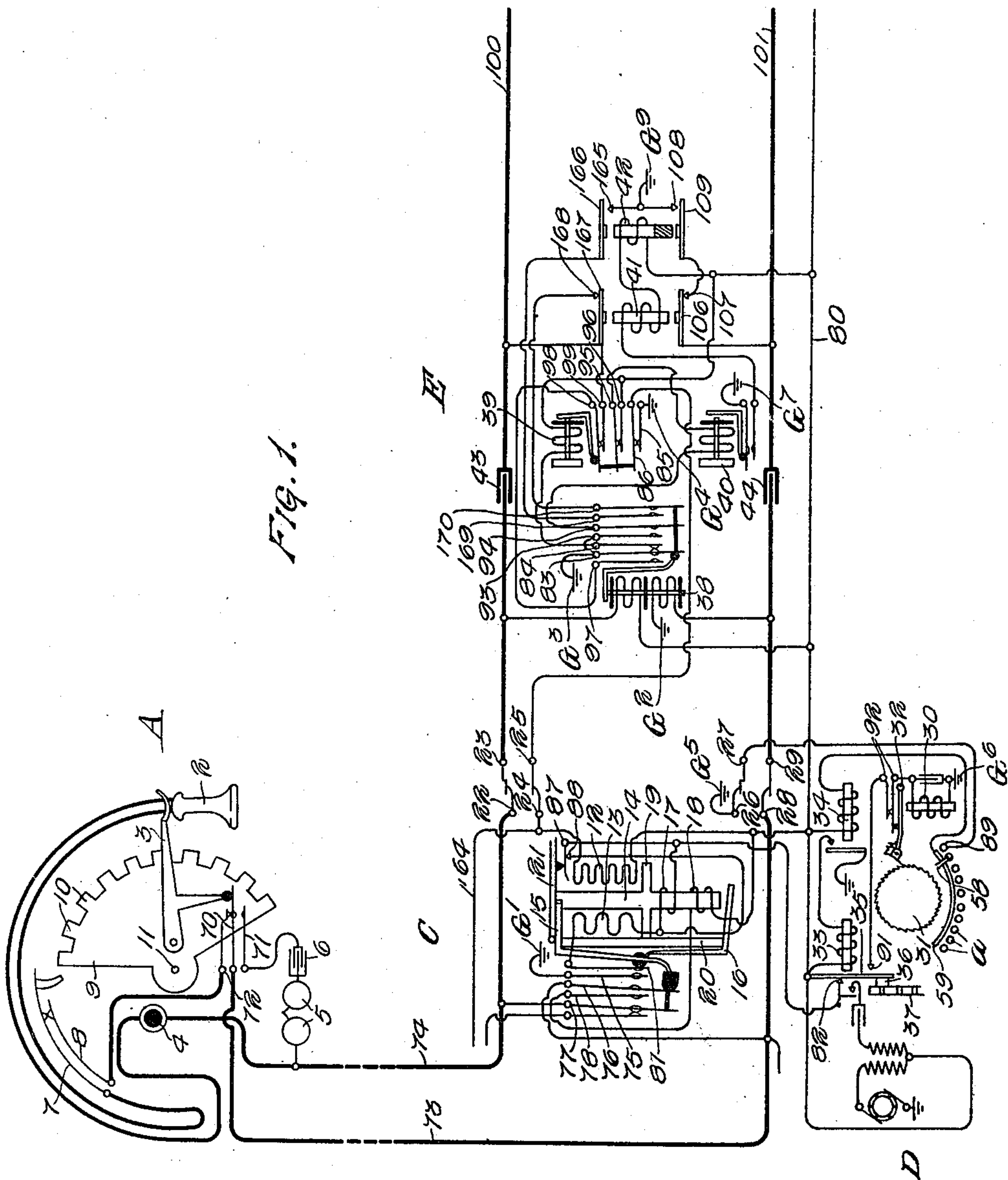


1,230,694.

E. D. FALES.
TWO-WIRE TO THREE-WIRE TELEPHONE SYSTEM.
APPLICATION FILED APR. 16, 1910.

Patented June 19, 1917.
4 SHEETS—SHEET 1.



WITNESSES
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A. J. Ray

INVENTOR:
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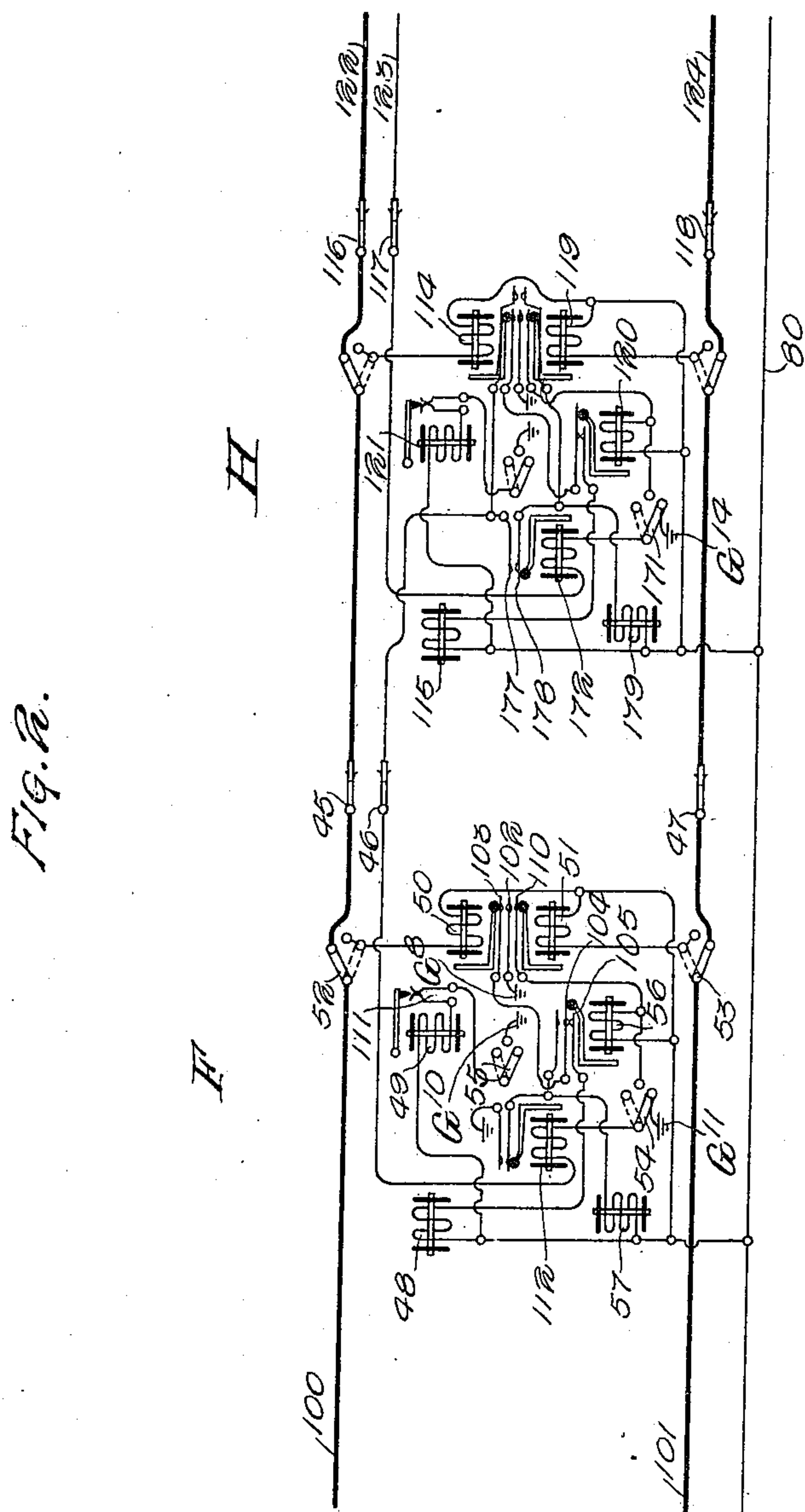
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4 SHEETS—SHEET 2.

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4 SHEETS—SHEET 3.

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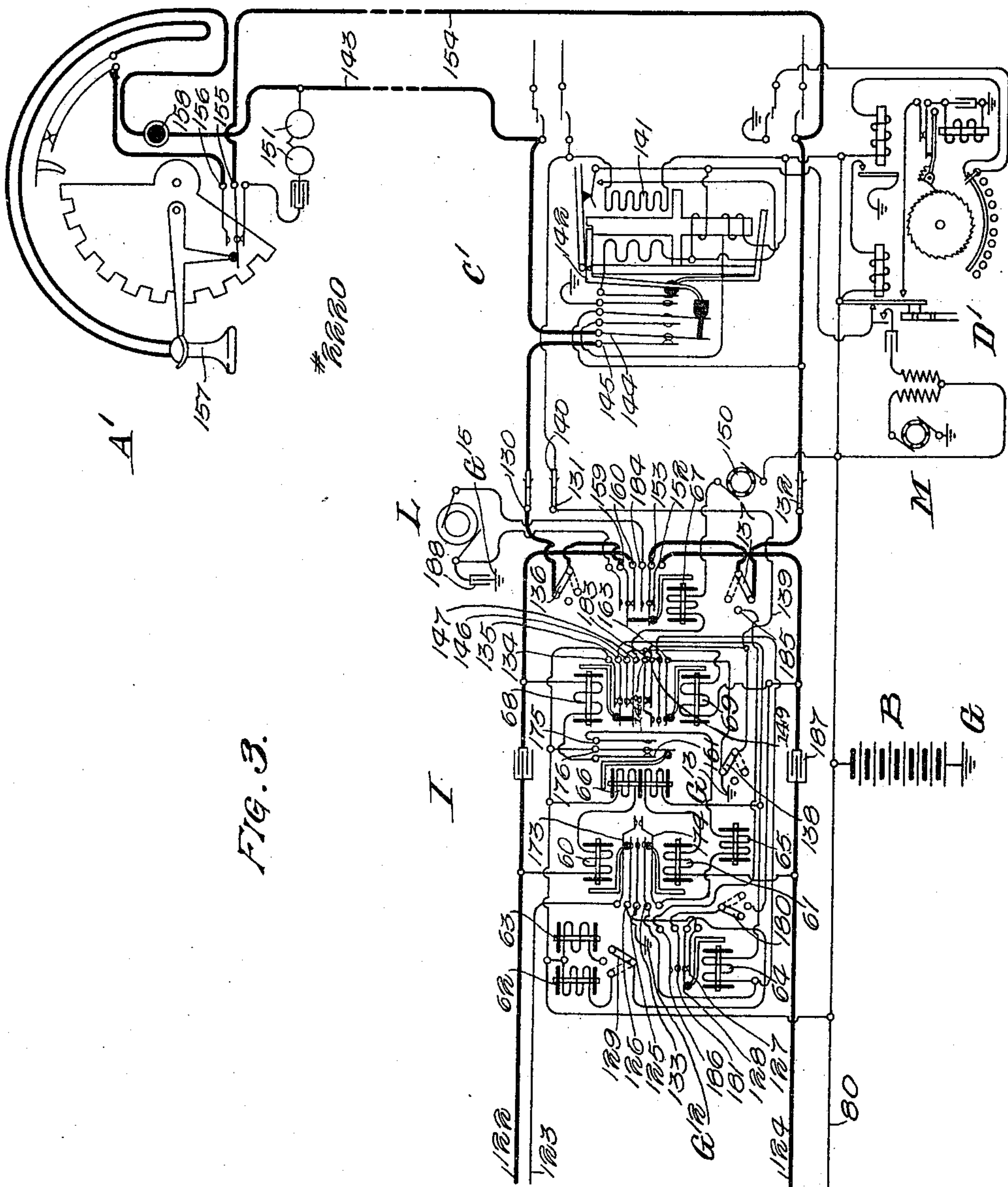


FIG. 3.

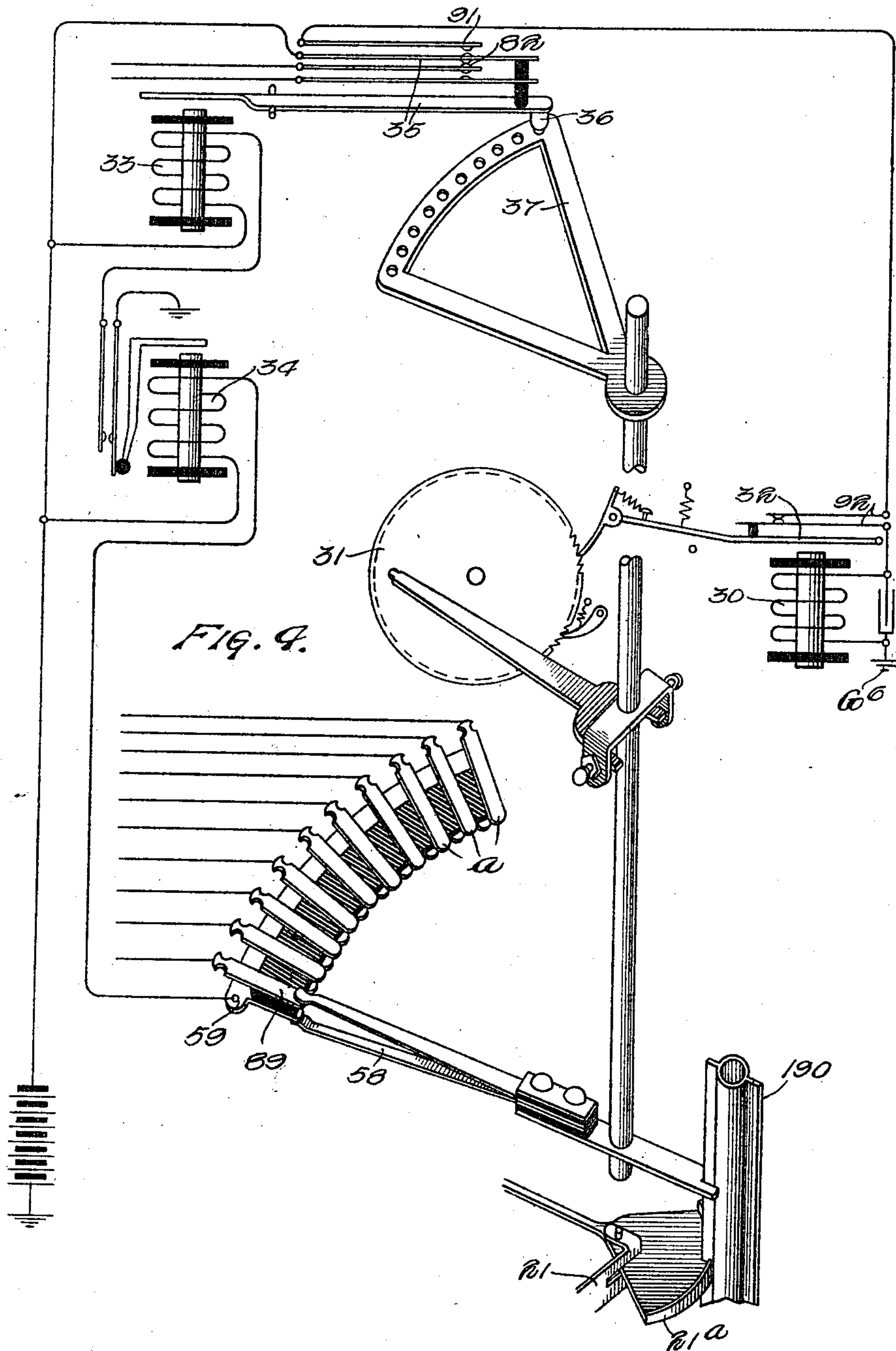
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4 SHEETS—SHEET 4.



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EDWARD D. FALES, OF LA GRANGE, ILLINOIS, ASSIGNOR TO AUTOMATIC ELECTRIC COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

TWO-WIRE TO THREE-WIRE TELEPHONE SYSTEM.

1,230,694.

Specification of Letters Patent.

Patented June 19, 1917.

Application filed April 16, 1910. Serial No. 555,890.

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 Two-Wire to Three-Wire Telephone Systems, of which the following is a specification.

My invention relates to automatic or semi-automatic telephone exchange systems of that kind in which means are provided for transmitting electrical impulses in accordance with one or more digits of the called number to extend the connection in the direction of the called subscriber.

Prior to my invention systems of this kind have been proposed and used in which the selectors and connectors, and other similar switches, have been controlled over grounded circuits—that is to say, by grounding first one side of the line and then the other at the calling substation. Systems of this kind have also been proposed and used in which no grounded operating connections are employed at the substations, and in which the selectors and connectors, and other switches, are all controlled over metallic line circuits—that is to say, over the two sides of the calling subscriber's line in series. There has also been some trunking from exchanges of the three-wire character to exchanges of the two-wire character, and vice versa, whereby calls have been extended from one type of system to the other.

My invention contemplates, however, a system in which no operating grounds are employed at the substations, but in which the switches are nevertheless controlled over grounded circuits, with the exception, perhaps, of the line switches that are individual to the subscribers' lines, whereby all electrical impulses corresponding to the first or any other digit of the called number are received by a repeater, which latter then repeats the said impulses over grounded or three-wire circuits, thus making the system two-wire outside and three-wire inside, so to speak, as will hereinafter more fully appear.

In the accompanying drawings Figures 1, 2 and 3 taken together show a complete connection between two substations A and A' in a system embodying the principles of my invention.

In Fig. 1 there is shown an automatic

substation A, a line switch C, master switch D and an impulse repeater E.

In Fig. 2 there are shown two selector switches F and H.

In Fig. 3 there is shown a connector switch I, a substation A' with its line switch C' and a master switch D'. At L there is shown a ringing current generator and at M a busy signaling machine is represented. At B there is shown a battery, having one terminal grounded, which furnishes current for operating the switches and for talking purposes.

Fig. 4 illustrates the essential features of the master switch D shown in Fig. 1.

The automatic substations A and A' may be of any suitable or approved type. As here shown, the substations are alike. Among other details the substation A comprises the usual receiver 2, switch hook 3, transmitter 4, ringer 5 and condenser 6. Since it is an automatic substation it is also provided with a pair of impulse springs 7 and 8 and an impulse wheel 9. The impulse wheel 9 is provided with the impulse teeth 10 and is secured to a shaft 11, to which there is also secured a dial (not shown) provided with finger holes by means of which it may be rotated. When the impulse wheel is rotated forward by the calling subscriber through the medium of the dial, the impulse springs are not operated; but, as the impulse wheel is returned to normal position by a spring (not shown), each of the teeth 10 that pass the end of the spring 7 forces it out of engagement with the spring 8.

The line switch C, which is individual to the line of substation A, is of the general type shown in British Patent No. 26,301 of 1906, and in the *American Telephone Journal* of New York of June 6, 1908, but is of a somewhat modified construction. The usual plunger 21^a (Fig. 4) is carried upon the end of a plunger arm 21 which is controlled by the windings 12 and 13 of the magnet 14. These windings also control the relay armature 15. At the other end of the magnet there is an armature 16 which is controlled by the windings 17 and 18. The magnetic circuit of the windings 12 and 13 is made separate from that of the windings 17 and 18 by the lateral projection 19 on the core of the magnet, by means of which the magnet is attached to the bracket 20 upon

which the armatures are pivoted. When the winding 13 is energized it operates both the plunger arm 21 and the cut-off armature 15. The winding 12 operates the armature 15. It is not strong enough to attract the plunger arm 21 from its normal position, but is strong enough to hold it in its operated position after it has once been pulled down by the winding 13. Each line switch C is also provided with a number of groups of contact springs 22, 23, 24, 25, 26, 27, 28 and 29, only one of which is shown here. Each of these groups forms the terminal of a trunk line leading to a selector switch F through a repeater E. Each trunk is common to a number of line switches. When the line switch is operated its plunger closes contact between the different pairs of springs of one of these groups to connect the subscriber's line with a trunk. The plungers of the idle line switches are adapted to engage a so-called plunger shaft 190 (Fig. 4) in a well-known manner. This plunger shaft is controlled by the master switch D in such a manner as to always keep the plungers of the idle line switches opposite the terminal of an idle trunk. As herein shown, the master switch D is of the general type disclosed in the above-mentioned British patent and *American Telephone Journal*. Among its essential features it comprises a motor magnet 30 which operates a ratchet wheel 31 through the medium of the armature 32. The circuit of the magnet 30 is controlled by the relay 33, which in turn is controlled by the relay 34. The armature 35 of the relay 33 is provided at its end with a pin 36 which normally engages some one of a number of openings in a locking plate 37 which is attached to the plunger shaft. These openings in the plate 37 are so spaced that the pin 36 can engage one of them only when the plungers that are engaged with the plunger shaft are directly opposite the terminal of a trunk line. Thus, when the master switch is once started by the energization of relay 33, the operating circuit of the motor magnet 30 can not again be broken until the plungers have reached the next trunk, even though the relay 33 be deenergized in the mean time, because the armature 35 can not fall back until the pin 36 engages an opening in the plate 37. The wiper 58 is attached to the plunger shaft and is adapted to always keep the common segment 59 in electrical contact with the individual contact *a* corresponding to the trunk before which the idle plungers are being held by the master switch.

The repeater E is adapted to receive impulses which are transmitted from the substation over the two sides of the line in series and to deliver impulses to switches over the two sides of the line separately. The repeater E comprises a double-wound line

relay 38, two slow-acting relays 39 and 40, and two release relays 41 and 42, of which the latter is slow acting. By "slow acting" I mean relays that are slow to deenergize after their circuits have been broken. This slow action may be obtained in a number of ways, preferably by adding a short-circuited winding or copper ring around one end of the magnet core. The line circuit through the repeater contains two condensers 43 and 44.

The selector switch F (Fig. 2) is of the well known type disclosed in United States Letters Patent #815,321, granted March 13, 1906, to Keith, Erickson and Erickson. Among its essential features it comprises a set of wipers 45, 46 and 47 which are carried upon a shaft having a vertical motion controlled by the vertical magnet 48 and a rotary motion controlled by the rotary magnet 49. These wipers are adapted to engage a bank of contacts from which trunk lines lead to second selectors H. The selector F is controlled by the calling subscriber through the medium of the line relays 50 and 51. The usual side switch comprising the wipers 52, 53, 54 and 55 is controlled by the private magnet 56 in a well known manner. Means for restoring the selector to normal position are provided in the release magnet 57.

The connector I is of the general type shown in United States Letters Patent #815,176, granted March 13, 1906, to Keith, Erickson and Erickson. Like the selectors F and H, the connector I is provided with two line relays 60 and 61, vertical magnet 62, rotary magnet 63, private magnet 64 and release magnet 65. In addition, the connector is provided with a double-wound relay 66, ringing relay 67 and two so-called back-bridge relays 68 and 69.

Having given a general description of the apparatus, I will now explain in detail its manner of operation by explaining how the subscriber at substation A may obtain connection with substation A', the number of which will be assumed to be 2220. When the receiver is removed from the switch hook at substation A preparatory to making a call, the spring 70 is permitted to disengage spring 71 and to engage spring 72, whereby the circuit through the ringer 5 and condenser 6 is opened and a bridge consisting of the receiver, transmitter and impulse springs is closed across the line conductors 73 and 74. The closure of this bridge completes an energizing circuit for the line winding 18 of the line switch C. This circuit extends from ground G' through springs 75 and 76, line 73, hook switch springs 70 and 72, impulse springs 8 and 7, receiver 2, transmitter 4, line 74, springs 77 and 78, and winding 18 to battery lead 80, and thence through the battery B to ground G.

The winding 18, upon energizing, attracts armature 16, which forces spring 81 into contact with spring 75, whereby a circuit is completed through the pull-in winding 13. This circuit extends from ground G' through springs 75 and 81, windings 13 and 17, contact point 82 and armature 35 to battery lead 80. The winding 13 thereupon attracts both the plunger arm 21 and cut-off armature 15. The armature 15 operates to disconnect the ground G' and winding 18 from the line conductors. The operation of the plunger arm 21 causes the line switch plunger to force springs 22, 24, 26 and 28 into engagement with springs 23, 25, 27 and 29, respectively, whereby the line connection is extended to the repeater E, and the master switch D is caused to advance the idle plungers to an idle trunk. The extending of the line connection to the repeater E causes its line relay 38 to be energized over a circuit extending from ground G^2 through the lower winding of said relay, springs 29 and 28, line 73, substation A, as previously traced, line 74, springs 22 and 23 and upper winding of relay 38 to battery lead 80. The relay 38, upon energizing, completes a circuit extending from ground G^3 through springs 83 and 84, and through relay 39 to battery lead 80. The relay 39, upon energizing, completes a circuit extending from ground G^4 through springs 85 and 86, springs 25 and 24 and winding 12 to battery lead 80. This circuit is closed before the circuit of the pull-in winding 13 is broken by the falling back of the armature 16, and thus the plunger arm 21 and armature 15 remain held in their operated positions by winding 12. To insure that the plunger arm 21 shall not fall back before the circuit of winding 12 is closed, the lower end of the magnet 14 is provided with the auxiliary winding 17, the circuit of which, it will be remembered, is closed in series with that of winding 13. Thus, in case the armature 15 operates to break the circuit of winding 18 before the plunger arm 21 entirely reaches its operated position, the armature 16 will still be held up by the winding 17 until said winding is short-circuited by the closure of contact between springs 87 and 88, which occurs just before the arm 21 reaches the limit of its travel. Since the winding 17 is short-circuited, it also deenergizes slowly, thus insuring that the winding 13 shall be energized long enough to prevent the arm 21 from falling back before winding 12 is energized.

As before stated, the operation of the line switch C starts the operation of the master switch D. This is brought about by the engagement of springs 26 and 27, whereby a circuit is closed through the relay 34. This circuit extends from ground G^5 through springs 26 and 27, contact point 89 (which

corresponds to the trunk line just seized), wiper 58, segment 59 and relay 34 to battery lead 80. The relay 34, upon energizing, closes the circuit of relay 33, which in turn attracts its armature 35, thereby unlocking the plunger shaft by withdrawing the pin 36 from the plate 37. The engagement of the armature 35 with the contact point 91 completes a circuit through the motor magnet 30. This circuit extends from ground G^6 through said magnet 30, interrupter springs 92, contact point 91 and armature 35 to battery lead 80. Since this circuit includes the interrupter springs 92, the magnet 30 operates in a manner similar to that of a buzzer to give the ratchet wheel a continuous step by step rotation as long as the armature 35 engages contact point 91. After the line switch plungers have been advanced a short distance by this operation of the master switch, the wiper 58 passes off of the contact 89, allowing the relays 34 and 33 to deenergize. The armature 35, however, cannot drop back out of engagement with contact point 91 until the next opening in the plate 37 passes under the pin 36, whereupon, if said trunk is idle, the circuit of the magnet 30 is broken and the idle plungers are brought to rest in front of the next trunk line after the one seized by the line switch C, and the wiper 58 comes to rest on the corresponding contact of the master switch bank. If this next trunk happens to be in use, however, the wiper 58 finds the corresponding contact grounded in the same way in which contact 89 was grounded, the relays 34 and 33 remain energized while the next opening in the plate 37 passes under pin 36 and the plungers are not allowed to stop in front of the busy trunk, but are carried on to an idle one.

The foregoing are the operations of the central office apparatus which follow immediately upon the removal of the receiver at the calling substation. The calling subscriber now operates his calling device for the first digit 2 by inserting his finger in the #2 finger hole of the dial, rotating it forward to the limit of its travel, and then permitting it to be returned to normal position. As the dial and impulse wheel 10 thus return to normal position, the springs 7 and 8 are twice momentarily separated, each time breaking the circuit of the line relay 38 of the repeater E. The relay 39 of the repeater, being slow-acting, does not have time to deenergize during the momentary interruption of its circuit by the deenergization of relay 38; consequently, each time the relay 38 deenergizes, a circuit is closed extending from ground G^3 through springs 93 and 94, relay 40 and springs 95 and 96 of relay 39 to battery lead 80. The relay 40 being a slow acting relay is energized by the first impulse for each digit and remains in

its energized position until after the last impulse for the digit is delivered. In its energized position, the relay 40 completes a circuit from ground G^7 through relays 41 and 42 in series to the battery lead 80. The energization of these relays is without a direct result at this time. Also, each time the relay 38 is deenergized a circuit is closed extending from ground G^8 through springs 83 and 97, 98 and 99, conductor 100, side switch wiper 52 of the selector F and relay 50 to battery lead 80. Each time the relay 50 is energized a circuit is closed through the vertical magnet 48, said circuit extending from ground G^8 through springs 102 and 103, 104 and 105 and magnet 48 to battery lead 80. Since the digit called is 2, the vertical magnet 48 receives two impulses operating to raise the shaft two steps to carry the wipers 45, 46 and 47 to a position opposite the second row or level of bank contacts. Shortly after the last impulse for the first digit is delivered by the substation, the relay 40 of the repeater E deenergizes, breaking the circuit of the relays 41 and 42. The armatures of relay 41 fall back immediately, while those of the slow-acting relay 42 remain held up for an instant. As soon as the armature 106 engages contact point 107 a circuit is closed extending from ground G^9 through contact point 108 and armature 109 of relay 42, contact point 107, armature 106, conductor 101, side switch wiper 53 of selector F and rotary relay 51 to battery lead 80. This circuit is broken as soon as the relay 42 deenergizes. The energization and deenergization of the rotary relay 51 of the selector F sends one impulse from ground G^8 through springs 102 and 110 and private magnet 56 to battery lead 80. The private magnet 56, upon energizing and deenergizing, causes the side switch to pass from first to second position in a well-known manner. The engagement of side switch wiper 55 with its second-position contact point completes a circuit from ground G^{10} through interrupter springs 111 and rotary magnet 49 to battery lead 80. Upon the completion of this circuit the rotary magnet attracts its armature, which operates to press down the armature of the private magnet 56, so as to rotate the wipers one step and to break the circuit of its own magnet at the interrupter springs 111. The rotary magnet armature thereupon falls back, and if the first trunk line of the second level is idle, the armature of the private magnet falls back also, allowing the side switch to pass to third position. If, however, the first trunk line is busy a locking circuit is closed for the private magnet 56, said circuit extending from ground through some other occupying switch (not shown) to the private bank contacts of the busy trunk, thence over wiper 46, relay 112, side

switch wiper 54 (in second position) and private magnet 56 to battery lead 80. The relay 112 has a comparatively low resistance and is not energized over this circuit, but the private magnet 56 locks the side switch in second position, causing the rotary magnet 49 to continue to rotate the wipers step by step until the wiper 46 finds a non-grounded contact indicating an idle trunk. The private magnet thereupon deenergizes and allows the side switch to pass to third position, whereby the circuit of the rotary magnet 49 is broken, the relays 50 and 51 are disconnected from the line and the connection is extended through the wipers 45 and 47 to the selector H. The trunk line leading to the selector H is protected from seizure by any other first selector by a guarding ground extending from ground G^{11} through side switch wiper 54, relay 112 and wiper 46 to the selector private bank contacts of the occupied trunk.

When the substation calling device is operated for the second digit 2 the repeater E operates in the same manner as for the first digit to send two impulses over the conductor 100, followed by one over the conductor 101. Since the connection has been extended to the selector H, this selector operates in response to these impulses to extend the connection to an idle connector I (Fig. 3). The operation of the selector H is like that of the selector F which has just been explained. First, the vertical relay 114 operates to close the circuit of the vertical magnet 115 twice, which in turn operates to raise the wipers 116, 117 and 118 two steps. The rotary relay 119 then operates to momentarily close the circuit of the private magnet 120, which causes the side switch to pass to second position. The rotary magnet 121 then automatically rotates the wipers onto the terminals of an idle trunk line, after which the side switch passes to third position.

The repeater E operates in response to the impulses for the third digit 2 in the same manner as for the two previous digits. The two impulses which it delivers to the conductor 100 pass through the selectors F and H, over conductor 122, and through relay 60 and upper winding of relay 66 of the connector I to battery lead 80. The energization of relay 66, in response to these impulses is without function. Each time the relay 60 is energized it operates to close a circuit extending from ground G^{12} through springs 125 and 126, 127 and 128, side switch wiper 129 and vertical magnet 62 to battery lead 80. The vertical magnet receives two impulses over this circuit, operating to raise the shaft wipers 130, 131 and 132 two steps. The impulses through the vertical relay 60 are followed by one through the rotary relay 61, which operates to momentarily close

the circuit of the private magnet 64. This circuit extends from ground G^{12} through springs 125 and 133, magnet 64, and springs 135 and 134 of relay 68 to battery lead 80. The energization and deenergization of the private magnet causes the side switch to pass to second position. The passage of side switch wiper 129 from first to second position transfers the connection of impulse spring 126 from the vertical magnet 62 to the rotary magnet 63.

Since the last digit is 0, the repeater E operates in response to the operation of the substation calling device to repeat ten impulses over conductor 100 and one impulse over conductor 101. The impulses over the line 100 operate the connector vertical line relay 60, as did the impulses for the previous digit. The operation of the relay 60 in response to these impulses closes the circuit of the rotary magnet 63 ten times, causing the wipers to be rotated ten steps onto the contacts of the desired line. The rotary magnet circuit is the same as that for the vertical magnet up to sideswitch wiper 129, whence it extends through magnet 63 to battery lead 80. The last impulse delivered by the repeater E passes over the rotary side of the line and through the connector rotary relay 61 over a circuit previously traced. The relay 61 operates to close the circuit of the private magnet 64 as in the previous instance, which causes the side switch to pass to third position. The arrival of the side switch wipers at third position completes the connection through the shaft wipers 130 and 132 to the called line. When the side switch wiper 138 reaches third position it completes a circuit from ground G^{13} through said wiper, conductor 139, private wiper 131, bank contact 140 and cut-off winding 141 of line switch C' to battery lead 80. The winding 141, upon energizing, attracts the armature 142, which operates to disconnect the switch C' from the called line and to extend the line conductor 143 through springs 144 and 145 to the bank contact which is engaged by the wiper 130. The engagement of side switch wiper 138 with its third-position contact point also provides a circuit for the ringing relay 67. This circuit extends from ground G^{13} through wiper 138, springs 149 and 148 of relay 69, springs 146 and 147 of relay 68, relay 67 and interrupter 150 to battery lead 80. The energization of the ringing relay 67 serves to disconnect the calling and called lines and to connect the ringing current generator L across the called line to ring the bells 151. Since the circuit of the relay 67 includes the interrupter 150, said relay is energized only intermittently so as not to ring the bells at the called substation continuously. When the receiver at substation A' is removed from the switch hook the circuit of

the bells 151 is broken and the talking circuit is bridged across the line instead. When this occurs, or as soon thereafter as the ringer relay 67 deenergizes, the called substation is provided with talking battery 70 current over a circuit extending from ground G^{13} through side switch wiper 138, springs 149 and 148, relay 69, ringing relay springs 152 and 153, side switch wiper 137, shaft wiper 132, line 154, hook switch springs 155 and 156, receiver 157, transmitter 158, line 143, springs 144 and 145, wiper 130, side switch wiper 136, springs 159 and 160, relay 68 and springs 161 and 176 to battery lead 80. The relays 68 and 69 are both energized over this circuit. As the relay 69 energizes, the spring 148 engages spring 163 before it breaks contact with spring 149 (this is indicated in the drawings by the letters M. B. B., meaning make before break), thereby connecting the ground G^{13} directly with the relay 69 without going through side switch wiper 138. The relay 68, upon energizing, operates to break the circuit of the relay 67 at the springs 146 and 147 to prevent further energization of said relay after the called subscriber has answered. The complete talking circuit between the two connected substations is shown by heavy lines in the drawings. During the times the lines are connected the called line is protected from interference by a guarding ground potential extending from ground G^{13} through side switch wiper 138 and shaft private wiper 131, bank contact 140 and the corresponding contact in the bank of each connector which has access to the line of substation A' . The calling line is guarded, as soon as its line switch C operates, by a ground potential extending from ground G^4 at the repeater E through relay springs 85 and 86 and bank springs 25 and 24 to the conductor 164, which extends to the connector private bank contacts of the calling line.

After the conversation is completed the release of the central office apparatus is initiated by the hanging up of the receiver at the calling substation. The separation of the switch hook springs 70 and 72 upon the hanging up of the receiver breaks the circuit of the repeater line relay 38. The relay 38 thereupon deenergizes, closing the circuit of relay 40 and breaking the circuit of relay 39 in a manner already explained. The relay 40, upon energizing, again closes the circuit of relays 41 and 42. The relay 39 deenergizes shortly after its circuit is broken and breaks the circuit of relay 40 and of the winding 12 of the line switch C. The winding 12, upon deenergizing, permits the plunger arm 21 and armature 15 to be returned to normal position. The relay 40 of the repeater E also deenergizes shortly after its circuit is broken by the relay 39,

thereby breaking the circuit of relays 41 and 42. The relay 41 falls back immediately, closing an energizing circuit through both the vertical and rotary line relays 60 and 61 of the connector I. The circuit of relay 61 extends from ground G^9 through armatures 109 and 106, trunk conductors 101 and 124, relay 61, lower winding of the relay 66 and springs 135 and 134 (assuming that the called subscriber has hung up his receiver) to battery. The circuit of relay 60 extends from ground G^9 through contact point 165, armature 166, springs 169 and 170, contact point 168, armature 167, trunk line 100, thence to and through the relay 60, as has already been traced. The relay 66 is also energized in series with the relays 60 and 61, as previously explained. The simultaneous energization of the relays 60, 61 and 66 completes a circuit from ground G^{14} at the selector H, through side switch wiper 171, relay 172, wiper 117, conductor 123, release springs 173 and 174 of the connector, release magnet 65 and springs 175 and 176 to battery lead 80. The magnet 65, upon energizing, causes the mechanism of the connector to be restored to normal position. The relay 172, upon energizing, operates to close a circuit through the release relay 112 of the selector F in series with the release magnet 179 of the selector H. The relay 112 in turn operates to close a circuit through the release magnet 57. The release magnets 57 and 179 thus attract their respective armatures and hold them in readiness to release their respective switches when the slow relay 42 of the repeater E deenergizes to break the circuits of the connector line relays. The deenergization of the connector line relays allows the release magnets 179 and 57 to be in turn deenergized, causing the selectors H and F to be restored to normal position, and all the apparatus employed in the connection is left in readiness for another call.

From the above it is apparent that the energization of the rotary relay 61 during the release is dependent upon the relay 68 being deenergized. If the called subscriber has not hung up, and the relay 68 is still energized when the two sides of the trunk are grounded at the repeater I, only the vertical relay 60 and upper winding of the relay 66 receive current at first. The relay 66, however, energizes and opens the circuit of the relay 68, which immediately deenergizes and completes the energizing circuit of the rotary relay 61, so that it energizes and brings about the release, as above described.

The foregoing is an explanation of how a connection is obtained with an idle line. It will now be explained how the calling subscriber is given a busy signal in case the called line is busy. It has been shown how there is a guarding ground potential

upon the connector private bank contacts. When the called line is busy the operations are the same as have been described up to the point when the private magnet 64 is energized to trip the side switch to third position after the connector wipers have been brought into contact with the desired line. When the called line is busy, however, the energization of the private magnet completes a circuit extending from ground through the guarded private bank contact, private wiper 131, springs 149 and 148, relay 69, side switch wiper 180 (which is in second position), private magnet springs 181 and 128, side switch wiper 129 and rotary magnet 63 to battery lead 80. The relay 69 is energized over this circuit, but has a sufficiently high resistance to prevent the energization of the rotary magnet 63. As the relay 69 energizes, the spring 148 engages spring 163 before disengaging spring 149, thereby forming a locking circuit for the relay 69 from ground G^{13} instead of from the guarded bank contact 140. Also, in its energized position the relay 69 forms a locking circuit for the private magnet 64, thereby locking the side switch in second position. This circuit extends from ground G^{13} through springs 163 and 183 of relay 69, private magnet 64 and springs 135 and 134 to battery lead 80. Since the side switch does not pass to third position, connection is not completed to the called line. While the side switch is thus locked in second position a circuit is completed for the ringer relay 67, said circuit extending from ground G^{13} through the springs 163, 148, 146 and 147, relay 67 and interrupter 150 to the battery lead 80. Each time the relay 67 is energized ringing current flows from one terminal of the generator L through the springs 184 and 153, side switch wiper 137, contact point 185, private magnet springs 186 and 181, side switch wiper 180, condenser 187, trunk conductor 124, thence over the heavy conductor to and through the receiver at substation A and back over the other side of the line to and through the upper winding of the relay 38, and through battery B to ground G, thence from ground G^{15} through the condenser 188 to the other terminal of the generator. This ringing current passing through the receiver at substation A signifies to the calling subscriber that the desired line is busy. When the receiver at the calling telephone is hung up the switches are released in practically the same manner as if connection had been obtained with an idle line.

From the foregoing it will be seen that my improved system is organized on the two-wire principle outside of the exchange and on the three-wire principle inside of the exchange, whereby all of the selectors and connectors are controlled over grounded line

circuits, as distinguished from the two-wire subscribers' line circuits by which the non-numerical line or trunking switches are controlled, and by which the repeaters are also
 5 controlled. There are certain objections to the use of grounded operating connections at the substations, but in some ways the selectors and connectors which are constructed to operate on the three-wire principle are as
 10 good, and in some ways perhaps better, than those which are constructed to operate on the two-wire principle. My improved system, therefore, it will be seen, combines the advantage of having no operating grounds
 15 at the substations, with the good qualities and reliability in the mode of operation of the three-wire switches at the exchange, the subscribers' line switches and the repeaters being the only elements which are directly
 20 controlled over metallic line circuits. The repeaters control the selectors and connectors by grounding first one side of the line circuit and then the other, thus obviating the necessity, for example, of relatively quick
 25 and slow acting relays, and other similar devices, as heretofore employed in two-wire systems.

There are other advantages which will be obvious to those skilled in the art.

30 What I claim as my invention is:—

1. In a telephone system, a calling line, a pair of talking conductors individual thereto, a first selector adapted to operate in accordance with the first digit of any called
 35 number, a line leading to said first selector, a repeater for controlling said selector by grounding first one side of said line and then the other, a non-numerical trunking switch for automatically finding said repeater, and
 40 a circuit including said talking conductors in series for controlling said repeater.

2. In a telephone system, a calling line, a pair of talking conductors individual thereto, a series of selectors adapted to operate
 45 successively in accordance with successive digits of any called number, a connector adapted to operate in accordance with the last two digits of any called number, lines leading to said selectors and connector, a
 50 repeater for controlling said selectors and connector by grounding first one side of said lines and then the other, a non-numerical trunking switch for automatically finding the said repeater, and a circuit including
 55 said talking conductors in series for controlling said repeater.

3. In a telephone system, a calling line, a pair of talking conductors individual thereto, a plurality of first selectors each adapted

to operate in accordance with the first digit 60 of any called number, lines leading to said first selectors, a non-numerical trunking mechanism for finding idle first selectors, repeaters interposed between the said mechanism and the first selectors for controlling 65 the selector by grounding first one side of said lines and then the other, and circuits including said talking conductors in series for controlling said mechanism and repeaters. 70

4. In a telephone system, a calling line, a pair of talking conductors individual thereto, a first selector adapted to operate in accordance with the first digit of any called number, a line leading to said selector, 75 a repeater for controlling said selector by grounding one side of said line and then the other, a circuit including said talking conductors in series for controlling said repeater, a non-numerical trunking switch for 80 automatically finding said repeater, and a central source of operating and talking current.

5. In a telephone system, a calling line, a pair of talking conductors individual thereto, a plurality of first selectors each adapted 85 to operate in accordance with the first digit of any called number, lines leading to said selectors, a non-numerical trunking mechanism for finding idle first selectors, repeaters 90 interposed between the said mechanism and the first selectors for controlling said selectors by grounding first one side of said lines and then the other, circuits including said talking conductors in series for controlling 95 said mechanism and repeaters, and a central source of operating and talking current.

6. In a telephone system, a calling line, a pair of talking conductors individual thereto, a first selector adapted to operate in accordance with the first digit of any called 100 number, a line leading to said selector, a repeater for controlling said selector by grounding first one side of said line and then the other, a non-numerical trunking switch 105 for automatically finding said repeater, a circuit including said talking conductors in series for controlling said repeater, said selector being provided with a switching element having one motion to find a group and 110 another motion to find an idle trunk in the predetermined group.

Signed by me at Chicago, Cook county, Illinois, this 29th day of March, 1910.

EDWARD D. FALES.

Witnesses:

ARTHUR J. RAY,
A. ANDERSEN.