B. D. WILLIS.

AUTOMATIC MANUAL TELEPHONE SYSTEM.

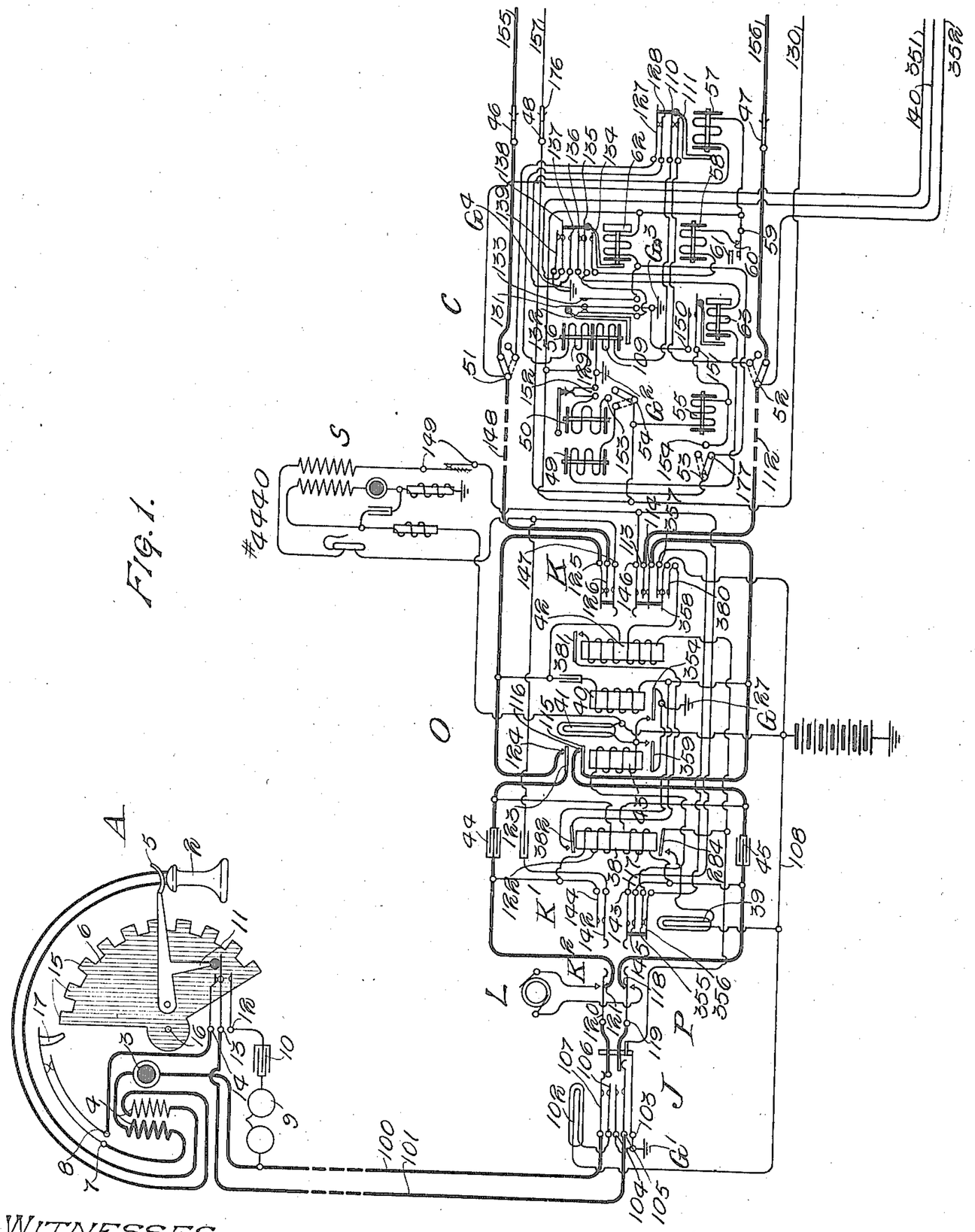
APPLICATION FILED JAN. 18, 1910. RENEWED AUG. 31, 1917.

1,268,068.

Patented May 28, 1918.

4 SHEETS—SHEET 1.

FIG. 1.



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4 SHEETS—SHEET 2.

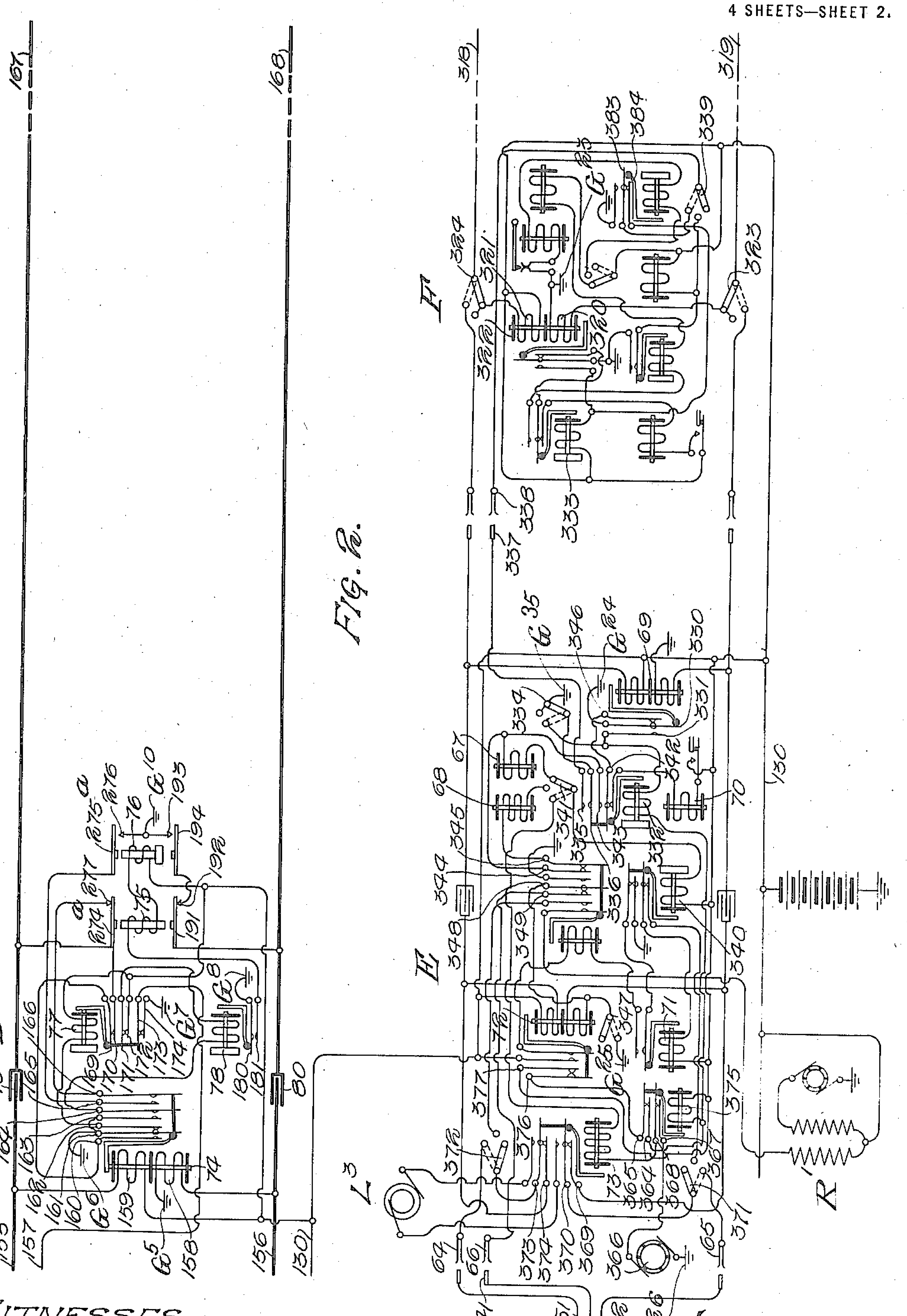

FIG. 2.

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4 SHEETS—SHEET 3.

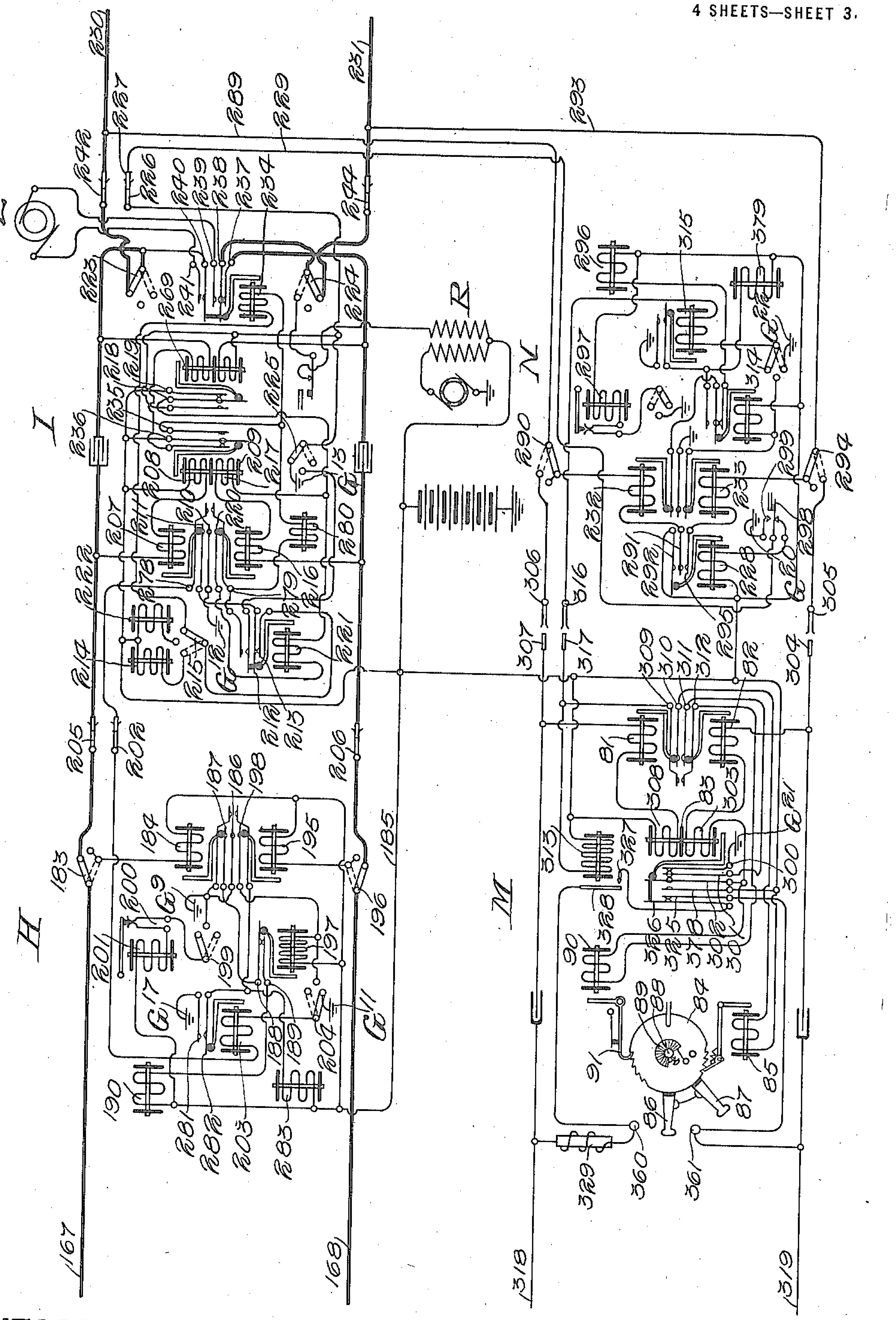

Fig. 3.

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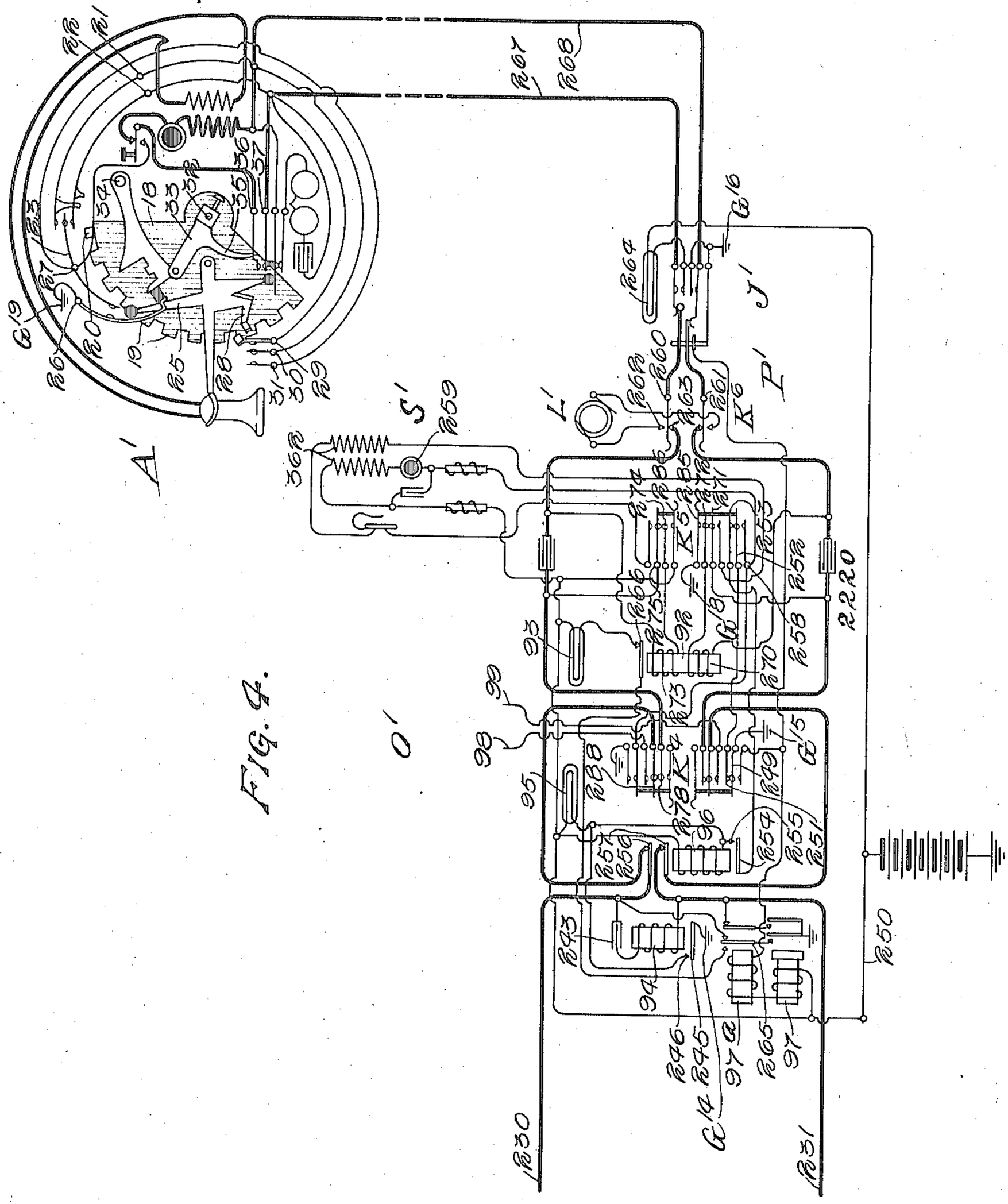

FIG. 4.

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AUTOMATIC MANUAL TELEPHONE SYSTEM.

1,268,068. Specification of Letters Patent. Patented May 28, 1918.

Application filed January 18, 1910, Serial No. 538,583. Renewed August 31, 1917. Serial No. 189,224.

To all whom it may concern:

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

My invention relates to telephone exchange systems in general, but more particularly to systems in which automatic switches are employed, and more especially to telephone exchanges in which both manual and automatic switching operations are necessary in order to extend a call from a calling to a called line.

Generally stated, the object of my invention is to provide an improved arrangement for semi-automatically extending a call from a calling line to a called line.

A special object is to provide a system in which the trunking between a calling and a called line is automatic and controlled either by the calling subscriber or by the operator who answers the call, and in which means are provided for manually completing the connection with the called line, both the calling and the called lines being equipped with line signals which indicate that a connection is desired, and each line being also provided with a dial or other calling mechanism for controlling the automatic switches that are employed in extending connection from one manual switchboard to another, as will hereinafter more fully appear.

Another object is to provide an arrangement whereby, if the called operator inadvertently or for any other reason neglects to withdraw the cord plug from the jack of the called subscriber, it will not be possible for any other subscriber, including the subscriber who has just called, to at such time ring the bell at the station of the said called subscriber, or at the station of any line which is still connected with the cord of the manual switchboard.

Another object is to provide, in conjunction with the arrangement last stated, a further arrangement whereby, whenever an attempt is made by any subscriber to call a subscriber whose line is still connected with the cord circuit, a signal will be given the operator at the said cord circuit, and in such case, if the desired subscriber is the one with whose line the cord circuit is still connected, the plug of the cord is allowed to remain in place, or if some other subscriber is desired the operator must, of course, remove the said plug and insert it in the jack of the desired line.

A further object is to provide an arrangement whereby automatic trunking may be carried on between two manual switchboards, and whereby the calling and called lines are both manually connected with the said automatic trunking apparatus after the trunking connection has been established between the two boards, one of the subscribers' lines being what is known as a two-wire line, no operating ground being employed at the substation, and the other of the two connected lines being what is known as a three-wire line, a ground connection being employed at the substation thereof for controlling the automatic switches at the central station.

Another object is to provide, in a system of this kind, an improved arrangement involving a repeater for use in extending a calling connection from a two-wire line to a three-wire line, as above defined, whereby a trunking connection may be established from a two-wire exchange to a three-wire exchange, either by the calling subscriber or by the operator who answers the call.

Another object is to provide, in a system of this kind, an improved arrangement involving a repeater for use in extending a calling connection from a three-wire line to a two-wire line, as above defined, whereby a trunking connection may be established from a three-wire exchange to a two-wire exchange, either by the calling subscriber or by the operator who answers the call.

Another object is to provide an arrangement comprising a connector by means of which a calling subscriber, or a calling operator, may find and extend connection to a predetermined cord circuit, so that connection is made with the particular cord and no other.

Another object is to provide an arrangement whereby a calling subscriber, or a calling operator, may automatically extend connection to a cord at the manual switchboard to signal the operator, and in which said cord is not only provided with a signaling device responsive to said ringing current,

but is also provided with means responsive to said current for opening the two sides of the cord circuit, whereby if the cord is, for any reason whatsoever, still connected with a subscriber's line no ringing current will be transmitted to the substation thereof.

It is also an object to provide certain details and features of improvement tending to increase the general efficiency and service ability of a telephone exchange system of this particular character.

To the foregoing and other useful ends my invention consists in matters hereinafter set forth and claimed.

In the accompanying drawings Figures 1, 2, 3 and 4 taken together show diagrammatically a complete connection between a calling private branch exchange substation A and a called private branch exchange substation A′, in a system embodying the principles of my invention.

In Fig. 1 the lines of the substation A are shown terminating in a jack J at a private branch exchange. The private branch exchange is provided with an operator's cord O which is connected to a trunk line leading to a main automatic exchange, where it terminates in a so-called first selector switch C and in bank contacts of a number of connector switches E (Fig. 2). The first selector switch F (Fig. 2) is connected to a trunk line leading from a second exchange (Fig. 3). At D is shown a repeater for repeating impulses from one exchange to the other. The switches C, D, E and F all belong to one exchange and are adapted to operate in a two-wire system, *i. e.*, a system in which no ground is required at the substation.

In Fig. 3 there is shown part of the equipment of a second exchange. This equipment consists of two selectors N and H, a connector I and a repeater M. The selector H is connected to a trunk line leading from the two-wire exchange (Figs. 1 and 2). The first selector N is connected to a trunk line leading from a private branch exchange (Fig. 4). At the main exchange the trunk line also terminates in bank contacts of a connector switch I. At the private branch exchange the trunk line terminates in a cord circuit O′. The central office apparatus shown in Fig. 4 is adapted to operate in a three-wire system, *i. e.*, a system in which a ground connection is required at the calling substation.

In the various drawings a number of ringing current generators L, L′, L^2 and L^3 are shown, while at R and R′ two busy signaling machines are represented. As shown, each exchange is provided with a battery B having one terminal grounded. The substation A′, first selector N, repeater M, first selector F and connector E are shown in normal position, all other apparatus being shown operated.

The automatic substations may be of any suitable or approved type. As herein represented the substation A comprises a receiver 2, transmitter 3, induction coil 4, switch hook 5, impulse wheel 6, impulse springs 7 and 8, ringer 9 and condenser 10. The switch hook 5 controls the substation circuits through the medium of the cam arm 11 and springs 12, 13 and 14. The impulse wheel 6 carries upon its periphery a number of impulse teeth 15. The impulse wheel is secured to the shaft 16, to which there is also secured a dial (not shown) provided with finger holes. The impulse teeth of the wheel 6 are so arranged that, as the wheel is rotated forward by the subscriber through the medium of the dial, the springs 7 and 8 are not operated; but as the dial is returned to normal position by a spring (not shown) each tooth of the impulse wheel 6 that passes the cam 17 on the end of the spring 7 forces the spring 7 out of engagement with spring 8.

The automatic substation A′ (Fig. 4) is of the same general type as substation A, but is modified somewhat in order to operate in a three-wire system. The impulse wheel 18 of the substation A′ is provided with a number of so-called vertical impulse teeth 19 and one rotary impulse tooth 20. As the impulse wheel 18 returns to normal position after being rotated for any digit, first the vertical impulse spring 22 is forced into engagement with the ground post 23 a number of times, depending upon the digit called, by the vertical impulse teeth 19, and then the rotary spring 21 is forced into engagement with the post 23 once by the rotary tooth 20. When the receiver is on the hook the cam arm 25 holds the spring 26 out of engagement with spring 27, thus disconnecting the ground from the ground post 23. The switch hook is also provided with a cam arm 28 which momentarily forces springs 29, 30 and 31 into engagement as the switch hook is lowered. Secured to the shaft 32 there is a locking dog 33 through the medium of which the cam 34 locks the dial when the receiver is on the hook. When the receiver is removed the cam arm 25 raises the cam 34 sufficiently to unlock the dog 33. When the dial is rotated the arm 35 on the dog 33 permits the springs 36 and 37 to disengage to prevent impulses from passing from one side of the line to the other. As soon as the dial returns to normal position these springs are forced into engagement again.

The operator's cord O is a modification of the usual manual common battery trunk cord, since it is adapted to establish connection with an automatic exchange. The cord circuit comprises a supervisory relay 38 and lamp 39, a signaling relay 40 and lamp 41, a locking relay 42, cut-off relay 43, a calling key K, a listening key K′ and

ringing key K^2. The coils of relay 38 are bridged by the condensers 44 and 45 to increase the talking efficiency. At S is shown an operator's set provided with a calling device.

The first selector switch C is of the general type shown and described in United States Letters Patent #815,321, granted March 13, 1906, to Keith, Erickson and Erickson, but, as here represented, is slightly modified to operate in a two-wire system. Among other details the selector C comprises a set of wipers 46, 47 and 48 carried upon a shaft (not shown) which has a vertical motion controlled by the vertical magnet 49 and a rotary motion controlled by the rotary magnet 50. A side switch comprising the wipers 51, 52, 53 and 54 is controlled by the private magnet 55 in a well-known manner. The operation of the switch is controlled by the operator or calling subscriber through the medium of the double-wound line relay 56. By means of the relay 57 the relay 56 may be disconnected from the line when a call comes into the branch exchange from the main exchange. Means for releasing the switch are provided in the release magnet 58. Normally, the magnet 58 is disconnected from battery by the springs 59 and 60 which are held out of engagement by the arm 61 as long as the switch shaft is in its lowest position. The selector C is provided with the so-called connector release—that is, its mechanism is released immediately by the energization of the release magnet, rather than by its deënergization, as shown in the said selector patent. The relays 62 and 63 are slow-acting relays—that is, relays that are slow to deënergize after their energizing circuits have been broken. The selector F is similar to the selector C.

The connector E is of the general type disclosed in United States Letters Patent No. 815,176, granted March 13, 1906, to Keith, Erickson and Erickson, but, like the selectors C and F, is modified to operate in a two-wire system. Like the selectors, the connector comprises a set of wipers 64, 65 and 66 carried upon a shaft having a rotary motion controlled by the rotary magnet 68 and a vertical motion controlled by the vertical magnet 67. The line relay 69 and release magnet 70 are similar to the relay 56 and magnet 58, respectively, of the selector C. The side switch is controlled by the private magnet 71 in the usual manner. A back-bridge relay 72 is provided through which the called substation is provided with talking current after a connection is completed. The ringer relay 73 provides means whereby the generator L^3 may be connected with the called line.

The repeater D is adapted to repeat impulses from a two-wire to a three-wire system. The repeater is provided with a double-wound line relay 74, which is similar to the line relays of the selector and connector switches. Two release relays 75 and 76 are provided, one of which (relay 76) is a slow-acting relay. The relays 77 and 78 are also slow-acting. The talking circuit through the repeater is divided by the condensers 79 and 80.

The selectors H and N are also of the general type disclosed in the said selector Patent No. 815,321, but are not modified to operate in a two-wire system. The essential features are the same as those of the selectors C and F except that the double-wound line relay is herein replaced by two single-wound relays.

The connector I is of the general type disclosed in the said connector Patent No. 815,176, the general features being the same as those of connector E, but, like the selectors H and N, the connector I is adapted to operate in a three-wire system.

The repeater M is adapted to receive impulses from a three-wire central office and repeat these impulses to operate switches in a two-wire exchange. The repeater M comprises the usual vertical and rotary line relays 81 and 82 connected in series with the windings of the differential relay 83. The rotary magnet 85 is provided for the purpose of rotating the ratchet wheel 84. The ratchet wheel 84, together with the wiper arms 86 and 87, are secured to a shaft 88 which is held in normal position by the spring 89. The release relay 90 is provided for the purpose of withdrawing the pawl 91 to allow the ratchet wheel 84 to return to normal position after a conversation is completed.

The operator's cord circuit O′ is similar to the cord circuit O, being adapted, however, to extend connection to a three-wire exchange. Like the cord O, the cord O′ comprises a supervisory relay 92 and lamp 93, a signaling relay 94 and lamp 95, a cut-off relay 96, a calling key K^4, listening key K^5 and ringing key K^6. In addition the cord O′ is provided with two release relays 97 and 97^a, one of which (relay 97) is slow-acting. The operator's set S′ may be of any suitable type. The conductors 98 and 99 lead to a calling device which is similar to the calling device of substation A′. In the operator's calling device the transmitter and primary winding of the induction coil of the substation would be replaced by a resistance coil, and since no switch hook is required a push button would be added to operate the release springs corresponding to the springs 29, 30 and 31 at the substation.

In order to give a clearer understanding of my improved trunk circuits I will give a detailed description of their operation when

one subscriber calls another over them. It will first be explained how the subscriber A may obtain connection with the subscriber A′. For the purpose of explanation it will be assumed that the number assigned to the trunk line leading to the branch exchange to which substation A′ belongs is #2220. When the receiver at substation A is removed preparatory to making a call the spring 13 disengages the spring 12 and engages spring 14, thereby bridging the primary talking circuit of the substation across the line conductors 100 and 101. The closure of this bridge across the line closes a circuit through the lamp 102. This circuit extends from ground G′ through the springs 104 and 105, line 101, substation springs 13 and 14, impulse springs 8 and 7, primary winding of induction coil 4, transmitter 3, line 100, jack springs 107 and 106 and lamp 102 to battery lead 108, thence through the battery B to ground G. The operator, upon observing the signal of the lamp 102, inserts the plug P into the jack J. When the plug P enters the jack J the line is extended to the cord O and the circuit of lamp 102 is broken by the disengagement of springs 106 and 104 from the springs 107 and 105, respectively. The extending of the connection through the plug P closes an energizing circuit through the line relay 56 of the selector C. This circuit extends from ground G^2 through winding 109 of relay 56, springs 110 and 111 of relay 57, trunk conductor 112, springs 113 and 114, armature 115, contact point 116, winding 117 of relay 38, springs 118 and 119 of key K^2, ring conductors of plug P and jack J, line 101, thence through the substation A and back over line conductor 100, tip conductors of jack J and plug P, springs 120 and 121 of key K^2, winding 122 of relay 38, armature 123, contact point 124, springs 125 and 126 of key K, side switch wiper 51, springs 127 and 128 of relay 57, and through the winding 129 of relay 56 to battery lead 130, thence through the battery B to ground G. The relay 56, upon energizing, shifts spring 131 out of engagement with spring 132 and into engagement with spring 133, whereby an energizing circuit is closed through the release relay 62. This circuit extends from ground G^3 through springs 131 and 133 and relay 62 to battery lead 130, thence through the battery B to ground G. The relay 62, upon energizing, shifts springs 135 and 138 out of engagement with springs 134 and 137 and into contact with springs 136 and 139, respectively. The shifting of spring 135 transfers the connection of the impulse spring 132 from the release magnet 58 to the vertical magnet 49. The engagement of springs 138 and 139 extends a guarding potential from ground G^4 through said springs, and over conductor 140 to the connector private bank contact 141 and thence to the corresponding contact in the bank of each of the connectors which have access to the trunk. This ground potential at the connector private bank contacts protects the trunk from seizure at the main exchange as soon as the plug is inserted into the jack. After inserting the plug into the jack the operator operates the key K′ to force springs 142 and 143 into contact with springs 144 and 145, respectively, whereby the operator's set S is bridged across the line to permit the operator to communicate with the calling subscriber. After ascertaining the number of the substation desired the operator may call the desired line or, if the calling substation is an automatic substation, the calling subscriber may do the calling. In case it is desired to let the calling subscriber do the calling the operator simply restores the key K′ and pays no more attention to the connection until the disconnect signal is received. If the operator makes the call the key K′ is restored and the key K operated to shift springs 113 and 126 out of engagement with springs 114 and 125 and into contact with springs 146 and 147, respectively, whereby the calling line is disconnected from the trunk conductors 112 and 148, and the operator's set S is bridged across the trunk instead. The operation of the central office switches is identical whether the calling subscriber or the operator makes the call, the only difference being that in one instance the impulses are produced by the substation calling device and in the other by the operator's calling device. For the purpose of explanation it will be assumed that the operator makes the call.

After the key K is operated in the manner described, the operator operates the calling device in the usual manner for each digit of the number to be called. When the calling device is operated for the first digit of No. 2220 the impulse springs 149 are separated twice, thus momentarily breaking the energizing circuit of the selector line relay 56. Each time the relay 56 deënergizes it momentarily breaks the energizing circuit of the relay 62 and permits spring 131 to engage spring 132. The relay 62 being slow-acting does not have time to deënergize during this momentary interruption of its circuit, and consequently the engagement of springs 131 and 132 closes an energizing circuit through the vertical magnet 49. This circuit extends from ground G^3 through springs 131 and 132, 135 and 136, relay 63, vertical magnet 49 and side switch wiper 54 to battery lead 130. Since the digit called is 2 the vertical magnet receives two impulses over this circuit and operates to raise the shaft and wipers two steps to a position opposite the second row or level of bank contacts. As soon as the shaft is raised the first step the arm 61 permits the

spring 59 to engage spring 60 to connect the release magnet 58 with battery. The relay 63, which is included in the energizing circuit of the vertical magnet, is energized by the first impulse, but being a slow-acting relay does not have time to deënergize until after the last impulse is delivered to the vertical magnet. The relay 63, upon energizing, closes a circuit extending from ground G^3 through springs 150 and 151 and private magnet 55 to battery lead 130. When the relay 63 deënergizes after the last impulse is delivered to the vertical magnet it opens the circuit of the private magnet 55, which in turn deënergizes and permits the side switch to pass from first to second position. The movement of side switch wiper 54 from first to second position disconnects the vertical magnet 49 from battery and closes a circuit through the rotary magnet 50. This circuit extends from ground G^2 through interrupter springs 152, magnet 50, contact point 153 and side switch wiper 54 to battery lead 130. The rotary magnet 50, upon energizing, attracts its armature, which rotates the wipers onto the first contact of the second level, presses down the armature of the private magnet and opens the circuit of its own magnet at the interrupter springs 152. The armature of the rotary magnet falls back when the circuit of the magnet is thus broken and, if the trunk upon the terminals of which the wipers have just been rotated is idle, the armature of the private magnet falls back also and permits the side switch to advance to third position. If, however, the first trunk line of the second level is busy the corresponding private bank contact will be grounded by the repeater D of the busy trunk, as will be explained later. At the instant the private wiper 48 strikes this grounded contact a circuit is closed extending from ground at the repeater D of the busy trunk through the private bank contact and wiper 48, side switch wiper 53, contact point 154 and private magnet 55 to battery lead 130. The private magnet is thus energized and locks the side switch in second position to maintain the connection between the rotary magnet and battery. The rotary magnet will then be energized again by the engagement of springs 152, and will operate to advance the wipers a second step. The rotary magnet thus continues to advance the wipers step by step until the private wiper 48 engages the non-grounded contact of an idle trunk, whereupon the private magnet 55 deënergizes and permits the side switch to pass from second to third position. When the side switch wiper 54 leaves its second-position contact point 153 it permanently opens the circuit of the magnet 50 to prevent further rotation of the wipers. The movement of side switch wipers 51 and 52 from second to third position cuts off the line relay 56 and extends the connection to the repeater D over the conductors 155 and 156. When the connection is thus extended to the repeater the line relay 74 is energized over a circuit extending from ground G^5 through winding 158 of relay 74, conductor 156, shaft wiper 47, side switch wiper 52, trunk conductor 112, thence through the springs of key K, operator's set S, and back through key K to trunk conductor 148, thence through side switch wiper 51, shaft wiper 46, conductor 155 and winding 159 of relay 74 to battery lead 130. The relay 74, upon energizing, forces spring 161 out of engagement with spring 160 and into contact with spring 162, and forces springs 164 and 166 out of engagement with springs 163 and 165, respectively. The engagement of springs 161 and 162 closes an energizing circuit extending from ground G^6 through said springs 161 and 162 and relay 77 to battery lead 130. The relay 77, upon energizing, operates to force springs 169, 171 and 173 into engagement with springs 170, 172 and 174, respectively. The engagement of springs 173 and 174 furnishes a guarding potential to protect the trunk from seizure by any other selector C, and closes a new holding circuit through the release relay 62 of the selector C. This circuit extends from ground G^7 through springs 174 and 173 and conductor 157 to the selector private bank contact 176, and thence to the corresponding contact in the bank of each selector which has access to the conductors 155 and 156. From the contact 176 the circuit also extends through wiper 48, side switch wiper 53, contact point 177 and relay 62 to battery lead 130. This holding circuit of the relay 62 is closed before the said relay has time to deënergize after its former circuit is broken by the deenergization of relay 56, when the side switch passes from second to third position. The repeater D is now in position to receive the impulses for the second digit and to repeat them over the conductors 167 and 168 to the three-wire selector H.

When the calling device is operated for the second digit 2 the circuit of the relay 74 is broken twice momentarily. Each time the relay 74 deënergizes the springs 161, 164 and 166 momentarily engage the springs 160, 163 and 165, respectively, and the spring 161 disengages spring 162. Since the relay 77 is slow-acting it does not deënergize during the momentary interruption of its circuit by springs 161 and 162. The engagement of springs 165 and 166 has no utility at this time. The engagement of springs 163 and 164 closes a circuit extending from ground G^6 through the said springs 163 and 164, relay 78, and springs 171 and 172 to battery lead 130. The relay 78 is energized over this circuit the first time the relay 74 deënergizes,

and since the said relay 78 is slow-acting it remains in its operated position until all the impulses for the digit are delivered. The relay 78, upon energizing, operates to close a circuit extending from ground G^8 through springs 180 and 181, and through relays 75 and 76 to battery lead 130. Both relays 75 and 76 are energized over this circuit, but without any direct result at this time. Each time the spring 161 engages the spring 160 an impulse is transmitted over the vertical trunk conductor 167 to the selector H (Fig. 3). The path of this impulse extends from ground G^6 through springs 161 and 160, 169 and 170, conductor 167, side switch wiper 183 and vertical relay 184 to battery lead 185. The relay 184, upon energizing, closes a circuit extending from ground G^9 through springs 186 and 187, 188 and 189, and vertical magnet 190 to battery lead 185. Since the digit called is 2 the vertical magnet receives two impulses over the circuit just traced and operates to raise the shaft and wipers two steps. After the impulses for the second digit are all transmitted the repeater relay 74 remains in its energized position, maintaining the circuit of relay 77 and permanently breaking the circuit of relay 78. The relay 78 deënergizes after a short time and breaks the circuit of relays 75 and 76. The relay 75 is a quick-acting relay, while relay 76 is slow, and consequently the armatures of the relay 75 fall back first. At the instant the armature 191 engages the contact point 192 a circuit is closed through the rotary relay 195 of the selector H. This circuit extends from ground G^{10} through contact point 193, armature 194, contact point 192, armature 191, conductor 168, side switch wiper 196 and relay 195 to battery lead 185. An instant later the relay 76 deënergizes and breaks this circuit, allowing the rotary relay 195 to deënergize. This energization and deënergization of relay 195 transmits one impulse from ground G^9 through springs 186 and 198 and private magnet 197 to battery lead 185. The consequent energization and deënergization of the private magnet causes the side switch to pass from first to second position. When the side switch wiper 199 engages its second-position contact point a circuit is closed from ground G^9 through the interrupter springs 200 and rotary magnet 201 to battery lead 185. The rotary magnet 201 then operates to rotate the wipers onto the contacts of an idle line in the manner explained for the rotary magnet 50 of the selector C, after which the side switch passes to third position. While the wipers of the selector H are being rotated over the contacts of busy trunks the locking circuit of the private magnet 197 passes through the relay 203, but the said relay does not operatively energize on account of the comparatively high resistance of the magnet 197. The side switch wiper 199, upon leaving second position, disconnects the ground from the rotary magnet to prevent its further operation. The movement of the side switch wipers 183 and 196 from second to third position cuts off the line relays of the selector H and extends the connection through the shaft wipers 205 and 206 to the connector I. The connector I is protected from seizure by any other selector by a ground potential extending from ground G^{11} through the side switch wiper 204 (in third position), relay 203 and private wiper 202 to the selector private bank contact. The impulses for the last two digits are now repeated to the connector I, which operates to extend the connection to the called line.

When the calling device is operated for the third digit 2 the repeater D operates in the same manner as for the second digit to repeat two impulses to the vertical trunk conductor 167 and one impulse to the rotary conductor 168. In this instance the impulses over the conductor 167 pass through the vertical relay 207 and winding 208 of relay 209 to battery lead 185. The operation of the relay 209 in response to these impulses is without utility. Each time the vertical relay 207 energizes in response to the impulses for the third digit it operates to close a circuit extending from ground G^{12} through springs 210 and 211, 212 and 213, side switch wiper 215 and vertical magnet 214 to battery lead 185. The vertical magnet receives two impulses over the circuit just traced and operates to raise the switch shaft and wipers two steps. The impulse over the conductor 168 passes through the rotary relay 216, winding 217 of relay 209 and springs 218 and 219 to battery lead 185. The relay 216, upon energizing and deënergizing, operates to send one impulse from ground G^{12} through springs 210 and 220, private magnet 221 and springs 218 and 219 to battery lead 185. The private magnet 221, upon energizing and deënergizing, permits the side switch to pass from first to second position. The movement of side switch wiper 215 from first to second position places the vertical relay 207 in control of the rotary magnet 222 instead of the vertical magnet, so that the rotary magnet may respond to the operation of the said relay 207 for the last digit. Since the last digit is 0 the vertical relay 207 receives ten impulses, which it repeats to the rotary magnet 222, causing it to operate to rotate the wipers ten steps onto the contacts of the desired line #2220. The following impulse over the rotary side of the line operates the rotary relay 216, which responds to send one more impulse through the private magnet 221. The energization and deënergization of the private magnet in response to this impulse causes the side switch to pass from second to third position, thus extending the

connection to the called line by means of wipers 223 and 224. As soon as the side switch passes to third position the called line is protected from seizure by any other connector by a guarding ground potential extending from ground G^{13} through side switch wiper 225 and shaft private wiper 226 to the connector private bank contact 227, and thence to the corresponding contact in the bank of each connector which has access to line #2220. The engagement of side switch wiper 225 with its third-position contact point also closes an energizing circuit through the cut-off relay 228 of the selector N. This circuit extends from ground G^{13} to the private bank contact 227 and thence over conductor 229 and through relay 228 to battery lead 185. The relay 228, upon energizing, operates to open the bridge across the line conductors 230 and 231 through the relays 232 and 233. In order to signal the operator at the cord O' the calling operator must operate the calling device once more for some digit, it makes no difference which one. This last operation of the calling device causes one or more impulses to be delivered to the vertical relay 207 of the connector I, in the manner previously explained. Since the side switch wiper 215 is now in third position this last operation of relay 207 transmits a series of impulses through the ringer relay 234 and springs 235 and 236 of relay 209 (which is energized in series with relay 207) to battery lead 185. Each time the relay 234 energizes, one side of the established connection is opened by the separation of springs 237 and 238, and the ringer generator L^2 is bridged across the trunk conductors 230 and 231. The path of the ringing current extends from one side of generator L^2 through springs 241 and 240, side switch wiper 223, shaft wiper 242, conductor 230, condenser 243 at the cord O', relay 94, conductor 231, shaft wiper 244, side switch wiper 224 and springs 238 and 239 to the other side of the generator. The relay 94 energizes in response to this ringing current and closes an energizing circuit extending from ground G^{14} through springs 245 and 246, and through relay 96 in multiple with the lamp 95 to battery lead 250. The relay 96, upon energizing, closes a locking circuit for itself in multiple with the lamp 95. This circuit extends from ground G^{15} through springs 249 and 251, 252 and 253, armature 254, contact 255, and through relay 96 and lamp 95 in multiple to the battery lead 250. The relay 96 will thus remain locked and the lamp 95 continue to glow until the operator answers.

Upon seeing the signal of lamp 95 the operator throws key K^5 to communicate with the calling operator. The disengagement of springs 252 and 253 by the operation of key K^5 breaks the circuit of relay 96 and the lamp 95. Also, in the operated position of the key K^5 the secondary circuit of the operator's set S' is bridged across the line, and the primary circuit is provided with talking current over a circuit extending from ground G^{15} through springs 249 and 251, 252 and 258, transmitter 259 and primary of induction coil 362 to battery lead 250. After ascertaining the number of the desired line the operator restores key K^5, inserts the plug P' into jack J', and operates the key K^6 to force springs 260 and 261 into contact with springs 262 and 263, respectively. This operation of key K^6 disconnects the calling from the called line and connects the generator L' with the called line. After ringing the called substation the key K^6 is restored to normal position.

When the plug P' is inserted in the jack J' the lamp 264 is disconnected from the called line and a circuit is closed through the relays 97 and 97^a. This circuit extends from ground G^{16} through the sleeve conductors of the jack J' and plug P' and through the relays 97^a and 97 to the battery lead 250. The relay 97^a, upon energizing, attracts its armatures from their back contact points and the relay 97 operates to connect ground to the armatures of the relay 97^a. The grounding of the armature 265 of the relay 97^a while it is attracted completes an energizing circuit extending through the armature 266 of the relay 92 and its back contact, and through the lamp 93 to the battery lead 250.

From the foregoing it is evident that the relay 96 is energized immediately upon the application of ringing current to the trunk conductors 230 and 231, and that the said relay remains in its operated position until the operator answers the call. In its energized position the relay 96 holds the armatures 256 and 257 out of engagement with their contact points, thus disconnecting the conductors 230 and 231 from the plug P'. This opening of the circuit through the cord is for the purpose of preventing the ringing of a subscriber in case the connection is made with the trunk conductors 230 and 231 by an automatic connector before the plug P' has been removed from the jack after a previous call has been terminated. It is evident that without the provision of relay 96 ringing current could pass from the conductors 230 and 231 to the plug P'. If the plug were not removed from the jack promptly after the release of a previous connection this ringing current would be enabled to pass from the plug P' to a subscriber's line, thus giving a false signal at the substation unless the call happened to be for the particular substation that last used the cord O'.

After the calling operator has completed the call the key K is restored to normal po-

sition, whereby the operator's set S is disconnected from the line and the connection is extended to the calling substation through the windings of relay 38. When the key K is first operated a circuit is closed through the lower winding of relay 42. This circuit extends from ground G′ through jack J and plug P, winding of relay 42 and springs 380 and 358 to battery lead 108. The relay 42, upon energizing, attracts the armature 381 against its contact, thus bridging the upper winding of the relay 42 across the cord O through the armature 382 of relay 38. If the calling subscriber hangs up his receiver while the operator is making the call the upper winding of relay 42 forms a bridge across the line, after the key K is restored, to prevent the deënergization of the line relay of the repeater D. After the key is restored the relay 42 also remains energized by its upper winding. When the calling subscriber again removes his receiver the substation talking circuit is bridged across the line in multiple with the upper winding of relay 42. The substation is then provided with talking current from the repeater D through the windings of relay 38. The relay 38, upon energizing, opens the bridge through the upper winding of the relay 42 and allows it to deënergize. Of course, if the calling subscriber does not hang up his receiver while the operator is calling, the relay 38 is energized as soon as the key K is restored and the relay 42 deënergizes immediately.

When the called subscriber removes his receiver in response to the signal from generator L′ the spring 37 engages spring 36 to bridge the primary talking circuit across the line. At the instant this bridge is closed across the line conductors 267 and 268 the called substation is provided with talking current over a circuit extending from ground G^{13} at the connector I, through the lower winding of relay 269, ringer relay springs 237 and 238, wipers 224 and 244, conductor 231, armature 257, springs of key K^4, springs 271 and 272 of key K^5, winding 270 of relay 92, thence through plug P′ and jack J′ to line conductor 268, thence through the substation A′ and back over conductor 267, tip of jack J′ and plug P′, winding 273 of relay 92, springs 274 and 275, key K^4, trunk conductor 230, wipers 242 and 223 and through the upper winding of relay 269 to battery lead 185. The relays 269 and 92 are energized, but the relay 269 has no particular utility at this time. The relay 92, upon energizing, breaks the circuit of the lamp 93, thus signifying to the operator that the called subscriber has answered.

When the receiver at the called substation is restored to the switch hook upon the completion of the conversation the energizing circuits of the relays 92 and 269 are broken. The relay 92, upon deënergizing, again closes the circuit of the supervisory lamp 93, which signifies to the operator that the called subscriber has hung up his receiver and that the plug P′ may be removed from the jack J′. When the receiver is restored at the calling substation the release of the central office apparatus is initiated as follows: When the receiver at the substation A is hung up the switch hook opens the bridge across the conductors 100 and 101, thus allowing the supervisory relay 38 of the cord O and the line relay 74 of the repeater D to deënergize. The relay 38, upon deënergizing, again closes the energizing circuit of the lamp 39 to notify the operator that the calling subscriber has hung up. The relay 74, upon deënergizing, breaks the energizing circuit of relay 77, closes a circuit to slow relay 78 at springs 163 and 164, and completes a connection between the armatures 274^a and 275^a of relays 75 and 76, respectively. Relay 78, upon energizing, closes a circuit to relays 75 and 76 from ground G^8 through the springs 180 and 181 through said relays to battery. The relay 77, upon deënergizing, opens the energizing circuit of slow relay 78 and of the release relay 62 of the selector C. The relay 62, upon deënergizing, closes an energizing circuit through the release magnet 58. This circuit extends from ground G^3 through springs 131 and 132, 135 and 134, magnet 58 and springs 60 and 59 to battery lead 130. The magnet 58, upon energizing, causes the mechanism of the selector to be restored to normal position. As soon as the switch shaft reaches its lowest position the circuit of the magnet 58 is opened, allowing it to deënergize.

When the relay 78 of the repeater D deenergizes it opens the energizing circuits of the relays 75 and 76. The relay 75 deënergizes immediately, while the armatures of relay 76 remain in their operated position for an instant. This deënergization of relay 75 before that of relay 76 grounds both the conductors 167 and 168. This ground for the conductor 168 extends from ground G^{10} through contact 193, armature 194, contact 192 and armature 191. The ground for conductor 167 extends from ground G^{10} through contact point 276, armature 275^a, springs 165 and 166, contact 277 and armature 274^a. This simultaneous grounding of conductors 168 and 167 causes the simultaneous energization of the relays 207, 216 and 209 of the connector I. The energization of these relays closes an energizing circuit extending from ground G^{11} at the selector H through side switch wiper 204, relay 203, private wiper 202, springs 278 and 279, release magnet 280 and springs 235 and 236 to battery lead 185. The magnet 280 and

relay 203 are both energized over this circuit. The magnet 280 operates to restore the connector mechanism to normal position immediately, while the relay 203 closes a circuit extending from ground G^{17} through springs 281 and 282 and release magnet 283. The magnet 283, upon energizing, attracts its armature and holds it in readiness to release the selector H as soon as the energizing circuit of the said magnet is broken. The repeater relay 76 deënergizes shortly after the relay 75 and removes the ground from the conductors 167 and 168, whereupon the connector line relays become deënergized. The connector relays, upon deënergizing, break the energizing circuit of the selector release relay 203, which in turn breaks the circuit of the magnet 283, which releases its armature and allows the mechanism of the switch to be restored to normal position.

In the foregoing it has been explained how the subscriber at substation A may obtain connection with the substation A′. It will now be explained how the subscriber at substation A′ may call substation A. When the subscriber at substation A′ removes the receiver from the hook the primary circuit is bridged across the line, closing the circuit of lamp 264 in the same manner in which the circuit of lamp 102 was closed by the removal of the receiver at substation A. The operator, noticing the glowing of lamp 264 inserts the plug P′ into the jack J′ and throws the key K^5 to communicate with the calling subscriber. When the plug P′ enters the jack J′ the lamp 264 is cut from the line, the line is connected with the cord O′ and a circuit is closed through the relays 97^a and 97 in the same manner as when the substation A′ was called. The operation of key K^5 bridges the secondary of the operator's set S′ across the line and provides the primary circuit with talking current in a manner previously explained. The calling substation A′ is provided with talking battery current over a circuit extending from ground G^{18} through springs 285 and 272, winding 270 of relay 92, ring conductors of plug P′ and jack J′, thence through the sub-station A′ and back through the tip of jack J′ and plug P′, winding 273 of relay 92 and springs 274 and 286 to battery lead 250. Upon finding that the call comes from an automatic substation the operator may either call the desired line or let the calling subscriber do the calling himself. If the operator does the calling the key K^5 is restored to normal position and the key K^4 operated, whereby the calling line is cut off and the operator's calling device is bridged across the trunk. If it is desired that the subscriber do the calling the operator simply restores key K^5 and pays no more attention to the call until the disconnect signal is given. In the following description it is assumed that the subscriber does the calling.

When the key K^5 is restored the connection from the substation A′ is extended to the selector N. When the substation calling device is operated for the first digit 4 the vertical impulse spring 22 is forced into engagement with the ground post 23 four times, and then the rotary spring 21 is grounded once. Each time the vertical spring 22 engages the ground post a circuit is closed extending from the substation ground G^{19} through springs 26 and 27, 23 and 22, line 267, tip of jack J′ and plug P′, winding 273 of relay 92, springs 274 and 275, 278 and 288, armature 256, conductors 230 and 289, side switch wiper 290, vertical relay 232 and springs 291 and 292 to battery lead 185. The grounding of rotary impulse spring 21 completes a circuit extending from ground G^{19} through springs 23 and 21, rotary line 268, ring conductors of jack J′ and plug P′, winding 270 of relay 92, springs 272 and 271 of key K^5, through key K^4 and contacts of relay 96, conductors 231 and 293, side switch wiper 294, rotary relay 233 and springs 295 and 292 to battery lead 185. The vertical and rotary relays 232 and 233 operate in response to their respective impulses and cause the operation of the selector N in the manner explained for the selector H. First the vertical magnet 296 operates to raise the shaft wipers four steps, after which the rotary magnet 297 operates to automatically rotate the wipers onto an idle trunk leading to a repeater M. As soon as the shaft of the selector N is raised one step the spring 298 is permitted to engage spring 299, whereby a ground potential is extended from ground G^{20} over conductor 229 to the connector private bank contact 227, which has access to the trunk conductors 230 and 231. This ground potential at the connector private bank contacts protects the trunk from interference over the connectors.

At the instant the connection is extended to the repeater M by the selector N the vertical and rotary line relays 81 and 82 are energized over a circuit extending from ground G^{21} through springs 300 and 302, winding 303 of relay 83, rotary relay 82, bank contact 304, wiper 305, side switch wiper 294 (in third position), conductor 293, thence over the heavy conductors through cord O′ to and through substation A′ and back over the other side of the line and trunk to conductor 289, side switch wiper 290, shaft wiper 306, bank contact 307, relay 81 and winding 308 of relay 83 to battery lead 185. The relay 83 is not energized over this circuit because the current flows through its two windings in opposite directions. The relays 81 and 82,

upon energizing, force springs 309 and 310 into engagement with springs 312 and 311, respectively, the engagement of springs 309 and 312 having no function at this time however. The engagement of springs 310 and 311 completes a circuit extending from ground G^{21} through springs 300 and 301, 311 and 310 and rotary magnet 85 to battery lead 185. The magnet 85, upon energizing, operates to advance the wipers 86 and 87 one step. When the selector N completes the connection to the repeater M and the side switch passes to third position a circuit is also completed through the relay 313. This circuit extends from ground G^{22} through side switch wiper 314, relay 315, wiper 316, bank contact 317 and relay 313 to battery. The relay 315 is not energized over this circuit on account of the comparatively high resistance of relay 313. The relay 313, upon energizing, completes a bridge across the trunk conductors 318 and 319. The closure of this bridge across the trunk completes an energizing circuit extending from ground G^{23} at the selector F through winding 320 of relay 322, side switch wiper 323, conductor 319, springs 325 and 326 of repeater relay 83, contact point 327 and armature 328, impedance 329, conductor 318, side switch wiper 324, winding 321 of relay 322 to battery lead 130. The relay 322, upon energizing, places the selector F in position to receive impulses for the next digit in the manner explained for the selector C when its line relay 56 was energized.

When the dial at the substation is rotated for the second digit 4 the bridge across the line is opened by the separation of springs 36 and 37, thus allowing the relays 81 and 82 to deënergize and open the circuit of the magnet 85 of the repeater. As the impulse wheel returns to normal position for this digit it sends four ground impulses through the relay 81 and winding 308 of relay 83. Both relays 81 and 83 are energized by these impulses, but the energization of the relay 81 has no effect at this time because the relay 82 is deënergized. Each time the relay 83 energizes it opens the bridge across conductors 318 and 319 by separating springs 325 and 326. Since the digit called is 4 the bridge is opened four times, thus causing the line relay of the selector F to deënergize four times. The rotary impulse from the substation has no effect on the repeater because the rotary relay is connected to ground instead of to battery. After all the impulses are delivered the bridge across the line is again closed at the substation, causing both line relays of the repeater to again energize to close the circuit of the rotary magnet 85 and thus advance the wipers 86 and 87 a second step.

The impulses repeated by the repeater M to the relay 322 cause the selector F to operate in the manner explained for the selector C to extend the connection to the connector E. When the connection is thus extended to the connector its line relay 69 is energized in the same manner that the line relay of the selector F was first energized. The relay 69, upon energizing, closes a circuit extending from ground G^{24} through springs 330 and 331, release relay 332, springs 364, 365, 376 and 377 to battery lead 130. The relay 332, upon energizing, completes a holding circuit for the release relay 333 of the selector F. This circuit extends from ground G^{35} through the side switch wiper 334, springs 336 and 335, bank contact 337, private wiper 338, side switch wiper 339, springs 383 and 384 and relay 333 to battery lead 130. This holding circuit is closed before the relay 333 has time to deënergize after its former circuit is broken by the deënergization of relay 322 after the side switch passes to third position.

When the substation calling device is operated for the third digit 4 the repeater M operates in the same manner as for the previous digit to repeat four impulses to the trunk conductors 318 and 319. These impulses cause the relay 69 to deënergize four times to transmit four impulses from ground G^{24} through the vertical magnet 67 and slow-acting private magnet relay 340 in the same manner as explained for the selector C. The vertical magnet operates to raise the shaft four steps, while the relay 340 closes the circuit of the private magnet 71. The relay 340 deënergizes after the last impulse is delivered to the vertical magnet, and opens the circuit of the private magnet 71. The magnet 71, upon deënergizing, permits the side switch to pass from first to second position. The movement of side switch wiper 341 from first to second position places the rotary magnet 68 under the control of the line relay 69. When the bridge across the calling line is closed after the impulses are delivered for the third digit the magnet 85 operates to advance the wipers of the repeater M a third step.

When the substation calling device is operated for the last digit 0 ten impulses are repeated by the repeater M to the connector E. The operation of relay 69 in response to these impulses transmits ten impulses through the rotary magnet 68 and private magnet relay 340. The path of these impulses extends from ground G^{24} through springs 330 and 346, 342 and 343, 344 and 345, rotary magnet 68, side switch wiper 341 and relay 340 to battery lead 130. The rotary magnet 68 operates in response to these impulses to rotate the wipers ten steps into engagement with the line #4440. The relay 340 operates to again close the circuit of the

private magnet 71 while the impulses are being delivered to the rotary magnet. The private magnet deënergizes after the last impulse is delivered and permits the side switch to pass to third position, thus extending the connection to the trunk ending in the cord O. When the side switch wiper 347 reaches third position it completes a circuit extending from ground G^{25} through said wiper 347, springs 348 and 349, shaft wiper 66, bank contact 141, conductor 140, springs 138 and 137 and relay 57 to battery lead 130. The relay 57 upon energizing, disconnects the line relay 56 from the line to prevent the operation of selector C when the operator answers. When the side switch wiper 341 reaches third position it completes a circuit for the ringer relay 73. This circuit extends from ground G^{26} through interrupter 366, springs 367 and 368, relay 73, side switch wiper 341 and relay 340 to battery lead 130. Since this circuit includes the interrupter 366 the ringer relay will be intermittently energized as long as this circuit is closed. The relay 73, upon energizing, operates to disconnect the calling from the called line and to bridge the generator L^3 across the called line. When the generator is thus bridged across the line ringing current flows over conductors 351 and 352 to and through the relay 40 of the cord O. The relay 40, upon energizing, operates to close a circuit through the lamp 41 and relay 43. The circuit through the lamp extends from ground G^{27} through armature 354 and its contact, and lamp 41 to battery lead 108. The circuit through relay 43 extends from ground G^{27} through armature 354, relay 43, springs 355 and 356, 357 and 358 to battery lead 108. The relay 43, upon energizing, closes a locking circuit for itself through its armature 359, maintains the circuit of lamp 41, and cuts off the plug P to prevent ringing a subscriber in case the plug has not been removed from the jack since the last call. The office of relay 43 is the same as that of relay 96 of cord O′.

The rotary magnet 85 of the repeater M operates in a manner already explained to advance the wipers 86 and 87 a fourth step onto the contact points 360 and 361, thus bridging the impedance 329 across the trunk independent of the relay springs. This short-circuiting of the relay springs is to prevent the release of the switches of the two-wire exchange should the calling subscriber press his signaling button and thus cause the relay 83 to open the bridge across the trunk for a considerable length of time.

The operator at the branch exchange answers the signal of lamp 41 by operating the key K to connect the talking set S with the trunk. The operation of key K also breaks the circuit of relay 43 by the separation of springs 357 and 358. When the operator's set is bridged across the trunk, or as soon thereafter as the ringer relay 73 of the connector E deënergizes, if it is energized at the time, the back-bridge relay 72 of the connector is energized over a circuit extending from ground G^{25} through the lower winding of said relay, through springs 369 and 370 of relay 73, side switch wiper 371, shaft wiper 65, thence to and through the operator's set S and back over the other side of the line and through wiper 64, side switch wiper 372, springs 373 and 374 and upper winding of relay 72 to battery lead 130. The relay 72, upon energizing, removes the short-circuit of relay 375 by separating springs 376 and 377. The relay 375 thereupon energizes in series with the release relay 332 and disconnects the interrupter 366 from the ringer relay 73 to prevent its further operation after the call has been answered. The relay 375, in its operated position, also separates springs 364 and 365, thereby opening its short-circuit in a second place, and preventing the deënergization of relay 375 and the consequent energization of relay 73 when the operator restores key K.

After the operator has ascertained the number of the desired substation the key K is restored, the plug P is inserted into the jack J of the line wanted, and the key K^2 is operated to signal the called substation in the same manner in which the operator at cord O′ calls substation A′. When the plug P is inserted in the jack J the supervisory lamp 39 is lighted over a circuit extending from ground G′ through the sleeve conductors of jack J and plug P, armature 284 and its back contact, and lamp 39 to battery lead 108. When the called subscriber answers the called substation is provided with talking current through the back-bridge relay 72 of the connector E and supervisory relay 38 of the cord in a manner similar to that in which the substation A′ received talking current when it was called. The relay 38 is energized by this current and operates to break the circuit of lamp 39, which signifies to the operator that the called subscriber has answered.

When the receiver is restored to the switch hook at the called substation upon the termination of the conversation, the energizing circuit of relay 38 is destroyed. The relay 38, upon deënergizing, again closes the circuit of lamp 39 to give the operator the disconnect signal. When the receiver is restored at the calling substation the operator at cord O′ is given the disconnect signal, and the automatic switching mechanism is restored as follows: As the switch hook at the substation A′ descends it momentarily presses springs 29, 30 and 31 into contact, thereby grounding both the vertical and rotary line conductors 267 and 268. The grounding of the vertical line 267 maintains

the energizing circuit of the relay 81 and winding 308 of relay 83 at the repeater M while the grounding of the rotary line short circuits relay 82 and winding 303 of relay 83. Since only one winding of relay 83 carries current, the said relay energizes and at the same time relay 82 deënergizes. The relay 83, upon energizing, shifts spring 302 out of engagement with spring 301 and into contact with spring 378, whereby the connection of winding 303 and release magnet 90 is shifted from ground to the non-grounded terminal of the battery. The winding 303 now carries current in a direction to assist winding 308, and the relay 82 again energizes. The simultaneous energization of relays 81, 82 and 83 closes an energizing circuit extending from ground G^{22} at the selector N through relay 315, wiper 316, contact 317, springs 309 and 312, magnet 90 and springs 302 and 378 to battery lead 185. Both the magnet 90 and relay 315 are energized over this circuit, the magnet 90 operating to withdraw the pawl 91 to allow the repeater wipers to return to normal position, while the relay 315 closes an energizing circuit through the release magnet 379. The release magnet 379 attracts its armature and holds it in readiness to release the selector when the circuit of the magnet is broken upon the deënergization of relay 315, when the substation release springs separate to destroy the circuit of the repeatef relays 81, 82 and 83. After the calling subscriber has hung up, the circuit of the supervisory relay 92 is destroyed, allowing the said relay to deënergize and again close the circuit of the supervisory lamp 93 to give the disconnect signal. When the wipers of the repeater M return to normal position the energizing circuit of the line relay 69 of the connector E is broken, allowing said relay to deënergize and break the circuits of the release relays 332 and 333 of the connector E and selector F, respectively. The deënergization of relays 332 and 333 causes the release of their respective switches in the same manner as the selector C was released when the relay 62 was deënergized.

When the plug P′ is removed from the jack J′ the relay 97^a immediately deënergizes and grounds the line conductors 230 and 231. The relay 97 being slow-acting deënergizes a moment later and cuts off the ground from the trunk. This operation of the relays 97 and 97^a is exactly similar to that of the relays 75 and 76 of the repeater D. The purpose of the relays 97 and 97^a is to send a simultaneous ground impulse over both sides of the line to release the automatic switching apparatus in case the plug is removed from the jack before said switches have been released. It is evident that if the calling substation were a manual substation not provided with the release springs 29, 30 and 31, it would be necessary for the operator to press a releasing button to release the central office apparatus if the relays 97^a and 97 were not provided.

From the foregoing it will be seen that I provide a system in which a subscriber cannot be called by another subscriber if the line of the first subscriber is still connected with a cord circuit, in which event the operator will be signaled, but no ringing current will be transmitted to the called line. The subscriber A may do the calling after the operator has answered the call, or the said operator may transmit the impulses necessary for operating the automatic switches; but in either case the calling mechanism must be given an extra or additional operation in order to operate the means for transmitting ringing current to the cord circuit of the called operator. When the call is in the other direction, however, as from subscriber A′ to subscriber A, then the signaling of the called operator is automatic and requires no special operation of the calling mechanism at the substation A′ if the calling subscriber is doing the calling, or at the cord circuit O′ if the operator at the latter is doing the calling. In each case, though, the call is from a line that can call automatically, but which can be called only manually, each line terminating only in one or more jacks. The line at the substation A is a two-wire line—that is to say, there is no operating ground at the substation—whereas the line at the substation A′ is a three-wire line, there being a ground at the substation of this line for controlling the automatic switches at the central station. No subscriber can call the subscriber A′ while the cord O′ is connected with the line of this substation, as the supply of ringing current to this cord circuit will operate the relay 96 and thereby open the two sides of the cord circuit, thus signaling the operator, but preventing the ringing current from ringing the substation A′. On the other hand, when the cord O is still connected with the line of substation A, then no subscriber can call this substation, inasmuch as the supply of ringing current to the said cord will cause the relay 43 to open the two sides thereof, thus signaling the operator but preventing the substation A from being signaled. The repeater D, as explained, is for use in automatically trunking from a two-wire to a three-wire exchange, whereas the repeater M is for use in trunking from a three-wire to a two-wire exchange, in the manner explained. Each subscriber's line, as stated, is equipped with a rotary dial or other calling mechanism for controlling the automatic switches after the operator has answered, and each line is also equipped with a line signal by which the calling subscriber at-

tracts the attention of the operator. In this way the automatic apparatus is normally entirely disconnected from the subscribers' lines, and any calling subscriber is dependent upon an operator for gaining control of said apparatus. Thus I provide for automatic trunking between semi-automatic exchanges of different types; and also, among other things, I provide for the opening of the two sides of the cord circuit, in the event that the operator at such cord circuit is signaled while the cord is still connected with the line of a previous call. Thus in each case the supply of ringing current to the substation of the called subscriber is entirely under the control of the operator at whose board the line terminates. Other advantages will be obvious to those skilled in the art.

What I claim as my invention is:—

1. In a telephone system, a line, a cord for connecting therewith, a signal for said line, a relay, a source of current for operating said relay for opening the two sides of said cord to prevent current from said source from operating said signal, a second relay for controlling said first-mentioned relay, a condenser in series with the energizing circuit of said second relay, and substation-controlled means for operating said second relay.

2. In a telephone system, a line, a cord for connecting therewith, a signal for said line, a relay, a source of current for operating said relay for opening the two sides of said cord for preventing current from said source from operating said signal, a second relay for controlling said first-mentioned relay, a condenser in series with the energizing circuit of said second relay, and central station switchboard means for controlling said first relay.

3. In a telephone system, a line, a cord for connecting therewith, a trunk line for extending a connection to said cord, means for supplying ringing current to said cord over the trunk circuit, a signal at said cord responsive to said current, and means responsive to said current for opening the cord to prevent the ringing current from ringing said line.

4. In a telephone system, a line, a flexible cord for connecting therewith, a trunk line terminating in said cord, a signal at said cord, means for transmitting ringing current over the trunk line to operate the said signal, and a relay responsive to said current when the signal is operated for opening the cord to prevent the ringing current from ringing the said line.

5. In a telephone system, a line, a switchboard cord for connection therewith, means by which a calling subscriber may extend connection to said cord, means controlled by the calling subscriber for transmitting ringing current to the cord, a signal at the cord responsive to said ringing current, and means for preventing said current from ringing the said line if the latter is still connected with said cord.

6. In a telephone system, a line, a switchboard cord for connection therewith, means whereby a manual switchboard operator may extend connection to said cord, means controlled by the calling subscriber for transmitting ringing current to the cord, a signal at the cord responsive to said ringing current, and electro-mechanical means for preventing said current from ringing the said line if the latter is still connected with said cord.

7. In a telephone system, a called line, a cord for connection therewith, a calling line, another cord for connection with said calling line, means controllable by the calling subscriber for automatically extending connection from the second cord to the first cord, means for supplying ringing current to the first cord, means at said first cord for giving the operator a signal in response to said current, and a relay for said first cord, which relay is also responsive to said ringing current, adapted to open the cord circuit, whereby the ringing current will not ring the called line if for any reason the cord is still connected therewith.

8. In a telephone system, a called line, a cord for connection therewith, a calling line, another cord for connection with said calling line, means controllable by the answering operator for automatically extending connection from the second cord to the first cord, means for supplying ringing current to the first cord, means at said first cord for giving the operator a signal in response to said current, and a relay for said first cord, which relay is also responsive to said ringing current, adapted to open the cord circuit, whereby the ringing current will not ring the called line if for any reason the cord is still connected therewith.

9. In a telephone system, a line, a flexible switchboard cord for connection therewith, a trunk line for extending a connection to said cord, means for supplying ringing current over the trunk circuit to said cord, and means in said cord operating to prevent said current from ringing the line if the cord is still connected therewith.

10. In a telephone system, a line, a flexible switchboard cord for connection therewith, means for supplying ringing current to signal the operator at said switchboard, and electro-mechanical means for preventing said current from ringing the line if the cord is still connected therewith.

11. In a telephone system, a telephone line, a flexible switchboard cord for connection therewith, a trunk line terminating in said cord, means for supplying signaling

current over the trunk line, a signal at the cord responsive to said current, and electromechanical means to prevent such current from ringing the said line while the cord is connected therewith.

12. In a telephone system, a calling line, a called line, a calling mechanism for the substation of each line, automatic switches responsive to the calling device of one line, automatic switches responsive to the calling device of the other line, whereby calls may be extended in either direction, an operator's cord for connection with the calling line, another operator's cord for connection with the called line, a line signal for each line, and supervisory signals for said cords whereby either subscriber may signal for a connection or a disconnection, the said automatic switches serving to connect one cord with the other.

13. In a telephone system, a calling line, a called line, a calling mechanism for the substation of each line, automatic switches responsive to the calling device of one line, automatic switches responsive to the calling device of the other line, whereby calls may be extended in either direction, an operator's cord for connection with the calling line, another operator's cord for connection with the called line, a line signal for each line, and supervisory signals for said cords whereby either subscriber may signal for a connection or a disconnection, the said automatic switches serving to connect one cord with the other, and the said called line having a ground connection at the substation thereof, which ground connection is controlled by the dial or calling device of the called line.

14. In a telephone system, a calling line, a called line, a calling mechanism for the substation of each line, automatic switches responsive to the calling device of one line, automatic switches responsive to the calling device of the other line, whereby calls may be extended in either direction, an operator's cord for connection with the calling line, another operator's cord for connection with the called line, a line signal for each line, and supervisory signals for said cords whereby either subscriber may signal for a connection or a disconnection, the said automatic switches serving to connect one cord with the other, one or more of said automatic switches being controllable over the two sides of the calling line in series, said calling line being free from operating grounds at the substation thereof.

15. In a telephone system, a calling line, an automatic switch controllable over the two sides of the said line in series, means by which an operator connects the said automatic switch with the calling line to give the calling subscriber control thereof, a called line, and means including a switchboard cord and plug for completing the connection from the automatic switch to said called line.

16. In a telephone system, a calling line, a plurality of automatic switches successively controllable over the two sides of the calling line in series, a switchboard cord and plug for manually connecting one of said switches with the said line to give the subscriber control thereof, a called line, and means for completing connection from the said automatic switches to the said called line, including a jack for the called line and an operator's cord plug insertible in said jack.

17. In a telephone system, a cord circuit for answering the call, means at said cord circuit for transmitting calling impulses, and a repeater for receiving and repeating said impulses, said repeater provided with parallel voice-current conductors, a step-by-step-operated switching mechanism, and means operated by said mechanism to form a bridge between said voice-current conductors.

18. In a telephone system, a cord circuit for answering the call, means at said cord circuit for transmitting calling impulses, and a repeater for receiving and repeating said impulses, said repeater provided with parallel voice-current conductors, a ratchet mechanism, a relay for operating said ratchet mechanism, and means whereby a plurality of actuations of said mechanism will close a bridge between said voice-current conductors.

19. In a telephone system, a cord circuit for answering the call, means at said cord circuit for transmitting calling impulses, and a repeater for receiving and repeating said impulses, said repeater provided with parallel voice-current conductors, a step-by-step-operated switching mechanism, means operated by said mechanism to form a bridge between said voice-current conductors, and means including a release magnet for restoring said mechanism to normal position.

20. In a telephone system, a cord circuit for answering the call, means at said cord circuit for transmitting calling impulses, and a repeater for receiving and repeating said impulses, said repeater provided with parallel voice-current conductors, a ratchet mechanism, a relay for operating said ratchet mechanism, means whereby a plurality of actuations of said mechanism will close a bridge between said voice-current conductors, and means including a release magnet for restoring said mechanism to normal position.

21. In a telephone system, a line circuit, a cord circuit for answering the call, means at said cord circuit for transmitting calling impulses, a second circuit, and means for receiving said impulses over the two sides

of the line circuit in series, adapted to then repeat the said impulses over said second circuit by grounding first one side and then the other of the latter.

22. In a telephone system, a line circuit, a cord circuit for answering the call, means at said cord circuit for transmitting calling impulses over the two sides of the line circuit in series, a repeater for receiving and transmitting said impulses, a trunk line, and another line circuit over which the repeated impulses are transmitted, said repeater provided with relay mechanism for grounding first one side and then the other of the said last-mentioned line circuit.

23. In a telephone system, a cord circuit for answering the call, means at said cord circuit for transmitting calling impulses, relay coils for receiving said impulses, slow-acting relays controlled by said relay coils, a second pair of relays controlled in series by one of said slow-acting relays, a ground connection controlled by one of said second pair of relays, and repeating circuits controlled by said relays, substantially as described.

24. In a telephone system, a cord circuit for answering the call, a two-wire line circuit including the sides of said cord circuit, a three-wire line circuit, means for transmitting calling impulses over said two-wire line circuit, and means comprising quick and slow acting relays for repeating said calling impulses from the two-wire line circuit to the three-wire line circuit.

25. In a telephone system, calling and called lines, a cord circuit and a trunk line having a progressively movable switch for interconnecting the same, a step-by-step switch, and an impedance bridge across said circuit controlled by said step-by-step switch, said bridge included in the controlling circuit for said progressively movable switch.

26. In a telephone system, calling and called lines, means including an automatic switch controllable over two sides of the calling line in series for extending connection to the called line, said means also including a trunk line, an impedance bridge across said trunk line, said bridge included in the controlling circuit for said automatic switch, and a step-by-step switch for controlling said bridge.

27. In a telephone system, a line, a cord for connecting therewith, a relay for opening the two sides of said cord, a second relay for controlling said first mentioned relay, a condenser in series with the energizing circuit of said second relay, a source of current for operating said second relay, and automatic means for applying said current to the circuit of said second relay.

28. In a telephone system, a trunk line, a subscriber's line provided with means for transmitting impulses over two sides of the line in series, a second subscriber's line provided with means for transmitting impulses over two sides of said line with ground return, and means whereby a connection may be established from either of said lines over said trunk.

Signed by me at Chicago, Cook county, Illinois, this 4 day of January, 1910.

BERNARD D. WILLIS.

Witnesses:

EDWARD D. FALES,

ARTHUR J. RAY.