July 3, 1928. 1,675,886

A. E. HAGUE

TELEPHONE SYSTEM

Filed Jan. 8, 1927 7 Sheets-Sheet 1

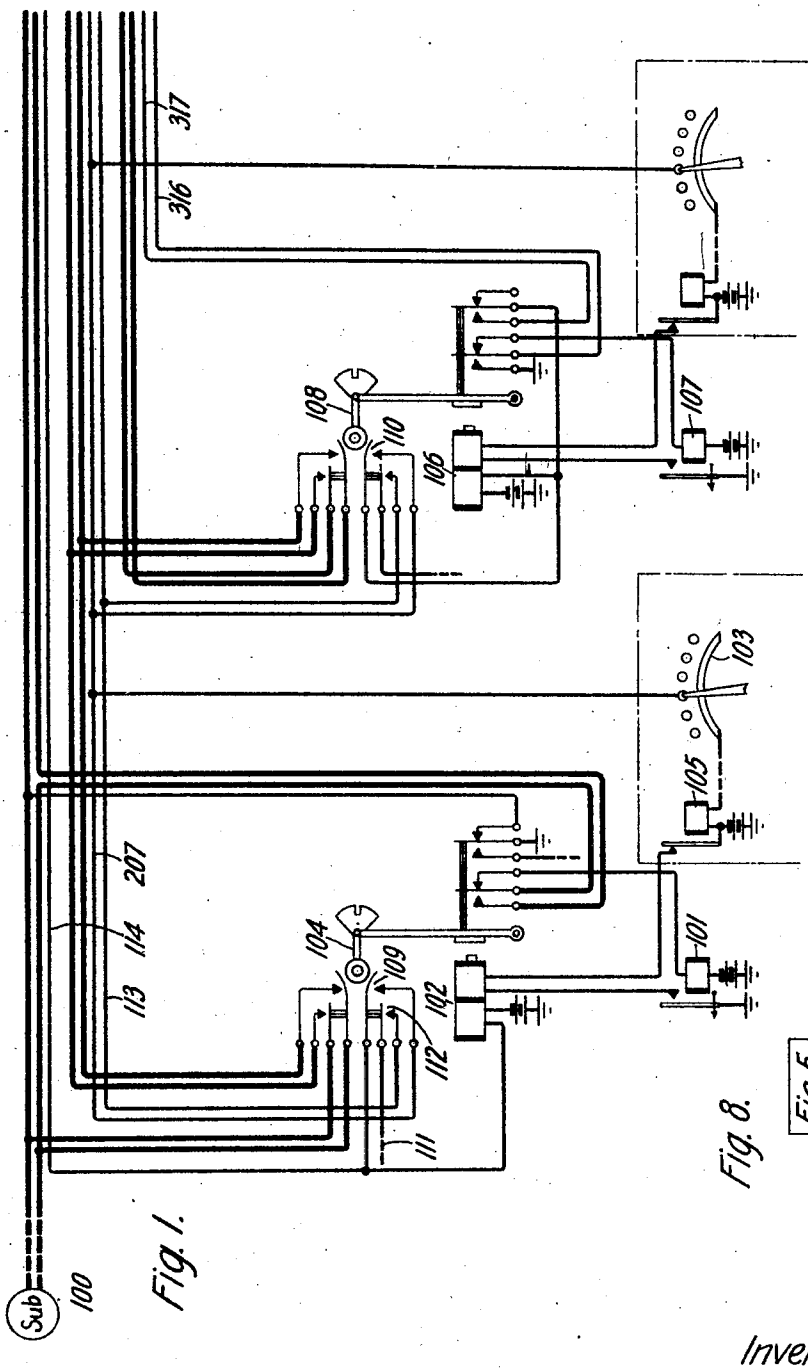


Fig. 1.

Fig. 8.

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

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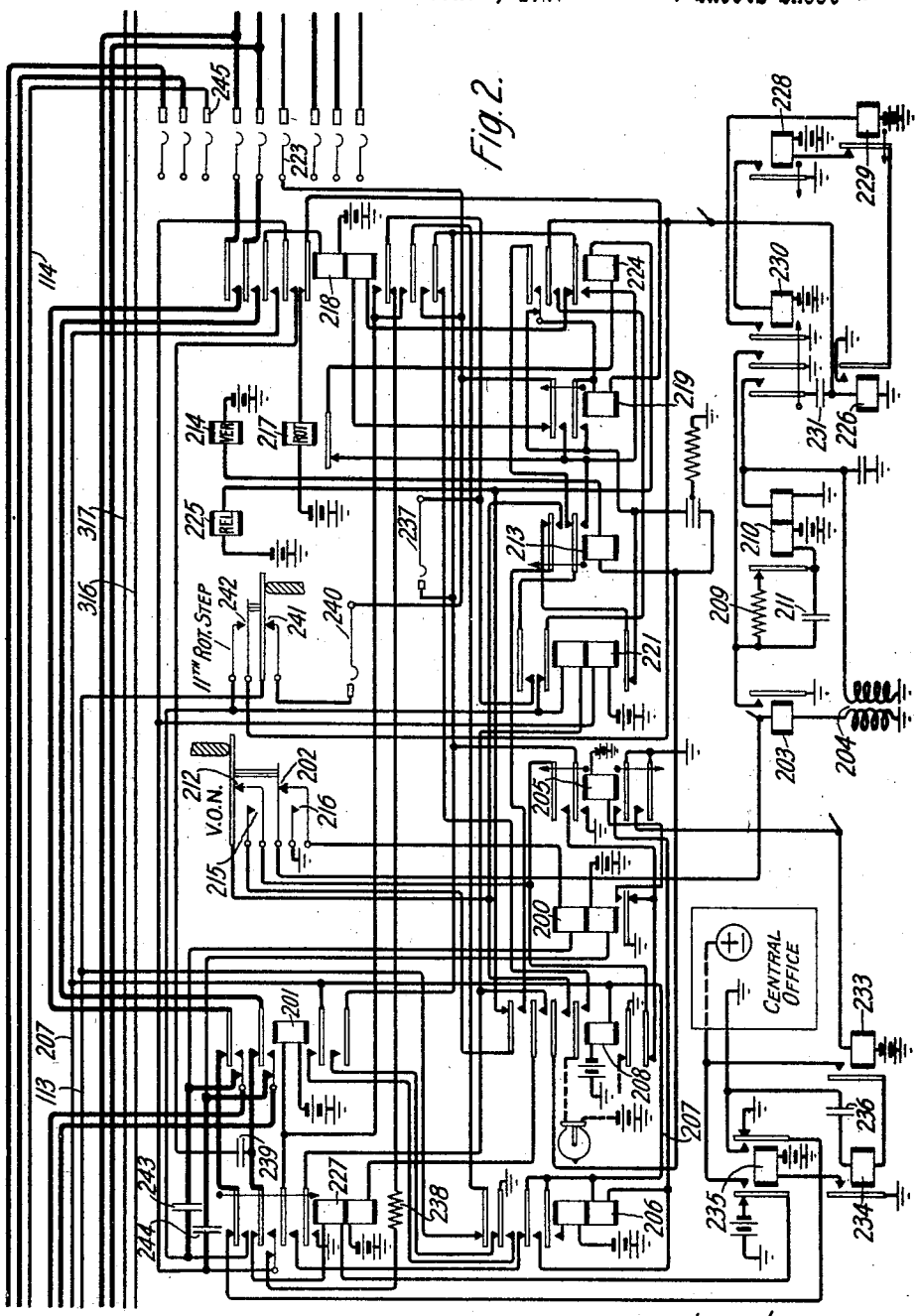
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Fig. 2.



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TELEPHONE SYSTEM

Filed Jan. 8, 1927 7 Sheets-Sheet 3

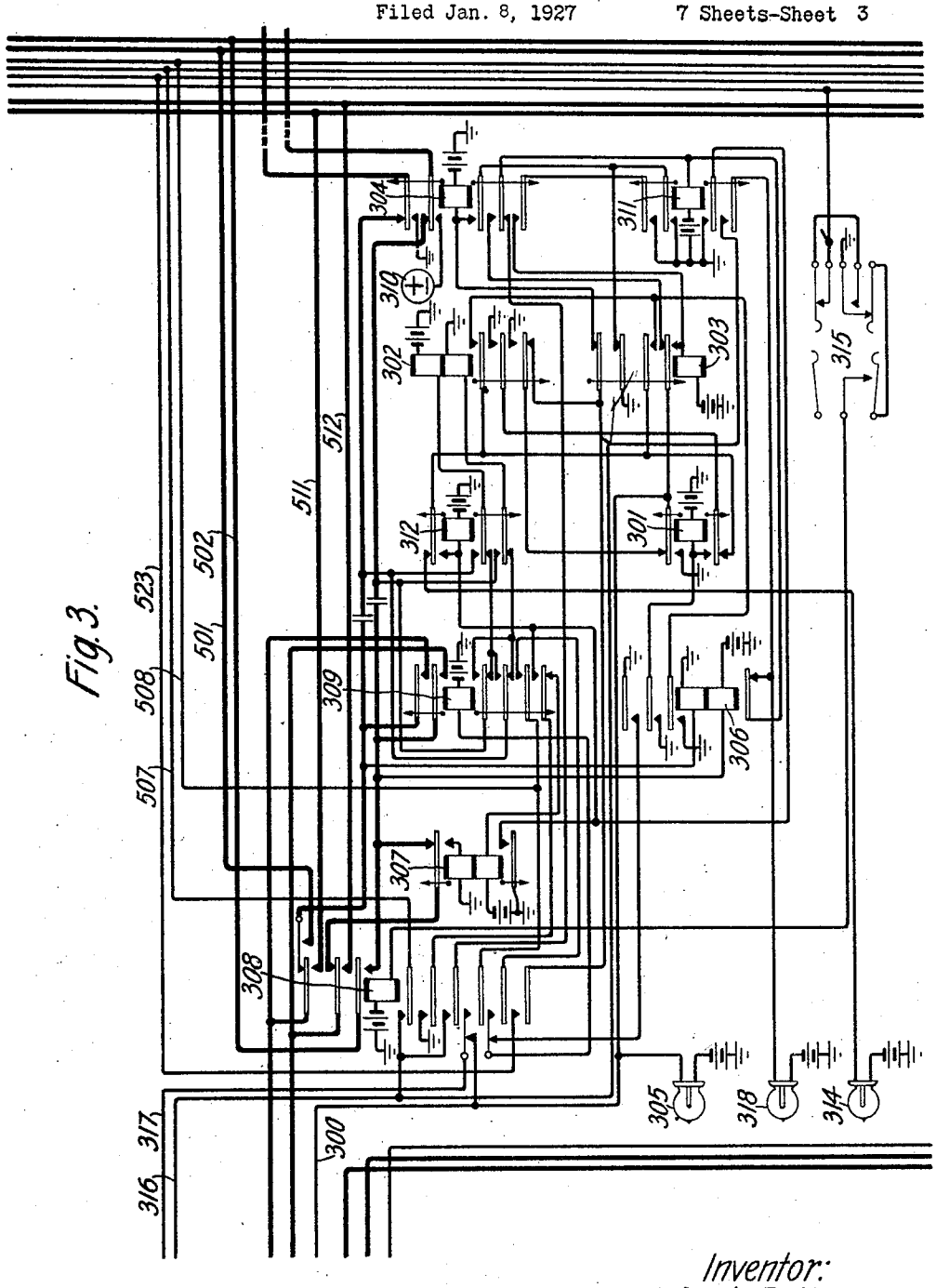


Fig. 3.

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TELEPHONE SYSTEM

Filed Jan. 8, 1927 7 Sheets-Sheet 4

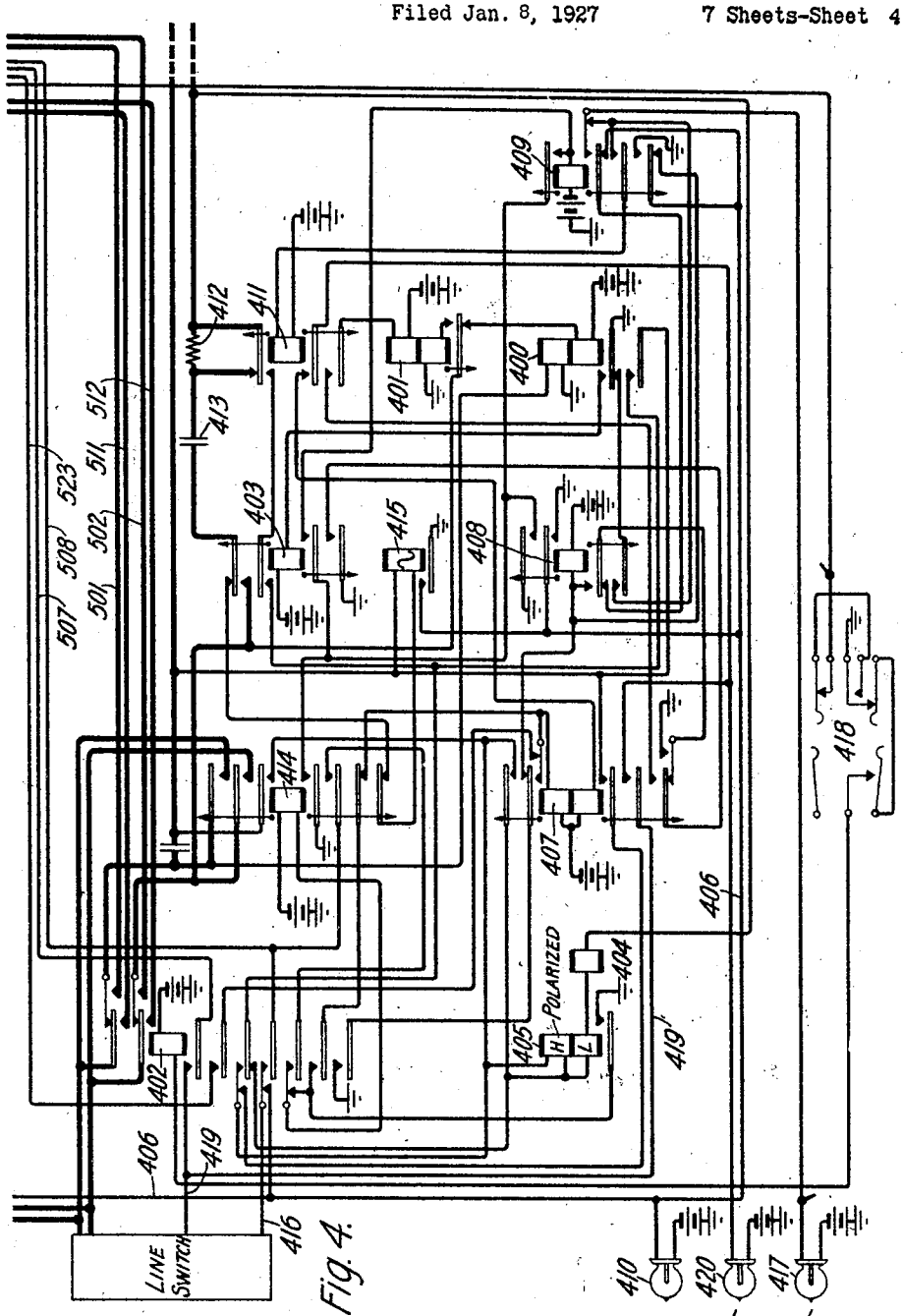


Fig. 4.

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TELEPHONE SYSTEM

Filed Jan. 8, 1927 7 Sheets-Sheet 5

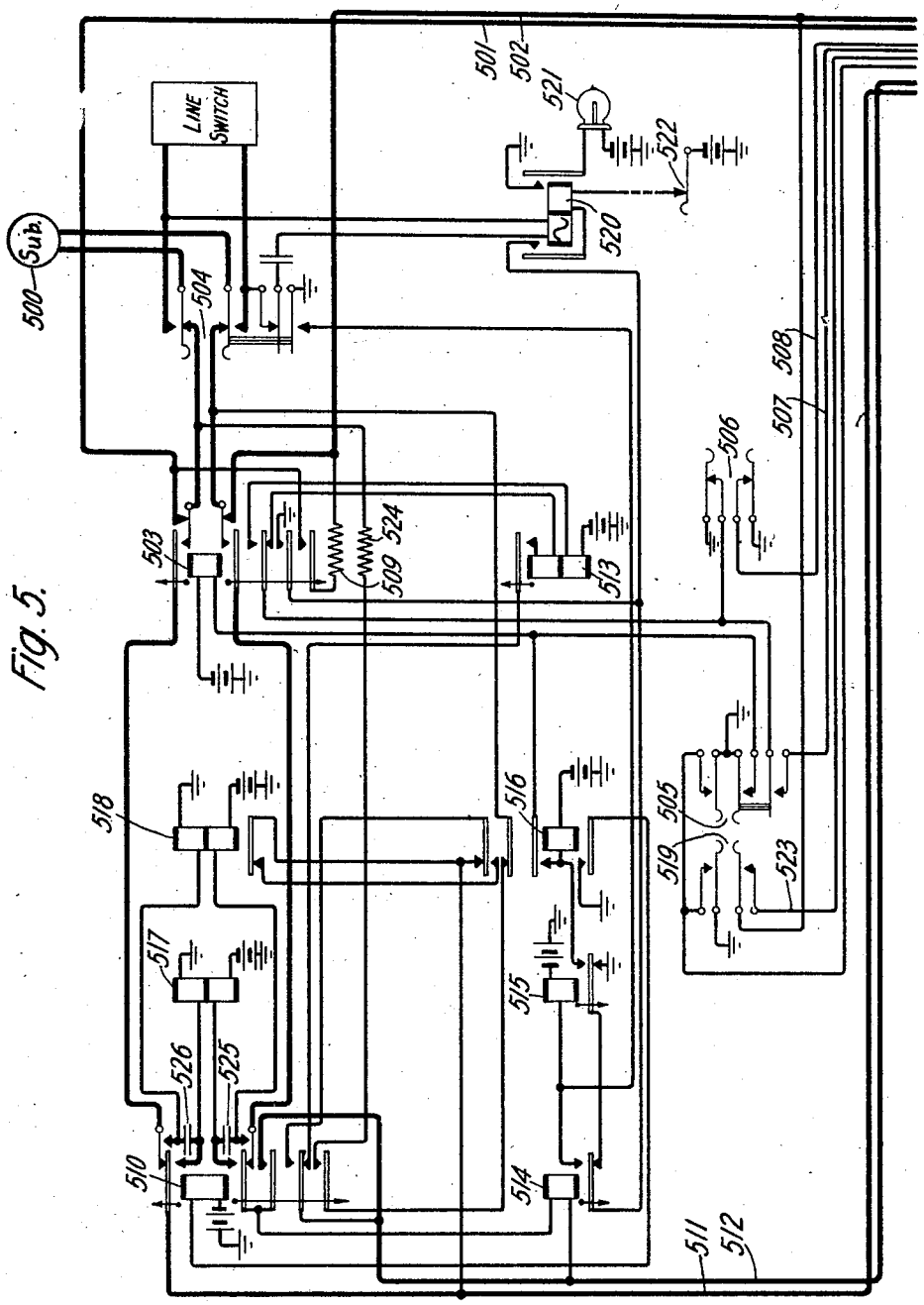


Fig. 5.

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TELEPHONE SYSTEM

Filed Jan. 8, 1927 7 Sheets-Sheet 6

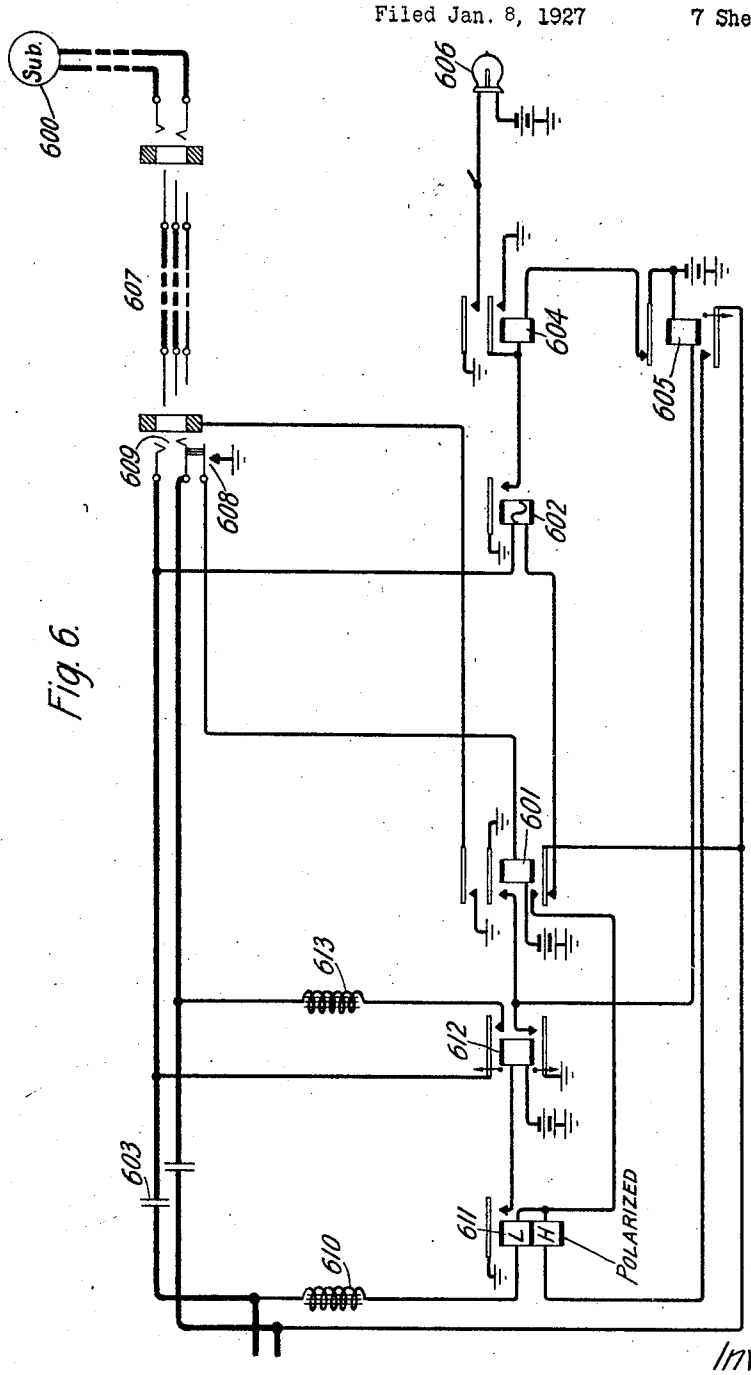


Fig. 6.

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1,675,886

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TELEPHONE SYSTEM

Filed Jan. 8, 1927

7 Sheets-Sheet 7

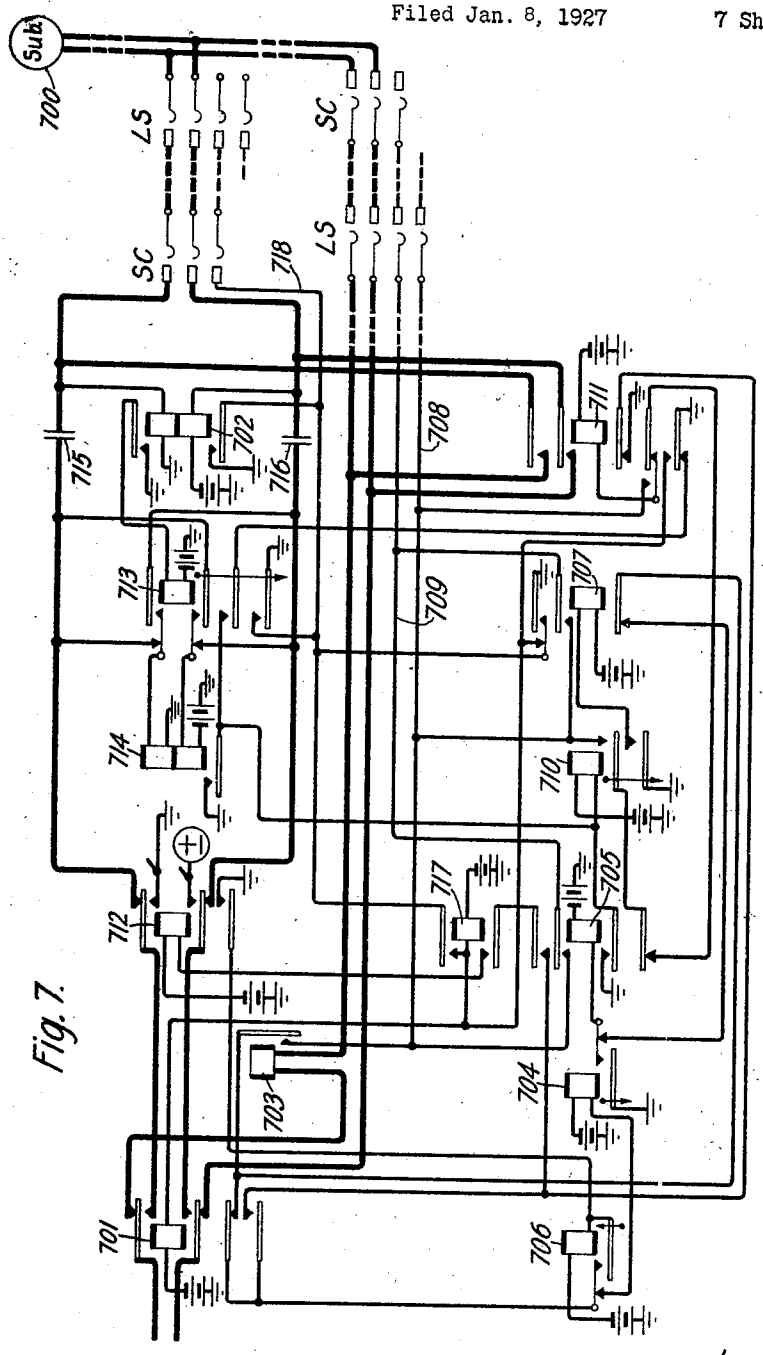


Fig. 7.

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Patented July 3, 1928. 1,675,886

UNITED STATES PATENT OFFICE.

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TELEPHONE SYSTEM.

Application filed January 8, 1927. Serial No. 159,760.

This invention relates to telephone exchange systems and more particularly to private branch exchanges, the object being to improve interconnection between branch exchanges of different types and between branch exchanges and central offices.

In particular, the invention is embodied in a branch exchange wherein local and outgoing calls may be completed automatically, whereas incoming calls are completed with the assistance of the operator. This private branch exchange is equipped with two-way trunk lines to the central office and two-way interoffice trunks or tie lines to other private branch exchanges. It is characterized by switching units one of which is employed in the completion of each connection whether local, incoming or outgoing. This switching unit is provided with means for discriminating between local calls and calls involving equipment outside of the exchange, which means controls the supply of talking current to the connection. It is also provided with means whereby on an incoming call, the local subscriber may signal the operator at the branch exchange. In addition, it is provided with means to prevent the release of the switching unit, if the operator after signaling the called subscriber, in response to an incoming call, immediately "listens out." Other features of the system cover the use of a trunk, which is provided with a normal pulsing circuit which is automatically disconnected following dialing and for which a talking circuit is then substituted. In addition, means are provided to introduce a talking bridge into the local listening circuit at the attendant's telephone circuit as soon as the called subscriber answers after the attendant finishes dialing a local station.

Briefly, the operation of a branch exchange embodying these features is as follows. If a call is originated at a local exchange, the line switch operates and extends the calling line to an idle selector-connector. In response to dial impulses, the connector will be operated to select a level, in which either local lines, interoffice lines, or central office trunk lines, appear. If a level is selected in which local lines appear, the switch will then be rotated, under the control of the dial to select a wanted subscriber. However, if the level selected is a trunk level, a local contact will be closed which will cause the switch to hunt for an idle trunk outgoing to the particular exchange. Where a branch exchange is called which is provided with similar apparatus, the trunk used for completing the connection at the called exchange has a normally closed pulsing circuit over which the connector may be controlled to reach the called subscriber. As soon as dialing has been completed, this pulsing circuit is disconnected and a talking circuit is substituted therefor. The trunks are also equipped at the local branch exchange with line switch apparatus so that in response to an incoming call, they may be associated with a selector connector. A trunk operates in response to incoming calls to signal the attendant who causes the association of the trunk with a selector-connector and then operates her dial to cause the connector to select the wanted subscriber. Since talking battery is supplied over the trunk, the selector-connector removes the local talking battery in response to such a call. The connector is also provided with a relay which is held operated from the trunk to prevent the release of the connector after the attendant dials the wanted subscriber and "listens out." If the called subscriber wishes to resignal the operator, the depression of the switchhook releases certain relays, without releasing the entire connection, and on the reclosure of the switchhook not all of these relays operate, providing a circuit for flashing the trunk lamp in response to the switchhook. The attendant's position equipment also substitutes a talking circuit for the dialing circuit as soon as she has completed dialing a local subscriber.

It is believed that the operation of the system will be more clearly understood from a consideration of the following description in connection with the attached drawings in which:

Fig. 1 shows two line switches;

Fig. 2 shows a selector-connector;

Fig. 3 shows one form of tie line;

Fig. 4 shows another type of tie line;

Fig. 5 shows the attendant's position equipment;

Fig. 6 shows the terminating end of the

tie line of Fig. 3 at a manual branch exchange;

Fig. 7 shows the terminating end of the tie line of Fig. 4 at an automatic branch exchange; and

Fig. 8 shows the manner of arranging Figs. 1 to 7 for an understanding of the invention.

Local connection.

Assuming that the subscriber at substation 100 wishes to converse with another subscriber in the same branch exchange, he will remove his receiver from the switch-hook, thereby closing a circuit from battery through the winding of relay 101, inner back contact of relay 102, through his substation, to ground at the outer back contact of relay 102. The line switch shown in Fig. 1 is of the well known Keith type, employing a master switch, indicated at 103, and a plurality of plungers 104. Relay 102 when energized through its right winding, operates the plunger 104 to close the corresponding contacts, but when energized through its left winding alone, merely closes the contacts to the right of the relay. However, if relay 102 is first energized over its right winding to operate the plunger, the current in its left winding is sufficient to hold the plunger in its operated position. When relay 101 operates in the circuit above traced, it completes a circuit from battery over the back contact of magnet 105, through the right winding of relay 102 to ground at the contact of relay 101. The energization of relay 102 in this circuit causes the plunger 104 to operate the plunger contacts and also closes the relay contacts. The plunger closes the tip and ring conductors from the subscriber's line through to the selector-connector in the usual manner. The selector-connector is a two-motion switch, which is moved vertically by magnet 214 and rotated by magnet 217. Rotation is normally under the control of the dial but certain levels are provided with auxiliary contacts which alter the circuit to cause the switch to hunt for an idle terminal in the level. The switch therefore acts either as a connector or a selector, whence the name selector-connector.

The operation of the line switch closes a circuit from battery through the lower winding of relay 200, inner upper normal contact of relay 201 to the ring conductor, through the plunger contacts, over the subscriber's line and back through the plunger contacts to the tip conductor, uppermost normal contact of relay 201, upper winding of relay 200, normal contact 202, winding of dial tone relay 203, secondary of transformer 204 to ground. Relay 200 operates, in turn operating relay 205, which immediately connects ground over its inner lower front contact, through the lower winding of relay 206 to conductor 207, over contact 109 of the plunger to the left winding of relay 102 and battery, holding relay 102 and the line switch operated. A branch of this circuit extends over sleeve conductor 114 to sleeve terminal 245, marking the line busy to calling selector-connectors. Ground is also extended from conductor 207, through the master switch 103 to magnet 105 and battery. The master switch magnet operates to align the remaining idle plungers with the next outgoing trunk, and, in operating, disconnects battery from relay 102. The circuit of relay 101 is opened when relay 102 operates, but relay 101 being slow-to-release, the holding circuit above traced is completed before the energizing circuit of relay 102 is opened.

Relay 206 operates in the above traced circuit, connecting ground from the contact of relay 205, over the middle front contact of relay 206 to conductor 207 directly. It also locks to conductor 207 over its upper winding and inner upper front contact. A branch of the circuit of relay 206 extends to the winding of relay 208 and battery, causing the operation of relay 208.

When relay 203 operates in the circuit of relay 200, it connects ground over its front contact through resistance 209, the back contact and left winding of relay 210 to battery. Relay 210 acts as a buzzer, interrupting its own circuit and generating a tone which is controlled by the capacity of condenser 211. This tone is transmitted to the circuit of the right winding of relay 210 and the primary winding of transformer 204, and thence over the dialing circuit to the subscriber's substation to serve as a dial tone. The calling subscriber responding to this tone, operates his dial to transmit a series of impulses. At the first impulse, relay 200 releases, closing a circuit from ground over its back contact, uppermost front contact of relay 205, normal contact 212, next to the innermost upper contact of relay 208, winding of relay 213, winding of vertical magnet 214 to battery. At the first step, contacts 212 and 202 are opened and contacts 215 and 216 closed. The closure of contact 216 substitutes direct ground for the ground through relay 203, and causes the dial tone relays to release. The closure of contact 215 transfers the circuit of vertical magnet 214 from contact 212 and next to the innermost front contact of relay 208, to contact 215, the uppermost front contact of relay 208, the uppermost front contact of relay 213, and the next to the innermost front contact of relay 208, putting the circuit under the control of relay 213 which operates in series with the vertical magnet 214. This relay, being slow-to-release, remains operated throughout the dialing of the first digit.

At the completion of the digit, relay 213 releases, opening the circuit of the vertical magnet. A circuit may now be traced from battery through the winding of rotary magnet 217, upper back contact of relay 218, winding of relay 219, upper normal contact of relay 224, lower back contact of relay 221, outer back contact of relay 213, uppermost front contact of relay 208, contact 215, outer upper contact of relay 205 to ground at the back contact of relay 200. The switch is rotated in response to the second digit to the terminals of the wanted subscriber's line.

Relay 219 operates in series with magnet 217, but is slow-to-release so that, following the dialing of the second digit, it remains operated for a time after the rotary magnet closes its back contact. A test circuit is therefore closed from the sleeve brush 223, over the outer front contact of relay 219, back contact of magnet 217, winding of relay 224, to battery through the winding of release magnet 225. A busy line is characterized by ground at its sleeve terminal so that, if the called line is busy, relay 224 will be operated, although the resistance of relay 224 prevents the operation of the release magnet at this time. Relay 224, in operating, locks in a circuit which may be traced as before to the back contact of magnet 217, extending thence over the innermost front contact of relay 224 to ground at the inner upper contact of relay 205.

The operation of relay 224 closes a circuit from ground through the winding of relay 226, middle upper front contact of relay 224, upper back contact and upper winding of relay 221, next to the uppermost contact of relay 208, lower winding of relay 227 to battery. Relay 226 operates in this circuit but its resistance prevents the operation of relays 221 and 227. Relay 226, in turn, operates relay 228 over the back contact of relay 229. Relay 228 operates relay 230, which closes a circuit for relay 210, starting the tone. The operation of relay 230 also operates relay 229 which opens the circuit of relay 228, thereby opens the circuit of relay 230 and, in turn, the circuit of relay 229. With relay 229 released, relay 228 operates and the cycle is repeated. Therefore, an intermittent tone will be transmitted to the calling subscriber over a circuit which may be traced from ground, through the right winding of relay 210, outer contact of relay 230, condenser 231, middle front contact of relay 224, upper back contact of relay 221, condenser 243, uppermost normal contact of relay 201, to the subscriber's substation and back over the dialing circuit as above traced. The time during which the tone is applied is measured by the operating time of relay 229 and the releasing time of relays 230 and 228, whereas the silent period is measured by the releasing time of relay 229 and the operating time of relays 228 and 230, combined. In response to this interrupted tone which is the busy tone, the calling subscriber restores his receiver to the switchhook releasing relay 200 and, in turn, relays 205, 208, 206, 224, etc. With these relays released, ground is disconnected from conductor 207 and relay 102 releases, to release the plunger 104.

If the called line is idle, relay 224 is not operated. The release of relay 219 therefore closes a circuit from ground over the innermost upper contact of relay 205, back contact of relay 224, lower winding of relay 218, back contact of relay 219, brush 223, to battery through the left winding of the relay of the called line, corresponding to relay 102 at substation 100. Relay 218, in operating, locks from battery through its upper winding and next to innermost upper front contact to grounded conductor 207. As soon as relay 218 operates, it connects ground over its lowermost front contact, from the inner upper front contact of relay 205, to the sleeve brush 223, to hold the relay of the called line and to mark the line busy.

When relay 205 operated it closed an obvious circuit for relay 233 and prepared the ringing current circuit. Interrupted ringing current is supplied from the central office and the operation of relay 233 supplies ringing current to the individual selector-connector, completing a circuit from the central office source of ringing current over the front contact of relay 233, winding of relay 234, condenser 236, to ground also at the central office. Relay 234 is intermittently operated under the control of an interrupter at the central office (not shown), and in turn intermittently operates relay 235. Therefore, with relay 218 operated, a circuit is intermittently closed from the ringing current source over the left front contact of relay 235, upper winding of relay 227, inner upper back contact of relay 227, inner back contact of relay 201, next to the uppermost contact of relay 218 over the ring conductor through to the called subscriber's line, back over the tip conductor to the uppermost contact of relay 218, upper back contact of relay 201, outer upper back contact of relay 227, right front contact of relay 235 to central office ground. During the silent intervals, this circuit is connected over the back contacts of relay 235 to local battery and ground. Relay 227 is unresponsive to alternating current but as soon as relay 235 releases after the called subscriber answers, relay 227 operates and locks over next to the uppermost front contact of relay 208, innermost front contact of relay 227 to ground. With relay 227 operated, the talking conductors which extend from the call-

ing substation to normal contacts of relay 201, and those which extend from the called substation over front contacts of relay 218 to back contacts of relay 201 are connected together through talking condensers 243 and 244. Talking current is supplied to the calling subscriber from relay 200 as previously described. Current is supplied to the called subscriber's line from battery through the lower winding of relay 221, next to the uppermost front contact of relay 227, inner upper back contact of relay 201 to the ring conductor, and from ground over the innermost front contact of relay 227, upper winding of relay 221, uppermost front contact of relay 227, uppermost back contact of relay 201 to the tip conductor. Relay 221 is held operated over the called line.

The release of the connection is under the control of the calling subscriber, the release of relay 221 when the called subscriber restores his receiver being ineffective.

When the calling subscriber restores his receiver to the switchhook, relay 200 releases, in turn releasing relays 205, 208, 227 and 221. As soon as relay 208 releases, a circuit is closed from battery, through the winding of release magnet 225, uppermost back contact of relay 208, off normal contact 215, lowermost back contact of relay 208 to ground at the back contact of relay 200. The release magnet operates in this circuit restoring the selector-connector to normal, at which time contact 215 is open. As soon as relay 205 releases, removing ground from conductor 207, relays 206 and 218 also release completing the restoration of the connector. The release of relay 205 also opens the holding circuit of relay 102 and that relay releases withdrawing plunger 104 from the line switch contacts. The release of relay 205 also removes ground from the sleeve brush 223, releasing the cutoff relay of the called subscriber's line.

Outgoing call to a distant manual PBX.

If subscriber 100 wishes to converse with the subscriber at substation 600 located in a manual PBX, he will perform the same operations that he did in calling the subscriber at his own PBX, except that the number dialed will be different. The operation of the selector-connector of Fig. 2 will be the same until the brushes come to rest on the level leading to the called branch exchange. This level, as well as other levels leading to tie lines to private branch exchanges or to trunks to the central office, is provided with a contact 237 which is closed when the brush comes to rest at that level. The closure of this contact causes the operation of relay 221 in a circuit which may be traced from battery, through its lower winding, upper normal contact of relay 227, resistance 238, inner lower back contact of relay 218, contact 237, inner upper front contact of relay 205 to ground. Relay 221 in operating opens the circuit whereby rotary magnet 217 was controlled by relay 200, and closes a circuit from battery through the release magnet 225, winding of relay 224, back contact of rotary magnet 217, front contact of relay 213, which being slow to release maintains its armatures attracted after the switch comes to rest, upper front contact of relay 221, contact 237 to ground at the inner upper contact of relay 205. Relay 224 operates and locks in a circuit extending as above traced to the back contact of rotary magnet 217, innermost front contact of relay 224 to ground at the inner upper front contact of relay 205. Magnet 225 cannot operate in series with relay 224. When relay 213 releases, a circuit is closed from battery, through the winding of rotary magnet 217, upper back contact of relay 218, winding of relay 219, uppermost front contact of relay 224, inner upper back contact of relay 213, upper front contact of relay 221, contact 237 to ground at the inner upper front contact of relay 205. The rotary magnet operates rotating the switch one step and opening the circuit of relay 224. The release of relay 224 opens the circuit of magnet 217 and that releases. A circuit is then prepared from brush 223, over the outer front contact of relay 219, back contact of relay 217, winding of relay 224 to battery through the winding of release magnet 225. If the first trunk is busy, ground will be connected to the terminal engaged by brush 223, as will be subsequently described, and relay 224 will operate to reclose the circuit of the rotary magnet. In this way, the switch is stepped over busy trunks to the first idle trunk.

If all trunks of the group are busy the selector will make eleven steps at which time contact 241 will be opened and contact 242 closed. A circuit will thereupon be closed from ground through the winding of relay 226, contact 242, upper winding of relay 221, next to the upper front contact of relay 208, to battery through the lower winding of relay 227. Relay 226 operates to generate the busy tone but relays 221 and 227 are not operated. The tone is transmitted to the calling subscriber over contact 242, through condenser 243 as in the case of a busy line.

When an idle trunk is found, relay 224 does not reoperate, and as soon as relay 219 releases, a circuit is closed from ground, over the inner upper contact of relay 205, inner back contact of relay 224, lower winding of relay 218, back contact of relay 219, to sleeve brush 223 and the sleeve terminal of the engaged tie line, over sleeve conductor 300, back contact of relay 301, back contact of relay 302, uppermost back contact of relay 303 to the winding of relay

304 and in parallel therewith through busy lamp 305 to battery. Relay 218 operates in this circuit but relay 304 does not. As soon as relay 218 operates, it closes a locking circuit for itself from battery, through its upper winding and next to the innermost upper front contact to grounded conductor 207. It also connects direct ground from the inner upper front contact of relay 205 over its lowermost front contact to sleeve brush 223 and the winding of relay 304, operating relay 304 and lighting lamp 305. Relay 218 also closes a circuit from battery, through the winding of relay 201, inner lower front contact of relay 218, contact 237 to ground at the inner upper front contact of relay 205. Relay 201 in operating disconnects the calling subscriber's tip and ring conductors from relay 200 and the outgoing tip and ring conductors from relay 221 and connects them together, thus providing a continuous circuit from the calling subscriber's line to the tie line. It also closes a circuit from ground at the middle upper back contact of relay 206, lowermost front contact of relay 201, lowermost front contact of relay 218, to sleeve brush 223 to hold relay 304 operated when relay 205 releases following the release of relay 200 and to mark the trunk busy. The operation of relay 201 also prevents the application of ringing current to the outgoing trunk.

As soon as the tip and ring conductors are connected to the trunk, a circuit is completed from battery, through the lower winding of relay 306, upper back contact of relay 307, inner upper back contact of relay 308, over the ring conductor through the selector-connector switch brush, next to the outermost upper contact of relay 218, inner upper alternate contact of relay 201, over the ring conductor to the line switch springs, through the subscriber's substation back through the line switch to the tip conductor, outer upper alternate contact of relay 201, uppermost front contact of relay 218, tip brush of the selector-connector over the tip conductor of the trunk, outer upper back contact of relay 308 to ground through the upper winding of relay 306. Relay 306 operates in this circuit, in turn operating relay 301 in an obvious circuit and operating relay 309 in a circuit which may be traced from battery, through the winding of relay 309, outer lower normal contact of relay 308 to ground at the uppermost contact of relay 306. The operation of relay 301 connects ground to sleeve conductor 300 which completes a circuit which may be traced from sleeve brush 223, over the outer lower front contact of relay 218, through contact 237, inner lower front contact of relay 218, winding of relay 201 to battery, holding relay 201 operated. A branch of this circuit extends over next to the innermost front contact of relay 227, inner back contact of relay 206, to conductor 207 holding relay 102 operated.

Relay 304 in operating locks over its innermost lower contact to ground at the middle back contact of relay 303. The operation of relay 304 closes a circuit from ringing current source 310 over the inner upper front contact of relay 304 and the ring conductor of the interoffice line to the distant PBX where the circuit may be further traced over the back contact of relay 601, winding of alternating current relay 602, through condenser 603, to the tip conductor of the interoffice line, back to the uppermost front contact of relay 304 and ground. Relay 602 operates in this circuit completing a circuit from ground over the front contact of relay 602, winding of relay 604, normal contact of relay 605 to battery. Relay 604 operates and locks to ground at its inner front contact and also connects ground to the circuit of lamp 606 to inform the operator at the distant branch exchange that a call awaits attention on this trunk. Although a single jack and lamp have been shown, it is obvious that multiple jacks and busy signals may be employed.

When relay 304 operated it closed a circuit for relay 311 over the middle lower front contact of relay 304, inner back contact of relay 303 to ground at the upper front contact of relay 301. When relay 311 operates it closes a circuit from battery through the winding of relay 303, lower front contact of relay 304 to ground at the outer upper contact of relay 311. Relay 303 is slow-to-operate but when it attracts its armatures, it opens the circuit of relay 311 and locks over its inner front contact to ground at the upper front contact of relay 301. Relay 311 in turn is slow-to-release and an interval elapses before its contacts are opened. When relay 311 does release, the locking circuit of relay 304 is opened, and the energizing circuit having already been opened by relay 303, relay 304 releases removing ringing current from the trunk after a definite measured interval.

When relay 304 releases it connects the tip and ring conductors of the interoffice trunk to the talking condensers and also extends them over contact of relays 309 and 312 to the windings of relay 302. When relay 311 operated it closed a circuit from battery, through the winding of relay 312, inner lower contact of relay 311 to ground. When relay 303 operated it completed a locking circuit for relay 312 over the upper front contact of relay 312, outer front contact of relay 303 to ground at the innermost front contact of relay 306. Therefore relay 312 remains operated when relay 311 releases. When relay 312 operated, battery was connected to the tip conductor of the interoffice line and ground to the ring conductor.

When the operator, whose cord circuit is shown at 607 responds to the lighting of lamp 606, she closes local contact 608 of jack 609 completing an obvious circuit for relay 601. With relay 601 operated, retard coil 610 and the low resistance winding of polarized relay 611 are connected over the lower front contact of relay 601 across the tip and ring conductors of the interoffice line. With battery connected to the tip conductor, relay 611 operates closing an obvious circuit for relay 612, which in turn connects retard coil 613 across the tip and ring conductors on the incoming side of the talking condensers to control the cord lamp. When relay 601 operated it connected ground to the sleeve of jack 609 to mark the line busy and also closed the circuit for relay 605. Relay 612 in operating closes a substitute circuit for relay 605. The operation of relay 605 opens the circuit of relay 604 and extinguishes tie line lamp 606. It also prepares a circuit through both windings of relay 611 across the tip and ring conductors but the high resistance lower winding of relay 611 is shunted at the front contact of relay 601. The operator at the manual branch exchange will then complete the call to the wanted subscriber by means of the calling plug of cord 607 in the usual manner, the calling line receiving battery from the cord circuit.

When the called subscriber restores his receiver to the switchhook the operator will remove the plug of cord 607 from jack 609 releasing relay 601 which disconnects ground from the sleeve of jack 609. It also reconnects relay 602 across the tip and ring conductors but in addition it opens the shunt around the high resistance winding of relay 611 so that relay 302 which has been held operated in circuit with relay 611 now releases. When relay 302 operated it completed a locking circuit for relay 301 which prevents the release of relay 301 should the calling subscriber disconnect first. When relay 302 releases, this locking circuit is opened but relay 301 may be held operated under the control of the calling subscriber. When the calling subscriber restores his receiver relay 306 is deenergized in turn releasing relay 301 if relay 302 is not operated, releasing relay 309 and relay 312 in the order named. With both relays 309 and 312 released, battery from the upper winding of relay 302 is connected over back contacts of relay 312 and 309 to the ring conductor, thus reversing the direction of current in the windings of relay 611 and releasing that relay which in turn releases relays 612 and 605 completing the restoration of the distant end of the trunk to normal. When relay 301 releases, it opens the locking circuit of relay 303 and that relay also releases. In addition it extinguishes lamp 305 and removes ground from conductor 300. When ground is removed from conductor 300, relay 201 in the selector connector circuit releases, removing ground from conductor 207 and opening the circuit of relays 208, and 218. Release magnet 225 is now energized over the circuit previously traced restoring the selector-connector to normal. The removal of ground from conductor 207 also releases relay 102 and restores the line switch springs.

Incoming call from a manual branch exchange.

If the subscriber at substation 600 should desire to converse with the subscriber at substation 100, he will signal his operator in the usual manner and the operator will insert the calling plug of cord 607 in jack 609. Relay 601 operates in the manner previously described to ground the sleeve of jack 609. It also connects retard coil 610 and the low resistance winding of polarized relay 611 across the tip and ring conductors at its lower front contact. In addition, it closes an obvious circuit for relay 605, preventing the lighting of lamp 606. The connection of relay 611 across the tip and ring conductors completes a circuit from battery through the upper winding of relay 302, inner lower back contact of relay 312, back contact of relay 309, inner upper back contact of relay 304 to the ring conductor, through relay 611 to the tip conductor, outer upper back contact of relay 304, middle back contact of relay 309, outer lower back contact of relay 312 to ground through the lower winding of relay 302. With the battery connected to the ring conductor, relay 611 does not operate, but relay 302 does. The operation of relay 302 connects ground over the back contact of relay 301 to lamp 305 and sleeve conductor 300 to mark the tie line busy at the local PBX and to light the busy lamp. In addition, it closes a circuit from battery through trunk lamp 314, upper back contact of relay 312, lower back contact of relay 301 to ground at the middle front contact of relay 302.

The lighting of lamp 314 informs the attendant, whose position apparatus is shown in Fig. 5, that a call has been extended to the trunk corresponding to that lamp. She then throws switch 315 to its middle or talking position. This closes a circuit from battery through the winding of relay 308, left contact of key 315, lower right normal contact of key 315 to ground. The operation of relay 308 completes the talking circuit from the tip conductor of the interoffice trunk over the outer upper back contact of relay 304 through the talking condenser, upper alternate contact of relay 308, conductor 501, upper normal contact of relay 503, upper normal contact of key 504 to the attendant's substation, back over

the lower normal contact of key 504 and the lower normal contact of relay 503 to conductor 502, inner upper front contact of relay 308 through the talking condenser and the inner upper back contact of relay 304 to the ring conductor. Battery through the lower winding of relay 306 is connected through the inner front contact of relay 308 to conductor 502 and ground through the upper winding of relay 306 to conductor 501, supplying talking current to the operator.

When relay 308 operated, it closed a circuit from battery through the lower winding of relay 307, lower back contact of relay 309 to ground at next to the innermost lower contact of relay 308. Relay 307, operating, closes an obvious circuit for relay 312. Relay 306 also operates in series with the attendant's telephone, closing a circuit for relay 301 which locks over its lower front contact to ground at the middle lower contact of relay 302. It also closes a locking circuit for relay 312 extending over the upper front contact of relay 312, inner lower contact of relay 302 to ground at the inner upper contact of relay 306. The operation of relay 301 removes the ground connected to conductor 300 and lamp 305 from the front contact of relay 302 but supplies a new ground from its own front contact. The operation of relay 312 extinguishes lamp 314. In addition, this relay reverses the connection of battery and ground to the distant end of the trunk, operating relay 611 which in turn operates relay 612 and closes the supervisory bridge through retard coil 613 which informs the calling operator that the attendant has answered and that she may communicate to her the number of the wanted subscriber.

Having received her instructions, the operator at substation 500 closes key 505 to control the selection of the wanted subscriber. The operation of key 505 connects ground from the upper normal contact of key 506 over the outer lower contact of key 505 to conductor 507, innermost lower front contact of relay 308 to conductor 316. Each trunk is provided with an individual line switch similar to the line switch supplied for each subscriber. The line switch individual to the trunk of Fig. 3 is shown at the right of Fig. 1. Therefore the operation of key 505 extends ground over the inner normal contact of relay 106 to the winding of relay 107 and battery. Relay 107 energizes relay 106 through its right winding, causing the operation of plunger 108 to extend the tie line through to an idle selector-connector. The operation of relay 106 completes a circuit from ground over the lower normal contact of key 506, conductor 508, the inner alternate contact of relay 308, conductor 317, outer front contact of relay 106 to the holding winding of relay 106 and also over line switch contact 110, conductor 207, winding of relay 208 to battery. It will be noted that this circuit closes ground to the upper end of the lower winding of relay 206.

A branch of the circuit above traced for relay 107, extends over a second front contact of relay 308, lower back contact of relay 304 to the winding of relay 311. Relay 311 closes a circuit from battery through guard lamp 318, outer lower contact of relay 311, innermost lower front contact of relay 318, to ground over conductor 507.

The operation of key 505 also closed an obvious circuit for relay 503. This relay, in operating, connects resistance 509 over its lowermost front contact, across conductors 501 and 502 to hold relay 306 operated and to prevent the release of the trunk while the attendant is calling the local subscriber. Relay 503 next connects the substation 500 over its alternate contacts, and normal contacts of relay 510 to conductors 511 and 512 which are further extended over the two uppermost front contacts of relay 308 and the upper contacts of the line switch to the selector-connector where they extend to the windings of relay 200 in the manner described in connection with a local call. Relay 200 operates relay 205 as before. Since ground has been connected over conductor 207 to the upper side of the winding of relay 206 it prevents the operation of relay 206 when relay 205 now connects ground to the lower side of that winding, thus discriminating between a call initiated at a local substation and a call from a trunk. The attendant now operates her dial to interrupt the circuit of relay 200 and the vertical and rotary magnets are operated as described for a local call to extend the connection to the wanted subscriber. Ringing current is supplied to the called subscriber's line in the manner previously described and induced tone is given back to the operator through the lower winding of relay 227, next to the outer front contact of relay 208, upper winding of relay 221 and condenser 243. An additional circuit is also provided through condenser 239, the innermost upper front contact of relay 218 and condenser 244 in order to give increased volume to the ringing induction.

When the operator hears this tone, she may at once listen out or may await the answer of the called subscriber, as seems more desirable. If she listens out at once, she first restores the key 505, releasing relay 503 which reconnects her substation to the outgoing end of the trunk. However, the operation of relay 503 closed a circuit from battery through the lower winding of relay 513, next to the inner front contact of relay 503 to ground at the upper normal contact of key 506. Relay 513 prepared a locking circuit for itself from conductor 512, over

the outer lower back contact of relay 510, front contact and upper winding of relay 513, lower back contact of relay 503 to ground at key 506. Relay 513 is slow-to-release and therefore this locking circuit is established before the relay releases in response to the opening of its circuit by relay 503. Conductor 512 extends, as will be remembered, through the lower winding of relay 200 to battery. Therefore, relay 200 is held operated and the selector-connector is not released by the restoration of key 505. The operator next restores key 315 to its left position, releasing relay 308. The release of relay 308 establishes a circuit from ground through the upper winding and upper contact of relay 307, inner upper back contact of relay 308, over the ring conductor through the line switch to the inner normal contact of relay 201 to battery through the lower winding of relay 200. This circuit continues to hold the selector-connector until the subscriber answers. The release of relay 308 disconnects the position apparatus from the trunk and releases relay 513. It also releases relay 306, but lamp 318 remains lighted and relay 311 remains operated over the back contact of relay 306, lower front contact of relay 311 to ground on conductor 316 supplied by the line switch.

If instead of a ringing tone the operator receives the busy tone she will restore key 505 as above described, which will reconnect her telephone to the calling subscriber and enable her to report that the line is busy. In order to release the attempted connection or to try to call the subscriber again she will operate release key 506 with key 315 operated. With key 315 operated, relay 308 is operated and the operation of key 506 opens conductor 507 and thereby deenergizes relay 311 and extinguishes lamp 318. It also removes ground from conductors 508 and 317 releasing the line switch and selector-connector, thus placing the apparatus in condition for reoperation or complete release.

When the called subscriber answers, relay 227 operates and locks, as previously described. The operation of relay 227 operates relay 201 in a circuit over next to the innermost upper front contact of relay 227, inner back contact of relay 206, conductor 207 to ground as previously traced at the upper front contact of relay 301. The operation of relay 201 disconnects the tip and ring conductors of the line switch from the windings of relay 200 and connects them to the called subscriber's substation.

The operator need not restore key 505 immediately. Relay 514 operates in the dialing circuit through the attendant's substation, closing a circuit for relay 515 over its front contact to ground at the next to the outer lower front contact of relay 503. When the called subscriber answers, the disconection of relay 200 causes relay 514 to release, closing a circuit from battery through the winding of relay 516, front contact of slow-to-release relay 515, back contact of relay 514 to ground at next to the front contact of relay 509. Relay 516 locks over its inner upper front contact to ground at key 505. Relay 516 in operating closes a circuit for relay 510 which establishes a talking circuit between the called subscriber and the operator. This circuit may be traced from conductor 510, over next to the innermost and the innermost lower front contacts of relay 512, through talking condenser 525, lower alternate contact of relay 510, lower alternate contact of relay 503, lower normal contact of key 504 to the operator's telephone, back over the upper normal contact of key 504, upper alternate contact of relay 503, upper alternate contact of relay 510, talking condenser 526, upper front contact of relay 510 to conductor 511 and thence as traced to the called subscriber's station. The called subscriber receives battery through the winding of feed coil 517, while the operator receives talking current through the windings of relay 518. The operator may then talk with the called subscriber, after which she will restore key 505, releasing relays 516 and 510. Relay 510 is slow-to-release, so that the release of relay 516 closes a momentary bridge across conductors 511 and 512 over the uppermost back contact of relay 516, and next to the outer lower front contact of relay 510. A similar bridge is closed across the operator's telephone circuit through resistance 524, lowermost front contact of relay 510 and middle contact of relay 516. These bridges absorb the discharge from the talking condensers. The restoration of key 505 also opens the holding bridge across conductors 501 and 502 and reconnects them with the operator's telephone. She will now restore key 315 to its normal left hand position, releasing relay 308. With relay 308 released, the talking circuit extends over the back contacts of relays 304 and 308, through the line switch, contacts of relay 201, contacts of relay 218 to the called subscriber.

If the called subscriber wishes to recall the attendant, he depresses his switch hook momentarily in the usual maner. Relay 306 releases, in turn releasing relay 309 and unlocking relay 312. When the switchhook is again closed, relays 306 and 309 reoperate, but relay 312 cannot. With relay 306 operated and relay 312 released, lamp 314 is lighted in a circuit extending over the upper back contact of relay 312, innermost front contact of relay 302 to ground at the inner upper front contact of relay 306. Therefore, lamp 314 will flash at each operation of the switchhook. This flashing is also trans-

mitted to the calling substation, since relay 309 in operating and releasing repeatedly reverses the connection of relay 302 to the interoffice trunk, causing relay 611 to be operated intermittently. Relay 611 in turn causes the intermittent opening of the supervisory bridge through retard coil 613 to operate the cord lamp, not shown. When the operator answers by moving the switch 315 to its middle position, relay 308 is operated as before, permitting the operator to talk with the called subscriber. Since relay 309 is operated at this time, a circuit is closed around the contacts of relay 308 so that the talking circuit between the calling and called subscribers remains intact. With relay 308 operated, relay 312 is reoperated in a circuit over the lowermost front contact of relay 309 to ground at next to the innermost lower contact of relay 308. Relay 312 again locks through the contact of relay 306. With relay 308 operated, conductor 317 is transferred from the control of relay 301 to conductor 508 over the inner alternate contact of relay 308. If the call is to be transferred to a different branch line, the operator will operate key 506, removing ground from conductor 508, thus releasing relay 106 and disconnecting the trunk from the selector-connector which was used in establishing the first connection. The operator will then restore the release key 506 and operate the dialing key 505 to cause the line switch to pick another selector-connector after which she will set up the call to the other PBX line in the manner described.

Release is under the joint control of the called and calling subscribers. When the local subscriber restores his receiver, relay 306 releases, in turn releasing relay 309 and relay 312. With relays 309 and 312 released, the polarity of current in the interoffice line is reversed and relay 611 releases. The release of relay 611 opens the supervisory bridge and lights the cord lamp to inform the operator that the called subscriber has hung up. The removal of the calling plug from jack 609 connects the high resistance winding of relay 611 across the interoffice line and releases relay 302. With relay 302 released, relay 301 also releases, removing ground from conductor 317 to release the line switch and thereby release the selector-connector employed.

The operator may originate a call to the distant branch exchange. To do so she will test the trunk by operating the trunk key 315. This connects her telephone to the trunk by operating relay 308 so that she may know the line is idle. Relay 306 operates as before, operating relay 301, lighting lamp 305 and grounding conductor 300 to mark the line busy. She then operates key 519. This key closes a circuit from battery through the winding of relay 304, uppermost back contact of relay 303, lowermost front contact of relay 308, conductor 523, key 519, through the attendant's telephone, conductor 501, upper alternate contact of relay 308 to ground through the upper winding of relay 306. Relays 304, 311 and 303 now operate to send an impulse of ringing current, relay 303 remaining locked to the upper front contact of relay 301 as before. When the attendant at the distant PBX answers the local attendant may restore key 519 and call the local subscriber as on an incoming call. She may also originate a call by calling the local subscriber first and then the distant branch exchange.

Outgoing call to automatic PBX.

The private branch exchange of the present invention also has access to a machine switching branch exchange by means of interoffice trunks. The local end of one trunk is shown in Fig. 4 and the distance end in Fig. 7 where it terminates in a line switch and appears before a selector-connector.

Assuming that the subscriber at substation 100 wishes to talk with the subscriber at substation 700 located at the distant machine switching branch exchange, he will originate a call in the manner previously described, setting the selector-connector on the terminals of an idle trunk leading to that branch exchange. When the selector-connector brushes come to rest on the terminals of the trunk, relay 400 operates in a circuit which may be traced from battery through the lower winding of relay 400, back contact of relay 401, inner upper back contact of relay 402, over the ring conductor to the ring brush of the selector-connector, next to the upper contact of relay 218, inner upper front contact of relay 201, over the ring conductor through the calling line switch contacts to the calling subscriber's line, and back over the outer upper front contact of relay 201, upper front contact of relay 218 to the tip brush of the selector-connector, outer upper back contact of relay 402, upper winding of relay 400 to ground.

Relay 400 in operating closes an obvious circuit for relay 403 and also closes a circuit across the tip and ring conductors of the interoffice line extending from the ring conductor through coil 404, low resistance winding of polarized relay 405, lower back contact of relay 402, outer lower front contact of relay 400 to the tip conductor. At the distance end of the line, this circuit is completed from the ring conductor over the inner back contact of relay 701 to battery through winding of a relay in the line switch and from the tip conductor over the upper back contact of relay 701 through the winding of relay 703 to ground at the line switch. The line switch operates its plunger to extend the conductors to a selec-

tor-connector similar in type to that shown in Fig. 2 but arranged to receive dialing from the trunk. The selector-connector at the distant office prepares a circuit for receiving pulses.

At the outgoing end of the trunk, the operation of relay 403 connects ground to conductor 406 over a circuit which may be traced from ground at its lower front contact, lower back contact of relay 407, back contact of relay 408, inner back contact of relay 409 to conductor 406 and busy lamp 410. A branch of this circuit extends from conductor 406 over the outer lower back contact of relay 409 to the winding of relay 408 which relay locks over its inner lower front contact, lower back contact of relay 407, to ground at the outer lower front contact of relay 403. With relay 408 operated a circuit is closed from battery through the winding of relay 409, inner lower front contact of relay 403, uppermost front contact of relay 408 to ground. Relay 409 locks over its upper front contact to ground at the outer upper front contact of relay 408, opening the energizing circuit of relay 408 and connecting a substitute ground to conductor 406 over its lower front contact. It also prepares a circuit for relay 411 which is completed when dialing is started.

At the distant branch exchange the operation of relay 703 closes a circuit for relays 704 and 705. This circuit may be traced from battery through the winding of relay 704, normal contact of relay 706, outer lower back contact of relay 701 to the armature of relay 703, and from battery through the winding of relay 705, normal contact of relay 704, back contact of relay 707 to the armature of relay 703, whence the circuit is completed to ground over conductor 708 which is grounded at the line switch in a manner similar to conductor 316. The operation of relay 705 connects ground from conductor 708 over its inner upper front contact to conductor 709 for the purpose of preventing the operation of a discriminating relay similar to relay 206 in the selector-connector. With relay 705 operated, relay 710 is operated in an obvious circuit, in turn operating relay 707. With relay 707 operated ground is connected to the sleeve terminal where the trunk appears before selector-connectors thus completing the making busy of the trunk at all points. It also connects conductors 708 and 709 together at a different point and opens the operating circuit of relay 705 which relay remains operated under the control of relay 704.

The subscriber at substation 100 now receives the dial tone from the distant selector-connector, informing him that he may complete the dialing of the wanted subscriber's number. At the first impulse, relay 400 releases closing a circuit from ground over its lower back contact, lower front contact of relay 408, middle lower front contact of relay 409 to the winding of relay 411 and battery. Relay 411 in operating closes a circuit from the ring conductor over its upper front contact, inner upper front contact of relay 403, lowermost front contact of relay 400 back to the tip conductor. This circuit shunts relay 405 and coil 404 while relay 400 is operated making a low resistance path for relay 703. However, when relay 400 releases, the circuit of relay 405 is also opened so that relay 703 releases following the release of relay 400. Relay 411 is slow-to-release and remains operated during dialing. It also connects resistance 412 and condenser 413 in the ring conductor to improve the dialing due to the surges of current through condenser 413.

At the completion of the first digit, relay 400 remains operated reclosing the circuit of relay 405 and releasing relay 411. The operation for dialing a second digit is essentially the same for that of the first digit and as soon as dialing is completed, the local end of the trunk is ready for talking.

At the distant end of the trunk, relay 703 follows the dial impulses but relay 704 is slow-to-release and remains energized. The selector-connector operates in a manner similar to the selector-connector of Fig. 2, supplying ringing current to the called station when dialing is completed. When the called station answers, the connector extends the connection from the called station through to the trunk conductors. When this happens, relay 703 releases since battery is no longer supplied to it from the connector. With relay 703 released, relay 704 in turn releases and releases relay 705. With relay 705 released, a circuit is closed from battery through the winding and lower normal contact of relay 711, back contact of relay 705, inner front contact of relay 710 to ground over conductor 708. Relay 711 locks through its lower alternate contact directly to conductor 708. It connects the tip and ring conductors from the called substation to the upper and lower windings of relay 702 respectively, to supply talking current to the called subscriber. It likewise closes a circuit from ground over its lowermost front contact to the windings of relays 701 and 717 in parallel, disconnecting the interoffice conductors from the normal pulsing circuit and connecting them over back contacts of relay 712 and the normal contacts of relay 713 to relay 714 and to the talking condensers 715 and 716. Relay 714 closes a substitute circuit for relay 710 holding that relay operated under control of the originating office. Relay 702 in operating closes a circuit for relay 713 which reverses the connection of battery through relay 714 to the interoffice trunk operating polarized re-

lay 405 at the originating office. The operation of relay 405 completes a circuit from battery through the winding of relay 414, lowermost normal contact of relay 402 to ground at the front contact of relay 405. Relay 414 provides an additional locking circuit for relay 409. The talking circuit is now complete and conversation may be carried on.

Assuming that the subscriber at substation 700 restores his receiver first, relay 702 will release in turn releasing relay 713. The release of relay 713 again reverses the connection of relay 714, over the interoffice line, producing current of such direction as to release relay 405. With relay 405 released, relay 414 also releases but relay 409 is held operated at the front contact of relay 408. When the subscriber at substation 100 restores his receiver, relay 400 releases in turn releasing relay 403 and relay 408. The release of relay 400 opens the circuit of relay 405 and therefore permits relay 714 to release, in turn releasing relays 710 and 707 and disconnecting conductors 708 and 709 from each other. This brings about the release of the selector-connector and line switch at the called office thereby releasing relay 711 and relays 717 and 701. The release of relays 409 and 403 removes ground from conductor 406 extinguishing lamps 410 and releasing the selector-connector and line switch at the originating office.

Incoming call from machine switching branch exchange.

If the subscriber at substation 700 wishes to call the subscriber at substation 100, he will remove his receiver from the switchhook causing his line switch to pick an idle selector-connector. This selector-connector will then be operated under the control of the subscriber's dial to select an idle outgoing trunk such as that shown in Fig. 7.

In the manner described in connection with the selector-connector of Fig. 2, a circuit is closed from ground in the selector-connector through a relay therein to conductor 718 whence it extends over the upper normal contact of relay 707 to the windings of relays 701 and 717 in parallel to battery. Current in this circuit causes the operation of the selector-connector relay whereupon the subscriber's line is connected through to the trunk and relay 702 is operated. Likewise direct ground is connected to conductor 718, operating relays 701 and 717. With relay 702 operated, ground is connected locally to conductor 718. The operation of relay 702 causes the operation of relay 713 reversing the current supplied to the interoffice trunk. Relay 713 also closes a circuit through the winding of relay 710, innermost lower front contact of relay 713, to ground at the back contact of relay 711. Relay 710 in turn operates relay 707. Relay 707 opens the energizing circuit of relays 717 and 701. These relays are held operated over the upper contact of relay 717 to conductor 718. With relay 701 operated the incoming dialing circuit and line switch are disconnected. A circuit is closed from battery through the winding of relay 704, normal contact of relay 706, lowermost front contact of relay 701, to ground at the inner lower back contact of relay 711. Relay 704 in operating closes an obvious circuit for relay 705. Since relay 717 is operated at this time, relay 712 is now operated in the circuit from battery through the winding of relay 712, lower contact of relay 717, uppermost contact of relay 705 to ground at the inner back contact of relay 711. Relay 712 connects ringing current over its inner lower front contact and front inner lower contact of relay 701 to the ring conductor of the interoffice line. It also connects ground over its upper front contact and the upper front contact of relay 701 to the tip conductor of the interoffice line.

At the incoming end of the trunk, this circuit extends through resistance 412, condenser 413, back contact of relay 403, lowermost back contact of relay 414, alternating current relay 415 to the tip conductor. Relay 415 operates in response to this ringing current and closes a circuit for relay 408 from ground at the front contact of relay 415, lowermost back contact of relay 409 to the winding of relay 408 and battery. Relay 408 in operating connects ground over its inner upper front contact to its energizing circuit to hold itself operated following the termination of the impulse of ringing current.

At the originating end of the trunk, the operation of relay 712 also closes a circuit from ground over its lowermost contact to the winding of relay 706 and battery, which relay locks over its alternate contact, lowermost front contact of relay 701, to ground at the inner lower back contact of relay 711. Relay 706 in operating opens the energizing circuit of relay 704 and that relay releases after an interval in turn releasing relay 705 and relay 712, terminating the impulse of ringing current. This impulse of ringing current is therefore measured by the operating time of slow-to-operate relay 706 and the releasing time of the slow-to-release relay 704 as well as the normal releasing times of relays 705 and 712.

With relay 408 operated at the terminating end of the trunk, a circuit is closed from ground at the back contact of relay 400, lowermost front contact of relay 408, lower normal contact of relay 409 to trunk lamp 417 and battery, indicating to the attendant that a call is awaiting his attention on the corresponding trunk. The oper-

ator will then move key 418 to its middle position closing a circuit from battery through the winding of relay 402, left contact of key 418, lower right normal contact of key 418 to ground. Relay 402 in operating connects the operator's telephone to the windings of relay 400 which in turn closes a circuit for relay 403 thereby completing the extension of the operator's telephone to the interoffice trunk. In addition the operation of relay 402 extends conductors 511 and 512 toward the line switch associated with the trunk which has been indicated by the rectangle at the left hand side of Fig. 4. This line switch is essentially the same as that shown at the right hand side of Fig. 1 which is individual to the trunk of Fig. 3. Relay 402 in operating also connects conductor 507 to conductor 419 corresponding to conductor 316 of the trunk of Fig. 3 and extends conductor 508 to conductor 416 corresponding to conductor 317.

When relay 400 operates it connects relay 405 across the tip and ring conductors through both windings and, since relay 713 is operated at this time, the polarity of the battery connected to the interoffice trunk is such as to operate polarized relay 405. The operation of relay 405 closes a circuit from battery through the upper winding of relay 407, inner lower back contact of relay 414, next to the lowermost front contact of relay 402 to ground at the front contact of relay 405. Relay 407 operates and locks over its inner upper front contact to ground at the lowermost front contact of relay 402. Relay 407 in operating closes a shunt at its uppermost front contact around the high resistance winding of relay 405 permitting relay 714 to operate. The operation of relay 714 provides an additional holding circuit for relay 710.

It will be noted that relay 405 does not operate unless the calling condition is present on the trunk. The operator may then listen in on a trunk without originating a call thereover, since the distant line switch cannot operate through the high resistance winding of relay 405.

The operator then inquires the number of the wanted subscriber. She then operates the dialing key 505 which operates relay 503 in the manner previously described. The operation of the attendant's circuit is the same as described in connection with Fig. 3. The operation of key 505 connects ground to conductor 507 lighting guard lamp 420 and causing the line switch to operate to extend the tie line to an idle selector-connector. When the attendant has completed dialing and the selector-connector rings the wanted subscriber as indicated to the operator by the ringing tone, the attendant may then restore key 505 as well as key 418. The restoration of key 418 permits the release of relay 402, thus disconnecting the operator's telephone circuit from the trunk. With relay 402 released, conductor 416 is connected to the front contact of relay 408 in order to hold the line switch operated. Relay 400 releases on the release of relay 402 since its operating circuit is now opened. Relay 403 in turn releases.

The release of relay 400 closes a circuit from battery through winding of relay 411, middle lower front contact of relay 409, lowermost front contact of relay 408 to ground at the back contact of relay 400. Relay 411 in operating closes a circuit from battery through the upper winding of relay 401, lowermost front contact of relay 411, lowermost front contact of relay 407, to ground at the lowermost front contact of relay 403. The operation of relay 411 extends conductor 419 over the middle lower front contact of relay 407, to guard lamp 420 and also over the inner lower front contact of relay 411 to the lower winding of relay 407 holding relay 407 operated and maintaining lamp 420 lighted since ground is supplied to conductor 419 from the line switch. A bridge is closed across the tip and ring conductors for holding the distant end of the trunk which may be traced from the ring conductor, through coil 404, low resistance winding of relay 405, uppermost front contact of relay 407, inner normal contact of relay 402, innermost lower contact of relay 407 to the tip conductor. Relay 401 closes a circuit from ground through its lower winding and front contact, inner upper normal contact of relay 402, over the ring conductor through the line switch to battery through the pulsing relay of the selector-connector to hold the selector-connector until the called subscriber answers. With relay 402 released, relay 414 operates over the lowermost normal contact of relay 402, lower contact of relay 405 to ground. When the called subscriber answers, the selector-connector extends the called subscriber's line directly through to the trunk. It also removes battery from the locking circuit of relay 401 and that relay releases again connecting relay 400 to the ring conductor. Relay 400 reoperates and operates relay 403 to complete the ring conductor.

The operation of relay 400 opens the circuit of relay 411 which in turn opens the circuit of relay 407 and extinguishes lamp 420 indicating to the operator that the connection has been closed through. The operation of relay 400 also closes a shunt circuit in combination with relay 402 around the high resistance winding of relay 405 in substitute for that over the front contact of relay 407. Relay 407 being slow-to-release, this circuit is completed before the first one is opened.

If the called line is busy, as indicated by the busy tone, or the subscriber fails to answer, as indicated by prolonged lighting of lamp 420, the operator may release the apparatus by operating key 418, followed by key 506. The operation of key 418 puts the control of the line switch and connector again under the position apparatus and the operation of key 506 removes ground from conductors 507 and 508 to release the switching apparatus. The attendant's telephone is connected to the trunk at this time and she may inform the calling subscriber that the called line is busy. The subsequent restoration of key 418 completes the release of the trunk.

If now the called subscriber wishes to recall the attendant, he may depress his switchhook in the usual manner. This causes the release of relays 400 and 403, opening the locking circuit of relay 408 permitting that relay to release. Relays 400 and 403 reoperate when the switchhook is reclosed but the energizing circuit of relay 408 is not restored. Lamp 417 is lighted over the inner lower front contact of relay 409, back contact of relay 408, back contact of relay 407, to the front contact of relay 403. Each time that the subscriber depresses the switchhook, this circuit is opened and lamp 417 flashes in accordance therewith. The intermittent release of relay 400 opens the bridge across the tip and ring conductors of the trunk permitting relay 714 to release but these reversals have no function in the machine switching exchange.

The response of the attendant causes the operation of relay 402 and the reoperation of relay 408 and extinguishes lamp 417. Relay 414 is held operated at this time over a front contact of relay 402, outer lower front contact of relay 414, conductor 508 to ground at key 506. Therefore, the connection of the operator's telephone to the trunk does not open the connection between the two subscribers. The attendant may transfer the call in a manner similar to that described for Fig. 3.

Disconnection is controlled by the calling subscriber. The restoration of the called subscriber's receivers deenergizes relays 400, 403 and 408, while the release of the calling subscriber's receiver deenergizes relays 405, 404 and 409. If the called subscriber restores his receiver first, the deenergization of relay 400 opens the shunt around the high resistance winding of relay 415 and releases relay 714. The restoration of the calling subscriber's receiver deenergizes relay 702 which releases relay 713. With relays 714 and 713 both released, relays 710 and 707 may release in turn releasing relays 717, 701 and 706. The release of relay 708 releases the line switch and the selector-connector, and restores the connection to normal.

The operator may also originate a call to the branch exchange of Fig. 7. As before, she tests the trunk by operating the trunk key 418, operating relay 402 in turn operating relays 400, 403 and 408. She then operates key 519 closing a circuit from ground through the upper winding of relay 400, outer upper alternate contact of relay 402, conductor 501, through the attendant's telephone, conductor 502, key 519, conductor 523, next to the inner front contact of relay 402, upper normal contact and upper winding of relay 407 to battery. Relay 407 locks to the lowermost front contact or relay 402 and closes a shunt around the high resistance winding of relay 405. With relay 400 operated relay 405 is bridged across the trunk conductors, initiating a connection as previously described. After the completion of the connection to the distant subscriber the operator may extend it to a local subscriber as previously described. Calls may also be established by the operator in the reverse order, i. e., to the local subscriber and then to the distant subscriber.

The attendant's telephone is assigned a line number and an individual line switch the same as other extension lines. An incoming call to her telephone will cause the operation of relay 520 which relay locks up through its right winding and front contact, back contact of relays 514 and 515 to ground. The operation of relay 520 lights lamp 521. The attendant responds to this signal by operating key 504 which operates relay 515 extinguishing lamp 521. It will be noted that the locking circuit of relay 520 extends through key 522 which is open when the position is unattended so as to prevent the locking of this relay. The operation of key 504 also connects the operator's telephone to the line terminals in the selector-connector completing the talking circuit. The attendant may also connect to a subscriber's substation by means of her line switch.

If any of the subscribers is not entitled to outgoing service, conductor 111 at the individual switch will be connected to ground. When the subscriber at that line switch attempts a call to a trunk or to the central office, at which levels contacts 237 and 240 are closed, ground will be connected from conductor 111 over line switch contact 112, conductor 113, normal contact 241, contact 240 to the same armature of relay 219 as is connected to sleeve brush 223. Therefore, at each rotary step when relay 224 tests the condition of the sleeve brush, it will find ground connected thereto and will release to permit another rotary step. When the last trunk in the level has been tested, the eleventh rotary step contact 241 will open and relay 224 will release. In this position contact 242 will close and relay 226 will operate in a circuit from ground through

the winding of relay 226, contact 242, upper winding of relay 221, and next to the uppermost front contact of relay 208 to battery through lower winding of relay 227. Relay 226 initiates the generation of busy tone which is applied to the calling subscriber's line through contact 242, condenser 243 and the uppermost normal contact of relay 201.

The branch exchange is, of course, provided with trunk lines extending to the central office. These trunks operate in substantially the same manner as do the trunks herein described and they have therefore not been shown or described.

What is claimed is:

1. In a telephone system, a local exchange, a distant exchange, telephone lines terminating in the local exchange, trunk lines extending between said exchanges, an automatic switch, means for associating a calling telephone line with said switch, means for associating a trunk line with said switch, means at said local exchange for supplying talking current to calling and called telephone lines when said switch is associated with a calling line, means for disconnecting said supply means, a device operable when said switch is associated with a calling telephone line to render said disconnecting means ineffective, and means for preventing the operation of said device when said switch is associated with a trunk line to render said disconnecting means effective.

2. In a telephone system, a local exchange, a distant exchange, telephone lines terminating in the local exchange, trunk lines extending between said exchanges, an automatic switch, means for associating a calling telephone line with said switch, means for associating a trunk line with said switch, means at said local exchange for supplying talking current to calling and called lines, means for disconnecting said supply means, a relay operable when said switch is associated with a calling telephone line to render said disconnecting means ineffective and means for preventing the operation of said relay when said switch is associated with a trunk line to render said disconnecting means effective.

3. In a telephone system, a local exchange, a distant exchange, telephone lines terminating in the local exchange, trunk lines extending between said exchanges, an automatic switch, means for associating a calling telephone line with said switch, means for associating a trunk line with said switch, means at said local exchange for supplying talking current to calling and called lines, means for disconnecting said supply means, a relay operable when said switch is associated with a calling telephone line to render said disconnecting means ineffective, and means controlled by said trunk for preventing the operation of said relay, when said switch is associated with a trunk line to render said disconnecting means effective.

4. In a telephone system, a local exchange, a distant exchange, telephone lines terminating in the local exchange, an attendant's position at the local exchange, trunk lines extending between said exchanges through said attendant's position, an automatic switch, supervisory means at said attendant's position, means at said attendant's position for controlling the extension of a connection from said trunk line over said switch to a telephone line, means for operating said supervisory means in a given manner, and means controlled from a called telephone line for operating said supervisory means in a different manner.

5. In a telephone system, a local exchange, a distant exchange, telephone lines terminating in the local exchange, an attendant's position at the local exchange, trunk lines extending between said exchanges through said attendant's position, an automatic switch, supervisory means at said attendant's position normally controlled from the distant exchange, means at said attendant's position for controlling the extension of a connection from said trunk line over said switch to a telephone line, and means effective following the completion of said connection to place said supervisory means under the control of the called telephone line.

6. In a telephone system, a local exchange, a distant exchange, telephone lines terminating in the local exchange, an attendant's position at the local exchange, trunk lines extending between said exchanges through said attendant's position, an automatic switch, supervisory means at said attendant's position normally controlled from the distant exchange, means at said attendant's position for controlling the extension of a connection from said trunk line over said switch to a telephone line, and means effective following the completion of said connection to reoperate said supervisory means under the control of the called telephone line and to remove said supervisory means from the control of said distant exchange.

7. In a telephone system, a local exchange, a distant exchange, telephone lines terminating in the local exchange, an attendant's position at the local exchange, trunk lines extending between said exchanges through said attendant's position, an automatic switch, supervisory means at said attendant's position normally controlled from the distant exchange, means at said attendant's position for controlling the extension of a connection from said trunk line over said switch to a telephone line, means effective following the completion of said

connection to reoperate said supervisory means under the control of the called telephone line and to remove said supervisory means from the control of said distant exchange, and means controlled by said attendant to restore said supervisory means to the control of the distant exchange.

8. In a telephone system, a local exchange, a distant exchange, telephone lines terminating in the local exchange, an attendant's position at the local exchange, trunk lines extending between said exchanges through said attendant's position, an automatic switch, means at said attendant's position to connect her position apparatus with said trunk, means at said position to control the extension of a call from said trunk line over said switch to a called telephone line, and means in said trunk for preventing the release of said switch following the disconnection of said position apparatus from said trunk.

9. In a telephone system, a local exchange, a distant exchange, telephone lines terminating in the local exchange, an attendant's position at the local exchange, trunk lines extending between said exchanges through said attendant's position, an automatic switch, means at said attendant's position to connect her position apparatus with said trunk, means at said position to control the extension of a call from said trunk line over said switch to a called telephone line, means in said trunk for preventing the release of said switch following the disconnection of said position apparatus from said trunk, and means operated from said called line to transfer the control of the release of said switch to said called line.

10. In a telephone system, a local exchange, a distant exchange, telephone lines terminating in the local exchange, an attendant's position at the local exchange, trunk lines extending between said exchanges through said attendant's position, an automatic switch, means at said attendant's position to connect her position apparatus with said trunk, means at said position to control the extension of a call from said trunk line over said switch to a called telephone line, means in said trunk for preventing the release of said switch following the disconnection of said position apparatus from said trunk, means operated from said called line to transfer the control of the release of said switch to said called line, and means for releasing said switch if said transfer means is not operated, effective only when said position apparatus is connected with said trunk.

11. In a telephone system, a local exchange, a distant exchange, automatic switching mechanism at said distant exchange, a trunk line extending between said exchanges having two branches, one of said branches comprising a continuous pulsing path normally connected into said trunk line, and the other of said branches comprising a normally disconnected talking path, means at the local exchange for transmitting control impulses over said first branch to control said switching mechanism, and means operative following the cessation of control impulses to disconnect said first branch from said trunk circuit and to connect said other branch to said trunk circuit.

12. In a telephone system a local exchange, a distant exchange, automatic switching mechanism at said distant exchange, a trunk line extending between said exchanges having two branches, one of said branches comprising a continuous pulsing path normally connected at each of its ends into said trunk line, and the other of said branches comprising a normally disconnected talking path, means at the local exchange for transmitting control impulses over said first branch to control said switching mechanism, and means operative following the cessation of control impulses to disconnect said first branch from said trunk circuit and to connect said other branch at each end thereof to said trunk circuit.

13. In a telephone system, an exchange, telephone lines terminating therein, an attendant's position, automatic switching mechanism, means at said attendant's position for transmitting impulses to control said switching mechanism to establish a connection from said position to a telephone line, a telephone subset at said attendant's position, means for supplying talking current to said subset, and means automatically operative following the transmission of said control impulses to connect said subset to said current supply means and to the connected telephone line.

14. In a telephone system, an exchange, telephone lines terminating therein, an attendant's position, automatic switching mechanism, means including a pulsing circuit at said attendant's position for transmitting impulses to control said switching mechanism to establish a connection from said position to a telephone line, a telephone subset at said attendant's position, a normally disconnected talking circuit, and means automatically operative following the transmission of said control impulses to insert said talking circuit in said pulsing circuit.

15. In a telephone system, an exchange, telephone lines terminating therein, an attendant's position, automatic switching mechanism, means including a pulsing circuit at said attendant's position for transmitting impulses to control said switching mechanism to establish a connection from said position to a telephone line, a telephone subset at said attendant's position, normally

disconnected means for supplying talking current to said subset and to said telephone line, and means automatically operative following the transmission of said controlled impulses to insert said current supply means in said pulsing circuit.

16. In a telephone system, an exchange, telephone lines terminating therein, an attendant's position, automatic switching mechanism, means including a pulsing circuit at said attendant's position for transmitting impulses to control said switching mechanism to establish a connection from said position to a telephone line, a telephone subset at said attendant's position, a normally disconnected talking circuit including current supply means for said subset and said telephone line, and means automatically operative following the transmission of said control impulses to insert said talking circuit into said pulsing circuit.

In witness whereof, I hereunto subscribe my name this 4th day of January A. D., 1927.

ALFRED E. HAGUE