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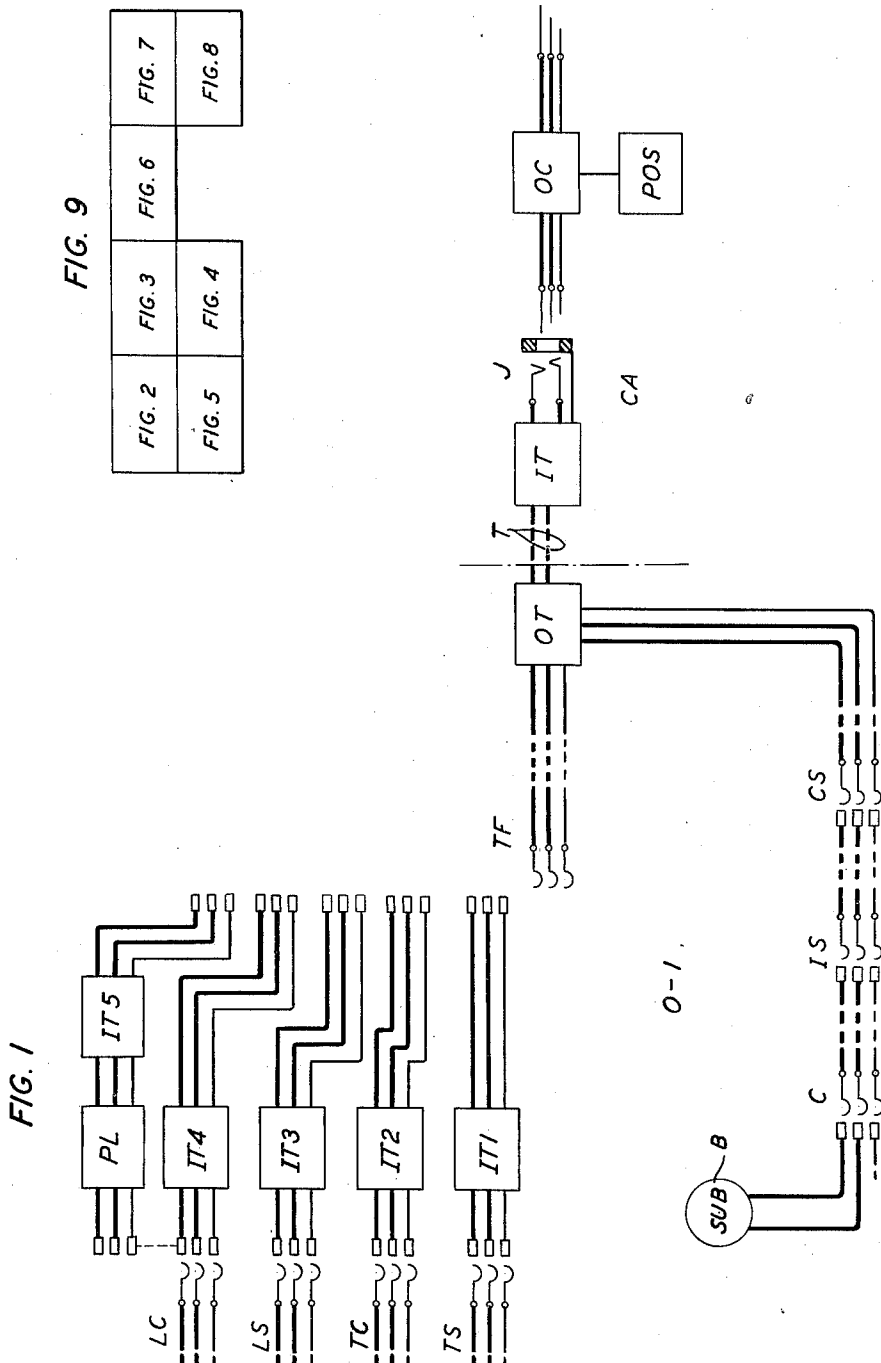
E. D. BUTZ ET AL

2,021,287

TELEPHONE SYSTEM

Filed May 5, 1934

8 Sheets-Sheet 1



INVENTORS **E. D. BUTZ**  
**C. D. KOECHLING**  
 BY *W. P. McFadden*  
 ATTORNEY

Nov. 19, 1935.

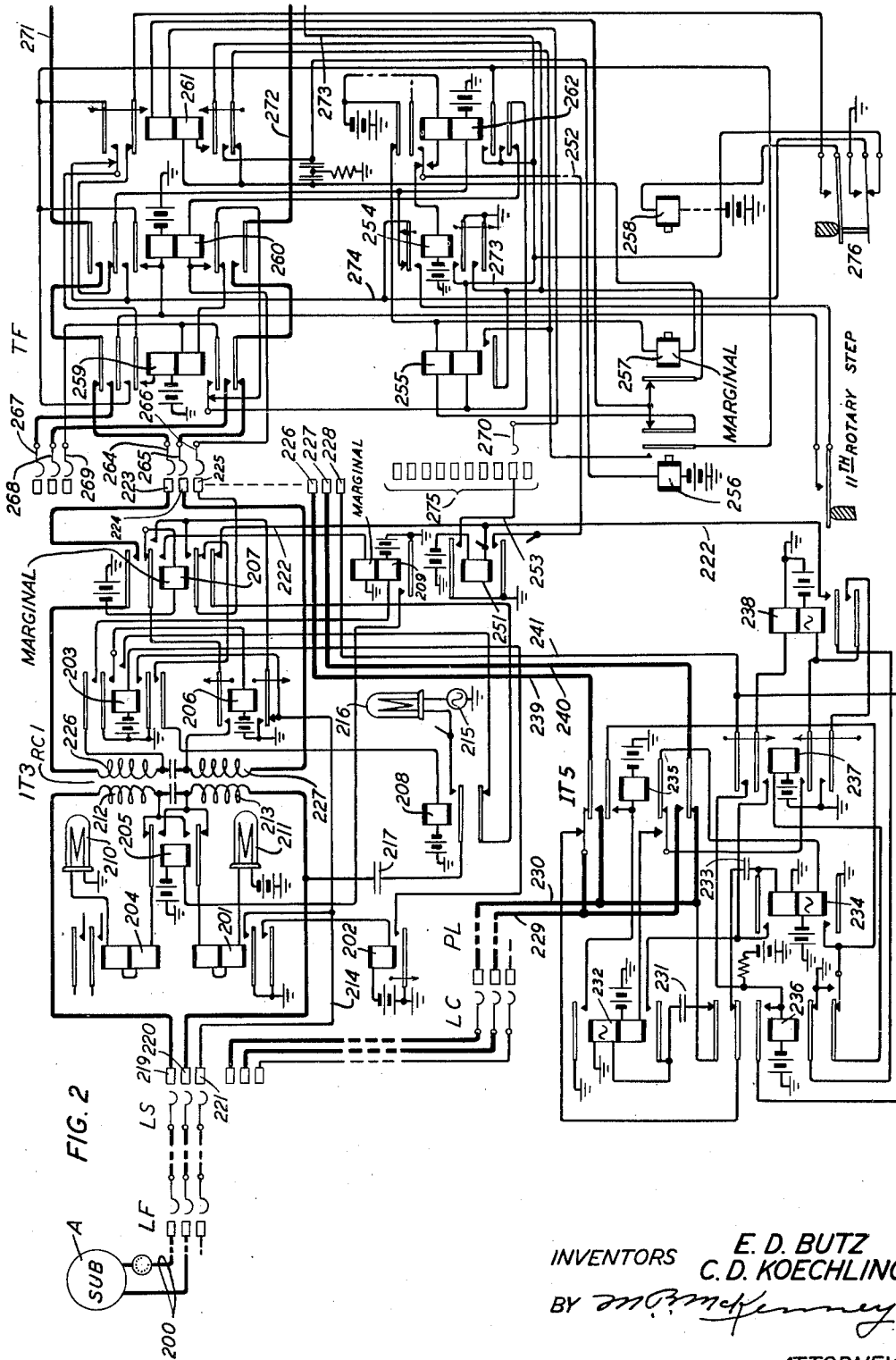
E. D. BUTZ ET AL

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TELEPHONE SYSTEM

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8 Sheets-Sheet 2



INVENTORS  
E. D. BUTZ  
C. D. KOECHLING  
BY *James H. McNamee*  
ATTORNEY

Nov. 19, 1935.

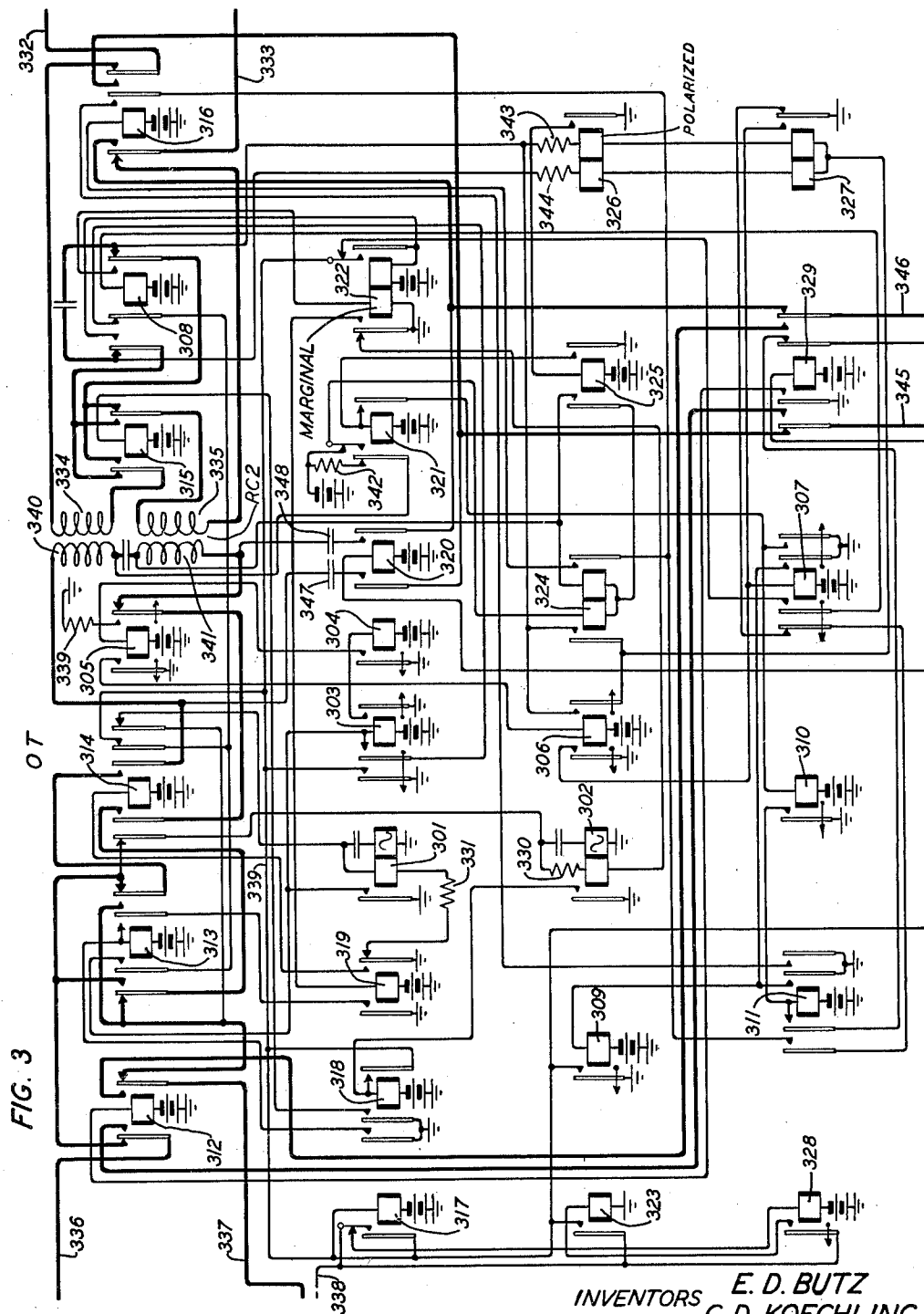
E. D. BUTZ ET AL

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TELEPHONE SYSTEM

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8 Sheets-Sheet 3



INVENTORS E. D. BUTZ  
C. D. KOEHLING  
BY *Wm. H. W. W. W.*  
ATTORNEY

Nov. 19, 1935.

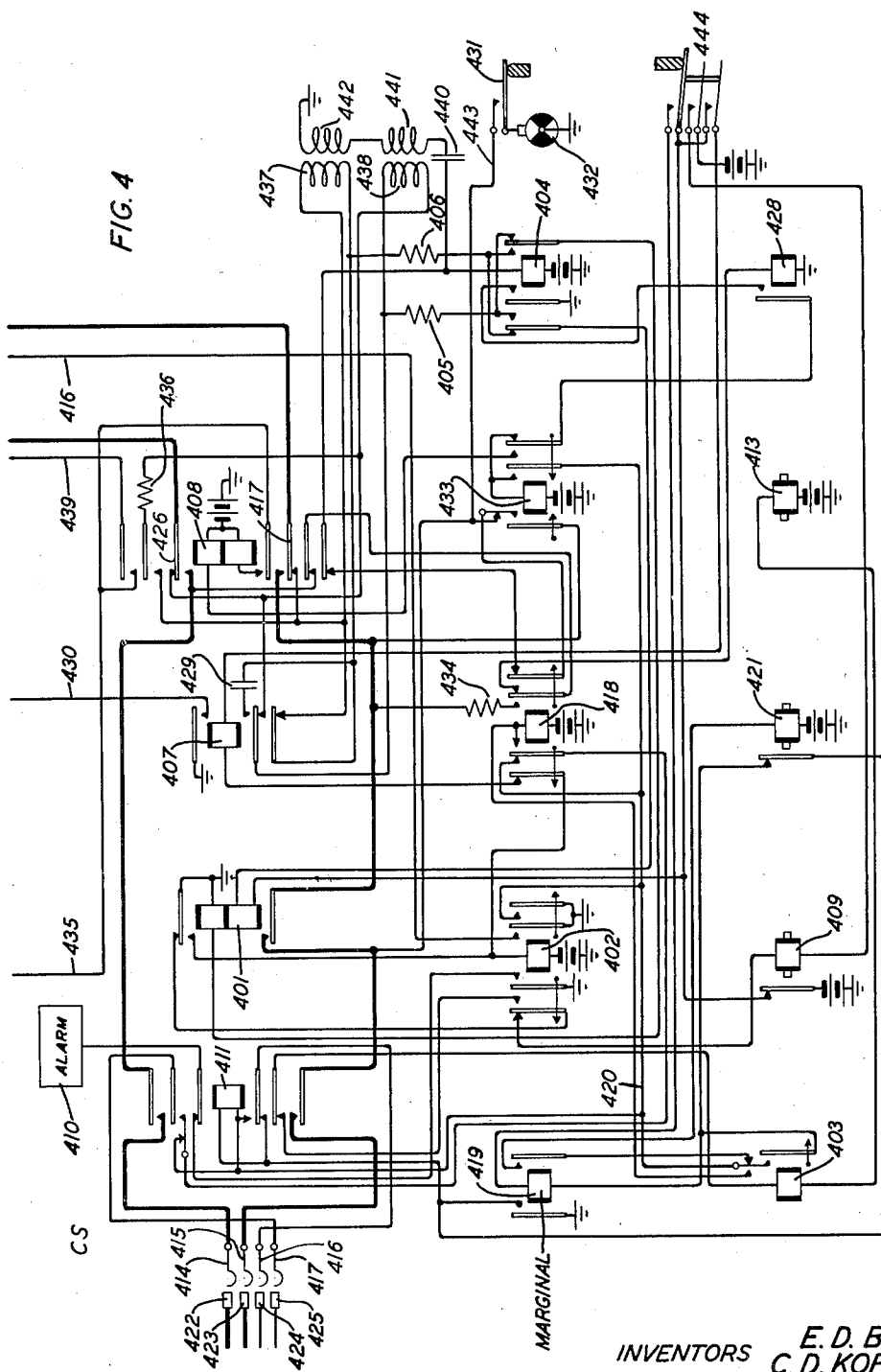
E. D. BUTZ ET AL

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TELEPHONE SYSTEM

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8 Sheets-Sheet 4



INVENTORS E. D. BUTZ  
C. D. KOECHLING  
BY *[Signature]*  
ATTORNEY

**Nov. 19, 1935.**

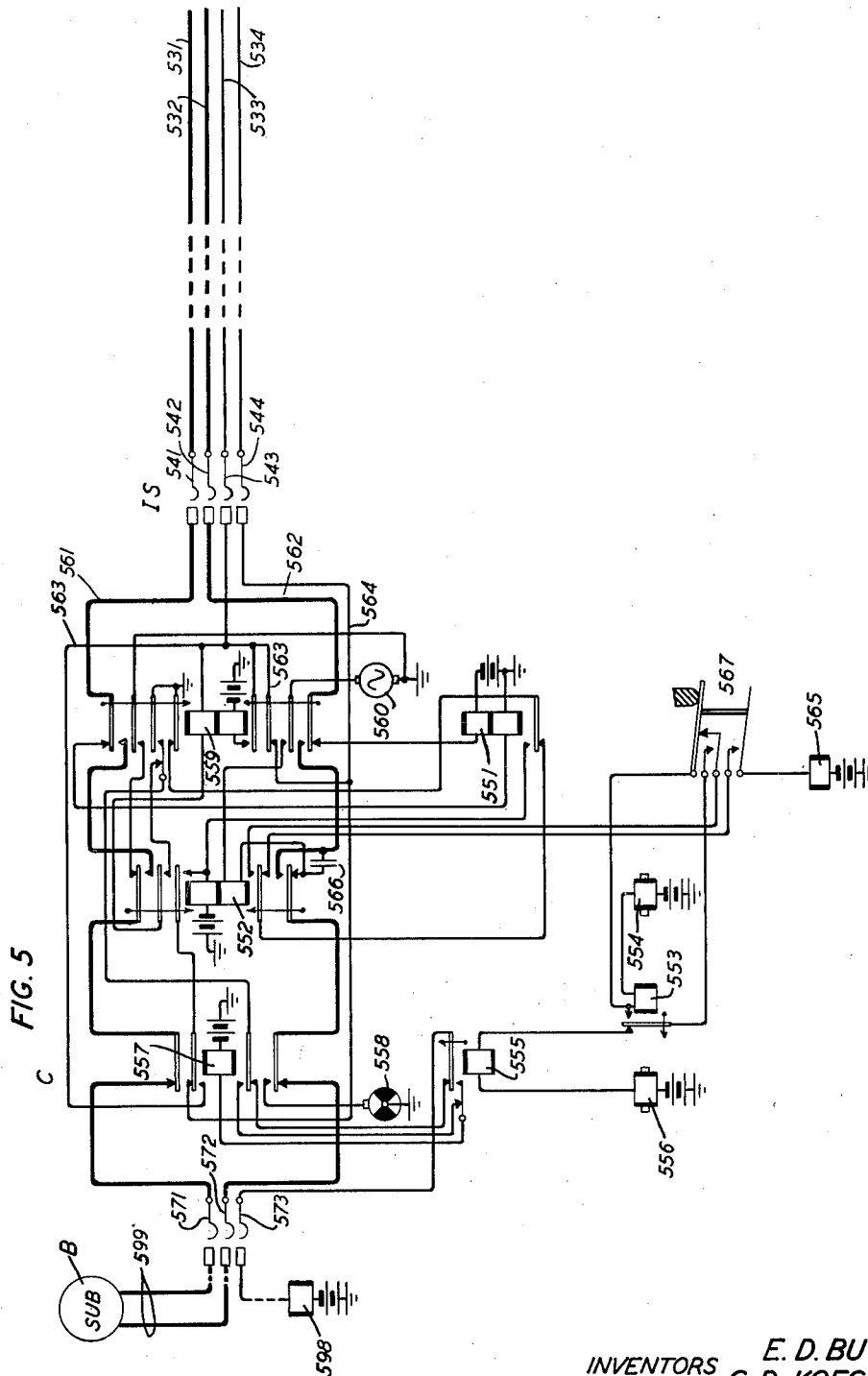
E. D. BUTZ ET AL

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TELEPHONE SYSTEM

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8 Sheets-Sheet 5



INVENTORS **E. D. BUTZ**  
**C. D. KOECHLING**  
BY *Wm. J. Kerney*  
**ATTORNEY**

Nov. 19, 1935.

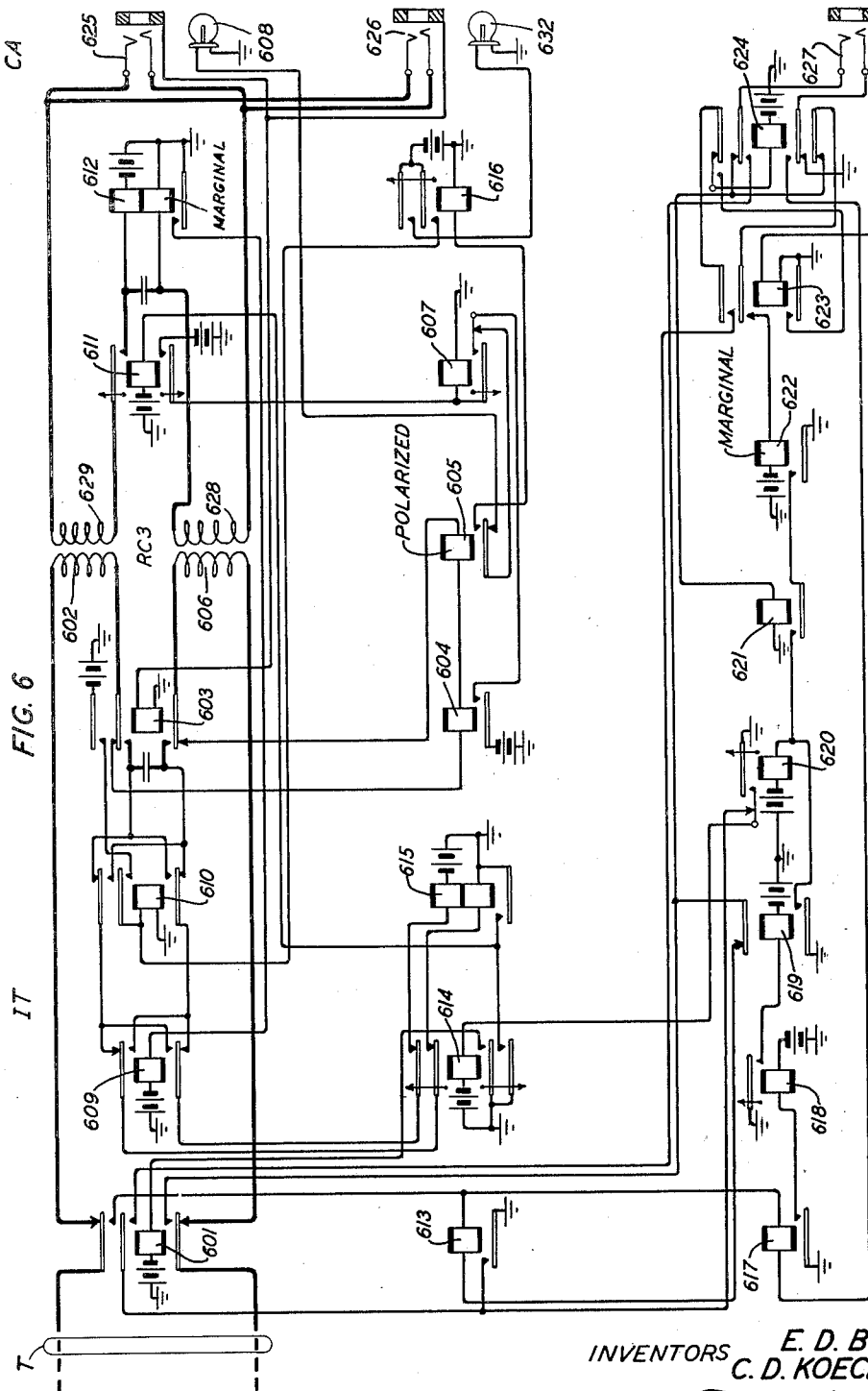
E. D. BUTZ ET AL

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TELEPHONE SYSTEM

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8 Sheets-Sheet 6



INVENTORS  
E. D. BUTZ  
C. D. KOECHLING  
BY *Wm. H. H. H. H. H.*  
ATTORNEY

Nov. 19, 1935.

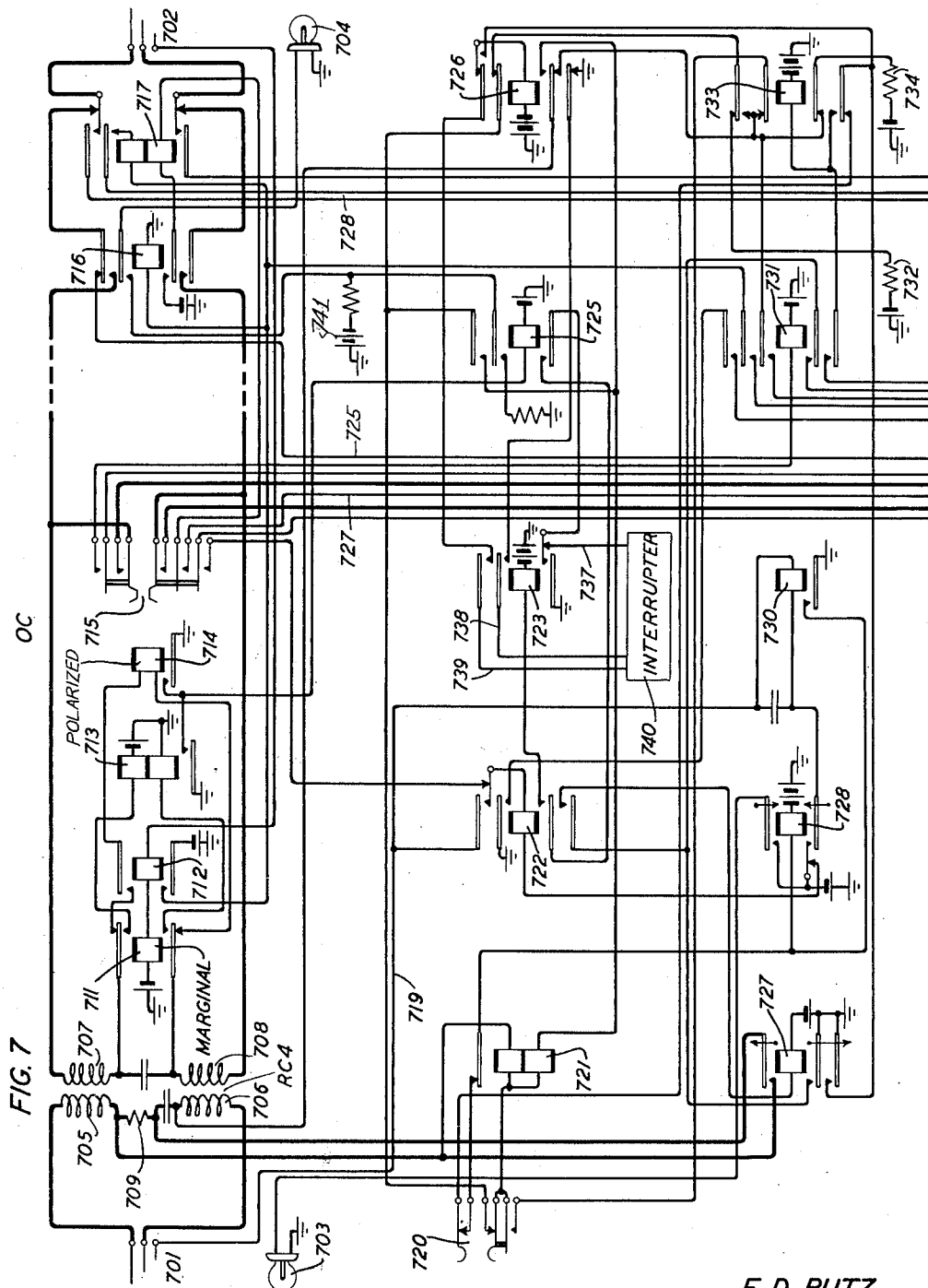
E. D. BUTZ ET AL

2,021,287

TELEPHONE SYSTEM

Filed May 5, 1934

8 Sheets-Sheet 7



INVENTORS E. D. BUTZ  
C. D. KOEHLING

BY *James H. White*  
ATTORNEY

Nov. 19, 1935.

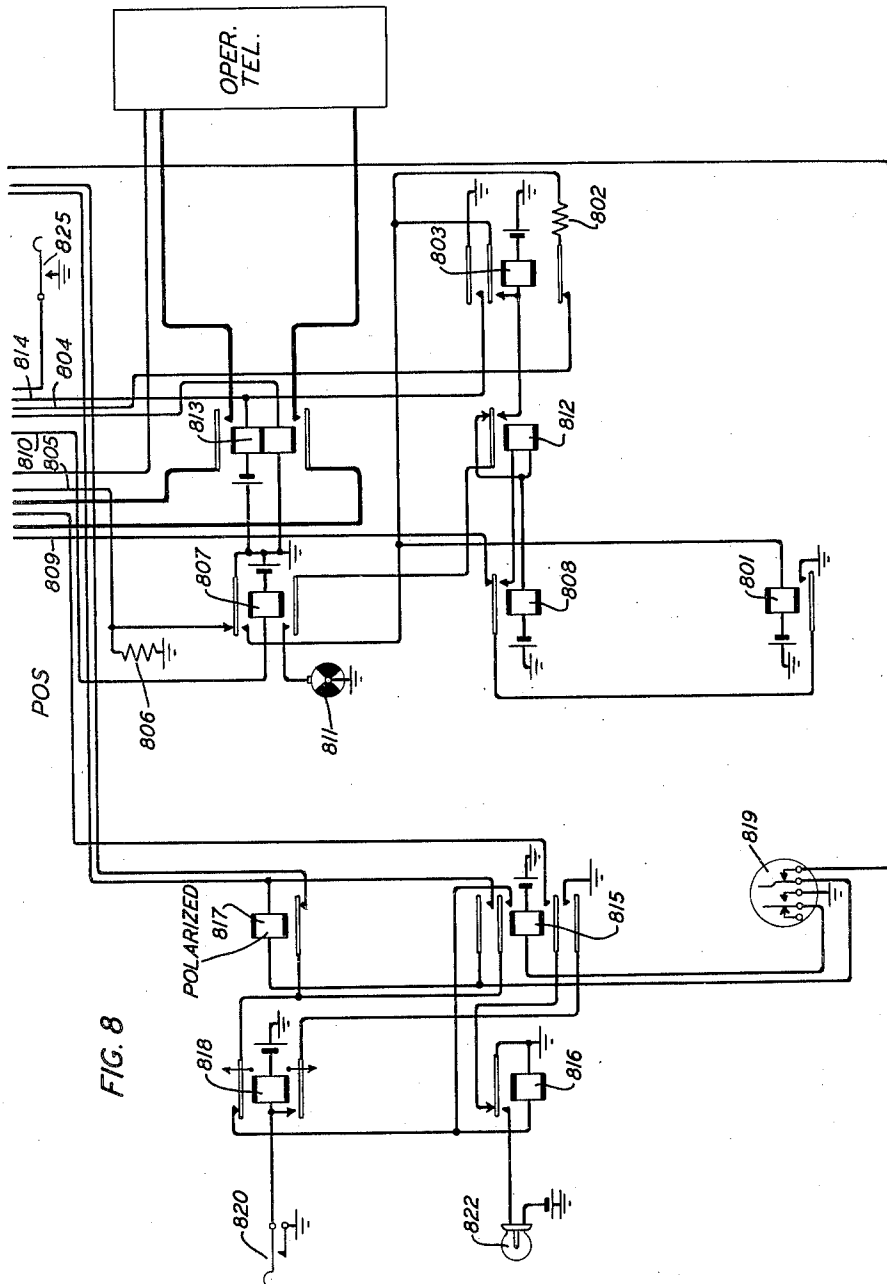
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TELEPHONE SYSTEM

Filed May 5, 1934

8 Sheets-Sheet 8



INVENTORS E. D. BUTZ  
C. D. KOECHLING

BY *Wm. H. H. H. H.*  
ATTORNEY



## UNITED STATES PATENT OFFICE

2,021,287

## TELEPHONE SYSTEM

Edward D. Butz, Palisade, N. J., and Charles D. Koechling, Floral Park, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application May 5, 1934, Serial No. 724,074

7 Claims. (Cl. 179—27)

This invention relates to telephone systems and more particularly to systems employing automatic switching equipment for completing connections between the subscribers' lines.

The object of this invention is to provide an improved arrangement for completing intercepted calls in an automatic telephone system.

In automatic telephone systems it is usual to connect an intercepting trunk to blank terminals in the selector and connector banks and also to provide an intercepting trunk from a plugging-up line for intercepting calls to a subscriber whose line is temporarily removed from service. When the intercepting positions for a plurality of offices are located at a central "A" switchboard the intercepting trunks may terminate in the banks of trunk-finder switches each associated with an outgoing trunk circuit to the central "A" switchboard. The call thus forwarded to an intercepting position in a distant office may be intercepted over a plugging-up line in which case the call can not be completed, or may be from a toll operator in which case there is no necessity for completion by the intercepting operator. It may, however, be desirable to complete other intercepted calls.

According to the features of this invention, a two-conductor trunk is provided for forwarding intercepted calls to an intercepting operator's position at a centralized "A" switchboard. A completing selector is associated with the outgoing end of the trunk for use in completing intercepted calls, and switching means at the outgoing end of the trunk, controlled from the intercepting operator's position, operatively connects the trunk to the completing selector so that dial impulses may be transmitted over the trunk to establish a connection with a desired line. Switching means is also provided for closing a talking circuit from the calling to the called station, supervisory means being provided in the completing selector for causing the operation of the last mentioned switching means in response to the answer of the called subscriber. The talking conductors of the completing train of switches are freed of all bridging apparatus and extended to a source of talking battery in the switch at which the call was intercepted or in the intercepting trunk connected to the terminals of this switch. A further feature of the invention is the arrangement whereby such a completing selector is held during a connection by ground fed forward over the sleeve conductor of the intercepting trunk.

The drawings which form a part of this specification represent, in schematic form, a telephone system in which the invention is embodied.

The invention is of course not limited in its application to the particular system shown and described herein.

Referring to the drawings:

Fig. 1 represents a telephone system comprising an automatic office O—1 and a centralized "A" switchboard CA;

Figs. 2 to 8, inclusive, show in detail the controlling circuits for the system represented in Fig. 1;

Fig. 9 shows the position in which the various Figures 2 to 8 inclusive are to be placed with respect to each other to form an operative system.

Considering first the general arrangement of the system, as shown in Fig. 1, IT1, IT2, IT3 and IT4 represent intercepting trunks connected, respectively, to terminals in the banks of a toll selector TS, toll connector TC, local selector LS and local connector LC, all of which switches are in office O—1. IT5 represents an intercepting trunk connected by a plugging-up line PL to another set of terminals in the bank of the local connector LC. These intercepting trunks are also connected to terminals in the bank of trunk-finder switch TF and other similar switches. The trunk-finder switch TF and the associated outgoing trunk equipment OT are permanently associated with the trunk T, the distant end of which is connected to the incoming trunk equipment IT and answering jack J at an intercepting operator's position of the centralized "A" switchboard CA. OC represents one of the intercepting operator's cords and POS represents the operator's position and telephone equipment. CS represents a completing selector in office O—1 individual to the outgoing trunk equipment OT; IS represents an intermediate selector, C represents a connector switch, and B represents a subscriber's station connected to terminals in the bank of connector switch C.

The finder, selector and connector switches are all of the two-motion step-by-step type. For a general description of the construction and operation of such switches reference may be had to pages 53 to 65 inclusive of the second edition of "Automatic Telephony" by Smith and Campbell. The selector and connector switches TS, TC, LS, LC are each represented by a set of brushes and one or two sets of terminals. The intercepting trunks IT1, IT2, IT3, IT4 and IT5 and the plugging-up line PL may be similar to correspondingly designated trunks shown and described in detail in the copending application of E. D. Butz, Serial No. 648,052, filed December

20, 1932. The intercepting trunk IT3, trunk-finder TF, outgoing trunk equipment OT, completing selector CS, intermediate selector IS, connector C, incoming trunk equipment IT, the operator's cord OC and the position equipment POS are shown in detail in Figs. 2 to 8, inclusive. The line-finder LF represented in Fig. 2 by one set of brushes and a single set of terminals may be similar to the line-finder disclosed in the patent to H. Hovland No. 1,711,682, granted May 7, 1929.

The operation of the system shown in the drawings will be most readily understood by assuming that a call originated by the subscriber at station A in Fig. 2 is intercepted by trunk IT3, extended by trunk-finder TF over trunk T to the intercepting position and that the call is completed under control of the intercepting operator by completing selector CS, intermediate selector IS, and connector C to the called subscriber's station B. The intermediate selector IS and connector C are similar to intermediate selectors and connectors employed in completing toll calls.

When the call is originated at station A, a line-finder LF hunts for and extends the calling line 200 to the associated local selector LS. The selector LS is selectively operated under the control of the impulses created by the dialing of the first digit of the called number to select a corresponding group of terminals and to then automatically hunt for and seize an idle set of terminals in the selected group. Assuming that the first digit represents an unassigned group of telephone numbers, the selected set of terminals will be connected to an intercepting trunk such as IT3. Since local selectors have no means for signaling over a selected trunk, as do connectors and toll selectors, the trunk IT3 is arranged to initiate the further extension of the connection to the intercepting operator and to hold the selector and line-finder switches in their operated positions.

Upon seizure of trunk IT3, the tip conductor of the calling line 200 is extended through the upper brushes of line-finder LF and selector LS to terminal 219, thence through winding 212 of repeating coil RC1, the upper back contact of relay 205, windings of relay 204, and through the lamp 210 to ground; and the ring conductor of line 200 is extended through the middle brushes of line-finder LF and selector LS to terminal 220, thence through winding 213 of repeating coil RC1, lower back contact of relay 205, windings of relay 201, and through the lamp 211 to battery. Relay 201 is operated by the current through its windings and closes an obvious circuit for operating relay 202. Relay 201, operated, also connects ground through its inner front contact to sleeve conductor 214 to hold the selector and line-finder switches in their operated position in the usual manner. Relay 202, operated, closes an obvious circuit for energizing relay 203. In operating, relay 203 connects ground through its inner lower front contact to sleeve conductor 214; connects battery through the winding of relay 203 and the outer lower front contact of relay 203, and through the inner lower back contact of relay 207 to sleeve terminal 25 in the bank of the trunk-finder switch TF; connects ground through its innermost upper front contact, back contact of relay 208, lowermost back contact of relay 207, over conductor 222 to battery through the winding of group relay 251 which is common to the group of trunks which includes trunk IT3.

Relay 203 also closes a circuit through its middle upper front contact for operating relay 206. It is assumed that the trunk IT3 and the other trunks in the same group are connected to terminals in the second level of the banks of trunk-finder TF. Group relay 251 connects ground through its upper front contact, over conductor 253, to the second off-normal segment of the vertical commutator 275 of finder TF and the corresponding segment of the commutators of all other trunk-finders having access to this group of trunks. Relay 251 also connects ground to the start lead 252 which is common to the group of trunk-finders having access to trunk IT3.

Assuming the trunk-finder TF to be the first idle finder in the group, the connection of ground to the start lead 252 effects the operation of relay 254. Relay 254 closes a circuit from battery through the uppermost back contact of relay 262, upper winding of relay 255, back contact of the rotary-stepping magnet 256, back contact of vertical-stepping magnet 257, and through the lowermost front contact of relay 254 to ground. Relay 255 operates, closing a circuit from battery through the uppermost back contact of relay 262, winding of vertical-stepping magnet 257, lower back contact of relay 261, front contact of relay 255, and through the lowermost front contact of relay 254 to ground. The magnet 257 operates, stepping up the two sets of brushes to the first level of terminals in the associated banks and stepping up the vertical commutator brush 270 to make contact with the first off-normal segment of the commutator 275. The vertical off-normal springs 270 are actuated by the movement of the shaft out of normal position. The operation of magnet 257 also causes the release of relay 253; and the release of relay 255 in turn causes the release of magnet 257. Since the trunk for which the trunk-finder TF is seeking, is connected to terminals in the second level, commutator brush 270 does not encounter ground potential on the first off-normal segment of the commutator. With magnet 257 released, relay 255 reoperates, again closing the circuit for operating magnet 257; and the brushes of switch TF are stepped up to the second level of the terminal banks. Since trunk IT3 is connected to terminals in the second level, a circuit is closed for energizing relay 261 as soon as the commutator brush 270 comes in contact with the second off-normal commutator segment; this circuit is traced from battery through the uppermost back contact of relay 262, upper winding of relay 255, back contact of magnet 256, upper winding of relay 261, commutator brush 270 and second off-normal segment of the commutator, conductor 253, and through the upper front contact of group relay 251 to ground. This circuit is also effective to hold relay 255 operated. Relay 261 is slow in operating to insure proper positioning of the brushes before the first rotary step is taken. The operation of relay 261 causes the release of magnet 257. Since the intercepting trunk IT3 is shown connected to terminals in the banks with which the brushes 264, 265 and 266 are associated, the description of the terminal hunting operation of the trunk-finder TF will be limited to the case where the calling trunk is encountered by this set of brushes. When relay 261 operates, it closes a circuit from battery through the winding of rotary-stepping magnet 256, lowermost front contact of relay 261, front contact of relay 255, and through the lowermost front contact of relay 254 to ground. The operation of magnet 256 rotates the two sets of

brushes into contact with the first set of terminals in the second level of each of the associated banks. The circuit through the upper winding of relays 255 and 261 is opened when magnet 256 operates and is also opened at the commutator due to the rotation of brush 270 out of alignment with the commutator segments. Relay 255 releases but relay 261 is held operated in a circuit from battery through the uppermost back contact of relay 262, winding of magnet 257, lower winding and inner lower front contact of relay 261, to ground at the lowermost front contact of relay 254. The current in this circuit is not sufficient to operate the magnet 257. The release of relay 255 causes the release of magnet 256 and, if the first set of terminals in the second level is not the set to which the calling trunk IT3 is connected, relay 255 reoperates and causes the reoperation of magnet 256 to advance the brushes into engagement with the second set of terminals. Relay 255 and magnet 256 continue to cooperate to advance the brushes until test brush 256 encounters the terminal 225 to which the winding of the cut-off relay 203 of trunk IT3 is connected. A circuit is thus closed from battery through the winding of relay 203, lowermost front contact of relay 203, inner lower back contact of relay 297, terminal 225, brush 266, lower winding of relay 260, lower back contact of relay 262, lower winding of relay 255, and through the inner lower front contact of relay 254 to ground. Relay 203 operates, relay 255 is held operated, and relay 260 operates sufficiently to close at its inner upper front contact a circuit for completing its own operation; this circuit is traced from battery through the upper winding and inner upper front contact of relay 260, front contact of magnet 256, front contact of relay 255, to ground at the lowermost front contact of relay 254. Magnet 256 is held operated under control of relays 261, 255 and 254. The operation of cut-off relay 203 of the trunk IT3 disconnects the ground at trunk IT3 from group conductor 222 and connects the source of ringing current 215 through the lamp 216, front contact of relay 203, and condenser 217 to one of the talking conductors of trunk IT3, thereby transmitting a ringing tone to the calling subscriber. Group relay 251 releases unless conductor 222 is connected to ground at one of the other trunks in the same group. The complete operation of relay 260 closes a circuit for operating relay 262; this circuit is traced from battery through the lower winding of relay 262, middle upper front contact of relay 260, conductor 274, lower front contact of the vertical off-normal springs 276 to ground. The operation of relay 262 and the release of relay 251 are each effective to cause the release of relay 254. The operation of relay 262 and release of relay 254 cause the release of relays 255 and 261. With relay 254 released, the lower winding of relay 262 is also connected to conductor 274 by the back contact of relay 254. With relay 262 operated, the upper winding of relay 260 is connected through its inner upper front contact and the inner lower front contact of relay 262, over conductor 273 to sleeve conductor 338 of trunk equipment OT. Relay 262 extends the start conductor 252 through its outer upper front contact to the next trunk-finder in the same group.

With relay 260 operated, a circuit is closed from battery through the winding and upper back contact of relay 207 of trunk IT3, upper front contact of relay 208, winding 227 of the repeating coil RCI, terminal 224 and brush 265 of finder

TF, lowermost back contact of relay 259, lowermost front contact of relay 260, conductors 272 and 337, right back contact of relay 312 of trunk equipment OT, right outer back contact of relay 314, left winding of relay 301, resistance 331, and through the back contact of relay 319 to ground. Relay 301 operates in this circuit but relay 207 is marginal and does not operate. The operation of relay 301 is a signal to the trunk equipment OT that the call has been intercepted at the banks of a local selector or a toll selector. Had the call extended by trunk-finder TF to trunk equipment OT been intercepted at the bank of a toll or local connector, relay 301 would be operated due to the energization of its right winding by ringing current from the connector or due to the energization of its left winding by direct current during the silent part of the ringing cycle.

At the time that start relay 254 of trunk-finder TF operated, the connection of ground potential through the inner lower contact of this relay to conductor 273, thence over sleeve conductor 338 of trunk equipment OT, through the back contact of relay 317 to the winding of relay 328, causes the operation of relay 328. The three relays 317, 323 and 328 are provided for the purpose of maintaining the connection of ground potential to conductors 338 and 273 in case relay 254 of the finder TF releases prior to the operation of relay 303 of trunk equipment OT. The operation of relay 328 connects sleeve conductor 338 to the winding of relay 323. As long as conductor 273 is connected to ground at the inner lower front contact of relay 254, the winding of relay 323 is short-circuited. But when relay 254 releases, relay 323 is operated by current in a circuit from battery through the upper winding and inner upper front contact of relay 260, inner lower front contact of relay 262, conductor 273, sleeve conductor 338, front contact of relay 328, and through the winding of relay 323 to ground; the current in this circuit also holds relay 303 operated. When relay 301 operates as hereinbefore described, it closes an obvious circuit for operating relay 303. Relay 303 connects ground to conductor 339 thereby operating relay 317. Relay 317 connects conductor 339 to the sleeve conductor 338 thereby establishing a holding connection for relay 260 of trunk-finder TF. The operation of relay 317 causes the release of relay 328 and the release of relay 323, if operated. Relay 303 closes a locking circuit through its inner left front contact, inner left back contact of relay 308, inner right back contact of relay 314, over conductor 339, to ground at its own outer left front contact. Relay 303 also closes a circuit for operating relay 304; relay 304 closes a circuit for operating relay 305; relay 305 closes a circuit for operating relay 306; relay 306 closes a circuit for operating relay 307; and relay 307 closes circuits for operating relays 308, 309 and 310. The circuit for operating relay 308 is traced from battery through the winding of relay 308, left front contact of relay 307, right back contact of relay 322, over conductor 339 to ground at the outer left front contact of relay 303. Relay 309 connects ground to conductor 339 to hold relay 317 and from conductor 339 through the front contact of relay 317 over conductor 338 to hold relay 260 of the trunk-finder TF. Relay 310 closes a circuit for operating relay 311. Relay 308, in operating, opens the locking path for relay 303 and closes a circuit over conductors 332 and 333 of trunk T to signal an intercepting operator at the distant centralized "A" switchboard CA. 75

This circuit is traced from battery through the right winding of relay 322, left front contact of relay 308, left back contact of relay 315, winding 334 of repeating coil RC2, right back contact of relay 316, over conductor 332 of trunk T, through the upper back contact of relay 601 of the incoming trunk equipment IT, winding 602 of repeating coil RC3, upper back contact of relay 603, winding of relay 604, winding of relay 605, lower back contact of relay 603, winding 606 of repeating coil RC3, lower back contact of relay 601, over conductor 333 of trunk T, left back contact of relay 316, winding 335 of repeating coil RC2, right back contact of relay 315, right front contact of relay 308, and through the left winding of relay 322 to ground. Relay 604 is operated by the current over trunk T; but relay 322 is marginal and relay 605 is polarized so that neither of these two relays operates. Relay 604 closes a circuit from battery through its front contact, back contacts of relays 607 and 605, through lamp 608 to ground; the lamp lights to signal the operator.

The operator answers a call by operating key 715 and inserting the answering plug 701 of a cord OC in the answering jack 625 associated with the lighted lamp 608. The operation of key 715 closes a circuit for operating relay 731 provided no other key similar to key 715 is operated at the same time, this circuit is traced from battery through the winding of relay 731, upper outer front contact of key 715, conductor 805 to ground through the upper back contact of relay 807 in parallel with resistance 803. The operation of relay 731 closes a circuit from battery through the winding of relay 801, resistance 802, lower back contact of relay 803, conductor 804, inner upper front contact of relay 731, inner lower back contact of relay 726, winding 706 of repeating coil RC4, ring conductor of the plug 701 and jack 625, winding 628 of repeating coil RC3, lower winding of relay 612, to ground. Relay 612 is not operated by the current through its winding but relay 801 operates and closes a circuit from ground through its front contact, back contact of relay 808, conductor 809, lowermost front contact of key 715, upper back contact and winding of relay 722, and through the lower back contact of relay 728 to battery. Relay 722 operates and closes a locking circuit over the sleeve conductor 719 of the answering cord; this circuit is traced from ground through the winding of relay 603 of trunk equipment IT, sleeve conductors of the answering jack and plug 701, conductor 719, uppermost front contact and winding of relay 722, and through the lower back contact of relay 728 to battery. Relay 603 is operated by the current in this circuit thereby causing the release of relay 604. The release of relay 604 extinguishes lamp 608. The operation of relay 603 connects the windings of relay 615 to the conductors of trunk T to cause the operation of relay 615 of trunk equipment IT and the operation of relay 322 of trunk equipment OT, each winding of relay 615 being connected in a separate circuit in series with a different one of the windings of relay 322. One of these circuits is traced from ground through the left winding of relay 322, right front contact of relay 308, right back contact of relay 315, winding 335 of repeating coil RC2, left back contact of relay 316, conductor 333 of trunk T, lower back contact of relay 601, winding 606 of repeating coil RC3, lower front contact of relay 603, lower back contacts of relays 610 and 609, uppermost back contact of relay 614, through the upper winding

of relay 615 to battery. The other of these circuits is traced from battery through the right winding of relay 322, left front contact of relay 308, left back contact of relay 315, winding 334 of repeating coil RC2, right back contact of relay 316, conductor 332 of trunk T, upper back contact of relay 601, winding 602 of repeating coil RC3, inner upper front contact of relay 603, upper back contacts of relays 610 and 609, inner upper back contact of relay 614 and through the lower winding of relay 615 to ground. Relay 615 closes a circuit for operating relay 611. Relay 611 closes a circuit for operating relay 607 and closes a circuit from 48-volt battery through the upper winding of relay 612, winding 629 of repeating coil RC3, tip conductor of the answering jack 625 and plug 701, winding 705 of repeating coil RC4, upper winding of relay 721, lower back contact of key 720, inner upper back contact of relay 726, uppermost back contact of relay 733, and through resistance 732 to 24-volt battery; relay 612 remains normal but the answering cord supervisory relay 721 operates. Relay 322 locks in a circuit from battery through the right winding and right front contact, over conductor 339 to ground at the outer left front contact of relay 303 and at the front contact of relay 309. The operation of relay 322 causes the release of relay 308 and the operation of relay 319. The release of relay 308 again closes the locking circuit for relay 303, disconnects the windings of relay 322 from conductors 332 and 333 of trunk T and connects a dry bridge across these conductors; this bridge, which is effective to hold relay 615 of the trunk equipment IT operated, is traced from conductor 332, through the outer right back contact of relay 316, winding 334 of repeating coil RC3, left back contact of relay 315, outer left back contact of relay 308, resistance 344 and left winding of relay 326, left winding of relay 327, right front contact of relay 306, right back contact of relay 308, right back contact of relay 315, winding 335 of repeating coil RC3, and through the left back contact of relay 316 to conductor 333. Relay 327 operates but relay 326 is polarized and the current through its left winding is not at this time in the operating direction. The right windings of relays 326 and 327 are short-circuited by the right front contact of relay 306. Relay 327 closes a holding circuit for relay 307. The aforementioned operation of relay 319 opens the circuit through the left winding of relay 301 and closes a circuit for operating relay 314. Relay 314 disconnects the windings of relays 301 and 302 from conductors 336 and 337 causing the release of these relays, if operated. With relay 301 released and relay 314 operated, relay 303 releases. The ground at the front contact of relay 309 remains connected to conductor 339 as a holding potential. The release of relay 303 also causes the successive release of relays 304, 305 and 306, relay 307 remains operated under control of relay 327. Since relays 303, 304 and 305 are slow in releasing, the resistance 339 is temporarily connected through the right front contact of relay 305, left front contact of relay 314, and through back contacts of relays 313 and 312, over conductor 337 to cause the operation of relay 207 of the intercepting trunk IT3; or to cause the operation of the ringing cut-off relay of a toll or local connector if the call was intercepted at a connector switch. The circuit for operating relay 207 is traced from battery through the winding and upper back contact of this relay, upper front con-

tact of relay 206, winding 227 of repeating coil RC1, terminal 224 and brush 265 of trunk-finder TF, lowermost back contact of relay 259, lowermost front contact of relay 260, conductors 272 and 337, right back contact of relay 312, left back contact of relay 313, left front contact of relay 314, and through the right front contact of relay 305 and resistance 339 to ground. Relay 207, operated, locks through its continuity front contact to ground at the lower front contact of relay 206. The operation of relay 207 causes the release of relay 208, thereby disconnecting the ringing source 215 to terminate the audible ringing signal over the calling subscriber's line; and ground potential is connected through the lower front contact of relay 206 and the inner lower front contact of relay 207, to terminal 225 to hold the trunk-finder TF. With relays 207 and 314 operated, a circuit is closed from battery through resistance 342, left outer back contact of relay 321, winding 340 of repeating coil RC2, inner right front contact of relay 314, right back contact of relay 313, left back contact of relay 312, conductors 336 and 271, uppermost front contact of relay 260, uppermost back contact of relay 259, brush 264 and terminal 223 of trunk-finder TF, uppermost front contact of relay 207, winding 226 of repeating coil RC1, uppermost front contact of relay 203, through the lower winding of relay 209 to battery. This circuit is without effect, but if the call were one intercepted at the bank of a toll selector or connector, the connection of battery through resistance 342 of trunk equipment OT to brush 264 of trunk-finder TF and over the tip conductor of an intercepting trunk IT1 or IT2, (Fig. 1) would be effective to operate a relay in the toll transmission selector and thereby cause the connection of a tone to the talking conductor to inform the intercepting operator that the intercepted call is a toll call. When relay 305 releases, a circuit is closed from battery through the inner back contact of relay 321, both windings of relay 324, winding 341 of repeating coil RC2, back contact of relay 305, left front contact of relay 314, left back contact of relay 313, right back contact of relay 312, conductors 337 and 272, lowermost front contact of relay 260, lowermost back contact of relay 259, brush 265 and terminal 224 of trunk-finder TF, winding 227 of repeating coil RC1, upper front contact of relay 206, innermost upper front contact of relay 207, and through the upper winding of relay 209 to ground. Relay 324 is operated by the current in this circuit, but relay 209 is marginal and does not operate. Relay 324 operates before relay 305 releases thus maintaining the short circuit around the right windings of relays 326 and 327.

When relay 722 of the cord OC operates, as hereinbefore described, a circuit is closed for operating relay 807 of the position equipment POS; this circuit includes the uppermost front contact of relay 731. The operation of relay 807 disconnects the ground at its back contact from conductor 805 leaving this conductor connected to ground through resistance 806; this resistance is sufficiently high to prevent the operation of a relay similar to relay 731 in any other cord circuit if another cord circuit key similar to key 715 is operated inadvertently. Relay 807 also closes a holding circuit for relay 801 and connects interrupter 811 to the winding of relay 808. As soon thereafter as the brush of interrupter 811 is connected to ground relay 808 operates; and when the connection to ground is again opened

by interrupter 811, relay 812 is operated and relay 811 is held operated by current through their windings in series, to ground at the front contact of relay 801. When interrupter 811 again connects ground to the lower front contact of relay 807, after an interval of two-tenths of a second, relay 803 operates. Relay 803 locks through its inner upper front contact to ground at the upper front contact of relay 807. While relays 808, 812 and 803 were being operated, ground potential is connected through the upper front contact of relay 807, resistance 802, lower back contact of relay 803, inner upper front contact of relay 731, inner lower back contact of relay 726, and through winding 706 of repeating coil RC4 to the ring conductor of plug 701 for the purpose of operating the ring cut-off relay on calls incoming directly over intercepting trunks from connectors in the same office with the intercepting operator's position. Relay 803 closes at its uppermost front contact a circuit through the upper winding of relay 813, and a circuit over conductor 814 through the inner lower front contact of relay 731, lowermost front contact of relay 722, and through the winding of relay 727, relays 813 and 727 both operate. Relay 803 also disconnects at its lower back contact the ground potential connected to the ring conductor of plug 701. Relay 727 locks under control of relay 722. The operation of relay 808 disconnects ground from conductor 809. The operation of relay 813 closes through the talking circuit from the operator's telephone set to the tip and ring conductors of the answering plug.

If upon answering the call the intercepting operator hears a tone indicating that the call has been intercepted at the bank of a toll selector or toll connector, operation of the tone-removal key 625 causes the operation of relay 733 of cord OC. Relay 733 locks through its lower front contact under control of relay 727. Relay 733 short-circuits, at its upper front contacts the lower winding of the answering supervisory relay 721 thereby disconnecting the tip and ring conductors of the answering cord from resistances 732 and 734 and bridging the upper winding of the answering supervisory relay 721 across these conductors to cause the operation of relay 612 of trunk equipment IT. Relay 612 closes a circuit for operating relay 609; and relay 609 interchanges the connections between the windings of relay 615 and the conductors of trunk T, thereby reversing the current through the left windings of relays 326 and 327 to cause the release of relay 327 and the operation of relay 326. Relay 327 is not polarized and reoperates immediately. Relay 326 closes a circuit for operating relay 325; and relay 325 closes a circuit for operating relay 321. The release of relay 327 opens the operating circuit of relay 307. Relay 321 closes a holding circuit for relay 310, thereby maintaining relays 311 and 309 operated. With relays 325 and 321 operated the circuit from battery through resistance 342 over conductor 336 and the circuit from battery through the windings of relay 324 over conductor 337 are both opened and the left winding of relay 324 is bridged across conductors 336 and 337 to cause the operation of a supervisory relay in the toll transmission selector (not shown) and thereby cause the disconnection of the toll indicating tone from the connection. If the flashing key 720 of cord OC is now operated, the bridge through the upper winding of relay 721 is opened and relay 612 releases each time the flashing key is operated. Each release of



relay 612 causes a corresponding release of relay 609 and the reversal of current over trunk T. Relays 326 and 327 of trunk equipment OT are thereby alternately released and operated to cause the alternate opening and closing of the bridge across conductors 336 and 337 and a resulting flashing of a supervisory signal at the toll operator's position.

If a call originated by a local operator is intercepted at the bank of a local selector or connector, it may be found necessary to signal this operator. In such a case repeated operation of the flashing key 720 intermittently bridges the upper winding of the answering supervisory relay 721 across the conductors of the answering cord to cause the alternate operation and release of relays 612 and 609 of trunk equipment IT, the alternate operation and release of relay 326, the alternate release and reoperation of relay 327 and the alternate operation and release of relays 325 and 321 as hereinbefore described. The intermittent bridging of the left winding of relay 324 across conductors 336 and 337 is effective to cause the alternate operation and release of relay 209 of trunk IT3. Relay 209 causes the intermittent operation of relay 205 thereby interchanging the connections between the incoming line conductors of trunk IT3 with respect to battery and ground to cause the flashing of the local operator's supervisory lamp (not shown).

If the call has been intercepted at a local selector or at a local connector but not from a plugging-up line, and if the information received from the calling subscriber indicates that it is desirable to complete the connection, the operator inserts the calling plug 702 into the dialing jack 627 associated with the trunk over which the intercepted call was received. The windings of relays 711 and 712 of the cord OC are thereby connected in series with the winding of relay 623 of the trunk equipment IT; relays 712 and 623 operate but relay 711 is marginal and does not operate. Relay 712 closes a circuit for operating relay 716. Relay 623 closes a circuit through the windings of relays 622 and 621 in series. Relay 621 operates but relay 622 is marginal and does not operate until the plug is fully seated in jack 627 unless the tip and ring springs of jack 627 are short-circuited while the plug is being inserted; in which case ground at the inner lower back contact of relay 624 is connected to the winding of relay 622 causing the release of relay 621 and the premature operation of relay 622. The release of relay 621 is then effective to prevent the premature operation of relay 620. With relay 716 operated, the operator's busy-test conductor 725 is disconnected from the tip conductor of plug 702; and with plug 702 fully seated, a circuit is closed from battery through the winding of relay 622 of trunk equipment IT, inner upper front contact of relay 623, lowermost back contact of relay 624, inner upper back contact of relay 624, tip conductors of dialing jack 627 and plug 702, upper back contact of relay 717, uppermost front contact of relay 716, winding 707 of repeating coil RC4, upper back contact of relay 711, upper front contact of relay 712, winding of relay 714, lower back contact of relay 711, winding 706 of repeating coil RC4, lowermost front contact of relay 716, lower back contact of relay 717, ring conductors of plug 702 and jack 627, to ground at the inner lower back contact of relay 624. The current in this circuit is effective to operate relay 622 but is ineffective to operate polarized relay 714. With relay 621 operated, the operation of

relay 622 causes the operation of relay 620; and relay 620 closes a circuit for operating relay 614. Relay 614 disconnects the windings of relay 615 from the conductors of trunk T, closes a holding circuit for relay 611, and closes an operating circuit for relay 601. Relay 601 bridges the high resistance winding of relay 613 across the conductors of trunk T. The disconnection of the windings of relay 615 from the trunk and the connection of winding of relay 613 across the conductors 332 and 333 causes the release of relay 327 of trunk equipment OT. The release of relay 327 causes the release of relay 307. The release of relay 307 closes a circuit for operating relay 316; this circuit is traced from ground through the back contact of relay 327, back contact of relay 307, outer left front contact of relay 311, right front contact of relay 324, and through the winding of relay 316 to battery. Relay 316 locks under control of relays 324 and 311; the locking circuit is traced from battery through the winding of relay 316, right front contact of relay 324, inner right front contact of relay 316, to ground at the outer right front contact of relay 311. The operation of relay 316 disconnects the tip and ring conductors 332 and 333 of trunk T from the windings of repeating coil RC2 and connects these conductors through the outer back contacts of relay 329, over conductors 345 and 346, through the armatures 426 and 417 and back contacts of relay 408 of the completing selector CS, back contacts of relay 407, resistances 405 and 406, back contacts of relay 404, through the windings of line relay 401 to ground and battery, respectively. The line relay 401 of selector CS and bridge relay 613 of trunk equipment IT are, therefore, operated in series. Relay 613 closes a circuit for operating relay 624; this circuit is traced from ground at the front contact of relay 613, inner upper front contact of relay 601, uppermost front contact of relay 623, and through the uppermost back contact and winding of relay 624 to battery. Relay 624 locks through its uppermost front contact to ground at the lower front contact of relay 623. The operation of relay 624 causes the release of relays 621 and 622 and extends the incoming conductors of trunk T through the tip and ring conductors of dialing jack 627 to the cord OC, the winding of relay 617 of trunk equipment IT and winding of relay 714 of cord OC, being thereby connected in parallel with the winding of relay 613 and in series with the windings of line relay 401 of completing selector CS. The polarized relay 714 remains normal but relay 617 operates, closing a circuit for operating relay 618; and relay 618 closes a circuit for operating relay 619. Relay 619 opens the circuit through the winding of relay 613 and closes a holding circuit for relay 620. The purpose of relays 617, 618 and 619 is to hold relays 620, 614, 611 and 721 operated during dialing and thereby prevent the lighting of the answering supervisory lamp 703. During the transmission of dial impulses, as hereinafter described, relay 617 is alternately released and reoperated but relay 618 is slow in releasing and remains operated during dialing.

The operation of line relay 401 of selector CS as hereinbefore described causes the operation of relay 402. Relay 402 connects ground over conductor 416 through the inner right back contact of relay 329 of trunk equipment OT to hold relay 311, and connects ground through the inner upper back contact of relay 411 to the alarm equipment 410. When the intercepting operator moves the dial 619 off-normal to dial the first

digit of the number of the station with which the calling subscriber desires connection, relay 815 operates in an obvious circuit. Relay 815 closes a circuit for operating relay 717 of cord OC; this circuit is traced from battery through the inner lower front contact of relay 716, lower winding of relay 717, middle lower front contact of key 715, conductor 727, inner lower front contact of relay 815 to ground at the back contact of relay 816. Relay 717 locks in a circuit from battery through the lower front contact of relay 712, upper winding and inner upper front contact of relay 717, conductor 728, back contacts of relays 817 and 818, to ground through the winding of relay 816. Relay 816, operated by the current in this circuit, disconnects ground from conductor 727 so that no other relay similar to relay 717 in any other cord will be operated in case the key corresponding to key 715 should be operated inadvertently. Relay 717, operated, bridges the interrupter contacts of dial 819 in series with the uppermost front contact of relay 815 across the tip and ring conductors of plug 702, in place of the winding of relay 714. During its return movement, the circuit through the winding of relay 817 of trunk equipment IT, over the conductors of trunk T and through the windings of line relay 401 of selector CS are alternately opened and closed, by the interrupter contacts of dial 819, as many times as there are units in the digit dialed. Relay 401 is released by each opening of the circuit and reoperated by each succeeding closing of the circuit. The first release of relay 401 closes a circuit from ground through its upper back contact, outer left front contact of relay 402, lowermost back contact of relay 411, winding of relay 403 and through the winding of the vertical-stepping magnet 413 to battery. Relay 403 and magnet 413 both operate. The operation of magnet 413 steps the shaft and brushes of selector CS up to the first level of the terminal bank. When relay 401 reoperates magnet 413 releases. Each succeeding release and reoperation of relay 401 causes a corresponding operation and release of magnet 413, thereby stepping the brushes of selector CS to the level corresponding to the digit dialed. The off-normal contacts 444 are actuated as soon as the shaft leaves normal position. The circuit through the winding of relay 402 is opened each time relay 401 releases, but relay 402 is slow in releasing and remains operated during receipt of dial impulses. Relay 403 is also slow in releasing and remains operated until all of the impulses in the train have been received. Relay 403 closes a circuit, for operating relay 419, from ground through the outer right front contact of relay 402, conductor 420, inner front contact of relay 402, to battery through the winding of relay 418. Relay 418 closes a locking circuit through its winding and inner left front contact, uppermost back contact of relay 411, over conductor 420 to ground at the outer right front contact of relay 402. The operation of relay 403 and actuation of the off-normal springs 444 closes a circuit for operating relay 419; this circuit is traced from battery through the back contact of release magnet 409, uppermost front contact of off-normal springs 444, winding of relay 419, outer front contact of relay 403, over conductor 425, to ground at the outer right front contact of relay 402. Relay 419 closes a locking circuit from ground at its left front contact, through the back contact of rotary-step-

ping magnet 421, winding of relay 419, uppermost front contact of vertical off-normal springs 444, to battery through the back contact of release magnet 409. The reoperation of relay 401, after receiving the last impulse of the first digit from the dial, causes the release of relay 403; and the release of relay 403 closes a circuit from battery through the winding of rotary-stepping magnet 421, right front contact of relay 419, back contact of relay 403, over conductor 420 to ground at relay 402. The operation of magnet 421 rotates the shaft one step so that the brushes 414, 415, 416 and 417 engage the first set of terminals in the selected level. In operating magnet 421 opens the circuit through the winding of relay 419. Relay 419 releases in turn opening the circuit through the winding of magnet 421. If the trunk connected to the first set of terminals is idle, the brushes are not further advanced; but if this trunk is busy, the test brush 416 encounters ground potential thereby causing the reoperation of relay 419 and the further advance of the brushes. Assuming that the trunk connected to the first set of terminals is busy, the circuit for reoperating relay 419 is traced from ground through brush 416, inner lower back contact of relay 411, back contact of magnet 421, winding of relay 419, uppermost front contact of off-normal springs 444, to battery through the back contact of release magnet 409. Relay 419 again locks through its left front contact and closes the operating circuit for magnet 421; and the brushes are advanced another step into contact with the second set of terminals in the selected level. Relay 419 is released when brush 416 breaks contact with the test terminal of the first trunk; the release of relay 419 causes the release of magnet 421. Relay 419 and magnet 421 continue to repeat this cycle of operation to advance the brushes until an idle set of terminals is encountered. Such a set of terminals is represented by terminals 422, 423, 424 and 425. Brush 416 encounters no ground potential on terminal 424 and relay 411 is thereupon operated by the current in a circuit from ground at the outer right front contact of relay 402, conductor 420, winding of relay 411, back contact of magnet 421, winding of relay 419, uppermost front contact of off-normal springs 444, to battery through the back contact of release magnet 409. Relay 419, being marginal, does not operate in this circuit. Relay 411 disconnects ground from the alarm equipment 410 and connects ground potential from conductor 420 through its inner lower front contact and through test brush 416 to terminal 424 to guard against seizure of the trunk connected to terminals 422, 423, 424 and 425 by any other hunting selector having access thereto. Relay 411 completes a bridge across the tip and ring brushes 414 and 415 of selector CS to repeat succeeding trains of dial impulses received by relay 401 and thereby selectively operate the intermediate selector IS connected to terminals 422, 423, 424 and 425 and the connector switch seized by switch IS. This bridge is traced from brush 414, through the uppermost front contact of relay 411, middle lower back contact of relay 403, right front contact of relay 418, resistance 434, lower front contact of relay 401, lowermost front contact of relay 411, to brush 415. Upon operation of relay 411, the circuit for holding relay 418 is traced from the winding and left front contact of relay 418, through the inner upper front contact of relay 411, through brush 417 and terminal 425 of selec-

tor CS, over control conductor 534 and through a back contact of cut-through relay (not shown) of selector IS, back over sleeve conductor 533, terminal 424 and test brush 416, inner lower front contact of relay 411, over conductor 420 to ground at relay 402.

Should all the trunks in the level selected by switch CS be busy, the rotary-stepping magnet 421 will advance the brushes to the eleventh rotary position in which position the brushes will be beyond the bank and not in engagement with any of its terminals. In this condition relay 411 operates as hereinbefore described but there is no circuit for holding relay 410 operated. The release of relay 413 closes a circuit for operating relay 407 from ground through the upper front contact of relay 401, outer left back contact of relay 413, winding of relay 407, lower front contact of the off-normal springs 444, to battery at the back contact of release magnet 409. Relay 407 opens short circuits across the windings 437 and 438 of the repeating coil and bridges condenser 420 across the inner ends of these windings. Relay 407 also connects ground through its upper front contact over conductor 430 to operate relay 320 of the trunk equipment OT. In the eleventh rotary-step position the springs 431 are actuated and connect the interrupter 432 over conductor 443, through the left back contact of relay 433, outer right back contact of relay 413, and lowermost back contact of relay 408 to the winding of relay 404 and through condenser 440 and windings 441 and 442 of the repeating coil to ground. The intermittent connection of ground to conductor 443 by interrupter 432 causes the intermittent operation of relay 404. The alternate operation and release of relay 404 interchanges the connection between the windings of relay 401 and the incoming line conductors 345 and 346 to intermittently reverse the current over trunk T as a signal to the intercepting operator that all the trunks are busy. A busy tone is also transmitted through the front contacts of relay 320 and condenser 347 and 348 of trunk equipment OT to the calling subscriber's station.

Assuming the connection to have been extended, by the operation of relay 411, through brushes 414, 415, 416 and 417 and terminals 422, 423, 424 and 425, the alternate release and reoperation of line relay 401 in response to the impulses created by the dialing of the second digit of the number of the called station is effective to repeat these impulses to the line relay (not shown) of the intermediate selector IS. The intermediate selector is thereby selectively operated to select the level corresponding to the second digit of the number dialed and is then automatically operated to select a set of terminals in that level and to extend the connection through brushes 541, 542, 543 and 544 and the selected set of terminals, to an idle connector switch C. The line relay 551 of connector C is now operated by the current in a circuit from battery through the upper winding of relay 551, lowermost back contact of relay 559, terminal and brush 542 of switch IS, conductor 532, terminal 423 and brush 416 of switch CS, lowermost front contact of relay 411, lower front contact of relay 401, resistance 434, inner right front contact of relay 412, middle lower back contact of relay 408, uppermost front contact of relay 411, brush 414 and terminal 422 of switch CS, conductor 531, brush 541 and terminal of switch IS, uppermost back contact of relay 559 to ground through

the lower winding of relay 551. Relay 401 is under control of the intercepting operator's dial as previously described. The operation of relay 551 closes a circuit from ground through the inner upper back contact of relay 559, front contact of relay 551, and through the upper winding of relay 552 to battery. Relay 552 operates and closes a locking circuit from battery through its upper winding and inner upper front contact, inner upper back contact of relay 557, inner lower back contact of relay 559, conductor 533, terminal and brush 543 of switch IS, conductor 533, terminal 424 and brush 416 of switch CS, through the inner lower front contact of relay 411, over conductor 420, to the busy and holding ground potential at the outer right front contact of relay 402. With the connection extended through the intermediate selector IS to the connector C, the holding circuit for relay 418 of selector CS is traced through the inner upper front contact of relay 411, brush 417 and terminal 425 of selector CS, conductor 534, brush 544 and terminal of selector IS, control conductor 564, inner lower back contact of relay 559 of connector C, sleeve conductor 563, terminal and brush 543 of selector IS, conductor 533, terminal 424 and brush 416 of selector CS, inner lower front contact of relay 411, over conductor 420 to ground at relay 402.

When the intercepting operator dials the next to the last digit of the number of the station being called, relay 401 of selector CS responds as hereinbefore described, the alternate opening and closing of its lower front contact being effective to repeat the dial impulses to line relay 551 of connector C. The release of relay 551, upon receipt of the first impulse, closes a circuit from ground through the inner upper back contact of relay 559, back contact of relay 551, inner lower front contact of relay 552, normally closed contacts of the vertical off-normal springs 567, winding of relay 553, and through the winding of the vertical-stepping magnet 554 to battery. Magnet 554 and relay 553 both operate, the operation of magnet 554 being effective to step the shaft and brushes of switch C up to the first level of the terminal bank. As soon as the switch moves out of its normal position the circuit for energizing the windings of magnet 554 and relay 553 is traced through the front contact of relay 553 and the upper front contact of the vertical off-normal springs 567 instead of the path previously described. The reoperation of relay 551 causes the release of magnet 554. Each succeeding release and reoperation of relay 551 causes a corresponding operation and release of magnet 554, thereby stepping the brushes of switch C up to the level corresponding to the digit dialed. During the response of relay 551 to the repeated dial impulses, relay 552 is held over conductor 563 to ground on conductor 420 of switch CS; and relay 553 is slow in releasing and remains operated until all of the impulses created by the dialing of this digit have been received.

When the last digit of the called number is dialed, the dial impulses are again repeated by relay 401 to relay 551. The first release of relay 551 closes a circuit from ground through the inner upper back contact of relay 559, back contact of relay 551, inner lower front contact of relay 552, upper front contact of the vertical off-normal springs 567, back contact of relay 553, winding of relay 555, and through the winding of the rotary-stepping magnet 556 to battery. Relay 555



and magnet 556 both operate; and when relay 551 releases, magnet 556 releases. Each release and reoperation of relay 551 causes a corresponding operation and release of magnet 556; but relay 555 is slow in releasing and remains operated until all of the dial impulses have been received. Each operation of magnet 556 rotates the shaft and brushes of switch C one step to engage successively the sets of terminals in the selected level. When the last step has been taken, the brushes 571, 572 and 573 are in engagement with the set of terminals to which the called subscriber's line is connected. With relay 555 operated, the winding of test relay 557 is connected through the front contact of relay 555 to the test brush 573 of switch C. Relay 557 is somewhat slow in operating and does not operate if brush 573 engages a grounded test terminal during the advance of the brushes; but as soon as the brushes come to rest on the selected set of terminals, relay 557 operates if the called line is busy as indicated by the presence of a ground potential on the engaged test terminal. If relay 557 operates, a locking circuit for this relay is closed as soon as relay 555 releases; this circuit is traced from battery through the winding of relay 557, inner back contact of relay 555, inner lower front contact of relay 557, middle upper back contact of relay 559, middle upper front contact of relay 552, upper winding of relay 559, to the sleeve conductor 563, and thence to ground at relay 402 of selector CS as hereinbefore described. Relay 557 is held operated by the current in this circuit and relay 559 is operated sufficiently to close its inner lower front contact and thereby energize its lower winding in a circuit from battery through this winding and contact over conductor 563 to ground at relay 402 of switch CS. Relay 559 disconnects the sleeve conductor 563 from control conductor 563 thereby causing the release of relay 418 of selector CS. The release of relay 418 causes the operation of relay 407 and establishes a connection from interrupter 558 of connector C, through the lowermost front contact of relays 557, 552 and 559, conductor 562, terminal and brush 542 of selector IS, conductor 532, terminal 423 and brush 415 of selector CS, lowermost front contact of relay 411, left back contact of relay 433, outer right back contact of relay 418, and through the lowermost back contact of relay 408 to the winding of relay 404. Relay 404 is thus intermittently operated under control of interrupter 558 to reverse the current over trunk T as a busy signal to the intercepting operator. After relay 557 operates, the locking circuit for relay 552 includes the upper front contact of relay 557 instead of the inner upper back contact of relay 557 and the inner lower back contact of relay 559.

Assuming that the called line is the line 599 connecting station B to the terminals adjacent brushes 571, 572 and 573, and that this line is idle when selected, the release of relay 555 closes a circuit from battery through the winding of the cut-off relay 598 of line 599, through brush 573, outer back contact of relay 534, inner lower back contact of relay 557, middle upper back contact of relay 559, middle upper front contact of relay 552, upper winding of relay 559 to sleeve conductor 563 and thence to ground at relay 402 of selector CS as hereinbefore described. Relay 559 operates sufficiently to close the circuit for energizing its lower winding. Complete operation of relay 559 causes the release of relays 551 and 552. The operation of relay 559 also discon-

nects control conductor 564 from sleeve conductor 563 thereby causing the release of relay 418 and the operation of relay 407 of selector CS as hereinbefore described. The release of relay 418 connects the windings of relays 404 and 428, through brushes 414 and 415 of switch CS over conductors 531 and 532 and through brushes 541 and 542 of switch IS, to the tip and ring conductors 561 and 562 of connector C, respectively. The release of relay 418 also connects the grounded conductor 420 through the inner left back contact of this relay and the inner upper front contact of relay 411, to the control brush 417 and thence over conductor 534 of selector IS and through brush 544 to control conductor 564 of connector C. Since relay 418 is slow in releasing, relay 552 releases before ground is thus reconnected to conductor 564. The release of relay 552 applies ringing current to the called line; the ringing circuit is traced from the ringing current supply 560, through the middle lower front contact of relay 559, lower winding and lowermost back contact of relay 552, lowermost back contact of relay 557, brush 572 over line 599 and through the ringer at station B, back through brush 571, uppermost back contact of relay 557, uppermost back contact of relay 552, middle upper front contact of relay 559 to ground. Ringing tone is transmitted through condenser 566, lowermost front contact of relay 559, terminal and brush 542 of selector IS, conductor 532, terminal 423 and brush 415 of selector CS, lowermost front contact of relay 411, left back contact of relay 433, outer right back contact of relay 418, lowermost back contact of relay 408, through condenser 440 and windings 441 and 442 of the repeating coil of selector CS, to ground. The induced current in windings 437 and 438 of the repeating coil gives an audible ringing-tone signal to the intercepting operator. With relay 407 of selector CS operated as hereinbefore described, ground is connected to conductor 430 to cause the operation of relay 320 of trunk equipment OT; audible ringing-tone is thereby transmitted through condensers 347 and 348 to the calling subscriber.

When the called subscriber answers, relay 552 is operated by the current through its lower winding and again locked through its upper winding and inner upper front contact over the control conductor 564, through the terminal and brush 544 of selector IS, conductor 534, terminal 425 and brush 417 of selector CS, middle upper front contact of relay 411, inner left back contact of relay 418, over conductor 420 to ground at the outer right front contact of relay 402. With relay 552 operated, a circuit is closed from battery through the winding of relay 404, lowermost back contact of relay 408, outer right back contact of relay 418, left back contact of relay 433, lowermost front contact of relay 411, brush 415 and terminal 423 of switch CS, conductor 532, brush 542 and terminal of switch IS, conductor 562, lowermost front contacts of relays 559 and 552, lowermost back contact of relay 557, brush 572 of switch C, over line 599 and through the subscriber's station B, back through brush 571, uppermost back contact of relay 557, uppermost front contacts of relays 552 and 559, conductor 561, terminal and brush 541 of switch IS, conductor 531, terminal 422 and brush 414 of switch CS, uppermost front contact of relay 411, middle lower back contact of relay 408, inner right back contact of relay 418 and through the winding of relay 428 to ground. Relays 428 and 404 operate in this circuit. Relay 404, 75

operated, interchanges the connections between the windings of relay 401 and conductors 345 and 346 of trunk equipment OT thereby reversing the current over trunk T to operate the polarized relay 817 of the operator's position circuit.

The reversal of current over trunk T, by the operation of relay 404, due to an all-trunks-busy condition having been encountered by selector CS or selector IS, due to a line busy condition having been encountered by connector C, or due to the answer of the called subscriber, is in any case effective to cause the operation of relay 817 at the intercepting operator's position unless the dial release key has been operated prior to the reversal of current. The operation of the dial release key 820 before relay 817 is operated by the reversal of current over trunk T, closes a circuit for operating relay 818. If the dial has not reached normal position when relay 818 operates, relay 818 locks to ground at the front contact of relay 815 until the dial reaches normal position, at which time relays 815 and 818 release. The operation of relay 817 and the operation of relay 818 are each effective to cause the release of relays 816 and 717. The release of relay 717 disconnects the tip and ring conductors of plug 702 from the dial and connects these conductors to the winding of relay 714 so that the reversal of current over trunk T is now effective to cause the operation of polarized relay 714. The operation of relay 714 causes the operation of relay 725. Relay 725 shunts lamp 704, the deenergization of this lamp indicating to the operator that the called subscriber has answered or that a busy condition has been encountered. Relay 725 closes a circuit from battery through the winding of pick-up relay 723, inner lower front contact of relay 722, lower front contact of relay 725, through the back contact of relay 723 to the pick-up conductor 737 of interrupter 740. As soon thereafter as ground is connected by the interrupter 740 to conductor 737 the pick-up relay 723 operates thereby connecting ground from the lowermost back contact of relay 726 through the inner upper front contact of relay 723 over conductor 738 to the interrupter 740. After an interval of from 2 to 5 seconds, the interrupter connects ground over conductor 739 through the outer upper front contact of relay 723 and the uppermost back contact of relay 726, to the winding of relay 726. Relay 726 then operates and locks through its upper front contact to ground at the lowermost front contact of relay 727. Relay 726 disconnects the battery through resistances 732 and 734 from the tip and ring conductors of plug 701 and bridges the low resistance upon winding of supervisory relay 721 across these conductors. The bridge is effective, on a call intercepted at the bank of a switch in the same office as that in which the intercepting operator's position is located, to operate the supervisory relay of the connector switch and thereby establish the charge condition for the calling subscriber. However, since the call here being described is one intercepted at the bank of a switch in a distant office, the bridging of the low resistance winding of relay 721 across the tip and ring conductors of plug 701 is without effect.

The aforementioned operation of relays 428 and 404 closes a circuit for operating relay 433; this circuit is traced from battery through the winding and outer right back contact of relay 433, front contact of relay 428, to ground at the inner left front contact of relay 404. Relay 433 locks through its inner right front contact to ground at the outer right front contact of relay 402 and

closes a circuit for operating relay 408; this circuit is traced from ground at the inner left front contact of relay 404, front contact of relay 428, outer right front contact of relay 433 and through the upper winding of relay 408 to battery. Relay 408 locks through its lower winding and inner lower front contact over conductor 435 to ground at the front contact of relay 309. Relay 408 disconnects the windings of relays 404 and 428 from the called line and extends the connection from the called line through the front contacts of springs 426 and 417, to conductors 345 and 346 of trunk equipment OT. Relays 404 and 428 then release. Relay 408 also disconnects the windings of relay 401 from conductors 345 and 346 but relay 401 is held operated by the closing of a circuit from battery through the contact of release magnet 409, lower winding of relay 401, left back contact of relay 404, resistance 406, winding 437 of the repeating coil, middle upper front contact of 438, resistance 426, winding 438 of the repeating coil, resistance 405, right back contact of relay 404, to ground through the upper winding of relay 401. Relay 408 also closes at its uppermost front contact a circuit for operating relay 329 of trunk equipment OT; and relay 329 closes a circuit for operating relay 312. With relays 312 and 329 operated, conductors 336 and 337 of trunk equipment OT are connected to conductors 345 and 346 thereby completing a circuit from battery through the lower winding of relay 209 of the intercepting trunk IT3, uppermost front contact of relay 203, winding 226 of repeating coil RC1, uppermost front contact of relay 207, terminal 223 and brush 264 of trunk-finder TF, uppermost back contact of relay 259, uppermost front contact of relay 260, conductors 271 and 336, left front contact of relay 312 of trunk equipment OT, outer left front contact of relay 329 over conductor 345, inner upper front contact of relay 406, uppermost front contact of relay 411, brush 434 and terminal 422 of switch CS, conductor 531, brush 541 and terminal of switch IS, conductor 561, uppermost front contacts of relays 559 and 552, uppermost back contact of relay 557, brush 571 of connector C over line 599 and through the subscriber's instrument at station B, back through brush 572 of switch C, lowermost back contact of relay 557, lowermost front contacts of relays 552 and 559, conductor 562, terminal and brush 542 of switch IS, conductor 532, terminal 423 and brush 415 of selector CS, lowermost front contact of relay 411, lower front contact of relay 401, lowermost front contact of relay 408, over conductor 346, right front contact of relay 329, right front contact of relay 312, over conductor 337, conductor 272, lowermost front contact of relay 260, lowermost back contact of relay 259, brush 265 and terminal 224 of trunk-finder TF, through winding 227 of repeating coil RC1, upper front contact of relay 236, inner upper front contact of relay 207, and through the upper winding of relay 209 to ground. The marginal relay 209 is operated in this circuit thereby closing a circuit for operating relay 205 of the trunk IT3. Relay 205 interchanges the connections between the windings of relays 201 and 294 and the windings 212 and 213 of repeating coil RC1 thereby reversing the current over the calling line to indicate that the called subscriber has answered.

The aforementioned operation of relay 329 of trunk equipment OT also opens the holding circuit of relay 311; and the release of relay 311 causes the release of relay 309. With relay 309 released the connection is now held over sleeve

conductor 338 solely under control of the originating subscriber. That is, the ground at the lower front contact of relay 206 is extended through the lower front contact of relay 207, terminal 225 and brush 266 of trunk-finder TF to hold relay 260 of trunk-finder TF operated, thence through the inner lower front contact of relay 260, inner lower back contact of relay 259, lowermost front contact of relay 262, over conductors 273 and 338, through the front contact of relay 317 to hold relay 317 operated, thence over conductor 435 to hold relay 408 operated. The aforementioned operation of relay 312 also causes the release of relays 324 and 316. A talking connection is thus established between stations A and B, and all bridging apparatus which was used in intercepting and answering the call is disconnected at the contacts of relays 329 and 312 and restored to normal as hereinafter described. Talking battery for the calling subscriber is furnished through the windings of relays 201 and 204; and talking battery for the called subscriber is furnished through the windings of relay 209.

When the windings of relay 401 are disconnected from conductors 345 and 346, by the operation of relay 408 as hereinbefore described, relay 617 of the trunk equipment IT and relay 714 of cord OC release. The release of relay 617 causes the successive release of relays 618, 619, 620, 614, 601 and 611. The release of relay 601 reconnects the conductors 331 and 332 of trunk T to the windings 602 and 606 of the repeating coil RC3. The release of relay 611 disconnects the upper winding of relay 612 from the tip conductor of jack 625 thereby causing the release of relay 721 of cord OC. The release of relay 721 causes the operation of relay 728 in a circuit from battery through the winding of relay 728, back contact of relay 721, upper normally closed contact of key 720, lowermost back contact of relay 733, to ground at the lowermost front contact of relay 727. The operation of relay 728 closes a circuit for lighting lamp 703 as a signal to the operator to remove the plugs 701 and 702 from the jacks 625 and 627. With key 715 normal the cord and the position equipment is fully restored to normal. The release of sleeve relays 603 and 623 of trunk equipment IT when the plugs 701 and 702 are removed, completes the restoration of trunk equipment IT to normal.

When the connection is released by the subscriber at station A, relay 201 releases thereby causing the successive release of relays 202, 203, 206, 207 and 209. The release of relay 203 disconnects ground from the sleeve conductor 214 allowing the selector LS and line-finder LF to return to normal in the usual manner. The release of relay 206 disconnects the holding ground from the sleeve terminal 225 to cause the release of relay 260 of trunk-finder TF, the release of relay 317 of trunk equipment OT, and the release of relay 408 of completing selector CS. The release of relay 260 closes a circuit from battery through the release magnet 253, upper front contact of off-normal springs 276, inner upper back contact of relay 261, upper back contact of relay 260, back contact of relay 254, over conductor 274 to ground at the lower front contact of off-normal springs 276. Release magnet 253 operates in this circuit and returns the shaft and brushes to their normal position. When the shaft reaches normal the springs 276 open the circuits of the release magnet 258 and relay 262.

The release of relay 408 of selector CS causes the successive release of relays 329 and 312. The

outgoing trunk equipment OT is now normal. The release of relay 408 also causes the release of relays 401 and 402. The release of relay 402 disconnects holding ground potential from conductor 429 causing the release of relay 411. The release of relay 402 also closes a circuit from ground through the upper back contact of relay 401, back contact of relay 402, winding of release magnet 409, and through the middle front contact of off-normal springs 444 to battery. Release magnet 409 operates in this circuit and returns the selector CS to normal, in which position the circuit through the winding of release magnet 409 is opened at the off-normal springs.

Disconnecting ground from the conductor 420 also causes the return of the intermediate selector IS to normal and causes the release of relays 552 and 559 of connector C. A circuit is now closed from battery through the winding of release magnet 565, lower front contact of off-normal springs 567, inner lower back contact of relay 552, back contact of relay 551, inner upper back contact of relay 559 to ground. Release magnet 565 operates in this circuit and returns the shaft and brushes of connector C to normal position. Magnet 565 releases when the shaft reaches normal. The release of relay 559 also causes the release of the cut-off relay 593 of the called line 599. All of the equipment units involved in completing the connection from the intercepting trunk IT3 to the intercepting operator and thence to a called subscriber's station B have now been restored to normal.

Referring now to the intercepting trunk IT5 of Fig. 2, reference may be had to the aforementioned copending application of E. D. Butz Serial No. 648,052 for a description of the plugging-up line PL and the extension of an incoming call to the intercepting trunk. Upon seizure of line PL relay 234 or relay 232 of trunk IT5 is operated by ringing current from the connector LC. If the called line is a party line the ringing current source in the connector may be connected either to conductor 229 or conductor 230 of the plugging-up line PL depending upon which of the stations is the called station. If the ringing current circuit includes conductor 229, it is traced from this conductor through the uppermost back contact of relay 235, the inner upper back contact of relay 236, condenser 233 and the upper winding of relay 234; if the ringing circuit includes conductor 230, it is traced from this conductor through the uppermost back contact of relay 236, condenser 231, and upper winding of relay 232 to ground. If relay 234 is operated by the ringing current it closes a circuit for directly operating relay 237. If relay 232 is operated, it closes a circuit for operating relay 235; and relay 235 then closes a circuit for operating relay 237. Relay 235 also interchanges the connections between the conductors 229 and 230 of plugging-up line PL and the outgoing conductors 239 and 240 of trunk ITS; so that the ringing current circuit from connector LC will in either case be further extended over the tip conductor 239 and not over the ring conductor 240. The operation of relay 237 connects the winding of cut-off relay 236 over the sleeve conductor 241 to test terminal 228 in the bank of trunk-finder TF. Relay 237 also connects the upper winding of relay 238 in parallel with the upper winding of relay 232, if relay 232 has responded to the ringing current, or in parallel with the upper winding of relay 234, if relay 234 has responded to ringing current. The upper winding of relay 238 is not energized suffi-

ciently to cause its operation. Relay 238 locks in a circuit from battery through its lower winding and lowermost front contact, to ground at the lowermost front contact of relay 237. Whichever of relays 232 and 234 responded to ringing current is held operated by the energization of its lower winding in parallel with the lower winding of relay 233. Relay 238 also connects ground from the inner lower back contact of relay 236, to the group conductor 222, it being assumed that terminals 226, 227 and 228 are in the same group as are terminals 223, 224 and 225; the group relay 251 is thus operated to cause the operation of trunk-finder TF or some other idle trunk-finder in the same group to hunt for the terminals 226, 227 and 228. When the trunk-finder finds these terminals the cut-off relay 236 is energized in series with the lower winding of relays 260 and 255; the operation of relay 260 of the trunk-finder extends the connection from conductors 240 and 241 of trunk IT5, to conductors 336 and 337 of the trunk equipment OT. The operation of cut-off relay 236 disconnects ground from the conductor 222 and causes the release of relay 237. The release of relay 237 causes the release of relay 233 and the release of relay 232 or relay 234. Relay 235, if operated, is locked through its inner upper front contact to ground at the lower front contact of relay 235. After relay 262 of trunk-finder TF operates, as hereinbefore described, the cut-off relay 235 is held operated by the circuit from battery through its winding and inner upper front contact, sleeve conductor 241, terminal 228 and brush 255 of trunk-finder TF, inner lower front contact of relay 260, inner lower back contact of relay 255, lowermost front contact of relay 262, over conductor 273 to sleeve conductor 339 of trunk equipment OT, thence through the front contact of relay 238 and winding of relay 322 to ground or through the front contact of relay 317 over conductor 339 to ground as hereinafter described. The impedance of the windings of relays 232, 234 and 238 is sufficient to prevent the operation of the tripping relay, (not shown) in the connector LC so that relay 302 of trunk equipment OT operates due to the energization of its right winding by the ringing current from connector LC or due to the energization of its left winding by direct current during the silent part of the ringing cycle. Relay 302 closes a circuit for operating relay 318; and relay 318 closes circuits for operating relays 313 and 315. Relays 313 and 318 close a circuit for operating relay 303; this circuit is traced from battery through the winding of relay 303, inner left front contact of relay 313, inner right back contact of relay 314, conductor 339, right front contact of relay 318 to ground at the front contact of relay 302. The ground connection at the front contact of relay 302 extended through the right front contact of relay 318 to conductor 339, is also effective to operate relay 317 so that the cut-off relay 236 of trunk IT5 and relay 260 of trunk-finder TF are now held over conductors 273 and 339 through the front contact of relay 317, to the ground potential connected to conductor 339. The operation of relay 303 is followed by the operation of relays 304, 305, 306, 307, 308, 309, 310 and 311 as hereinbefore described. The operation of relay 313 interchanges the connections between conductors 336 and 337 and the windings 340 and 341 of repeating coil RC2. The operation of relay 315 interchanges the connections between conductors 332 and 333 of trunk T and the outer armature springs of relay 308, so that the operation of relay 308 causes the current through the windings of relay 322 over trunk T and through the windings of relays 604 and 605 of the incoming trunk equipment IT to be in the direction in which it is effective to operate polarized relay 605 in addition to operating relay 604. With both of relays 604 and 605 operated a circuit is closed for operating relay 616; and relay 616 closes a circuit for lighting lamp 632 thereby indicating to the intercepting operator that the incoming call has been intercepted at a plugging-up line. Relay 616 also closes a circuit for operating relay 610. Relay 610 also closes a locking circuit for operating relay 610. Relay 610 interchanges the connections between the conductors of trunk T and the windings of relay 615. When the call is answered by insertion of plug 701 in jack 626, associated with lamp 632, relay 603 operates in series with relay 722 of the cord OC. The operation of relay 603 disconnects the windings of relays 604 and 605 from the conductors of trunk T and extends these conductors to the windings of relay 615. Relays 604 and 605 release thereby releasing relay 616 to deenergize lamp 632. After relay 616 releases relay 610 is held operated through its own inner upper front contact under control of relay 603. With relays 610 and 603 both operated, the connections between the conductors of trunk T and the windings of relay 615 are interchanged from that existing on the call intercepted by trunk IT3; since the connections between the conductors of trunk T and the windings of relay 322 were also interchanged, by the operation of relay 315, from that existing on the call intercepted by trunk IT3, the windings of relays 615 and 322 are connected in the same relation to each other on the call intercepted by trunk IT5 as that described on the call intercepted by trunk IT3. The operation of relay 615 causes the operation of relay 611; and the operation of relay 322 causes the operation of relay 319 and the release of relay 308. Relay 322 is held operated, after relay 308 releases, by the energization of its right winding in a circuit through its right front contact, over conductor 339 to ground at relay 303. The operation of relay 319 causes the operation of relay 314 and closes a holding circuit for relay 313. The operation of relay 314 causes the release of relay 303 and connects the incoming conductors 336 and 337, through the windings 340 and 341 of repeating coil RC2 to battery potential at the back contacts of relay 342 as hereinbefore described. The release of relay 303 is followed by the release of relays 304, 305 and 306, the tripping resistance 399 being temporarily connected through the right front contact of relay 395, left front contact of relay 314, and outer left front contact of relay 313 over conductors 336, 271, 239 and 229 to operate the tripping relay (not shown) of the connector LC. The aforementioned operation of relay 611 closes a circuit for operating relay 607 and connects the upper winding of relay 612 to the tip conductor of jack 626, relay 721 of cord OC being thereupon operated as hereinbefore described. The aforementioned release of relay 308 bridges the left windings of relays 326 and 327 across the conductors of trunk T, the operation of relay 327 being effective to hold relay 307 operated after relay 306 releases.

The talking connection between the intercepting operator and the calling subscriber having been completed as a result of the insertion of plug 701 in jack 626 in the same manner as that hereinbefore described for the call intercepted by trunk IT3, the intercepting operator informs the

calling subscriber that the call cannot be completed. When the operator removes plug 701 from jack 626, relay 603 releases, thereby causing the release of relays 615, 610 and 327. The release of relay 603 reconnects the windings of relays 604 and 605 to the conductors of trunk T and the release of relay 615 causes the release of relay 611. The incoming trunk equipment IT is now normal. The release of relay 327 causes the release of relay 307 and the temporary operation of relay 316. The release of relay 307 causes the release of relays 310, 311, 309 and 316. The release of relay 309 causes the release of relays 317, 318, 322, 319, 313, 314, 315 and 324 of trunk equipment OT, the release of relay 260 of trunk-finder TF and the release of relays 236 and 235 of trunk IT5. The trunk-finder TF is returned to normal as hereinbefore described. The connector LC, selector LS and line-finder LF are restored to normal under control of the calling subscriber in usual manner.

What is claimed is:

1. In a telephone system, subscribers' lines, an automatic switch for use in completing calls, a trunk connected to terminals in the bank of said switch for intercepting calls, which can not be regularly completed, an intercepting operator's position, another trunk for extending an intercepted call from said intercepting trunk to said position, a selector associated with the outgoing end of said other trunk and operatively controlled from said position for use completing an intercepted call, switching means associated with the outgoing end of said other trunk for disconnecting the talking conductors leading to said selector from the conductors leading to said position and for connecting said talking conductors to the conductors incoming from said intercepting trunk, and supervisory means in said selector responsive to the answer of a called subscriber for causing the operation of said switching means.

2. In a telephone system, subscribers' lines, an automatic switch for use in completing calls, a trunk connected to terminals in the bank of said switch for intercepting calls which can not be regularly completed, an intercepting operator's position, another trunk for extending an intercepted call from said intercepting trunk to said position, a selector associated with the outgoing end of said other trunk and operatively controlled from said position for use in completing an intercepted call, switching means associated with the outgoing end of said other trunk for disconnecting the talking conductors leading to said selector from the conductors leading to said position and for connecting said talking conductors to the conductors incoming from said intercepting trunk, and means in said automatic switch effective over the sleeve conductor of said intercepting trunk for holding said selector until the connection is released at the calling end.

3. In a telephone system, subscribers' lines, an automatic switch for use in completing calls, a trunk connected to terminals in the bank of said switch for intercepting calls which can not be regularly completed, an intercepting operator's position, another trunk for extending an intercepted call from said intercepting trunk to said position, a selector associated with the outgoing end of said other trunk and operatively controlled from said position for use in completing an intercepted call, switching means associated with the outgoing end of said other trunk for disconnecting the talking conductors leading to

said selector from the conductors leading to said position and for connecting said talking conductors to the conductors incoming from said intercepting trunk, and means in said intercepting trunk for connecting a holding ground over the sleeve conductor leading to said selector for holding said selector until the connection is released at the calling end.

4. In a telephone system, subscribers' lines, an automatic switch for use in completing calls, a trunk connected to terminals in the bank of said switch for intercepting calls which can not be regularly completed, an intercepting operator's position, another trunk for extending an intercepted call from said intercepting trunk to said position, a selector associated with the outgoing end of said other trunk and operatively controlled from said position for use in completing an intercepted call, switching means associated with the outgoing end of said other trunk for disconnecting the talking conductors leading to said selector from the conductors leading to said position and for connecting said talking conductors to the conductors incoming from said intercepting trunk, and means in said trunk for supplying the holding ground for said selector.

5. In a telephone system, a calling line, a called line, an operator's position, a two-wire trunk extending to said position, an intercepting circuit, means for extending said calling line to said circuit, a switch for connecting said intercepting circuit to the outgoing end of said trunk, a selector associated with the outgoing end of said trunk, means controlled by said operator for disconnecting said trunk at its outgoing end from said switch and connecting it to said selector, means at said position for sending pulses over said trunk to operate said selector to extend the outgoing end of said trunk to said called line, means controlled by the response of the called subscriber for disconnecting said selector from the conductors leading to said position and for connecting said selector to said switch, and a source of talking current in said intercepting circuit for said called line.

6. In a telephone system, a calling line, a called line, an operator's position, a two-wire trunk extending to said position, an intercepting circuit, means for extending said calling line to said circuit, a switch for connecting said intercepting circuit to the outgoing end of said trunk, a selector associated with the outgoing end of said trunk, a supervisory bridge at the incoming end of said trunk for signaling the operator, supervisory means at the outgoing end of said trunk controlled by said operator, means operated by said supervisory means for disconnecting said trunk at its outgoing end from said switch and from said supervisory means and connecting it to said selector, means at said position for sending impulses over said trunk to operate said selector to extend the outgoing end of said trunk to said called line, means controlled by the response of the called subscriber for disconnecting said selector from the conductors leading to said position and for connecting said selector to said switch, and a source of talking current in said intercepting circuit for said called line.

7. In a telephone system, a calling line, a called line, an operator's position, a two-wire trunk extending to said position, an intercepting circuit, means for extending said calling line to said circuit, a switch for connecting said intercepting circuit to the outgoing end of said trunk, a se-

lector associated with the outgoing end of said trunk, means controlled by said operator for disconnecting said trunk at its outgoing end from said switch and connecting it to said selector, 5 means at said position for sending pulses over said trunk to operate said selector to extend the outgoing end of said trunk to said called line, means controlled by the response of the called subscriber for disconnecting said selector from

the conductors leading to said position and for connecting said selector to said switch, a source of talking current in said intercepting circuit for said calling and called lines, and means in said intercepting circuit for holding said selector 6 until the connection is released at the calling end.

EDWARD D. BUTZ.

CHARLES D. KOECHLING.