B. D. WILLIS.

AUTOMATIC TELEPHONE SYSTEM.

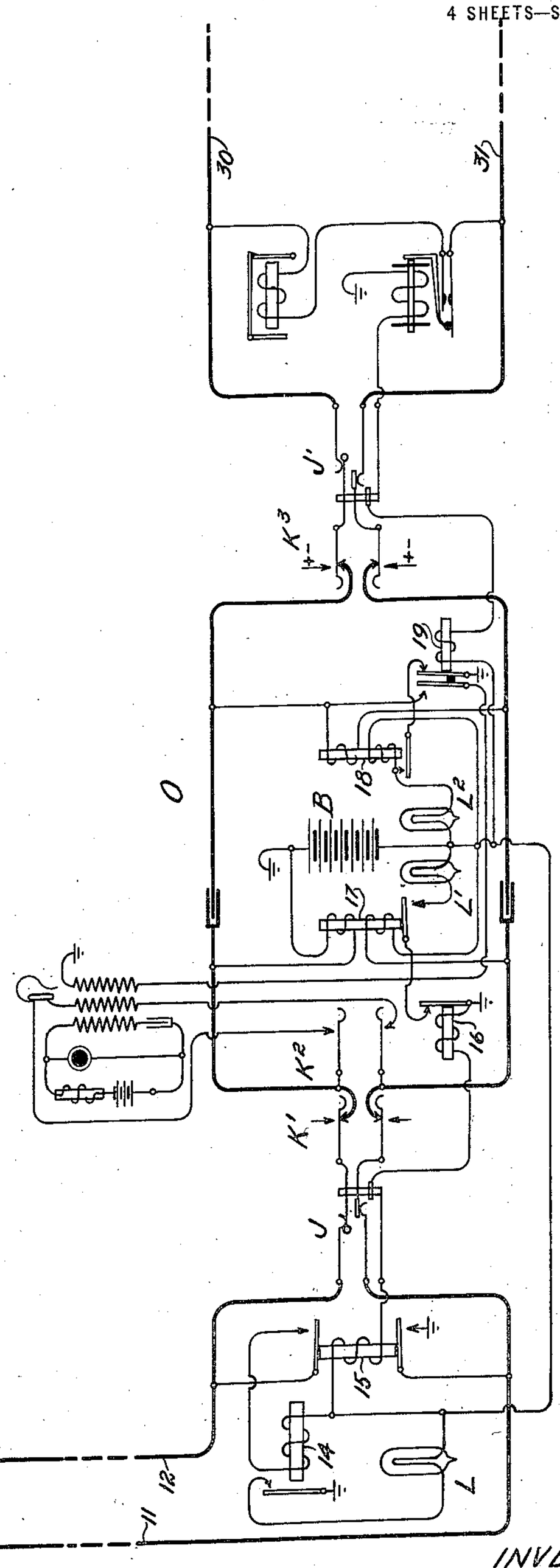
APPLICATION FILED JUNE 7, 1916.

1,315,442.

Patented Sept. 9, 1919.

4 SHEETS—SHEET 1.

FIG. 1.



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4 SHEETS—SHEET 2.

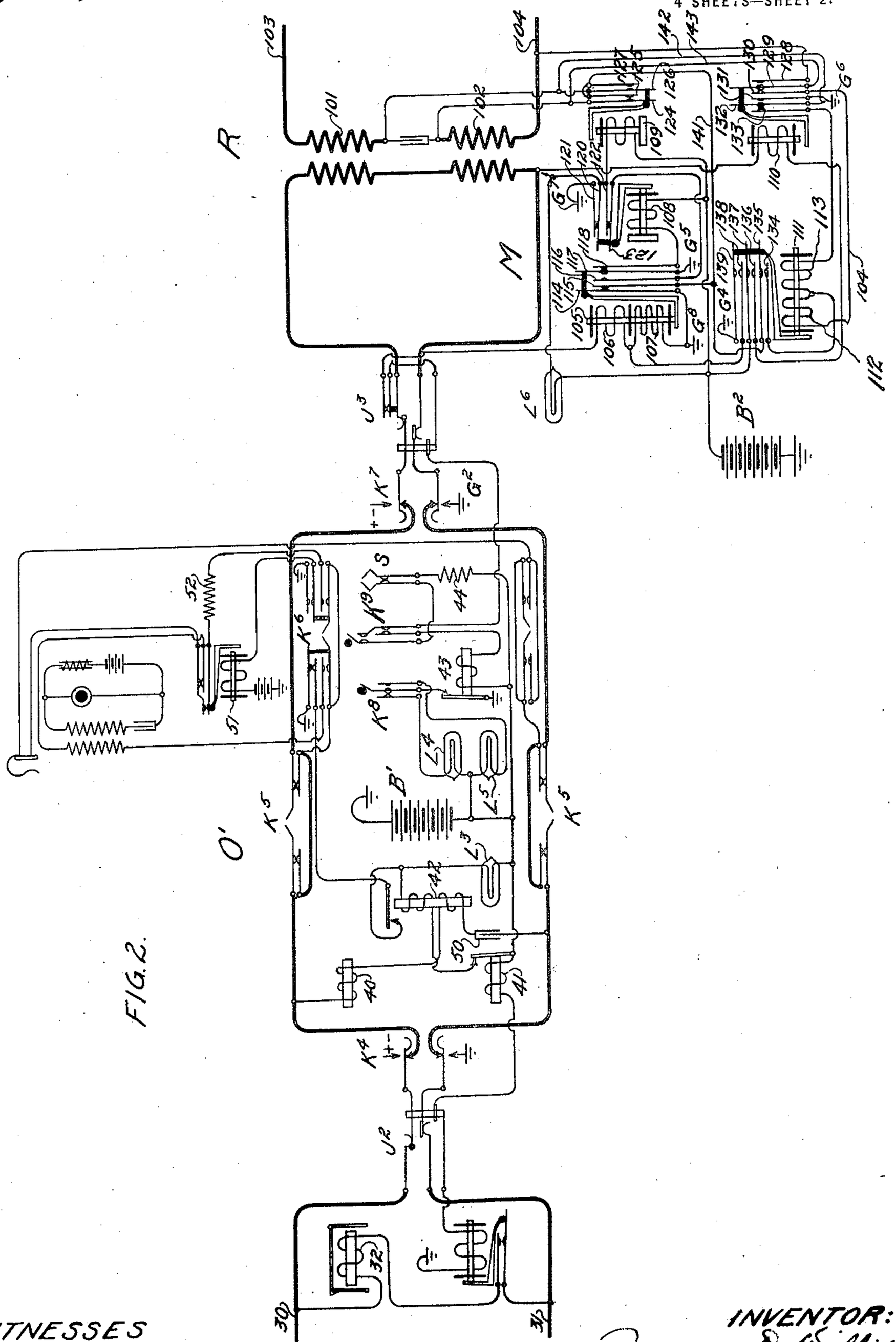

FIG. 2.

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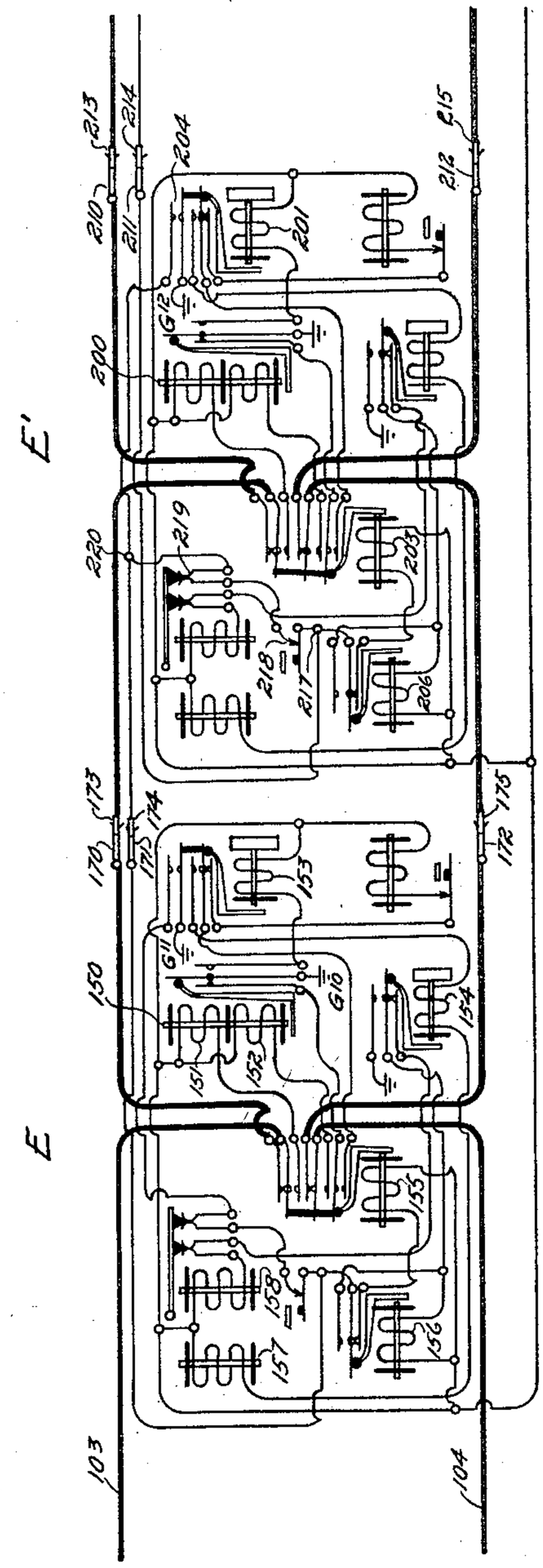
4 SHEETS—SHEET 3.

FIG. 3.



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4 SHEETS—SHEET 4.

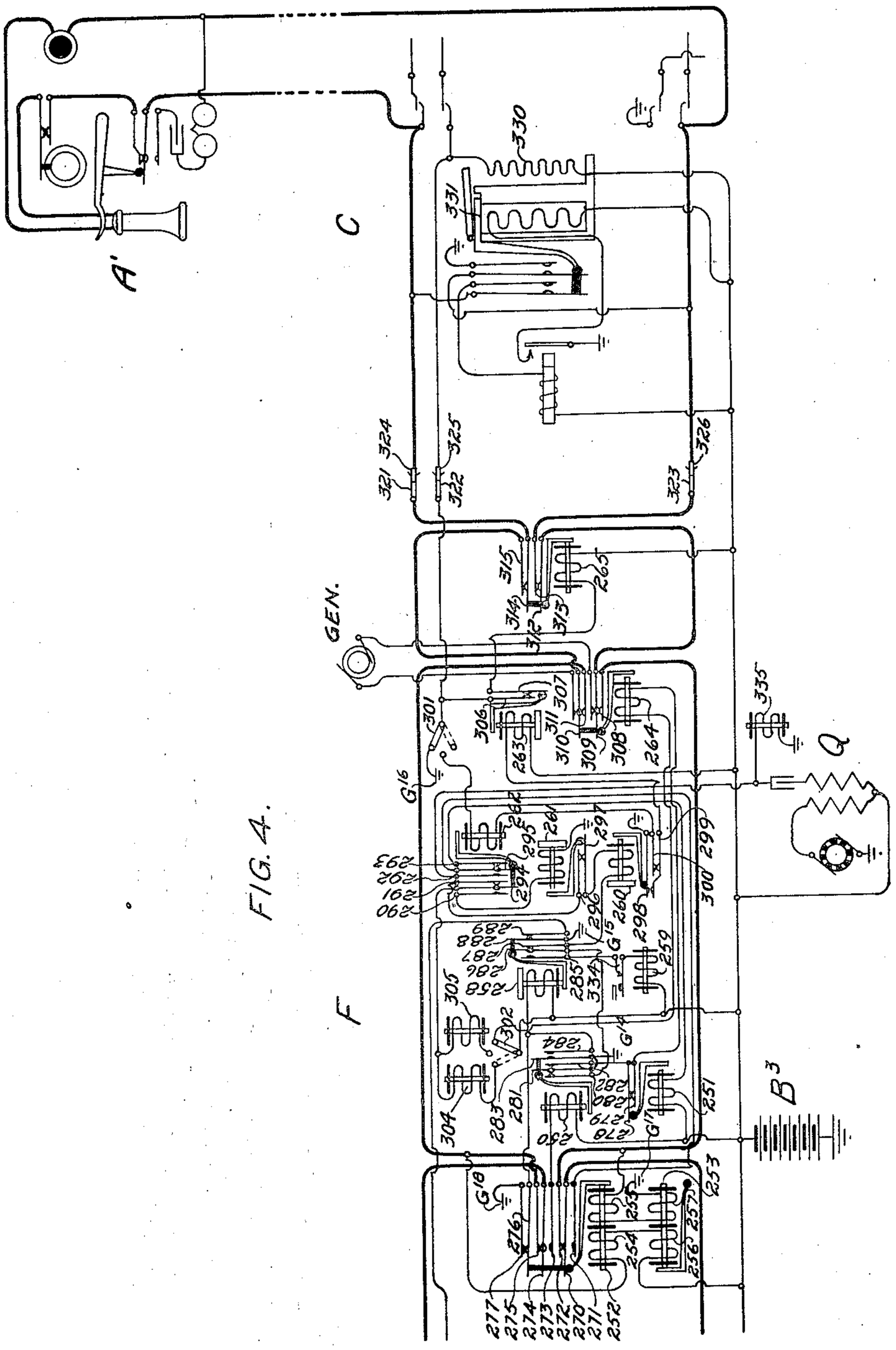

FIG. 4.

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AUTOMATIC TELEPHONE SYSTEM.

1,315,442. Specification of Letters Patent. Patented Sept. 9, 1919.

Application filed June 7, 1916. Serial No. 102,180.

To all whom it may concern:

Be it known that I, BERNARD D. WILLIS, a citizen of the United States of America, and a resident of Chicago, county of Cook, and State of Illinois, have invented certain new and useful Improvements in Automatic Telephone Systems, of which the following is a specification.

My invention relates in general to automatic telephone systems and is particularly concerned with the handling of long distance connections in such systems. More specifically, my invention discloses improved means for completing long distance connections to local subscribers served by a modern automatic central exchange.

The principal object of my invention is the provision, in a system of automatic toll service trunks entirely separate from the regular trunking system, of improved controlling circuits for the automatic switches and improved supervisory circuits for the toll operator, together with certain other details of circuit arrangement, whereby toll connections involving a minimum of transmission loss may be completed automatically with rapidity and certainty.

The foregoing and other objects of my invention and the preferred means for carrying out the same, will appear more clearly and will be explained more fully hereinafter, reference being had to the accompanying drawings, in which Figures 1, 2, 3, and 4, when taken in order with the lines at the ends thereof in alinement, represent diagrammatically a complete long distance connection between a calling substation A, in a manual exchange, and a called substation A′, in an automatic exchange. The said connection has been established through the medium of the operator's cord circuit O (Fig. 1), the toll line 30—31, connecting the two exchanges, the operator's cord circuit O′ (Fig. 2), the toll service trunk 103—104, the toll selector E (Fig. 3), the toll selector E′, and the toll connector F (Fig. 4).

Referring now to Fig. 1, the substation A may be of any suitable or approved type and as shown herein consists of the usual common battery arrangement in which the transmitter and receiver are connected in series. The line conductors 11 and 12 have allotted to them at the exchange the usual line and cut-off relays 14 and 15, the answering jack J, and the lamp signal L.

The toll operator's cord circuit O may likewise be of any suitable type. As shown herein it comprises essentially a bridged relay 17 which, in conjunction with sleeve relay 16, controls the supervisory lamp L′, and the ringing up locking relay 18 which, in conjunction with sleeve relay 19, controls the supervisory lamp L^2. Keys K′ and K^3 are ringing keys, while key K^2 is a listening key whose function it is to bridge the operator's head set across the two strands of the cord circuit.

The toll operator having the cord circuit O has access to a number of toll lines extending to the distant automatic exchange and terminating there at a toll board before other operators. One of these toll lines is indicated by reference characters 30 and 31 and extends from jack J′ at the toll board in the manual exchange to the jack J^2 at the toll board in the automatic exchange. In addition to the jacks J′ and J^2, which may be multiplied if desired, the toll line 30—31 is provided at each end with a regulation drop and cut-off relay.

It is to be understood that the equipment described thus far, including all that shown in Fig. 1 and the line equipment belonging to the toll line 30—31 and partly shown in Fig. 2, is old and well known, and has been included simply to facilitate an understanding of the invention.

The cord circuit O′ (Fig. 2), while it resembles other well known cord circuits in a great many respects, is nevertheless considerably modified in order to reduce transmission losses and to enable it to coöperate with the special toll service trunks, a single supervisory bridge comprising the lower winding of the ringing up and locking relay 42, the condenser 50 and the impedance coil 40, is connected across the two strands of the cord circuit and controls the supervisory lamp L^3. The lamp L^4 is the answering supervisory lamp and is controlled by the mar-

ginal sleeve relay 43, while the lamp L^5 is a special supervisory signal controlled by the same relay and whose function it is to inform the operator when a busy line has become idle, all of which will be fully explained hereinafter. Key K^8 is provided to enable the operator to shift the control of relay 43 from one lamp to the other. Keys K^4 and K^7 are the regular ringing keys. The double throw key K^6 is a combined listening and monitoring key. When thrown in one direction the operator's head set is bridged across the two strands of the cord circuit in the regular manner, but when thrown in the opposite direction the relay 51 is operated, whereby the receiver in series with the resistance 52 is connected across the cord circuit for monitoring purposes. The double throw key K^5 is provided to enable the operator to open the cord circuit conductors on either side of her listening key, whereby she is able to cut off the subscriber at either end while talking to the subscriber at the other end. The key K^9 is a calling device key through the medium of which the operator may insert the calling device S in the sleeve conductor of the cord. The calling device S may be common to a number of cord circuits and as shown herein is of the well known two-wire type, such as is disclosed in the British patent to Dicker, No. 29654 of 1910.

The toll operator at the toll board in the automatic exchange, whose cord circuit O' has just been described, has before her the multiple jacks of a group of toll service trunks each of which extends to a toll first selector. One of these trunks may be seen extending from jack J^3 (Fig. 2) by way of repeating coil R and conductors 103 and 104 to the toll first selector E (Fig. 3). The apparatus just below the repeating coil R and indicated collectively by reference character M is individual to the toll service trunk terminating in jack J^3. It comprises a group of relays whose functions can best be explained in the detailed description of the operation.

The toll selector E (Fig. 3) is of the general type of selector switch disclosed in U. S. Letters Patent No. 815,321, granted March 13, 1906, to Keith, Erickson, and Erickson; being, however, more nearly of the particular type disclosed in the British patent to the Automatic Telephone Mfg. Co., No. 2543 of 1914. Such a selector switch, as is well known, may be operated in response to the first digit of a called number to select one out of a plurality of groups of trunk lines to which it has access, after which it operates automatically to select an idle trunk in the selected group.

One of these trunks is shown extending from bank contacts 173, 174, and 175 to the toll second selector E' which is similar in construction to selector E. The toll selector E' is operable in response to the second digit of the wanted number to select an idle toll connector which has access to the line of the wanted subscriber. For this purpose the selector E' is given access to a plurality of groups of trunk lines in the same way as is selector E, one of these trunk lines being shown extending from bank contacts 213, 214, and 215 to the toll connector F (Fig. 4).

The toll connector F is of the general type of connector switch disclosed in U. S. Letters Patent No. 815,176, granted March 13, 106, to Keith, Erickson, and Erickson; being modified, however, to a considerable extent in order to help accomplish the objects of my invention. The connector switch F is given access to a single group of subscribers' lines and is operable in response to the two final digits of a called number to establish connection with any line in the group to which it has access.

One of the subscribers' lines to which the toll connector has access, is shown extending from the bank contacts 324, 325 and 326 to the substation A'. This substation may be of any suitable automatic type such, for example, as is shown in the British patent to Martin, No. 1419 of 1910. For calling purposes the line conductors of substation A' are provided at the exchange with an individual line switch indicated by reference character C. The line switch C is of the general type of line switch disclosed in the British patent to James, No. 26301 of 1906; being, however, of the particular type disclosed in U. S. Letters Patent No. 1,078,690, granted Jan. 17, 1912, to Frank Newforth. The line switch C is operable in a well known manner when the subscriber at substation A' is calling to extend connection to an idle selector switch.

To sum up the foregoing briefly in order that the trunking scheme may be fully comprehended, the subscribers' lines in the automatic exchange are divided in the well known manner into a large number of groups, each group being provided with a plurality of connectors which are accessible through the medium of the regular line and selector switches to calling subscribers and which have access to called lines in their associated groups. In addition, each group of subscribers' lines is provided with a separate and lesser plurality of toll connectors, similar to toll connector F, which are accessible only to the toll operators through the medium of selectors E and E'. It will be seen, therefore, that the exchange comprises two separate and distinct trunking systems, one of which is used by local subscribers for completing connections to other local subscribers, while the other is used by toll operators for completing long distance connections to the same local subscribers.

While I have shown throughout the drawings a plurality of batteries, it is to be understood that there are preferably but two batteries, one at each exchange, each battery having its positive pole grounded. In connection with the toll connectors F I have shown a ringing current generator Gen for signaling purposes and a busy machine Q for supplying a busy signal to the operator when the called line is busy.

Having given a brief description of the apparatus, I will now proceed to a more detailed description of the operation of the same. For the purposes of the explanation it will be assumed that the subscriber at substation A (Fig. 1) desires to obtain a connection with the subscriber at substation A′ (Fig. 4), this being the complete circuit connection shown in the drawings and previously referred to.

Referring now to Fig. 1, the substation A is shown as having the answering jack J at the toll operator's position. This, of course, would be the case only in a small exchange, but since the method of receiving toll calls in a large exchange is somewhat complicated, involving as it does a subscriber's operator and a so-called recording operator, the present showing is preferred on account of its simplicity.

Upon removing his receiver to initiate the call, the subscriber at substation A completes an energizing circuit for the line relay 14, thereby lighting the lamp signal L to attract the attention of the operator. Upon perceiving the signal, the operator will insert the answering plug of an idle cord circuit (cord circuit O in this case) in the answering jack J and will then throw her listening key K^2 and answer the call. Communications having been established with the operator, the calling subscriber gives her the usual information regarding the party wanted and also his own name and telephone number, and then replaces his receiver.

Since the required party is a subscriber in the distant automatic exchange, the toll operator will now insert the calling plug of her cord circuit in the multiple pack J′ and operate her ringing key, thereby actuating the drop 32 at the distant exchange. In response to the signal thus displayed, the toll operator having the cord circuit O′ will answer by inserting the answering plug of such cord circuit in jack J^2 and operating her listening key. Since the particular routine followed by the operators in setting up a connection, including the making out of toll tickets, timing and supervising the connection, etc., varies greatly with the different operating telephone companies and since this invention is not particularly concerned with these details, the description of this part of the operation will be very general.

We may assume, at least, that the answering toll operator is given the telephone number of the required subscriber and that she immediately proceeds to set up the connection, which in accordance with my invention is done substantially as described hereinafter. Observing first that the service trunk 103—104 is idle, as indicated by the unlighted condition of busy lamp L^6, the calling plug of cord circuit O′ is inserted in jack J^3, thereby completing the following circuit over the sleeve of the cord: ground at G^4, contact springs 139 and 138, winding 106 of relay 105, contact springs of jack J^3 closed by the insertion of the plug, sleeve of jack J^3, sleeve of plug, contact springs of key K^9, and winding of sleeve relay 43 to battery B′. Relay 43, upon energizing, lights the supervisory lamp L^4 in an obvious manner. Relay 105, upon energizing, completes a circuit for slow-acting relay 108 as follows: ground at G^5, contact springs 117 and 118, and winding of relay 108 to battery B^2. Relay 108, upon attracting its armature, prepares an energizing circuit for relay 109 and also closes a circuit to the busy lamp L^6 as follows: ground at G^7, contact springs 121 and 120, and lamp L^6 to battery B^2. It is to be understood that other busy lamps, associated with the multiple jacks of service trunk 103—104 in other positions, are connected in multiple with lamp L^6 and are lighted at the same time.

As a further result of the energization of relay 105, a circuit is closed for the line relay 150 of the selector E (Fig. 3) as follows: ground at G^8, contact springs 114 and 115, contact springs 135 and 134, windings 112 and 113 of relay 111 in parallel, contact spring pairs 130—129 and 133—132 in parallel, windings 102 and 101 of repeating coil R in parallel, conductors 104 and 103 in parallel, normally closed contact spring pairs of relay 155 in parallel, and windings 152 and 151 of the line relay 150 in parallel to battery B^3. Relay 111 is differentially wound and is not operated upon the closure of the above circuit. Relay 150, however, attracts its armature and thereby closes an energizing circuit for the slow-acting relay 153, which relay, upon energizing, prepares circuits for the vertical and rotary magnets 157 and 158 in the well known manner.

The foregoing operations have taken place as a result of the insertion of the plug in jack J^3. Preliminary to dialing the required number, the operator is required to operate the calling device key K^9, whereby the resistance 44 and the calling device S are substituted for relay 43 in the circuit of relay 105. The supervisory lamp L^4 is, of course, temporarily extinguished. The manipulation of the dial of the calling device S in accordance with the first digit of the desired number results in a number of inter-

ruptions of the circuit of relay 105. At the first retraction of its armature, relay 105 completes a circuit for slow-acting relay 109 as follows: ground at G^5, contact springs 117 and 116, contact springs 123 and 122, and winding of relay 109 to battery B^2. Relays 108 and 109, being slow-acting, retain their armatures in operated position during the operation of relay 105 in response to the calling device S, after which relay 109 again retracts its armature. In its operated position relay 109, through the medium of contact springs 124–127, inclusive, short-circuits the windings of relay 111. It will be clear now that at each deënergization, relay 105 interrupts the circuit of the line relay 150 of the toll selector E, the successive closures of the circuit between interruptions being by way of a direct path via conductor 141 and the contact springs of relay 109.

As a result of these interruptions of its circuit the line relay 150 deënergizes a corresponding number of times, and sends at each deënergization an impulse from ground at G^{10} to the slow-acting relay 154 and the vertical magnet 157 in series. The vertical magnet in response to these impulses steps up the switch shaft until the wipers 170, 171, and 172 stand opposite the horizontal level in which are located contacts which are terminals of the desired group of trunk lines. The relay 154, being slow-acting, retains its armature during the series of impulses and closes a circuit for the test relay 156, which latter relay prepares a circuit for the rotary magnet 158 and locks itself to ground at G^{11}. At the end of the series of impulses the relay 154 deënergizes, thereby completing the aforementioned circuit of the rotary magnet 158, whereupon the wipers 170, 171, and 172 start rotating in search of an idle trunk line. As is well known, the rotary magnet interrupts its own circuit and also the locking circuit of the test relay 156 at every energization, the contacts in the latter circuit, however, being short-circuited by the test or private wiper 171 while passing over grounded busy contacts. As soon, therefore, as the test wiper 171 arrives at an ungrounded test contact the test relay 156 deënergizes and opens the rotary magnet circuit, thereby bringing the wipers to rest upon the terminals of an idle trunk line, assumed to be in this case the contacts 173, 174, and 175. As a further result of the deenergization of the test relay 156, a circuit is completed for the line switching relay 155 which relay, upon energizing, disconnects the conductors 103 and 104 from the windings of the line relay 150 and extends them by way of wipers 170 and 172, bank contacts 173 and 175, and normally closed contacts of relay 203 to the double wound line relay 200 of the toll second selector E′.

The line relay 200 thereupon energizes over the previously traced circuit extending from ground G^8 over the two conductors 103 and 104 in parallel and completes an energizing circuit for the slow-acting relay 201. Relay 201, upon attracting its armature completes a holding circuit for the switching relay 155 of selector E over the following path: ground at G^{12}, contact springs 204, bank contact 174, wiper 171, normally closed contacts of relay 156, and winding of relay 155 to battery B^3. It will be understood that the slow-acting relay 153 retains its armature for a sufficient length of time following the deënergization of line relay 150 to prevent the release of the selector until the above holding circuit has been established.

The toll operator may now manipulate her calling device in accordance with the second digit of the desired number, whereupon the resulting interruptions are repeated as before by the relay 105 until they affect the line relay 200 of the toll second selector E′. The selector E′ is accordingly operated substantially as described in the case of selector E to raise the wipers 210, 211, and 212 until they stand opposite the horizontal level which contains terminals of trunk lines extending to the desired group of connectors. After the level selection has been acomplished the wipers are automatically rotated to select an idle trunk line, and the trunk line selected is assumed to have been in this case the trunk line extending to the connector F. Through the medium of the line switching relay 203 the extended conductors 103 and 104 are then disconnected from the line relay 200 and are further extended, respectively, by way of wipers 210 and 212, bank contacts 213 and 215, and contact spring pairs 274—273 and 270—271 of relay 252 to the line relays 250 and 251 of the connector F. It should be noted that the lower conductor 104 also passes through contact springs 295 and 293 of busy test relay 262 before reaching the winding of line relay 251. The line relays 250 and 251 are accordingly energized over a previously traced circuit extending from ground at G^8 via conductors 103 and 104 and attracts their armatures, relay 250 closing thereby a circuit for the slow-acting relay 258 as follows: ground at G^{14}, contact springs 283 and 284, and winding of relay 258 to battery B^3. Upon energizing, relay 258 completes a holding circuit for the switching relays in the selector switches as follows: ground at G^{15}, contact springs 288 and 289, bank contact 214, and wiper 211 to wire junction 217, where the circuit divides, one branch extending by way of normally closed contacts of relay 206 and the winding of switching relay 203 to battery B^3, and the other branch extending by way of off-

normal contact 218 and interrupter contact 219 to the wire junction 220, where it joins the previously described holding circuit for the switching relay 155 of selector E.

The toll operator may now operate her calling device in accordance with the next digit of the desired number, resulting now in deënergizations of the line relays 250 and 251 of the toll connector F. At each deënergization, relay 250 sends an impulse to the vertical magnet 304 over the following path: ground at G^{14}, contact springs 281 and 280, contact springs 286 and 287, winding of relay 260, contact springs 297 and 296, contact springs 291 and 294, winding of vertical magnet 304, and side switch wiper 302 (in first position) to battery B^3. In response to these impulses the vertical magnet steps up the switch shaft until the wipers 321, 322, and 323 stand opposite the horizontal level of bank contacts in which are located contacts of the line extending to substation A′. The private control relay 260 is energized in series with the vertical magnet and, being slow-acting, retains its armature attracted during the series of impulses to close a circuit in the regular manner for the private magnet 263. At the end of the series of impulses relay 260 and the private magnet deënergize, the latter controlling the side switch wipers 301 and 302 in the well known manner to advance them to their second position.

The toll operator may now operate her calling device in accordance with the final digit of the desired number, resulting as before in deënergizations of line relays 250 and 251. As before, the line relay 250, at each deënergization, transmits an operating impulse over a path previously traced, except that now, side switch wiper 302 being in its second position, these impulses pass through the rotary magnet 305. In response thereto, the rotary magnet operates to rotate the wipers 321, 322, and 323 until they arrive, respectively, at bank contacts 324, 325, and 326, which contacts are associated with the line extending to substation A′. As before, the private magnet 263 is maintained energized during the series of impulses through the medium of relay 260 and operates at the end of the series of impulses to advance the side switch wipers to their third position (it being assumed that the line of substation A′ was idle when called). It is to be noted here that the private magnet 263 holds the circuit of relay 265 open during the rotation of the wipers so that if the private wiper 322 should pass over busy or grounded contacts before arriving at contact 325 the relay 265 will not be energized.

As side switch wiper 301 comes into its third position the following circuit is completed: ground at G^{16}, side switch wiper 301, private wiper 322, bank contact 325 and holding winding 330 of line switch C to battery B^3. The cut-off armature 331 is thereupon attracted to disconnect the line of substation A′ from its connections in line switch C. A branch of the above circuit extends from contact 325 to multiple contacts in the banks of the remaining connectors, both toll and local, whereby the line of substation A′ is made busy to other calls. A second branch extends from side switch wiper 301 by way of contact springs 306 and 307 of the private magnet and winding of relay 265 to battery B^3. Relay 265 is operated over the foregoing branch circuit and connects the line wipers 321 and 323, respectively, with the upper and lower talking conductors of the connector.

Having finished dialing the number, the toll operator will now restore the calling device key K^9. The relay 43 is thereby again included in the sleeve circuit and operates to light the lamp signal L^4 as before. The called subscriber is signaled by the operation of the ringing key K^7 of the cord circuit. When key K^7 is operated, a grounded ringing current generator (not shown) is connected with the tip strand of the calling end of the cord and direct ground is connected with the ring strand. This is obviously a common method of projecting ringing current over a called line to operate a bridged signal and the ringing key K^7 is so arranged to adapt it for signaling over toll lines, etc., as well as over the service trunk shown. To proceed with the ringing operation, when key K^7 is operated the following circuit is closed: ground at G^2, lower contact of key K^7, ring of plug, ring spring of jack J^3, winding of relay 110, and contact springs 136 and 137 to battery B^2. Upon energizing, relay 110, through the medium of contact springs 128, 129, and 130, disconnects conductor 143 from winding 112 of relay 111 and connects it instead to conductor 104, thereby short-circuiting winding 102 of repeating coil R; and, by means of contact springs 131, 132, and 133, disconnects conductor 142 from winding 113 of relay 111 and connects it instead to ground. As a result of the foregoing circuit changes the effect of the ringing current from key K^7 is localized (winding 102 of repeating coil R being short-circuited); relay 251 of the toll connector retracts its armature (conductor 143 having been disconnected from ground at G^8); and relay 250 is maintained energized over the following path: ground at G^6, contact springs 131 and 132, conductor 142, winding 101 of repeating coil R to conductor 103 and thence over the previously traced circuit to battery B^3 by way of winding of relay 250. An energizing circuit has now been completed for the ringing relay 264 of the connector

as follows: ground at G^{14}, contact springs 281 and 282, contact springs 278 and 279, winding of relay 264, and side switch wiper 302 to battery B^3. The ringing relay 264, upon energizing, operates to bridge the ringing current generator Gen across the called line to signal the called subscriber in the usual manner. It will be seen that the ringing operation is not automatic but is controlled by the operator by means of an ordinary ringing key, whereby she may actuate the bell at a called substation as often as desired.

When the called subscriber removes his receiver in response to the ringing of his bell, the following circuit is closed: ground at G^{17}, winding 257 of retardation coil 253, winding 255 of relay 252, contact springs 308 and 309, contact springs 312 and 313, wiper 323, bank contact 326, to and through substation A', bank contact 324, wiper 321, contact springs 314 and 315, contact springs 310 and 311, winding 254 of relay 252, and winding 256 of retardation coil 253 to battery B^3. Upon the closure of the foregoing circuit, relay 252 attracts its armature with the following results: ground at G^{18} is extended via contact springs 277 and 276 to the slow-acting relay 258, whereby this relay may be maintained energized independent of relay 250; and, through the medium of contact springs 270–275, inclusive, the incoming line conductors are disconnected from the line relays 250 and 251 and are connected instead with the windings of relay 252 in parallel with the called line.

It will be remembered that the relay 111 (Fig. 2) has remained inoperative up to this time owing to its differential winding. Now when the extended conductor 104 is disconnected from the battery B^3 by way of relay 251 and is connected instead to ground G^{17} as described, relay 111 is unbalanced, attracts its armature, and is maintained energized over a circuit which may be traced from ground G^{17} through the right-hand windings of coil 253 and relay 252 to the lower heavy talking conductor, thence back through the wipers of selectors E' and E to conductor 104, thence by way of winding 102 of repeating coil R, conductor 143, contact springs 129 and 130, windings 112 and 113 of relay 111 in series, contact springs 133 and 132, conductor 142, and winding 101 of repeating coil R to conductor 103, and thence over the upper heavy talking conductor through the wipers of selectors E and E' and the left-hand windings of relay 252 and coil 253 to battery B^3.

By the operation of relay 111, ground G^8 is removed from the junction of its windings, battery B^2 is disconnected from the ring spring of jack J^3, and ground G^4 is disconnected from the junction of windings 106 and 107 of relay 105. By the latter operation the high resistance winding 107 of relay 105 is included in the sleeve circuit in series with winding 106 and with relay 43 in the cord circuit. Relay 43 is marginal and under these conditions retracts its armature to extinguish the lamp signal L^4, whereby the operator is informed that the called party has answered his telephone.

The calling subscriber at substation A may now be recalled to his telephone, the services of the operator at the originating exchange being required for this purpose, whereupon the complete connection between the calling and called substations will have been established. The path for voice currents has been drawn in heavy lines and may be readily traced without further explanation. It is to be observed that the talking circuit at the automatic end of the connection includes a single high impedance bridge across the talking conductors at the cord circuit O', a repeating coil R, and a single high impedance battery supply bridge across the talking conductors at the connector switch, thereby providing a highly efficient connection.

The purpose of the retardation coil 253 in the connector is partly to increase the impedance of the battery supply bridge (relay 252), and partly to balance the called end of the connection. Since the bridged relay 252 has an armature only on one end of its core the impedance of its windings 254 and 255 will be different and the line will not be perfectly balanced. This trouble could, of course, be remedied by a special design of the windings 254 and 255 but a far simpler method is to use a retardation coil 253 in the form of a relay, but with the armature on the opposite end as shown. The effects of the two armatures therefore balance each other.

When the conversation is over both subscribers will hang up their receivers. By the replacing of the receiver at substation A the relay 17 is deënergized, thereby lighting the supervisory lamp L'. In this manner the operator at the originating exchange is informed that the subscribers are through talking and she will therefore remove both plugs from the jacks, whereupon the subscriber at substation A is free to make another call or to be called.

At the automatic exchange, when the subscriber at substation A' hangs up his receiver the bridged battery supply relay 252 deënergizes, the windings of relay 111 being of high resistance, and again connects the incoming line conductors to the relays 250 and 251 and to the free pole of the battery. As a result relay 111 is deënergized and short-circuits the winding 107 of relay 105, whereupon the sleeve relay 43 in the cord circuit operates to light the supervisory lamp L^4. By this means the toll oper-

ator at the automatic exchange is informed that the conversation is over with, whereupon she may withdraw both plugs from the jacks. By the removal of the plug from jack J^3, the sleeve circuit is broken and relay 105 is deënergized. Upon retracting its armature relay 105 disconnects ground G^8 from the line conductors extending to relays 250 and 251 of the connector F, thereby causing these relays to deenergize. Relay 250, upon retracting its armature, breaks the circuit of slow-acting relay 258 which relay, upon deënergizing, disconnects ground G^{15} from the holding circuit and also closes a circuit for the connector release magnet 259. The release magnet operates in the usual and well known manner to restore the connector switch to normal position after which its circuit is opened at the shaft controlled springs 334. By the removal of ground from the holding circuit the switching relays of selectors E and E′ are deënergized, each switching relay closing the circuit of the associated release magnet, whereupon the selector switches are also restored to normal position in the same way as the connector. At the toll board the busy lamps similar to lamp L^6 will be extinguished by the deënergization of relays 105 and 108, whereupon the toll service trunk will be ready for use by the same or another operator in establishing a new connection.

I will now describe briefly the operation when the called line is busy. It is understood that whenever substation A′ is busy the test or private contact 325 and similar multiple contacts in other connectors will be connected to ground. In the operation of connector F, therefore, when the private control relay 260 deënergizes after the last series of impulses, if the called line is busy the following circuit will be established: ground on private bank contact, wiper 322, side switch wiper 301 in second position, winding of test relay 262, contact springs 300 and 299, and winding of private magnet 263 to battery B^3. By the closure of the above circuit the private magnet is maintained energized to retain the side switch wipers in second position and test relay 262 is energized with results which will be explained. Through the medium of contact springs 290, 291, and 294 the operating circuit of the rotary magnet is broken and said magnet is connected in series with relay 261. Relay 261 is of high resistance so as not to allow the operation of the rotary magnet and is provided for a purpose to be mentioned later. Through the medium of contact springs 292, 293, and 295 the lower incoming heavy line conductor is disconnected from line relay 251 and is connected instead to a lead from the busy signaling machine Q to inform the operator that the line is busy. It will be observed that the busy machine lead has a branch extending by way of resistance coil 335 to ground. The proper conditions now exist for unbalancing the relay 111, as described in the case when the called subscriber answers, whereupon this relay is operated to extinguish the lamp L^4.

When the operator hears the busy signal she need not withdraw her plug and release the switches, but instead she restores her listening key and operates the key K^8 to shift the control of sleeve relay 43 from supervisory lamp L^4 to supervisory lamp L^5. The lamp L^5 is preferably a red lamp to distinguish from the ordinary supervisory lamps such as L^4. The operator now pays no further attention to the call until she is recalled by the lighting of the lamp L^5 which is brought about when the called line becomes idle.

When the subscriber at substation A′, assumed to have established connection with another subscriber, hangs up his receiver, the automatic switches including the line switch C are released and ground potential is removed from private bank contact 325. The private magnet and relay 262 accordingly deënergize, the former allowing the side switch wipers to pass to third position and closing the circuit of relay 265 to complete connection to the called line, and the latter relay breaking the circuit of relay 261 and restoring the lower heavy line conductor to its battery connection at relay 251. During the time the connector was locked on busy, the line relay 250 was energized in series with the windings of relay 111 and the resistance coil 335, ground at G^8 being disconnected by the operation of relay 111. Now the instant this circuit is broken by the deënergization of the test relay 262 the line relay 250 and relay 111 deënergize. Relay 111 again connects ground at G^8 to the junction of its windings whereupon the line relay 250 immediately energizes again. Were it not for relay 261, which is slow-acting and which holds the rotary magnet circuit open, the momentary deënergization of the line relay would have operated the rotary magnet to rotate the wipers to the next set of contacts.

As soon as the operator perceives the red lamp signal L^5, which, of course, is lighted by the deënergization of relay 111, she knows that the called line is no longer busy and that the connection thereto is completed. She will therefore proceed to operate her ringing key, etc., in the manner already described with the result that the connection between the calling and called subscribers will be completed as before.

While I have found it convenient in ex-

plaining my invention to show and describe a certain specific embodiment thereof, I do not wish to limit myself to the exact and specific disclosure contained herein, for I consider it probable that modifications may be made by persons skilled in the art in order to adapt the principles of the invention to various methods of operating routine and to other types of automatic systems. I desire, therefore, to include and have protected by Letters Patent all forms and modifications of my invention which may come within the scope of the appended claims.

What I claim as my invention is:

1. In a telephone system, a calling and a called line, means including a selector switch and a connector switch having access to the called line for connecting said lines, a continuous section of a metallic talking circuit completed after the lines are connected and extending through movable terminals of said selector and connector to the called line, a relay in bridge of the talking conductors of said section and controlled over the called line for maintaining said section intact, and a trunk release circuit separate from said talking conductors for said selector controlled by said relay.

2. In a telephone system, a calling and a called line, means including a selector switch and a connector switch having access to the called line for connecting said lines, a continuous section of a metallic talking circuit completed thereafter and extending through movable terminals of said selector and connector to the called line, a relay in bridge of the talking conductors at the connector for controlling the continuity of said section, and a second relay in said connector coöperating with said first relay to control the release of said switches.

3. In a telephone system, a calling and a called line, means including a selector switch and a connector switch having access to the called line for connecting said lines, a continuous section of a metallic talking circuit completed after the lines are connected and extending through movable terminals of said selector and connector to the called line, a source of talking current in a bridge of the talking conductors at the connector, a relay included in said bridge for directly controlling contacts in the talking conductors to maintain the continuity of said section, and an inductive winding connected in series with said relay to increase the impedance of the bridge.

4. In a telephone system, a calling and a called line, a trunk line terminating in an automatic selector switch, means for connecting the calling line with said trunk line, a connector switch accessible to said selector switch, means for operating said switches to extend the calling line via said trunk line into connection with the called line, a repeating coil in said trunk line, and continuous metallic talking conductors extending from windings of said repeating coil to the called line.

5. In a telephone system, a calling and a called line, a trunk line terminating in an automatic selector switch, means for connecting the calling line with said trunk line, a connector switch accessible to said selector switch, means for operating said switches to extend the calling line via said trunk line into connection with the called line, a repeating coil in said trunk line, continuous metallic talking conductors extending from windings of said repeating coil to the called line, an impedance bridge across said conductors, and a battery in series therewith to supply talking current to the called line.

6. In a telephone system, a first line and a second line, means including in serial relation and in the order named an operator's cord circuit, a trunk line accessible thereto, and selector and connector switches for completing a continuous metallic talking circuit between said lines in two sections, a repeating coil in said trunk line for inductively connecting said sections, a battery in a bridge of one section to supply talking current to said second line, and a signal controlling relay in bridge of the other section.

7. In a telephone system, a first line, a trunk line in two sections inductively connected by a repeating coil, an operator's cord circuit for connecting said first line and trunk line, a second line, means including selector and connector switches for connecting said trunk line with said second line, normally open contacts in said connection, and a relay and a battery in series therewith in a bridge of the connected second line, said relay operable upon the response of the called subscriber to close said contacts.

8. In a telephone system, a first line, a trunk line in two sections inductively connected by a repeating coil, an operator's cord circuit for connecting said first line and trunk line, a second line, means including a plurality of selector and connector switches for connecting said trunk line with said second line, normally open contacts in said connection, a relay and a battery in series therewith in a bridge of the connected second line, said relay operable upon the response of the called subscriber to close said contacts, a signal in the said cord circuit, and a relay responsive to said battery upon the closure of said contacts to control said signal.

9. In a telephone system, a trunk line terminating in an automatic switch, a bridge at each end of said trunk line, the bridge at one end comprising a controlling relay for said switch, a battery having opposite poles connected, respectively, to the middle points of said bridges, and means for intermittently

interrupting one of said battery connections to operate said switch.

10. In a telephone system, a trunk line terminating in an automatic switch, a bridge at each end of said trunk line, the bridge at one end comprising a controlling relay for said switch, a battery having opposite poles connected, respectively, to the middle points of said bridges, means for intermittently interrupting one of said battery connections to operate said switch, a second automatic switch and associated controlling relay, and means whereby upon the operation of said first switch the controlling relay thereof is disconnected and the controlling relay of said second switch is substituted therefor in bridge of said trunk line.

11. In a telephone system, a trunk line, means including a plurality of automatic switches for extending said trunk line in successive stages into connection with a called line, and operating magnets for each switch controlled exclusively over the two sides of the extended trunk line in parallel, the operating magnets of the first switch controlled over a portion of said trunk line in parallel, and the operating magnets of the succeeding switches controlled over the same portion together with a second portion of said trunk line.

12. In a telephone system, a trunk line terminating in an automatic connector switch, a called line, means for controlling said switch over the two conductors of said trunk line in parallel to connect with the said called line, a source of current in the controlling circuit, means operated thereafter to connect the two conductors of said trunk line in series with said source, a signal, and a relay operated over the said trunk line conductors in series to control said signal.

13. In a telephone system, a trunk line terminating in an automatic connector switch, a called line, means for controlling said switch over the two conductors of said trunk line in parallel to connect with the said called line, a source of current in the controlling circuit, means operated thereafter to connect the two conductors of said trunk line in series with said source, a signal, and a relay controlled by the shifting of said trunk line conductors from parallel to series connection for controlling said signal.

14. In a telephone system, a trunk line terminating in an automatic connector switch, a called line, means for controlling said switch over the two conductors of said trunk line in parallel to connect with the said called line, a source of current in the controlling circuit, means operated thereafter to connect the two conductors of said trunk line in series with said source, a signal, said relay having a winding in series with each conductor of said trunk line and controlled by the change in direction of the current in one conductor thereof.

15. In a telephone system, the combination with an operator's cord circuit and a trunk line terminating in an automatic connector switch, of means for connecting said cord circuit and trunk line, a called line, means for controlling said switch over the two sides of said trunk line in parallel to connect with the called line, a source of current included in the controlling circuit, means controlled over the connected called line for connecting the two conductors of said trunk line in series with said current source, a signal in said cord circuit, and a relay operated over the said trunk line conductors in series to control said signal.

16. In a telephone system, the combination with an operator's cord circuit, and a trunk line terminating in an automatic connector switch, of means for connecting said cord circuit and trunk line, a called line, means for controlling said switch over the two sides of said trunk line in parallel to connect with the called line, a source of current included in the controlling circuit, means controlled over the connected called line for connecting the two conductors of said trunk line in series with said current source, a signal in said cord circuit, and a relay controlled by the shifting of said trunk line conductors from parallel to series connection for controlling said signal.

17. In a telephone system, the combination with an operator's cord circuit, and a trunk line terminating in an automatic connector switch, of means for connecting said cord circuit and trunk line, a called line, means for controlling said switch over the two sides of said trunk line in parallel to connect with the called line, a source of current included in the controlling circuit, means controlled over the connected called line for connecting the two conductors of said trunk line in series with said current source, a signal in said cord circuit, and a relay for controlling said signal, said relay having a winding in series with each conductor of said trunk line and controlled by the change in direction of the current in one conductor thereof.

18. In a telephone system, a trunk line, means including a series of automatic switches for extending said trunk line to a called line, a line relay for controlling each switch, means for transmitting operating impulses over the two conductors of said trunk line in parallel to operate each switch, except the last, through the medium of its line relay to extend said conductors to the line relay of the next switch, and means for disconnecting each line relay after its associated switch is operated.

19. In a telephone system, the combination with an automatic selector switch having a double wound controlling relay, of a line whose two conductors each terminate in a winding of said relay, a battery, connections from one pole of said battery to both windings of said relay, means for connecting both conductors of said line to the other pole of said battery, and means for intermittently interrupting the latter connection whereby said switch may be controlled over the two line conductors in parallel, to extend a connection from said first mentioned line.

20. In combination, a line, an automatic selector switch, a double wound controlling relay for said switch in bridge of said line, a battery having one pole connected to the junction of the windings of said relay, a second double wound relay in bridge of said line, means for connecting the junction of the windings of said second relay to the other pole of said battery, and means for intermittently interrupting the latter connection whereby said switch may be controlled over the two conductors of said line in parallel.

21. In a telephone system, the combination with a trunk line terminating in an automatic selector switch, of an operator's cord circuit for connecting with said trunk line, a battery, a circuit for controlling said switch including the two conductors of said trunk line in parallel, a controlling relay in bridge thereof having its middle point connected to said battery, a second circuit including the third conductor of said cord circuit, a relay in said second circuit for closing said controlling circuit, a calling device, and means for including said device in said second circuit to operate said switch, to extend a connection from said first mentioned line.

22. In a telephone system, a first line and a signal in bridge thereof, a second line extending to an automatic connector switch, a ringing relay in said connector switch, an operator's cord circuit, means for connecting said cord circuit with either of said lines, a ringing key adapted when the said cord circuit is connected with the manual line to project ringing current thereover to operate said signal, and means controllable by said key when the said cord circuit is connected with the second line and adapted to close a controlling circuit for said ringing relay.

23. In a telephone system, a first line and a signal in bridge thereof, a second line extending to an automatic connector switch, a ringing relay in said connector switch, an operator's cord circuit, means for connecting said cord circuit with either of said lines, sources of alternating and direct current, and a ringing key in said cord circuit adapted when said cord circuit is connected with said first line to actuate said signal through the medium of said alternating current source and adapted when said cord circuit is connected with said second line to close a controlling circuit for said ringing relay including said direct current source.

24. In a telephone system, a connection between a calling and a called line including an operator's cord circuit, a trunk line, and an automatic connector switch, a repeating coil in said trunk line, a ringing relay in said connector switch, a grounded source of ringing current, a ringing key in said cord circuit adapted to connect said source of ringing current across said trunk line, a grounded battery, a second relay bridged from a conductor of said trunk line to the ungrounded pole of said battery, and means controlled by said second relay for operating the said ringing relay.

25. In a telephone system, a connection between a calling and a called line including an operator's cord circuit, a trunk line, and an automatic connector switch, a repeating coil in said trunk line, a ringing relay in said connector switch, a grounded source of ringing current, a ringing key in said cord circuit adapted to connect said source of ringing current across said trunk line, a grounded battery, a second relay bridged from a conductor of said trunk line to the ungrounded pole of said battery, and means controlled by said second relay for operating the said ringing relay, and for short-circuiting a secondary winding of said repeating coil to shunt the current from said ringing current source.

26. In a telephone system, a metallic circuit talking connection between two subscribers' stations, a bridge across the two conductors of said circuit comprising a pair of serially connected double wound magnets, and armatures for said magnets disposed at opposite ends thereof to equalize the impedance of said windings.

27. In a telephone system, a metallic circuit talking connection between two subscribers' stations, a source of current, a bridge comprising a double wound relay in series with said current source for supplying talking current to one of said stations, and a double wound impedance coil included in said bridge and having its magnetic circuit arranged to balance the talking circuit.

28. In a telephone system, the combination with an operator's cord circuit and a trunk line terminating in an automatic connector switch, of means for connecting said cord circuit and trunk line, a called line, means for controlling said switch over the two sides of said trunk line in parallel to

connect with the called line, a source of current included in the controlling circuit, means for preventing the completion of the connection if the called line is busy and for connecting at the same time the two conductors of said trunk line in series with said current source, a signal in the operator's cord circuit, and a relay controlled by the shifting of the conductors of said trunk line from parallel to series connection for controlling said signal.

29. In a telephone system, the combination with an operator's cord circuit and a trunk line terminating in an automatic connector switch, of means for connecting said cord circuit and trunk line, a called line, means for controlling said switch over the two sides of said trunk line in parallel to connect with the called line, a source of current in the controlling circuit, means for preventing the completion of the connection if the called line is busy and for connecting at the same time the two conductors of said trunk line in series with said current source, means for automatically completing the connection when the called line becomes idle and for again connecting the two conductors of said trunk line in parallel, a signal in the said cord circuit, and a controlling relay for said signal responsive to the change in direction of the current in one conductor of said trunk line.

30. In a telephone system, an operator's cord circuit, a trunk line accessible thereto and terminating in an automatic switch, a signal, a circuit including the third conductor of said cord circuit and an impulse transmitting relay for operating said switch, and a second relay in said circuit for controlling said signal.

31. In a telephone system, an operator's cord circuit, a trunk line accessible thereto and terminating in an automatic switch, a signal, a circuit including the third conductor of said cord circuit and an impulse transmitting relay for operating said switch, a second relay in said circuit for controlling said signal, means for sending impulses over said third conductor to control said first relay, and means for changing the resistance of said circuit to control said second relay.

32. In a telephone system, an operator's cord circuit, a trunk line accessible thereto and terminating in an automatic switch, a circuit including the third conductor of said cord circuit, means for interrupting said circuit, means responsive to such interruptions for operating said switch, a signal in said cord circuit, and a circuit for controlling said signal including the third conductor of said cord circuit.

33. In a telephone system, an operator's cord circuit, a trunk line accessible thereto and terminating in an automatic switch, a signal, a circuit including the third conductor of said cord circuit and an impulse transmitting relay for controlling said switch, said relay having a low and high resistance winding in series, a second relay in said circuit for controlling said signal, means for normally short-circuiting said high resistance winding to render said second relay operative and means for removing said short circuit to deënergize the same.

34. In a telephone system, an operator's cord circuit, a trunk line accessible thereto and terminating in an automatic switch, a circuit including the third conductor of said cord circuit and having a normally connected branch and a normally disconnected branch, means for substituting the latter branch in said circuit, means for then sending current impulses over said circuit, means responsive to said impulses for controlling said switch, a signal, and means for controlling said signal over said circuit after said branches are restored to normal condition.

35. In a telephone system, an operator's cord circuit, a trunk line accessible thereto and terminating in an automatic switch, a circuit including the third conductor of said cord circuit and having a normally connected branch and a normally disconnected branch, means for substituting the latter branch in said circuit, means for then sending current impulses over said circuit, means responsive to said impulses for controlling said switch, a signal, a relay in said normally connected branch for controlling said signal, and means operable after said branches are restored to normal condition for controlling said relay over said circuit.

36. In a telephone system, a calling line and a trunk line, said trunk line terminating in an automatic switch, a called line accessible to said switch, means including an operator's cord circuit for connecting the calling line with said trunk line, a signal in said cord circuit, a controlling circuit including the third conductor of said cord circuit and provided with two branches, means responsive to interruptions of one of said branches for operating said switch to connect with the called line, and means actuated upon the response of the called subscriber for altering the electrical condition of said controlling circuit to control said signal through the medium of the other branch.

37. In a telephone system, means including an operator's cord circuit and a series of automatic switches for connecting a calling and called line, a signal at the cord circuit, a circuit including the third conductor of said cord circuit, and means for operating said switches and for controlling said signal over said circuit.

38. In a telephone system, means includ-

ing an operator's cord circuit, a trunk line, and an automatic switch for connecting a calling and called line, a signal at the cord circuit, a circuit including the two sides of said trunk line in parallel for operating said switch, and a metallic circuit including the two sides of said trunk line in series for controlling said signal, said last mentioned circuit energized when the called subscriber closes a talking circuit over his line.

Signed by me at Chicago, Cook county, State of Illinois, this first day of June, 1916.

BERNARD D. WILLIS.