, armature 361 and working contact, conductor 390, and through the winding of relay 401 to battery. At armatures 492 and 493 relay 401 connects the talking conductors 252 and 255 of the link to the connector group relays, at armature 494 connects the test conductor 382 to the test conductor 34 of line 71; at armature 435 completes a locking circuit for itself from grounded lock conductor 278 through the armatures of the unoperated connector unit relays, at armatures 436 prepares a circuit to the succeeding even connector unit relay 402, at armature 437 prepares a point in the circuit for the trunk switch-through relay 213, and at armature 438 grounds conductor 392. Line relay 207 energizes at the end of each pulse and again completes the circuit for energizing repeating relay 303 in case relays 308 and 309 have operated or released, as previously described.

In order to describe the operation of the connector unit relays it will be assumed that the second digit being dialled is more than the digit 1. Relays 207, 303 and 309 deenergize in the same manner as previously described for the second pulse. At armature 353 relay 309 opens the circuit to connector unit relay 401, now held over its locking circuit, and at armature 352 disconnects ground from the odd pulse conductor 383 and connects ground to the even pulse conductor 385 to energize the second connector unit relay 402. This circuit may be traced as follows: ground by way of armature 476 and resting contact, armature 343, armature 352 and resting contact, armature 359 and working contact, even pulse conductor 385, armature 436 and through the winding of relay 402 to battery. At its two uppermost armatures relay 402 connects the link line conductors 252 and 255 to the contacts of the connector group relays, at the third uppermost contact connects the link test conductor 382 to the test conductor of line 72 by way of the operated contacts on connector group relay 471. At armature 433 relay 402 completes a locking circuit for itself from grounded locking conductor 278 by way of armatures 412 and 416 and similar armatures on other connector unit delays (not shown); at armature 432 opens the locking circuit of relay 401 which now deenergizes and at armature 434 connects the third connector unit relay 403 (not shown) to the odd pulse conductor 383. At the end of the second pulse relays 207 and 303 reenergizes and relays 309 deenergize, as previously described.

In response to the third pulse relays 207 and 303 deenergize and relay 309 reenergizes to ground the odd pulse conductor 383, as previously described. The third connector unit relay 403 (not shown) is energized to connect up the test conductor of line 73; to unlock the second connector relay 402 which accordingly deenergizes; to lock itself to lock conductor 278; and to connect the fourth connector unit relay (not shown) to the even pulse conductor 385. Relays 207, 303 and 308 energize at the end of the third pulse, as previously described.

In response to the fourth pulse relays 207, 303 and 309 deenergize, as previously described. At armature 352 relay 309 grounds the even pulse

conductor 385 to energize the fourth connector unit relay. The fourth connector unit relay connects up the test conductor of line 74; unlocks the third connector unit relay which deenergizes; locks itself to lock conductor 278; and connects the fifth connector unit relay (shown dotted) with the odd conductor 383. In the same manner as just described the remaining connector unit relays are energized and deenergized in response to succeeding pulses to connect the test conductors of the succeeding lines in the group to the link test conductor 382. Since, in this case subscriber S4 on line 71 is being called, the second digit therefore comprises only one pulse and therefore the first connector unit relay 401 is energized to connect the test conductor 34 of line 71 to the link test conductor 382.

After the last impulse of the second digit relays 207 and 303 remain energized and relay 307 falls back after an interval. At armature 343 relay 307 opens the locking circuit of relay 306 which thereupon deenergizes. Relay 306, upon deenergizing, at armature 337 opens the locking circuit of relay 311 which likewise deenergizes; at armature 336 opens the circuit extending through the lower windings of relays 308 and 309 to deenergize the same if they are energized; and at armature 340 grounds conductors 269 and 394. Relay 311, upon deenergizing, at armature 357 opens a point in its own locking circuit, and at armatures 358, 359, 360 and 361 prepares the impulsing circuit to the code selecting relays CSR shown in Fig. 6.

The calling subscriber now dials the third or code selecting digit of the desired called subscriber's line. Line relay 207 follows the impulses transmitted by the calling subscriber again causing relay 303 to deenergize for each pulse. Relays 306, 307 and 309 energize in the same manner as previously described. At armature 339 relay 306 prepares the circuit for busy relay 305. At armature 343 relay 307 completes the locking circuit for relay 306, and at armature 345 prepares the circuit for relay 610. At armature 352 relay 309 grounds the odd pulse conductor 398 in response to the first pulse and at armature 353 completes an energizing circuit for relay 610. This circuit may be traced as follows: from grounded armature 323, conductor 278, armature 241, conductor 279, armatures 652, 632 and 622, conductor 395, resting contact and armatures 367 and 361, armatures 353 and 345, armatures 360 and 366 and their resting contacts, conductor 396, and through the winding of relay 610 to battery.

The first code selecting relay 610 energizes over the above traced circuit, and at armature 611 closes the circuit for energizing the busy test relay 305 in its first step in series with test relay 315 in case the called line is busy. At armature 613 relay 610 completes a locking circuit for itself through the armatures 622, 632, 642 and 652 to the grounded lock conductor 279, at armature 614 connects the second code selecting relay 620 to the even pulse conductor 397, and at armatures 615 and 616 prepares points in the code ringing circuit. At the end of the first pulse relays 207, 303 and 306 energize as before.

In response to the second pulse relays 207, 303 and 309 deenergize, as previously described. At armature 353 relay 309 opens the original energizing circuit of relay 610, which is now held energized over its locking circuit, and at armature 352 grounds the even pulse conductor 397 to energize relay 620. This circuit may be traced as follows: from ground by way of armature 376 and resting contact, armature 343, armature 352 and resting contact, armatures 359 and 365 and their resting contacts, conductor 397, armature 614, and through the winding of relay 620 to battery. At armature 621 relay 620 connects the test relay 315 in series with the busy relay 305 to test the idle or busy condition of the called line, at armature 622 opens the locking circuit of relay 610 which now deenergizes, at armature 623 closes its own locking circuit to grounded lock conductor 279, at armature 624 connects the third code selecting relay 630 to the odd pulse conductor 398, and at armatures 625 and 626 prepares points in the code ringing circuit.

Code selecting relays 630, 640 and 650 energize in response to the third, fourth and fifth impulses as a result of relay 309 alternately grounding the odd and even pulse conductors 398 and 397. Each subsequently operated code selecting relay opens the locking circuit to the previously operated code selecting relay to cause its deenergization. In response to the sixth pulse relay 650 energizes over the even pulse conductor 397. At armature 661 relay 660 again completes the busy test circuit, at armature 663 locks itself to grounded lock conductor 279, at armature 664 opens its original energizing circuit after completion of its locking circuit, at armature 665 switches from one set of code ringing contacts to the other set, and at armature 666 completes the circuit for energizing the ring reversing relay 314. This circuit may be traced as follows: from ground by way of armatures 456 and 438, conductors 392, armature 666, conductor 379, and through the winding of relay 314 to battery. At armatures 371 and 372 relay 314 reverses the ringing connection so that generator will now be connected with the positive line conductor instead of the negative line conductor.

In response to the seventh pulse relay 309 at armature 353 completes an energizing circuit for relay 610 as follows: from grounded lock conductor 279, armature 663, armature 664 and working contact, armatures 642, 632 and 622, conductor 395, resting contacts of armatures 367 and 361, armatures 353—345, armatures 360 and 366 and their resting contacts, conductor 396 and through the winding of relay 610 to battery. Relay 610 operates its armature for the purpose previously stated and in addition at armature 612 opens the locking circuit of code selecting relay 650 to cause its deenergization. In response to the eighth, ninth and tenth pulses code selecting relays 620, 630 and 640, respectively, energize and lock, and deenergize the previously energized code selecting relay in the same manner as previously described. From the foregoing it will be seen that code selecting relays 610, 620, 630, 640, and 650 are energized in response to the first five impulses in the code selecting digit, that relays 650 and 660 are energized for the sixth pulse, that relays 610 and 660, relays 620 and 660, relays 630 and 660 and relays 640 and 660 are energized for the seventh, eighth, ninth and tenth pulses.

In case the called line is busy a circuit is completed for energizing the busy test relay 305 in its first step in series with the marginal test relay 315 as follows: from ground on the test conductor 34 of the called line, armatures 373 and 393, conductor 382, through the upper winding of marginal test relay 315, conductor 381, through the operated one of the multiple con-

tacts 611 to 661, inclusive, conductor 394, resistance 341, armature 339 and through the winding of busy test relay 305 to battery. Busy relay 305, due to resistance 341 closes only its "X" contact at armature 334 to prepare a circuit for fully energizing itself when relay 306 later on deenergizes. After the last pulse of the code selecting digit relays 307 and 308 again energize, and relays 306, 307, 308 and 309 deenergize, as previously described. Relay 306, upon deenergizing, at armature 339 completes the circuit for fully energizing the busy test relay 305 as follows: from grounded conductor 259, armature 334 and working contact, normally closed springs controlled by armature 339 and through the winding of busy relay 305 to battery.

Assuming, however, that the called line is idle, then busy relay 305 is not energized because no ground is connected to the test conductor 34 of the called line. Now, when relay 306 deenergizes after the code selecting digit a circuit is completed for energizing the test relay 315 in series with the cut-off relay 22 of the called line as follows: from grounded conductor 259 armature 334 and resting contact on the unoperated busy relay 305, armature 340, conductor 394, through the operated one of the armatures 611 to 661, inclusive, conductor 391, through the upper winding of test relay 315, conductor 382, armatures 494 and 474, conductor 34, armature 25 and resting contact, and through the winding of cut-off relay 22 to battery. At armature 377 relay 315 completes its own locking circuit before operating its remaining armatures as follows: from ground at the normally closed springs controlled by armature 228, conductor 275, armature 322, conductor 153, armature 377, and through the lower winding of test relay 315 to battery. At armature 373 relay 315 prepares a circuit for connecting ground to the negative link conductor 252 since ring reversing relay 314 is energized, at armature 374 prepares the circuit for connecting generator to the positive link conductor 255, at armature 375 connects direct ground to conductor 382 to maintain the called line busy; at armature 376 grounds conductor 268 to energize the prepared connector group relay, in this case relay 470, and at armature 378 prepares the circuit for energizing the pick-up relay 670.

The circuit for energizing connector group relay 470 may be traced as follows: from grounded armature 376 and working contact, conductor 268, armature 455 on the operated connector group relay 471, and through the winding of relay 470 to battery. At armatures 472 and 473 relay 470 connects the line conductors 32 and 33 of the called line to the link conductors 252 and 255. When cut-off relay 22 energizes in series with relay 315 that relay at armatures 27 and 29 disconnects the line relay 21 from the line conductor 32 and ground, at armature 28 connects the grounded test conductor 34 to the finder test conductor 35 to mark this line as busy in the finder end of the link, and at armature 29 completes an obvious circuit for energizing the lock-out relay 23. Relay 23, at armature 31 opens a point in the start circuit to start conductor 67.

At the beginning of each code ringing cycle generated by the ringing machine (not shown) the ringing machine grounds the pick-up lead and completes the circuit for energizing relay 670 as follows: from grounded pick-up lead extending from the ringing machine, normally closed springs controlled by armature 672, conductor 380, armature 378, conductor 276, armature 240, conductor 277, and through the winding of pick-up relay 670 to battery. At armature 671 relay 670 prepares a circuit for ringing relay 313, at armature 672 opens its original energizing circuit and completes its locking circuit to lock conductor 279, and at armatures 673 and 674 prepares further points in the circuit to ringing relay 313.

The ringing machine is arranged to ground the code ring conductors at certain predetermined times during its cycles of operations, as indicated at the lower left-hand corner of Fig. 6. For example, 4—4 indicates that this conductor is grounded at predetermined periods in each cycle to operate the ringing relay 313 to generate four short rings, then a pause, followed by four more short rings. In this case, assuming that the code ring conductor 2—2 has been selected, then ringing relay 313 is energized over the following circuit: from ground at the ringing machine over the conductor marked 2—2, resting contact and armature 601, armatures 645 and 673, working contact and armature 665, conductor 680, armature 671, conductor 399, and through the winding of ringing relay 313 to battery. The code ring conductor 2—2 was selected because in this case it is assumed that the code selecting digit dialled was the digit 0, in which case code selecting relays 640 and 660 have been operated and locked in operated position. Each time ringing relay 313 is energized from the ringing machine, said relay at armature 368 connects ground by way of armatures 371 and 373 to the negative link conductor 252 since relay 314 is energized, at armature 369 connects generator to the positive link conductor 255 by way of armatures 372 and 374 to code ring the called subscriber, and at armature 370 completes an obvious circuit for energizing condenser discharging relay 310. Relay 310 follows the impulses transmitted by ringing relay 313, but due to its slow release characteristics this relay lags behind ringing relay 313 and at armature 354 connects battery through resistance 355 to the negative link conductor 352 momentarily after each application of generator in order to discharge the condensers associated with the ringers on the called line. At armature 356 relay 310 completes a circuit for transmitting ring back tone to the calling subscriber as follows: from generator through working contact and armature 356, working contact and armature 328, the tone condenser TC to conductor 254 and thence over the calling subscriber's loop, as previously described.

Ringing current to the called subscriber may now be traced as follows: from generator, working contact and armature 372, working contact and armature 369, armature 374, positive link conductor 255, armatures 493 and 473, conductor 33, through the ringers connected to the positive line conductor of this line to ground. In case the ringers of this line should be bridged instead of grounded, then the ground return circuit extends back by way of negative line conductor 32, armatures 472 and 492, conductor 252, armatures 373, 368 and 371 to ground.

When subscriber S4 answers his code ring during the silent period or when ringing relay 313 is in deenergized position back bridge relays 211 and 212 energize in case the called line is a metallic line, or in case the called line is a grounded line then relay 211 alone is energized. The circuit for energizing back bridge relays 211 and 212 in case of a metallic line may be traced as follows: from ground through the winding of

relay 212, lower right-hand winding of repeating coil RC, conductor 256, resting contact and armature 369, armature 374, over the circuit to the called subscriber's loop previously traced for ringing current, back to conductor 252, armatures 373 and 368, conductor 253, through the upper right-hand winding of repeating coil RC over armatures 238 and 327 in multiple, through the winding of relay 211 to battery. In case the called line is a grounded line relay 212 is short circuited over the following path: from the grounded positive line conductor of the called line over armatures 473 and 493, conductor 255, armatures 374 and 369, conductor 256, through the right-hand winding of repeating coil RC, and through the winding of relay 212 to ground.

Relay 211, upon energizing, at armature 242 and resting contact opens a point in the circuit to disconnect relay 206 and at its working contact completes a circuit for energizing relay 210. At armature 243 relay 211 completes a circuit for energizing the battery reversing relay 209 in case the calling line is such as to require reverse battery supervision. The circuit for energizing relay 210 may be traced as follows: from ground at armature 321, conductor 265, armature 242 and working contact, normally closed springs controlled by armature 237, and through the winding of relay 210 to battery. At armature 237 relay 210 completes its own locking circuit to grounded conductor 259 and opens its original energizing circuit, at armature 238 completes the talking circuit, at armature 236 removes the short circuit from around relay 208 to permit its energization in case the calling line is a metallic line, at armature 239 opens one of the multiple circuits to relay 302, at armature 240 opens the circuit to pick-up relay 670 which accordingly deenergizes and at armature 241 disconnects ground from lock conductor 279 to cause the deenergization of the operated code selecting relays. Relay 208 now operates in series with the calling subscriber's loop and relay 207 in case the calling line is a metallic line as follows: from ground through the winding of relay 208, normally closed springs controlled by armature 234, lower left-hand winding of repeating coil RC, resting contact and armature 249, conductor 151, armatures 173 and 113, positive line conductor 15 of line 17 and thence through the calling subscriber's loop and over the previously traced circuit through the winding of line relay 207 to battery. In case the calling line is a grounded line then the positive line conductor such as conductor 15 will be grounded and relay 208 is prevented from operating. Relay 208, upon energizing, if the calling line is a metallic line, at armature 232 completes a circuit for energizing battery reversing relay 209 in case the calling line is in a group requiring reverse battery supervision, in which case conductor 158 is connected to contacts, such as contacts 118, to conductor 157 which is grounded thereby completing the circuit by way of armature 243 for energizing the battery reversing relay 209.

All the code selecting relays in Fig. 6 now restore and relay 660 at armature 666 opens the circuit to ring reversing relay 314 and relay 670 at armature 671 opens the circuit to ringing relay 313. Relay 209, upon energizing, at armatures 233 and 234 reverse battery to the calling line, and at armature 235 completes a locking circuit for itself independent of armature 232.

When the calling line is a metallic line, talking battery is supplied from the windings of relays 207 and 208 through the left-hand windings of the repeating coil RC over the resting contacts and armatures 246 and 247 to conductors 150 and 151, and thence over the calling loop. In case the calling line is a grounded line, then talking battery is supplied through the winding of line relay 207 and from the grounded positive line conductor of the calling line. When the called line is a metallic line talking battery is supplied through the windings of relays 211 and 212 over the previously traced circuit to the called subscriber's loop and in this case if relay 210 is operated the circuit for relay 211 extends from the winding of repeating coil through armature 327 and conductor 266. In case the called line is a grounded line then the battery is supplied through the winding of relay 211 and from ground on the grounded positive line conductor of the called line.

After conversation and responsive to the called party replacing his receiver, relays 211 and 212 deenergize. At armature 243 relay 211 opens the circuit of relay 209 in case it is energized, and at armature 242 prepares the circuit for the disconnect relay 206 so that this link will be automatically released after a predetermined interval if the calling subscriber fails to replace his receiver. Battery reversing relay 209, if energized, now deenergizes and reverses battery to the calling line for supervisory purposes. In response to the calling subscriber replacing his receiver, line relay 207 deenergizes and likewise relay 208, if energized. At armature 230 line relay 207 opens the circuit of relay 303 which deenergizes and at armature 231 opens one of the multiple ground circuits to slow to release relay 301. Relay 303, upon deenergizing, at armature 325 opens the circuit of slow to release relay 301, at armature 327 disconnects relay 211 from conductor 253 and at armature 326 closes the circuit for relays 306, 307 and 309. Relay 301, upon deenergizing, at armature 318 opens the circuit of relay 302 and disconnects ground from test conductor 152 to open the circuit of the cut-off relay 2. Cut-off relay 2, upon deenergizing, at armature 10 opens the circuit of lock-out relay 3, and at armatures 8 and 10 operatively connects the line relay 1 to the calling line. After an interval lock-out relay 3 deenergizes and at armature 12 prepares the circuit for start lead 61.

Slow to release relay 302, upon deenergizing, at armature 320 disconnects ground from relays 306, 307 and 309 to cause their deenergization, at armature 321 disconnects ground from conductor 265 to open a point in the circuit of the disconnect relay 206, at armature 322 opens the locking circuit of relay 315 and disconnects ground from conductors 153 and 157 to unlock the operated finder group relays 110 and 111, the operated finder unit relay 107, and relays 204 and 202. At armature 323 relay 302 disconnects ground from the lock conductor 278 to unlock the operated connector unit relay 401 and connector group relay 471. Relay 401, upon deenergizing, at armatures 492, 493 and 494, disconnects the conductors of line 71 from the control relays in the link. Relay 471, upon deenergizing, at armature 474 disconnects the test lead 34 from the link circuit thereby opening the circuit to cut-off relay 22. At armature 455 relay 471 opens the circuit to relay 470 which accordingly deenergizes and disconnects the line conductors 32 and 33 from the link. Relay 315, upon deenergizing, at armature 375 disconnects

ground from test conductor 286, at armature 376 disconnects ground from conductor 368 to open the circuit of relay 470, and at armatures 373 and 374 opens a point in the talking circuit. Relay 204, upon deenergizing, at armature 221 opens the locking circuit from relays 201 and 304 to cause the latter relays to deenergize.

Relay 110, upon deenergizing, at armatures 112 and 133, disconnects the line conductors 14 and 15 from the repeating coil RC. Relay 111, upon deenergizing, at armature 114 disconnects the test lead of the line from test conductor 152. Relay 107, upon deenergizing, at armatures 172, 173 and 174, disconnects the control relays of the link from the calling line. Relay 202, upon deenergizing, at armature 217 transfers the transfer relay 201 from direct ground to the IN lead 281 of the start chain so that if the IN lead 281 is grounded at this time the transfer relay 201 will not restore and interfere with the operation of a succeeding link. In case the in lead 281 is not grounded 201 deenergizes and at armature 216 opens a point in the all link busy chain. At armature 215 relay 201 disconnects the out lead 382 and connects up the in lead 281 to line relay 207. Relay 210, upon deenergizing, at armature 236 short circuits relay 206 and grounds conductor 151, at armature 237 opens a point in its own locking circuit as well as preparing its own original energizing circuit, and at armature 238 separates the right-hand windings of repeating coil RC. Relay 304, upon deenergizing, at armature 328 restores the circuit for connecting dial tone to a calling line, and at armature 330 prepares a point in the circuit to relay 312 as well as a point in its own original energizing circuit. Cut-off relay 22, upon deenergizing, at armatures 27 and 29 prepares the circuit for line relay 21 and at armature 29 opens the circuit to lock-out relay 23. Lock-out relay 23 restores and at armature 31 prepares the circuit to start lead 67. All relays are now in their normal position and the link circuit may be used in a subsequent call.

Assuming now that the called line was busy instead of idle, and returning to the operation at a time when busy relay 205 was fully energized after the code selecting digit was dialled, busy relay 305, upon energizing, at armature 331 connects the busy tone to the calling line as follows: from busy tone by way of armature 331, resting contact and armature 356, working contact and armature 336, tone condenser TC, conductor 254, resting contact and armature 247, and thence over the calling subscriber's loop, as previously described. At armature 332 relay 305 prepares a circuit for grounding test lead 382, and at armature 333 opens the circuit to relays 306, 307 and 309, and likewise prepares a circuit for reoperating relay 303 in case relay 207 is again operated. At armature 335 relay 305 prepares a point in the circuit to reverting call relay 205 and at armature 334 completes a locking circuit for itself as follows: from grounded locking conductor 259, armature 334 and working contact, normally closed springs controlled by armature 339, and through the winding of busy relay 305 to battery. After receipt of busy tone the calling subscriber replaces his receiver, thereby opening the circuit to line relay 207, which accordingly deenergizes and causes the release of the operated relays in the manner as described for the release of an idle line. In this case, since busy relay 305 is energized, the deenergization of relay 204 at armature 221 opens the circuit of busy relay 305 to cause its deenergization.

The foregoing circuit descriptions are the circuit operations for ringing the subscribers, such as subscribers S4 and S6, which have their ringers connected to the positive line conductor. As diagrammatically illustrated in Fig. 4 line 71 has ten substations connected thereto, five of such sub-stations having their ringers connected to the negative line conductor and the remaining lines having their ringers connected to the positive line conductor. In order to ring the subscribers having their ringers connected to the positive line conductor, the code ringing digit dialled is six or more so that the code selecting relay 660 will be energized to cause the energization of ring reversing relay 314, as previously described. In order to ring the subscribers having their ringers connected to the negative line conductor the code ringing digit dialled is less than six, and therefore relays 660 and 314 are not energized. In this case the operation of ringing relay 313 connects generator to the negative line conductor to operate the ringers thereon. This arrangement is known as ten party divided ringing.

Some of the party lines have as many as twenty subscribers on a line, for example, the line Nos. 26 and 27 shown in Fig. 4, illustrates a grounded line having twenty subscribers thereon. As will be noticed armatures 424 and 430 on connector group relay 421 are tied together and connected to the test conductor 44 of this line. Armatures 422 and 427 and armatures 423 and 428 are tied together and connected respectively to the negative and positive line conductors 42 and 43. From the foregoing description it will be therefore understood that this line may be connected with in response to dialling the digits 2—6 or 2—7. The first ten subscribers on this line are signalled by dialling digits 2 and 6 and then a code selecting digit 1 to 0. In response to the calling subscriber dialling the digits 2 and 6 the control relays operate in the same manner as previously described to cause the energization of the connector unit and connector group relays 421 and 406. In response to dialling the code selecting relays CRS are energized as previously described to select the desired code. Since in this case ring reversing relay 314 is not energized, ringing relay 313 always connects the generator to the negative line and since relay 600 is not energized, the code selected by the code digit dialled is determined by the conductor selected over the resting contacts of armatures of relay 600. The second ten subscribers on this line are signalled by dialling the digits 2 and 7 and then a code selecting digit 1 to 0. In response to the calling subscriber dialling the digits 2 and 7 the control relays operate as previously described to cause the energization of the connector unit and connector group relays 421 and 407. When relay 407 operates its armature 414 a circuit is completed for energizing the code switching relay 600, as follows: from grounded conductor 279, armatures 469 and 414, conductor 393, and through the winding of code switching relay 600 to battery. Relay 600 at its resting contact disconnects the first ten code ring conductors and at the working contact of these armatures connects the second ten code ring conductors. In response to dialling the code selecting digit the code selecting relays are operated as before to select the desired code ring conductor in the

second set. Now, when the ringing relay 313 is energized over the selected code ring conductor, generator is connected to the negative line conductor in accordance with the selected code ring conductor. The following chart shows the digits dialled and the code ring conductors selected in accordance therewith.

20-party code ring

Digits	Ring cond.	Digits	Ring cond.
26—1	1	27—1	2—3
26—2	2	27—2	2—4
26—3	3	27—3	3—1
26—4	4	27—4	3—2
26—5	1—1	27—5	3—3
26—6	1—2	27—6	3—4
26—7	1—3	27—7	4—1
26—8	1—4	27—8	4—2
26—9	2—1	27—9	4—3
26—0	2—2	27—0	4—4

Reverting calls

In order to describe a reverting call it will be assumed that substation S desires to call another subscriber on his own line, for example subscriber #1. Subscriber S therefore removes his receiver and dials the line selecting digits 1 and 7 and then the code selecting digit assigned to subscriber S1. The finder group relays 110 and 111 and the finder unit relay 107 operate to connect the control relays of the link to line 17. The connector group relay 411, the connector unit relay 407 and the code selecting relays in Fig. 6 operate also in the same manner as previously described. Since the called subscriber, subscriber S1, is on the same line as the calling subscriber S, line 17 is marked busy and busy relay 305 energizes in the same manner as previously described to transmit the busy tone to the calling subscriber. In response to the receipt of busy tone subscriber S now replaces his receiver thereby opening the circuit of line relay 207 which accordingly deenergizes. At armature 230 relay 207 opens the circuit of relay 303. Relay 303, upon deenergizing, at armature 325 opens the circuit of relay 301 and at armature 324 grounds the test conductor 382 to maintain the line busy and to hold the cut-off relay 2 and slow release relay 302 in energized position as follows: from grounded armature 324 and resting contact, armature 332, conductor 382, armature 478, armature 497, test conductor 16 of line 17, armature 6 and resting contact, one branch extending to the winding of relay 2 to hold said relay and the other branch extending by way of armature 9, armatures 114 and 174, conductor 152, armature 222, armature 239, conductor 272, and through the winding of relay 302 to battery for holding the latter relay.

Slow to release relay 301, upon deenergizing, at armature 318 and working contact, opens the original energizing circuit of relay 302 now maintained energized over the previously traced circuit, and the resting contact of armature 318 completes a circuit for energizing reverting call relay 205. This circuit may be traced as follows: from ground at the resting contact of armature 324 over the previously traced circuit for holding cut-off relay 2 and relay 302 energized to conductor 152, conductor 271, armature 318 and resting contact, armature 335, conductor 273 and through the winding of reverting call relay 205 to battery. At armature 225 relay 205 opens the circuit to finder group relay 110 which deenergizes, at armature 226 opens one of the multiple circuits to relay 302, and at armature 227 completes a circuit for energizing test relay 315 as follows: from ground at the normally closed springs controlled by armature 228, conductor 275, armature 322, conductor 153, armature 227, conductor 274, and through the lower winding of relay 315 to battery. Relay 110, upon deenergizing, at armatures 112 and 113 disconnects the line conductors 14 and 15 from the link conductors 150 and 151 thereby opening the circuit to line relay 207. At armature 377 relay 315 completes a locking circuit for itself, at armature 378 prepares a circuit for energizing pick-up relay 670, at armatures 376 completes the circuit for energizing relay 410, at armature 375 grounds the test lead 382 to maintain this line busy, and at armatures 373 and 374 prepares points in the ringing circuit. The circuit for energizing relay 410 may be traced as follows: from grounded armature 376 and working contact, conductor 268, armature 492 and through the winding of relay 410 to battery. At armatures 495 and 496 relay 410 connects the line conductors 14 and 15 to the link conductors 252 and 255.

At the beginning of the code ringing cycle the pick-up conductor is grounded in the ringing machine to cause the energization of pick-up relay 670 as previously described. At armature 672 pick-up relay 670 completes its own locking circuit, and at armature 671 prepares the circuit for ringing relay 313. When the selected code ring conductor is grounded by the ringing machine, ringing relay 313 is energized over the previously traced circuit in accordance with the number of times the code ringing conductor is grounded by the ringing machine in order to transmit ringing current to line 17. The ringing circuit may be traced as follows: from generator, resting contact of armature 371, working contact, and armature 368, armature 373, conductor 252, armatures 475 and 495 to negative line conductor 14 of line 17 and thence through the ringers on line 18 to positive line conductor 15, armatures 496 and 497, conductor 255, armature 374, armature 369 and working contact, and armature 372 and resting contact to ground.

At completion of the code ring and in response to either the calling or called subscriber answering during the silent period relay 211 energizes in series with relay 212 over the following circuit: from ground through the winding of relay 212, lower right-hand winding of repeating coil RC, conductor 256, resting contact and armature 369, and thence over the previously traced ringing circuit through the substation loop, back to armature 368 and resting contact, conductor 253, upper right-hand winding of repeating coil RC, armature 238 and resting contact, and through the winding of relay 211 to battery. At armature 242 relay 211 completes the circuit for energizing relay 210 and opens a point in the circuit to the disconnect relay 206. Relay 210, upon energizing, at armature 237 closes its own locking circuit and opens its original energizing circuit, at armature 236 removes the short circuit from around relay 208, at armature 241 disconnects ground from conductor 279 to deenergize the code selecting relays, at armature 238 opens the circuit to relays 211 and 212 which accordingly deenergize, and at armature 239 opens the circuit to relay 302 to cause its deenergization. After an interval slow to release relay 302 deenergizes and at armature 323 opens the locking circuit of relays 407 and 411; and at armature 322 opens the circuit to relays 315, 111, 107, 204, and 202. Relay 407, upon deenergizing, at armatures 475, 476 and 478 disconnects the link conductors 252,

255 and 382 from line 17. Relay 411, upon deenergizing, opens at armature 497 the circuit to test conductor 16 and at armature 492 opens the circuit of relay 410 which accordingly deenergizes. Relay 315, upon deenergizing, at armatures 373 and 374 opens further points in the talking and ringing circuits, at armature 375 disconnects ground from test conductor 382, at armature 376 disconnects ground from conductor 268, at armature 377 opens a point in its locking circuit, and at armature 378 opens a point in the original energizing circuit of pick-up relay 670. Relay 111, upon deenergizing, at armature 113 opens the circuit to relay 110 which accordingly deenergizes, and at armature 114 disconnects the test lead of line 17 from the link. Relay 107, upon deenergizing, at armatures 172, 173 and 174 opens further points in the link circuit. Relay 204, upon deenergizing, at armature 221 opens the locking circuit of relays 210, 304 and 305. Relay 202, upon deenergizing, at armature 217 transfers relay 201 from direct ground to the in start lead 231. Reverting call relay 205, upon deenergizing, at armature 227 opens a point in the original energizing circuit of relay 315.

Cut-off relay 2, upon deenergizing, at armature 10 opens the circuit of lockout relay 3, and at armatures 8 and 10 reconnects line relay to the conductors of line 17. Line relay 1 now energizes over the subscriber's loop as follows: ground by way of armature 10 and resting contact, lower winding of line relay 1, conductor 15, the substation loop conductor 14, armature 8, and through the upper winding of relay 1 to battery. At armature 6 line relay 1 grounds the test conductor 16 to busy this line in the connector end of the link circuit, and at armature 7 completes the locking circuit for lock-out relay 3. Lock-out relay 3 is maintained energized to prevent grounding of the start lead 61. Relays 305, 210 and 304 now deenergize. Relay 201 deenergizes in case the in lead 231 is not grounded as previously described. The entire link is now released and talking battery is furnished through line relay 1 to the subscribers on line 17. After conversation and in response to both parties replacing their receivers line relay 1 restores and opens the circuit of lock-out relay 3 which is likewise deenergized and restores the line circuit to normal.

Call to switch-through trunk

It will now be assumed that subscriber S desires to call a subscriber in a distant automatic exchange, and in order to do so dials the digits 8 and 1 to connect with the trunk line extending to this automatic exchange. In response to subscriber S removing his receiver and dialling the digits 8 and 1 the finder relays, the control relays, and the connector relays are operated as previously described to complete a connection with the called trunk line. In this case, since the digits 8 and 1 have been dialled, connector relays 481 and 491 are energized. At armatures 484 and 494 relays 491 and 481 connect the test lead of the trunk line 81 to test lead 382. At armatures 437 and 445 busy relay 305 is connected in series with the upper winding of switch through relay 213 to the test conductor 382 to test the busy or idle condition of this trunk line. In case the trunk line 81 is busy, ground on the test conductor 487 of trunk line 81 completes a circuit for energizing busy relay 305 to close its "X" contacts thereby preparing a circuit for fully energizing itself when relay 306 deenergizes shortly after the impulsing period. This circuit may be traced as follows: from grounded test conductor 487, armatures 484 and 494, conductor 382, armatures 437 and 445, conductor 270, upper winding of switch through relay 213, conductor 269, armature 317, resistance 341, armature 339, and through the winding of busy relay 305 to battery. Due to resistance 341 in the circuit relay 213 is not energized over the above traced circuit and the busy relay 305 operates to close only its "X" contact at armature 334. When relay 306 deenergizes shortly after the second impulsing period, as previously described, said relay at armature 339 closes the circuit for fully energizing busy relay 305 from grounded conductor 259. Busy relay 305 now operates as previously described and connects busy tone to the calling line. The calling subscriber then hangs up to restore the link.

In case the trunk line 81 is idle when called, then there is no ground on test conductor 487 and busy relay 305 is not energized. Now when relay 306 deenergizes shortly after the second impulsing period a circuit is completed for energizing switchthrough relay 213 in series with the cut-off relay of trunk line 81 as follows: from grounded conductor 259, armature 334 and resting contact, armature 340, armature 317, conductor 269, upper winding of switchthrough relay 213, conductor 270, armatures 445 and 437, conductor 387, armatures 494 and 484, conductor 487, and through the cut-off relay associated with this trunk line to battery. At armature 250 relay 213 closes its own locking circuit to ground at armature 318 and at armatures 246 and 247 disconnects the calling line from the left-hand windings of the repeating coil and connects the calling line to conductors 252 and 255 direct. At armature 248 relay 213 opens a point in the circuit to disconnect relay 206, at armature 249 disconnects ground from conductor 262 to open one of the multiple grounds to relay 301 and to open the locking circuit of relay 304. At armature 249 and working contact relay 213 grounds conductor 268 to complete an energizing circuit for relay 480 by way of armature 444, and at armature 251 connects grounded conductor 271 to test conductor 382 by way of armatures 445 and 437 to maintain the test conductor 387 grounded. Line relay 207 deenergizes when its circuit is opened at armatures 246 and 247 and at armature 230 opens the circuit to relay 303. Relay 480, upon energizing, at armatures 482 and 483 connects the trunk conductors 485 and 486 to the link conductors 252 and 255. Relay 303, upon deenergizing, at armature 325 opens the circuit of slow release relay 301 which deenergizes after an interval. The trunk equipment operates and connects ground to test conductor 487 to hold relays 213, 302 and cut-off relay 2 energized. The circuit for holding relay 213 energized extends from grounded conductor 487, armatures 484 and 494, conductor 382, armatures 437 and 445, conductor 270, armatures 251 and 253, through the lower winding of cut-through relay 213 to battery. The circuit for maintaining relay 302 in energized position extends from grounded conductor 487 over the previously traced circuit to armature 251 and thence over armatures 239 and 226 in multiple to conductor 272 and through the winding of relay 302 to battery. The circuit for maintaining cut-off relay 2 in energized position is the same as that previously traced and extends from armature 251 by way of conductor 271, armature 222, conductor 152, armatures 174 and 114, armature

9, and through the winding of cut-off 2 to battery. The calling line conductors 14 and 15 are now both connected directly to the trunk conductors 485 and 486 whereby the calling subscriber may now dial the digits of the desired subscriber at the automatic exchange to operate the automatic switches therein to complete the desired connection in the well known manner. Talking battery to both the calling and called subscriber is furnished from the automatic exchange.

After conversation and in response to the calling subscriber replacing his receiver, the switches in the automatic exchange release and disconnect ground from test conductor 487, thereby opening the holding circuit of relays 213, 302 and cut off relay 2. Relay 213, upon deenergizing, at armature 249 opens the circuit of relay 480. Cut-off relay 2 deenergizes and opens the circuit to lock-out relay 3 and connects the line relay 1 to the line conductors of line 17. Slow to release relay 302 deenergizes and at armature 322 opens the circuit to the finder relays 110, 111 and 107 and relays 204 and 202. At armature 323 relay 302 opens the circuit to connector relays 401 and 481. Relay 480, upon deenergizing, at armatures 482 and 384 disconnect the talking conductors of the link from the trunk line. The lock-out relay 3, the finder relays 110, 111, and 107 deenergize as previously described. Relays 204 and 202 deenergize and the latter relays connect the transfer relay 201 to the in lead 281. Connector relays 401 and 481 likewise deenergize. In case the IN lead 281 is grounded transfer 201 is maintained energized, otherwise relay 201 deenergizes and the link may be used on subsequent calls.

Incoming trunk calls operate the link circuit the same as previously described for a local subscriber calling another local subscriber. In this case, however, reverse battery supervision is needed and when the local called subscriber answers relay 211 energizes and at armature 243 closes the circuit for battery reversing relay 209 to reverse battery over the calling trunk line.

Calls to ring-down trunks are made in the same manner as described for called between local subscribers' lines. On disconnect, however, it is necessary to transmit a disconnect signal over the ring-down trunk to signal the distant operator. After completion of conversation over a ring-down trunk the calling subscriber replaces his receiver to cause the deenergization of relay 207. At armature 230 relay 207 opens the circuit of relay 303 which deenergizes and at armature 327 disconnects battery through the winding of relay 211 from the negative conductor 252 whereby battery is disconnected from the negative ring-down trunk conductor to cause the distant operator to receive a disconnect supervision. Relay 211, upon deenergizing, at armature 243 opens the circuit to reversing relay 209 which deenergizes if operated and at armature 242 closes a holding circuit for slow to release relay 301 before the same deenergizes in response to the deenergization of relay 303. This circuit may be traced from ground at armature 321, conductor 265, armature 242 and resting contact, armature 245 and working contact, conductor 264, and through the winding of relay 301 to battery. The restoration of the link circuit is now controlled by the operator over the ring-down trunk. When the operator at the distant end disconnects the circuit to relay 212 is opened and said relay deenergizes to open the circuit of relay 301 at armature 245 to cause the deenergization of relay 301 and the release of the link as previously described.

Permanents

The link circuit is considered held by a permanent if it remains in a non-talking position for a minimum of two minutes after seizure or after the called subscriber disconnects. Relays 580 and 590 and interrupter 593 in Fig. 5 comprise a timing device for causing the operation of disconnect relay 206 if a fault, such as a permanent, appears. At two minute intervals interrupter contacts 593 are closed to complete a circuit for relay 590. At armature 592 relay 590 disconnects ground from conductor 284 and at the working contact of armature 592 completes an obvious circuit for energizing relay 580. At armature 581 relay 580 prepares the circuit for connecting battery to conductor 285 to energize the disconnect relay 206 if a permanent exists. When interrupter spring 593 opens relay 590 deenergizes and at armature 591 momentarily connects battery to conductor 285 to energize disconnect relay 206 if a permanent exists. At armature 592 and its working contact relay 590 opens the circuit of relay 580 which deenergizes after an interval and at the resting contact of armature 592 grounds conductor 284. Relay 580, upon deenergizing, at armature 581 disconnects battery from conductor 285.

In case the link is held by a permanent condition and the same is not in talking position, that is in case relays 211, 212 or 213 are not energized, a circuit is completed for disconnect relay 206 when relay 580 is energized and relay 590 deenergized as follows: from grounded armature 321, conductor 265, armatures 242, 245 and 248 and their resting contacts, winding of disconnect relay 206, normally closed springs controlled by armature 229, conductor 285, armatures 581 and 591, resistance 594 to battery. Relay 206 at armature 228 disconnects the ground at the normally closed springs controlled by armature 228 and connects the ground on conductor 284 extending from the resting contact of armature 592 to conductor 275 to maintain a holding condition on conductor 275 until the relay 590 is again operated. At armature 229 relay 206 opens a point in its original energizing circuit and completes a locking circuit for itself over conductor 286. Now, in case the link circuit has not switched through to talking position by the energization of either relays 211, 212 or 213, before relay 590 again energizes, then relay 590 at armature 592 disconnects ground from hold conductor 275 with the result that the link is released and the calling line is locked out. In case a calling subscriber fails to dial or the subscriber's line is held by a short circuit the disconnection of ground from conductor 284 at armature 592 opens the circuit to the finder relays such as 110, 111 and 107 and the link control relays 202 and 204. Restoration of the finder relays disconnect the calling line from the link causing the deenergization of line relay 207 and cut-off relay 2. At armature 221 relay 204 opens the circuit of relay 312 which thereupon deenergizes. At armature 217 relay 202 connects the transfer relay 201 to the in start lead 281. Relays 207, 312 and 303 deenergize in the same manner as previously described. Relay 303 at armature 325 opens the circuit of slow to release relay 301 which accordingly deenergizes and at armature 318 opens the circuit for relay 302. Relay 302 deenergizes and causes the release of

the remaining operated relays in the same manner as previously described.

In case the calling subscriber dials only one digit and then fails to disconnect, the removal of ground from conductor 284 causes the release of the link as just described and in addition in this case since relay 311 is energized, such relay is deenergized in response to the restoration of relays 204, which at armature 221 opens the circuit thereto. The operator connector group relay is deenergized in response to the removal of ground from lock conductor 278 by the restoration of relay 302. In case the calling subscriber dials two digits and then fails to disconnect the removal of ground from conductor 284 causes the release as previously described and in addition causes the release of the operated connector relays in response to the restoration of relay 302.

In case the called subscriber does not answer within the predetermined time the removal of ground from conductor 284 causes the deenergization of the relays as previously described and in addition the deenergization of relay 315. At armature 376 relay 315 opens a circuit to the connector group relay, at armatures 373 and 374 disconnects generator from the calling line, at armature 378 opens the circuit of relay 670, at armature 375 disconnects ground from the test lead to free the called line. Relay 302, upon deenergizing, at armature 323 opens the locking circuit of the operated connector relays and the operated code selecting relays. Pick-up relay 670, upon deenergizing, at armature 671 opens the circuit to ringing relay 313. The operated connector relays deenergize to disconnect the called line from the link and the code selecting relays deenergize thereby restoring the link to normal. In case the calling subscriber fails to hang up his receiver after the called subscriber disconnects, then the removal of ground from conductor 284 causes the release of relays as previously described, and in this case relay 210 deenergizes in response to the deenergization of relay 204 when the locking circuit of relay 210 is opened at armature 221. In a similar manner in case the calling subscriber fails to disconnect after receipt of busy tone then the link is released as previously described, and relay 204 at armature 221 opens the circuit of busy relay 305 and relay 304 which thereupon deenergize. In case both the calling and called subscriber fail to answer a reverting call, then the removal of ground from the conductor 284 causes the release of relays 110, 111, 107, 202, 204 and 315, as previously described. The deenergization of relays 111 and 107 opens the test leads over which relays 302 and 205 were held energized on a reverting call. Relays 304, 305, 410, 302, 205, 670, 411 and 401 and the operated code selecting relays deenergize as previously described to free the link.

When ground is removed from test lead the cut-off relay, such as relay 2, deenergizes and at armatures 8 and 10 reconnects line relay 1 to the link conductor to cause its reenergization in case a permanent condition exists on the line. At armature 10 relay 2 opens the circuit of lock-out relay 3. Line relay 1 immediately reenergizes in case the line is permanent and at armature 7 locks the lock-out relay 3 in energized position before the same deenergizes. At armature 6 relay 1 grounds the line to make this line busy. When the permanent condition is cleared from the line the circuit of line relay 1 is opened and this relay deenergizes to free the line at armature 6 and at armature 7 opens the locking circuit of lock-out relay 3 which accordingly deenergizes. The line circuit is now at normal and may be used both for incoming and outgoing calls.

In case the finder unit relays fail to find the calling line relay 107 at armature 148 completes a circuit for energizing relay 202 as follows: from grounded conductor 153, armature 223 and resting contact, armature 220 and working contact, conductor 155, armatures 142, 145, and similar armatures on the finder unit relays, armature 148 and working contact, conductor 154, and through the lower winding of relay 202 to battery. At armature 217 relay 202 completes the circuit for energizing transfer relay 201. Relay 201 at armature 216 closes a point in the all link busy chain, at armature 214 completes its own locking circuit, at armature 215 and working contact transfers the in start lead 281 to the out lead 282 to start the next idle link searching for the calling line, and at armature 215 and its resting contact opens the circuit to line relay 207. The deenergization of line relay 207 causes the release of the link as previously described.

When all the links become busy a circuit is completed for energizing all link busy relay 500 as follows: from ground at terminal 573, over conductors similar to conductors 283 and 280 to terminal 574, in a similar manner over conductors from terminals 575 to 576, and from terminals 577 to 578 to conductor 283, armature 216, conductor 280, and through the winding of all link busy relay 500. At armature 501 all link busy relay 500 removes ground from the start circuit to prevent a waiting call from holding the transfer relays 201 energized. As soon as any one link becomes idle all link busy relay 500 deenergizes.

If the circuit of start relay 510 remains closed for a predetermined time ground from springs 503 operated by the time switch TS completes the circuit for relay 560. Relay 560 at armature 561 prepares the circuit to relay 570 and the start lamp ST, at armature 562 completes a locking circuit for itself by way of armatures 541, 512 and 501. At armature 563 opens a point in its original energizing circuit, at armature 564 prepares a circuit for relay 540 and at armature 565 prepares the circuit for the alarm lamp AL and opens a point in the circuit to relay 550. When time switch TS closes springs 502 a circuit for energizing relay 540 is completed as follows: ground by way of springs 502, armature 564, through the normally closed springs controlled by armature 542 and through the winding of relay 540 to battery. At armature 541 relay 540 opens the locking circuit of relay 560 which thereupon deenergizes, at armature 542 completes its own locking circuit, at armature 543 opens the circuit to relay 530 if the same is energized, and at armature 544 opens the circuit to relay 520 and removes the shunt from around relay 530 in case relay 520 is energized. Relay 560, upon deenergizing, at armature 565 completes the circuit for energizing relay 550, and at armature 563 prepares a point in its original energizing circuit. If relay 520 is energized at this time relay 530 energizes in series with relay 520 when the shunt is removed at armature 544. At armature 531 relay 530 transfers the start lead to the middle of the chain so as to select the next idle link near the middle of the chain. If relay 530 is already energized the same is now deenergized in response to the operation of armature 543 because its circuit is open thereat. Relay 530, upon deenergizing, transfers the start circuit from the middle

to the beginning of the chain. The circuit for energizing relay 550 may be traced as follows: from ground by way of armature 545, armature 565 and resting contact, through the normally closed springs controlled by armature 563, and through the winding of relay 550 to battery. At armature 553 relay 550 completes its locking circuit and opens its original energizing circuit, at armature 552 prepares a locking circuit for relay 560, at armature 551 prepares a circuit to the start lamp ST, and at armature 554 prepares a circuit to the alarm lamp AL. When the time switch TS again closes springs 503 relay 560 again energizes. At armature 562 relay 560 completes its locking circuit, at armature 561 completes the circuit for lighting the start lamp ST and for energizing relay 570, at armature 565 closes the circuit for lighting the alarm lamp AL. At armature 572 relay 570 closes a multiple circuit to the alarm lamp or alarm sender. When the circuit to start relay 510 is opened relay 510 deenergizes and at armature 511 removes ground from the start circuit, at armature 512 opens the locking circuit of relays 540, 550 and 560, and opens the circuit to the time switch TS to stop the same. Relay 540, upon deenergizing, at armature 545 opens one of the multiple circuits to the alarm lamp AL. Relay 560, upon deenergizing, at armature 561 opens the circuit to the start lamp ST and relay 570. Relay 550, upon deenergizing, at armature 551 opens a point in the circuit to the start lamp ST and relay 570, and at armature 554 opens the circuit to lamp AL. Relay 570, upon deenergizing, at armature 572 opens the circuit to the alarm lamp AL or the alarm sender. From the foregoing, it will therefore be seen that if the start relay 510 is maintained energized for a predetermined time, which in this case would indicate some fault, then the switch TS which is started in operation in response to the operation of relay 510 will have had sufficient time to cause the operation just described. The operation of the time switch is slow enough so that under normal conditions no alarm is operated.

Having described the invention and what is considered new and is desired to be protected by Letters Patent will be set forth in the following claims.

What is claimed is:

1. In an impulse repeating arrangement, a line relay and a line over which it is energized, a pulse relay, an impulse repeating relay controlled by said pulse relay, a circuit for said pulse relay jointly controlled by said line relay and said impulse repeating relay, and means controlled by said impulse repeating relay for repeating impulses.

2. In an impulse repeating arrangement, a line relay and a line over which it is energized, a pulse relay, an impulse repeating relay controlled by said pulse relay, a circuit for said pulse relay jointly controlled by said line relay and said impulse repeating relay, a priming circuit for said line relay completed whenever said line relay is in deenergized position, and means controlled by said impulse repeating relay for repeating impulses.

3. In an impulse repeating arrangement, a line relay and a line over which it is energized, a pulse relay, an impulse repeating relay controlled by said pulse relay, a circuit for said pulse relay jointly controlled by said line relay and said impulse repeating relay, a locking circuit for said pulse relay controlled by said line relay independently of said impulse repeating relay, and means controlled by said impulse repeating relay for repeating impulses.

4. In an impulse repeating arrangement, a line relay and a line over which it is energized, a pulse relay, an impulse repeating relay controlled by said pulse relay, a circuit for said pulse relay jointly controlled by said line relay and said impulse repeating relay, a pair of pulse conductors, and contacts on said impulse repeating relay for transmitting an impulse over one of said conductors upon energizing and for transmitting an impulse over the other of said conductors upon deenergizing.

5. In an impulse repeating arrangement the combination of a circuit, a relay for closing said circuit on deenergizing in order to produce an impulse therein, means including an impulse repeating relay energized in response to each odd impulse and deenergized in response to each even impulse over said circuit, contacts on said impulse repeating relay for reoperating said first relay to terminate the impulse each time one is received, and contacts on said impulse repeating relay for repeating each impulse received.

6. In an impulse repeating arrangement the combination of a circuit, a relay for closing said circuit on deenergizing in order to produce an impulse therein, means including an impulse repeating relay energized in response to each odd impulse and deenergized in response to each even impulse over said circuit, contacts on said impulse repeating relay for reoperating said first relay to terminate the impulse each time one is received, contacts on said impulse repeating relay for repeating each impulse received, and means including a line relay response to impulses received over a line for controlling the deenergizations of said first relay and jointly with said impulse repeating relay for controlling the reoperations of said first relay.

7. In an impulse repeating arrangement, the combination of a line relay having a stiff adjustment so that it will respond to rapid interruptions of a leaky line, a priming circuit for said line relay to enable the line relay to respond to rapid interruptions on a high resistance line, a pulse relay, an impulse repeating relay controlled by said pulse relay, a circuit for said pulse relay jointly controlled by said line relay and said impulse repeating relay, back contacts on said line relay for completing said priming circuit, and contacts on said impulse repeating relay for repeating the impulses transmitted to said line relay.

8. In a telephone system, a calling line, a line relay, means for connecting the calling line to said line relay to energize said relay, a pulse relay, an impulse repeating relay controlled by said pulse relay, a circuit for said pulse relay jointly controlled by said line relay and said impulse repeating relay, means controlled by the calling subscriber in response to dialling the digits of a called line for energizing and deenergizing said line relay in accordance therewith, means for deenergizing said pulse relay over said circuit in response to each deenergization of said line relay, and means for energizing said impulse repeating relay in response to each alternate deenergization of said pulse relay and for deenergizing said impulse repeating relay in response to the other alternate deenergizations of said pulse relay.

9. In a telephone system, a calling line, a line relay, means for connecting the calling line to said line relay to energize said relay, a pulse

relay, an impulse repeating relay controlled by said pulse relay, a circuit for said pulse relay jointly controlled by said line relay and said impulse repeating relay, means controlled by the calling subscriber in response to dialling the digits of a called line for energizing and deenergizing said line relay in accordance therewith, means for deenergizing said pulse relay over said circuit in response to each deenergization of said line relay, means for energizing said impulse repeating relay in response to each alternate deenergization of said pulse relay and for deenergizing said impulse repeating relay in response to the other alternate deenergizations of said pulse relay, and means including a pair of conductors over which impulses are transmitted in response to each energization and each deenergization of said impulse repeating relay.

10. In a telephone system, a called line, means operated in response to dialling either one of two different unit digits and the same group selecting digit for connecting with said line, means thereafter responsive to dialling any one code ring digit for transmitting one of two different ringing codes corresponding to this digit over the called line, and means jointly dependent upon the group, the unit, and the code ring digits dialled for determining the particular ringing code to be transmitted over said line.

11. In a telephone system, a called line having two different unit digits and the same group digit in its called number, a first group of substations on said line each having a different code ring digit in its called number, a second group of substations on said line each having the same code ring digit as a corresponding substation in said first group in its called number, means for transmitting a different ringing code for each substation on said line, and means dependent upon the unit digit and the code ring digit dialled for determining the substation ringing code to be transmitted.

12. In a divided code ringing telephone system, a called line having a positive and a negative line conductor, means responsive to a group and a unit selecting digit dialled by a calling subscriber for extending a connection to said line, ringing means including a set of counting relays responsive to the receipt of a code ring digit for operating said counting relays to select a particular ringing code in accordance therewith, a source of ringing current, a ringing relay for connecting said ringing source to said line in accordance with said selected code, and means dependent upon the group and unit selecting digits dialled for determining whether said ringing source is to be connected to said positive line conductor or said negative line conductor.

13. In an all relay system, subscribers' lines divided into groups, a plurality of all-relay finders for extending calling lines, a start relay common to all said finders, means for marking the calling line and the calling group of such calling line in all said finders and for energizing said common start relay in response to any one of said lines initiating a call, means responsive to the energization of said common start relay for selecting an idle one of said finders, relays automatically operated responsive to said selection to search for the marked calling group, a group test relay operated to stop said group searching relay operations when the calling group is found, other relays automatically operated responsive to the operation of said group test relay to search for the marked calling line in said marked group, and a line test relay operated to stop said line searching relay operations when the calling line is found.

14. In a telephone system, subscribers' lines, a plurality of all-relay links for interconnecting said lines, means responsive to the initiation of a call on one of said lines for seizing an idle one of said links, relays in said seized link operated responsive to said seizure to search for the calling line, and a transfer relay in said link operated in case said relays fail to find the calling line for transferring said call to another idle link.

15. In a telephone system, subscribers' lines, a plurality of all-relay links for interconnecting said lines, a chain circuit connecting all said links, a first start circuit extending to the beginning of said chain circuit, a second start circuit extending to the middle of said chain circuit, means responsive to the initiation of alternate calls by said lines for seizing an idle one of said links over said first start circuit and the beginning of said chain circuit, means responsive to the initiation of intervening calls by said lines for seizing an idle one of said links over said second start circuit and the middle of said chain circuit, and relays in said links operated responsive to said seizures for searching and finding the calling line.

16. In a telephone system, subscribers' lines, a plurality of all-relay links for interconnecting said lines, a start circuit normally connected to the first one of said links, means responsive to the initiation of a call on one of said lines for taking said start circuit into use and for seizing the first idle one of said links over said start circuit, relays in the seized link operated responsive to said seizure to search for and find the calling line, a transfer relay in said link energized in response to said relays finding the calling line for transferring said start circuit to the next link, means for maintaining said transfer relay energized during an established connection and for deenergizing said relay on termination of said connection, and means for preventing the deenergization of said transfer relay on termination of said connection in case said start circuit is in use at such time in response to the initiation of another call.

17. In a telephone system, subscribers' lines, a plurality of all-relay links for interconnecting said lines, a start circuit normally connected to the first one of said links, means responsive to the initiation of a call on one of said lines for taking said start circuit into use and for seizing the first idle one of said links over said start circuit, relays in the seized link operated responsive to said seizure to search for and find the calling line, a transfer relay in said link energized in response to said relays finding the calling line for transferring said start circuit to the next link, means for maintaining said transfer relay energized during an established connection and for deenergizing said relay on termination of said connection, means for preventing the deenergization of said transfer relay on termination of said connection in case said start circuit is in use at such time in response to the initiation of another call, an all-link busy relay energized in case all said links become busy, and contacts on said all-link busy relay for disabling said start circuit to allow the deenergization of said transfer relays when all

said links are busy regardless of the initiation of further calls.

18. In a telephone system, subscribers' lines, a plurality of all-relay links for interconnecting said lines, a first start circuit, a second start circuit, means for grounding said first start circuit in response to the initiation of alternate calls and for grounding said second start circuit in response to the initiation of the intervening calls by subscribers on said lines, means including a chain circuit responsive to the grounding of said first start circuit for seizing the first idle one of the links beginning with the first half thereof and responsive to the grounding of said second start circuit for seizing the first idle one of said links beginning with the last half thereof, relays in the seized link operated responsive to said seizure to search for and find the calling line, said first means removing ground from either start lead in response to said relays finding said line, a transfer relay in said seized link energized in response to said relays finding the calling line for transferring said start circuit over said chain circuit to the next link, and means for preventing the deenergization of said transfer relays as long as either start circuit is grounded.

19. In an automatic telephone system, a plurality of subscribers' lines, a plurality of all-relay links for interconnecting said lines, means responsive to a call on one of said lines for seizing an idle one of said links, finder relays in said link responsive to said seizure for finding and connecting the calling line thereto, connector relays in said link responsive to the calling subscriber dialling the digits in the telephone number of a called one of said lines for connecting therewith, means in said link for switching through to talking condition in response to the called party answering, and means for freeing the seized link in case such link fails to reach its talking condition within a predetermined time after its seizure.

20. In a telephone system, groups of subscribers' lines, an all-relay link for interconnecting said lines, a finder-group relay in said link for each group of lines, finder unit relays in said link corresponding to the number of lines in any one group, means responsive to a call by a line in one of said groups for automatically operating said finder-group relays until the finder-group, relay corresponding to said calling group is operated and for automatically operating said finder-unit relays until the finder-unit relay corresponding to the calling line is operated to connect the calling line to said link, means in said link for reversing the direction of current flow over the calling line, and a circuit for controlling said reversing means including contacts on certain of said finder group relays corresponding to the groups of lines requiring reverse battery supervision.

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