1,180,286.

E. D. FALES.

TELEPHONE TRUNKING SYSTEM.

APPLICATION FILED DEC. 1, 1908.

Patented Apr. 25, 1916.

4 SHEETS—SHEET 1.

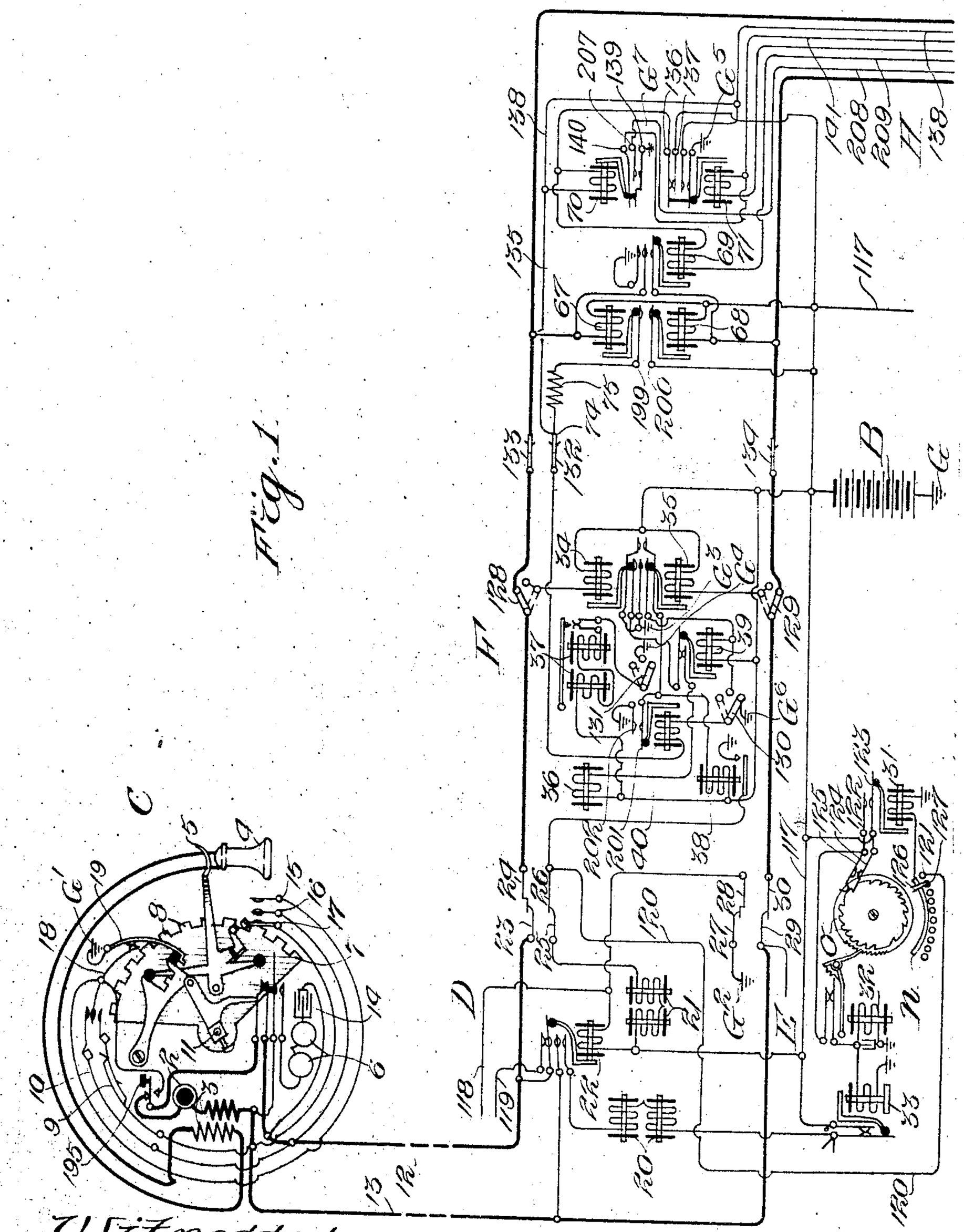

Fig. 1.

Witnesses.

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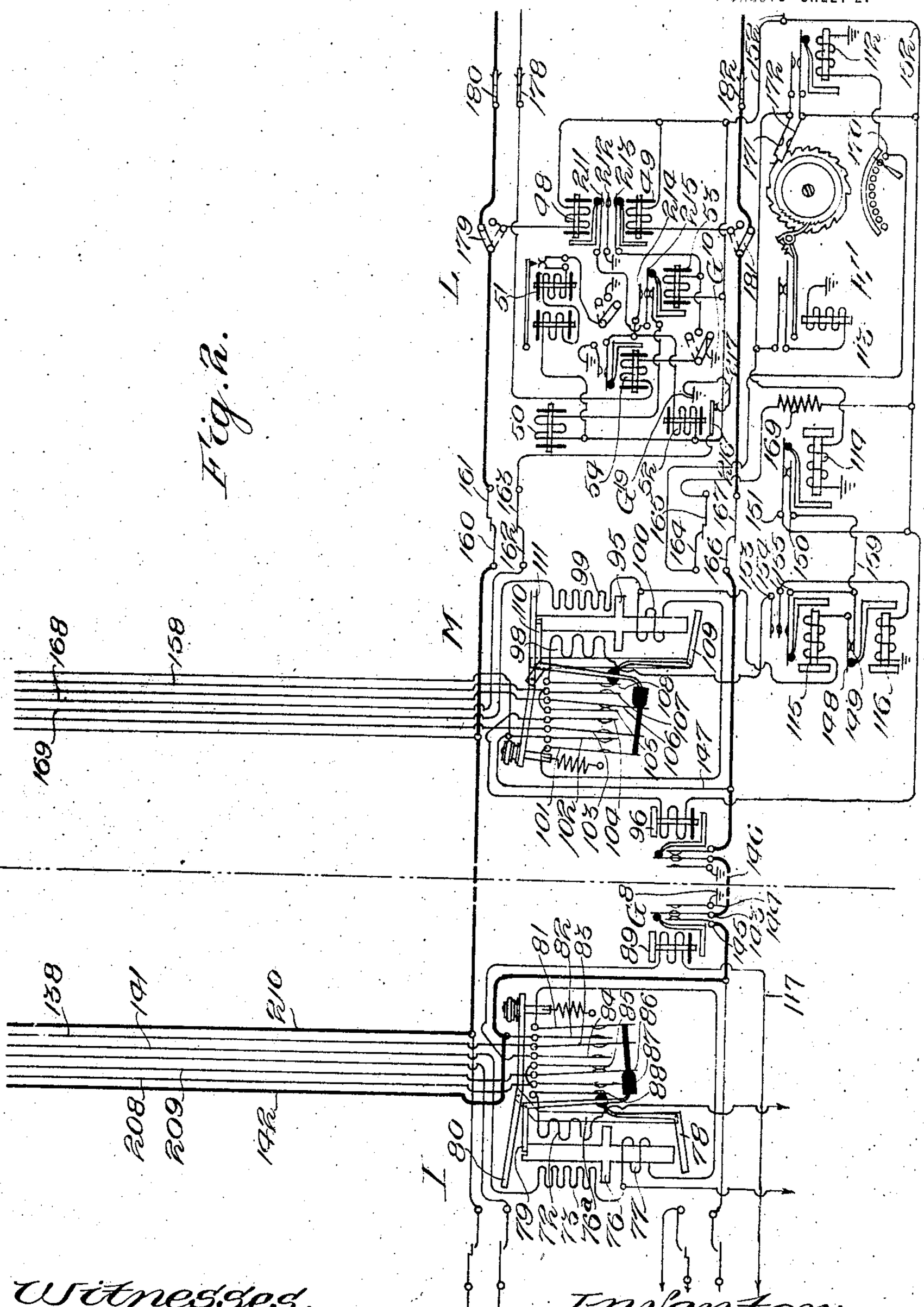
4 SHEETS—SHEET 2.

Fig. 2.



Witnesses.

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4 SHEETS—SHEET 3.

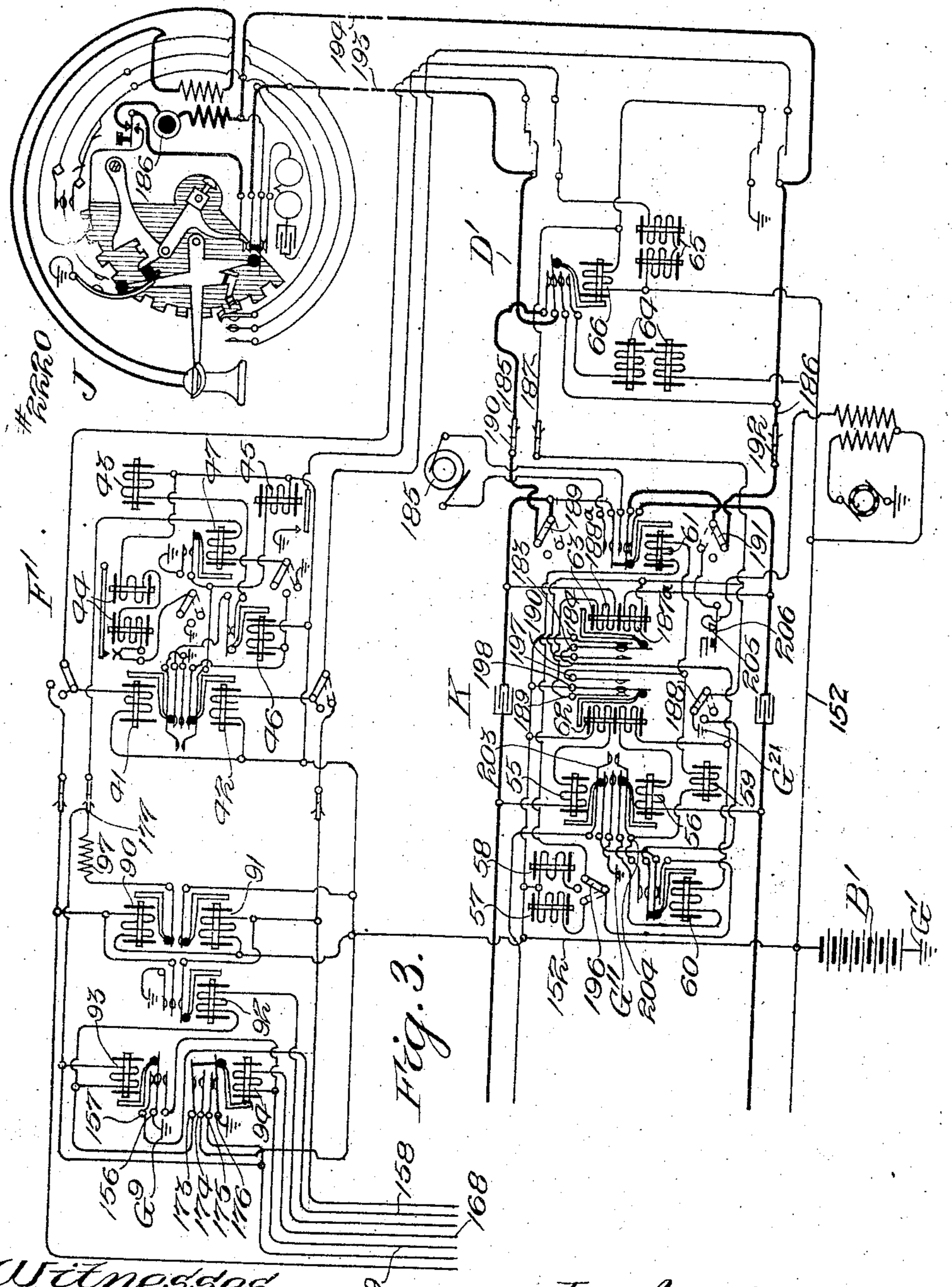

Fig. 3.

Witnesses.

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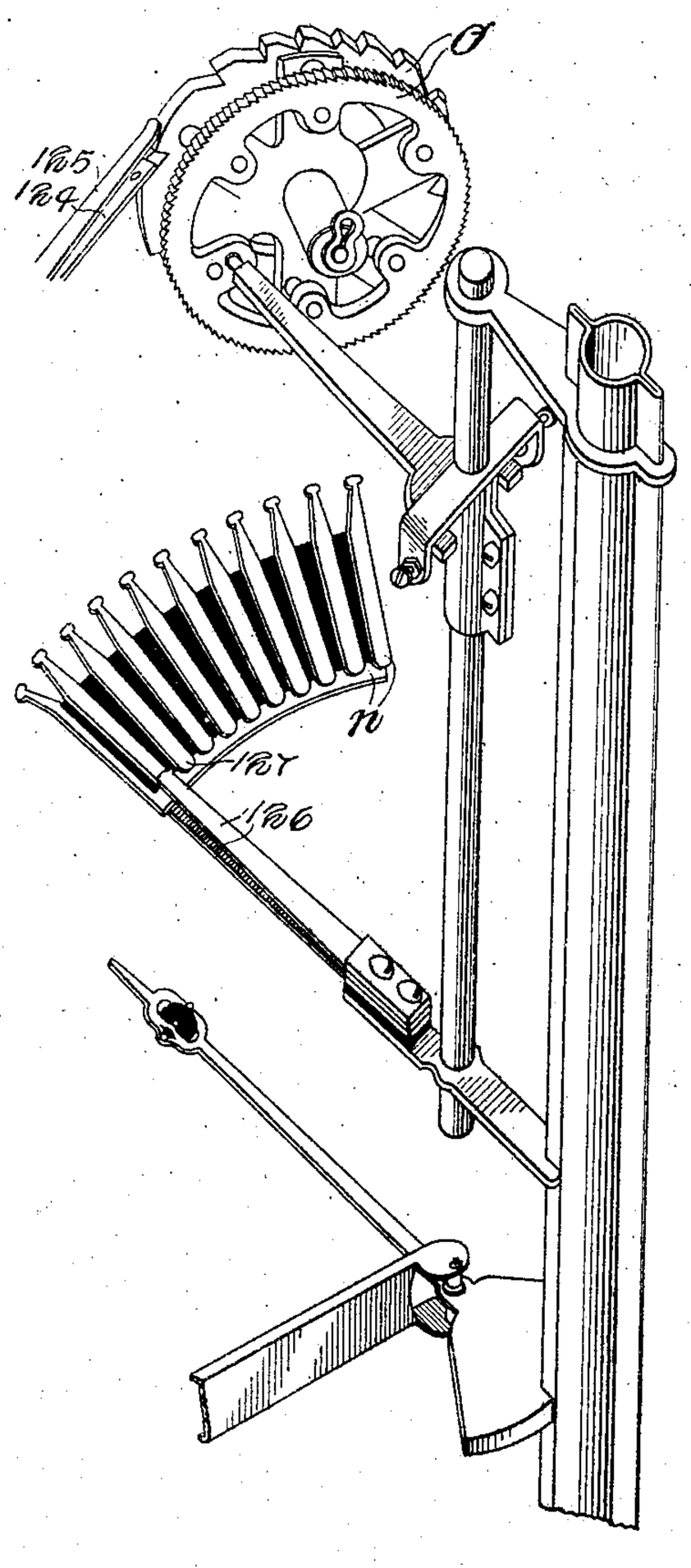
4 SHEETS—SHEET 4.

FIG. 4.



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TELEPHONE TRUNKING SYSTEM.

1,180,286. Specification of Letters Patent. Patented Apr. 25, 1916.

Application filed December 1, 1908. Serial No. 465,561.

To all whom it may concern:

Be it known that I, EDWARD D. FALES, a citizen of the United States of America, and resident of La Grange, Cook county, Illinois, have invented a certain new and useful Improvement in Telephone Trunking Systems, of which the following is a specification.

My invention relates to trunking systems for telephone or other service, and it relates more particularly to two-way trunks for use in automatic telephone exchange systems, as, for example, trunking in opposite directions between two automatic exchanges, although in certain respects, as will hereinafter appear, my invention is not limited to either a two-way or a one-way trunk.

In certain respects my invention has to do with the type of system shown in my Patent No. 1,064,719, issued June 17, 1913, for improvement in telephone trunking systems.

Objects of my present invention are to provide an improved two-way trunk-line having a non-numerical trunking switch at each end thereof, whereby the seizure of either end of the trunk-line serves to automatically operate a non-numerical trunking switch at the other end thereof, and to thus automatically extend connection therefrom to an idle switch, such, for example, as a selector or connector, according to the size and character of the exchange; to provide an improved two-way trunk in a three-wire automatic telephone exchange system—that is to say, in a system in which the subscribers control or operate the automatic switches by means of a ground and two metallic conductors; to provide an improved three-wire system in which non-numerical trunking switches are provided for extending connection from one set of numerical switches to another, such non-numerical trunking switches being previously interposed between the said numerical switches, as, for example, between first-selectors and second-selectors, as herein shown; to provide an arrangement in a three-wire system whereby whenever the numerical switch is disconnected from the trunk provided with the non-numerical trunking switches, all of the switches of the said trunk are automatically restored to normal condition, putting the trunk in a non-busy condition at both ends, whether the disconnecting operation of the numerical switch has been effected electrically or otherwise, as, for example, by hand; and to provide certain details, combinations and features of improvement tending to increase the general efficiency of a telephone exchange system of this particular character, as will hereinafter more fully appear.

In the accompanying drawings Figures 1, 2 and 3 are a diagrammatical representation of a circuit connection established between a calling subscriber in Fig. 1 at one exchange and a called subscriber in Fig. 3 at a second exchange. The said connection is established over the two-way trunk shown in Figs. 1, 2 and 3. Fig. 4 is a representation of the essential features of the master switch E shown in Fig. 1.

The exchange in which the calling subscriber shown in Fig. 1 is located will be designated as exchange A. This exchange is provided with a central battery B having a terminal preferably grounded at G. This battery may be used for supplying all talking and operating current to the exchange A.

Of the apparatus allotted to the exchange A the drawings show the calling subscriber's station C, the line switch D allotted to the said statioin and individual to the same, but controlled, together with a number of similar line switches, by the common mechanism E usually known as the master switch. Accessible to the line switch D is the numerical switch F usually known as the first-selector, which is one of a group of selectors common to a number of line switches D. Through the medium of the selectors F the two-way trunks of my invention, such as the two-way trunk H, may be reached by the subscriber C, as indicated in the drawings. The selectors F may or may not have access solely to two-way trunks H. The arrangement may be such, for example, that the selector F will have access to trunks H from only a certain level, or from certain levels, while from still other levels other switches, such as second-selectors or connectors, may be reached. It will be seen that the two-way trunk H terminates in the A-exchange in a non-numerical switch I to the left of which are shown conductors which may terminate in a connector switch or in a selector switch. This non-numerical switch I is more or less in character like the line switch D and, together with other similar switches I, it is con-

trolled by a master switch. The exchange to which the called subscriber J belongs will be designated as the A¹-exchange, which exchange comprises the called subscriber's line switch D¹, and which line switch is identical with the line switch D of Fig. 1 in the A-exchange. The said A¹-exchange also comprises a first-selector F¹, the same as selector F of the A-exchange, a connector switch K, a second-selector switch L and the non-numerical switch M which is the terminal at the A¹-exchange of the trunk-line, which, at the A-exchange, terminates in the non-numerical switch I. In the A¹-exchange there is shown another battery B¹ having a terminal preferably grounded at G¹. This battery may be used for supplying all talking and operating current to the exchange A¹. It is not absolutely essential that these exchanges A and A¹ should be supplied with current from separate batteries, inasmuch as a single battery may be used for the purpose. It will be understood that in the usual arrangement the line switch D (Fig. 1) is provided with a bank comprising the terminals of ten trunks, each trunk being a duplicate of the trunk shown which terminates in the selector F. It will also be understood that each of these trunks is made common to all of the line switches of a group, as, for example, common to all of the line switches controlled by the master switch E, and it is obvious, therefore, that, although the trunk running from the selector F to the line switch D is shown with only one line switch bank terminal, this trunk is in reality provided with as many terminals as there are line switches. In like manner the trunk H, although shown with only one bank terminal in the selector F, has in reality as many multiples as there are selectors to which this trunk H is common. In a similar manner the non-numerical switch M at the A¹-exchange is provided with ten trunks, each terminating in a selector L, while the selector F¹ has access to the two-way trunks H just as the selector switch F in Fig. 1 has access to the said trunks H. Of course, the second-selector L has access to connectors K in the usual manner. It will be seen that that section of the two-way trunk H to the left of the dotted line found in Fig. 2 is an exact duplicate of the section to the right thereof.

In general the mode of operation is as follows: When the subscriber C (Fig. 1) wishes to call the subscriber J (Fig. 3) the subscriber C removes his receiver, thereby operating the line switch D to establish connection with the selector F. The selector F is then operated by the subscriber C upon the first move of his dial. This first move of the dial raises the wiper of the selector F to a certain bank level, from which the switch, by automatically rotating, automatically picks out the first idle two-way trunk available. As soon as the selector F stops on the trunk selected, the line switch I is cut off from the trunk, while at the same time the line switch M at the other exchange is operated to establish connection with the second-selector L. Of course, the selector F makes the trunk H busy at the A-exchange at all other selectors F to which the said trunk H is accessible at the A-exchange. At the A¹-exchange the operation of the line switch M makes the trunk busy to all switches which have access to the trunk H from the A¹-exchange. It will be understood that by this operation the trunk is made instantly busy at both ends. When the line switch M establishes connection with the selector L it cuts itself off from the trunk, thus giving the calling subscriber C a clear line from the A-exchange to the A¹-exchange. By the second operation of the dial the calling subscriber operates the second-selector L, which latter operates in a similar manner to the selector F to find the connector K. The said connector now, as is usually the case, responds to the last two operations of the calling subscriber's dial, and in this manner the calling and called subscribers are placed in connection. After the connection is established, and as soon as the calling subscriber hangs up his receiver, all of the switches are restored. It will be be seen that when a call passes from the A¹-exchange to the A-exchange, as, for example, when the subscriber J calls the subscriber C, the order of operation is exactly reversed. First the line switch D¹ operates to connect with the selector F¹ which in turn responds to the first operation of the dial at the station J and finds the two-way trunk H. As soon as the connection is established with the said trunk the line switch M is cut off from the trunk, while the line switch I is caused to operate to establish connection with a suitable switch similar to the selector L, Fig. 2, and from there on the operation of this selector and of the connector following is the same as in the previous instance explained. It should be stated here that whether the selector F at the A-exchange is operated to establish connection with the trunk H electrically as when the subscriber C is calling, or mechanically as when an exchange attendant manipulates the selector F, the non-numerical switch I is cut off and the non-numerical switch M is operated just the same. After the switches I and L have been thus once operated they are automatically restored when the selector F is disconnected from the trunk, whether this operation is done electrically as by the calling subscriber C, or mechanically as by the exchange attendant by manual operation. In other words, the restoration of the switches I and M is

dependent upon the simple fact of whether or not the selector F is connected with the trunk or not. Of course, the same is true with regard to the selector F^1 at the A^1-exchange.

Having thus outlined the general mode of operation, a more detailed description will now be given as follows: The subscribers' instruments, the subscribers' line switches, the master switches for controlling these subscribers' line switches, the first-selectors, the second-selectors and the connectors are of the type shown and described in the *Western Electrician* of January 11, 18 and 25, 1908, and also described in English Patent No. 26,301 of 1906. More specifically, however, the telephone is provided with the usual transmitter 2, induction-coil 3, receiver 4, switch-hook 5 and ringer 6. In addition, it is provided with the usual calling mechanism comprising the impulse wheel 7 having on its periphery the impulse teeth 8 for operating the impulse springs 9 and 10. The said impulse wheel 7 is, of course, mounted on the same shaft 11 as the dial, being rigid with the same. Normally—that is, when the switch-hook is down—the bell 6 is bridged across the line conductors 12 and 13 through the condenser 14. For releasing purposes the telephone is also provided with the release springs 15, 16 and 17, the spring 15 being connected with the so-called ground post 18 which is normally disconnected from the ground spring 19. The connection between the springs 18 and 19, however, is made whenever the dial is moved, thereby supplying ground not only for releasing purposes but for calling purposes as well.

The line switch D comprises a trip magnet 20, a release magnet 21 and a bridge-cut-off relay 22. The trip magnet 20 is designed to operate the usual plunger for pressing the bank springs 23 and 24, 25 and 26, 27 and 28, and 29 and 30 into contact. This plunger may be arranged as shown in the *Western Electrician* publications previously mentioned, so that when in normal position it is under the control of the master switch E, whereby the said plunger may always be removed from opposite a busy trunk to a position opposite an idle trunk. The said master switch E is provided with a motor magnet relay 31, a motor magnet 32, an auxiliary relay 33 for opening the circuit of all trip magnets 20 of a group while the master switch is operating over the master switch bank *n*, and with an operating wheel O directly connected with the shaft through the medium of which the plungers are controlled.

The selector switch F, which is of the type shown in United States Letters Patent No. 815,321, issued March 13, 1906, to Keith, Erickson & Erickson, is provided with the usual vertical line relay 34, rotary line relay 35, vertical magnet 36, rotary magnet 37, release magnet 38, private magnet 39 and back-release relay 40. The selector F^1 (Fig. 3) is provided with exactly the same magnets, namely the vertical line relay 41, rotary line relay 42, vertical magnet 43, rotary magnet 44, release magnet 45, private magnet 46 and back-release relay 47. The selector switch L is likewise provided with the vertical line relay 48, rotary line relay 49, vertical magnet 50, rotary magnet 51, release magnet 52, private magnet 53 and back-release relay 54.

The connector switch K, which is of the same general character as the connector switch shown in United States Letters Patent No. 815,176, issued March 13, 1906, to Keith, Erickson & Erickson, is provided with a vertical line relay 55, rotary line relay 56, vertical magnet 57, rotary magnet 58, release magnet 59, private magnet 60, ringer relay 61, front-bridge double-wound relay 62, and back-bridge double-wound relay 63. The line switch D^1 of the called line being the same as the line switch D and being likewise represented, the magnets 64, 65 and 66 are, respectively, the trip and release magnets and the bridge-cut-off relay. It will be understood, of course, that this line switch, together with other line switches of the same group, are controlled by a master switch the same as the master switch E.

At the A-exchange there is allotted to the two-way trunk H, in addition to the non-numerical switch I, a set of auxiliary back-release relays 67 and 68 for controlling the release of the switches that have established connection with the trunk. These relays will be referred to as the vertical auxiliary back-release relay 67 and the rotary auxiliary back-release relay 68. In addition, there is provided the relay 69 for controlling the release of the apparatus at the A^1-exchange, which will be referred to as the forward release relay. There are also provided two additional relays 70 and 71, the former 70 for removing ground from the plunger-operating winding 72 of the non-numerical trunk switch I and supplying operating current to the bridge-cut-off winding 73 of the said trunk switch when a call is being sent from the A-exchange to the A^1-exchange, and the latter 71 for breaking the energizing circuit of the relay 70 and for supplying guarding potential at the private bank contact 74 of the selector switch F at the A-exchange and all multiples of the said contact 74 when a call comes from the A^1-exchange to the A-exchange. The resistance 75 shown in the release circuit controlled by the auxiliary back-release relays 67 and 68 is to control the flow of current through the low-wound back-release relay 40 of the selector F. The non-numerical

trunk switch I is provided with a magnet 76 having three windings, namely the windings 72, 73 and 77, two auxiliary armatures 78 and 79 and the plunger armature 80. These various armatures control the springs 81, 82, 83, 84, 85, 86, 87 and 88 in the manner hereinafter fully described. The magnetic circuit of the winding 77 is made separate from that of the windings 72 and 73 by the lateral projection on the core, by means of which the magnet 76 is attached to the bracket 76ª. Although the arm 80 is included in the magnetic circuit of the winding 73, as well as that of the winding 72, the winding 73 is not strong enough to attract the arm 80 from its normal position, but has sufficient strength to maintain said arm in its operated position after it has been drawn down by the winding 72. The armature 79 may be operated by either the winding 72 or the winding 73. The two-way trunk H is also provided at the A-exchange with an addditional auxiliary relay 89 for opening the rotary side of the trunk and sending an impulse over the rotary side of the trunk to the A¹-exchange when a call is going from the A-exchange to the A¹-exchange. Since the apparatus allotted to the trunk H at the A¹-exchange is an exact duplicate of that allotted to the said trunk at the A-exchange, it will be observed that the relays 67, 68, 69, 70, 71, 76 and 89 are duplicated by the corresponding relays 90, 91, 92, 93, 94, 95 and 96. Similarly the resistance 75 at the A-exchange is duplicated by the resistance 97 and the trunk-release circuit controlled by the auxiliary back-release relays 90 and 91, the windings 72, 73 and 77 of the non-numerical switch I are duplicated by the windings 98, 99 and 100 in the non-numerical switch M; likewise the springs 81 to 88, inclusive, in the switch I perform similar functions as the springs 101 to 108, inclusive, while the armatures 78, 79 and 80 perform functions similar to the armatures 109, 110 and 111 of the line switch M. It should be understood that the non-numerical switches I at the A-exchange are controlled by a master switch just as the non-numerical switches M at the A¹-exchange are controlled by the master switch E¹. This master switch is provided with a motor relay 112, motor magnet 113, the auxiliary relay 114 for preventing any of the line switches M from operating while the master switch E¹ is operating, and in addition the relays 115 and 116, the uses of which will become apparent in the course of the detailed description. It will be seen that the relay 115 is connected to the magnet 95 of the line switch M at a point between the windings 99 and 100. In like manner the magnet 76 of the line switch I is connected to a relay similar to the relay 115 at a point between the windings 73 and 77. It will also be seen that the winding 98 of the magnet 95 is connected to the top spring of the relay 115. In like manner the winding 72 of the magnet 76 is connected to a similar spring at the A-exchange.

Having thus pointed out the details of the apparatus, the circuits and operations will now be more easily understood. Assuming that the number of the subscriber J is #2220, the subscriber C proceeds to operate his dial in accordance with the digit 2, after having removed his receiver. In thus rotating the dial he first causes the springs 18 and 19 to come into contact, thus supplying operating current for the impulse springs 9 and 10. Upon advancing from normal position the dial carries the rotary spring 9 into engagement with the ground post 18, thereby energizing the trip magnet 20 of the line switch D by a flow of current from ground G¹ at the telephone C over the rotary conductor 13, and through the trip magnet 20 to battery lead 117, thence through battery B to ground G. By attracting its armature the trip magnet 20 unlocks the plunger which is resting opposite an idle trunk, assumed in this case to be the trunk running to the switch F, which plunger then presses the springs 23 and 24, the springs 25 and 26, the springs 27 and 28, and the springs 29 and 30 into contact as shown. It will be seen, of course, that the engagement of the springs 23 and 24 on one side, and the engagement of the springs 29 and 30 on the other, extends the calling subscriber's line to the switch F. It will also be seen that the closure of contact between the springs 27 and 28 supplies ground to the private normal conductor 118 for making the calling line busy to any subscriber who may wish to call the subscriber C. This same ground, it will be seen, supplies current for energizing the private cut-off relay 22, which thereupon energizes and connects the vertical line conductor 12 with the vertical normal conductor 119, at the same time disconnecting the trip magnet 20 from the line. The plunger being in the nature of a disconnector has no tendency to return to normal position after having once been operated. It is not necessary to maintain the trip magnet 20 energized. It will be noted that the closure of contact between the springs 25 and 26 establishes a non-grounded potential at the first contact of the master switch bank *n* by way of the conductor 120 and through the release or restoring magnet 21. This guarding potential serves to drive the master switch from opposite the trunk running to the switch F, and also prevents the master switch from ever stopping on this trunk again as long as this guarding potential is maintained at the said point, designated as 121. The master switch is driven on because the motor relay 31 is ener-

gized, which relay, by pressing the springs 122 and 123 into contact, closes an energizing circuit through the motor magnet 32. This motor magnet 32 energizes a number of times and thereby rotates all plungers in normal position opposite the next trunk. The energizing circuit for the magnet 32 is maintained by the springs 124 and 125 being brought into contact at the first impulse of the magnet 32, but these two springs 124 and 125 are separated as soon as the master switch reaches the next trunk, and, of course, since the master switch bank wiper 126 has left the contact 121, the energizing circuit for the motor relay 31 is broken, thus bringing the master switch to a standstill. It will be seen, however, that if the next trunk is busy the contact 127 will also have a guarding potential just as the contact 121 has a guarding potential, and the master switch will be advanced to the next step and so on until an idle trunk is found.

It will be seen that in multiple with the motor magnet 32 the slow-acting relay 33 energizes and opens the connection between all trip magnets 20 and the battery B of the group of line switches D controlled by the master switch E. The object of this arrangement is to prevent any subscriber from tripping into a busy trunk while the master switch E is passing over such busy trunks. Having thus extended connection to the switch F and caused the master switch to drive all other line switches D from opposite the trunk of the said switch F by the time that the subscriber is ready to let the dial run back, the impulses which are transmitted by the dial on its return motion are then taken up by the switch F for carrying that switch to a given level (in this case the second level), and then causing it to automatically pick out the first trunk H that is idle. As the dial returns toward normal, the rotary spring 9 having in the meantime disengaged from the spring 18, the vertical impulse spring 10 is pressed onto the spring 18 twice, thereby sending two impulses over the vertical line conductor 12, and through the vertical line relay 34 of the switch F to battery B and to ground G. After these vertical impulses have been sent in the rotary spring 9 is again pressed onto the ground spring 18 once, thereby sending another impulse over the rotary conductor 13, which now operates the rotary line relay 35 once. The vertical line relay 34, upon energizing twice, in turn closes the energizing circuit of the vertical magnet 36 twice from ground G^3 through the said vertical magnet to battery B. By this operation the shaft and wipers of the switch F are raised opposite the first contact of the second level, thereto remain until the rotary impulse comes in. The rotary line relay 35, in response to the rotary impulse, then closes an energizing circuit for the private magnet 39 from ground G^3 through the said private magnet to battery B. This private magnet, upon energizing and deënergizing, trips the side switch to second position, thereby carrying the side switch wipers 128, 129, 130 and 131 to second position. By this operation the side switch wiper 131 is carried into connection with ground G^4, thereby closing the energizing circuit of the rotary magnet 37. The rotary magnet, upon energizing, rotates the shaft and wipers into engagement with the first trunk, and at the same time depresses the armature of the private magnet, thereby placing the side switch in readiness to pass to third position as soon as the armature of the private magnet is permitted to return to normal. This will, of course, occur if the first trunk is idle, because as the rotary armature falls back there is nothing to hold the private armature depressed. But if the first trunk is busy the private wiper 132 will find the private contact 74 grounded, thereby energizing the private magnet 39 and retaining the said private magnet energized as long as the private wiper 132 continues to find guarded contacts. The energizing circuit for the private magnet in this case is from ground, as, for example, from ground G^5 at the relay 71 to the private contact 74, private wiper 132, back-release relay 40 (which is low-wound), side switch wiper 130 in second position, and private magnet 39 to battery B. The side switch being thus retained in second position, the energizing circuit for the rotary magnet 37 is thus prolonged until an idle trunk is found, at which time the private magnet armature, upon falling back, permits the side switch to pass to third position, thereby cutting the subscriber's line through to the trunk H by way of the side switch wipers 128 and 129 in third position and the shaft wipers 133 and 134. It will be seen, furthermore, that as soon as the side switch passes to third position the side switch wiper 130 supplies ground from ground G^6 to the private wiper 132, and thereby causes the energization of the relay 70 and of the relay 89. The relay 89, it will be seen, energizes because the springs 83 and 84 of the non-numerical switch I are in contact. The energizing circuit for the relay 70 is as follows: from ground G^8 to the private wiper 132, conductor 135, relay 70, springs 136 and 137 of the relay 71 to battery B. The energizing circuit of the relay 89 is as follows: from the same ground G^8 to the same conductor 135, thence to the conductor 138, through the springs 83 and 84 of the switch I and through the relay 89 to battery B. The relay 70, upon energizing, energizes the winding 73 of the switch I by a flow of current from ground

G^7 at the relay 70, through the springs 139 and 140, conductor 141 and through the winding 73 to battery. The winding 73, upon energizing, attracts the armature 79, which thereupon disconnects the springs 81 and 82 and the springs 83 and 84, and carries the springs 85 and 86 into contact. The separation of the springs 81 and 82 disconnects the line winding 77 from the rotary conductor 142, thus leaving the trunk clear.

The closure of contacts 85 and 86 is made preparatory for a release when the switch F is disconnected from the trunk, and the springs 83 and 84 are separated for breaking the energizing circuit of the relay 89. It therefore follows that the relay 89 is only energized for a moment, with the result that the spring 143 is carried into engagement with the spring 144, while disconnected from the spring 145. The engagement of the springs 143 and 144 sends an impulse over the conductor 146 for tripping the non-numerical switch M by a flow of current from ground G^8 over the conductor 146, conductor 147, through the springs 102 and 101 of the switch M, through the line winding 100, relay 115, springs 148 and 149, springs 150 and 151 to battery lead 152, and through the battery B^1 to ground G^1. When the line winding 100 energizes, the armature 109 is attracted and the springs 108 and 107 are carried into contact, thereby closing an energizing circuit for the trip winding 98, since the same circuit that energizes the winding 100 also energizes the slow-acting relay 115, whereby the springs 153, 154 and 155 are pressed into contact. The energizing circuit for the trip winding 98 therefore is as follows: from ground G^9 at the relay 93 of the A^1-exchange through the springs 156 and 157 to the conductor 158, through the springs 107 and 108, winding 98, springs 153, 154 and 155, conductor 159, springs 150 and 151 to the battery lead 152, and through battery B^1 to ground G^1. It will be seen that the relay 115 not only closes the energizing circuit for the trip winding 98, but it also closes an energizing circuit for the auxiliary slow-acting relay 116. The said relay 116, upon energizing, operates the springs 148 and 149, and thus destroys the energizing circuit for the relays 115 and 100. The relay 89, like its corresponding relay 96, is herein shown slow in order that the length of the impulse that energizes the relays 100 and 115 may be controlled; but the impulse of these relays may, of course, be made of any desired length. This is also true of the relays 114, 115 and 116. As soon as the relay 115 deënergizes, the energizing circuits for the relay 116 and for the trip winding 98 is broken, but in the meantime the winding 98 has had opportunity to attract the armature 111 and thus press the bank springs 160 and 161, the springs 162 and 163, the springs 164 and 165, and also the springs 166 and 167 into contact. Of course, the closure of contact between the springs 160 and 161 on one side, and 166 and 167 on the other, extends the calling subscriber's line over the trunk H to the second-selector switch L. At the same time the closure of contact between the springs 162 and 163 closes a locking circuit through the bridge-cut-off winding 99 of the switch M as follows: from ground G^{19} at the second-selector L through the contacts of the release magnet 52, through the springs 163 and 162, conductor 168, relay 94, conductor 169, bridge-cut-off winding 99 and through the battery lead 152. The non-numerical switch M, unlike the line switch D, must hold its armature down or it will return to normal, and for this reason it is necessary to energize the bridge-cut-off winding 99; but since it requires very little force to hold the plunger down after it is once down, the winding 99 is made of high resistance—in fact high enough to prevent the relay 115 from energizing in series therewith. Of course, when the armature 111 is attracted, then the armature 110 is depressed and the springs 106 and 105 are held in contact, but the springs 104 and 103 are separated, as well as the springs 102 and 101. It will be seen that as soon as the springs 164 and 165 close in contact a guarding potential is established from battery B^1 through the resistance coil 169 to the master switch bank contact 170 for the purpose of driving the master switch from opposite the trunk line representing the switch L. The action of the master switch E^1 is the same as the action of the master switch E. The motor relay closes the energizing circuit for the motor magnet 113 which then, by operating the first step, closes its own circuit through springs 171 and 172 to insure the maintenance of its own circuit until the master switch has arrived opposite the next trunk. From the previous description it will be seen that the locking circuit for the bridge-cut-off winding 99 of the switch M contains the relay 94. This relay 94 energizes, together with the winding 99, and, upon energizing, operates the springs 173 and 174 for breaking the circuit of the relay 93; and at the same time the relay 94, by pressing the springs 175 and 176 into contact, supplies guarding potential at the private bank contact 177 of the switch F^1 and to all multiples thereof in order to make the trunk H busy to the exchange A^1.

The connection between the calling subscriber and the switch L having been thus completed by the stopping of the switch F (Fig. 1) on the trunk H, the circuits are now prepared to receive the impulses cor-

responding to the second digit 2, which the subscriber sends in by operating his dial a second time. Upon operating the dial for the second digit 2 two impulses are transmitted to the vertical conductor 12, and one impulse to the rotary conductor 13. It should be stated that the preliminary impulse which is now sent in over the rotary line conductor 13 is received at the selector L, but is wasted for the reason that operating the rotary line relay of either of the selectors or of the connector while the shaft is in normal position does not operate to change the condition of these switches. The vertical impulses that are sent in by the subscriber upon the operation of his dial for the second digit operates the vertical line relay 48, which in turn operates the vertical magnet 50 to raise the shaft and wipers to the proper level, in this case the second level. As in the selector F the shaft remains in this position until the rotary impulse is sent in, at which time the rotary line relay 49 is energized, which relay in turn operates the private magnet 53, causing the side switch to trip to second position, thereby closing the energizing circuit of the rotary magnet 51, thus bringing about the conditions which cause the selector L, as the selector F, to automatically rotate until an idle trunk is found. In this case the trunk found is represented as being the trunk terminating in the connector switch K. Of course, as soon as the selector switch L stops on the trunk that terminates in the connector switch K, the side switch passes to third position, and guarding potential is set up as the private wiper 178 from ground G^{10}, while the line circuit is extended through the side switch wiper 179, and the line wiper 180 on one side, and through the side switch wiper 181 and the line wiper 182 on the other. The connection having thus been extended, the subscriber again operates his dial in accordance with the third or tens digit 2. The vertical impulses operate to energize the vertical line relay 55, thereby in turn energizing the vertical magnet 57 from ground G^{11}, and raising the connector switch shaft two steps to a point opposite the first contact of the second level. The rotary impulse—that is, the impulse to the rotary line conductor 13—which follows then operates the rotary line relay 56, which relay in turn energizes the private magnet 60 by a flow of current from ground G^{11} through the private magnet 60, and through the springs 183 and 184 to the battery lead 152, thence to battery B^1 and to ground G^1. By this operation of the private magnet 60 the side switch is allowed to pass to second position, whereby the rotary magnet 58 is put under the control of the vertical line relay 55 in place of the vertical magnet 57. Therefore, when the subscriber operates his dial for the last digit 0 the ten vertical impulses to the vertical line conductor 12 energize the vertical line relay 55 ten times, whereby the rotary magnet 58 is energized ten times, and the shaft and shaft wipers are so rotated that the wipers engage the terminals 185, 186 and 187 of the switch D^1 of the called line. The rotary impulse that follows energizes the rotary line relay 56, which in turn energizes the private magnet 60 as before, thereby tripping the side switch to third position.

In the third position the side switch wiper 188, by closing the circuit to ground G^{21}, establishes a guarding potential at the private normal 187 of the called line so as to make the called line busy. At the same time the line circuit is extended from the calling telephone through the side switch wiper 189 and line shaft wiper 190 on one side, and through the side switch wiper 191 and the line shaft wiper 192 on the other side, to the line conductors 193 and 194 of the called line. After the side switch has passed to third position the calling subscriber presses his signaling button 195, thereby grounding the vertical line conductor 12 and thus energizing the vertical line relay 55 and the differential relay 62. As a result the ringer relay 61 is energized from ground G^{11} through the side switch wiper 196, ringer relay 61, and through the differential relay springs 197 and 198 to the battery lead 152, thence through battery B^1 to ground G^1. The ringer relay 61, upon energizing, throws the ringer generator 185 across the called subscriber's line, thereby signaling the said subscriber whose bell is across the line as long as his receiver is on the hook. As soon as the called subscriber removes his receiver from the hook he throws his transmitter across the line conductors 193 and 194 in place of the ringer. As a result, a circuit is established through the transmitter 186 of the called telephone, which circuit includes the windings of the back-bridge double-wound relay 63. This circuit may be traced from ground G^{21} at the connector through the side switch wiper 188, through the winding 187^a of the coil 63 to one side of the called line 194, thence through the transmitter to the other side of the line 193, back through the other winding 188^a of the coil 63, through the springs 189 and 198 to the battery lead 152, thence to battery B^1. The relay 63 therefore energizes, thereby shifting the spring 183 from the non-grounded battery spring 184 to the grounded battery spring 190, thus supplying talking battery current to the calling telephone line. The flow of current is as follows: from ground G^{21} through the springs 190 and 183, through one winding of relay 62 and the rotary line relay 56 to the calling telephone and back on the other side, through the vertical line relay

55 and the other winding of relay 62 to battery B′ and to ground G′. It will be seen that the guarding potential that protects the called line at the same time energizes the bridge-cut-off relay 66, which relay, upon thus energizing, disconnects the trip magnet 64 from the line and at the same time cuts the vertical normal conductor 185 through to the vertical line conductor 193. After the subscribers are through talking, if the calling subscriber hangs up his receiver first he presses the release springs 15, 16 and 17 together, thereby grounding both sides of the line at the same time, thus energizing the auxiliary back-release relays 67 and 68 (Fig. 1) at the same time, and also the connector line relays 55 and 56 and the differential relay 62. The energizing of the relays 67 and 68 at the same time presses the springs 199 and 200 into contact, thereby closing an energizing circuit for the back-release relay 40 of the selector F, which in turn, upon energizing closes an energizing circuit for the release magnet 38 by pressing the springs 201 and 202 into contact. The release magnet 38 in turn closes an energizing circuit for the line switch release magnet 21, which latter withdraws the plunger from the bank. In this way the selector switch F and the line switch D are restored, and a similar energization of the connector line relays 55 and 56 and of the double-wound coil 62 closes an energizing circuit for the release magnet 59 of the connector in series with the back-release relay 54 of the second-selector L. This energizing circuit may be traced from ground G^{10} at the second selector L through the back-release relay 54, springs 203 and 204, release magnet 59, springs 197 and 198 to the battery lead 152, and through battery B^1 to ground G^1. The connector switch is thus released, whereby the line switch D^1 of the called station is likewise released. The second-selector back-release relay 54, upon energizing, closes an energizing circuit for the release magnet 52, whereby the selector L is released, while the release magnet 52, upon energizing, breaks the locking circuit through the winding 99 of the switch M, thus restoring the switch M to normal and at the same time restoring the relay 94 (Fig. 3).

It will be seen that when the selector F (Fig. 1) leaves the trunk H, the energizing circuit for the relay 70 is broken, and therefore the energizing circuit for the bridge-cut-off winding 73 of the trunk switch I is broken, whereby the armature 79 is allowed to return to normal, and in this manner the central office apparatus is completely restored. It will be seen that if the called subscriber had hung up before the calling subscriber, the connection would not have been released until the calling subscriber had hung up, the only difference in the condition being that if the calling subscriber had hung up first he would have had to release while there was battery in the talking circuit, as explained, which battery is cut off as soon as the double-wound coil 62 at the connector energizes, since as soon as this coil energizes the circuit of the back-bridge coil 63 is broken. It will be seen that if the called subscriber had been busy when the connector K attempted to pass the side switch to third position by energizing the rotary line relay 56, instead of the connection being established the connector switch would have been released as follows: The side switch being in second position and there being ground at the normal conductor 187, an energizing circuit would have been established through the release magnet 59 at the instant that the private magnet 60 was energized. This energizing circuit may be traced as follows: from ground at the conductor 187 through the side switch wiper 188 in second position, through the top pair of the private magnet springs, through the release magnet 59, and through the springs 197 and 198 of the coil 62 to the battery lead 152. It will be seen, of course, that at the time the rotary line relay 56 is being energized the coil 62 is at the same time energized, and that therefore the springs 198 and 197 are in contact. The connector having thus been released, then when the subscriber attempts to signal by pressing his button 195, instead of ringing the called subscriber as he intends, he energizes the vertical line relay 55, which raises the connector switch shaft and closes the busy-signaling circuit to the calling line by pressing the contacts 205 and 206 together. It will be seen that if the subscriber J had wished to call the subscriber C the connection would have been made by first operating the line switch D^1 (Fig. 3), thereby establishing connection with some first-selector such as the first-selector F^1, which in turn would have been operated to select the trunk H, thereby tripping the switch I at the A-exchange, and thus establishing connection with a second-selector such as the second-selector L, through which a connector such as the connector K would be reached, and through the medium of which final connection with the desired subscriber would be established in the same manner as heretofore described. In an exchange of this character it becomes necessary that the switches such as the selector F (Fig. 1) should be inspected and tested out, and in the course of these operations the switches F may be operated manually and caused to stop on a trunk H. The effect of this operation, it will at once be seen, is that the trunk switch M at the exchange A^1 is operated, and it therefore becomes important that as soon as the switch

F is removed from the trunk manually the trunk and its switches will be automatically restored to normal. This is in fact what will occur. As soon as the switch F is forcefully removed from the trunk the ground is, of course, removed from the private contact 74, with the result that the relay 70 is de-energized. The relay 70, upon permitting its armature to fall back, allows the spring 139 to pass into engagement with the contact 207 before it leaves the contact 140. As soon as connection is established with the contact 207 the forward release relay 69 is energized over the following circuit: from ground G^7 through the springs 139 and 207, conductor 208, through the trunk switch springs 85 and 86, conductor 209, relay 69, through the springs 136 and 137 to battery B and to ground G. As a result, the conductors 142 and 210 are grounded, thereby energizing the line relays 48 and 49 of the selector L. These relays 48 and 49, upon energizing, press the springs 211, 212 and 213 into contact, thereby energizing the private magnet 53, which latter, by pressing the springs 214 and 215 into contact, closes an energizing circuit through the release magnet 252 by way of the springs 212 and 211. The release magnet 52, of course, separates the springs 216 and 217, thereby unlocking the trunk switch M and restoring the same. Of course, as soon as the relay 70 falls back sufficiently to separate the springs 139 and 140, the energizing circuit of the bridge-cut-off winding 73 of the switch I is broken, and the armature 79 permitted to return to normal.

From the foregoing it will be seen that by my invention I provide a two-way trunk for use in connection with a three-wire system, whereby two-way trunking is accomplished without the danger of a trunk being made busy when one of the seizing switches stops on the trunk, and left busy after the seizing switch is disconnected from the trunk in some manner otherwise than electrically. Furthermore, with my improved two-way trunk arrangement the switches can be inspected and tested at the exchange by manually causing a switch to receive one of the two-way trunk lines, and at the same time automatically making the trunk busy at both ends. And to this, of course, is added the feature already explained, namely that when the exchange inspector releases the switch he is testing (in a mechanical manner)—that is, by forcefully and mechanically releasing the same—there is then no danger of the other end of the trunk being left in a busy condition: and consequently the switches can be freely tested without danger of leaving the two-way trunk in a busy condition, as has heretofore been the case in certain kinds of apparatus.

My invention, it will be seen, relates to automatic telephone systems in which are used switches of the general character disclosed in United States Letters Patent Nos. 815,176 and 815,321, granted March 13, 1906, to Keith, Erickson & Erickson, British Patent No. 26,301 of 1906, the *Western Electrician* of Chicago, Illinois, of January 25, 1908, and in the *American Telephone Journal* of New York, N. Y., of June 6, 1908.

What I claim as my invention is:—

1. In a telephone system, a two-way trunk line, a non-numerical switch for each end of the trunk line, a switch for seizing the trunk at one end, means whereby the non-numerical switch at the other end is then automatically and at once operated to make connection with another line, and whereby the non-numerical switch at the one end of the trunk line is automatically cut off, and means for sending impulses over one side only and subsequently over the other side of the trunk for operating purposes.

2. In a telephone system, a two-way trunk line, a non-numerical switch for each end of the trunk, a switch for seizing the trunk at one end, means whereby the non-numerical switch at the other end is operated to automatically set up a connection with another line when the trunk is thus seized, and whereby the non-numerical switch at the one end of the trunk line is automatically cut off, and the trunk is made busy at both ends as soon as seized, and means for sending impulses over either one of the trunk conductors separately.

3. In a telephone system, a two-way trunk line, a non-numerical switch for each end of the trunk line, a switch for seizing the trunk at one end, means whereby the non-numerical switch at the other end is then automatically and at once operated to make connection with another line, and whereby the non-numerical switch at the one end of the trunk line is automatically cut off, and means for sending impulses over one side only and subsequently over the other side of the trunk for operating purposes, together with means whereby, whenever the seizing switch is disconnected from the trunk in any manner, both of the non-numerical switches are automatically restored.

4. In a telephone system, a two-way trunk line, a non-numerical switch for each end of the trunk, a switch for seizing the trunk at one end, means whereby the non-numerical switch at the other end is operated to automatically set up a connection with another line when the trunk is thus seized, and whereby the non-numerical switch at the one end of the trunk line is automatically cut off, and the trunk is made busy at both ends as soon as seized, and means for sending impulses over either one of the trunk conductors separately, together with means whereby, whenever the seizing switch is dis-

connected from the trunk in any manner, both of the non-numerical switches are automatically restored.

5. In a telephone system, a trunk adapted for making connection between two exchanges or points in either direction, a non-numerical switch at each end of the trunk, a switch for seizing the trunk at one exchange, and a switch for seizing the trunk at the other exchange, means whereby, whenever the trunk is seized at either end, said non-numerical switches at both ends are disconnected from the trunk, and at the same time the non-numerical switch at the opposite end of the seizing switch is automatically operated to set up a connection with another line, and means for sending impulses over either side of the trunk separately.

6. In a telephone system, a two-way trunk line, a non-numerical switch for each end of the trunk line, a switch for seizing the trunk at one end, means whereby the non-numerical switch at the other end is then automatically and at once operated to make connection with another line, and whereby the non-numerical switch at the one end of the trunk line is automatically cut off, and means for sending impulses over one side only and subsequently over the other side of the trunk for operating purposes, in combination with means whereby two telephone subscribers may be connected together for conversational purposes over a circuit including the said trunk, and whereby battery current may be supplied to both of the subscribers for talking purposes from a source other than at the telephone.

7. In a telephone system, a two-way trunk line, a non-numerical switch for each end of the trunk, a switch for seizing the trunk at one end, means whereby the non-numerical switch at the other end is operated to automatically set up a connection with another line when the trunk is thus seized, and whereby the non-numerical switch at the one end of the trunk line is automatically cut off, and the trunk is made busy at both ends as soon as seized, and means for sending impulses over either one of the trunk conductors separately, in combination with means whereby two telephone subscribers may be connected together for conversational purposes over a circuit including the said trunk, and whereby battery current may be supplied to both of the subscribers for talking purposes from a source other than at the telephone.

8. In a telephone system, a two-way trunk line, a non-numerical switch for each end of the trunk line, a switch for seizing the trunk at one end, means whereby the non-numerical switch at the other end is then automatically and at once operated to make connection with another line, and whereby the non-numerical switch at the one end of the trunk line is automatically cut off, and means for sending impulses over one side only and subsequently over the other side of the trunk for operating purposes, together with means whereby, whenever the seizing switch is disconnected from the trunk in any manner, both of the non-numerical switches are automatically restored, in combination with means whereby two telephone subscribers may be connected together for conversational purposes over a circuit including the said trunk, and whereby battery current may be supplied to both of the subscribers for talking purposes from a source other than at the telephone.

9. In a telephone system, a two-way trunk line, a non-numerical switch for each end of the trunk, a switch for seizing the trunk at one end, means whereby the non-numerical switch at the other end is operated to automatically set up a connection with another line when the trunk is thus seized, and whereby the non-numerical switch at the one end of the trunk line is automatically cut off, and the trunk is made busy at both ends as soon as seized, and means for sending impulses over either one of the trunk conductors separately, together with means whereby, whenever the seizing switch is disconnected from the trunk in any manner, both of the non-numerical switches are automatically restored, in combination with means whereby two telephone subscribers may be connected together for conversational purposes over a circuit including the said trunk, and whereby battery current may be supplied to both of the subscribers for talking purposes from a source other than at the telephone.

10. In a telephone system, a trunk adapted for connection between two exchanges or points in either direction, a non-numerical switch at each end of the trunk, a switch for seizing the trunk at one exchange, a switch for seizing the trunk at the other exchange, and means whereby, whenever the trunk is seized at either end, said non-numerical switches at both ends are disconnected from the trunk, and at the same time the non-numerical switch at the opposite end of the seizing switch is automatically operated to set up a connection with another line, in combination with means whereby two telephone subscribers may be connected together for conversational purposes over a circuit including the said trunk, and whereby battery current may be supplied to both of the subscribers for talking purposes from a source other than at the telephone, and means for sending impulses over either side of the trunk separately.

11. In a telephone system, a two-way trunk line, an automatic non-numerical trunking switch for each end of said line

and individual thereto, means for conveying calling impulses over the talking conductors of said trunk separately and at different times, and for simultaneously conveying impulses, and means for talking over said conductors.

12. In a telephone system, a two-way trunk line, an automatic non-numerical trunking switch for each end of said line and individual thereto, instrumentalities operative to make either end of the line busy when the other end is seized, means for conveying calling impulses over the talking conductors of said trunk separately and at different times, and for simultaneously conveying impulses, and means for talking over said conductors.

13. In a telephone system, a two-way trunk line, a non-numerical trunking switch for each end of said line, each switch adapted to automatically extend a trunking connection from said line in the direction of the called subscriber, numerical trunking switches for seizing either end of said trunk line, and instrumentalities operative to render either end of said trunk line busy when the other end is seized, means for conveying impulses over the conductors of said trunk separately and at different times, and for simultaneously conveying impulses.

14. In a telephone system, a two-way trunk line, a non-numerical trunking switch for each end of said line and individual thereto, instrumentalities operative to make both ends of said trunk-line busy when either end thereof is seized, means for conveying calling impulses over the talking conductors of said trunk separately and at different times, and for simultaneously conveying impulses, and means for talking over said conductors.

15. In a telephone system, a two-way trunk-line, a non-numerical trunking switch for each end of said line, each switch adapted to automatically extend a trunking connection from said line in the direction of the called subscriber, numerical trunking switches for seizing either end of said trunk-line, and instrumentalities operative to render both ends of said trunk line busy when either end thereof is seized, and means for conveying impulses over the trunk conductors separately and at different times, and for simultaneously conveying impulses.

16. In a telephone system, a set of two-way trunks, a set of non-numerical trunking switches for the said trunks at one end thereof, a master switch for said set of trunking switches, another set of non-numerical switches for said trunks at the other end thereof, and another master switch for said last-mentioned set of trunking switches, means for conveying impulses over the conductors of each of said trunks separately and at different times, and for simultaneously conveying impulses.

17. In a telephone system, a two-way trunk, automatic switches for seizing either end of said trunk, having provisions for permitting an inspector to test and manually operate a switch to seize the trunk without making the other end thereof busy, means for conveying impulses over the trunk conductors separately and at different times, and for simultaneously conveying impulses.

18. In a telephone system, a two-way trunk line, an automatic switch at each end of said line for seizing the same, means for rendering said trunk line busy at both ends when said trunk is seized by a direct hand operation of either of said switches; and means for automatically removing said busy condition from the trunk when the seizing switch is disconnected from the trunk.

Signed by me at Chicago, Cook county, Illinois, this 25th day of November, 1908.

EDWARD D. FALES.

Witnesses:
J. NORBY,
C. E. TAYLOR.