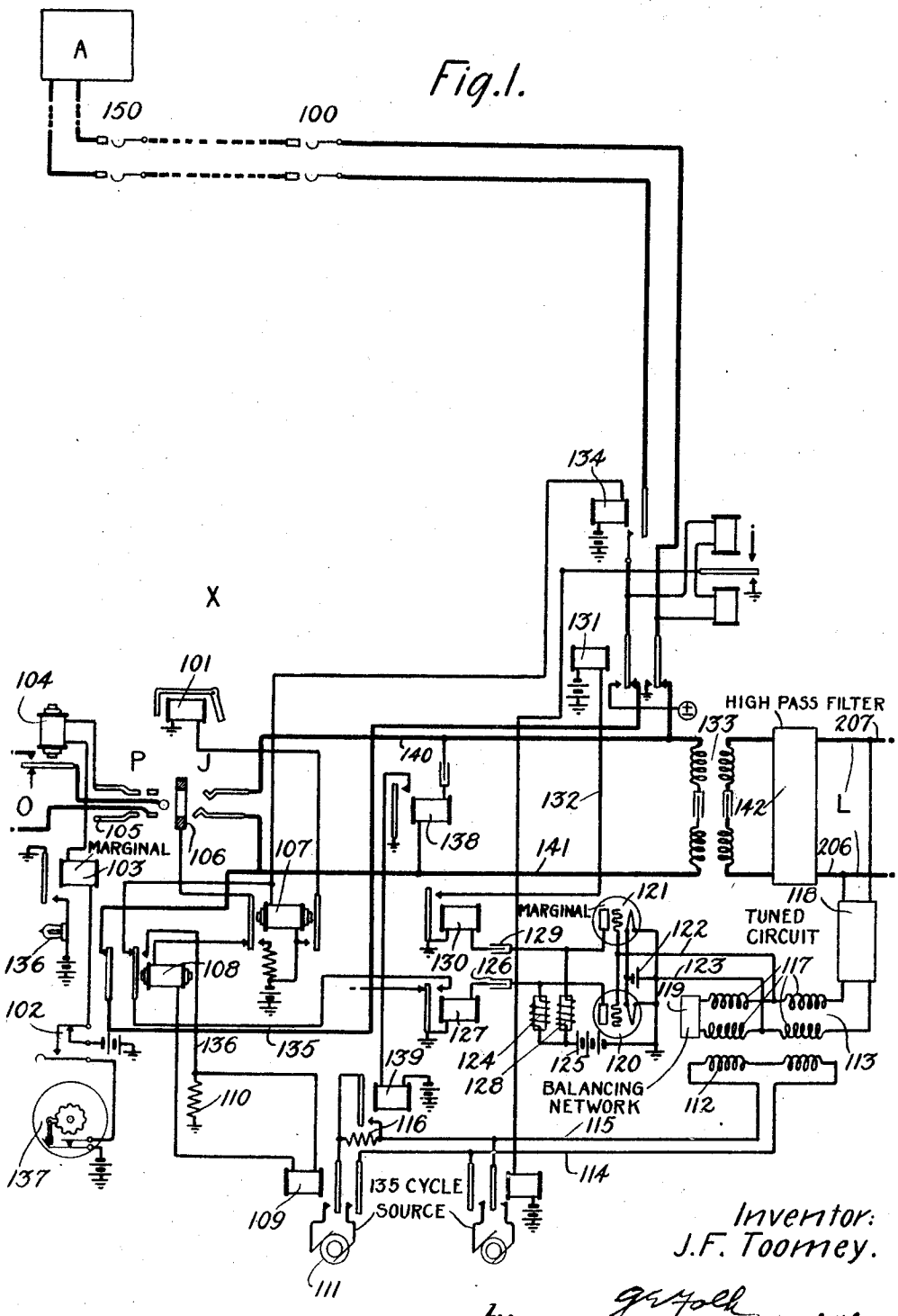
Nov. 27, 1923. 1,475,201

J. F. TOOMEY

TELEPHONE EXCHANGE SYSTEM

Filed Dec. 18, 1920 2 Sheets-Sheet 1

Fig. 1.



Inventor:
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by Gifford Atty

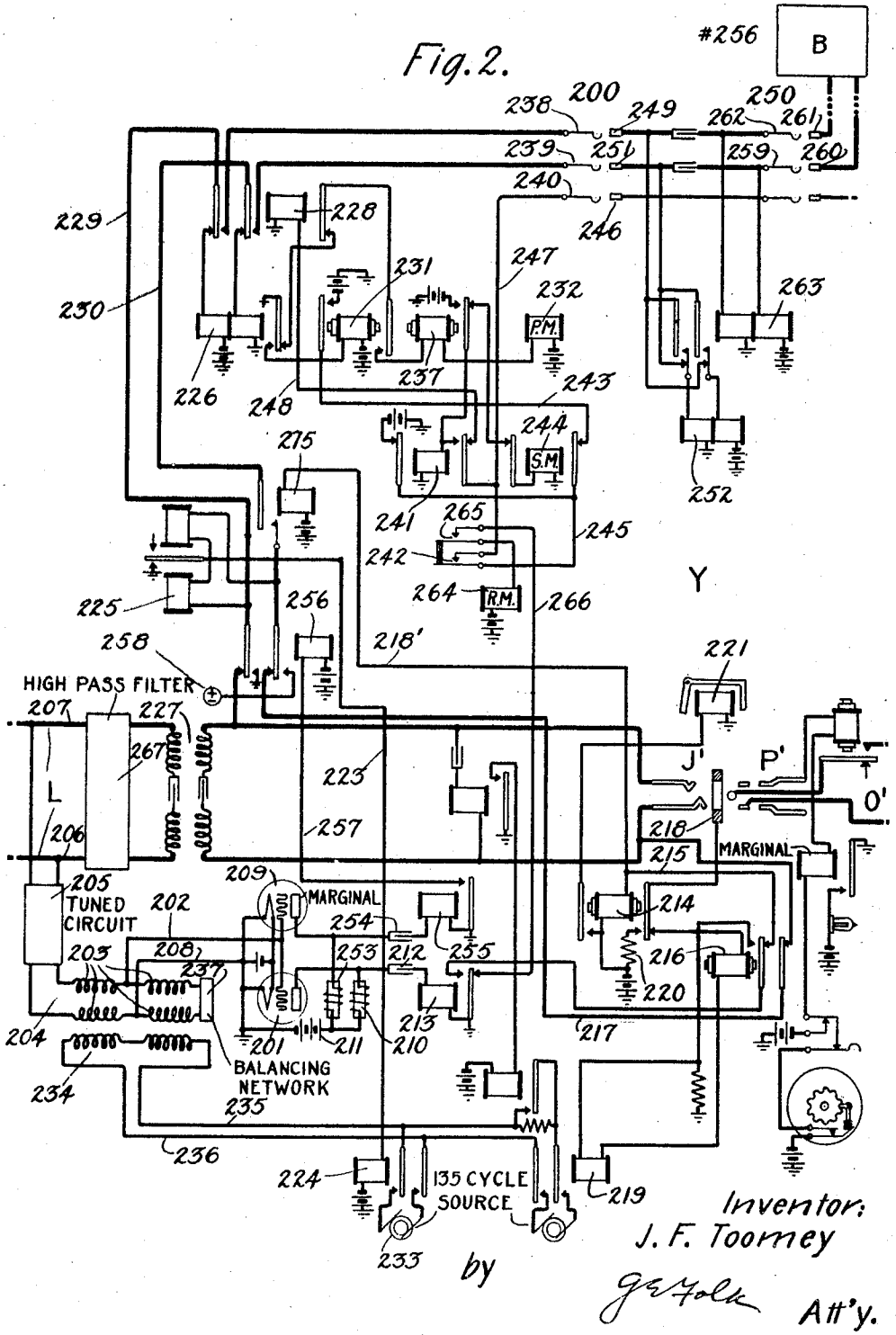
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Fig. 2.



Patented Nov. 27, 1923. 1,475,201

UNITED STATES PATENT OFFICE.

JOHN F. TOOMEY, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

TELEPHONE-EXCHANGE SYSTEM.

Application filed December 18, 1920. Serial No. 431,704.

To all whom it may concern:

Be it known that I, JOHN F. TOOMEY, residing at New York, in the county of New York and State of New York, 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 the toll lines.

Under the present practice followed in connection with one system of this nature the subscriber in one exchange desiring a connection with a subscriber in a distant exchange, first obtains a connection with a toll operator in his own exchange who then extends the connection over a toll line 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 desired local office of the distant exchange which latter operator then proceeds to extend the connection to the desired line.

This method of extending toll connections may be simplified by eliminating the services of the incoming toll and terminating operators at the distant exchange. This is accomplished by terminating the toll lines in automatic selector switches in such a manner that the toll operator at the originating exchange can 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 switches it is not only possible to effect great economy, due to the elimination of the distant toll operator, 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. Furthermore, due to the greater accuracy and speed with which the operator can secure connections with desired subscribers' lines in the distant exchange, the toll line holding time is reduced and the service materially improved.

Toll lines, unless employed to their full capacity for speech and Morse transmission channels, are unprofitable to maintain. It is therefore desirable when adapting such toll lines for automatic operation to follow manual practice and permit operation over such lines in both directions while still maintaining the toll lines as efficient Morse channels. To accomplish this desired end it is proposed to associate automatic switching mechanism with each end of each toll line and to control the mechanism at each end over the toll line from the other end thereof by directive impulses of alternating current. The employment of alternating current for controlling the switching mechanism, not only affords more efficient transmission, but also permits the use of the conductors of the toll line as direct current Morse channels without interference therewith. It is further proposed to supervise the establishment of such a connection by the employment of the line as a duplex channel over which supervisory signals of alternating current may be sent simultaneously in both directions. Each toll line therefore is a self-contained unit which may be employed for the establishment of connections in either direction.

It is therefore an object of this invention to provide an improved means for directly establishing a connection from a toll line to a subscriber's line by means of automatic switching mechanism.

Further objects of this invention are to control automatic switching mechanism and the supervision of connections in either direction over a toll line by means of currents of a selected frequency without interfering with the efficiency of the toll line for speech transmission or the employment of the toll line for the transmission of Morse signals.

A feature of the invention is to selectively operate thermionic devices in accordance with the strength of current supplied thereto.

These and other objects of the invention will be more readily understood by reference to the accompanying drawings in which Fig. 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 automatic switch mechanism, together with the apparatus necessary to control the trans-

mission and reception of switch controlling and supervisory impulses, and the calling end of an originating toll operator's cord circuit; and Fig. 2 shows circuits similar to those of Fig. 1, located at the incoming end of the toll line.

In general the system functions in the following manner:

A subscriber in the exchange X, Fig. 1, desiring a connection with a subscriber in the exchange Y, Fig. 2, which exchange may be reached directly from exchange X over the toll line L, first obtains a connection through the position of the usual "A" or answering operator, with the toll operator. After receiving instructions from the calling subscriber through the "A" operator's position, the toll operator reaches the calling subscriber's line over a toll switching trunk by means of the cord O, and extends the connection by means of the calling plug of her cord circuit to an idle toll line extending to the desired distant exchange Y. In response to the seizure of the toll line, alternating current of 135 cycles frequency is connected to the toll line at the outgoing end thereof and causes the toll line to be cut through to the first selector switch in which the toll line terminates at the distant exchange. Following the cutting through of the toll line, current of 135 cycles frequency is connected to the toll line at its incoming end for operating a supervisory signal associated with the originating toll operator's cord circuit for giving the toll operator a dialing signal. The operator then proceeds to transmit switch controlling impulses over the toll line by interrupting the flow of the 135 cycle current which current was connected to the toll line at the time the toll line was taken for use.

In response to the switch controlling impulses the automatic switching mechanism at the exchange Y is operated to select the terminals of the desired line B. After dialing the number of the desired line B, the toll operator disconnects the dial from her cord circuit and throws the ringing key of the cord circuit to apply ringing current to the outgoing terminals of the toll line. The application of ringing current to the outgoing terminals of the toll line causes the strength of the 135 cycle current flowing over the toll line to be increased whereby mechanism is operated at the incoming end of the toll line for applying ringing current to the line of the called subscriber. Upon the response of the called subscriber, the 135 cycle current which up to this time has been flowing over the toll line from the distant exchange to the originating exchange is cut off, thereby causing the supervisory signal at the cord circuit of the toll operator to be extinguished to signify to the toll operator that the called subscriber has responded.

Upon the termination of the conversation and the restoration of the receiver at the substation of the called subscriber in the distant exchange Y, the 135 cycle current is again connected to the toll line at the incoming end thereof and the supervisory signal at the originating toll operator's cord circuit is again lighted to indicate to the operator that the connection is no longer needed and may be restored. When the originating 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 which was employed in the establishment of the connection is restored.

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 apparatus necessary for establishing a connection from the exchange X to the line of a subscriber in the distant exchange Y has been disclosed in full. At the exchanges X and Y the calling end only of the toll operators' cord circuits O and O′ have been disclosed since the invention is not concerned with the manner in which connections are established between calling lines and the cord circuits of the toll operators' positions. At the exchange Y only such portions of the circuits of the connector switch 250 have been disclosed as are deemed necessary to disclose the invention, it being understood that any well known connector switch of the step-by-step type may be employed. At the exchange X the selector switch 100 and the connector switch 150, corresponding respectively to selector switch 200 and connector switch 250 of exchange Y, have been diagrammatically represented by the respective wipers of the switches.

The toll line is branched at each end, one branch being provided with a high pass filter which is so arranged as to attenuate and practically extinguish current of 135 cycles frequency and to transmit without attenuation current of voice frequency. These filters are represented by rectangles labeled "High pass filter" and may be of the type disclosed in the patent to Osborne 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 rectangles labeled "Tuned circuit" and may be of the type disclosed in the patent to Stone 729,104, issued May 26, 1903. The 135 cycle current incoming to either end of the toll line through the branches of the toll line provided with the tuned circuit above described is received by a pair of thermionic relays of the audion

type, one of these thermionic relays being responsive only to current of increased strength. These thermionic relays each control an alternating current relay which is connected to the output circuit of the respective thermionic relay.

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 from the line of a subscriber in the exchange X to the line of the subscriber B in the exchange Y, it being assumed that the directory number of subscriber B is 256. The subscriber in the exchange X upon initiating the call, lights the line signal before the answering or "A" operator, which operator answers the call and upon ascertaining from the calling subscriber that a toll connection is desired extends the connection from the line of the calling subscriber 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 secures 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 exchange Y, the busy trunk lines of the group extending to this exchange being marked by the busy battery potential upon the sleeves of the jacks of these trunk lines and also by drop signals 101 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 jack J of this trunk line. A circuit is thereupon established extending from grounded battery through the normally closed make contacts of the dialing key 102, the winding of marginal supervisory relay 103, the winding of the slow-to-release relay 104, sleeve contact 105 of the plug P, sleeve contact 106 of the jack J, the left-hand armature and back contact of slow-to-release relay 107, the winding of slow-to-release relay 108, the winding of impulse relay 109 and thence to ground through the resistance element 110. Relays 104, 108 and 109 are energized in this circuit but relay 103 being marginally wound does not receive sufficient current at this time to energize.

The energization of relay 104 establishes the continuity of the tip strand of the operator's cord circuit O. The energization of relay 108 is without effect at this time except that the opening of its left-hand normal contact interrupts the connection between the ring conductor of the trunk and the inner contact of relay 131 thus effectively disconnecting the automatic apparatus at exchange X from the trunk. Relay 109 upon energizing connects the source 111 of 135 cycle alternating current to the primary transmitting winding 112 of the circuit 113 over a circuit which may be traced from one terminal of the source 111 through the outer armature and front contact of relay 109, conductor 114, primary winding 112, conductor 115, resistance element 116 and thence through the inner armature and front contact of relay 109 to the other terminal of the source 111. Since resistance element 116 is included in the circuit above traced the current from the source 111 will not be transmitted through the primary winding 112 at its full strength. Current flowing through the primary transmitting winding 112 induces current into the secondary transmitting windings 117 of the circuit 113 and thence to the conductors of the toll line L through the tuned circuit 118 to the grid and filament of thermionic relay 201. This circuit may be traced from the grid of the thermionic relay 201 at the exchange Y over conductor 202, through the upper left-hand coil of the secondary winding 203 of the circuit 204, through the tuned circuit 205, conductor 206 of the toll line L, through the tuned circuit 118 at the exchange X, thence through the upper coils of the secondary winding 117, through the balancing network 119, thence through the lower coils of the secondary winding 117, through the tuned circuit 118, conductor 207 of the toll line L, through the tuned circuit 205 at the exchange Y, thence through the lower left-hand coil of the secondary winding 203, conductor 208 to the filament of the thermionic relay 201. A circuit in parallel with a portion of the circuit above traced extends from the grid of the thermionic relay 209 to the conductor 202, and from the filament of the thermionic relay 209 to the conductor 208. It is to be noted that current flowing in the circuit 113 at the exchange X and impressed thereon from the primary winding 112 has no effect upon the thermionic relays 120 and 121.

The thermionic relay 201 responds to the current received in its input circuit, but thermionic relay 209 being marginal does not respond to the weakened current transmitted from the source 111 through resistance 116. Thermionic relay 201 upon responding causes an alternating current to flow in its output circuit, which extends from the plate of relay 201 through condenser 212 and the alternating current re-

lay 213 to ground. The "B" battery 211 supplies a constant potential to the plate of relay 201 through the impedance coil 210.

Relay 213 is now energized and at its armature end front contact closes a circuit extending in parallel through the windings of relays 214 and 275, which circuit may be traced from grounded battery through the winding of slow-to-release relay 214, conductor 215, the armature and back contact of slow-to-release relay 216, conductor 217, and thence to ground at the armature and front contact of relay 213. The circuit of relay 275 may be traced from grounded battery through the winding of this relay, conductor 218′ thence over conductor 215 and to ground as previously traced at the armature and front contact of relay 213. Relay 214 is energized and at its right-hand armature and front contact opens the circuit normally extending from the sleeve 218 of jack J′ through the windings of relays 216 and 219 for preventing the toll operator at the exchange Y from operating these relays to initiate a call. At its right-hand armature and front contact relay 214 connects grounded battery through the resistance element 220 to the sleeve 218 of the jack J′ for marking the jack of the toll line L with busy potential so that the toll operator at the exchange Y upon testing the jack of this toll line will know that the toll line is in use. At its inner left-hand armature and front contact relay 214 establishes a circuit for the drop 221 which may be traced from grounded battery through the inner left-hand armature and front contact of relay 214 and thence to ground through the winding of drop 221. The operation of drop 221 serves to further signify that the toll line L is in use.

Relay 275 upon energizing opens at its right-hand armature and back contact the circuit extending over conductor 222, conductor 223 and through the winding of relay 224 for preventing a false operation of relay 224 at this time. At its left-hand armature and front contact relay 275 establishes a circuit through the windings of polarized supervisory relay 225 and the windings of line relay 226 of the selector switch 200. The circuit of relay 226 may be traced from grounded battery through the left-hand winding of relay 226, the outer left-hand armature and back contact of switching relay 228, conductor 229, the windings of polarized supervisory relay 225, the left-hand armature and front contact of relay 275, conductor 230, the inner left-hand armature and back contact of relay 228 and thence to ground through the right-hand winding of relay 226. Relays 226 and 225 energize in this circuit, relay 226 closing at its armature and front contact a circuit for the slow-to-release relay 231 which in turn at its right-hand armature and front contact prepares a circuit through the primary stepping magnet 232 of the selector switch 200.

The current flowing through the windings of polarized relay 225 is now in such a direction as to cause this relay to attract its armature against its lower contact thereby establishing a circuit for the relay 224 which may be traced from grounded battery through the winding of relay 224, conductor 223 and thence to ground through the armature and lower contact of relay 225. The energization of relay 224 connects the source 233 of 135 cycle alternating current to the primary transmitting winding 234 of the circuit 204 over a circuit which may be traced from one terminal of the source 233 through the inner armature and front contact of relay 224, conductor 235, primary winding 234, conductor 236 and thence to the other terminal of source 233 through the outer armature and front contact of relay 234. Current flowing in this circuit from the source 233 is of full strength and causes current to flow by induction over the conductors of toll line L to the originating exchange X. The circuit over which this current flows may be traced from the grids of thermionic relays 120 and 121, conductor 122, the upper right-hand coil of the secondary winding 117 of the conjugate circuit 113, tuned circuit 118, conductor 206 of toll line L, tuned circuit 205 at exchange Y, the upper coils of secondary winding 203, balancing network 237, the lower coils of secondary winding 203, tuned circuit 205, conductor 207 of the toll line L, tuned circuit 118 at the exchange X, the lower right-hand coil of the secondary winding 117, conductor 123 and thence in parallel to the filaments of thermionic relays 120 and 121. It is to be noted that current flowing in the circuit 204 at the exchange Y and impressed thereon from the primary winding 234 has no effect upon the thermionic relays 201 and 209.

Since current of full strength has been transmitted over the toll line from the source 233 both thermionic relays 120 and 121 at the exchange X respond, current therefore flowing in the respective output circuits of these relays. The output circuit of thermionic relay 120 may be traced from the plate of this relay through the condenser 126 and the winding of alternating current relay 127 to ground. The output circuit of thermionic relay 121 may be traced from the plate of this relay through the condenser 129 and the winding of alternating current relay 130 to ground. The "B" battery 125 supplies constant potential to the plates of relays 120 and 121 through the impedance coils 124 and 128 respectively. Both relays 127 and 130 become energized.

The energization of relay 130 closes a circuit for ringing relay 131 which may be traced from grounded battery through the

winding of this relay to conductor 132 and thence to ground through the armature and front contact of relay 130. The operation of relay 131 is without effect since the circuit leading to the automatic apparatus at exchange X is open at the alternate contact of relay 134 and the polarized relay corresponding to relay 225 is not affected by the alternating current impressed upon its windings by relay 131.

Relay 127 upon energizing establishes a shunt around resistance element 110 for the purpose of reducing the resistance of the circuit previously traced through the winding of marginal relay 103. This shunt circuit may be traced from ground at the armature and front contact of relay 127, conductor 135, the armature and front contact of relay 108, which relay is at this time energized over the sleeve circuit extending through the winding of relay 103, and over conductor 136 to the ungrounded terminal of resistance element 110. The current flowing through the winding of marginal relay 103 is now increased to such an extent that the relay energizes, closing a circuit for lighting the supervisory lamp 136 which lamp when lighted at this time signifies to the operator that the connection over the toll line has been cut through to the first selector switch 200 in which the toll line terminates at the distant exchange and that she may now proceed to dial the number of the desired subscriber.

The toll operator now throws the dialing key 102, which at its break contact opens the direct connection from the sleeve conductor to battery and at its make contact substitutes a new connection to battery through the contacts of impulse transmitting mechanism 137. Under the assumption that the number of the desired subscriber B is 256 the toll operator will first operate the impulse transmitting mechanism to transmit two impulses over the toll line. The impulse transmitting mechanism may be of the usual dial type which when rotated from normal in accordance with any digit which it is desired to transmit and allowed to return to normal will open the impulsing circuit a number of times corresponding to the digit which it is desired to send. In accordance with the setting of the impulse mechanism 137 for the first digit two the sleeve circuit, previously traced through the windings of relays 103, 104, 108 and 109, is opened twice thereby causing two de-energizations of relay 109. The relays 108 and 104 do not de-energize upon the momentary interruptions of the circuit through their windings since they are designed to be slow-to-release and therefore the circuits established by the energization of these relays are not disturbed at this time.

Upon each de-energization of impulse relay 109 current from the source 111 is momentarily disconnected from the primary winding 112 and therefore current momentarily ceases to flow through the input circuit of the thermionic relay 201 at the distant exchange Y, and in response to each momentary stoppage of current flow in the input circuit of relay 201, relay 213 becomes de-energized and at its armature and front contact opens the circuits previously traced through the windings of relays 214 and 275. Relay 214 being slow to de-energize does not retract its armatures upon the momentary interruptions of current through its winding but relay 275 becomes de-energized upon each de-energization of relay 213. Upon each de-energization of relay 275 the circuit of line relay 226 of selector switch 200 is opened and the circuit of primary stepping magnet 232 is completed from grounded battery through the winding of magnet 232, the winding of slow-to-release relay 237, right-hand armature and front contact of slow-to-release relay 231, the right-hand armature and back contact of switching relay 228 and thence to ground at the armature and back contact of relay 226. Stepping magnet 232 and slow-to-release relay 237 energize in this circuit and since two impulses are transmitted over the toll line L by the originating operator, the stepping magnet 232 is energized twice to step the switch shaft of the selector switch 200 two steps vertically to position and wipers 238, 239 and 240 before the second level of bank terminals to which the switch wipers have access. Relay 237 being slow-to-release maintains its armature attracted so long as stepping impulses flow through the winding of stepping magnet 232, and thus maintains an energizing circuit for the test relay 241 which may be traced from grounded battery through the armature and front contact of relay 237 and the winding of test relay 241 to ground. After the switch shaft is moved upwardly one step the off normal contacts 242 close and establish a locking circuit for the test relay 241 which may be traced from grounded battery through the left-hand armature and front contact of relay 231, conductor 243, the right-hand armature and back contact of secondary stepping magnet 244, conductor 245, off normal contacts 242 and thence to ground through the armature and front contact and winding of relay 241.

Following the transmission of the two impulses, relay 109 at the exchange X remains energized and the current from source 111 is steadily transmitted over the toll line L and the thermionic relay 201 and relay 275 remain steadily energized to maintain the circuit of line relay 226 closed. Relay 226 now being steadily energized holds open the circuit previously traced through the winding of slow-to-release relay 237 and the

winding of stepping magnet 232 and after an interval relay 237 retracts its armature opening the initial energizing circuit of test relay 241 and closing at its armature and back contact an initial energizing circuit for the secondary stepping magnet 244. This circuit may be traced from grounded battery through the left-hand armature and front contact of relay 231, conductor 243, right-hand armature and back contact of stepping magnet 244, conductor 245, off normal contacts 242, the right-hand armature and front contact of test relay 241, armature and back contact of relay 237, the left-hand armature and back contact of stepping magnet 244 and thence to ground through the winding of stepping magnet 244. Stepping magnet 244 energizes in this circuit and advances the switch wipers to the first set of bank terminals in the selected second level. If the trunk line terminating in this first set of bank terminals is busy there will be battery potential upon the test terminal of this trunk and the test relay 241 will therefore be maintained energized even though its locking circuit previously traced through the right-hand armature and back contact of stepping magnet 244 is opened upon the energization of stepping magnet 244. The new locking circuit for test relay 241 may be traced from grounded battery on the test terminal of the busy trunk, test wiper 240, conductor 247, and thence to ground through the right-hand armature and front contact and winding of relay 241. Stepping magnet 244 which upon energizing opens its own circuit at its left-hand armature and back contact and upon de-energizing, causes the advance of the switch wipers to the first set of bank terminals, now re-energizes in view of the fact that test relay 241 is still locked up, the circuit of magnet 244 extending as previously traced from grounded battery at the left-hand armature and front contact of relay 231. In this manner stepping magnet 244 continues to advance the switch wipers over the bank terminals of the second level until the terminals of an idle trunk extending to a connector switch 250 are encountered when the locking circuit of test relay 241 is opened at the right-hand armature and back contact of stepping magnet 244 to open the circuit of stepping magnet 244.

Upon the de-energization of test relay 241 a circuit is established for the switching relay 228 which may be traced from grounded battery through the left-hand armature and back contact of relay 241, conductor 245, off normal contacts 242, the right-hand armature and back contact of relay 241, conductor 248 and thence to ground through the winding of relay 228. A branch of this circuit extends from off normal contacts 242 over conductor 247 to test wiper 240 for connecting battery potential to the multiples of test terminal 246 of the engaged trunk to mark this trunk as busy to all other selector switches having access thereto. The energization of switching relay 228 opens the circuit previously traced through the windings of relay 226 and the windings of polarized relay 225 and extends the trunk conductors 229 and 230 over wipers 238 and 239 and bank terminals 249 and 251 of selector switch 200 to the windings of line relay 252 of the connector switch 250, and polarized relay 225 and line relay 252 now energize in this circuit. At its right-hand armature and back contact switching relay 228 opens the circuit previously traced through the windings of slow-to-release relay 237 and the primary stepping magnet 232 to prevent the false energization of stepping magnet 232 due to the de-energization of relay 226 when its windings are disassociated from trunk conductors 229 and 230. The circuits at the exchange Y are now in condition to receive the last two digits of the number of the called subscriber's line for setting the wipers of the connector switch 250 upon the terminals of this line.

The current flowing through the windings of line relay 252 of connector switch 250 and through the windings of polarized supervisory relay 225 is still in such a direction as to maintain the armature of polarized relay 225 attracted against its lowermost contact thereby maintaining current from the source 233, connected over the toll line for continuing the illumination of supervisory lamp 136 at the toll operator's cord circuit. Line relay 252 of the connector switch functions in the well known manner to cause the wipers of the connector switch to be stepped vertically in response to the digit five to the 5th level of bank terminals and then rotated six steps to the 6th set of terminals in this level. Following the transmission of the digits of the number of the called subscriber, the toll operator restores the dialing key 102 thereby disconnecting the impulse transmitting mechanism 137 from the sleeve conductor of the cord circuit. The setting of the wipers of the connector switch 250 upon the terminals of the desired line and testing of the line take place in the usual manner.

The operator now proceeds to apply ringing current to the outgoing terminals of the toll line for ringing the bell at the substation of line B by throwing the usual ringing key (not shown) associated with the cord circuit. Ringing current now flows through the winding of ring-down relay 138 which relay becomes energized closing a circuit for relay 139. The circuit of relay 139 may be traced from grounded battery through the winding of relay 139 and thence

to ground through the armature and front contact of relay 139. Relay 139 upon energizing attracts its armature thereby shunting the resistance element 116 in the circuit extending from the source of current 111 through the primary winding 112, whereupon the current flowing through the winding 112 is increased thereby increasing the current flowing through the input circuits of thermionic relays 201 and 209 at the exchange Y. Thermionic relay 209 now receives sufficient current to respond so that current flows in its output circuit from the plate through condenser 254 and alternating current relay 255. Relay 255 upon energizing closes a circuit for ringing relay 256 extending from grounded battery through the winding of relay 256, conductor 257 and thence to ground at the armature and front contact of relay 255. Relay 256 energizes in this circuit and at its armatures and back contacts opens the circuit extending from the incoming end of the toll line through the contacts of relay 275, over conductors 229 and 230 to the wipers of connector switch 250, and at its armatures and front contacts establishes a circuit which may be traced from the source of ringing current 258, the inner armature and front contact of relay 256, the armature and front contact of relay 275, conductor 230, the inner left-hand armature and front contact of relay 228, wiper 239 and terminal 251 of selector switch 200, wiper 259 and bank terminal 260 of connector switch 250 thence over the subscriber's line and through the bell at the substation thereof and returning through bank terminal 261 and wiper 262 of connector switch 250, terminal 249 and wiper 238 of selector switch 200, the outer left-hand armature and front contact of ringing relay 256 to ground.

Following the application of ringing current and upon the response of the called subscriber, relay 263 at the connector switch becomes energized and by attracting its armatures reverses the battery connections through line relay 252 of the connector switch to the circuit previously traced extending through the windings of polarized relay 225. The current now flowing through relay 225 is in such a direction that its armature is attracted against its upper contact thereby opening the circuit of relay 224 and disconnecting the source of current 233 from the primary transmitting winding 234. At the originating exchange X the thermionic relays 120 and 121 are now deprived of current in their input circuits and relays 127 and 130 thereupon de-energize. The de-energization of relay 127 disconnects the shunt previously traced from around resistance element 110 thereby increasing the resistance of the sleeve circuit extending through the winding of marginal supervisory relay 103 whereupon relay 103 de-energizes to open the circuit of lamp 136 to signal the toll operator that the called subscriber has responded.

The talking circuit extending from the exchange X to the line of subscriber B may be traced over the heavy conductors 140, 141, 207 and 206 to the exchange Y and thence through armatures and back contacts of relay 256, conductors 229 and 230 to the line of the called subscriber, the called subscriber receiving talking current at the connector switch through the windings of relay 263. Voice currents are allowed to pass freely through the high pass filter 142 at the exchange X and the high pass filter 267 at the exchange Y but due to the tuning of tuned circuits 118 and 205 at the outgoing and incoming ends of the toll line the voice currents are not transmitted through the circuits 113 and 204 respectively.

Upon the termination of the conversation both the calling and the called subscribers restore their receivers to their respective switch hooks. At the exchange X the toll operator is given a disconnect signal upon the restoration of the calling subscriber's receiver to its switch hook in the well known manner. Upon the restoration of the called subscriber's receiver to its switch hook relay 263 becomes de-energized and reconnects battery through the windings of line relay 252 to the circuit extending through the windings of polarized relay 225 in such a manner that the current flowing through the relay 225 now flows in such a direction as to cause this relay to attract its armature against its lower contact. The circuit of relay 224 is again established and current from the source 233 is again transmitted over the toll line L to the originating exchange where thermionic relays 120 and 121 again respond to cause the energization of relays 127 and 130. Relay 127 upon energizing reconnects the shunt around resistance element 110 thereby causing the energization of marginal supervisory relay 103 at the toll operator's cord circuit to close the circuit of supervisory lamp 136.

The toll operator noting the illumination of the supervisory lamps of her cord circuit withdraws the plug P from the jack J thereby opening the circuit previously traced over the sleeve contacts of the plug and jack through the windings of relays 103, 104, 108 and 109. The de-energization of relay 104 opens the tip strand of the cord circuit, the de-energization of relay 103 opens the circuit of supervisory lamp 136 and the de-energization of relay 109 disconnects the source of current 111 from the transmitting circuit including the primary winding 112. Relay 108 in releasing reconnects the conductor leading to the automatic switching apparatus at exchange X in preparation for the receipt of a call from exchange Y. Alter-

nating current now ceases to flow over the toll line from the originating exchange X to the distant exchange Y and relay 213 at the exchange Y is now deprived of current and de-energizes.

Relay 213 upon de-energizing opens the circuit previously traced extending through the windings of relays 214 and 275. Relay 275 upon de-energizing opens the circuit previously traced through windings of relays 225 and 252 whereupon the connector switch is restored in the well known manner. The de-energization of relay 213 at its back contact closes a circuit for restoring the selector switch 200 which may be traced from grounded battery through the winding of release magnet 264 of the selector switch, off normal contacts 265, conductor 266 and thence to ground at the armature and back contact of relay 213. The release magnet 264, upon energizing, causes the release of the selector switch in the well-known manner, which switch, upon reaching its normal position, opens the off normal contacts 265 and 242, thereby opening the previously traced circuit through the winding of release magnet 264. Relay 214, upon de-energizing, disconnects battery potential from sleeve 218 of the jack J' and opens the circuit previously traced through the drop signal 221, thereby removing the busy condition from the outgoing terminal of the toll line L at the exchange Y. The apparatus employed in the establishment of the connection is now entirely restored to normal.

The establishment of a connection from the exchange Y over the toll line L to the exchange X is attained in exactly the same manner as hereinbefore described in connection with the establishment of a connection from exchange X to exchange Y, the apparatus at the two ends of the toll line being identical and functioning in exactly the same manner on outgoing and incoming calls.

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 might 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 any specified frequency as any suitable frequency of current may be employed.

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 trunk line extending between said exchanges, automatic switching mechanism at said distant exchange associated with the incoming end of said trunk line for extending a connection from said trunk to said subscriber's line, a control circuit for said switching mechanism, a relay for controlling said circuit, a cord circuit at the originating exchange for connection with said trunk line, means operative over the sleeve conductor of said cord circuit upon connection with said trunk line for causing the application of alternating current to said trunk line for energizing said relay, an impulse transmitting means associated with the sleeve conductor of said cord circuit for thereafter interrupting the application of said current for operating said relay while said cord circuit and said trunk line are interconnected to control said switching mechanism.

2. In a telephone system, an originating exchange, a distant exchange, a subscriber's line terminating in the said distant exchange, a trunk line extending between said exchanges, automatic switching mechanism at the said distant exchange associated with the incoming end of said trunk line for extending a connection from said trunk line to said subscriber's line, a control circuit for said switching mechanism, a relay for controlling said circuit, means operative upon the seizure of said trunk line at the originating exchange for applying alternating current to said trunk line for causing the energization of said relay, means at said distant exchange responsive to the energization of said relay for transmitting alternating current from said distant exchange over said trunk line to said originating exchange, and means at said originating exchange responsive to said current for producing a dialing signal.

3. 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, automatic switching mechanism at said distant exchange associated with the incoming end of said trunk for extending a connection 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, a supervisory signal associated with said cord circuit, means operative upon connection with said trunk line for applying alternating current to said trunk line for causing the energization of said relay, and means responsive to the energization of said relay for transmitting alternating current over said trunk line from said distant exchange to said originating exchange for operating said supervisory signal.

4. 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, automatic switching mechanism at said distant exchange associated with the incoming end of said trunk line for extending a connection from said trunk line to said subscriber's line, a control circuit for said switching mechanism, a relay for controlling said circuit, means at said distant exchange for applying ringing current to said subscriber's line, means operative upon the seizure of said trunk line at the originating exchange for applying alternating current to said trunk line for causing the energization of said relay, means for thereafter interrupting the application of said current for operating said relay to control said switching mechanism, and means at said originating exchange for increasing the strength of said alternating current for operating said ringing current applying means.

5. 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, automatic switching mechanism at said originating exchange associated with the incoming end of said trunk line for extending a connection 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, a supervisory signal associated with said cord circuit, means operative upon connection with said trunk line at the originating exchange for applying alternating current to said trunk line for causing the energization of said relay, impulse transmitting means associated with said cord circuit for thereafter interrupting the application of said current for operating said relay for controlling said switching mechanism, and means at said distant exchange responsive to the response of the called subscriber for transmitting alternating current over said trunk line to said originating exchange for controlling said supervisory signal.

6. In a telephone system, two exchanges, subscribers' lines terminating in each of said exchanges, a two-way trunk line extending between said exchanges said trunk line terminating at each exchange in an outgoing terminal and an incoming terminal, said incoming terminal having associated therewith automatic switching mechanism for extending connections to said subscribers' lines terminating in the associated exchange, means at each exchange for seizing the outgoing terminal of said trunk line and for thereafter transmitting impulses of alternating current over said trunk line for controlling the switching mechanism at said other exchange, and means at each exchange for simultaneously transmitting impulses of alternating current over said trunk line for supervising the establishment of the connection.

7. 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 and for controlling supervision of the connection, a filter in one of said branches for attenuating said impulses of alternating current but transmitting current of voice frequency without attenuation, and a tuned circuit in said other branch tuned to respond only to current of said switch controlling and supervisory frequency.

8. In a telephone system an originating exchange, a distant exchange, a subscriber's line terminating at 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 with 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 thereafter interrupting the application of said current for operating said relay to control said switching mechanism, means at said distant exchange under the control of said called subscriber for transmitting alternating current over said trunk line to said originating exchange for controlling said supervisory signal, a filter in one branch of said trunk line at each exchange for attenuating said alternating current but transmitting current of voice frequencies without attenuation, and a tuned circuit in the other branch of said trunk line at each exchange responsive only to said alternating current.

9. 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 incoming end, automatic switching mechanism at said distant exchange associated with one branch of said trunk line for extending a

connection from said trunk line 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 to said trunk line for causing the energization of said relay, means for thereafter interrupting the application of said current for operating 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 alternating current but transmitting current of voice frequencies without attenuation, a tuned circuit in said other branch responsive only to said alternating current and means at said originating exchange for increasing the strength of said alternating current for operating said ringing current transmitting means.

10. 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 incoming end, automatic switching mechanism at said distant exchange associated with one branch of said trunk line for extending a connection from said trunk line 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 to said trunk line for causing the energization of said relay, means for thereafter interrupting the application of said current for operating 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 alternating current but transmitting without attenuation, current of voice frequencies, a tuned circuit in said other branch responsive only to said alternating current, means associated with said tuned circuit responsive to said alternating current of one strength for controlling said relay, a second means associated with said tuned circuit responsive to said alternating current of increased strength for controlling said ringing current transmitting means and means at said originating exchange for increasing the strength of said alternating current.

11. 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 incoming end, automatic switching mechanism at said distant exchange associated with one branch of said trunk line for extending a connection from said trunk line 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 to said trunk line for causing the energization of said relay, means for thereafter interrupting the application of said current for operating 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 alternating current but transmitting without attenuation, current of voice frequencies, a tuned circuit in said other branch responsive only to said alternating current, a thermionic relay associated with said tuned circuit responsive to said alternating current of one strength for controlling said relay, a second thermionic relay associated with said tuned circuit responsive to said alternating current of increased strength for controlling said ringing current transmitting means and means at said originating exchange for increasing the strength of said alternating current.

12. In a telephone system, an originating exchange, a terminating exchange, a subscriber's line terminating in said terminating exchange, a trunk line extending between said exchanges, automatic switching mechanism at said terminating exchange associated with the incoming end of said trunk line for extending a connection from said trunk line to said subscriber's line, a relay for controlling said switching mechanism, means operative upon the seizure of said trunk line at the originating exchange for applying alternating current to said trunk line for causing the energization of said relay, means at said originating exchange for interrupting the application of said current for further controlling said relay while said cord circuit and said trunk line are interconnected to cause the operation of such switching mechanism, means at said terminating exchange responsive to the energization of said relay for transmitting alternating current from said terminating exchange over said trunk line to said originating exchange, and means at said originating exchange responsive to said current for producing a dialing signal.

13. In a telephone system, an originating exchange, a terminating exchange, a subscriber's line terminating in said terminating exchange, a trunk line extending between said exchanges, automatic switching mechanism at said terminating exchange for extending a connection 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, a supervisory signal associated with said cord circuit, means operative upon connection with said trunk line for applying alternating current thereto for causing the energization of said relay, means responsive to the energization of said relay for transmitting alternating current over said trunk line from said terminating exchange to said originating exchange for operating said supervisory signal, and means at the originating exchange for interrupting said alternating current applied to said trunk line thereat while said cord circuit and said trunk line are interconnected to further control said relay for operating said switching mechanism.

14. In a telephone system, an originating exchange, a terminating exchange, a subscriber's line terminating in said terminating exchange, a trunk line extending between said exchanges, automatic switching mechanism at said terminating exchange for extending a connection from said trunk line to said subscriber's line, a control circuit for said switching mechanism, a relay for controlling said circuit, means at said terminating exchange for applying alternating current to said subscriber's line, means operative upon the seizure of a trunk line at the originating exchange for applying alternating current to said trunk line for causing the energization of said relay, means for thereafter interrupting the application of said current while said trunk line remains seized for operating said relay to control said switching mechanism, and means at said originating exchange for increasing the strength of said alternating current for operating said ringing current applying means.

15. 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 incoming end, automatic switching mechanism at said distant exchange associated with one branch of said trunk line for extending a connection from said trunk line 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 to said trunk line for causing the energization of said relay, 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 alternating current but transmitting without attenuation currents of voice frequencies, a tuned circuit in said other branch responsive only to said alternating current, means associated with said tuned circuit responsive to said alternating current of one strength for controlling said relay, a second means associated with said tuned circuit responsive to said alternating current of increased strength for controlling the ringing current transmitting means, and means at said originating exchange for increasing the strength of said alternating current.

16. 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, means at said distant exchange for interconnecting said trunk line and said subscriber's line, a relay for controlling said interconnecting means, means at said originating exchange operative upon the seizure of said trunk line for applying alternating current to said trunk line for energizing said relay, means at said distant exchange for transmitting ringing current to said subscriber's line, a tuned circuit at said distant exchange associated with said trunk line responsive to said alternating current, a thermionic relay associated with said tuned circuit responsive to said alternating current of one strength for controlling said relay, a second thermionic relay associated with said tuned circuit responsive to said alternating current of increased strength for controlling said ringing current transmitting means, and means at said originating exchange for increasing the strength of said alternating current.

17. 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.

18. 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.

19. A transmission circuit, a plurality of thermionic devices having input circles connected to said transmission circuit and having separated output circuits, an element associated with each of said output circuits, a source of current, switching means for impressing current from said source upon said transmission circuit to operate one of said devices and thereby control the associated element, and additional switching means for increasing the intensity of the current from said source to operate a plurality of said devices and thereby control the associated elements.

20. A transmission circuit, a plurality of thermionic devices connected to said transmission circuit, a source of current, switching means for connecting said source to said transmission circuit to operate a plurality of said thermionic devices and regulating means to vary the intensity of the current from said source to operate one of said thermionic devices singly.

21. A transmission circuit, means for supplying currents of different intensity thereto, and a plurality of thermionic devices associated with said circuit and selectively operable by said currents.

In testimony whereof, I have signed my name to this specification this 15th day of December 1920.

JOHN F. TOOMEY.