Nov. 13, 1923.

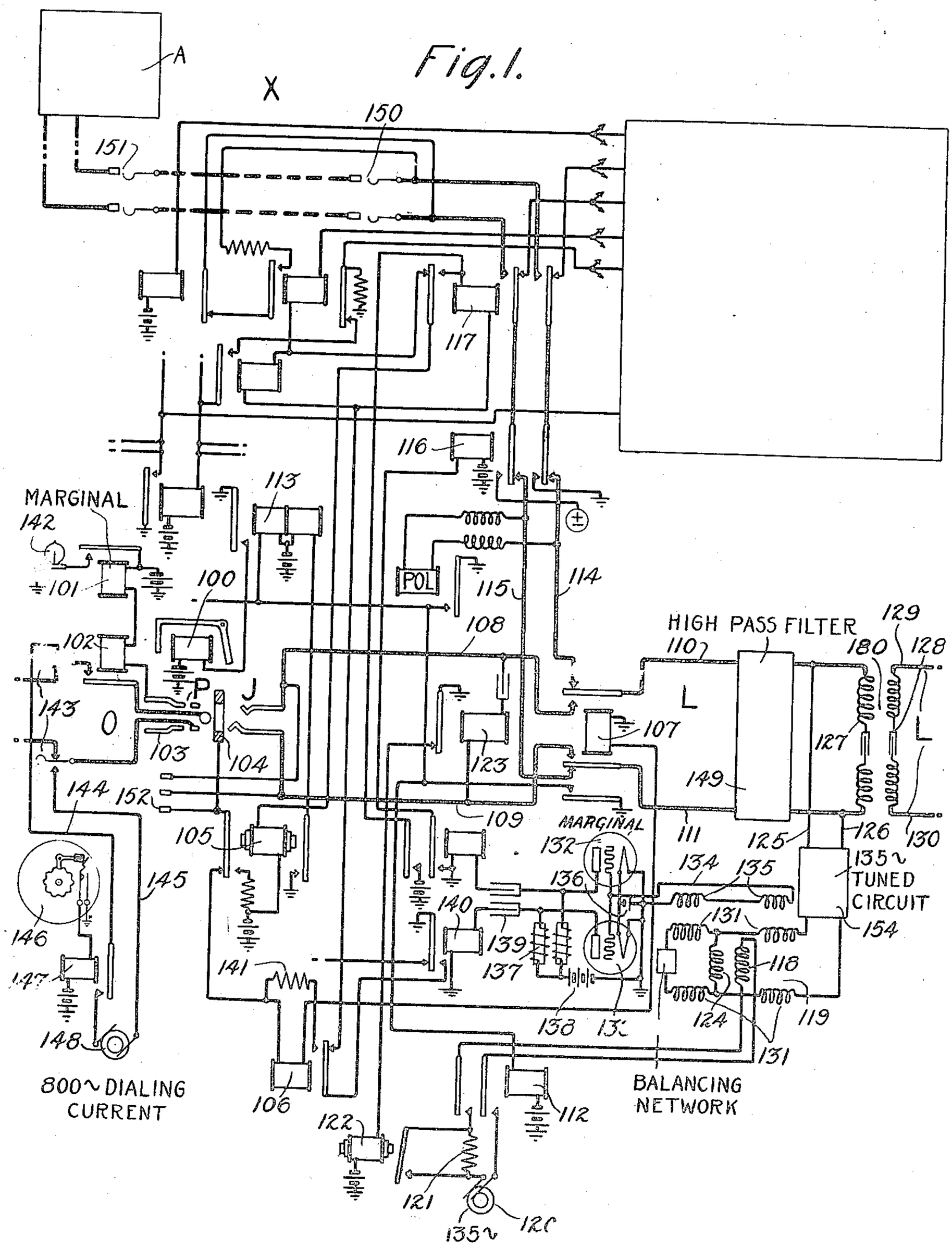
1,473,671

J. DAVIDSON, JR

TELEPHONE EXCHANGE SYSTEM

Filed Dec. 18, 1920 3 Sheets-Sheet 1

Fig. 1.



Inventor:
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1,473,671

J. DAVIDSON, JR

TELEPHONE EXCHANGE SYSTEM

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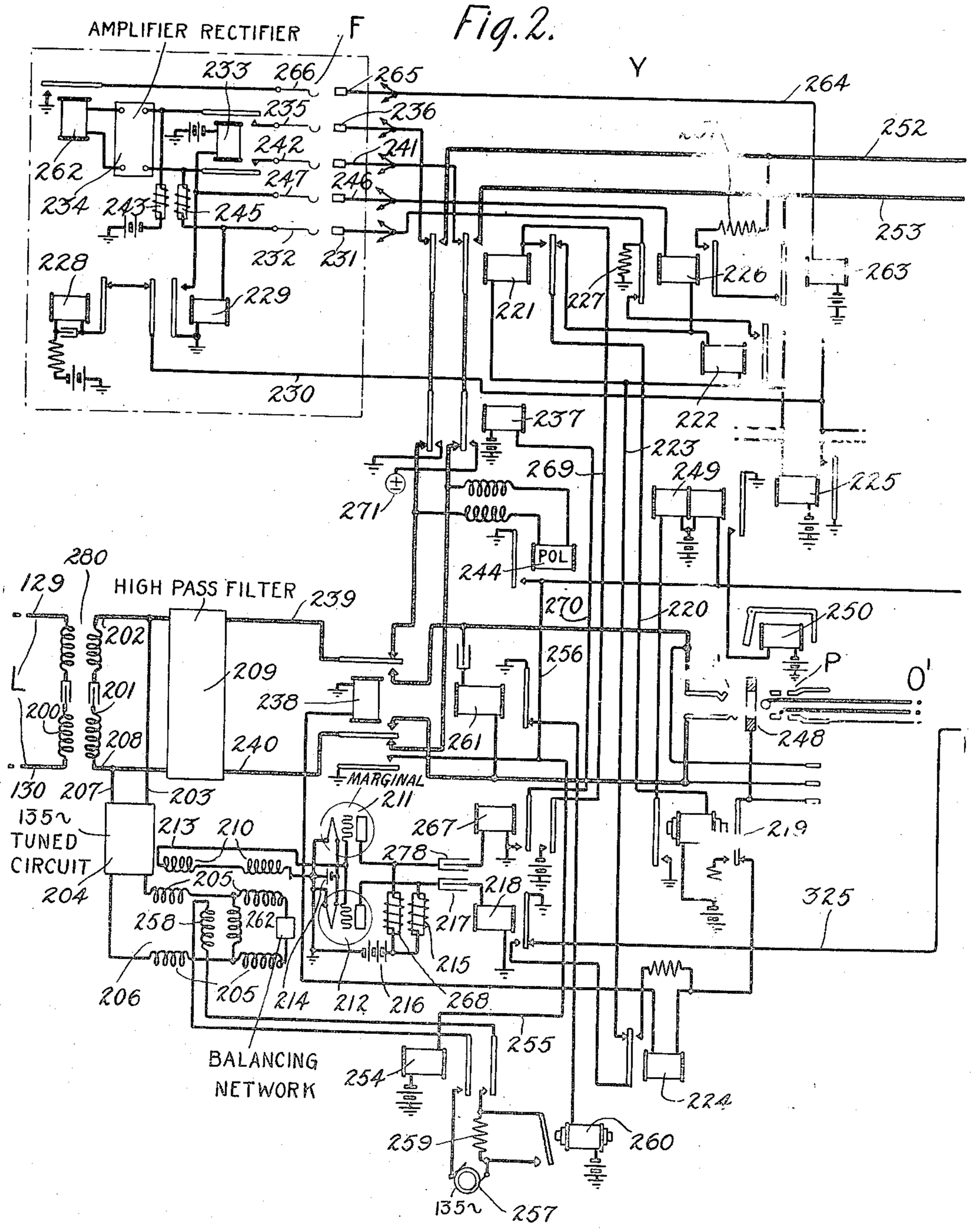
Fig. 2.



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Nov. 13, 1923. 1,473,671

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TELEPHONE EXCHANGE SYSTEM

Filed Dec. 18, 1920 3 Sheets-Sheet 3

Fig. 3.

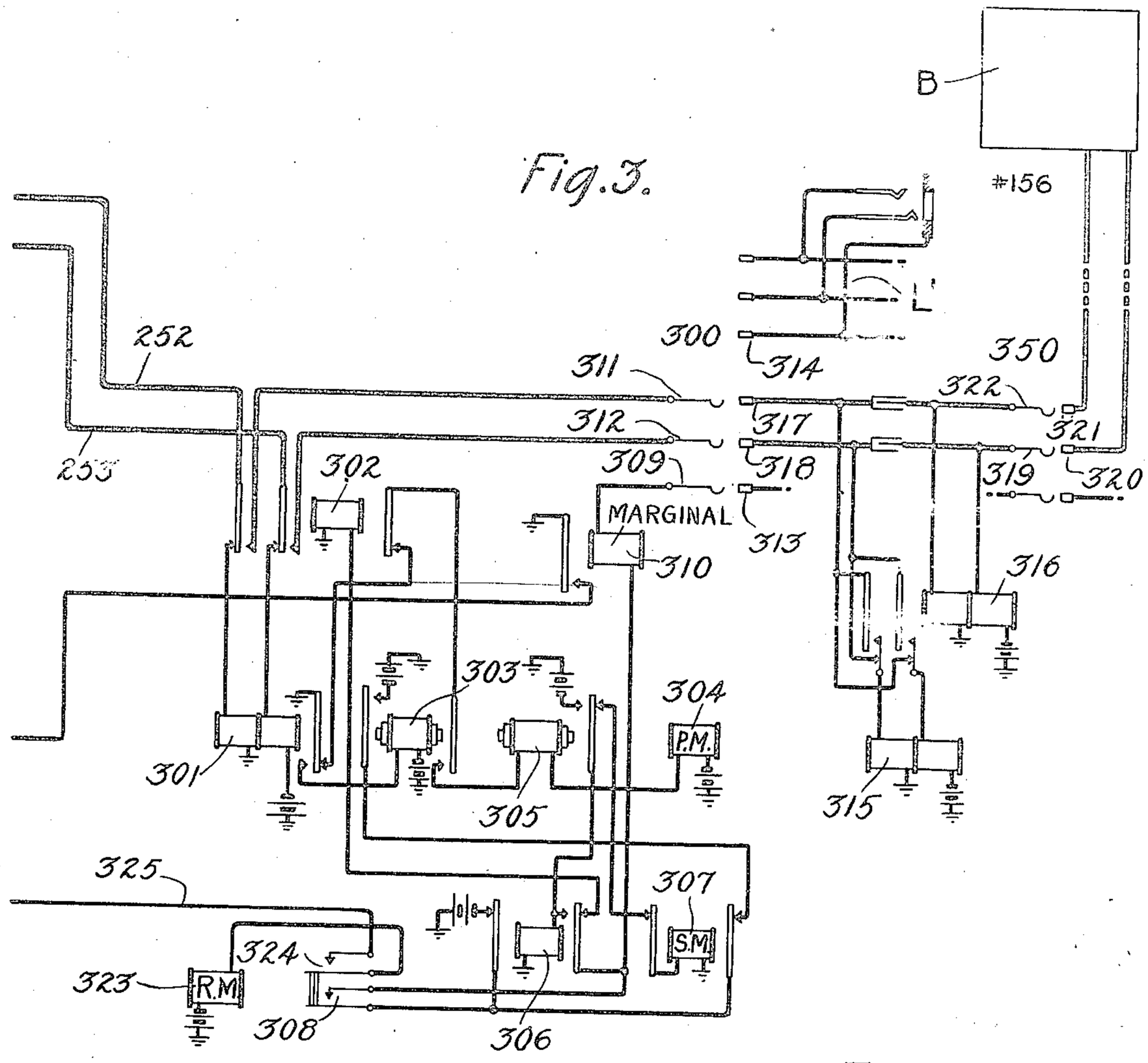
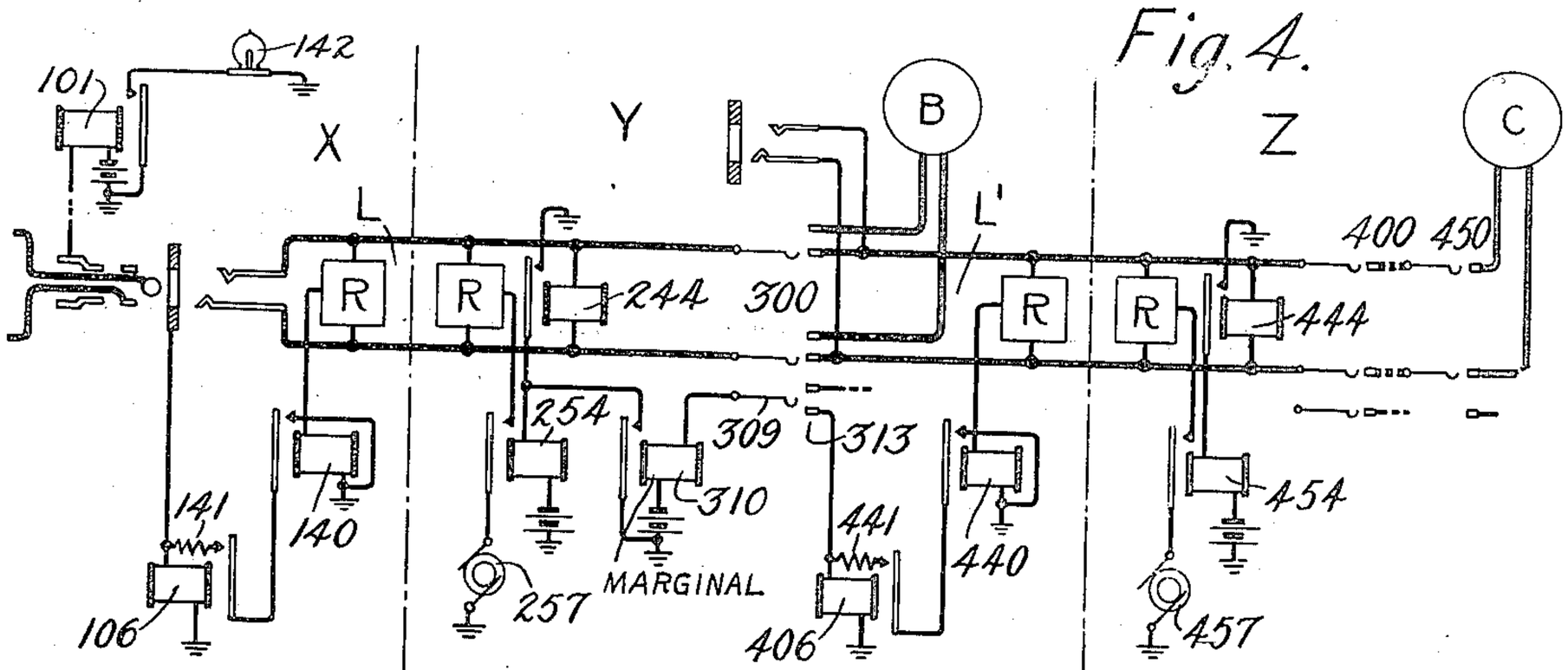


Fig. 4.



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Patented Nov. 13, 1923.

1,473,671

UNITED STATES PATENT OFFICE.

JOHN DAVIDSON, JR., OF TRENTON, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

TELEPHONE-EXCHANGE SYSTEM.

Application filed December 18, 1920. Serial No. 431,718.

To all whom it may concern:

Be it known that I, JOHN DAVIDSON, Jr., residing at Trenton, in the county of Mercer and State of New Jersey, have invented certain Improvements in Telephone-Exchange Systems, of which the following is a specification.

This invention relates to a telephone exchange system and more particularly to a system in which toll connections are established between exchanges by means of machine switching equipment controlled over toll lines.

Under the present practice in connection with one system of this nature, a subscriber in one exchange desiring a connection with a subscriber in a distant exchange, first secures a connection with a toll operator in his own exchange, who then extends the connection over a toll line to the distant exchange and rings up the toll operator at such exchange. The toll operator at the distant exchange, upon answering, requests of the originating toll operator the number of the desired line, and then extends the connection over a switching trunk to the position of a terminating operator in the proper local office, which latter operator then proceeds to extend the connection to the desired line.

In certain cases, it is necessary to build up a connection through several intermediate toll centers to reach the desired exchange. It then becomes necessary to employ not only the services of an answering and toll operator at the originating exchange, and the services of an incoming toll operator and terminating operator at the distant exchange, but also the services of through operators at all of the intermediate toll centers. If the traffic is particularly heavy between toll centers, the method of extending a toll connection as above outlined is still further complicated due to the fact that it is then necessary to divide the toll lines extending between toll centers into two groups, each group handling traffic in one direction only.

This method of extending toll connections, may be simplified by eliminating the services of the incoming toll and terminating operators at the distant exchange or if the connection is to be established through intermediate toll switching centers, by eliminating also the services of the through operators at such intermediate centers. This is accomplished by terminating the toll lines in automatic switching mechanism in such a manner that the toll operator at the originating exchange may obtain a connection with a desired subscriber's line at a distant exchange without the assistance of other toll operators. By the use of automatic switching mechanism, it is not only possible to effect great economy due to the elimination of the distant toll operators, and in certain cases, the elimination of the through operators, but also due to the improved traffic conditions, the work of the originating toll operator is materially reduced and the time during which her circuits are held is shortened. Futhermore, due to the greater accuracy and speed with which the operator can secure the desired subscriber's line, the toll line holding time is reduced and the service materially improved.

When the traffic between toll centers is heavy and a relatively large group of toll lines is necessary to handle the traffic, it has been proposed to terminate each toll line of the group in automatic switching mechanism for extending the toll lines to subscriber's lines in the distant exchange, and to control the switching mechanism over the toll lines by means of alternating current impulses of 800 cycles, and to control the supervision of the connections over a signaling path common to the toll lines of the group by means of start-stop distributor mechanism. Such a system is disclosed in my copending application, Serial No. 402,632, filed August 10, 1920.

If the traffic between toll centers is not extremely heavy and therefore a small group of toll lines is adequate to handle the traffic the method of employing a common signaling path and start-stop distributor mechanism as disclosed in the aforesaid application, is not feasible due to the fact that such mechanism would not be efficiently employed and therefore would be expensive to install and maintain.

It is, therefore, an object of this invention to provide an improved means for extending a connection from a toll line to a subscriber's line by means of automatic switch-

ing mechanism and especially adapted for use where small groups of toll lines are employed between toll centers, although the invention is equally applicable to large toll line groups.

A further object of the invention is the provision of means for directively controlling automatic switches over the toll line by means of current impulses of one frequency, and for supervising the connection by the transmission over the toll line of current impulses of a different frequency.

A further object is the provision of means for controlling a plurality of devices over a transmission circuit by means of electromotive forces of different intensity.

These and other objects of the invention will be more readily understood by reference to the accompanying drawings in which Figure 1 shows the outgoing end of a toll line which is provided with an outgoing calling branch terminating in a jack, and an incoming called branch terminating in an automatic switch, together with the apparatus necessary to control the transmission and reception of switch controlling and supervisory impulses, and the calling end of an originating toll operator's cord circuit; Fig. 2 shows circuits similar to those of Fig. 1, located at the incoming end of the toll line; Fig. 3 shows the circuits of a selector switch by means of which the called branch of the incoming end of the toll line is extended to a connector switch in the desired office of the distant exchange, a fragmentary representation of the connector switch in the desired office and a diagrammatic representation of a subscriber's line to which a connection may be extended; and Fig. 4 illustrates diagrammatically the manner in which the invention may be employed to extend a toll connection through an intermediate toll switching center to a distant exchange or between adjacent toll centers.

In general, the system functions in the following manner: A subscriber in the exchange X desiring a connection with a subscriber in the exchange Y which may be reached directly from the exchange X over the toll line L, first obtains a connection through the position of the usual "A" or answering operator, with a toll operator. After receiving instructions from the calling subscriber through the "A" operator's position, the toll operator obtains a connection with the calling line over a toll switching trunk and extends the connection by means of her calling plug to an idle toll line extending to the desired distant exchange. In response to the seizure of the toll line, 135 cycle current is connected to the toll line and causes the operation of a toll line hunting switch at the incoming end of the toll line, to associate an amplifier-rectifier with the incoming end of the selected toll line for receiving dialing impulses and repeating them as direct current impulses to the selector switch in which the toll line terminates. Following the association of the rectifier with the toll line, 135 cycle current is connected to the toll line at the incoming end thereof for operating a supervisory signal in the cord circuit of the originating toll operator to inform the operator that she may begin dialing. The toll operator then proceeds to transmit dialing impulses over the toll line by the application of 800 cycle current thereto. These impulses are received by the rectifier and repeated to the automatic switching mechanism in which the toll line terminates. Through the operation of the switching mechanism and other switches to which the switching mechanism has access, the connection is then extended to the desired line in the distant exchange.

After dialing the desired number, the operator disconnects the dial at her cord circuit and throws her ringing key. The application of ringing current to the toll line causes the transmission of 135 cycle current of increased strength, which current at the incoming end of the toll line causes the disassociation of the rectifier from the toll line, the cutting through of the toll line to the called line terminals and the application of ringing current to the line of the called subscriber. As soon as the rectifier is disassociated from the toll line, 135 cycle current is disconnected from the toll line at the incoming end and the supervisory signal at the toll operator's position is extinguished. When the toll line becomes connected through to the connector switch in the desired office of the distant exchange, 135 cycle current is again connected to the toll line at the incoming end for reoperating the supervisory signal at the toll operator's cord circuit. Upon the response of the called subscriber, this 135 cycle current is withdrawn and the supervisory signal in the cord circuit of the originating toll operator's position is again extinguished to denote that the called subscriber has responded.

Upon the termination of the conversation and the restoration of the receiver to the switch hook at the substation of the called subscriber in the distant exchange, the 135 cycle current is again connected to the toll line at the incoming end thereof, and the supervisory signal at the cord circuit of the originating toll operator is again lighted to indicate that the connection may be taken down. When the originating toll operator withdraws the plug of her cord circuit from the jack of the toll line, 135 cycle current is withdrawn from the toll line at the outgoing end thereof and the apparatus at the

incoming end of the toll line, which was employed in the establishment of the connection, is restored.

In case it is necessary to build the connection through the intermediate toll center Y in order to reach the desired exchange Z as illustrated in Fig. 4, the connection is extended over the toll line L from the originating exchange X to the intermediate toll center Y, and the automatic switching mechanism in which the toll line terminates is then set upon the outgoing terminals of the toll line L′, extending from the intermediate toll center Y to the distant exchange Z, and automatic switching mechanism in which the toll line L′ terminates at the distant exchange Z is then set to extend the connection to the terminals of the desired line by controlling impulses transmitted thereto over toll line L, switching mechanism at toll center Y, over toll line L′ and the rectifier and switching mechanism of the distant exchange Z.

As the toll line is adapted for use as a two-way trunk, the apparatus at the two ends of the toll line is identical. To simplify the drawings, only the necessary apparatus for establishing a connection from the exchange X to the exchange Y, is disclosed in full. The cord circuit of the toll operator's position at exchange Y, Fig. 2, has been merely indicated by the calling plug P′, and the amplifier-rectifier at the exchange X for receiving and repeating dialing impulses incoming from the exchange Y, has been represented by a blank square in Fig. 1, it being understood that the apparatus contained within the square is identical with that fully disclosed within the dotted square, Fig. 2. Further, the automatic switching mechanism in Fig. 1 which is controlled to extend connections to subscriber's lines in exchange X is indicated only by the wipers of the respective switches comprising the switching mechanism.

The toll line is branched at each end, one branch being provided with a high pass filter which is so arranged as to offer high impedance to 135 cycle current and current of lower frequency, while passing current of higher frequency as the 800 cycle switch controlling current and current of voice frequencies. This filter is represented by a rectangle labeled "High pass filter" and may be of the type disclosed in the patent to Osborn No. 1,314,827, issued September 2, 1919. The other branch of the toll line is tuned to respond only to current having a frequency of 135 cycles. This tuning is provided by apparatus which has been disclosed in the drawing as included within the small rectangle labeled "135 cycle tuned circuit" and may be of the type disclosed in the patent to Stone No. 729,104, issued May 26, 1903.

The amplifier-rectifier associated with the toll line finder switch F, Fig. 2, has been represented by a small rectangle and may be of any suitable type as, for example, an audion tube which is capable of receiving alternating current impulses in its input circuit and retransmitting them from its output circuit as amplified and rectified impulses.

Having now outlined, in a general manner, the operation of the system and described briefly the nature of the apparatus employed, it is believed that a clearer understanding of the invention may be had from the following detailed description of the method of extending a connection, first, from the line of a subscriber in exchange X to the line of subscriber B in exchange Y, and then from the line of subscriber X to the line of subscriber C, in exchange Z. A subscriber in exchange X, upon initiating a call, lights a line signal before the answering operator, which operator answers the call and upon ascertaining from the calling subscriber that a toll connection is desired, extends a connection from the line of the calling subscriber over the usual recording trunk to the toll operator's position. The toll operator answers the call in the usual manner and receives instructions from the calling subscriber for further extending the connection. The toll operator then obtains a connection with the calling line over a toll switching trunk in the usual manner.

It will be assumed in this case that the toll operator employs an idle cord circuit O at her position, the calling end only of this cord circuit being disclosed in Fig. 1 of the drawing. The toll operator selects an idle toll trunk line extending to the desired exchange Y, the busy trunk lines of the group extending to this exchange being marked by busy battery potential upon the sleeves of the jacks of these trunk lines and also by drop signals 100 which are operated when the respective trunk lines are busy. It will be assumed that the trunk line L disclosed in the drawing is idle and that therefore the operator inserts the plug P of the cord circuit O into the jack J of this trunk line. A circuit is thereupon established extending from grounded battery, through the winding of marginal relay 101, winding of relay 102, sleeve contact 103 of plug P, sleeve contact 104 of jack J, the left hand armature and back contact of the slow-to-release relay 105, winding of relay 106 and thence to ground through the winding of relay 107. Relays 102, 106 and 107 energize in this circuit but relay 101, being marginal does not receive sufficient current to energize at this time.

The energization of relay 102 closes the tip strand of the cord circuit O, and the energization of relay 107 connects the tip

and ring contacts of the jack J of the outgoing terminal of the toll line L, over the tip and ring conductors 108 and 109, through the upper armature and front contact and the intermediate armature and front contact of relay 107, to the conductors 110 and 111 respectively of the toll line L. At its lowermost armature and front contact, relay 107 establishes a circuit which extends from ground, through the lower armature and front contact of relay 107 and thence in parallel, through the winding of relay 112 and the left hand winding of relay 113. The energization of relay 106 in the sleeve circuit previously traced is without effect at this time. Relay 113, upon energizing, establishes a circuit from grounded battery, through the winding of drop signal 100 and thence to ground through the armature and front contact of relay 113 whereupon the drop signal 100 becomes operated to mark the outgoing terminal of the trunk line L as busy. The energization of relay 107 also disconnects the conductors 110 and 111 of toll trunk L from conductors 114 and 115 respectively, extending through the back contacts and armatures of relay 116, and the back contacts and right hand armatures of relay 117, for the purpose of disconnecting the incoming branch of the toll trunk from the toll trunk.

Relay 112, upon energizing, connects a source of 135 cycle alternating current with the primary transmitting winding 118 which is associated with the circuit 119, over a circuit which may be traced from the source of 135 cycle alternating current 120, through the inner armature and front contact of relay 112, the primary winding 118, the outer armature and front contact of relay 112, resistance element 121, and thence back to the source of current 120. The resistance element 121 is not shunted at this time by the armature and back contact of the slow-to-release relay 122 since at this time relay 122 is energized over a circuit extending from grounded battery, through the winding of relay 122 and thence to ground, through the armature and back contact of ringing relay 123. The alternating current flowing in the circuit previously traced is inductively transmitted to the secondary transmitting winding 124 of the circuit 119 and thence through the tuned circuit 154 over conductors 125 and 126 and through the left-hand winding 127 of the repeating coil 180 in the outgoing end of the toll trunk L. This current is then inductively transmitted over the right-hand winding 128 of the repeating coil 180 in the outgoing end of the toll line L, thence over conductors 129 and 130 of the toll line to the distant exchange Y and through the left-hand winding 200 of the repeating coil 280 in the incoming end of the toll line L at such distant exchange.

The current is then inductively transmitted to the right-hand winding 201 of repeating coil 280, through conductor 202, conductor 203, through the tuned circuit 204, upper left-hand primary winding 205 of the circuit 206, though the lower left-hand primary winding 205, thence back through the tuned circuit 204, conductor 207, conductor 208 to the winding 201. Since filter 209 which is connected to conductors 202 and 208 of the toll line L, is a high-pass filter and therefore attenuates current of 135 cycles frequency so that it is practically extinguished, this current will not pass through the filter and therefore all of the current passes through the tuned circuit 204 and through the primary receiving windings 205 of the circuit 206. The current flowing in the windings 205 is inductively transmitted to the secondary windings 210 in the receiving circuit which terminates in the thermionic relays 211 and 212. This circuit may be traced from the grid of thermionic relay 211, over conductor 213, windings 210 and thence to the filament of the thermionic relay 211. A branch of this circuit may be traced from the grid of thermionic relay 212, conductor 213, windings 210 thence through the A battery 214 to the filament of the thermionic relay 212. The thermionic relay 212 responds to current received in its input circuit whereas the thermionic relay 211 being marginal does not respond to current transmitted from source 120 through resistance 121. The response of the thermionic relay 212 causes current to flow in the well-known manner in its output circuit from the plate through the condenser 217 and relay 218 to ground. The "A" battery 214 supplies current to the filaments of relays 211 and 212.

Relay 218 responding to current flowing in the output circuit of relay 212 attracts its armature thereby closing a circuit extending from grounded battery through the winding of the slow-to-release relay 219, conductor 220, right-hand armature and back contact of relay 221, the winding of relay 222, conductor 223, the armature and back contact of relay 224 and thence to ground at the armature and front contact of relay 218. Relay 222, energizing in this circuit, establishes a circuit for the starting relay 225 which relay is common to the group of finder switches which have access to the terminals of the group of toll lines in which the toll line L is included. The circuit of relay 225 may be traced from grounded battery, through the winding of relay 225, the armature and front contact of relay 222, the left-hand armature and back contact of relay 226 and thence to ground

through resistance element 227. Relay 225, upon energizing, closes starting circuits for all idle finders, only one of which F has been disclosed in the drawing. The starting circuit of the finder F, may be traced from grounded battery, through the winding of the motor magnet 228 of the finder F, the armature and back contact of this motor magnet, the outer left-hand armature and back contact of the stop relay 229, start conductor 230 and thence to ground through the armature and front contact of the starting relay 225.

The motor magnet 228 energizing in this circuit, advances the wipers of the finder F one step and at its armature and back contact opens its own energizing circuit. If the wipers of the switch are not at this time in engagement with the terminals of the toll line which has been taken for use, the motor magnet 228 will again energize and advance the wipers another step. This action of the motor magnet continues until the wipers have been positioned upon the terminals of the calling toll line L. The calling condition of the toll line is marked upon the test terminal 231 appearing in the terminal banks of all finders by battery potential which is connected to this terminal over the circuit previously traced, through the armature and front contact of relay 222 and winding of relay 225. Thus, when the test wiper 232 of the finder switch F engages terminal 231, a circuit is established from grounded battery, through the winding of relay 225, armature and front contact of relay 222, the left-hand armature and back contact of relay 226, terminal 231, wiper 232 and the winding of stop relay 229 to ground. Relay 229 energizes in this circuit, opening at its outer left-hand armature and back contact, the energizing circuit of the motor magnet 228 and at its inner armature and front contact, establishing a circuit for relay 233, extending from grounded battery, through the winding of relay 233 and thence to ground at the inner armature and front contact of relay 229.

The energization of relay 233 now connects the input circuit of the amplifier-rectifier 234 through the high-pass filter 209 to the right-hand winding 201 of the repeating coil 280 in the incoming end of the toll line L, over a circuit which may be traced from the upper right-hand terminal of the amplifier-rectifier, through the upper armature and front contact of relay 233, wiper 235, terminal 236, the outer left-hand armature and back contact of relay 221, the outer armature and back contact of relay 237, the upper armature and back contact of relay 238, trunk conductor 239, thence through the high-pass filter 209, trunk conductor 202, winding 201, trunk conductor 208, high-pass filter 209, trunk conductor 240, the intermediate armature and back contact of relay 238, the inner armature and back contact of relay 237, the inner left-hand armature and back contact of relay 221, terminal 241, wiper 242, the lower armature and front contact of relay 233, and thence to the lower right-hand terminal of the amplifier-rectifier 234.

A locking circuit for relay 229 is also established at this time which may be traced from grounded battery through the impedance coil 243, the upper armature and front contact of relay 233, wiper 235, terminal 236, the outer left-hand armature and back contact of relay 221, the outer armature and contact of relay 237, the winding of polarized relay 244, the inner armature and back contact of relay 237, the inner left-hand armature and back contact of relay 221, terminal 241, wiper 242, the lower armature and front contact of relay 233, impedance coil 245 and thence to ground through the winding of relay 229. Polarized relay 244 energizes in this circuit for a purpose to be described hereinafter. At its armature and front contact, relay 229 also closed a circuit for relay 226, which circuit may be traced from grounded battery through the winding of slow-to-release relay 219, conductor 220, the right hand armature and back contact of relay 221, the winding of relay 226, terminal 246, brush 247, and thence to ground at the armature and front contact of relay 229. Relay 226 energizes in this circuit, opening at its left-hand armature and back contact the circuit previously traced through the winding of starting relay 225, which relay deenergizes to open the start circuits of all finder switches which were started in search of the calling toll trunk L, provided that no other toll trunks have, in the meantime, been taken for use. At its right hand armature and front contact, relay 226 connects the resistance 251 in bridge of the conductors 252 and 253 extending to the first selector switch 300 in which the toll line L terminates.

The slow-to-release relay 219 which was initially energized in series with relay 222, and is now energized in series with relay 226, at its right-hand armature and front contact, connects battery potential to the sleeve 248 of jack J′ of the outgoing branch of the toll trunk L, and at its left hand armature and front contact establishes a circuit for the relay 249 which circuit may be traced from grounded battery through the left-hand winding of relay 249 and thence to ground at the armature of relay 219. Relay 249 energizes in this circuit and closes an obvious circuit for the drop signal 250 to mark the outgoing terminal of the toll line L as busy to all toll operators at the exchange Y.

Polarized relay 244 which energizes in the locking circuit of relay 229 upon energizing establishes a circuit for relay 254 which circuit may be traced from grounded battery through the winding of relay 254, conductor 255, conductor 256 and thence to ground at the armature and front contact of relay 244. Relay 254 energizes in this circuit and connects the source of 135 cycle alternating current 257 to the primary transmitting winding 258 of the circuit 206 over a circuit which may be traced from one terminal of the source 257, the inner armature and front contact of relay 254, primary transmitting winding 258, the outer armature and front contact of relay 254, resistance element 259 and thence to the other terminal of the source 257. The resistance element 259 is not at this time shunted at the armature and back contact of the slow-to-release relay 260, since at this time the relay 260 is energized over a circuit extending from grounded battery through the winding of relay 260 and thence to ground at the armature and back contact of ringing relay 261.

Current from the source 257 flowing through the primary winding 258 causes current to be induced in the secondary winding 262, thence through the upper left-hand coil of winding 205, tuned circuit 204, conductor 203, trunk conductor 202, the right-hand winding 201 of repeating coil 280, trunk conductor 208, conductor 207, tuned circuit 204, lower left-hand coil of winding 205 and thence to the other terminal of secondary winding 262. Current is then inductively transmitted over the trunk conductors of the toll line L to the originating exchange where it is again inductively transmitted into a circuit extending from the left-hand winding 127 of the repeating coil 180, conductor 125, the tuned circuit 154, the upper primary receiving windings 131 of the circuit 119, the lower primary receiving windings 131 of the circuit 119 and thence through the tuned circuit 154 and conductor 126 to the winding 127 of repeating coil 180. Current flowing in this circuit is again inductively transmitted into the input circuits of the thermionic relays 132 and 133. The input circuit of the thermionic relay 132 may be traced from the grid of this relay, through conductor 134, secondary receiving windings 135 of the circuit 119 and thence to the filament of the thermionic relay 132. The input circuit of the thermionic relay 133 may be traced from the grid of this relay through conductor 134, windings 135 to the filament. The battery 136 supplies filament current to both relays 132 and 133. Thermionic relay 133 responds to current flowing in its input circuit from the source 257 at the distant exchange Y, but thermionic relay 132 being marginal, as for example having internal characteristics different from relay 133, does not respond. Thermionic relay 133 in responding causes current to flow in its output circuit from the plate through condenser 139 and relay 140 to ground.

Upon the response of relay 140 to the current transmitted from source 257 at the distant exchange which source was inductively connected to the toll line as soon as the amplifier-rectifier became associated with the incoming end of the toll line at the distant exchange, a circuit is established extending from grounded battery through the winding of marginal relay 101, relay 102, sleeve contact 103 of the plug P, sleeve contact 104 of the jack J, the left-hand armature and back contact of relay 105, resistance element 141, the armature and front contact of relay 106, which relay was energized over the sleeve circuit above traced when the toll operator initially seized the toll trunk L, thence to ground at the armature and front contact of relay 140. It will be noted that the resistance element 141 is now connected to the sleeve circuit in parallel with the windings of relays 106 and 107 and that therefore the resistance of the sleeve circuit becomes reduced to such an extent that the marginal relay 101 associated with the cord circuit O now energizes and closes a circuit for the supervisory lamp 142. The toll operator, noting the illumination of the lamp at this time is apprised of the fact that the amplifier-rectifier has been associated with the selected toll line at the distant exchange and that she may now proceed to dial the necessary number for setting the automatic switching mechanism at the distant exchange to extend the connection to the line of the desired subscriber B.

In response to this dialing signal, the operator throws the dialing key 143 to connect the dialing leads 144 and 145 to the tip and ring strands of the cord circuit which she has taken for use. She then proceeds to set the impulse sender 146 in accordance with the first digit of the number of the desired subscriber. It will be assumed that the number of the desired subscriber is 156 and that therefore the operator first sets the impulse sender for transmitting the digit 1. During the return of the impulse sender to normal position, the circuit of relay 147 is therefore closed once for connecting the source of 800 cycle dialing current 148 to the dialing leads 144 and 145 for transmitting over the toll line a single impulse of high frequency current. This impulse of current flows over a circuit which may be traced from one terminal of the source 148, dialing lead 145, the lower alternate contact of dialing key 143, the ring contacts of plug P and jack J, trunk conductor 109, the intermediate armature and front contact of relay 107,

trunk conductor 111, high-pass filter 149, left-hand winding 127 of the repeating coil 180, thence back through the high-class filter 149, trunk conductor 110, the upper armature and front contact of relay 107, trunk conductor 108, tip contacts of the jack J and the plug P, armature and contact of relay 102, the upper alternate contact of dialing key 143, dialing lead 144, the armature and front contact of relay 147 and thence to the other terminal of the source 148. Current flowing in this circuit induces current into the right-hand winding 128 of the repeating coil 180, thence over the conductors of the toll line to the distant exchange and through the left-hand winding 200 of the repeating coil 280. From this circuit, current is again induced into the right-hand winding 201 of repeating coil 280 and into a circuit which may be traced from the upper terminal of the winding 201 over trunk conductor 202, high-pass filter 209, trunk conductor 239, the upper armature and back contact of relay 238, the outer armature and back contact of relay 237, the outer armature and back contact of relay 221, terminal 236, wiper 235, the upper armature and front contact of relay 233, the upper right-hand terminal of the amplifier-rectifier 234, the lower right-hand terminal of the amplifier-rectifier 234, the lower armature and front contact of relay 233, wiper 242, terminal 241, the inner left-hand armature and back contact of relay 221, the inner armature and back contact of relay 237, the intermediate armature and back contact of relay 238, trunk conductor 240, the high-pass filter 209, and thence to the lower terminal of the repeating coil winding 201.

In response to the impulse of 800 cycle current transmitted over the toll line, the amplifier-rectifier 234 responds and causes a single energization of relay 262. Relay 262 in response to the single impulse closes a momentary circuit through the winding of relay 263 which may be traced from grounded battery through the winding of relay 263, conductor 264, terminal 265, wiper 266 and thence to ground through the armature and front contact of relay 262. Relay 263, upon energizing, disconnects at its armature and back contact the bridge across the conductors 252 and 253 including the resistance element 251, which was established by the energization of relay 226. At the time this bridge was established by relay 226, a circuit was established through the windings of line relay 301 of the selector switch 300 which may be traced from grounded battery through the right-hand winding of relay 301, the inner left-hand armature and back contact of switching relay 302, conductor 253, the armature and back contact of relay 263, the armature and front contact of relay 226, resistance element 251, trunk conductor 252, the outer left-hand armature and back contact of switching relay 302, and thence to ground through the left-hand winding of relay 301. Relay 301 energized in this circuit and at its armature and front contact established a circuit extending from grounded battery, through the winding of slow-to-release relay 303, and to ground at the armature and front contact of relay 301. Relay 303 was energized and prepared a circuit for the primary magnet 304 which circuit becomes effective as soon as relay 301 deenergizes in response to the opening of the bridge circuit, through resistance element 251 by the momentary energization of relay 263. The circuit of magnet 304 may be traced from grounded battery, through the winding of magnet 304, the winding of slow-to-release relay 305, the right-hand armature and front contact of relay 303, the right-hand armature and back contact of switching relay 302 and thence to ground at the armature and back contact of line relay 301. In response to the single impulse transmitted through its winding, primary magnet 304 steps the wipers of selector switch 300 one step vertically opposite the first level of bank contacts. Slow-to-release relay 305 which energizes in series with magnet 304 establishes a circuit from grounded battery, through its armature and front contact, and thence to ground through the winding of test relay 306. This circuit is maintaned as long as stepping impulses flow through the winding of magnet 304. Since relay 305 is slow to release, it does not deenergize between impulses. Relay 306, upon energizing, closes a locking circuit for itself extending from grounded battery, through the left-hand armature and front contact of relay 303, the right-hand armature and back contact of the secondary stepping magnet 307, off normal contact 308 which closes as soon as the switch shaft moves one step from normal, and thence to ground through the right-hand armature and front contact and winding of relay 306.

Following the transmission of the stepping impulses, in this case one impulse, relay 301 remains energized thereby opening the circuit through the primary magnet 304 and the slow-to-release relay 305. After an interval, relay 305 deenergizes closing a circuit for the secondary stepping magnet 307 which may be traced from grounded battery, through the left-hand armature and front contact of relay 303, the right-hand armature and back contact of magnet 307, off normal contact 308, right-hand armature and front contact of relay 306, armature and back contact of relay 305, the left-hand armature and back contact and winding of magnet 307, to ground. Stepping magnet 307 energizing in this circuit advances the

wipers of the switch to the first set of contacts in the first level of the terminal bank.

Upon the energization of stepping magnet 307, the locking circuit of relay 306 is opened at the right-hand armature and back contact of magnet 307. If, however, the first set of terminals engaged by the wipers of switch 300 are the terminals of a busy trunk extending to a busy connector switch 350, then relay 306 is maintained energized over a new locking circuit extending from grounded battery connected to the test terminal of the busy trunk, the test wiper 309, winding of marginal relay 310, the right-hand armature, front contact and winding of relay 306 to ground. The first locking circuit of relay 306 is not opened until magnet 307 has completed its stroke so that the new locking circuit becomes effective before the first is opened. Secondary stepping magnet 307 is now again energized over the circuit previously traced, the magnet 307 opening its own energizing circuit each time it is energized, at its left-hand armature and back contact, and the wipers 309, 311 and 312 of the switch are therefore moved step-by-step over the terminals of the first level until an idle set of terminals is encountered. The locking circuit of relay 306 is now opened and relay 306 deenergizes. Upon the deenergization of relay 306, the stepping circuit of secondary magnet 307 is opened at the right-hand armature and front contact of relay 306, and a circuit is closed for the switching relay 302 extending from grounded battery, through the left-hand armature and front contact of relay 303, the right-hand armature and back contact of stepping magnet 307, off normal contact 308, the right-hand armature and back contact of relay 306, and thence to ground, through the winding of switching relay 302.

Relay 302, upon energizing disconnects the windings of line relay 301 from trunk conductors 252 and 253 and extends these trunk conductors through the left-hand armatures and front contacts of relay 302 to the wipers 311 and 312 respectively of the selector switch 300. At its right-hand armature and back contact, relay 302 opens the stepping circuit previously traced through the winding of stepping magnet 304 to prevent this circuit from being again established upon the deenergization of line relay 301 when this line relay is disconnected from trunk conductors 252 and 253.

Upon the deenergization of relay 301, the circuit for relay 303 is opened and grounded battery is disconnected from the circuit previously traced, through the winding of switching relay 302 but this relay is maintained energized over a circuit extending from grounded battery, through the left-hand armature and back contact of relay 306, off normal contacts 308, the right-hand armature and back contact of relay 306, and thence to ground through the winding of switching relay 302. Battery potential is also connected to the test wiper 309 and the test terminal 313 upon which it is resting for marking the multiple terminals of the trunk line which has been seized by selector switch 300 as busy to other selector switches. This battery potential is connected to the wiper 309 over a circuit extending from grounded battery through the left-hand armature and back contact of relay 306, off normal contacts 308, winding of marginal relay 310, wiper 309, thence to the test terminal 313. As it has been assumed that a connection is to be established with a subscriber's line in the exchange Y, the marginal relay 310 does not become energized when the test wiper 309 engages the test terminals of trunk circuits extending to connector switches such as 350 having access to subscribers' lines. The marginal relay 310 becomes energized only when the test wiper 309 of the selector switch 300 makes connection with test terminal 314 associated with the outgoing branch of a toll trunk line L' extending from the exchange Y to another exchange such as exchange Z (Fig. 4).

Upon the extension of conductors 252 and 253 to the wipers 311 and 312 of the selector switch 300, a circuit is established for the line relay 315 of the connector switch 350, extending from grounded battery through the right-hand winding of relay 315, the normally closed break contacts of the inner armature of relay 316, bank terminal 317, wiper 311, the outer left-hand armature and front contact of relay 302, conductor 252, resistance element 251, armature and front contact of relay 226, armature and back contact of relay 263, conductor 253, inner left-hand armature and front contact of relay 302, wiper 312, bank terminal 318, the normally closed break contacts of the outer armature of relay 316, and thence to ground through the left-hand winding of relay 315. The toll operator now proceeds to dial the last two digits 5 and 6 of the desired number, whereupon, first, five impulses are transmitted in a manner previously described to the line relay 315 of the connector switch 350 for stepping the wipers of the connector switch to the fifth level of bank terminals, and then six impulses are transmitted for rotating the wipers of the switch to the sixth set of terminals in the fifth level which set of terminals are the terminals of the desired line B. The connector switch 350 functions in the well-known manner to select and test the terminals of the desired line.

Having now finished dialing the number of the subscriber's line, the toll operator

releases the dialing key 143 and operates the usual ringing key (not shown) of her cord circuit for transmitting ringing current to the toll line. Upon throwing the ringing key, ringing current is transmitted over tip and ring contacts of plug P and jack J, trunk conductors 108 and 109 and through the winding of ring-down relay 123. Relay 123 responding to the ringing current opens the previously traced circuit of slow-to-release relay 122 thereby causing relay 122 to deenergize to close a shunt around resistance element 121 in the transmitting circuit of generator 120. The current transmitted from generator 120 is thereupon increased to such an extent that the thermionic relay 211 at the incoming end of the toll trunk L responds whereby current flows in the output circuit of the thermionic relay 211 over a circuit extending from the plate, through condenser 278 and relay 267 to ground.

Relay 267 responds to the current flowing in the output circuit of the thermionic relay 211 and closes a circuit extending from grounded battery through its outer armature and front contact, conductor 269, winding of relay 221, conductor 223, armature and back contact of relay 224 and thence to ground at the armature and front contact of relay 218. Relay 221 energizes in this circuit closing a locking circuit for itself extending from grounded battery through the winding of relay 219, conductor 220, the right-hand armature, front contact and winding of relay 221, conductor 223, armature and back contact of relay 224, thence to ground at the armature and front contact of relay 218. At its right-hand armature and back contact, relay 221 opens the circuit of relay 222 and the circuit of relay 226 and these relays now deenergize. Relay 221 opens the circuit previously traced from the amplifier-rectifier to the conductors 239 and 240 of the toll trunk line L, and also the circuit previously traced, through the winding of relay 229 and winding of polarized relay 244. These relays now deenergize. The deenergization of relay 229 opens the circuit of relay 233 and the circuits of the amplifier-rectifier are now in normal condition and the amplifier-rectifier is disassociated from the toll line. At its left-hand armatures and front contacts, relay 221 associates the conductors 239 and 240 with the trunk conductors 252 and 253 which have been extended by the selector switch 300 and the connector switch 350 to the terminals of the subscriber's line B.

Upon the opening of the circuit through polarized supervisory relay 244 and the deenergization of this relay, the circuit previously traced through relay 254 is opened and the source of current 257 is thereupon disconnected from the toll line to cause the supervisory lamp 142 at the toll operator's position to become extinguished.

At the time relay 267 energized upon the response of the thermionic relay 211, a circuit was also closed for the ringing relay 237 extending from grounded battery through the winding of relay 237, conductor 270 and thence to ground at the inner armature and front contact of relay 267. Relay 237, upon energizing disconnects the conductors 239 and 240 of the toll trunk from trunk conductors 252 and 253 and connects the source of ringing current 271 and ground to conductors 252 and 253 and thence to the called subscriber's line. Ringing current now flows to the called subscriber's line from the source of ringing current 271, over the inner armature and front contact of ringing relay 237, the inner armature and front contact of relay 221, conductor 253, the inner left-hand armature and front contact of relay 302, wiper 312 and bank terminal 318 of the selector switch 300, wiper 319 and bank terminal 320 of the connector switch 350, thence over the subscriber's line loop and returning over terminal 321 and wiper 322 of connector switch 350, bank terminal 317 and wiper 311 of selector switch 300, the outer left-hand armature and front contact of relay 302, conductor 252, the outer left-hand armature and front contact of relay 221 and thence to ground through the outer armature and front contact of ringing relay 237.

Following the application of ringing current to the line of the called subscriber, relay 237 becomes deenergized, again connecting conductors 252 and 253 with conductors 239 and 240 of the toll line and connecting the winding of polarized relay 244 over conductors 252 and 253 with the windings of line relay 315 of the connector switch. The circuit of relay 244 may be traced from grounded battery through the right-hand winding of relay 315, the normally closed break contacts of the inner left-hand armature of relay 316, bank terminal 317 and wiper 311 of selector switch 300, the outer left-hand armature and front contact of relay 302, conductor 252, the outer left-hand armature and front contact of relay 221, the outer armature and back contact of ringing relay 237, the winding of polarized relay 244, the inner armature and back contact of relay 237, the inner left-hand armature and front contact of relay 221, conductor 253, the inner left-hand armature and front contact of relay 302, wiper 312 and terminal 318 of selector switch 300, the normally closed break contacts of the outer armature of relay 316 and thence to ground, through the left-hand winding of relay 315. Polarized relay 244 energizes in this circuit and in the manner previously described, closes the cir-

cuit of relay 254 which connects the source of 135 cycle current 257 to the toll line. At the exchange X, marginal supervisory relay 101 becomes reenergized as previously described closing a circuit for supervisory lamp 142. The illumination of lamp 142 at this time apprises the operator of the fact that the called subscriber has not yet responded.

Upon the response of the called subscriber B, following the application of ringing current to his line, a circuit is established for relay 316, which at its left-hand armatures disassociates the windings of relay 315 from the circuit previously traced through the polarized relay 244 and reassociates the windings and associated grounded battery in a reverse manner with the conductors of the circuit whereby the current flowing in the circuit through the winding of relay 244 is reversed. The current now flowing through relay 244 is in such a direction that relay 244 is reversely energized and therefore opens the circuit for relay 254 to disconnect the current source 257 from the toll line. At the originating exchange X, relay 101 is now deenergized to extinguish the supervisory lamp 142 to denote to the operator that the called subscriber has responded.

Upon the termination of the conversation, the called subscriber B restores his receiver to its switch hook thereby opening the circuit of relay 316, which upon deenergizing again connects the windings of relay 315 to the circuit extending through the winding of relay 244 in such a manner as to again reverse the current flowing in this circuit whereby polarized relay 244 responds to again close the circuit of relay 254. Relay 254 is now energized and reconnects the source of current 257 to the toll line to cause the energization of marginal supervisory relay 101 at the originating exchange and thereby cause the illumination of supervisory lamp 142. The toll operator, noting the illumination of lamp 142, becomes aware of the fact that the connection is no longer desired and proceeds to take down the connection.

Upon withdrawing the answering plug of the cord circuit O from the jack of the switching trunk extending toward the calling subscriber's line, a supervisory signal in the switching "B" operator's cord circuit is lighted in the well-known manner to signal the operator that the connection is no longer desired. As soon as the calling subscriber hangs up his receiver, the operator then takes down her cord to restore the circuits at her position all in the manner well known in the art.

At the toll operator's position when the plug P of the cord circuit O is removed from the jack J, the circuit previously traced through the windings of relays 101, 102, 106 and 107 is opened. The deenergization of relay 101 opens the circuit of lamp 142, and the deenergization of relay 102 opens the tip strands of the cord circuit thereby restoring the cord circuit to its normal condition. The deenergization of relay 106, is at this time, without effect. The deenergization of relay 107 disconnects the conductors 108 and 109 of the outgoing branch of the toll line from conductors 110 and 111 respectively of the toll line and connects conductors 110 and 111 of the toll line with conductors 114 and 115 extending to the incoming branch of the toll line so that the incoming end of the toll line at the exchange X is placed in a position to respond to any incoming call.

At its lowermost armature and front contact, relay 107 opens the circuit extending through the left-hand winding of relay 113 to deenergize the drop signal 100 to thereby remove the busy singal from the outgoing terminal of the line L, and opens the circuit of relay 112. Relay 112, upon deenergizing, disconnects the source of 135 cycle current 120 from the toll line. At the incoming end of the toll line at exchange Y, upon the disassociation of the source of current 120 from the toll line, relay 218 deenergizes opening at its armature and front contact the locking circuit of relay 221 and the circuit of slow-to-release relay 219. The release of relay 221 disconnects trunk conductors 252 and 253 from conductors 239 and 240 of the toll line and reassociates the conductors of the toll line with the bank terminals of all toll line finder switches having access to toll line L. Relay 219, upon deenergizing, removes busy potential from the sleeve 248 of jack J' and reconnects the sleeve of the jack with the windings of relays 224 and 238 thereby placing the outgoing calling branch of the toll line L in a condition to be seized by a toll operator at the exchange Y. The deenergization of relay 219 also opens the circuit of relay 249 which in turn opens the circuit of drop signal 250 which signal returns to normal position to signify that the toll line L is free to be seized for establishing connections with the exchange X.

Relay 218, upon deenergizing, establishes a release circuit for selector switch 300 which may be traced from grounded battery through the winding of release magnet 323, off normal contacts 324, conductor 325 and thence to ground at the armature and back contact of relay 218. Magnet 323, upon energizing, causes the restoration of selector switch 300. The connector switch 350 may be restored in any well-known manner upon the restoration of selector switch 300. All of the apparatus employed in the establish-

ment of the connection is now in normal condition.

If the toll operator at exchange Y desires to establish a connection with the subscriber's line A in exchange X, the operator inserts the plug P′ of her cord circuit O′ in the jack J′ of the outgoing calling branch of an idle toll line such as L and the connection is established through the operation of the selector switch 150 and connector switch 151, and the establishment of the connection is supervised in exactly the same manner as described hereinbefore in connection with the establishment of a connection from the exchange X to the subscriber's line B terminating in exchange Y. Since the operations are exactly similar and the apparatus of identically the same construction is employed, it is thought unnecessary to described the establishment of such a connection.

If a calling subscriber in the exchange X desires to establish a connection with the line of subscriber C which terminates in the exchange Z, it is then necessary to build up a toll connection from exchange X, through the intermediate exchange Y to the exchange Z. The establishment of a connection from the exchange X to the exchange Y, proceeds in the manner previously described up to the point where the selector switch 300 is set by impulses transmitted over the toll line L from the impulse sending mechanism 146 associated with the cord circuit O at the exchange X. Since it is now assumed that the connection is to be extended through the exchange Y to a toll line L′ extending to the distant exchange Z, it is now necessary to set the selector switch 300 upon the outgoing terminals of an idle toll line L′. Therefore, the originating toll operator will dial the first digit, for example 0, which will set the wipers of the selector switch 300 upon a level of bank terminals in which toll line L′ extending to the exchange Z terminates.

When the selector switch 300 has been so set and has rotated over the level of bank terminals until an idle toll line L′ has been found, then a circuit is established for causing the transmission of 135 cycle current over the toll line L′ to the exchange Z for causing the association of an amplifier-rectifier at such exchange with the incoming end of the toll line L′.

In Fig. 4, a part of the circuits employed in establishing a connection from the exchange X to the exchange Z, have been disclosed with special reference to that portion of the circuits by means of which a dialing signal and supervisory signals are transmitted from the exchange Z through the exchange Y to the exchange X. Following the association of an amplifier-rectifier with the incoming end of the toll line at the exchange Z, the polarized relay 444, corresponding to polarized relay 244 at exchange Y, is energized in a manner similar to that previously described, and establishes a circuit for relay 454, corresponding to relay 254, for transmitting current from the source of current 457 over the toll line L′ to the exchange Y for energizing the relay 440, which relay corresponds to relay 140 at exchange X. Current from the source 457 is transmitted over the toll line L′ in exactly the same manner as current from the source 257 is transmitted over the toll line L. In Fig. 4, the tuned circuit, circuit and associated thermionic relays have been represented at each end of the toll lines L and L′ by rectangles designated R.

Relay 440 energizes in response to current from the source 457 and closes a circuit extending from ground through its armature and front contact, armature and front contact of relay 406, which was energized in series with the marginal relay 310, when the selector switch 300 seized the outgoing end of the toll line L′ at exchange Y, thence through the resistance element 441, through test terminal 313, test wiper 309, winding of marginal relay 310 and to grounded battery. Since now resistance element 441 is connected in parallel with the winding of relay 406, marginal relay 310 receives sufficient current to energize.

Relay 310, upon energizing, closes a circuit for relay 254, extending from grounded battery through the winding of relay 254, the armature and front contact of relay 310 and thence to ground. Relay 254, upon energizing, connects the source of 135 cycle current 257 to the toll line L for causing the energization of relay 140 at the exchange X as has been previously described. The energization of relay 140 connects resistance element 141 in parallel with the winding of relay 106 thereby causing the energization of marginal supervisory relay 101 at the originating operator's cord circuit for lighting the lamp 142 to signify to the toll operator that the toll connection has been extended to exchange Z and that the amplifier-rectifier at such exchange has been associated with the toll line L′ through the selector switch 300 and the toll line L′.

The toll operator at exchange X then proceeds to dial the remaining digits to set the selector switch 400 and the connector switch 450 at the exchange Z for extending the connection to the line of the desired subscriber C.

When the connection has been extended to the desired subscriber's line, the originating toll operator applies ringing current to the toll line L in the manner previously described which causes the energization of ringing relay 237 at the exchange Y to connect the source of ringing current 271 to

the trunk conductors 252 and 253. thence over the wipers of selector switch 300 to the outgoing terminals of toll line L′. In response to the ringing current, the relay corresponding to ring-down relay 123 is energized to cause the transmission of 135 cycle current of increased strength over toll line L′ for causing the energization of a ringing relay corresponding to ringing relay 237 for applying ringing current to the line of the desired subscriber C.

The response of the called subscriber C operates the polarized relay 444 at the exchange X in the same manner as the response of subscriber B operates the polarized relay 244 at the exchange Y as previously described, and causes the transmission of a supervisory signal to the cord of the originating toll operator in the same manner as hereinbefore described in connection with the transmission of a dialing signal from the exchange Z through exchange Y to exchange X.

Upon the termination of the conversation and the withdrawal of plug P from jack J at the originating exchange X, the apparatus at exchanges X and Y is restored in the manner previously described. The restoration of selector switch 300 at exchange Y initiates the restoration of the apparatus employed at exchange Z in exactly the same manner as the withdrawal of plug P from jack J initiated the restoration of apparatus at the exchange Y.

While the invention has been illustrated as operating upon a full mechanical basis at the incoming ends of the toll lines, it is to be understood that the selector switches in which the toll lines terminate may equally well extend the toll lines to jacks appearing in manual operators' positions so that toll connections could then be extended from the incoming ends of the toll lines semi-automatically.

Furthermore the invention is not to be considered as limited to the use of alternating current of the frequencies specified for controlling supervision and the setting of the automatic switching mechanism, since the sources of alternating current and the elements of the filters and tuned circuits may be selected from a wide range of values, it being necessary only to employ supervisory current of a frequency below the lower range of voice current frequencies.

What is claimed is:

1. In a telephone system, an originating exchange, a distant exchange, a subscriber's line terminating in said distant exchange, a plurality of trunk lines extending between said exchanges, automatic switching mechanisms at said distant exchange in which said trunk lines terminate for extending connections from said trunk lines to said subscriber's line, an impulse repeater at said distant exchange common to said trunk lines, means for associating said repeater with one of said trunk lines, impulse transmitting means at said originating exchange for transmitting impulses of one frequency over any one of said trunk lines to said repeater for controlling the switching mechanism in which said trunk line terminates, means at said originating exchange for transmitting an impulse of a different frequency over any one of said trunk lines for controlling the association of said repeater with a particular trunk line, means at said distant exchange operative upon the association of said repeater with said trunk line for transmitting an impulse of said latter frequency over said trunk line and means at said originating exchange responsive to said latter impulse for producing a dialing signal.

2. In a telephone system, an originating exchange, a distance exchange, a subscriber's line terminating in said distant exchange, a plurality of trunk lines extending between said exchanges, automatic switching mechanism at said distant exchange in which said trunk lines terminate for extending connections from said trunk lines to said subscriber's line, an impulse repeater at said distant exchange common to said trunk lines, means for associating said repeater with any one of said trunk lines, means at said distant exchange for transmitting ringing current to said subscriber's line, impulse transmitting means at said originating exchange for transmitting impulses of one frequency over any one of said trunk lines to said repeater for controlling the switching mechanism in which said trunk line terminates, means at said originating exchange for transmitting an impulse of a different frequency over any one of said trunk lines for controlling the association of said repeater with a particular trunk line and means at said originating exchange for transmitting an impulse of said latter frequency but of greater strength over said trunk line for operating said ringing current transmitting means.

3. In a telephone system, an originating exchange, a distant exchange, a called subscriber's line terminating in said distant exchange, a trunk line extending between said exchanges, automatic switching mechanism at said distant exchange in which said trunk line terminates for extending said connection from said trunk line to said subscriber's line, a cord circuit at said originating exchange for connection to said trunk line, a supervisory signal associated with said cord circuit, means at said originating exchange for transmitting impulses of one frequency over said trunk line for controlling said switching mechanism and means at said distant exchange operative upon the response

of the called subscriber for transmitting current of a different frequency over said trunk line for operating said supervisory signal.

4. In a telephone system, an originating exchange, an intermediate exchange, a distant exchange, a subscriber's line terminating in each of said exchanges, trunk lines extending between said originating exchange and said intermediate exchange, trunk lines extending between said intermediate exchange and said distant exchange, automatic switching mechanisms at each exchange in which said trunk lines terminate, means at said originating exchange for seizing a trunk line extending to said intermediate exchange and for transmitting impulses of one frequency thereover for operating said mechanism in which said seized trunk line terminates for extending a connection to said trunk line extending to said distant exchange, means controlled thereby and thereover for then transmitting impulses of the same frequency over said latter trunk line for controlling the switching mechanism in which said latter trunk line terminates to extend said connection to a desired subscriber's line in said distant exchange, and means for then transmitting impulses of a different frequency over said trunk lines for supervising said connection.

5. In a telephone system, an originating exchange, an intermediate exchange, a distant exchange, subscribers' lines terminating in each of said exchanges, trunk lines extending between said originating exchange and said intermediate exchange, trunk lines extending between said intermediate exchange and said distant exchange, automatic switching mechanisms at each exchange in which said trunk lines terminate, the switching mechanisms of said intermediate exchange having access to the subscribers' lines of said exchange and to said trunk lines extending to said distant exchange, means at said originating exchange for seizing a trunk line extending to said intermediate exchange and for transmitting impulses of one frequency thereover to operate the switching mechanism of said intermediate exchange in which said trunk line terminates to select at will a subscriber's line in said intermediate exchange or a trunk line extending to said distant exchange, means for thereafter transmitting impulses of said frequency over said latter trunk line to control said switching mechanism in said distant exchange to extend said connection to a desired subscriber's line in said distant exchange when said switching mechanism in said intermediate exchange has been operated to extend the connection to said distant exchange, and means for transmitting impulses of a different frequency over said trunk lines for supervising said connection.

6. In a telephone system, an originating exchange, an intermediate exchange, a distant exchange, subscribers' lines terminating in each of said exchanges, trunk lines extending between said originating exchange and said intermediate exchange, trunk lines extending between said intermediate exchange and said distant exchange, automatic switching mechanisms at each exchange in which said trunk lines terminate, the switching mechanisms of said intermediate exchange having access to the subscribers' lines of said exchange and to trunk lines extending to said distant exchange, means at said originating exchange for seizing a trunk line extending to said intermediate exchange and for transmitting impulses of one frequency thereover to operate the switching mechanism of said intermediate exchange in which said trunk line terminates to select at will a subscriber's line in said intermediate exchange or a trunk line extending to said distant exchange, means for thereafter transmitting impulses of said frequency over said latter trunk line to control said switching mechanism in said distant exchange to extend said connection to a desired subscriber's line in said distant exchange when said switching mechanism in said intermediate exchange has been operated to extend the connection to said distant exchange, and means associated with the switching mechanism of said intermediate exchange and operable only when said mechanism has extended a connection to said distant exchange for controlling the transmission of an impulse of a different frequency over said seized trunk line for supervising said connection.

7. In a telephone system, an originating exchange, an intermediate exchange, a distant exchange, subscribers' lines terminating in each of said exchanges, trunk lines extending between said originating exchange and said intermediate exchange, trunk lines extending between said intermediate exchange and said distant exchange, automatic switching mechanisms at said intermediate and distant exchanges in which said trunk lines terminate, the switching mechanisms of said intermediate exchange having access to the subscribers' lines of said intermediate exchange and to the trunk lines extending from said intermediate exchange to said distant exchange, means at said originating exchange for seizing a trunk line extending to said intermediate exchange, means at said originating exchange for transmitting impulses of one frequency over said seized trunk to operate the switching mechanism of said intermediate office in which said trunk line terminates to select at will a subscriber's line in said intermediate exchange or a trunk line extending to said distant exchange, means for transmitting impulses of

said frequency over said latter trunk line to control said switching mechanism in said distant exchange to extend said connection to a desired subscriber's line in said distant exchange after said switching mechanism in said intermediate exchange has been operated to extend the connection to said distant exchange, a marginal relay associated with the switching mechanism of said intermediate exchange inoperable when said mechanism has extended a connection to a subscriber's line of said intermediate exchange but operable when said mechanism has extended a connection to said distant exchange upon the response of the called subscriber for controlling the transmission of an impulse of another frequency over the trunk line employed in said connection, and a supervisory signal at the originating exchange responsive to said latter impulse.

8. In a telephone system, two exchanges, subscribers' lines terminating in each of said exchanges, a plurality of two-way trunk lines extending between said exchanges, each of said trunk lines terminating at each of said exchanges in outgoing and incoming terminals, said incoming terminals comprising automatic switching mechanism for extending connections to said subscribers' lines terminating in the associated exchange, means at each exchange for seizing the outgoing terminals of one of said trunk lines and for thereafter transmitting impulses of one frequency over said trunk line for controlling the switching mechanism in which said trunk line terminates at said other exchange, and means at each exchange for transmitting impulses of a different frequency over said trunk line for supervising the establishment of the connection.

9. In a telephone system, two exchanges, subscribers' lines terminating in each of said exchanges, a plurality of two-way trunk lines extending between said exchanges, each of said trunk lines terminating at each of said exchanges in out-going terminals and incoming terminals, said incoming terminals comprisng automatic switching mechanism for extending connections to said subscribers' lines terminating in said associated exchange, an impulse repeater at each of said exchanges common to said trunk lines, means at each exchange for associating the repeater thereat with any one of said trunk lines, means at each exchange for seizing the out-going terminals of one of said trunk lines whereby an impulse of one frequency is transmitted over said trunk line for controlling the association of the repeater at the other exchange with said trunk line, and means at each exchange for transmitting impulses of a different frequency over said trunk line to the repeater at the other exchange for controlling the switching mechanism in which said trunk line terminates.

10. In a telephone system, an originating exchange, a distant exchange, a trunk line extending between said exchanges, said trunk line having two branches at its incoming end, automatic switching mechanism in which one of said branches terminates, means at said originating exchange for transmitting impulses of one frequency over said trunk line for controlling said switching mechanism and for transmitting impulses of a different frequency over said trunk line for controlling the supervision of the connection, a filter in one of said branches for attenuating impulses of supervisory frequency but transmiting impulses of switch controlling frequency and of voice frequency without attenuation and a tuned circuit in said other branch tuned to respond only to impulses of supervisory frequency.

11. In a telephone system, an originating exchange, a distant exchange, a subscriber's line terminating in said distant exchange, a plurality of trunk lines extending between said exchanges, each trunk line having two branches at its incoming end, automatic switch mechanism at said distant exchange in which one branch of each trunk line terminates for extending connections from said trunk lines to said subscriber's line, an impulse repeater at said distant exchange common to said trunk lines, means for associating said repeater with any one of said trunk lines, impulse transmitting means at said originating exchange for transmitting impulses of one frequency over any one of said trunk lines to said repeater for controlling the switching mechanism in which said trunk line terminates, means at said originating exchange for transmitting an impulse of a different frequency over any one of said trunk lines for controlling the association of said repeater with a particular trunk line, a filter in one branch of each trunk line for attenuating impulses of said latter frequency but transmitting impulses of said first frequency and to impulses of voice frequency without attenuation, and a tuned circuit in the other branch of said trunk line tuned to respond only to impulses of said latter frequency.

12. In a telephone system, an originating exchange, a distant exchange, a subscriber's line terminating in said distant exchange, a plurality of trunk lines extending between said exchanges, each trunk line having two branches at its outgoing and incoming ends, automatic switching mechanisms in which one branch of each trunk line terminates at said distant exchange for extending connections from said trunk lines to said subscriber's line, an impulse repeater at said distant exchange common to said trunk lines, means for associating said repeater with any one of said trunk lines, impulse transmitting means at said originating

exchange for transmitting impulses of one frequency over any one of said trunk lines for controlling the switching mechanism in which said trunk line terminates, means at said originating exchange for transmitting an impulse of a different frequency over any one of said trunk lines for controlling the association of said repeater with said trunk line, a filter in one branch of the incoming end of each trunk line for attenuating impulses of said latter frequency, a tuned circuit in the other branch at the incoming end of each trunk line tuned to respond only to impulses of said latter frequency, means at said distant office operative upon the association of said repeater with said trunk line for transmitting an impulse of said latter frequency over said trunk line, a tuned circuit in one branch of said trunk line at the outgoing end of said trunk line responsive only to the impulse of said latter frequency, and means under the control of said latter tuned circuit for producing a signal at said originating exchange.

13. In a telephone system, an originating exchange, a distant exchange, a subscriber's line terminating in said distant exchange, a plurality of trunk lines extending between said exchanges, each trunk line having two branches at its incoming end, automatic switching mechanisms at said distant exchange in which one branch of said trunk line terminates for extending connections from said trunk line to said subscriber's line, an impulse repeater at said distant exchange common to said trunk lines, means for associating said repeater with any one of said trunk lines, means at said distant exchange for transmitting ringing current to said subscriber's line, impulse transmitting mechanism at said originating exchange for transmitting impulses of one frequency over any one of said trunk lines to said repeater for controlling the switching mechanism in which said trunk line terminates, means at said originating exchange for transmitting an impulse of a different frequency over any one of said trunk lines for controlling the association of said repeater with a particular trunk line, a filter in one branch of each trunk line for attenuating impulses of said latter frequency but transmitting without attenuation impulses of said first frequency, a tuned circuit responsive only to impulses of said latter frequency, means associated with said tuned circuit responsive to impulses of said latter frequency of one strength for controlling said repeater associating means and a second means associated with said tuned circuit responsive to impulses of said latter frequency but of increased strength for controlling said ringing current transmitting means.

15. In a telephone system, an originating exchange, a distant exchange, a subscriber's line terminating in said distant exchange, a plurality of trunk lines extending between said exchanges, each trunk line having two branches at its incoming end, automatic switching mechanisms at said distant exchange in which one branch of said trunk line terminates for extending connections from said trunk line to said subscriber's line, an impulse repeater at said distant exchange common to said trunk lines, means for associating said repeater with any one of said trunk lines, means at said distant exchange for transmitting ringing current to said subscriber's line, impulse transmitting mechanism at said originating exchange for transmitting impulses of one frequency over any one of said trunk lines to said repeater for controlling the switching mechanism in which said trunk line terminates, means at said originating exchange for transmitting an impulse of a different frequency over any one of said trunk lines for controlling the association of said repeater with a particular trunk line, a filter in one branch of each trunk line for attenuating impulses of said latter frequency but transmitting without attenuation impulses of said first frequency, a

14. In a telephone system, an originating exchange, a distant exchange, a subscriber's line terminating in said distant exchange, a plurality of trunk lines extending between said exchanges, each trunk line having two

tuned circuit responsive only to impulses of said latter frequency, a thermionic relay associated with said tuned circuit responsive to impulses of said latter frequency of one strength for controlling said repeater associating means and a second thermionic relay associated with said tuned circuit responsive to impulses of said latter frequency but of increased strength for controlling said ringing current transmitting means.

16. In a telephone system, two exchanges, subscribers' lines terminating in each of said exchanges, a plurality of two-way trunk lines extending between said exchanges, each of said trunk lines terminating in each exchange in outgoing terminals and incoming terminals, said incoming terminals comprising automatic switching mechanism for extending connections to said subscribers' lines terminating in said associated exchange, an impulse repeater at each of said exchanges common to said trunk lines, means at each exchange for associating the repeater thereat with any one of said trunk lines, means at each exchange for seizing the outgoing terminals for one of said trunk lines whereby an impulse of one frequency is transmitted over said trunk line for controlling the association of the repeater at the other exchange with said trunk line, means at each exchange for transmitting impulses of a different frequency over said trunk line to the repeater at the other exchange for controlling the switching mechanism in which said trunk line terminates and means controlled by said impulse of the first frequency for rendering said trunk line busy at the outgoing terminals at the other exchange.

17. In a telephone system, an originating exchange, a distant exchange, a trunk line extending between said exchanges, said trunk line having two branches at its incoming end, automatic switching mechanism associated with one of said branches, means at said originating exchange for transmitting impulses of alternating current over said trunk line for controlling said switching mechanism, additional means for transmitting impulses of alternating current of another frequency over said trunk line for controlling supervision of the connection, a filter in one of said branches for attenuating said impulses of alternating current of the supervisory frequency but transmitting impulses of alternating current of the switch controlling frequency without attenuation, and a tuned circuit in said other branch tuned to respond only to current of said supervising frequency.

18. In a telephone system, an originating exchange, a distant exchange, a subscriber's line terminating in said distant exchange, a trunk line extending between said exchanges having two branches at its outgoing and incoming ends, automatic switching mechanism associated with one branch of said trunk line at said distant exchange for extending connections from said trunk line to said subscriber's line, a control circuit for said switching mechanism, a relay for controlling said circuit, a cord circuit at said originating exchange for connection with said trunk line, means operative upon connection of said trunk line for applying alternating current to said trunk line for causing the energization of said relay, a supervisory signal associated with said cord circuit, impulse transmitting means associated with said cord circuit for applying alternating current of another frequency to said trunk line for controlling the switching mechanism, means at said distant exchange under the control of the calling subscriber for transmitting alternating current over said trunk line to said originating exchange for controlling the supervisory signal, a filter in one branch of said trunk line at each exchange for attenuating the current of the supervisory frequency but transmitting without attenuation current of the switch controlling frequency and a tuned circuit in the other branch of the trunk line at each exchange responsive only to said supervisory frequency.

19. In a telephone exchange system, an originating exchange, a distant exchange, a subscriber's line terminating in said distant exchange, a trunk line extending between said exchanges having two branches at its incoming end, automatic switching mechanism at said distant exchange associated with one branch of said trunk line for extending a connection to said subscriber's line, a control circuit for said switching mechanism, a relay for controlling said circuit, means at said originating exchange operative upon the seizure of said trunk line for applying alternating current of a certain frequency to said trunk line for energizing said relay, means for applying current of another frequency to said trunk line for also causing the operation of said relay to control said switching mechanism, means at said distant exchange for transmitting ringing current to said subscriber's line, a filter in one branch of said trunk line for attenuating said first mentioned alternating current but transmitting current of the second mentioned frequency without attenuation, a tuned circuit in said other branch responsive only to said first mentioned alternating current, and means at said originating exchange for increasing the strength of said alternating current for operating said ringing current transmitting means.

In testimony whereof, I have signed my name to this specification this 17th day of December, 1920.

JOHN DAVIDSON, JR.