May 31, 1938. O. C. HALL ET AL 2,119,209

TELEPHONE SYSTEM

Filed April 7, 1936 9 Sheets-Sheet 1

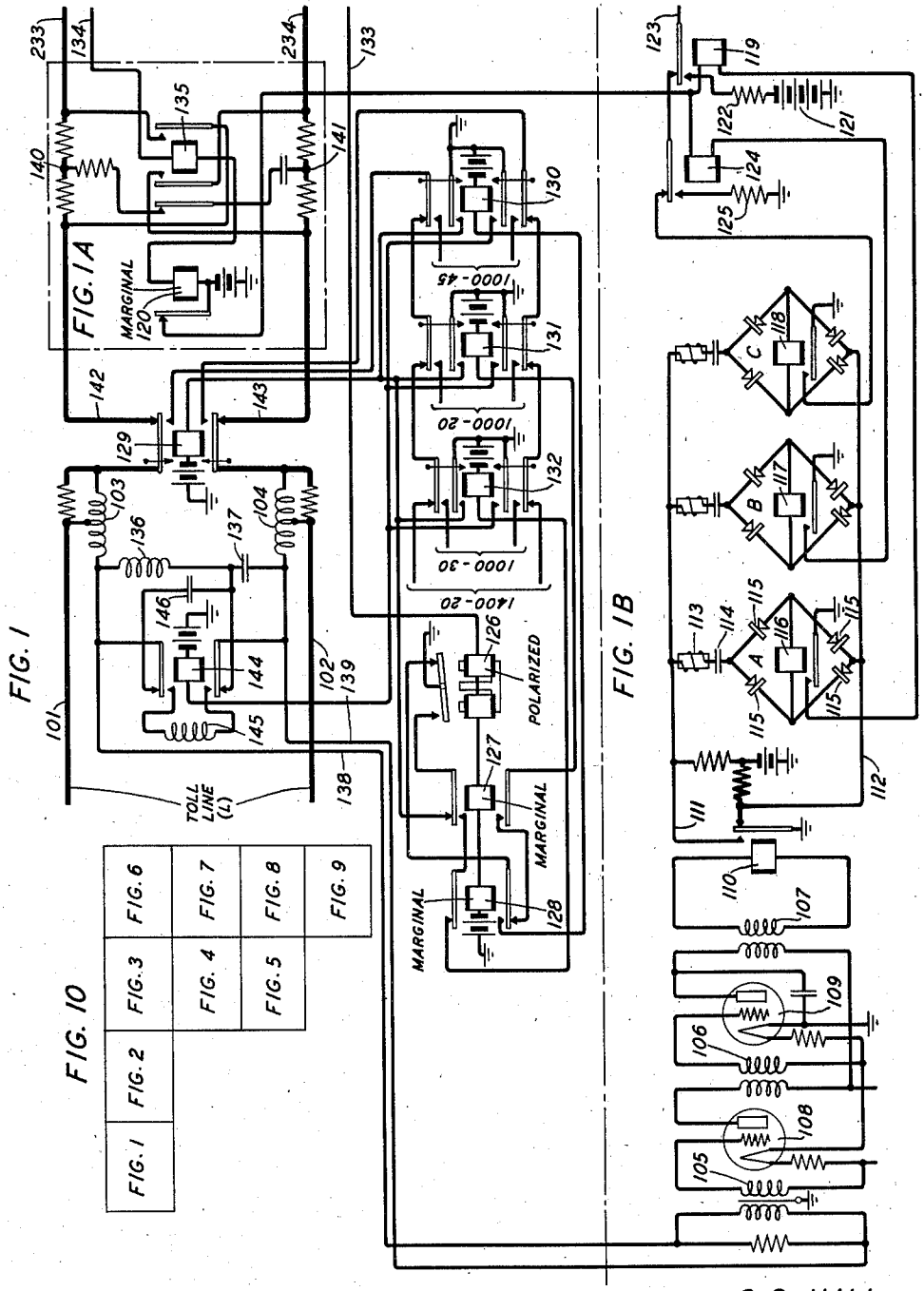

FIG. 10

FIG. 6	FIG. 7	FIG. 8	FIG. 9
FIG. 3	FIG. 4	FIG. 5	
FIG. 2			
FIG. 1			

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TELEPHONE SYSTEM

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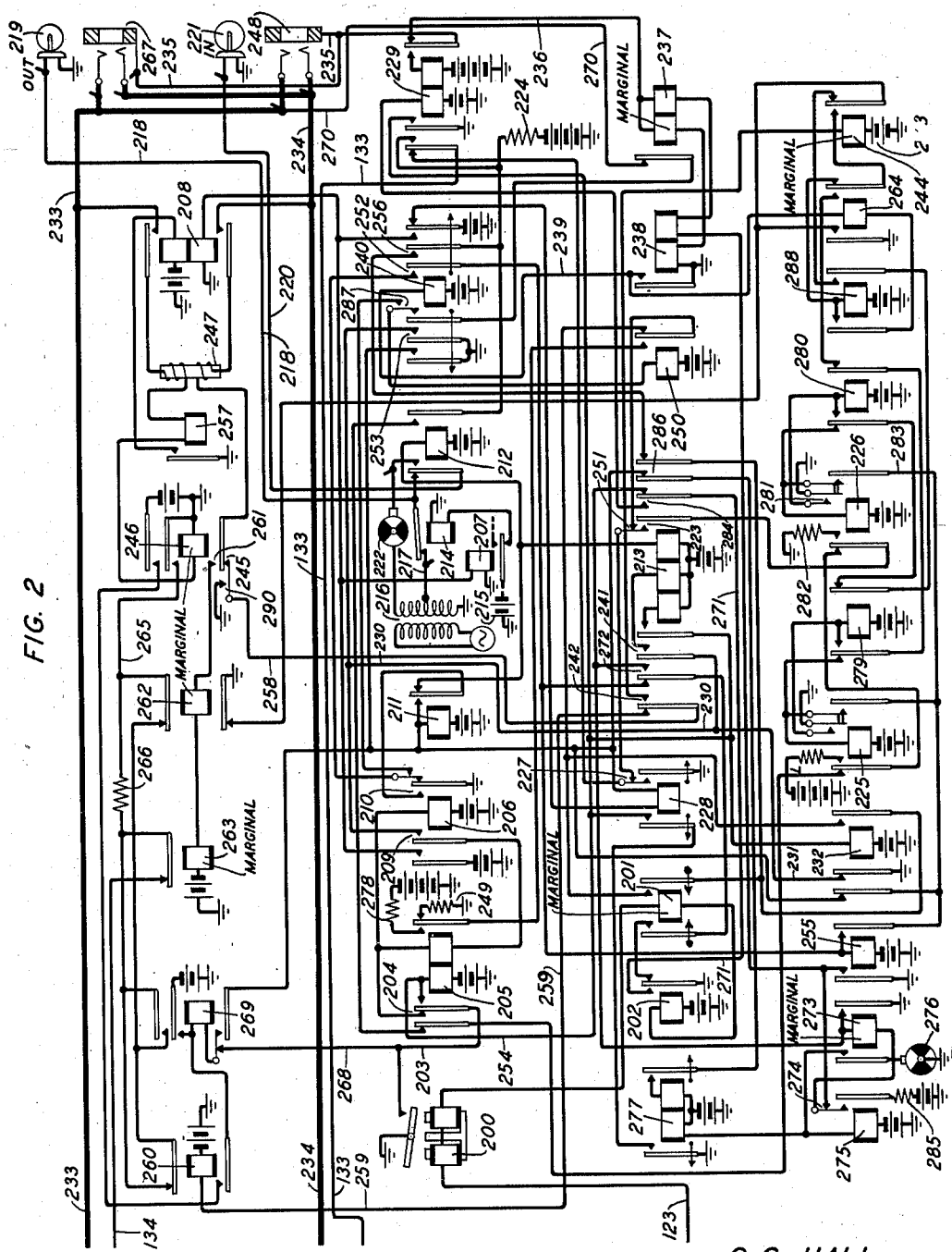

FIG. 2

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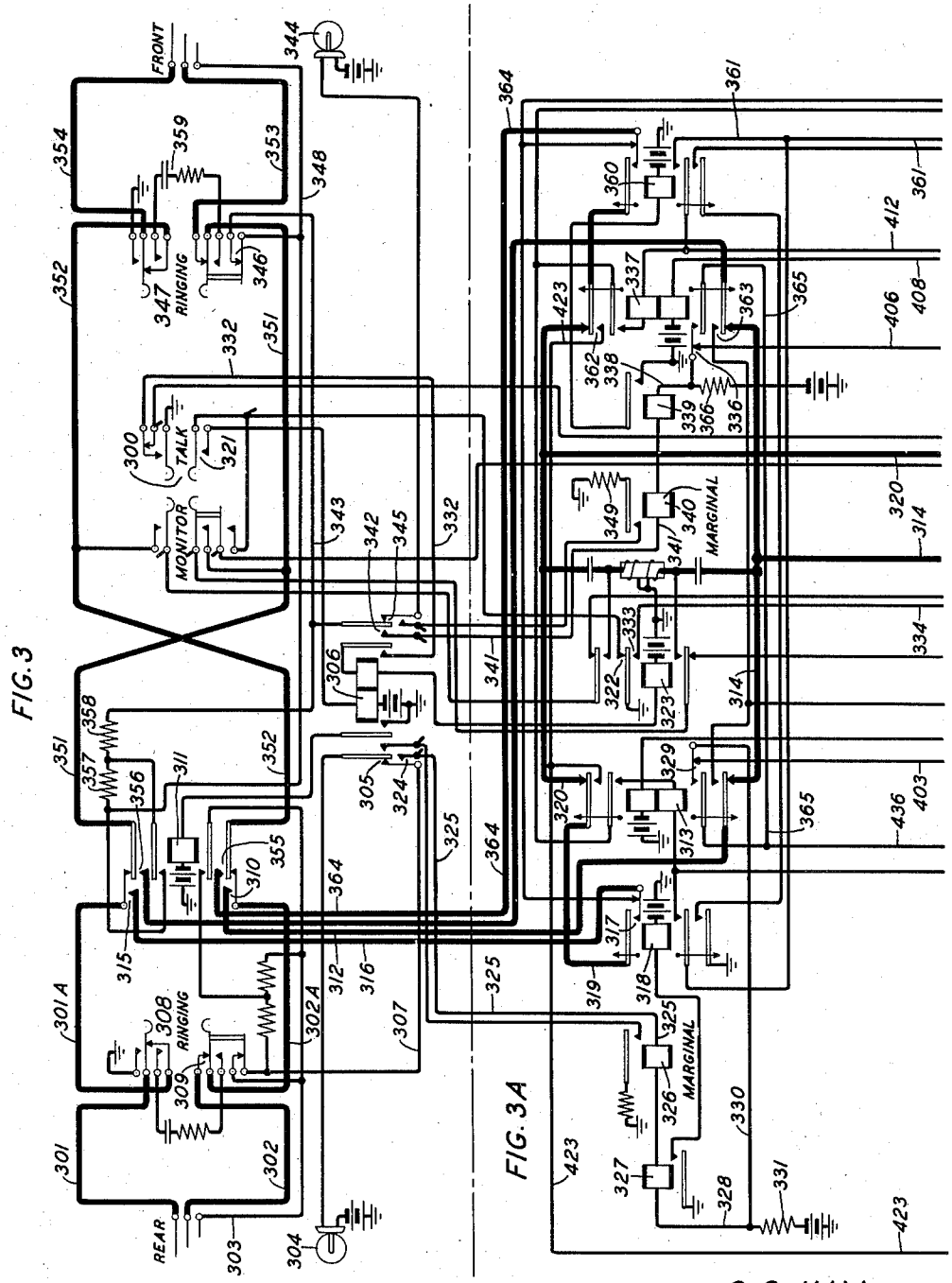

FIG. 3

FIG. 3A

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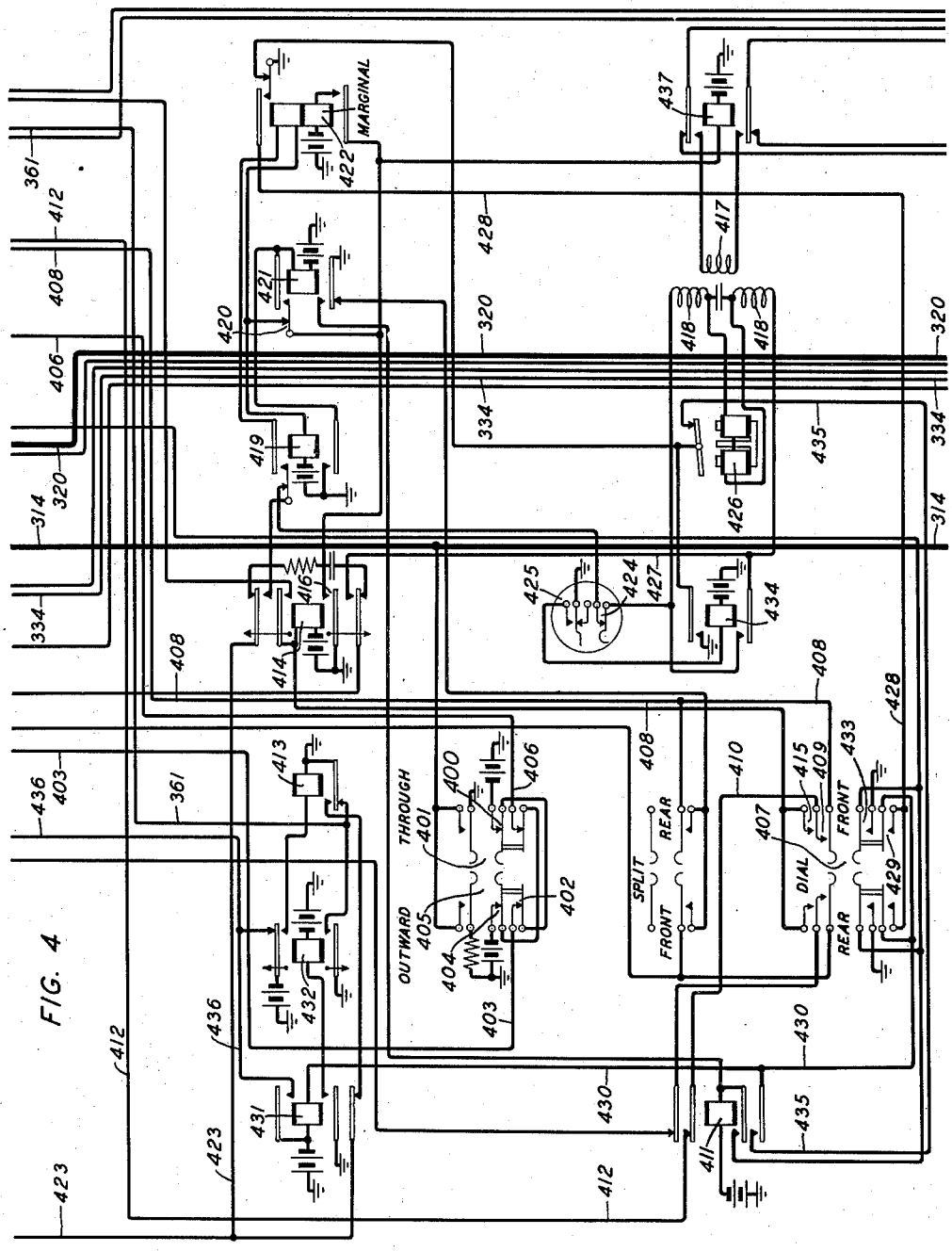

FIG. 4

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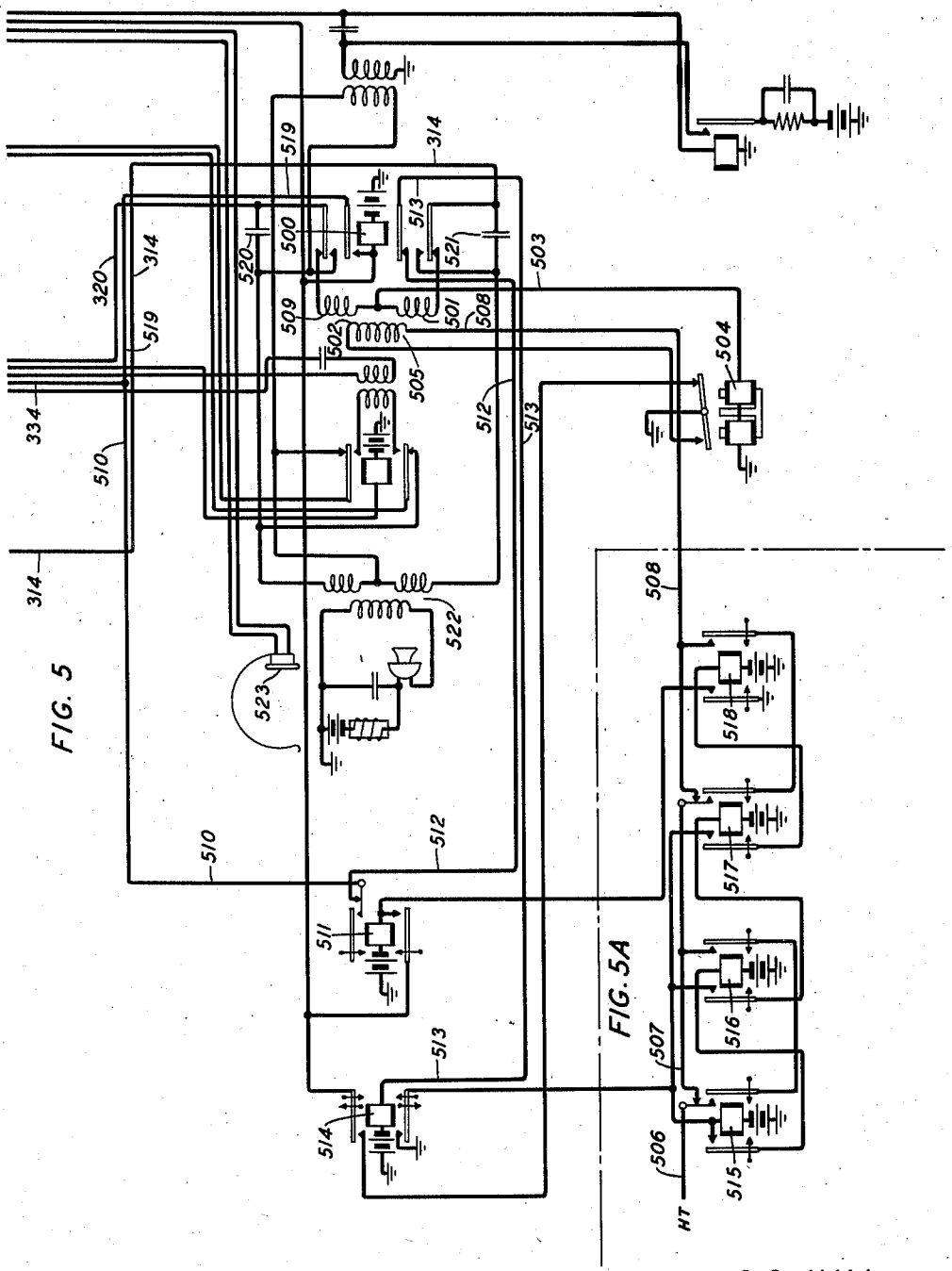

FIG. 5

FIG. 5A

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Filed April 7, 1936 9 Sheets-Sheet 6

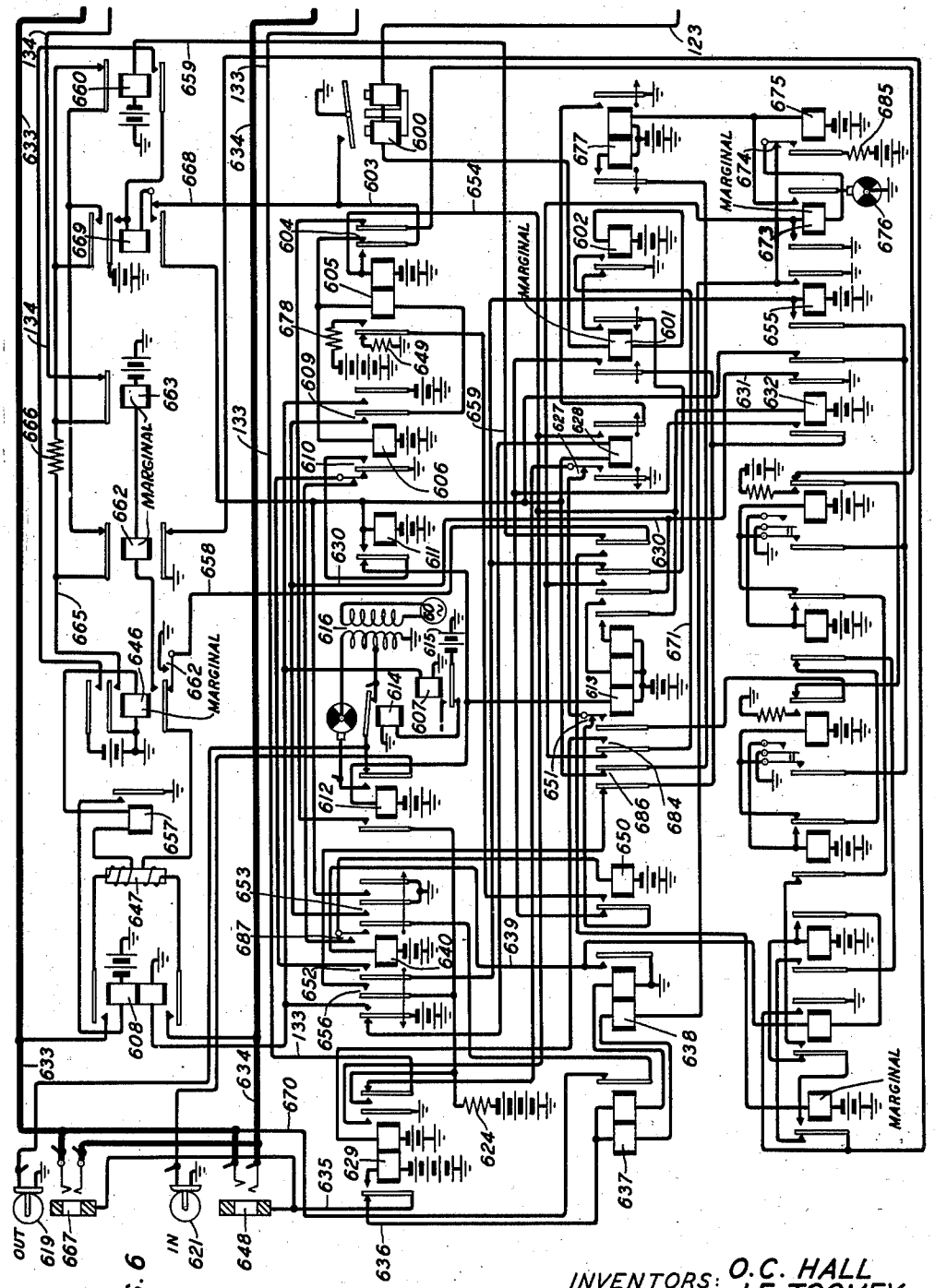

FIG. 6

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TELEPHONE SYSTEM

Filed April 7, 1936 9 Sheets-Sheet 7

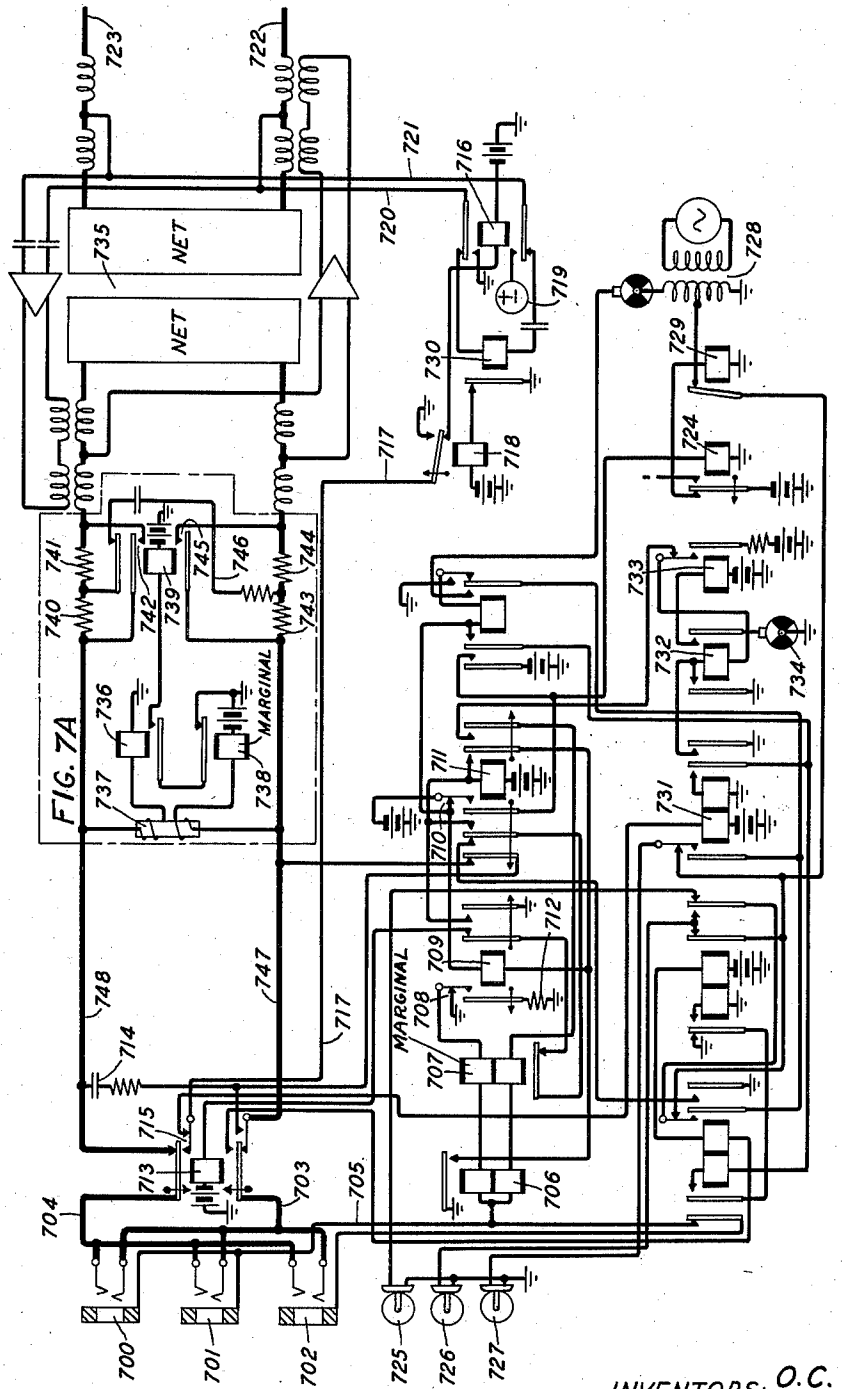

FIG. 7

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TELEPHONE SYSTEM

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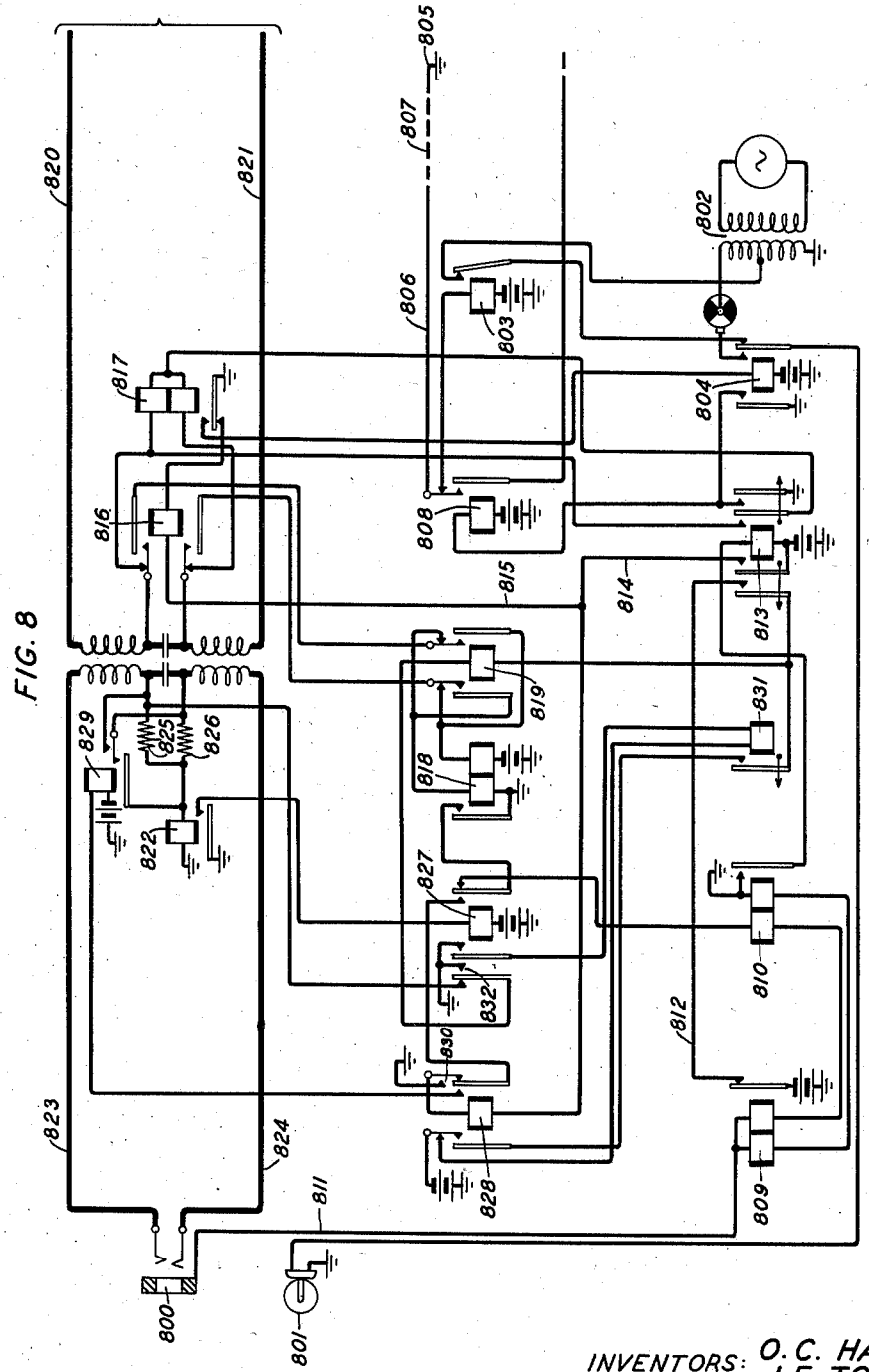

FIG. 8

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TELEPHONE SYSTEM

Filed April 7, 1936 9 Sheets-Sheet 9

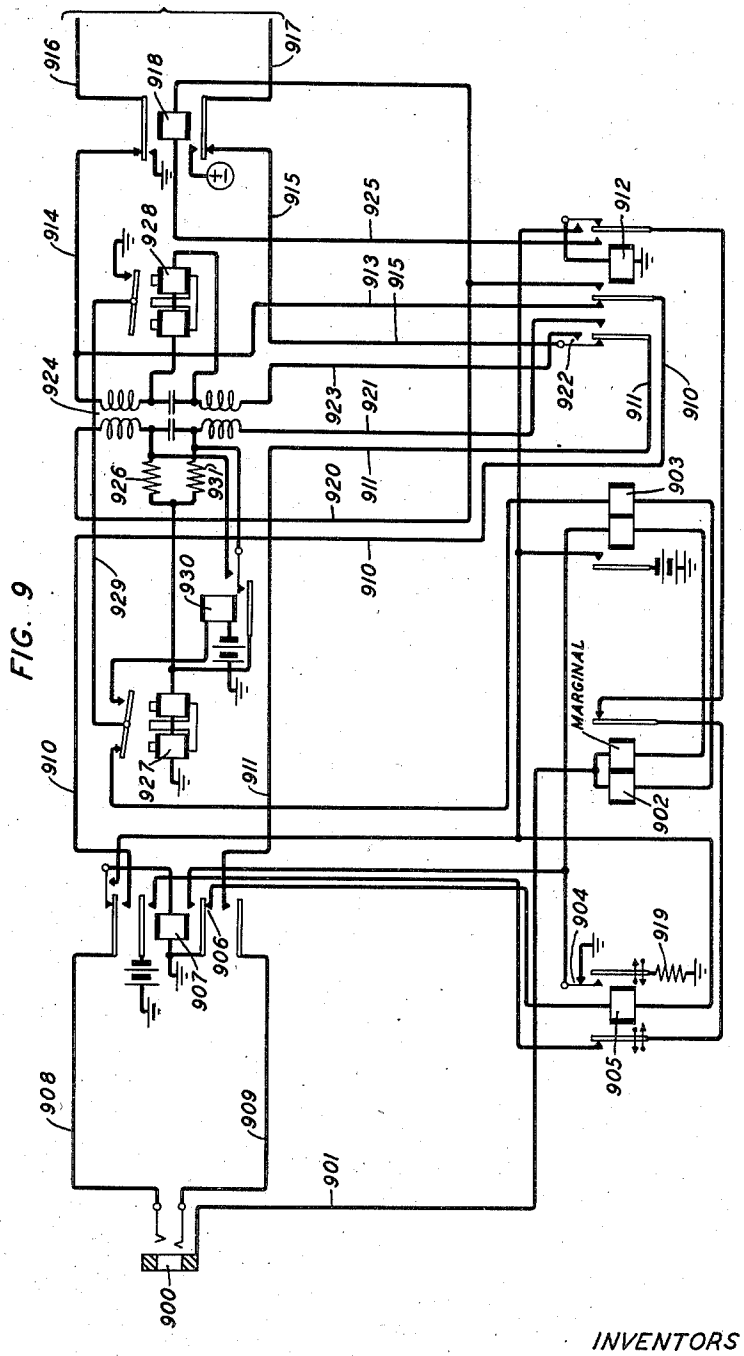

FIG. 9

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Patented May 31, 1938

2,119,209

UNITED STATES PATENT OFFICE

2,119,209

TELEPHONE SYSTEM

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Application April 7, 1936, Serial No. 73,110

20 Claims. (Cl. 179—43)

This invention relates to telephone systems and more particularly to systems for switching toll or long distance lines of different characters.

In a copending application, Serial No. 108,146, filed on Oct. 29, 1936, by Meszar and Wiese, an arrangement is disclosed whereby when an incoming automatic or voice-frequency straightforward toll line is connected in tandem to a second line of the same type, or to a completing trunk circuit, the supervisory signals originating at the terminal office or subscriber's station are transmitted back through the switching point to the outward toll operator.

In the Meszar et al. arrangement mentioned the straightforward lines terminate in a single cord and plug at the inward or through position.

When the outward toll operator connects a calling line to the outgoing straightforward line the distant inward and through operator is automatically connected, receives the order and inserts the plug terminal of the line either in a trunk jack, in the case of a terminating connection or into the outgoing jack of another toll line. In the case of a terminating connection supervision received from the terminating local office or called subscriber's station will be transmitted through the toll operator's position back over the incoming line to the outward or originating toll operator's position without displaying any signals at the inward and through position. In case the call is to be routed to a distant city the inward and through operator plugs the calling line into a second straightforward line outgoing to the desired point. In this case, also, any supervisory signals originating at the distant end of the connection are transmitted back over both straightforward lines to the outward operator without displaying any supervisory signals at the inward and through positions.

At the inward and through position outgoing ring-down toll lines are also terminated over which the operator may extend a calling straightforward line. In this case a reverting ring from the distant end of the line such as a "ring-off" passes through the intermediate operator's position and signals the outward operator without affecting the supervisory signals at the intermediate through office.

In the Meszar et al. arrangement, due to the fact that the inward ends of the straightforward lines are plug-ended, separate inward and through and outward switchboards are required, the inward and through board being used exclusively for terminating through calls and the outward board, which is equipped with the usual double-ended cord circuit, being used for outward calls, i. e. calls originating locally for extension over toll lines to a distant point.

This system is very efficient and satisfactory for large offices, but may be undesirable, from a cost standpoint, for small offices where a small number of operators, operating as a single group, could handle all of the toll traffic both inward, through and outward were they in a position to do so.

An object of the present invention, therefore, is to provide such an arrangement that a single operator can handle all types of toll calls.

A feature of the invention whereby the foregoing object is obtained resides in such an arrangement of toll lines, trunk circuits and cord circuits, that all such types of lines, i. e., both inward and outward trunks, straightforward toll lines and ring-down toll lines may be terminated at a single operator's position and interchangeably connected at will by means of a universal double-ended toll cord circuit arranged to adapt itself for the proper kind of supervision, i. e., through or terminating depending upon the types of lines connected thereby.

Another feature resides in a novel method of controlling the exclusion of transmission loss pads from toll lines when two lines, so equipped, are connected together by means of a cord circuit which method consists in so connecting the pad control relay of each line to the line conductors in series with a battery, and so arranging the cord circuit that, when the lines are connected together, and the cord circuit talking key is not operated, the talking conductors of the cord circuit are reversed with respect to the two ends thereof, thereby connecting the tip of one line to the ring of the other line and vice versa whereby the pad control relay of each line will receive operating current to exclude the respective pads from the lines.

Another feature resides in so arranging the cord circuit that when the operator plugs into a calling straightforward toll line and actuates the talking key, a "zip" order tone will be connected to the calling line as an indication to the outward operator that the inward and through toll operator is connected and that she may pass the order.

In the patent to L. F. Porter 1,608,524, issued November 13, 1926 a toll system comprising a toll cord Fig. 2 and a ring-down toll line Fig. 3 is disclosed whereby ringing current is connected to the toll line by means (relay 307) controlled by direct current connected to the tip of the cord

by operation of the ringing key. This general arrangement is standard practice at the present time, but has the disadvantage that the tip conductor of the line is permanently grounded through a retard coil and the ringing control means. As the ring conductor of the line is also used in a similar manner to perform other functions such as "transfer", which necessitates a similar permanent ground thereon through the lower winding of the retard coil and left-hand winding of relays **315** and **314**, it will be noted that an impedance bridge exists across the line which may be traced from the tip through the upper winding of the retard coil, winding of relay **307** and resistance **308** to ground and from ground through relays **314** and **315** and lower winding of the retard coil to the ring of the line.

Another feature of the present invention, therefore, resides in a novel means for controlling the various desired signaling functions, over the tip and ring as heretofore, which obviates the necessity of a permanent ground connection to the line conductors.

Ringing is accomplished in this case by a marginal relay arrangement controlled over the sleeve of the cord and line, whereby, when the ringing key is operated the ringing relay is connected to the tip of the line only while the key is operated. Operation of the ringing key also connects ground to the tip of the line causing the ringing relay to operate. Other functions previously controlled over the ring are likewise controlled over the sleeve by the operation of keys in the operator's position which connects the proper relay to the ring conductor which operates to ground simultaneously applied to the ring conductor by the actuation of the same key.

Another feature of the invention is a single lamp per line which serves both as an idle line indicating signal and also as a line or calling signal. When the line is idle the lamp burns steadily at reduced brilliancy. When a call is received the brilliancy increases and the lamp starts to flash.

The invention will be more fully understood from the following description in which; Fig. 1 represents the line end of an automatic toll line together with Fig. 1A representing a pad circuit for transmission purposes; Fig. 2 represents the toll office end of the automatic toll line; Fig. 6 represents the toll office end of another automatic toll line identical with Fig. 2 for the purpose of more readily tracing a call from one line to another of said lines, Fig. 7 represents a two-way ring-down toll line; Fig. 8 represents a two-way trunk circuit for use in recording and completing calls originating from subscribers in manual offices and for completing connections to subscribers on connections terminating at the toll office; Fig. 9 represents an out-dialing trunk circuit for completing calls on a dial basis to subscribers on connections terminating at the toll office. A description of the initiation and completion of calls over these circuits in conjunction with a toll operator's cord circuit of Fig. 3, the operator's position circuit of Fig. 3A, a position dial circuit of Fig. 4, an operator's telephone circuit of Fig. 5 and order tone circuit of Fig. 5A will serve to illustrate the various features of this invention wherein Fig. 10 represents the arrangement of Figs. 1 to 9 of the drawings. For convenience the reference characters used have been chosen in groups of **100**, those from **100** to **199** referring to Fig. 1, **200** to **299** to Fig. 2, etc.

General description of operation

In general the operation of the present system may be briefly outlined as follows: Both the automatic toll line and the ring-down toll line in this system are arranged to function on calls in either direction. When therefore the front plug of the toll cord of Fig. 3 at an outward position is plugged into the outgoing jack **667** of the toll line of Fig. 6 extending to a distant office, the relays of these circuits function; to extinguish the associated idle line indicating lamp **619** thereby enabling the next idle line indicating lamp to light; to light the associated cord supervisory lamp **344**; and to send out a voice-frequency signal over the talking conductors to the distant office. This signal is received at the distant office by a circuit organization such as shown in Figs. 1 and 2 and which functions; to return an acknowledgment signal to the originating office after the calling condition is registered, in order that the connect signal may then be cut off; to start the associated trunk lamp **221** to flashing for indicating an incoming call to the inward toll operator. The first inward operator answers by inserting the rear plug of her toll cord into the associated jack **248** and at the same time operating her talking key on the toll cord which results in; extinguishing the flashing line lamp **221**; automatically causing the toll cord of Fig. 3 to be associated with the common toll signal equipment shown in Figs. 3A, 4, 5 and 5A; and automatically sending zip tone back over the talking conductors to the calling operator as an indication that the second operator is ready to receive the number of the called subscriber.

When the calling toll operator passes the wanted subscriber number the incoming operator then plugs the front end of the toll cord into jack **667**, if the call is required to be completed over another automatic toll line or jack **700**, if the call is to be completed over a ring-down toll line, jack **800** if she completes the call over a toll switching trunk, or jack **900** if the call is to be completed to a dialed subscriber in the local office. In the case of the call being extended over another automatic toll line the same action takes place as when the first operator originated the call on the previous toll line, namely, extinguish the idle line indicating lamp, light the associated cord lamp and send on a connect signal to the next toll office. The next inward operator answers the incoming flashing signal, and the same action takes place as described for the previous operator except that now the original operator hears the zip tone from the last operator's telephone and order tone circuit. The first operator again passes the wanted subscriber number and the connection is then assumed to be completed over a standard toll switching trunk to the wanted number.

When the called subscriber answers, the toll line circuit then automatically sends back a receiver-off-hook signal which passes through the toll cord at the intermediate toll office, and is received by the originating toll line which returns an acknowledgment signal to the line and causes the first operator's toll cord lamp **344** to be extinguished. If the called subscriber hangs up for any reason, a receiver-on-hook signal is similarly transmitted to the originating toll line circuit where it is acknowledged and cord lamp **344** again lighted. If the called subscriber flashes-in the calling operator then the above noted signals are transmitted over the toll line alternately and the

cord lamp **344** thereby follows the called subscriber switchhook. When however the called subscriber hangs up at the end of conversation the lamp **344** burns steadily and the originating operator takes down the cord plug which causes the toll line to send a disconnect signal which the toll line at the through office acknowledges by giving the through operator a steady cord lamp **304** and sending back an acknowledgment signal to the originating toll line which in turn terminates the disconnect signal and the circuits restore to normal. The through operator in turn disconnects her plug in a similar manner which causes the toll line to send a disconnect signal to the terminating operator. The toll operator at the terminating office therefore receives a disconnect signal by noting a steady light **304** and she also then disconnects her toll cord and an acknowledgment signal is returned to the intermediate toll line causing the disconnect signal to cease and the apparatus all to restore to normal.

Assuming now, in the call described above, that the number had been such as to require completion at the intermediate toll office over the ringdown toll line of Fig. 7 instead of over a second automatic toll line. In this case the intermediate toll operator inserts the front toll cord plug into jack **700** instead of jack **667**.

Connection between two automatic toll lines

For the purpose of describing the through supervisory features, ringing, transfer, and other signaling and control functions on toll lines of this character a call will be traced; as it originates in one toll office, referred to as office X; as it is carried through an intermediate toll office, referred to as office Y; and as it terminates in a third office, referred to as office Z. Since the detailed description of the automatic toll line represented by Fig. 2 on such a call depends on whether the call is being described in an inward or an outward direction, Fig. 2 will be referred to when the call is inward and Fig. 6 will be referred to when the call is outward in direction. Thus on calls originating at office X a toll cord the same as in Fig. 3 is assumed as being plugged into a toll line the same as Fig. 6. The line end Fig. 1 of the toll line then is assumed to connect with a similar Fig. 1 at office Y and which in turn connects with Fig. 2. The toll cord of Fig. 3 in this office then serves to illustrate its use on through supervision. In extending the call outward to office Z the operator in office Y thus is assumed to plug into the toll line of Fig. 6 and again the line end Fig. 1 of the extended toll line is assumed to connect with a similar line end at office Z and which in turn connects to Fig. 2.

Before proceeding to trace the call outlined above it should be observed that the transmission and reception of high frequency signals over telephone lines for supervisory purposes is not new. To facilitate this description however reference may be had to Patent No. 1,860,446 to R. S. Bailey et al. which describes in detail that part of the toll line shown in Figs. 1 and 1B. Briefly this arrangement involves transmitting an acknowledgment signal of predetermined frequency back over the line whenever an incoming signal arrives. The receipt of the acknowledgment signal at the sending end results in cutting off the signal being sent. When the incoming signal ceases at the receiving end of the line it causes the acknowledgment signal to cease. Since this necessitates a circuit arrangement that both sends and receives high frequency signals simultaneously there is interposed in line L a directional selection circuit composed of coils **103**, **104**, **136**, and condenser **137** which is of the nature of a hybrid transformer. Such an arrangement is disclosed and claimed in the patent to George Crisson No. 1,755,243 issued April 22, 1930 and as it forms no part of the present invention, it is deemed sufficient to merely state that it prevents the voice frequency signal applied to the line L by relay **129** from becoming effective over leads **138** and **139** in operating the signal receiving apparatus of Fig. 1B without interfering with incoming high frequency signals which must be registered by the apparatus of Fig. 1B. To facilitate this selection, whenever an outgoing signal of 1400 cycle carrier frequency is being sent, relay **144** remains in its normal position, thus tuning the incoming leads **138** and **139** to receive signals having a frequency of 1000 cycles. When signals of 1000 cycles are being sent relay **144** is in an operated position which by connecting coil **145** and opening the condenser **146** tunes the incoming circuit to receive signals having a 1400 cycle carrier frequency.

High frequencies of any suitable values may be used in signaling of this character. For the system here described high frequencies of 1000 cycles and 1400 cycles are employed as the carrier frequency. Three separate signals are then obtained when 20 cycle, 30 cycle or 45 cycle current is superimposed on the carrier frequency of 1000 cycles. The acknowledgment signal has 20 cycle current superimposed on a 1400 cycle carrier frequency. The receiving apparatus shown in Fig. 1B for identifying the incoming signal includes transformers **105**, **106**, and **107**; an amplifier vacuum tube **108** and a rectifier tube **109** for separating the low frequency current from the carrier frequency; and a vibrating polar relay **110** for responding to the low frequency component. The output of this network connects over leads **111** and **112** with three low frequency tuned circuits designated A, B and C. Tuned circuit A responds to 20 cycle frequencies and consists of a tuned coil **113** connected in series with a condenser **114**, rectifiers **115** and direct current relay **116**. Similarly, tuned circuit B responds to 30 cycle frequencies for operating relay **117** and tuned circuit C responds to frequencies of 45 cycles for operating relay **118**. Incoming signals therefore operate relay **116**, **117** or **118**. If relay **116** operates it connects ground to winding of relay **119** thence to battery at break contact relay **120** thereby operating relay **119** and connecting 48 volt battery **121** through high resistance **122** to lead **123**. If relay **117** operates it connects ground to winding of relay **124**, thence to battery at break contact **120** thereby operating relay **124** to connect ground through resistance **125** to lead **123**. If on the other hand relay **118** operates, it connects ground through the back contact of relays **124** and **119** direct to lead **123**. The three different kinds of incoming signals therefore are transformed into three corresponding conditions that are connected to lead **123** as above described and these conditions will be referred to in the description that follows without repetition of the above explanation.

While the function of the apparatus shown in Fig. 1B is to receive and transform incoming signals from the toll line to battery or ground signals on lead **123** to Fig. 2, the function of relays **126** to **132** inclusive of Fig. 1 is to convert battery or ground signals on lead **133** coming from Fig. 2 to high frequency carrier signals

for transmission over the toll line. Lead 133 is connected in series through relays 126, 127 and 128 to negative 24 volt battery. Relay 126 being polarized responds by operating when negative 48 volt battery through either a high or low resistance is connected to lead 133 but does not operate on ground signals. Relay 127 is both sensitive and marginal and operates whenever direct ground, ground through a low resistance, or 48 volt battery through low resistance is connected to lead 133. It does not operate however when 48 volt battery is connected through a high resistance to lead 133. Relay 128 is marginal but not very sensitive and only operates when direct ground is connected to lead 133.

Fig. 1A represents a transmission pad circuit of the usual type controllable over lead 134 from Fig. 2 for reducing the transmission equivalent of the toll line at originating and terminating toll offices but removed from the line on through connections at intermediate offices. Lead 134 in this invention in addition to controlling the transmission pad also affects incoming signals to lead 123 depending on the type of circuit to which the automatic toll line is connected. This is accomplished by the addition of relay 120 connected from 24 volt battery in series with the pad control relay 135 to lead 134. Relay 120 being marginal operates for example when direct ground is connected to lead 134 by the toll line of Fig. 2 as will later be described, thus indicating that said toll line is connected to another automatic toll line. If, however, said toll line is connected to a ring-down toll line arranged for transmission pad control, then the ground to lead 134 is through a resistance which permits pad control relay 135 to operate but does not allow marginal relay 120 to operate. In the latter case the incoming signals are not altered. In the former case, however, when relay 120 operates it removes battery from the windings of relays 119 and 124 thus permitting only a disconnect signal to be received as will later be described. When the automatic toll line is connected to a ring-down toll line not arranged for transmission pad control, no ground will be connected to lead 134 thus preventing either of relays 120 or 135 from operating and in this way the transmission pad remains in the circuit and the incoming signals function the associated two-way automatic toll line relays of Fig. 2. Whenever the connection is interrupted, as will later be described, by the operation of a talking or splitting key in the toll cord of Fig. 3 or by the removal of a plug from the jack, ground will be removed from the lead 134 causing relay 135 to release also relay 120 if same had been operated.

Assuming now that the toll operator at the originating office X inserts the front cord plug in jack 667, a path is closed for lighting the cord lamp over a circuit traced from battery through cord lamp 344, contact 345, relay 306 which is assumed to be normal at this time, lead 343, contact 346 on key 347, sleeve lead 348, thence through plug and jack to sleeve lead 635 and 636, thence to ground both through right winding relays 637 and 638 in series, and to ground through the left windings of said relays and right front contact relay 655. The cord lamp 344 now remains lighted until the called subscriber in the distant office answers as will presently be described. The circuit thus traced causes relays 637 and 638 to operate and the latter relay in turn connects ground over lead 639 for operating relay 640 to battery. Relay 640 then closes a path for operating relay 650 traced from ground at left back contact relay 606, contact 687 on relay 640 to battery through winding relay 650. Relay 640 at its left inner contact closes a path for operating relay 655 traced from ground at left back contact relay 606, contact 652 on relay 640, to battery through winding relay 655. Relay 640 also operates relays 608 and 607 from battery at its left outer armature and contact to ground through lower winding relay 608 and winding of relay 607 in multiple. The operation of relay 607 thus opens the winding of relay 614 causing its contact to open thereby extinguishing idle indicating trunk lamps 619 and 621. The operation of relay 650 closes a path for causing a connect signal to be sent to the distant toll office Y which may be traced from ground through resistance 649, left back contact and armature relay 605, front contact and armature relay 650, contact 651 on relay 613, contact 627 on relay 628, right back contact and armature relay 629, thence over lead 133 and through windings in series of relays 126, 127 and 128 in Fig. 1 to negative 24 volt battery. Relay 127 operates and closes a path for operating relay 131 over a path traced from ground at right contact relay 126, bottom armature and back contact 120, lower front contact relay 127 to battery through winding relay 131. Relay 131 operating at its bottom inner contact connects ground to winding of relay 144 thus tuning the receiving circuit of Fig. 1B for an acknowledgment signal having a carrier frequency of 1400 cycles. Relay 131 at its top inner contacts also operates relay 129 for sending out a connect signal of 1000 cycles— 20 cycles which is connected to the front contact of relay 129 by relay 131.

The connect signal is registered by the automatic toll line at office Y which then returns an acknowledgment signal to office X as will presently be described. The receipt of an acknowledgment signal at the originating office X causes negative 48 volt battery 121 through a high resistance 122 to be connected to lead 123 as previously described. This causes relay 609 to operate and connect ground through contact 604 on relay 605 to winding relay 606 to battery. The latter relay in operating at its left armature and break contacts opens the ground path previously traced for operating relays 650 and 655. Relay 650 releases thereby opening the circuit to lead 133 and terminating the connect signal being sent to distant office Y. Termination of the connect signal at office Y in turn terminates the acknowledgment signal which will presently be described, thus releasing relay 609 which in turn removes ground for holding relay 606. The latter relay continues, however, to be held by ground traced at right back contact relay 632, leads 631 and 630, contact 609 on relay 606, thence through winding relays 605 and 606 in series to battery. Relay 605 operates in this circuit and thus prepares the circuit for further signaling which will later be described.

When the connect signal, on the call here being traced, comes in at office Y it may come in on toll line which is not the first idle line or it may come in on a line which is the first idle line. For the purpose of this description the latter case is assumed and relay 214 is accordingly shown in an operated position. Loops 219 and 223 at this time are burning dimly on low alternating current voltage extending from ground on transformer 216 over common lead 217, through front contact and armature; directly to lead 218

for lighting lamps 219 at outward toll positions; and through left break contact and armature relay 212 to lead 220 for lighting lamps 221 at the inward toll position.

The connect signal, upon first being received at office Y results in connecting 48 volt battery 121 through resistance 122 to lead 123 which may further be traced through winding of polarized relay 200 in series with slow operate relay 201 and marginal relay 202 to 24 volt battery. Relay 201 being marginal does not operate because of the high resistance 122. Polarized relay 200 is poled so that it operates at this time thereby connecting ground to lead 203 which is traced further through contact 204 on relay 205, then through winding relay 206 to battery. The operation of relay 206 at its left outer make contact connects battery to the winding of relay 207 and to the bottom winding relay 208 causing both relays to operate. Relay 206 at contact 209 prepares a path for operating relay 205 when battery is removed from lead 123. Relay 206 at contact 210 connects ground to the armature of relay 211, which path traced through the back contact of relay 211 is used to energize winding relay 212 and right winding relay 213 in multiple to battery.

Going back to the operation of relay 207 it will be observed that this relay functions as a busy relay because at its break contact it opens the circuit of relay 214 and that its make contact extends battery 215 through to the armature of relay 214 of the next automatic toll line. Battery 215 therefore operates relay 214 of the first toll line that is idle, that is, whose relay 207 is normal. The operation of relay 207 causes relay 214 to release and open the low voltage current path. At the same time relay 212 having operated, a high voltage 60 cycle current through a flashing interrupter 222 is connected, through the left front contact relay 212 to lamps 221 in front of inward operator positions. Lamps 219 in front of the outward positions, however, remain out due to the left break contact on relay 212. If instead of assuming an incoming call on this toll line we were to have assumed it to be taken for use by a toll operator then relay 207 would have operated as before but 212 would remain normal. In this case all lamps 219 and 221 would be extinguished. Again if this toll line had been assumed to be some intermediate idle toll line the lamps 219 and 221 would also be out. It will therefore be apparent that the use of a single lamp per line appearance serves as an idle indicating lamp for outward calls and also as a flashing line lamp on incoming calls.

The incoming or connect signal in addition to lighting lamp 221 causes an acknowledgment signal to be sent back to the calling toll line. This is accomplished by the operation of relay 213 previously mentioned. Contact 223 on said relay closes 48 volt negative battery through a high resistance 224 to lead 133, which path is further traced through the right front contact of the operated relay 212, left back contact and armature relay 205, left back contact and armature relay 225, left back contact and armature relay 226, contact 223 on relay 213, normal contact 227 on relay 228, thence through left back contact and armature relay 229 to lead 133.

As previously described polarized relay 126 operates under this condition and in turn operates relay 129 to send a 20 cycle signal superimposed on 1400 cycle carrier frequency. This constitutes an answer back or acknowledgment signal to the toll line circuit at the distant office which cuts off the connect signal being sent, thereby causing relay 200 to release. The removal of ground from conductor 203 which is holding relay 206 operated thus permits relay 205 to operate on its right-hand winding and at the same time continue to hold relay 206 operated. This path is traced from battery through winding relay 206, right winding relay 205, contact 209 on relay 206, conductors 230 and 231 to ground at left inner break contact relay 232. The operation of relay 205 at its left outer break contact then opens the 48 volt negative battery path previously traced to lead 133, thus cutting off the acknowledgment signal to the distant office.

The inward toll operator at office Y noting the flashing of toll line lamp 221 picks up the rear plug of a toll cord circuit such as shown in Fig. 3 and inserts it in jack 248 of the calling toll line of Fig. 2. This action causes a zip order tone to be transmitted to the calling toll operator at distant office X which is an indication to her that the toll operator at office Y is ready to receive the wanted subscriber's number. The insertion of the rear plug in jack 248 connects cord conductors 301 and 302 with toll line conductors 233 and 234 respectively. Also in like manner toll sleeve conductor 303 is connected with line sleeve 235. If it be assumed that the toll operator has not as yet thrown talking key 300, then the sleeve condition may be traced from battery through cord lamp 304, contact 305 on relay 306, lead 307, lower contact on ringing key 308, thence over sleeve 303 of plug and sleeve 235 of toll line jack, through right-hand armature and back contact relay 229, lead 236 and left-hand windings of relays 237 and 238 in series to ground. Sleeve relays 237 and 238 operate but the resistance of these left-hand windings is too high to permit cord lamp 304 to light. Relay 238 closes ground to lead 239 for operating relay 240 to battery. Relay 240 at its left outer contact connects ground to winding relay 211, causing it to operate, which in turn releases relay 212 to extinguish line lamp 221. Relay 213 which previously operated in multiple with relay 212 does not release due to battery through middle locking winding, contact 241 to ground at left inner armature relay 232. Therefore, contact 242 on relay 213 connects positive 24 volt battery 243 through relay 244 to break contact 245 on relay 246 and thence through lower winding of impedance coil 247 and lower contact relay 208 to ring conductor 234. When the toll operator throws her talking key 300 positive battery 243 connected to ring conductor 234 may further be traced over the ring 302 of the toll cord in Fig. 3, contact 309 on ringing key 308, conductor 302A, contact 310 on operated relay 311, thence over lead 312 and bottom break contact on relay 313, lead 314, bottom break contact relay 500, through winding 501 on repeating coil 502 over lead 503 and through winding polarized relay 504 to ground. Relay 504 operates and connects ground to winding 505, thus closing a circuit for zip order tone potential through winding 505 traced over leads 506, 507 and 508. This tone induced in windings 501 and 509 is then heard by the calling toll operator because talking conductor 302A of the toll cord is connected to the winding 501 by leads 312 and 314 and because talking conductor 301A is connected through contact 315 on operated relay 311 to lead 316, thence through

contact 317 on operated relay 318, lead 319 and top break contact on relay 313, to lead 320, thence through top break contact relay 500, to winding 509. Talking conductor 301 is traced through plug and jack over conductor 233, through pad circuit windings 140, conductor 142 and top break contact relay 129, directional selection coil 103, and conductor 101 to distant end of the toll line circuit similar to Fig. 1. Talking conductor 302 is similarly traced through plug and jack over conductor 234, through pad circuit windings 141, conductor 143 and bottom break contact 129, directional selection coil 104 and conductor 102 to distant end of the toll line.

A further description is here given of other actions that follow the throwing of talking key 300 mentioned in the previous paragraph. In the first place contact 321 on key 300 closes a circuit for operating relay 306 traced from ground at contact 322 on relay 323. Relay 306 at its inner left make contact, closes ground for operating relay 311 direct to battery; at contact 324 it transfers the sleeve lead 307 from lamp 304 to lead 325, which is further traced through relays 326 and 327 in series to battery on lead 328. The direct battery supply to lead 328 is further traced through contact 400 on transfer key 401, contact 402 on key 405, lead 403, thence through contact 329 on relay 313, lead 330 to lead 328. Battery through a high resistance 331 is also connected to lead 328 but has no function at this time. The grounded sleeve 235 of the toll line therefore is connected through relays 326 and 327 to battery. Relay 326 being marginal does not operate because the left-hand winding on sleeve relays 237 and 238 of the toll line have too high a resistance. Relay 327, however, does operate and therefore connects ground to winding relay 318 to battery, causing the latter to operate and close contact 317.

Another action takes place when relay 306 operating on its left-hand winding closes the locking circuit at its right-hand inner contact through a separate winding, said winding being included in a path from ground on talk key 300 traced over lead 332, winding relay 306 and winding relay 323 to battery. The latter relay operates in this path and at contact 333 connects ground to lead 334, which may be traced to lead 510 of Fig. 5, thence through normal contact on relay 511, lead 512, inner bottom break contact relay 500, lead 513 to battery through relay 514. The operation of relay 514 at its bottom make contact closes ground to winding of slow operate relay 515, causing it to operate and open the zip order tone circuit to induction coil 502. At the same time at its left make contact the operating ground is extended to winding of slow operate relay 516 which again restores the zip order tone circuit and at its left make contact extends ground to winding to slow operate relay 517. Relay 517 operates and again opens the zip tone circuit at its left make contact, operates slow operate relay 518 which again restores the zip tone circuit and at its left make contact connects ground to winding slow operate relay 511. Relay 511 operates and at its bottom make contact extends ground to winding relay 500, which then operates and opens the induction coil winding 501 and 509 from the talking leads 314 and 320 causing relay 504 to release. Relay 500 at its top inner contact locks over lead 519 to ground on lead 334 previously traced. Relay 500 at its bottom inner contact opens lead 513 allowing relay 514 to release, thereby releasing relays 515, 516, 517 and 518 in turn. In this manner a zip tone of three zips is transmitted to the calling toll operator. Relay 500 in operating also short circuits condensers 520 and 521 leaving the toll operator's induction coil 522 connected to leads 314 and 320 ready for receiving the wanted subscriber's number which is now passed by the distant calling toll operator.

Another action that follows throwing of talk key 300 has to do with insuring the connection of only one toll cord at a time to the position circuit of Fig. 3A. Inasmuch as this feature does not come within the scope of this invention no description will here be given. Description of this and other features of the toll cord of Fig. 3 may be found in Patent No. 1,608,524 to L. F. Porter.

Let it now be assumed that the called subscriber number requires that the incoming operator at office Y complete the connection over another automatic toll line such as the one shown in Fig. 6. Let it further be assumed that the toll line shown in Fig. 6 is the first idle line connected with the distant toll office through which the call must be connected. In this case relay 607 will be normal and all preceding line circuits will be busy so that battery 615 may be traced through armature and back contact relay 607 thence through winding relay 614 to ground. Lamps 619 and 621 are therefore burning dimly on induced 60 cycle current traced from ground at transformer 616 to front contact and armature relay 607, thence direct to lamp 619 and through right back contact and armature relay 612 to lamp 621. The operator knowing this call will be completed by another toll operator inserts the front cord plug in outgoing jack 667 and restores her talking key to normal. Sleeve conductor 348 thus connects with sleeve conductor 635 thereby closing a circuit for cord lamp 344 and for operating relays 637 and 638 over a path traced from battery through lamp 344, contact 345 on relay 305 now in its normal position, lead 343 and normal contact 346 on ringing key 347 thence over sleeve conductors 348 and 635, left back contact relay 629, lead 636, to ground through right windings relays 637 and 638 which operate. Relay 637 operating prevents tip conductor 633 from being grounded and relay 638 connects ground over lead 639 to winding relay 640, causing it to operate. Relay 640 at contact 652 closes a circuit from battery through winding of relay 655 to ground at back contact and armature relay 606 causing relay 655 to lock at its left front contact to ground at right outer make contact on relay 640 over right outer normal contact on relay 632. Relay 655 operated connects at its right make contact a ground circuit leading to left winding of relays 638 and 637 in series to the sleeve lead 636. This being low resistance in comparison with the circuit through the right-hand windings the overall resistance of the sleeve is materially lower thus causing the toll cord lamp 344 to light.

Insertion of the front plug of the cord of Fig. 3 in jack 667 as just described also removes from the talking circuit the pad circuit shown in Fig. 1A in the toll line from office X and the equivalent pad in the toll line to office Z, due to the operation of relay 135. The manner in which relay 135 in the incoming and outgoing ends of the toll lines is made to operate follows: Relays 208 and 608 having previously been operated on their lower windings and held operated to battery on the outer make contacts of operated relays

240 and 640 respectively, the circuit is completed for the operation of relays 246 and 646 respectively when the cord plug is inserted in jack 667. The path for relay 246 is traced from ground through winding relay 246, winding relay 257, retardation coil 247, top contact relay 208 thence over the tip conductor 233 of the incoming toll line, conductors 301, 351 and 353 of the toll cord, conductor 634 of the outgoing toll line, through bottom contact relay 608, retardation coil 647 bottom armature relay 646 to battery either over lead 658, right armature and back contact relay 613, leads 659 and winding of relay 660 or to battery through marginal relays 662 and 663. In a similar manner the path for operation of relay 646 may be traced from ground through winding relay 646 back over the other side of the talking circuit to battery either through winding of marginal relay 244 of Fig. 2 or through marginal relays 262 and 263. Both relays 246 and 646 operate and thereafter the circuit through winding relay 246 includes marginal relays 662 and 663 and the circuit through relay 646 includes marginal relays 262 and 263. However, the resistance of relays 246 and 646 is too high for the marginal relays just mentioned to operate. Relay 246 at contact 290 closes a ground path for operating relay 244 over lead 258 and contact 242 on relay 213. Relay 246 at its top inner contact closes ground to lead 265 traced further over top armature and contact relay 262, top armature and contact relay 260, top contact and armature relay 263 thence over lead 134 through winding relays 135 and 120 in series to battery. In addition to the operation of relay 135, which removes the pad from the incoming end of the first automatic toll line, relay 120 also operates thereby removing battery from the windings of relays 119 and 124 of Fig. 1B thus preventing any further incoming signals from reaching the toll line of Fig. 2 except a disconnect signal which would operate relay 118. Relay 646, operated, at contact 662 operates relay 660 over lead 658 and right back contact on relay 613. Also at its top inner contact it closes ground to lead 665 traced further through resistance 666, top armature and contact relay 663, thence over lead 134 through winding relays 135 and 120 of a circuit similar to Fig. 1 in series to battery. Relay 120 being marginal does not operate through resistance 666, thereby permitting Fig. 1B to receive incoming signals but relay 135 operates and removes the pad from the talking circuit at the outgoing end of the second automatic toll line. For transmission reasons it is desirable to leave the pads connected in the circuit when the toll operator at office Y has her talking key 300 operated. Under this condition relays 246 and 646, instead of operating as noted above fail to operate due to tip conductor 301 in cord circuit of Fig. 3 being connected straight through contacts 315 and 355 on relay 311 to tip conductor 352 and similarly ring conductor 302 is connected to ring conductor 351 through contacts 310 and 356 on relay 311. Thus, the ground circuit through relay 246 described above meets the ground circuit through relay 646 and said relay fails to operate thereby preventing the operation of relay 135 and leaving the transmission pads connected in the talking circuit.

Inserting the cord plug in jack 667 sends a connect signal to the toll office Z by connecting ground through resistance 649 at right back contact relay 605, front contact relay 650 which is operated by relay 640, contact 651 of relay 613, contact 627 on relay 628 and right back contact in the armature relay 629 to lead 133. As previously described this causes the equivalent of relay 127 of Fig. 1 to operate which in turn closes a ground path traced through normal contact on relay 126, bottom armature and back contact relay 128 and bottom front contact relay 127, for operating relay 131 to battery. Relay 131 operating also operates relay 129 and thus sends a connect signal of 20 cycle—1000 cycle to the toll line circuit at terminating office Z.

The toll operator at office Z receives a flashing signal in the same manner as previously described for the connect signal received by the toll operator at office Y. At the same time the toll line circuit at office Z sends back an acknowledgment signal of 20 cycles superimposed on 1400 cycles, also previously described. This signal received at office Y is transformed into a signal to the toll line of Fig. 6 wherein negative 48 volt battery is connected through a high resistance to lead 123. Said battery is further traced through relays 600, 601 and 602 to negative 24 volt battery causing relay 600 to operate, which closes ground to lead 668 for operating relay 669 to battery through lower contact on operated relay 660 and top outer contact 646. Relay 669 locks from battery on its top inner contact through its own lower make contact to ground on relay 640 and thus, at its top outer contact, shunts out resistance 666 in the ground path to lead 134 thereby operating the equivalent of relay 120 for disabling incoming signals except the disconnect signal. Relay 600 also connects ground over lead 603 through back contact 604 on relay 605 and winding relay 606 to battery. Relay 606 operates in this circuit and releases relay 650 because the operating ground for the latter relay is taken from the left-hand armature and back contact relay 606 traced further through contact 652 on the operated relay 640. Relay 650 releasing opens the ground path through resistance 649 to lead 133 previously traced, thereby causing relay 129 as in Fig. 1 to release and open the connect signal being sent to the distant toll office Z. The opening of this signal in turn causes the acknowledgment signal, being sent from office Z, to cease and thus allow relay 600 at office Y to release. Although ground is thereby removed from winding of relay 606 it remains operated on ground through the left winding of relay 605, right inner make contact relay 606 and contact 653 on relay 640 to ground. Relay 605 operates in this circuit.

When the toll operator at office Z answers, order tone is returned to the originating toll operator of office X who again passes the called number and the connection is completed to the subscriber line by the toll operator in the office Z. This portion of the connection wherein ringing current is automatically connected to the called line may be in accordance with the usual practices in completing inward connections through the local B or cordless B board and therefore need not be described here. As soon as the called subscriber answers, a receiver-off-hook signal of 20 cycles superimposed on 1000 cycles is sent back over the built up connection through the toll cord conductors of Fig. 3 in office Y to the outgoing automatic toll line in the originating office X.

This signal resuts from the subscriber removing his receiver from the switchhook thereby releasing relay 244 in the toll line circuit at office Z. Ground being removed from winding relay 288 at front contact relay 244, allows ground from contact on relay 238 through winding relay

264 to continue to hold relay 288 operated and thereby also to cause relay 264 to operate. Relay 264 at its left contact supplements ground to right armature and back contact relay 244 for operating relay 226 traced through right contact relay 288, right armature and contact relay 279, left armature and contact relay 280 to battery through winding of relay 226. Relay 226 locks to lead 283 traced further over left outer armature and contact relay 232 to ground at left outer contact relay 240. Relay 226 in turn operates relay 280 which locks over the right back contact and armature on relay 279, right front contact relay 288 to ground at back contact relay 244 for holding the operating circuit of relay 226 open. Relay 226 at its left front contact closes ground through resistance 282 to contact 223 on relay 213 and thence over a previously traced circuit through relays 228 and 229 to lead 133. This results in the operation of relays 127, 129 and 131 and the sending of the receiver-off-hook signal of 20 cycles superimposed on 1000 cycles back over the built up toll line through toll office Y.

At the originating office X this signal is transformed into negative 48 volt battery connected through high resistance 122 to a lead which is the equivalent of lead 123 of Fig. 1B. The outgoing toll line at office X may be considered as being identical with Fig. 6, previously described, except that signal control relay 660 is normal. Thus when battery through resistance 122 is connected to lead 123 it operates relay 600 which in turn operates relay 632 in a circuit traced over lead 603, operated right inner contact relay 605, and lead 654. The operation of relay 632 at its right outer break contact opens the holding circuit for relay 655 which in turn releases and opens a path through the left-hand windings of sleeve relays 638 and 637 thereby increasing resistance of said sleeve and causing relay 340 in the associated toll cord sleeve to release and put out supervisory lamp equivalent to lamp 344. The operation of relay 632 also sends an acknowledgment signal of 20 cycles superimposed on 1400 cycles back over the built up connection to the office Z by connecting negative 48 volt battery through high resistance 624 to lead 133. This path is traced further through contact 656 on relay 640, left outside contact on relay 613, left armature and front contact relay 632, back contact and armature relay 650, contact 651 on relay 613, contact 627 on relay 628, right outer back contact and armature relay 629 to lead 133. This signal at office Z terminates the receiver-off-hook signal releasing relays 600 and 632 at office Z. Release of relay 632 then terminates the acknowledgment signal and the completed connection is ready for conversation.

If the originating toll operator at office X, whose toll cord is identical with Fig. 3 and toll line is identical with Fig. 6, wishes to recall the toll operator at the terminating office Z she operates ringing key 347 which thereupon releases relay 637 due to breaking ringing key contact 346, thus introducing high resistance 358 in sleeve lead 348. At its top contact key 347 connects ground through tip conductor 354 which is further traced over what would be lead 670, back contact relay 637, right inner armature relay 640, and first make contact to battery through winding relay 650. The front contact of the latter relay prepares a path for sending out a recall signal of 30 cycles superimposed on 1000 cycles, traced from 48 volts through low resistance 678 front contact and armature relay 605, front contact and armature relay 650, to lead 133 over a path previously traced. Relays 126 and 127 operating close a ground path for operating relay 132 and thus sends out a 30 cycle—1000 cycle signal which passes through the toll line and toll cord talking conductors and is received at the terminating toll office Z by the toll line which is the equivalent of Fig. 1. Said signal operates the equivalent of relays 117 and 124 in Fig. 1B causing ground through a resistance 125 to be connected over lead 123 through relays 200, 201 and 202 in series to battery. Relay 200 being polarized does not operate and relay 202 being marginal operates only on direct ground. Relay 201 although marginal operates on this resistance ground and closes direct ground from back contact relay 202 to lead 271 armature and front contact 272 of relay 213, winding relay 273, contact 274 on relay 275 to right winding of sleeve relay 238 thence over the sleeve to battery through toll cord lamp 304 as previously traced. Relay 273 operates in this circuit and locks to the toll cord sleeve and to relay 275. Relay 273 at its left contact closes ground through interrupter 276 to winding relay 275 and to left winding relay 277 in parallel to battery causing both of said relays to operate. Relay 275 thus follows the interrupter 276 thereby opening and closing the lead to right winding relay 236 and causing the toll cord supervisory lamp 304 to flash indicating a recall signal. The toll operator at office Z upon throwing her talking key 300 causes the sleeve resistance to be increased thereby releasing relay 273 which in turn releases relays 275 and 277 and retiring the flashing lamp. The re-ring signal continues only as long as the originating operator holds the ringing key open.

When the called subscriber in office Z disconnects, a receiver-on-hook signal is sent back over the toll line which is received at office X as ground through a resistance over lead 123. This operates relay 601 and in turn relay 655 which locks to relay 632 over a path traced from ground at right contact relay 640, right back contact and armature relay 632 through left armature and contact and winding relay 655. Relay 655 at its right armature and contact closes ground to left winding of sleeve relay 638 which lowers the resistance of sleeve lead 636 and lights operator's toll cord lamp 344 as previously described. Relay 601 also sends an acknowledgment signal of 20 cycles superimposed on 1400 cycles by closing the circuit traced from 48 volts battery through high resistance 624, contact 656, relay 640, left outer contact and armature relay 613, left armature and contact relay 601, back contact and armature relay 650, thence over previously traced path to lead 133 which results in the operation of relay 129 and therefore the sending of the acknowledgment signal. This signal when received at office Z by the toll line terminates the receiver-on-hook signal which thus releases relay 201. Relay 201 released terminates the acknowledgment signal.

If in building up the connection the toll line at office Z encounters an all-trunks-busy or subscriber's-line-busy or if later on during conversation the call subscriber wishes to attract the original operator's attention by flashing his receiver on and off the hook the receiver-off-hook and receiver-on-hook signals will be sent back over the toll line in the same manner as is done in the case of the subscriber answering and disconnecting described above. If the called subscriber should flash very rapidly, a receiver-on-

hook signal will be transmitted and until the acknowledgment of the signal is received, further motion of the switchhook will be ineffective. If the receiver is off the hook when the acknowledgment signal is received at office Z relay 244 releasing opens the holding circuit for relay 279. Relay 279 at its right back contact thus closes the circuit for operating relay 226 and traced from ground at left front contact relay 264, armature and back contact relay 244, right contact and armature relay 263, right armature and back contact relay 279, left armature and back contact relay 280 to battery through winding relay 226. Relay 226 at its contact 281 connects ground to winding relay 280 which in turn locks to ground over the circuit thus traced to the right back contact relay 244. Relay 226 at its left make contact also connects ground through resistance 282 to right inner armature relay 213 and thence over a previously traced circuit through contacts on relays 213, 228 and 229 to lead 133 for sending a receiver-off-hook signal back to the originating toll operator. This in the same manner will render further motion of the switchhook ineffective until its acknowledgment signal is received. When the subscriber stops flashing, if switchhook is in the same position corresponding to the last signal transmitted, no further action will take place; but if the switchhook is in the opposite position then a final signal will be transmitted. From the above it has been made clear that no matter how rapidly the subscriber flashes flashing signals will be transmitted to the calling operator and a correct indication of the position of the subscriber's switchhook will be given when the flashing ceases. These voice-frequency signals of 20 cycles—1000 cycles and 30 cycles—1000 cycles, respectively, being connected directly to the talking circuit pass through the toll cord and associated automatic toll line circuits at the through toll office Y. They also, of course, are received in the associated receiving circuit equivalent to Fig. 1B but are made ineffective due to the operation of relay 120 in the Pad circuit equivalent to Fig. 1A previously described. Thus, in building up connections over automatic toll lines it makes no difference how many intermediate offices the call is routed through because at all through-points the Pad circuits are removed and the incoming signalling circuit is disabled except for the disconnect signal which will later be described. At the originating and terminating toll offices, however, the Pad circuits are not removed and the apparatus for receiving and sending signals is operable at all times.

When the calling toll operator at office X disconnects, a disconnect signal consisting of 45 cycles superimposed on 1000 cycles is caused to be transmitted to the built up toll line. The circuit arrangement for doing this may best be described by referring to Figs. 3 and 6 which may be assumed to represent the outgoing toll line at office X. The toll operator upon removing the cord from the equivalent of jack 667 releases sleeve relays 637, 638 and relay 660 connected to the ring side of the talking conductors. Relay 638 removes ground from winding relay 640 causing it to release. Relay 628 then operates in a path traced from battery at left back contact relay 640, winding relay 628, front contact and armature relay 611 to ground at contact 610 on relay 606, which still remains operated from ground at right inner armature relay 632 over leads 631 and 630, previously traced. Relay 628 operated connects ground directly to lead 133 through right outer break contact on relay 629, thereupon operating both relays 127 and 128 in a circuit the equivalent of Fig. 1. Relay 126 being normal connects ground through bottom armature and front contact relay 128 to battery through winding relay 130 which operates and prepares a path for the 45 cycle—1000 cycle disconnect signal. Relay 130 in turn operates relay 129 which thus completes said signal path to the toll line.

The disconnect signal is received both at office Y and office Z in a circuit the equivalent of Figs. 1 and 2 and results in operating relay 118 which thus connects direct ground to lead 123 through the back contacts of relays 124 and 119. This ground path is further traced through windings of relays 200, 201 and 202 in series to battery. With direct ground so connected, both relays 201 and 202 operate. Relay 202 operates relay 229 through contact 284 on relay 213. Relay 229 thus transfers the sleeve of the associated toll cord from ground through relays 237 and 238 to 48 volt battery through its own right winding. Relays 237 and 238 thereupon release, in turn releasing relay 240. The operation of relay 229 connects 48 volt negative battery through high resistance 224 to lead 133 as an acknowledgment signal all in a manner previously traced; operates relay 232 from ground at its left inner make contact; and holds relays 205 and 213 operated. The operation of relay 232 removes ground at its left inner contact for releasing relays 205 and 206 and in turn relay 211. When relay 229 operated, the 48 volt through its own right winding, being connected to sleeve lead 235 and the associated toll cord sleeve 302 and lamp 304, causes lamp 304 to light as a disconnect signal the same as if direct ground were so connected. Since the disconnect signal is received at both offices Y and Z it follows that the cord lamp 304 at these offices both light as a signal to the operator to disconnect which they proceed to do. When relay 229 operated and caused an acknowledgment signal to be sent back on the line this signal at office X causes the disconnect signal to terminate as explained below. The termination of the disconnect signal at office Y thus releases relays 201 and 202 and in turn relay 229. The release of relay 229 releases relays 205, 213 and 232 restoring the circuit to normal. The automatic toll line between office Y and office Z likewise restores to normal in a similar manner.

As mentioned in a previous paragraph, an acknowledgment signal was returned over the toll line to the toll office X which causes relay 116 to operate and in turn operates relay 119. The latter relay connects 48 volt negative battery 121 through high resistance 122 to lead 123 and operating the equivalent of relay 600 which in turn operates relay 632. The latter relay at its right inner contact removes the ground that has continued to hold relays 606, 611, 628 and 655 operated. These release and in turn release relay 608. The release of relay 628 terminates the disconnect signal which at offices Y and Z results in terminating the acknowledgment signal being received over the toll line. Upon termination of the acknowledgment signal at office X relays 600, 605 and 632 release thus restoring the circuit to normal.

If it be assumed that the toll operator at office Y pulls down her toll cord connecting the two toll lines before the calling operator at office X disconnects, a pulled down signal of 45 cycles—

1000 cycles is caused to be sent back over the toll line to office X as described above, due to the release of relays 237, 238, 240, 244, 263, 264, 279, 280 and the operation of relay 228. When this signal is registered and acknowledged by the toll line equivalent to Fig. 6 at office X sending back the 20 cycle—1400 cycle signal as will further be described, said signal operates relay 116 in a circuit at office Y equivalent of Fig. 1B. Relay 116 operates relay 119 thus connecting negative 48 volt battery through high resistance 122 to lead 123 for operating relays 200 and 232. The operation of relay 232 releases relays 206, 211, 228 and 208. The release of relay 228 terminates the disconnect signal which at office X causes the acknowledgment signal to terminate which in turn at office Y causes relays 200, 205, 213 and 232 to release, restoring the incoming end of the toll line at office Y to normal.

Under the assumption that the toll operator at office Y pulled down as above described and caused a disconnect signal to be sent to the toll line at office X, which for the purpose of this description may be assumed to be the same as shown in Figs. 6 and 1, this signal causes relay 118 to operate and connect direct ground to lead 123. Relays 601 and 602 operate in said circuit. Relay 602 connects ground over lead 671, armature and back contact relay 613, winding relay 673, contact 674 on relay 675 to left winding sleeve relay 638, thence over sleeve lead to battery through cord lamp 304. Relay 673 at its right contact locks up to the sleeve lead when relay 275 is normal or to battery through resistance 685 when relay 275 is operated. Relay 673 at its left contact operates relays 675 and 677 from ground through interrupter 676. Relay 677 locks to ground at contact 610 on relay 606 traced through armature and front contact on operated relay 611, thence through contact 686 on relay 613 to battery through armature, contact, and left winding relay 677. Thus when relay 275 operates on the first ground period of interrupter 676, it opens the lead to left winding of sleeve relay 638, thereby allowing the sleeve relays 638 and 637 to be held over a high resistance path which extinguishes the operator's toll cord lamp 304. When interrupter 676 opens the ground path to release relay 675, a low resistance ground path to left winding of relay 638 is again connected which causes toll cord lamp 304 to light. Thus the operator's cord lamp flashes in accordance with the period of the interrupter and informs her that the connection has been pulled down.

Relay 601 being previously operated as described above closes a path for sending back an acknowledgment signal to the toll line in office Y, said path being traced from 48 volts through high resistance 624, contact 656 on relay 640, left outer contact relay 613, right armature and contact relay 601, back contact and armature relay 650, thence through previously traced path, through contacts on relays 613, 628 and 629 to lead 133. This closure of 48 volts to lead 133 results in sending an acknowldgment signal back to office Y which, when it is received, terminates the pulled down signal in a manner as previously described. The termination of the pulled down signal thus releases relays 601 and 602. Relay 601 released in turn terminates the acknowledgment signal. The toll operator then disconnects and if necessary reorders the called number as on a new call. When the toll operator disconnects, relays 637, 638, 640 and 660 release and relay 628 operates, in turn releasing relay 632. The operation of relay 632 releases relay 606 which in turn releases relays 611, 608, 628 and 677. Relays 628 and 677 released, cause relays 605 and 632 to release, thus restoring the circuit to normal all in a manner as previously described.

Connection between automatic and ring-down toll lines

It is now assumed the called number was such that it required the connection to be completed over the ring-down trunk of Fig. 7 instead of over the second automatic toll line of Fig. 6.

The call having originated at office X and come in over Figs. 1 and 2 at office Y is assumed to have been answered by the toll operator inserting the rear plug of the toll cord of Fig. 3 in jack 248 of the automatic toll line of Fig. 2 as previously described. The operator at this point received the wanted subscriber number from the originating toll operator, requiring that a connection be established over a ring-down trunk such as the one shown in Fig. 7. The insertion of the front plug of the toll cord in jack 700 in addition to extending the talking conductor 353 to 703 and conductor 354 to conductor 704 closes the sleeve circuit. Assuming the talking key of the cord operated at this time, said sleeve circuit is traced from battery at contact 404 of key 405 in operator's dial circuit of Fig. 4, through battery contact key 401, lead 406, contact 336 on relay 337, through winding of relays 339 and 340 in series, contact 342 on relay 306, lead 343, contact 346 on key 347, lead 348, thence over sleeve lead 705 and upper winding relays 706 and 707 in series to ground at contact 708 on relay 709. Relay 706 operated, connects ground to winding relay 709 to battery at contact 710 on relay 711. Relay 709 operated, connects ground at its right contact to winding relay 711 to battery. Relay 707 performs no useful function at this time and releases as soon as relay 709 operates and connects ground through resistance 712. Relay 709 at its right inner contact opens the circuit through winding relay 713 to prevent false operation of the latter relay. Relay 711 in operating at its left outer contact removes the termination 714 from across the tip and ring and at contact 710 removes battery supply for relay 709. Relay 709 releases, reducing the sleeve resistance to normal and permitting relay 707 to reoperate. Relay 711 at its left inner contact connects battery to winding relay 724 to ground. Thus relay 724 in operating releases relay 729 and extinguishes idle indicating lamps 725, 726 and 727 which may be assumed to have been dimly lighted from ground through transformer 728 as described for the automatic toll line circuit of Fig. 2.

The operator then throws ringing key 347 for calling in the distant operator. Said key, in addition to placing the termination 359 across the calling end of the toll cord, connects ground to the tip conductor 354 and its bottom contact 346, opens the shunt around resistance 358. The sleeve circuit previously traced is thus now traced through resistance 358, top inner contact relay 311 to sleeve lead 343. This increase in sleeve resistance releases relay 707 which in turn closes a path for operating relay 713. Relay 713 operated closes a path at contact 715 for operating ringing relay 716 traced from ground at top contact ringing key 347, leads 354 and 704, contact 715 on relay 713, lead 717, armature and front

contact of normally operated relay 718, through winding relay 716 to battery. The latter relay operating closes a circuit at its front contact from ground and ringing generator 719 over leads 720 and 721 to toll line conductors 722 and 723, respectively. In this manner, ringing current will continue to be sent out over the toll line as long as the ringing key is held operated.

The distant operator upon receiving a flashing line signal in the manner similar to that described for Fig. 2 answers by inserting the rear plug of an idle cord in what would be the equivalent of jack 702 of this circuit. The ringing key 347 of the toll cord having now been restored to normal, relay 716 is released, thus preparing a circuit for the ring-down relay 730 so that when a distant toll operator rings at any subsequent time, relay 730 will operate and at its back contact open the circuit for relay 718 to release and connect ground to lead 717. Ground on the latter lead operates relay 731 through contact 715 on relay 713. Relay 731 at its right outer contact connects ground through winding relay 732, normal contact on relay 733, right outer contact on operated relay 716, thence through lower windings of relays 717 and 706 to sleeve 705 to battery in toll operator's cord circuit. Said path being of low resistance causes the operator toll cord lamp 344 to light. The operation of relay 732 locks through its left contact to the sleeve circuit and at its right contact connects ground through a flashing interrupter 734 to winding relay 733 to battery. The latter relay, following the intermittent interrupter ground, opens and closes the low resistance sleeve ground causing the toll cord lamp 344 to flash on and off in accordance with the interrupter 734. The toll operator, upon throwing her talk key 321 increases the resistance of the sleeve sufficiently to release relay 732 the next time relay 733 is released. In this way the toll cord lamp is extinguished.

The pad control arrangement shown in Fig. 7A is normally in the line leading to toll line repeater 735 and is cut out only when the two circuits arranged for pad control are connected together directly as in this case where an automatic toll line is connected to this circuit through a toll cord with the talking key in normal position. This transmission pad is cut out due to relay 736 being operated from ground in series with the upper winding of retard coil 737 to line conductors 748 and 704, thence over cord conductors 354, 352, 302A, 302 and 234 to lower contact on operated relay 208 in the toll line of Fig. 2, lower winding of retard coil 247, contact 261 on relay 246, thence through winding of relays 262 and 263 to battery. Battery through winding relay 738 may likewise be traced back to ground on winding of relay 246 but relay 738 being marginal does not operate. Thus a path is established for operating relay 739 traced through its winding, contact on operated relay 737, through armature and contact on relay 738 to ground. Relay 739 being operated is arranged to disconnect the pad by short-circuiting resistances 740 and 741 at contact 742, short-circuiting resistances 743 and 744 at contact 745 and opening bridge circuit 746 at its top break contact. The pad associated with the calling automatic toll line is likewise cut out due to ground being connected by relay 246 through resistance 266 and normal contact on relay 263 to lead 134, thence through relays 135 and 120 to battery. Relay 135 operating in the circuit thus traced cuts out the pad circuit in the same manner as did relay 739 of Fig. 7. Relay 120, however, being marginal, does not operate. Thus all supervisory signals are terminated on the incoming automatic toll line and the toll operator receives supervision from the calling subscriber.

If the connection is completed to a tributary ring-down toll line, the operation of the automatic toll line circuit is the same as described above for a regular ring-down toll line except that relay 263 of Fig. 2 also operates and opens the circuit to lead 134 so that the associated pad circuit cannot function to cut out the transmission pad.

Connection between automatic toll line and toll switching trunk

Assuming now that the incoming call over the automatic toll line at office Y from the originating toll office X previously described requires that the connection be completed to a subscriber in a manual office. In this case, the toll operator of office Y inserts the front plug of the toll cord of Fig. 3 in jack 800 of a trunk to a manual office shown in Fig. 8. Trunks of this type are provided with a single lamp which serves as a combined answering and idle indicating lamp. It serves as an answering lamp on incoming recording completing calls and as an idle indicating lamp for outgoing toll switching trunk calls. Thus in completing the call here described, the toll operator will observe one of the lamps 801 burning dimly in a circuit traced from ground on transformer 802, front contact on operated relay 803, right back contact relay 804, through lamp 801 to ground. This lamp indicates an idle trunk because ground at 805 must be connected to lead 806 through contacts 807 on relays in the preceding trunks. To do this, each relay equivalent to relay 808 in each preceding trunk must be operated that is, be in a busy condition. Also, relay 808 in this particular trunk must be normal because the trunk is not in use. In this manner, ground at 805 operates relay 803 individual to this trunk, thereby causing lamp 801 to light over the path described above.

When the toll operator plugs into jack 800 and the operator is not connected at the local office, sleeve relays 809 and 810 operate in a path traced from battery through lamp 344, contact 345 on relay 306, lead 343, contact 346 on key 347, sleeve lead 348, thence over sleeve 811 of the toll switching trunk and through left winding relay 809 and right winding relay 810 to ground. Relay 809 opens battery from lead 812 and relay 810 operates relay 813 over a path traced from ground at its own front contact through winding relay 813 to battery. Relay 813 at its left inner contact connects battery to lead 814, traced further over lead 815 through winding relay 816 to ground at bottom break contact on relay 817, thus operating relay 816. The latter relay through its continuity contacts connects an obvious battery and ground circuit through windings of relay 818 and contacts on relay 819 to the trunk conductors 820 and 821 connecting with the distant manual office. The closing of said circuit causes a suitable signal to be given to the B operator at the local manual office in accordance with well-known practices for this traffic. Relay 818, however, does not operate at this time.

Plugging a toll cord in jack 800 also closes a path for operating relay 822 traced from positive battery 243 through relay 244, contact 242 on relay 213, contact 245 on relay 246, through lower winding of retard coil 247, lower contact relay

208, thence over talking conductors 234, 302, 352, 354 and 823 through resistance 825 to ground through winding relay 822. Relay 822 operating closes an obvious path for operating relay 827 which in turn at its right inner contact closes a circuit for operating relay 828. Relay 828 at contact 830 locks to battery supplied at left inner contact relay 813 and in doing so closes a path for the operation of relay 829. The operation of relay 829 is thus placed under the control of relay 818.

When the B operator is connected to this trunk in answer to the previously described signal, order tone will be heard by the calling toll operator at originating office X who then passes the number of the wanted subscriber. In accordance with the usual practice, when the connection is completed to the subscriber line with the receiver on the hook, the supervisory path at the local office becomes low resistance, thereby causing relay 818 to operate as a ringing signal on all calls except inward calls from jack ended automatic toll lines. In the latter case, the operation of relay 818 prepares the toll line for receiving a receiver-off-hook signal and automatically starts the trunk to ringing the subscriber. The toll line is prepared for said signal by the closure of ground at make contact relay 818 for operating relay 829 over a path traced through right front contact relay 827, right inner front contact relay 828 to battery through winding relay 829. Operation of the latter relay causes resistances 825 and 826 to be shunted out, thereby lowering the resistance of the circuit of relay 244 in the automatic toll line previously described. The operation of relay 244 then operates relay 288 over a path traced from ground on lower back contact relay 262, right armature and front contact relay 244, right armature and back contact relay 264 through winding relay 288 to battery.

Ringing of the called subscriber line is automatically started by relay 819 which operated when relay 828 closed a circuit from battery at its left make contact, through contact and armature on relay 831, to ground at contact 832 on relay 827. Relay 831 being so released remains operated for a time after relay 828 has operated, in order to open the circuit of relay 831. In this way, relay 819 only remains operated for a short period when it releases and in turn causes relay 819 to release and terminates the initial ringing impulse. This momentary reversal of polarity back over conductors 820 and 821 causes ringing equipment at the manual office to start ringing the subscriber which continues until he answers.

As soon as the called subscriber answers, relay 818 of Fig. 8 releases which in turn releases relay 829 and again increases the resistance of the circuit previously traced through winding of relay 244 to positive battery. The latter relay then releases, allowing relay 264 to operate in series with relay 288 and maintains relay 288 in an operated condition. Thus a path is closed for the operation of relay 226 traced from battery through winding relay 226, left make contact and armature relay 280, right make contact and armature relay 279, right armature and make contact relay 288, right back contact and armature relay 244 to ground at left front contact relay 264. Relay 226 locks operated over lead 283, through left outer break contact relay 232 to ground at left outer contact relay 240. Relay 226 also operates relay 280 directly in a ground battery path. Relay 280 locks through the back contact on relay 244 to ground on left armature and contact relay 264 and opens the operating path of relay 226. Relay 226 thus connects ground through resistance 282 to lead 133 which as previously described sends a receiver-off-hook signal back to the calling operator. When the subscriber hangs up, relay 818 reoperates over trunk conductors 820 and 821, again operating relay 829 and shunting out resistances 825 and 826, which permits relay 244 in toll line circuit to operate and send out a receiver-on-hook signal as previously described. The receiver-on-hook and receiver-off-hook signals just described will likewise be passed back to the originating toll operator if the called subscriber operates his switchhook to flash in the toll operator. So also when the called subscriber hangs up, the receiver-on-hook signal will be passed to the toll operator at the originating office. Switchhook supervision is thus relayed through the toll cord to the two-way automatic toll line circuit without operating the supervisory signals of the toll cord.

Connection over automatic toll line to dial subscriber

Referring to that part of the above description in which a call is traced from one automatic toll line to another automatic toll line, and referring more particularly to the functioning of the toll operator's cord circuit at office Y there will now be described the manner in which a connection is completed to a dial subscriber in the toll office Y.

In this case the toll operator having received the number of a wanted subscriber from the toll operator at office X and finding that said subscriber may be reached by dialing over a trunk circuit such as shown in Fig. 9, inserts the front plug of the cord of Fig. 3 into jack 900 of Fig. 9. It will be assumed in this case that the operator has talking key 300 operated so that the sleeve circuit may then be traced from battery through contact 404 on key 405, bottom contact key 401, lead 406, contact 336, windings of relays 339 and 340 in series, lead 341, contact 342 on relay 306, lead 343, contact 346 on key 347, sleeve leads 348 and 901, right winding relay 902 and left winding relay 903 in series to ground at contact 904 on relay 905. Relays 902 and 903 operate. Relay 903 connects battery direct to winding relay 905, traced further through contact 906 to ground at relay 907. Operation of relay 905 replaces ground by a high resistance ground thus making the sleeve circuit previously traced high in resistance, thereby releasing relay 902 in the trunk and relay 340 in the toll cord which holds cord lamp 344 extinguished. When the talking and dialing keys of the cord circuit are operated, battery over the tip conductor 908 operates relay 907 which locks operated to battery on contact of operated relay 903 and thereby completes the dialing path as will later be described. Relay 907 at its bottom inner make contact connects direct ground to left winding relay 903 in shunt with resistance 919 thus reducing the resistance of the sleeve circuit. Relay 907 also removes ground for holding relay 905 operated so that it now releases. Relay 339 in the toll cord remains operated thereby operating relay 360 in the direct battery ground path.

The toll operator having plugged the toll cord into jack 900 proceeds to operate her position dial key preparatory to dialing the wanted subscriber's number. The operation of dialing key 407 therefore causes the operation of relay 337 in the

cord and relay 414 in the position circuit, traced from ground on bottom contact 413, lead 361, bottom inner contact on operated relay 360, lead 412, top inner break contact relay 411, lead 410 to top middle contact spring on dial key 407. Said ground path now divides, one path being traceable through contact 409 and the other through contact 415 of said key. Relay 337 in the cord operates from the ground through contact 409, traced further over lead 408 through bottom winding relay 337 to battery and at contacts 362 and 336 serves to extend the tip and ring conductors 354 and 353 to the dialing relay 414 common to the operator's position. Relay 414 operates at the same time on ground at contact 415 of key 407 traced direct to winding of relay 414 to battery and at its top and bottom outside contacts serves to remove the terminating bridge. At its top and bottom front contacts the tip and ring conductors of the front cord are extended through to the dial circuit proper. At contact 416 relay 414 operates relay 417 in a direct battery ground path. The latter relay thereby connects the operator's receiver 523 direct to repeating coil winding 417. The primary winding 418 of this coil will later be shown to be connected in the dialing loop circuit so that whenever the dial returns to normal the operator may observe any busy or line busy signals that may be present. Ground at contact 416 relay 414 at the same time operates relay 419 in a direct battery ground path through contact 420 on relay 421. Relay 419 at its bottom contact in turn connects ground direct to winding 421 which upon operating opens at contact 420 the operating path for relay 419. Relay 419, however, does not release because battery through its winding is connected to ground through winding of relay 907 in the dialing trunk circuit of Fig. 9. This path is further retraced through upper winding relay 422, top make contact relays 419 and 414, lead 423, contact 362 on relay 337, top armature and front contact relay 360, lead 364, contact 355 on relay 311, conductor 352 and contact on key 347, conductors 354 and 908, thence through top break contact relay 907 to ground through the winding of relay 907. The latter relay operated prepares the trunk of Fig. 9 for dialing as will further be described.

The top winding of relay 422 being included in the circuit just traced serves to make a test for one of several kinds of dialing trunks to which the trunk circuit of Fig. 9 may be connected. If it is of such type that a reversal is received when the subscriber's line is seized, the resistance of the trunk relay 907 in series with relay 422 will be high and relay 422 will not operate. If it is of such type that no change occurs when the line is seized, relay 907 will be of low resistance and relay 422 will operate. Assuming the latter to be the case, for purposes of this description, relay 422 operated locks direct to ground at contact 416 on dialing relay 414. Relay 907 also operates, in the previously described path, at the same time as relay 422 thereby disconnecting ground through winding relay 907 and connecting conductor 908 to conductor 910. This releases relay 419 which now completes the dialing loop to leads 423 and 408 over a path traced from lead 423, top front contact relay 414, top break contact relay 419, pulse contact 124 on dial 425, repeating coil winding 418, in series with winding relay 426, lead 427, and thence to lead 408 through bottom make contact relay 414. Leads 423 and 408 may readily be traced through the cord circuit to the tip and ring conductors 908 and 909, respectively, of the trunk circuit. The remaining part of the dialing loop to the switching equipment may be traced from conductor 908, through top make contact relay 907, conductor 910, left inner break contact relay 912 to lead 913, conductor 914, top break contact relay 918, conductor 916, thence over the tip conductor of the trunk to ground through the winding of pulse relay in any well-known switching equipment. Returning from battery through the second winding on the pulse relay the dialing loop may be traced over conductor 917, bottom break contact relay 918, conductor 915, left outside break contact relay 912, thence over conductor 911 and through bottom make contact relay 907 to conductor 909.

Operation of other relays in the position dial circuit takes place at this time in order to prepare the circuit for control of various functions when the circuit is released. When relay 422 operated as previously described, ground was connected to lead 428 which is further traced through contact 429 on dial key 407 thence over lead 430 and through winding relay 431 to battery. The operation of the latter relay in turn operates relays 432 and 413 through paths which are readily traced. Relay 411 likewise operated when relay 421 operated as previously described and closed a locking circuit for itself to ground at contact 433 on dial key 407. Relay 411 opens the operating path for relay 337 to prevent reoperation in case the dial circuit is automatically released before the dial key is restored.

When the toll operator pulls the dial off-normal, relay 434 operates as shown. The bottom contact short circuits the repeating coil winding 418 and relay winding 426 in order to remove all inductive apparatus from the loop during dialing. The upper contact on relay 434 connects ground to armature and back contact of relay 426 thence to lead 435 and bottom contact 411 for preventing release of dialing circuit, should dial key be restored while dial is still off-normal. After dial returns to normal following the first digit, the short circuit is removed from repeating coil winding 418 and relay 426. This enables the toll operator to hear busy tone in event an all-trunks-busy condition in the switches is encountered. The same sequence of events occurs for the dialing of each digit.

When dialing is completed and the subscriber's line has been seized, no reversal of line potentials returned, as previously assumed, and relay 426 does not operate. Relay 431 therefore does not release until the dial key is restored to normal. Upon the release of the dial key relay 431 releases and removes direct battery at its top make contact from relay 339, traced over leads 436 and 365, bottom inner make contact relay 337 and winding relay 339. Battery is still connected to relay 339 but now it is through the high resistance 366 which therefore causes relay 902 in the trunk circuit to release. Relay 431 releasing, at its bottom inner contact, removes ground from winding slow relay 432 which after a short interval releases. Relay 432 at its top inner contact removes battery from winding relay 413 causing it to release. During the interval, however, that relays 432 and 413 are releasing a ground is connected to the tip conductors 354 and 908 traced from ground at front contact relay 413, bottom outside break contact 431, lead 423, contact 362 on relay 337, thence through top contact on relay 360 to conductor 364, contact 355 on

relay 311, conductor 352, and contact on ringing key 347 to conductors 354 and 908.

Relay 902 of the trunk circuit of Fig. 9 releases, due to the high resistance sleeve referred to above, and closes an operating circuit for relay 912 traced from ground through winding relay 912, back contact relays 902 and 905 to battery at top inner contact relay 907. Relay 912 operated; closes a locking circuit for itself to battery on contact of relay 903; disconnects trunk conductors 910 and 911 from the outgoing end of the trunk and connects them at the two left front contacts to leads 920 and 921, respectively; at contact 922 connects conductor 923 to conductor 915, thereby cutting in repeating coil 924 and connecting relay 918 to the tip conductor 908 of the trunk over conductor 910, left inner make contact relay 912, winding relay 918, lead 925, right inner make contact relay 912, back contact on relays 902 and 905 to battery at top inner contact relay 907. Relay 918 operates in this circuit to connect ringing current to the trunk and automatically starting machine ringing of the subscriber line. Relay 918 releases after a short interval due to the timed removal of ground on the tip and high resistance sleeve in the operator position circuit as previously described. Thus relay 902 again operates and opens the circuit of ringing relay 918 which in turn releases.

The toll operator having released the dial and talking keys of the position causes the tip and ring conductors 233 and 234 of the automatic toll line to be extended through the toll cord to conductors 909 and 908, respectively, of the outdialing trunk of Fig. 9, all in the manner similar to that described above for a connection between two automatic toll line circuits. This being an inward connection, positive battery through relay 244 of the toll line is connected to ring conductor 234. When, therefore, the toll cord is cut through, said positive battery may be further traced to conductor 908, thence over conductor 910 and one winding repeating coil 924 and resistance 926 to ground through winding polarized relay 927. Upon seizing the wanted subscriber's line, polarized relay 928 operates on battery and ground returned over the trunk from the switching equipment. Ground at contact on relay 928 is thus connected to lead 929 and armature of relay 927 which being operated further connects ground to lead 929 to winding relay 930 to battery. Relay 930 thus short circuits resistances 926 and 931 in the tip and ring circuit traced back through the toll cord and automatic toll line and permits marginal relay 244 in the automatic toll line to operate and send back a receiver-on-hook signal as previously given in the case of the automatic toll line circuit. When the called subscriber answers by removing his receiver, relay 928 releases due to reversal battery in the subscriber's connector switch. This release of relay 928 releases relay 930 which again introduces resistances 926 and 931 into the tip and ring conductors connected with the automatic toll line. Relay 244 of the toll line circuit again operates and thereby sends a receiver-off-hook signal back to the originating toll operator in office X as previously described. In this manner relay 244 of the automatic toll line, which is only connected on inward connections, is made to relay supervision on to the toll operator at office X. No supervision is therefore furnished to the toll operator at office Y. When the toll operator at office X receives a disconnect signal at the end of a connection she will remove her plug circuit from the outgoing jack of the automatic toll line. This as previously described in the case of the automatic toll line causes a disconnect signal to be set to the toll line in office Y thereby giving the operator at Y a flashing disconnect signal. The toll operator at office Y disconnecting, causes all operated relays to release and the circuits to restore to normal.

What is claimed is:

1. In a telephone system, a toll operator's position, two-way automatic signaling straightforward toll lines, two-way ring-down toll lines, incoming trunks and outgoing trunks, all terminating at said position in jacks, a toll cord thereat adapted to interconnect any of said toll lines or any toll line and any trunk circuit, line signal devices at said position, one for each of said toll lines and incoming trunks supervisory signal apparatus associated with said cord circuit, and means associated with said automatic toll lines and with said cord circuit adapted to cooperate when two automatic lines are connected together or when an automatic line is connected to an outgoing trunk to cause supervisory signals received from the distant end of the called line to be retransmitted to the calling toll line without affecting the supervisory signal apparatus associated with the cord.

2. In a telephone system, first and second toll operators' positions, an automatic signaling straightforward toll line therebetween and terminating at the second position in an answering jack, a toll cord at said second position adapted to be connected to said toll line, a supervisory signal associated with said cord circuit, means at the first position for seizing said line and automatically transmitting signal current to the line, signal apparatus associated with the line at the second position responsive to said transmitted signal current, means responsive to connection of said cord circuit with said line to retire said signal, manually operated means associated with said seizing means at the first position for transmitting a re-ring signal to said line, means associated with the line at the second position responsive to said re-ring signal to display the cord supervisory signal thereat and cause it to flash as long as said re-ring signal persists, means associated with said line at the first position responsive to release of the line thereat for transmitting disconnect signal current to the line, and means associated with the line at the second position responsive to said disconnect signal to display and lock in said cord supervisory signal until the cord is disconnected from the line.

3. In a telephone system, a pair of lines, transmission loss pads normally in circuit with each line, a control relay associated with each pad adapted when operated to effectively disconnect the respective pad from its line, a cord circuit for interconnecting said lines, the talking conductors of said cord being normally transposed within the cord, a talking key associated with said cord circuit, means controlled by the operation of said talking key for reversing said transposition to connect the cord conductors straight through from one end of the cord to the other, a circuit including a relay connected in bridge of each line, a source of direct current serially included in each bridge and similarly poled, said bridge relays being adapted to be operated, when said lines are connected together by means of said cord circuit, the conductors of which are transposed, to operate the respective pad control relays.

4. In a telephone system, an operator's position, a line terminating thereat, a source of direct current potential, means responsive to a calling signal on said line for connecting said potential source to a talking conductor of said line, a cord circuit adapted to be connected to said line, a talk key associated with said cord, a source of audible frequency current, means for interrupting said audible frequency source, and means connected to the cord by operation of said key when the cord is connected to the line and responsive to said direct current potential thereon for connecting said audible frequency source to the talking conductors of the cord, and other means also responsive to operation of said key for initiating operation of said interrupting means.

5. In a telephone system, an exchange, a line terminating thereat and a lamp signal associated therewith, said lamp being arranged to burn at one brilliancy when the line is idle and to burn at a materially different degree of brilliancy and automatically flash at a predetermined rate when a calling signal is received over the line.

6. In a transmission system, a pair of lines, loss networks similarly associated with each line, relay means for disconnecting said networks from and for connecting them in their respective lines, a link circuit adapted to connect the conductors of one line to the non-respective conductors of the other line, bridge circuits each including a relay and a source of direct current adapted to be similarly connected across said lines, means responsive to connection of said link circuit to the respective line to connect the respective bridge circuit thereto, and means responsive to operation of said bridge relays to control said network relay means.

7. In a transmission system, lines having loss networks adapted to be connected therein and removed therefrom, individual means associated with each line for controlling the connection and disconnection of the respective networks including a relay and a source of direct current serially connected between the conductors of the line and a link circuit for connecting two of said lines together, characterized in this that the conductors of said link circuit are transposed between the ends thereof and the individual sources of current are poled in the same direction across each line.

8. In a transmission system, a pair of lines, transmission loss pads associated with each line, a link circuit having transposed conductors for interconnecting said lines, each of said lines having a bridge including a relay and a source of current, said relays being adapted to control the inclusion and exclusion of said pads in their respective lines.

9. In a transmission system, a pair of lines, transmission loss pads associated with each of said lines adapted to be included therein and excluded therefrom, a bridge across each line including a relay and a source of direct current, said relays being adapted to control their respective pads, a link having transposed conductors adapted to interconnect said lines, and a circuit for operating said relays including said transposed link conductors.

10. In a telephone system, first and second toll operators' positions, a first toll line therebetween and terminating at said second position in an answering jack, jack-ended trunk circuits and other toll lines extending outward from said second position, means at said first position to extend a call over said toll line to the second position, a toll cord at said second position adapted to connect said first toll line to any of said outward trunks or toll lines, supervisory signals associated with the first position means and with the toll cord of the second position, and means for transmitting supervisory signal currents from the distant end of said outward lines through said second position cord circuit to control the supervisory signals at the first position without affecting the supervisory signals associated with the cord circuit.

11. In a telephone system, a first toll position and a second toll position, ring-down toll lines and automatic signaling toll lines therebetween and terminating at said second position in answering jacks, other jack-ended ring-down and automatic signaling toll lines and trunk circuits extending outward from said second position, means at the first position for extending calls over any of said toll lines to the second position, a cord circuit at the second position adapted to connect any calling toll line incoming from the first position to any of said outgoing lines, supervisory signals associated with the means at the first position and with the second position cord circuit, and means effective upon connection of an automatic signaling line, by means of said cord circuit, to an outgoing trunk line or another automatic line for transmitting supervisory signals received from the distant end of the outward line through said cord circuit to the incoming line to control a supervisory signal at the first position without affecting the supervisory signals associated with the cord at the second position and effective upon the connection of an automatic line to an outgoing ring-down line for terminating signals received over the ring-down line in said cord circuit and for actuating a supervisory signal associated therewith.

12. In a telephone system, an operator's position, a cord circuit including supervisory signal apparatus thereat, incoming and outgoing trunk lines and two-way straightforward and ring-down toll lines terminating thereat, said cord circuit being adapted to connect for conversation any incoming trunk line to any toll line or any incoming toll line to any other toll line or outgoing trunk, and means associated with said straightforward lines, cord circuit and outgoing trunk lines adapted to cooperate, when a calling straightforward line is connected by said cord to a called straightforward line or outgoing trunk to adapt said cord circuit to transmit supervisory signals received from the called line through said cord to the calling line without affecting the supervisory apparatus in the cord circuit.

13. In a telephone system, an operator's position, a cord circuit including supervisory signal apparatus thereat, incoming and outgoing trunk lines and two-way straightforward and ring-down toll lines terminating thereat, said cord circuit being adapted to connect for conversation any incoming trunk line to any toll line or any toll line to any other toll line or outgoing trunk, characterized in this that said cord circuit is adapted to automatically adjust itself when connecting a calling straightforward line to a called straightforward line or outgoing trunk to transmit supervisory signals received from the called line through the cord to the outgoing end of the calling line without affecting the supervisory apparatus in said cord circuit.

14. In a telephone system, an operator's position, lines terminating thereat, a source of direct

current potential, means responsive to a calling signal on one of said lines for connecting said potential source to a talking conductor of said line, a cord circuit adapted to be connected to said lines, a talking key associated with said cord, a source of audible frequency alternating current, means for interrupting said source a predetermined number of times, and means connected to the cord by the operation of said key when the cord is connected to a line to which said direct current source is connected and responsive to said direct current for connecting said audible frequency source to the talking conductors of the cord, other means also responsive to operation of said key for initiating operation of said interrupting means, and means effective when the other end of said cord is connected to another line to prevent connection of said audible source to the cord.

15. In a telephone system, an operator's position, an automatic signaling straightforward toll line terminating thereat in a jack, means responsive to a calling signal thereover for establishing a predetermined direct current potential on one of the talking conductors thereof, a cord circuit adapted to be connected to said line, a talking key associated with said cord circuit, a source of audible frequency current, means for interrupting said source a predetermined number of times, means connected to the talking conductors of said cord by the operation of said key and responsive to said potential on said line conductor, when the cord is connected to the line, to connect said audible frequency source to the talking conductors of the cord, and means also controlled by the operation of said key for initiating operation of said interrupting means, said interrupting means being so arranged that after interrupting said audible source the predetermined number of times said source will be disconnected from the cord.

16. In a telephone system, an exchange, a plurality of operators' positions thereat, a line having multiple branches to each of said positions, means for transmitting a call signal over said line to said exchange, a lamp signal associated with each positional appearance of said line, means for causing all of said lamps to burn at a certain degree of brilliancy when said line is idle, means at each position for establishing a connection with said line, means responsive to such a connection at any position for extinguishing all of said lamps, and means responsive to a call signal over said line to change the degree of brilliancy of a predetermined one of said lamps and to extinguish all the other lamps.

17. In a telephone system, an exchange, a plurality of operators' positions thereat, a line having multiple members to each of said positions, means for transmitting a call signal over said line to said exchange, a lamp signal associated with each positional appearance of said line, means for causing all of said lamps to burn at a certain degree of brilliancy when said line is idle, means at each position for establishing a connection with said line, means responsive to such a connection at any position for extinguishing all of said lamps, and means responsive to a call signal over said line to change the degree of brilliancy and flash a predetermined one of said lamps and to extinguish all the other lamps.

18. In a telephone system, an exchange, lines terminating thereat and a lamp signal per line arranged to burn at one degree of visual brilliancy when the associated line is idle and to burn at a materially different degree of brilliancy when a calling signal is received over the line.

19. In a telephone system, an operator's position, a cord circuit having talking conductors and a sleeve conductor, a source of direct current and a resistance in said cord sleeve conductor, a line having talking conductors and a grounded sleeve conductor, means for connecting the conductors of said cord to the respective conductors of said line, a marginal relay in said line sleeve conductor, a key associated with said cord arranged when in its normal position to short-circuit said resistance and when operated to remove the short-circuit therefrom, said marginal relay being adapted to operate in series with said source when said resistance is short-circuited and to release when said short-circuit is removed, means responsive to the operation of said key to ground one of the talking conductors of said cord circuit, a second relay arranged to be operated when said marginal relay is released, and a circuit including a source of current and a functional relay adapted to be connected to the grounded talking conductor by the operation of the second relay, said functional relay being arranged to operate when connected to ground.

20. In a telephone system an operator's position, a cord circuit thereat, a line including a sleeve conductor accessible to said cord circuit, a relay for performing a specific function adapted to be connected to a talking conductor of said line, a marginal relay in said line sleeve conductor adapted to be operated when said cord is connected to said line, a key associated with the cord circuit adapted when operated to connect ground to said line talking conductor and to increase the resistance of the sleeve circuit sufficiently to cause release of the marginal relay, and means responsive to release of said marginal relay to connect said functional relay to said talking conductor, said functional relay being adapted to operate to the ground placed on said talking conductor by operation of said key.

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