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TWO WIRE AUTOMATIC AND MANUAL TELEPHONE EXCHANGE TRUNKING SYSTEM.

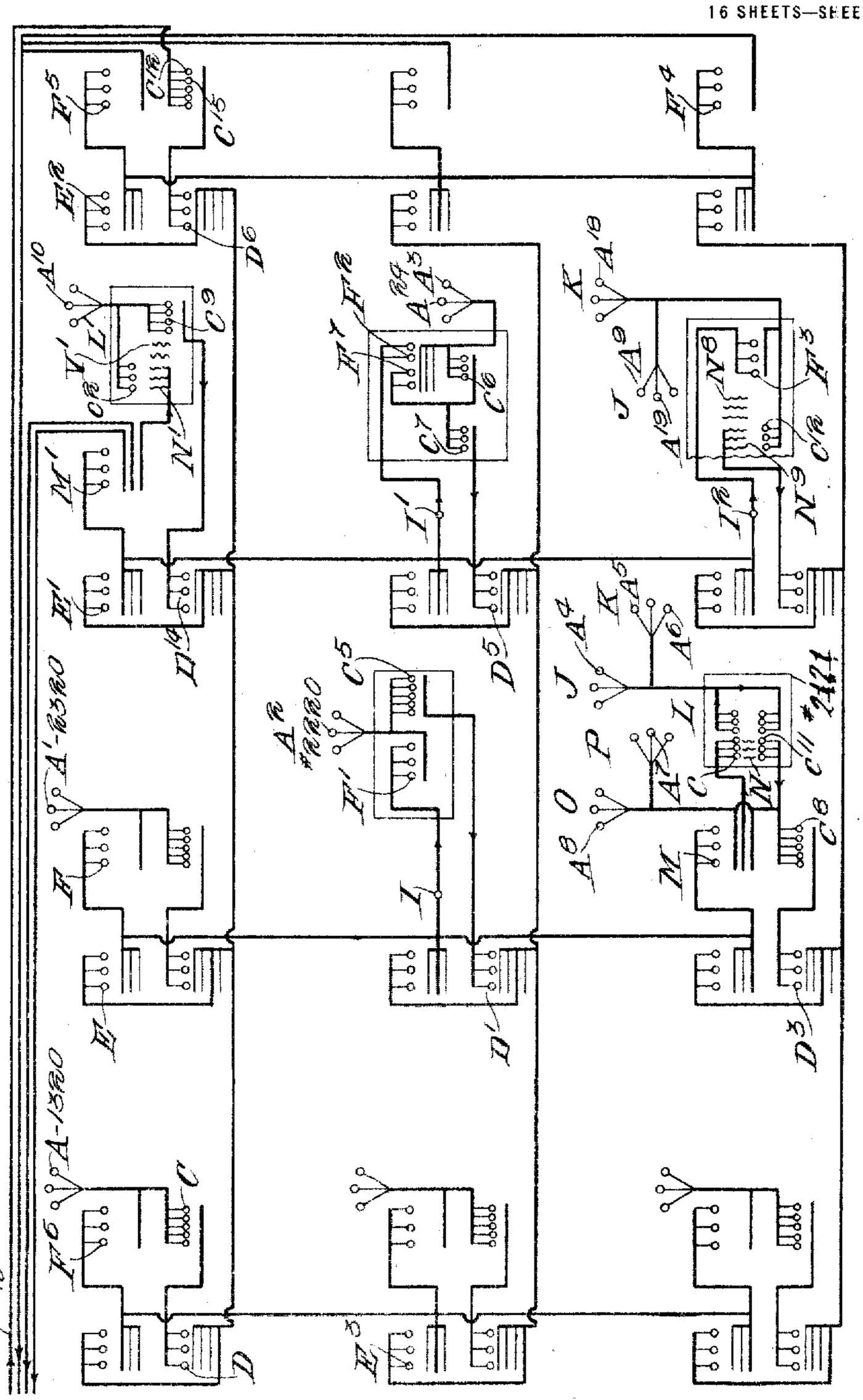
APPLICATION FILED MAR. 17, 1910. RENEWED NOV. 10, 1917.

1,270,277.

Patented June 25, 1918.

16 SHEETS—SHEET 1.

FIG. 1.



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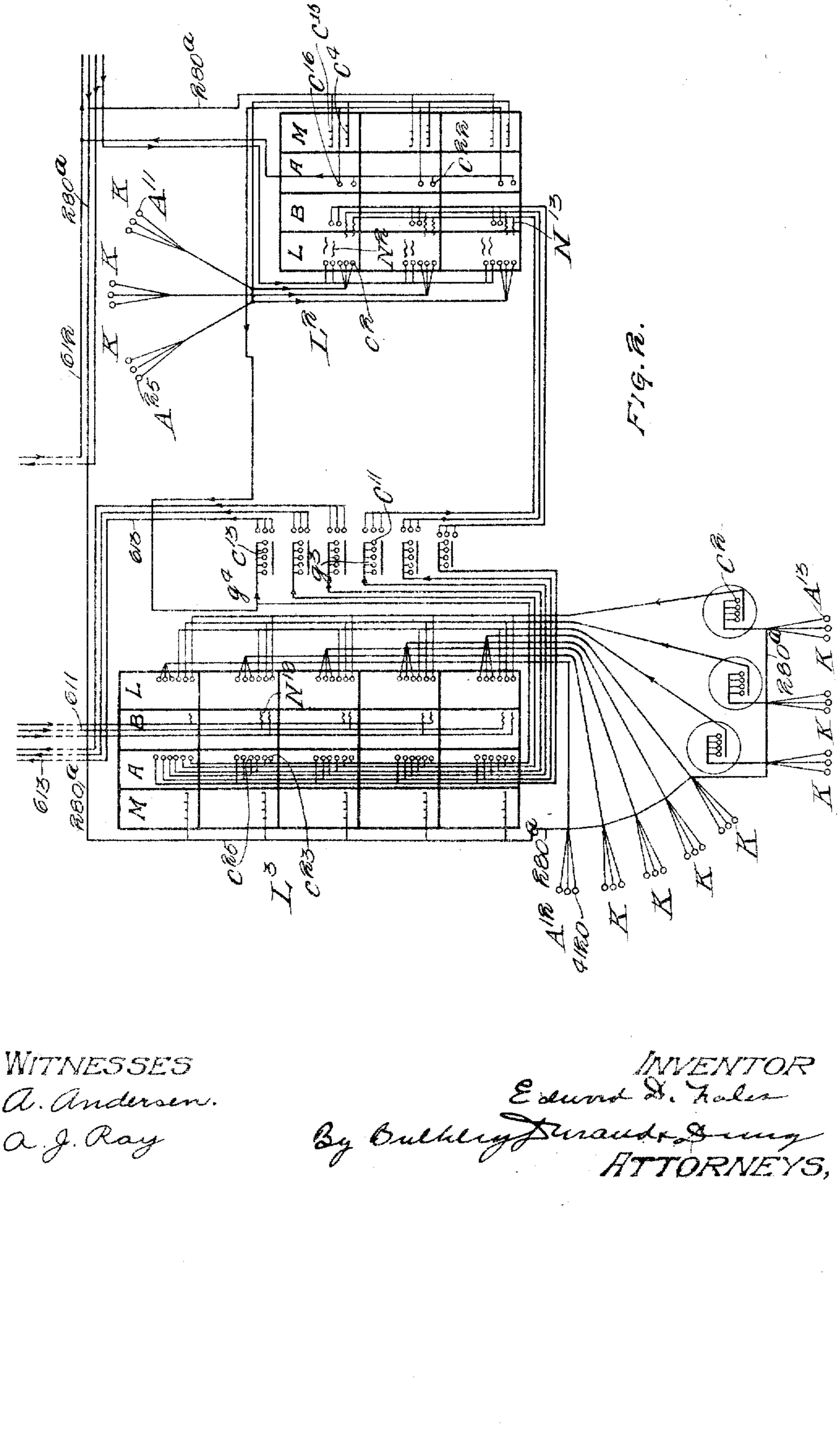

FIG. 2.

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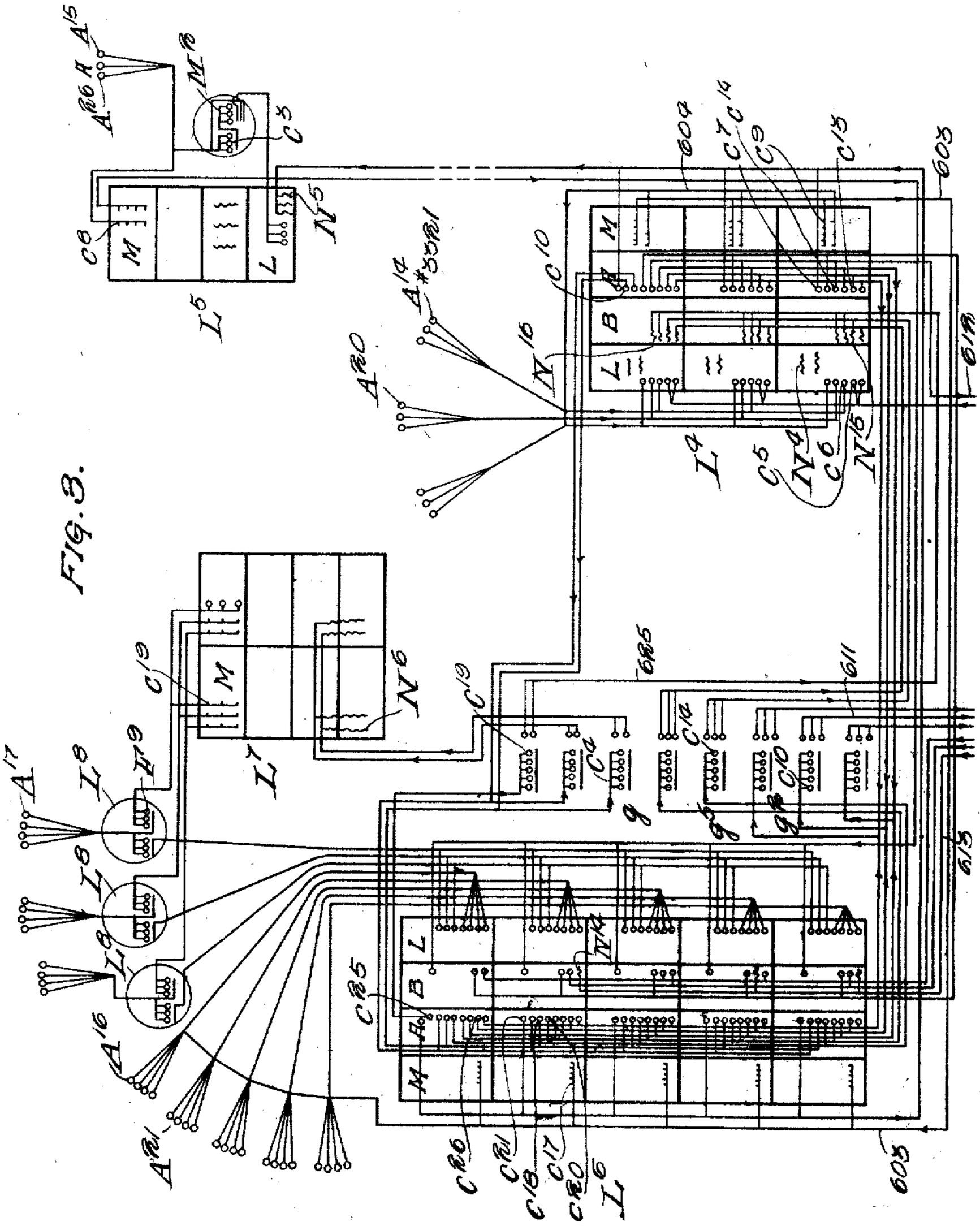
FIG. 3.



WITNESSES

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6 SHEETS—SHEET 4.

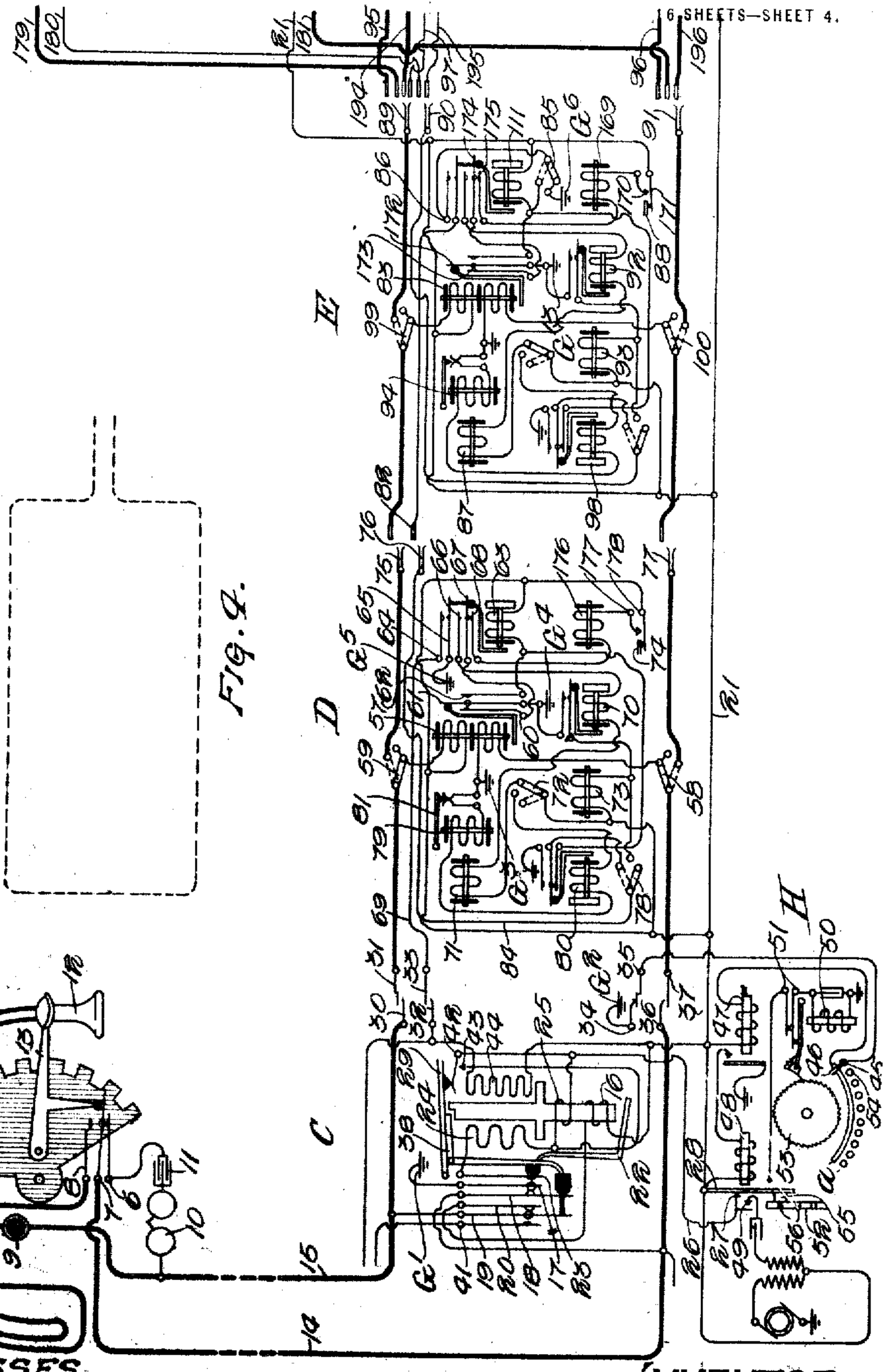

FIG. 4.

WITNESSES

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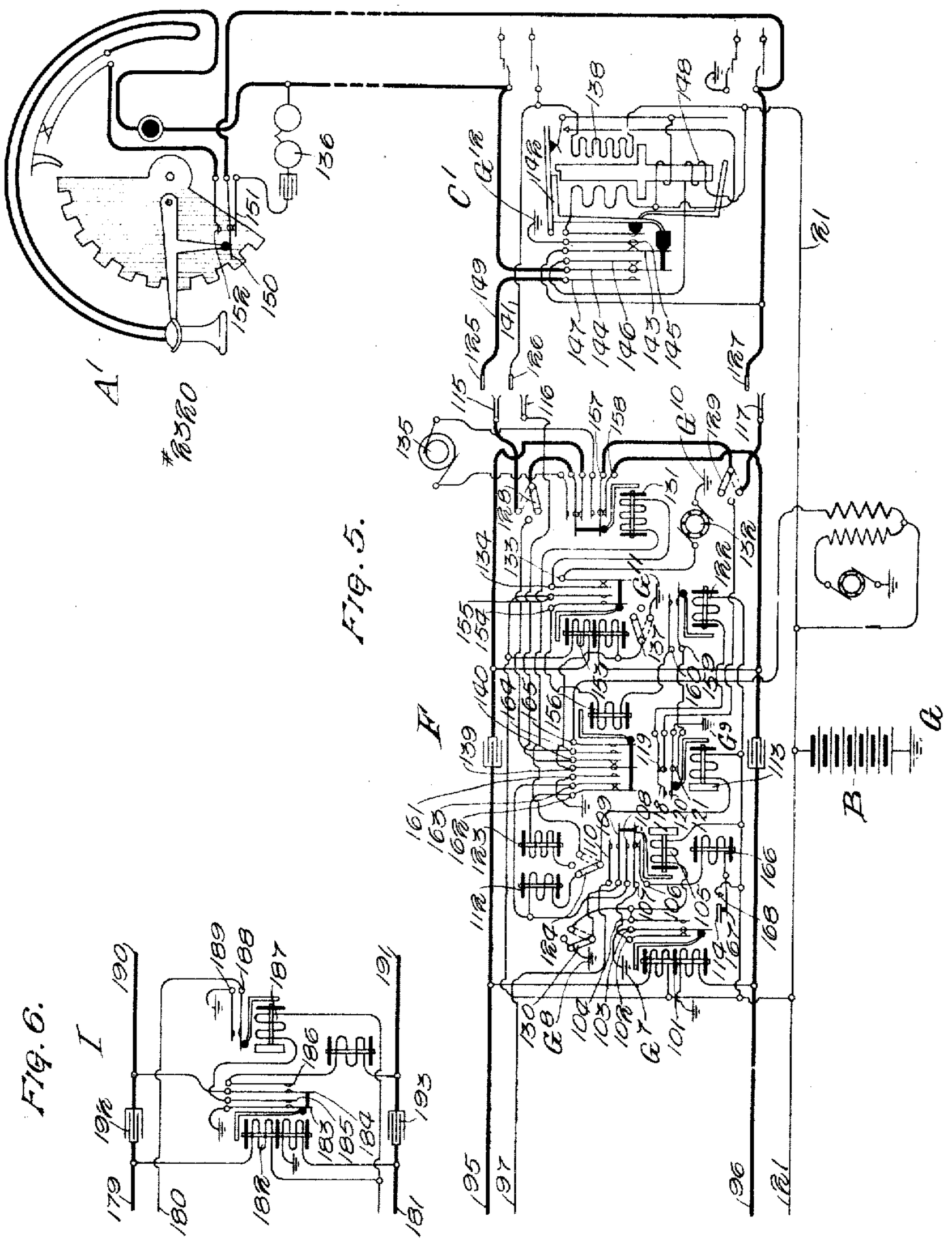

FIG. 5.

FIG. 6.

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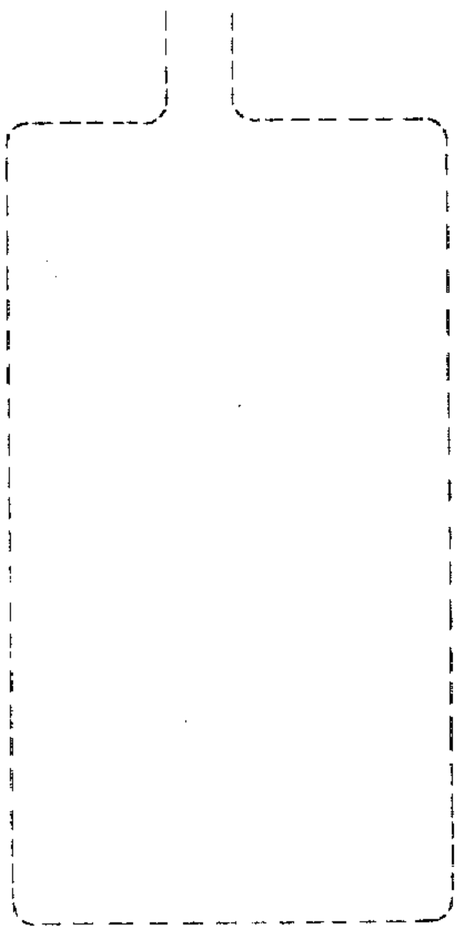


FIG. 7.

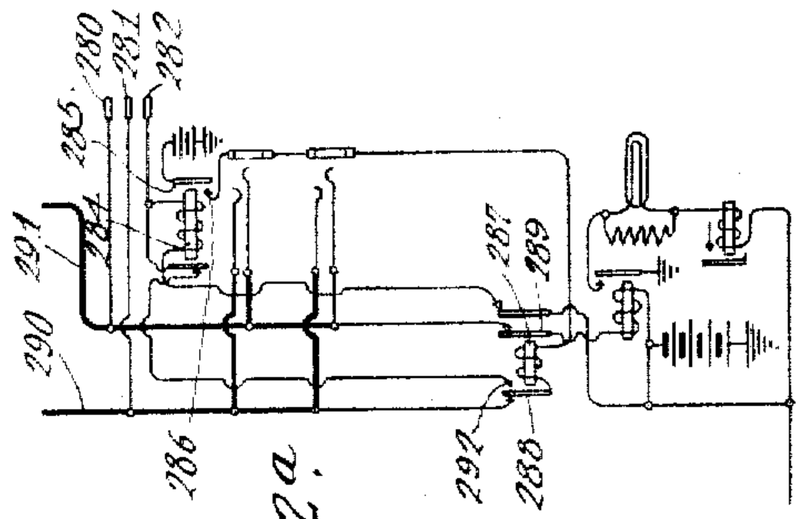
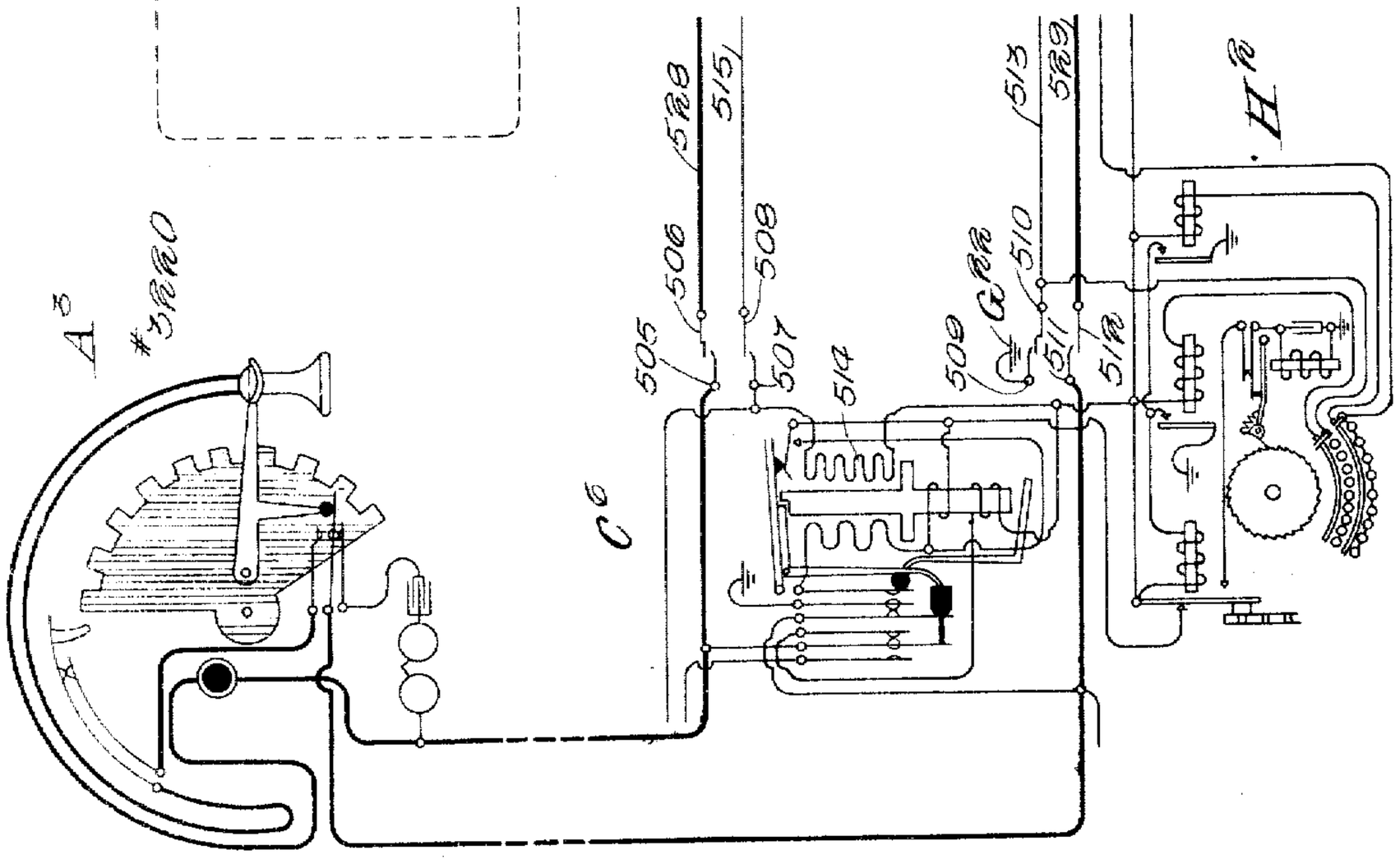


FIG. 12a.



WITNESSES
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16 SHEETS—SHEET 7.

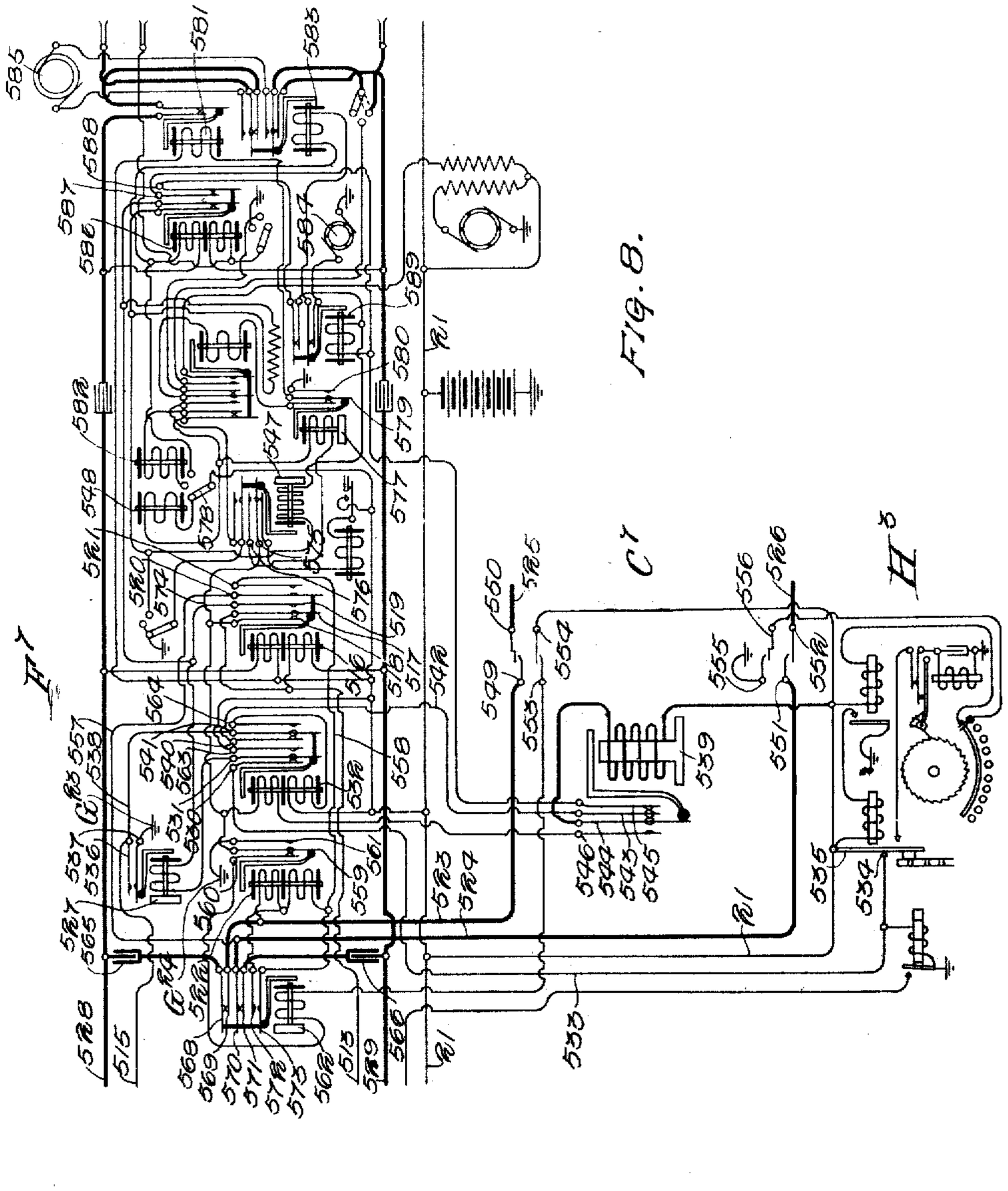

Fig. 8.

WITNESSES
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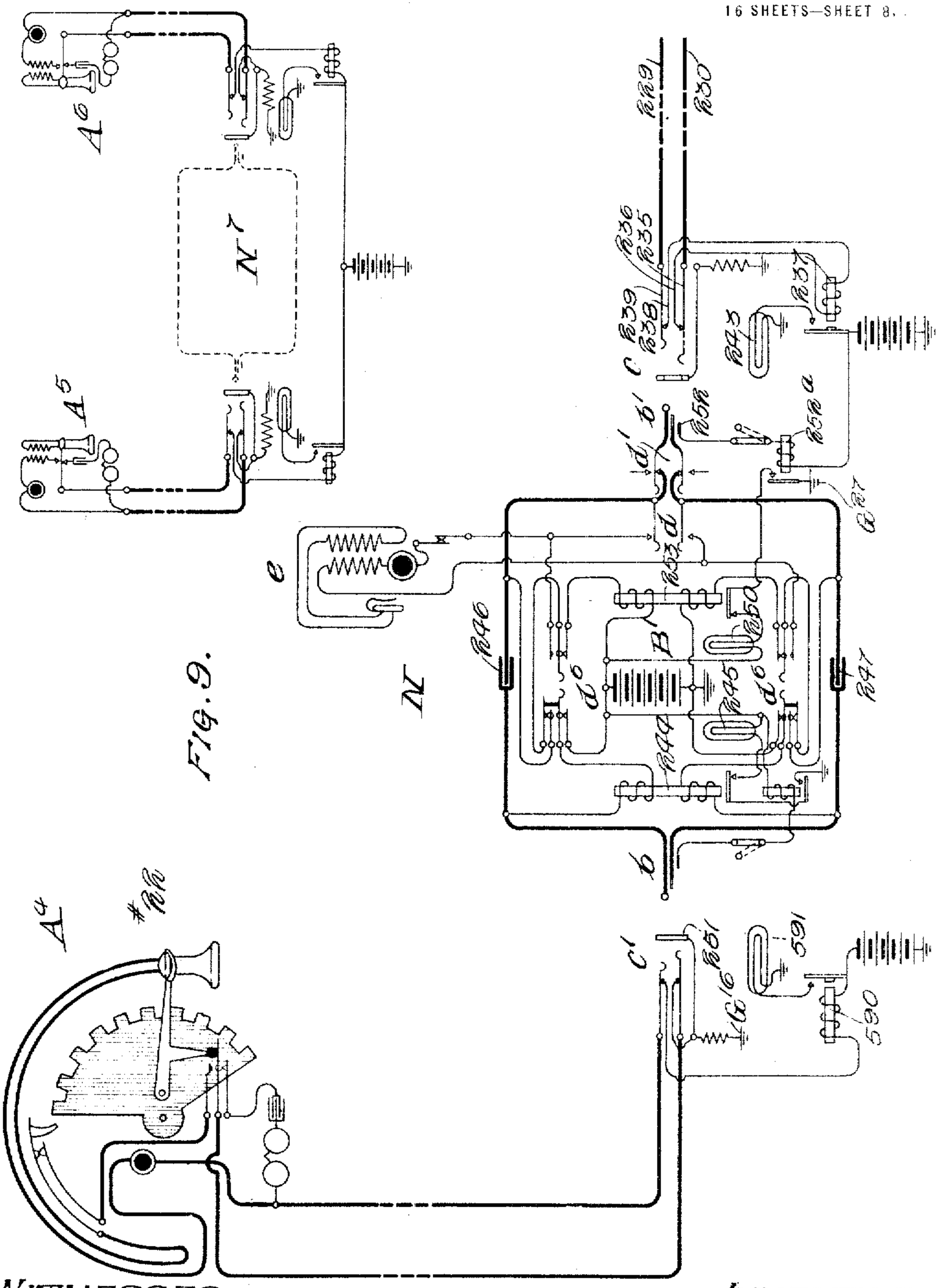

FIG. 9.

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16 SHEETS—SHEET 9.

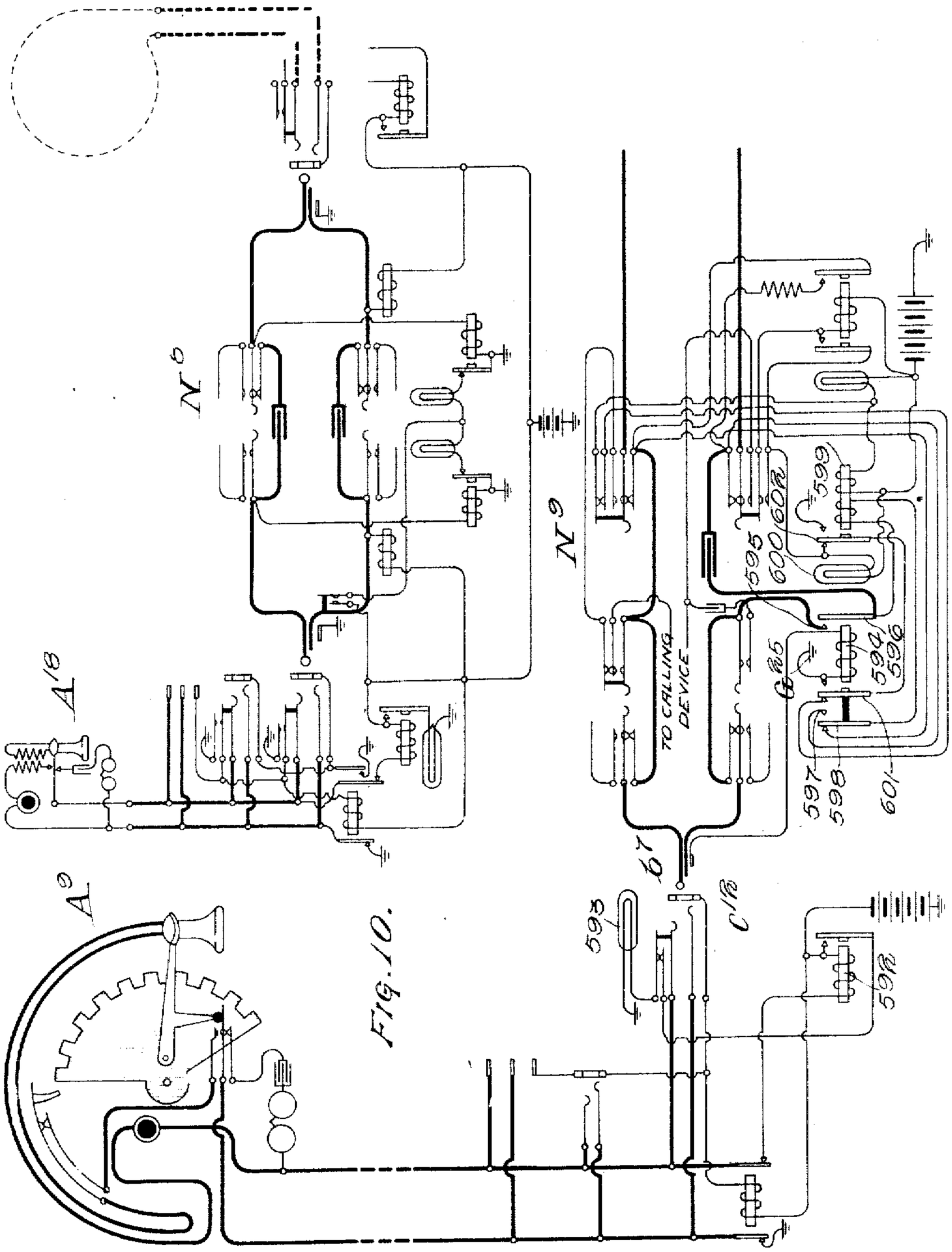

FIG. 10.

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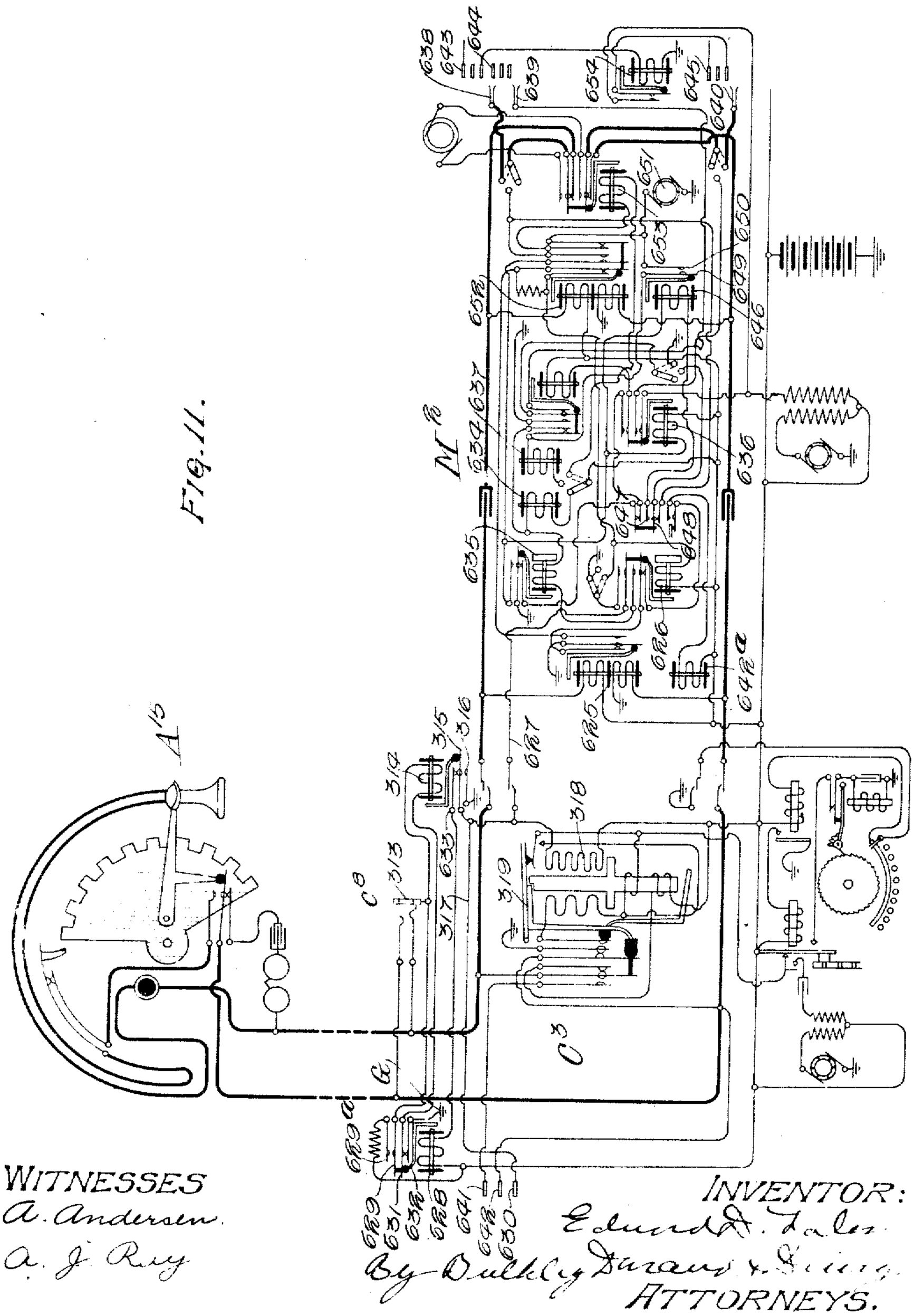
16 SHEETS—SHEET 10.

FIG. 11.



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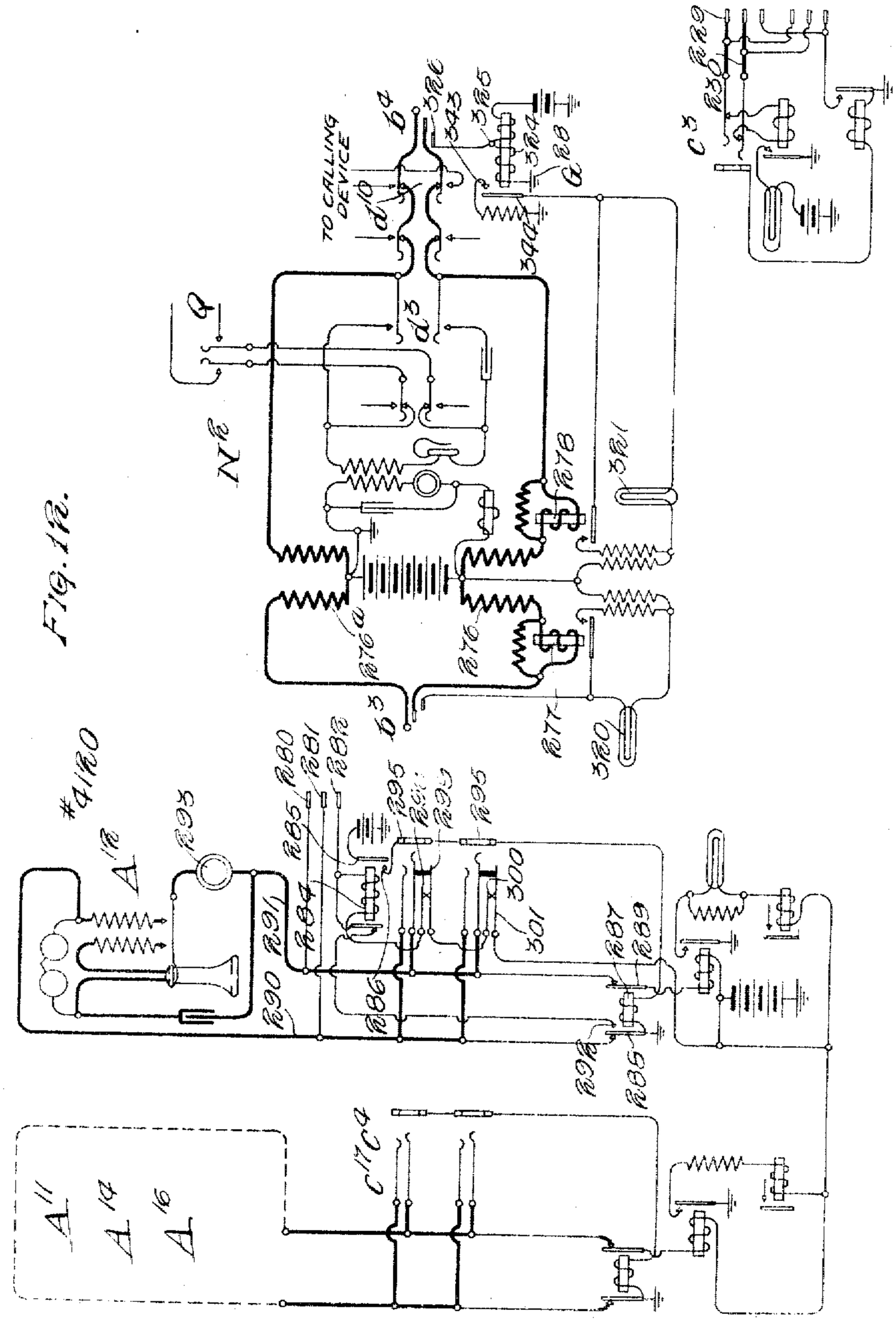
16 SHEETS—SHEET 11.

FIG. 12.



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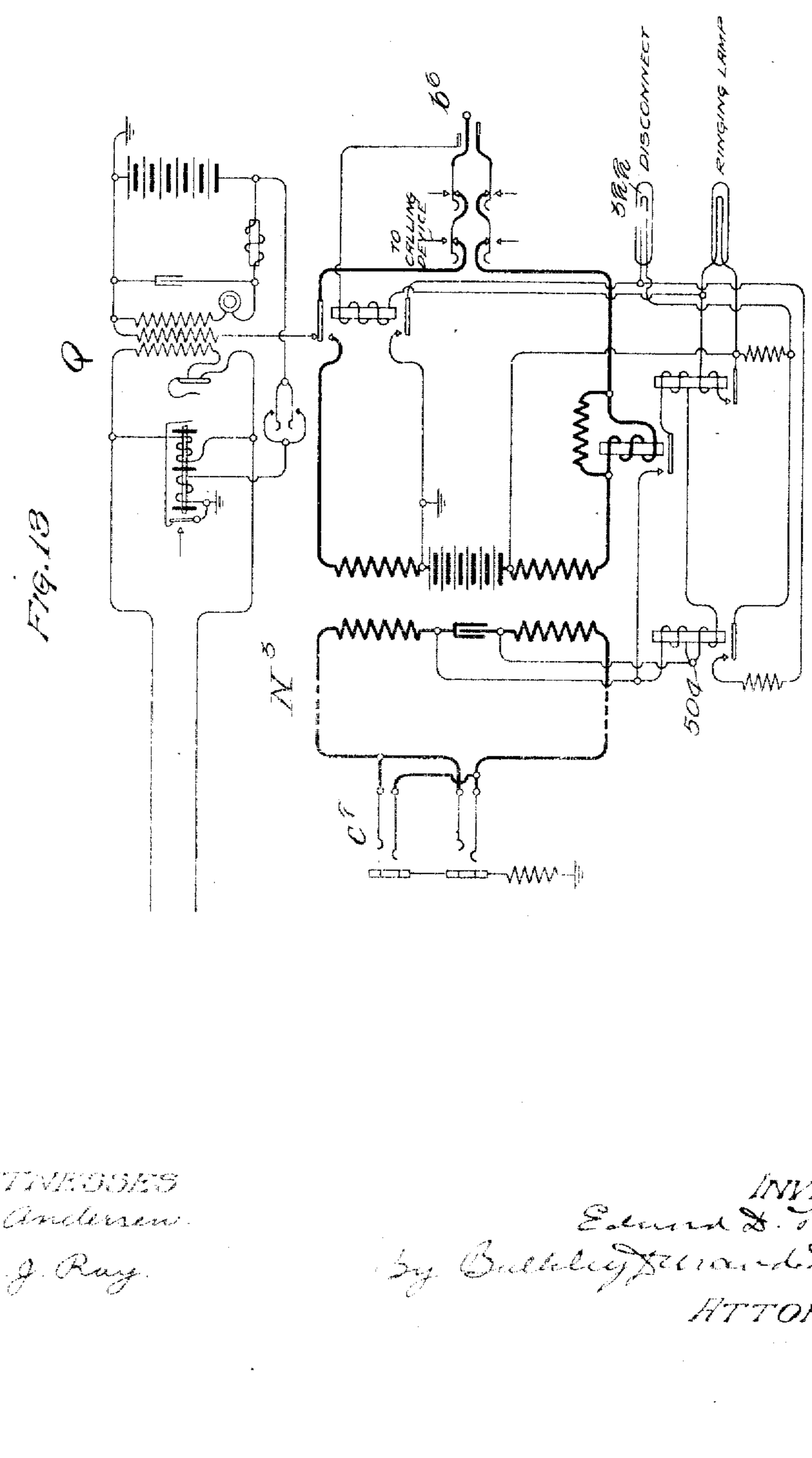

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TWO WIRE AUTOMATIC AND MANUAL TELEPHONE EXCHANGE TRUNKING SYSTEM.

APPLICATION FILED MAR. 17, 1910. RENEWED NOV. 10, 1917.

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16 SHEETS—SHEET 13.

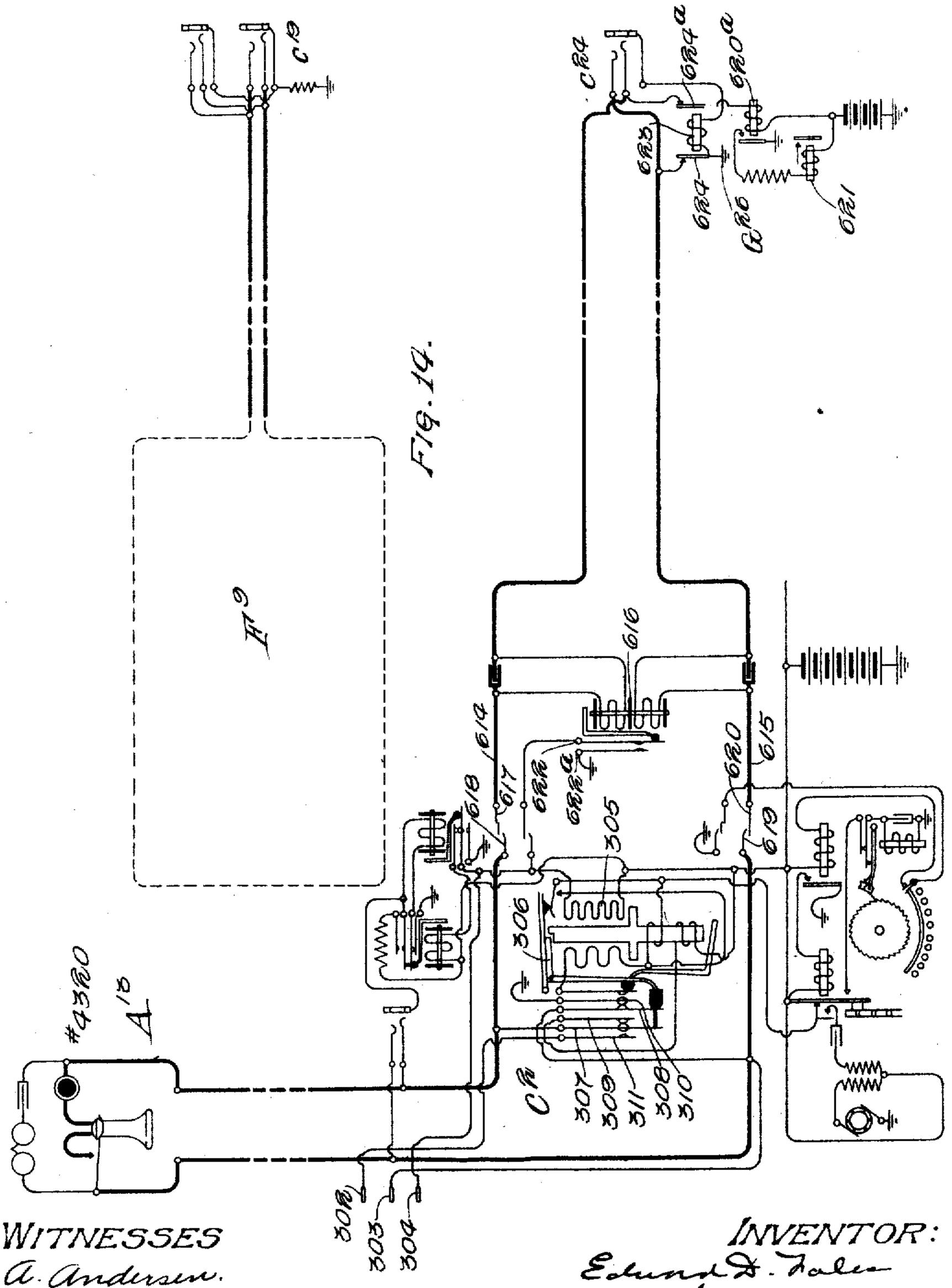

FIG. 14.

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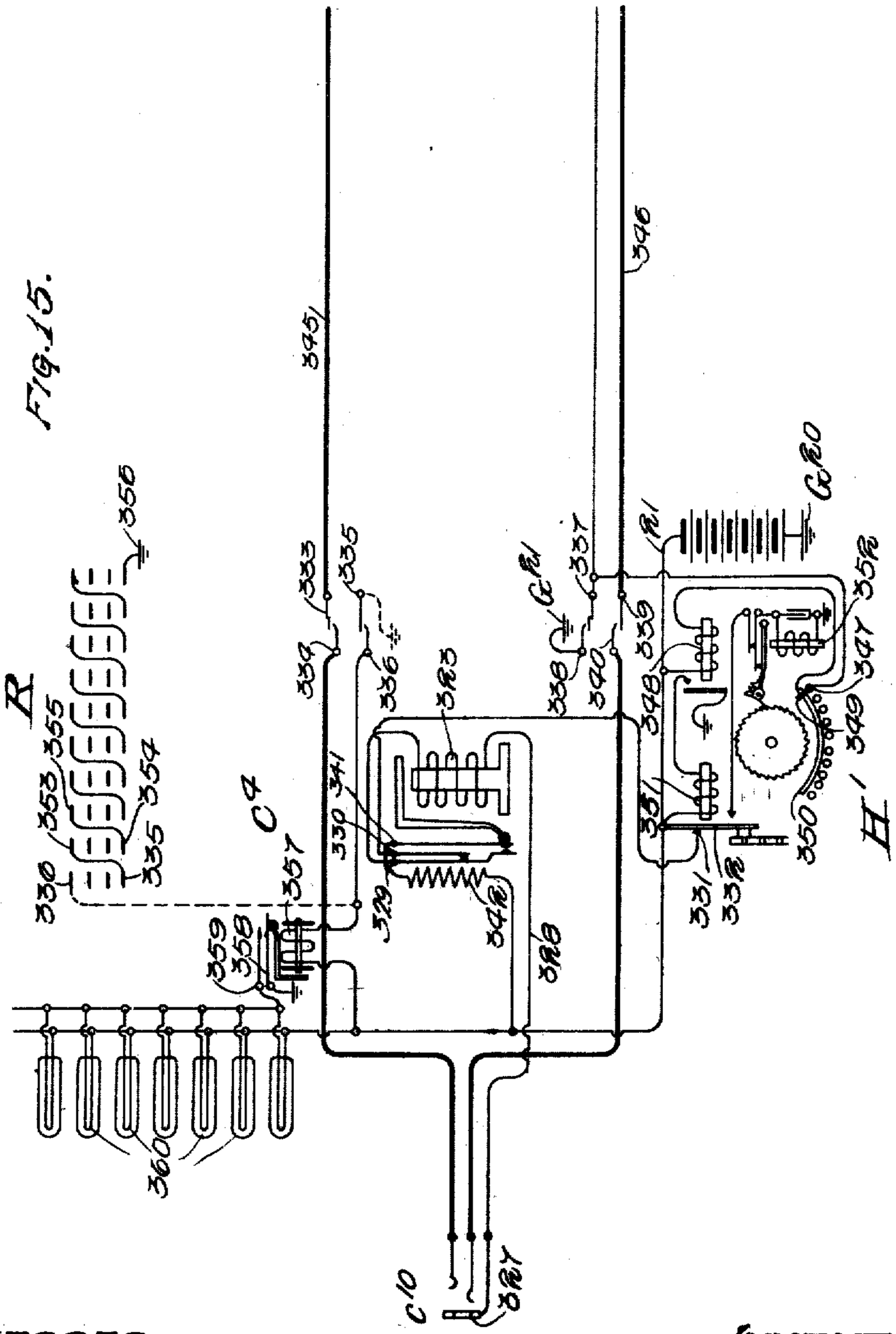
16 SHEETS—SHEET 14.

FIG. 15.



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APPLICATION FILED MAR. 17, 1910. RENEWED NOV. 10, 1917.

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16 SHEETS—SHEET 15.

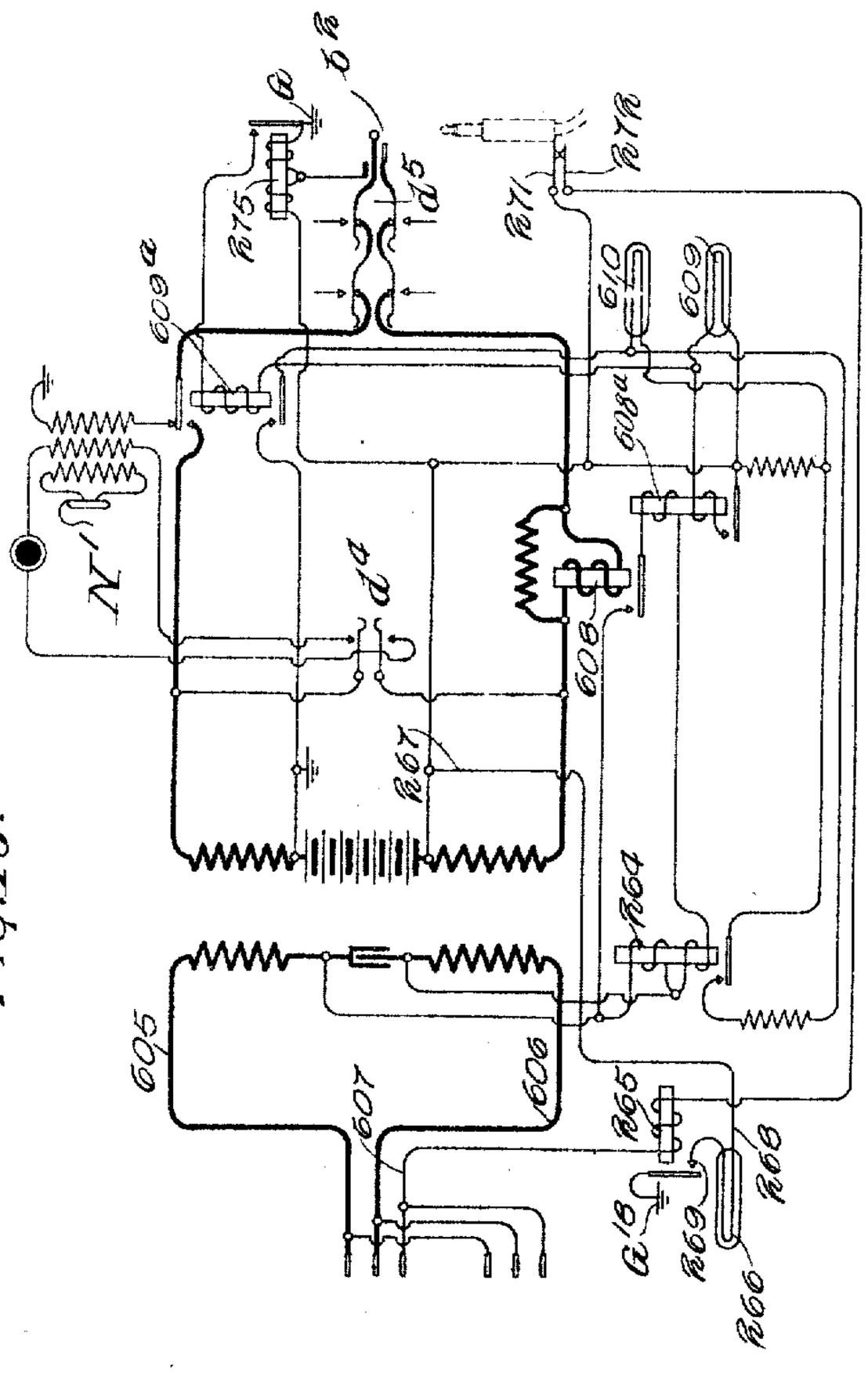

FIG. 16.

WITNESSES
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TWO WIRE AUTOMATIC AND MANUAL TELEPHONE EXCHANGE TRUNKING SYSTEM.

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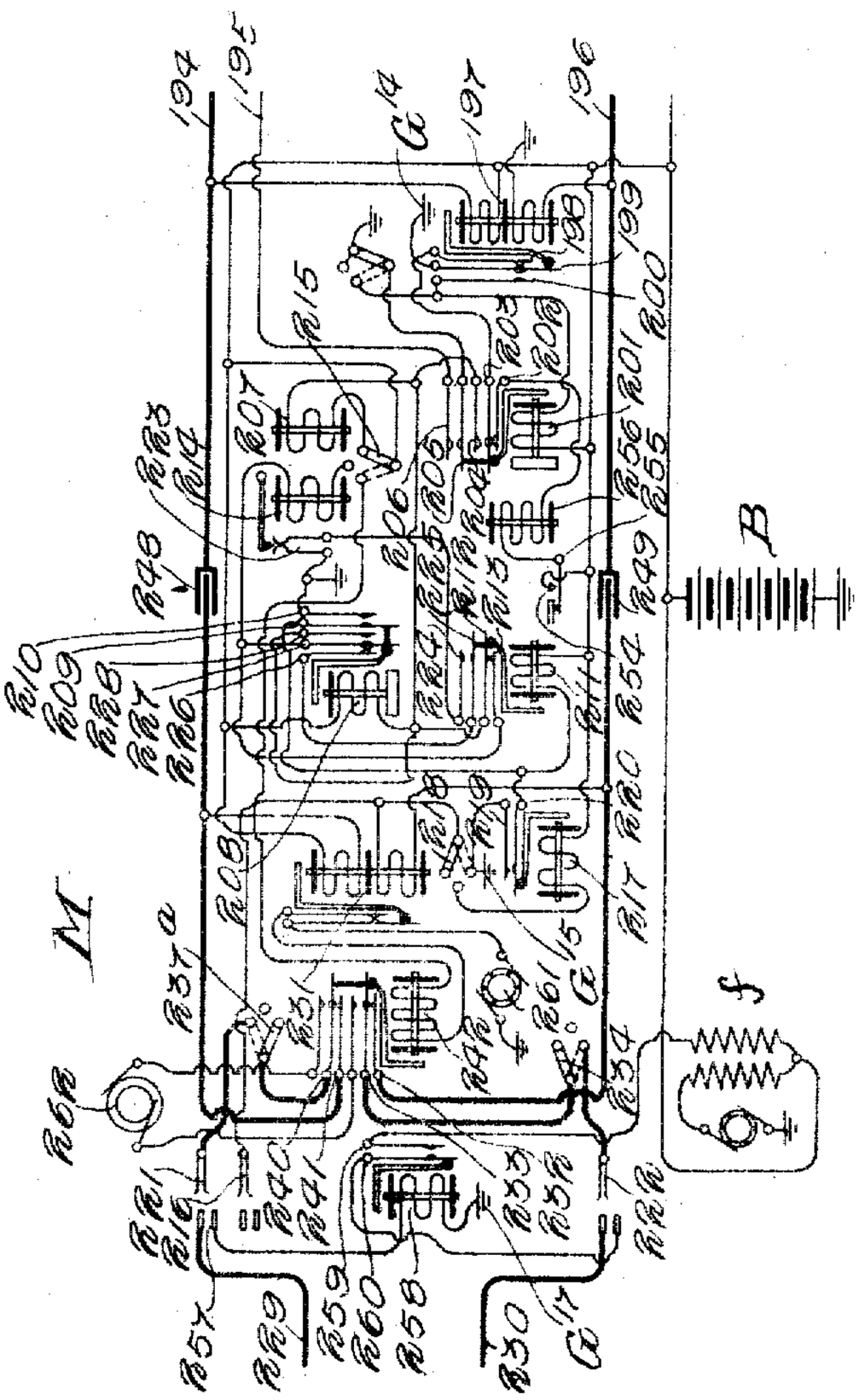

Fig. 17.

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UNITED STATES PATENT OFFICE.

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TWO-WIRE AUTOMATIC AND MANUAL TELEPHONE-EXCHANGE TRUNKING SYSTEM.

1,270,277. Specification of Letters Patent. Patented June 25, 1918.

Application filed March 17, 1910, Serial No. 549,816. Renewed November 10, 1917. Serial No. 201,397.

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 Automatic and Manual Telephone-Exchange Trunking Systems, of which the following is a specification.

My invention relates to telephone exchange systems in general, but more particularly to automatic or semi-automatic telephone exchange systems of that kind in which automatic switches are used between calling and called subscribers, and in which provision is made for controlling said switches over the two sides of the calling line in series, whereby no operating grounds are necessary at the substations.

Systems of this kind are commonly known as two-wire systems, as distinguished from the other kind of system in which the automatic switches are controlled by grounding first one side of the line and then the other at the calling substation, which latter is commonly known as a three-wire system, the ground or common return between the substations and the exchange being regarded as a third wire, whereas in a two-wire system, such as hereinafter described, the automatic switches at the exchange or central station are controlled without grounding the subscribers' lines.

In a two-wire system of this kind it often becomes necessary, especially in large cities where there are several exchanges, to transmit the call, for at least part of the way, through the medium of manual apparatus, and to provide means whereby an automatic subscriber may call a manual subscriber, or a manual subscriber may call an automatic subscriber, and it is always desirable, of course, to make adequate provision, as far as possible, for all of the different kinds of connections that may be found necessary in a complex system of this kind in as convenient and efficient a manner as possible, and in a way that will insure good telephone service for all of the subscribers thereof.

The object of my invention is, therefore, the provision of an improved construction and arrangement whereby certain calling connections heretofore considered impossible in a two-wire system are now made practicable, and whereby each subscriber, notwithstanding the many different kinds of apparatus employed, may converse with any other subscriber of the system, as will hereinafter more fully appear.

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

In the accompanying drawings Figure 1 is a diagrammatic representation of the automatic section of a combined manual and automatic office, in a system embodying the principles of my invention.

Fig. 2 is a similar view of the manual section of the same office.

Fig. 3 is a similar view of a distant manual office.

The drawings should be read with Fig. 2 to the left of Fig. 1, and with Fig. 3 above Fig. 2, this giving an idea of the whole system.

Figs. 4 and 5 illustrate diagrammatically the apparatus by means of which a subscriber of the automatic section of exchange may establish connection with another automatic subscriber of the same section, the lines of both of which subscribers terminate directly in the same exchange.

Fig. 6 is a diagram of a repeater involved in said system.

Figs. 7 and 8 are similar illustrations of apparatus used in connection with an automatic district office, in which district office the subscribers, in calling each other, do not monopolize any of the trunk lines running to the main office while maintaining a talking connection.

Fig. 9 is a similar view of private branch exchange apparatus associated with the automatic section of the combined manual and automatic office.

Fig. 10 is a similar view of a different type of private branch exchange connected with the same automatic section.

Fig. 11 is a similar view of a line equipment of the said system, said equipment adapted for semi-automatic use, together with a rotary connector.

Fig. 12 is a similar illustration of manual and semi-automatic equipment.

Fig. 12^a is a modification of a portion of Fig. 12.

Fig. 13 is a similar view of a B-cord equipped with a calling device.

Fig. 14 is a similar view of subscribers'

equipment and central office apparatus for signaling an operator, and by which the subscribers are called, used in connection with the district subscribers. (See Fig. 3).

Figs. 15 and 16 are similar illustrations of automatic apparatus used between A and B operators.

Fig. 17 is a similar view of an automatic switch known as the rotary connector.

Referring more in detail to Fig. 1, if the subscriber A, whose line terminates in the central office containing the automatic section, wishes to call subscriber A', similarly situated in the system, and whose number it will be assumed is 2320, the subscriber A removes his receiver and thereby operates his line switch C to establish connection with an idle first selector D. The first selector is then operated to raise its shaft two steps and rotate it until connection is made with an idle second selector E in the second thousand. The second selector E is then operated to raise its shaft three steps and rotate it until connection is established with an idle connector F, which connector is finally operated in accordance with the last two digits of the desired number, thus completing the connection if the desired subscriber is idle. Of course, if the subscriber should be busy the calling subscriber will be given the busy signal. In that case (and also in the event that connection has been made and the calling subscriber is through), upon hanging up his receiver the calling subscriber releases all of the apparatus brought into use. To explain still more in detail this operation of the subscriber A calling the subscriber #2320, reference is made to Figs. 4 and 5. It will be understood that the subscriber A, being an automatic subscriber, is provided with a suitable dial such as that shown in the article appearing in the *Western Electrician* of Chicago, Illinois, of January 11, 18 and 25, 1908. As is well known, this dial controls a suitable impulse wheel 2, which in turn, through the medium of a set of teeth 3 provided on its periphery, controls and operates the so-called impulse strings 4 and 5. This telephone is, of course, provided with the usual switch hook and receiver. The switch hook is shown adapted to control and operate the springs 6, 7 and 8. In addition, the telephone has the usual transmitter 9 and ringer 10 which is connected in series with a condenser 11. The subscriber A is also, as shown, provided with the line switch C to which reference has already been made in connection with Fig. 1, which line switch is of the general character described in the publication hereinabove referred to, and also of the general character of similar apparatus shown and described in British Patent No. 26,301 of 1906. This line switch C together with other line switches of the same group (usually one hundred in number) are controlled by the master switch H. The function of this master switch is to always maintain the line switch C, while idle, opposite an idle line which may be used by the subscriber A as soon as he removes his receiver without having to wait for a selector. This trunk line, of course, terminates in a selector switch such as the selector switch D, to which reference has already been made. The master switch H is also of the general character as that described in the *Western Electrician* and the British patent hereinabove referred to. Having decided to call the subscriber #2320, the subscriber A removes his receiver 12, thereby permitting the switch hook 13 to rise, which in turn permits the springs 6 and 7 to separate, thereby disconnecting the ringer 10 from the circuit, the spring 7 finally engaging the spring 8, thus closing the two sides of the lines 14 and 15 (known, respectively, as the positive and negative sides) through the transmitter 9 and the impulse springs 4 and 5 at the telephone. The closure of this circuit causes a flow of current through the line winding 16 of the line switch C. The path of the current may be traced from ground G' through the springs 17 and 18 of the line switch C to the positive conductor 14, thence to the springs 7 and 8 at the telephone and through the impulse springs 4 and 5, receiver 12, transmitter 9, negative conductor 15, springs 19 and 20 and the winding 16 to the battery lead 21, thence through battery B to ground G. This flow of current causes the line winding 16 to attract the armature 22 of the line switch C, with the result that the spring 23 is pressed onto the spring 17, whereby an energizing circuit is closed through the pull-in winding 24 and through the auxiliary winding 25, thence through conductor 26, contact 27 and armature 28 to the battery lead 21, thence through battery B to ground G. The pull-in winding 24 being thus energized attracts the plunger armature 29, which then causes the plunger to press the springs 30 and 31, springs 32 and 33, springs 34 and 35 and the springs 36 and 37 into contact. At the same time the winding 24 pulls the so-called bridge-cut-off armature 38 down, which in turn acts upon the springs 18 and 19 to separate them from the springs 17 and 20, respectively, carrying the spring 19 into engagement with the spring 41. It will be seen that this action of the cut-off armature 38 disconnects the line winding 16 from the line. In order to insure that the line armature 22 shall not fall back too quickly, the auxiliary winding 25 is provided, which winding is shunted or short-circuited by the closure of contact between the springs 42 and 43 when the

armature 29 reaches its operated position. At this point the armature 22 falls back and the circuit is broken through the pull-in winding 24. In the meantime, however, a holding circuit is established through the bridge-cut-off winding 44 for preventing the armature 29 from falling back until the connection is released. The act of the plunger, which is attached to the plunger armature 29, of pressing the springs 34 and 35 into contact, causes the master switch H to operate, starting it on its selection of the next idle trunk to have the same in readiness for a call. This operation of the master switch is as follows: The closure of the said springs 34 and 35 puts a positive potential on the bank contact 45 of the master switch bank *a* from ground G^2. This contact 45 corresponds to the trunk line which terminates in the switch D, there being one such bank contact for every trunk line associated with the master switch H. Assuming that the first selector D was idle at the time that the subscriber A removed his receiver, and that the master switch H was holding the line switch C in readiness to connect with the switch D; then the master switch wiper 46 is in the position indicated in Fig. 4 at the instant that the line switch C operates, and, therefore, the guarding potential established at the bank contact 45 by the said bank springs 34 and 35 causes a flow of current to pass through the master switch relay 47 through the said master switch wiper 46. The relay 47 upon energizing closes an energizing circuit for the relay 48, which in turn performs the following functions: First, it disconnects the main battery from the conductor 26, and from all such conductors, thereby rendering all line switches C of the group inoperative for starting a call. Second, the spring 49 is closed onto the conductor 26, whereby any subscriber of the group may receive the busy signal and hang up his receiver should he attempt to make a call while the master switch H is in operation. Last, an energizing circuit is closed through the operating magnet 50. This energizing circuit includes the interrupter springs 51. It will be seen that an auxiliary wheel 52 is provided on the same shaft with the gear wheel 53, both of which are controlled by the operating magnet 50. Normally—that is, while the master switch H is at rest—the armature 28 is in locking engagement with the wheel 52; but when the relay 48 is energized this wheel is unlocked at the same time that the energizing circuit for the magnet 50 is closed. The locking mechanism consists of a series of holes near the periphery of the wheel 52, and a pin on the armature 28 adapted to engage any one of these holes while the magnet 48 is deënergized. When once the circuit is closed through the operating magnet 50, the gear wheel 53 is rotated automatically, advancing the wiper 46, together with the wheel 52 and the plungers on the armatures 29 which are in engagement with the shaft and which are also controlled by the gear wheel 53. With the preferred arrangement it takes a number of steps—that is, a number of operations of the magnet 50—to carry the wiper 46 from the contact 45 and onto the next contact 54, and the circuit of the relay 47 is, therefore, broken before the wiper 46 reaches the contact 54. The circuit of the magnet 48 is, of course, in turn also broken before the end of the operation, but the pin 55 on the end of the armature 28 does not now register with any of the openings 56 near the outer edge of the wheel 52, and for this reason the circuit of the operating magnet 50 is held closed mechanically through the medium of the wheel 52. However, by the time the wiper 46 has advanced to the proper point, in engagement with the contact 54, the pin 55 on the armature 28 has arrived opposite one of the openings 56 and drops thereinto, with the result that the circuit through the magnet 50 is broken and the plunger shaft of the wheel 52, the gear 53 and the wiper 46 are locked—this, of course, provided the trunk corresponding to the contact 54 is idle. If it is not idle it is obvious that the relay 47 will be reënergized and that the magnet 48 will also be reënergized, thus preventing the pin 55 from falling into any of the openings 56, as explained, until an idle trunk is found. By pressing the springs 30 and 31 into contact at the same time the springs 36 and 37 are pressed into contact, the plunger also causes the line relay 57 of the first selector D to energize. This selector is of the general type of selector described and shown in United States Letters Patent No. 815,321, granted March 13, 1906, to Keith, Erickson and Erickson, with the circuits modified for two-wire work. The line relay 57 of this selector, as stated, energizes as soon as connection is extended thereto from the line. The current in this circuit, it will be seen, flows from ground G^3 through the lower winding of said coil to the side switch wiper 58, thence to the positive side of the line, through the telephone to the negative side of the line, back over the side switch wiper 59, through the upper winding of the relay 57 to the battery lead 21, thence through battery B to ground G. The line relay 57 upon energizing separates the springs 60 and 61, carrying the latter into engagement with the springs 62. As a result of the closure of contact between the springs 61 and 62, the slow-acting release relay 63 is energized by a flow of current from ground G^4 through the said springs 61 and 62 and through said relay 63 to the

battery lead. The relay 63 upon energizing presses the springs 64 and 65 and the springs 66 and 67 into contact, taking the latter out of engagement with the spring 68. The closure of contact between the springs 64 and 65 completes the holding circuit through the bridge cut-off-winding 44 of the line switch C for preventing the switch C from falling back as soon as the circuit through the pull-in winding 24 is broken. This holding circuit, it will be seen, extends from ground G^5 through the springs 65 and 64, conductor 69, bank springs 33 and 32, bridge-cut-off winding 44 of the line switch C to the battery lead 21. The connection having been extended thus far, the subscriber is now in readiness to operate his dial in accordance with the digits 2—3—2—0 for first operating the first selector D in accordance with the digit 2, next the second selector E in accordance with the digit 3 and last the connector F (Fig. 5) in accordance with the digits 2 and 0. When the subscriber operates his dial in accordance with the digit 2 he separates the impulse springs 4 and 5 at the telephone twice through the medium of the impulse wheel 2. As a result the relay 57 operates twice, thereby causing the spring 61 to engage the spring 60 twice. Two impulses of current are, therefore, sent through the springs 67 and 66 to the private magnet relay 70 (which is slow-acting) in series with the vertical magnet 71, thence through the side switch wiper 72 (in first position) to the battery lead 21. At the first impulse the slow-acting private magnet relay 70 energizes and remains energized until after the last impulse has been sent. This relay 70 upon energizing closes an energizing circuit through the private magnet 73, which private magnet attracts its armature and remains in readiness to release the side switch to second position after the vertical magnet 71 has been operated the desired number of times. In this instance the vertical magnet 71 is operated twice in accordance with the impulses delivered through this vertical magnet by the line relay 57, as described. As a result the shaft 74 and wipers 75, 76 and 77 are raised to the second level of the bank contacts. After the last impulse has been transmitted the slow-acting relay 70 deënergizes and, therefore, the private magnet 73 deënergizes, thereby permitting the side switch to pass to second position, carrying the side switch wipers 58 and 59 and 72 and 78 to second position. As soon as the side switch wiper 72 reaches the second position an energizing circuit is closed through the rotary magnet 79 from ground G^3 through the interrupter spring of said magnet 79, auxiliary slow-acting relay 80, second-position side switch contact point, side switch wiper 72 to the battery lead 21. By its automatic operation the rotary magnet 79 rotates the shaft and wipers until an idle trunk is found. If the first trunk is idle the shaft and wipers are rotated one step, and a finger on the rotary armature 81 trips the side switch to third position; but if the first trunk is busy the private magnet 73 is energized, since the side switch wiper 78 is also in second position, and remains energized until the wipers reach an idle trunk line. It is, of course, understood, that when a trunk line is busy the private bank contact (here shown as the contact 82, and which is in multiple with other private bank contacts of the same group) is connected with the positive battery. It is this positive battery that energizes the private magnet 73 and does not permit the side switch to trip to third position until after the wipers reach an idle trunk. As soon as the side switch trips to third position, in either case, the line relay 57 is disconnected from the line and the circuit from the calling line is extended directly through to the second selector switch E by way of the side switch wipers 58 and 59 and the shaft wipers 77 and 75, as indicated by the heavy conductors. It will be seen that the auxiliary relay 80, which energizes in series with the rotary magnet 79, performs two functions: It maintains positive potential on the third-position contact point of the side switch wiper 78 to insure a guarding potential at the private wiper 76 at the instant the side switch passes to third position, without having to wait for the line relay 83 of the second selector E to pull up. After the relay 80 has had time to deënergize, which, of course, is not until after the line relay 83 of the second selector E has energized and until guarding potential has been supplied for the private bank contact 82, the release relay 63 of the first selector D is connected through to the conductor 84 by way of the third-position contact point of the side switch wiper 78, whereby the said relay 63 will be maintained energized after the line relay 57 deënergizes, as a result of the side switch passing to third position. It will be seen that the second selector E is practically the same as the first selector D, with the exception that there is provided an extra side switch wiper 85 for controlling the ground to the spring 86 instead of connecting the spring 86 direct to ground, as is the corresponding spring 65 in the first selector D. The object of this arrangement is to cut off the ground G^6 at the side switch wiper 85 from the trunk release circuit when the side switch passes from second position. Connection having thus been extended to the second selector, the subscriber operates the dial for the digit 3. In so doing he operates the line relay 83 in the same manner that the line relay 57 of the selector D was operated. The result is

that the vertical magnet 87 is operated to raise the shaft 88 and wipers 89, 90 and 91 to the third level. It will be understood, of course, that the private magnet relay 92 operates to control the private magnet 93, in a manner already explained, to cause the side switch to trip to second position. After the side switch passes to second position, in the manner already explained, the rotary magnet 94 operates to rotate the shaft to the proper trunk which, in this case, it will be assumed is the trunk terminating in the connector F (Fig. 5), the conductors 95, 96 and 97 of which are shown. Of course, the auxiliary relay 98 performs the same function as the relay 80 in the switch D. When the idle trunk is found the side switch of the selector E passes to third position, at which time the connection between the line and the connector is completed through the side switch wipers 99 and 100, as well as through the line wipers 89 and 91. Of course, as soon as the connection is extended to the connector F the line relay 101 of the connector energizes, separating the springs 102 and 103 and carrying the latter into engagement with the spring 104. The closure of contact between the springs 103 and 104 establishes an energizing circuit for the slow-acting release relay 105 from ground G^7 through the said springs 103 and 104 and through the relay 105 to the battery lead 21. The relay 105 upon energizing separates the springs 106 and 107, carrying the spring 107 into engagement with the spring 108, and at the same time closing the springs 109 and 110 into contact. The closure of circuit between the springs 109 and 110 sends current back over the trunk-release conductor 97 from ground G^8 for holding up the release relays 111 of the second selector F and 63 of the first selector D to prevent the release of these switches. The subscriber is now in readiness to operate his calling device according to the last two digits (2 and 0) of the desired number. The calling subscriber now operates his dial for the digit 2, thereby operating the line relay 101 of the connector F twice. As a result two impulses are sent through the vertical magnet 112 in series with the slow-acting private magnet relay 113. As a result the vertical magnet 112 raises the switch shaft 114 two steps and carries the wipers 115, 116 and 117 opposite the first contact of the second bank level. The relay 113 being in series with the magnet 112, and also being slow-acting, energizes on the first impulse and remains energized as long as the impulses continue to come in. This relay 113 upon energizing separates the springs 118 and 119, carrying the latter into engagement with the grounded spring 120. At the same time it will be seen that the spring 121 is separated from the spring 120. Closure of contact between the springs 119 and 120 establishes an energizing circuit for the private magnet 122 as follows: from ground G^9 through the said springs and through the said magnet 122 to the battery lead 21. The private magnet remains thus energized as long as the private magnet relay 113 remains energized, and in readiness to allow the side switch to trip to second position shortly after the impulses to the vertical magnet 112 are discontinued. When the side switch trips to second position it will be seen that the vertical magnet 112 is disconnected from the circuit, and the rotary magnet 123 is substituted therefor by the movement of the side switch wiper 124 from first to second position. The calling subscriber now operates his dial according to the last digit 0, thereby sending ten impulses and operating the line relay 101 ten times. As a result of this operation the rotary magnet 123 is operated ten times, and the shaft and shaft wipers are rotated ten steps into engagement with the normal bank contacts 125, 126 and 127 of the called subscriber's line. It will be seen that the private magnet relay 113 energizes in this instance just as it did in connection with the vertical magnet 112, and for this reason the private magnet 122 is operated in the same manner, remaining in readiness to trip the side switch to third position as soon as the impulses through the rotary magnet 123 cease, provided the called line is not busy. Should the called line be busy the connector side switch is locked in second position, as will be presently described. As soon as the side switch passes to third position the talking circuit is extended from the connector to the called subscriber's line through the medium of the side switch wipers 128 and 129. At the same time the retaining current for the trunk-release conductor 97 is changed from ground G^8 to G^7 through the action of the side switch wiper 130. It will also be seen that when the side switch wiper 124 passes to third position an energizing circuit is established for the ringing relay 131. This circuit extends from ground G^{10} through the interrupter 132, back-bridge relay springs 133 and 134, ringer relay 131, side switch wiper 124 (in third position), private magnet relay 113 to battery lead 21. It should be stated that the ringer relay 131 is a high resistance coil, while the relay 113 is a low resistance coil and does not pull up. The relay 131 energizes each time that the circuit is closed by the interrupter 132, and each time the relay 131 is energized the calling and called lines are disconnected from each other and the ringing current generator 135 is bridged across the called line to ring the bell 136. When the side switch wiper 137 passes to third position a guarding potential is provided for the connector private bank contacts of the called line, and a cir-

cuit is closed through the cut-off winding 138 of the line switch C'. The guarding potential for the called line extends from ground G^{11} through the side switch wiper 137, springs 139 and 140 and private wiper 116 to the contact 126, thence to the corresponding contact in the banks of all connectors which have access to the line of the substation A'. From the bank contact 126 a circuit extends over the conductor 141 and through the winding 138 to the battery lead 21. The winding 138, upon energizing, attracts the armature 142, whereby the springs 143 and 144 are forced out of engagement with the springs 145 and 146, respectively, and the spring 144 is forced into engagement with the spring 147. By this operation of these springs the ground G^{12} and the line winding 148 of the switch C' are disconnected from the called line, and the conductor 149 which leads from the bank contact 125 is extended to the negative side of the called line.

As soon as the called subscriber hears the signal of his bell 136 he, of course, removes his receiver from the hook, with the result that the spring 150 is separated from the spring 151 and carried into engagement with the spring 152. The separation of the springs 150 and 151 opens the circuit of the bell 136, while the closure of circuit between the springs 150 and 152 closes the talking circuit. The closure of the talking circuit causes the back-bridge relay 153 of the connector switch F to energize, which relay thereupon separates the springs 133 and 134, thereby breaking the energizing circuit of the ringer relay 131 and cutting off the ringing current. It will be seen that at the same time the springs 154 and 155 are also closed, but at this time this has no effect.

Had the called subscriber's line been busy it would have been impossible for the side switch of the connector F to trip to third position. As a matter of fact, the side switch would have been locked in second position, giving the calling subscriber the busy signal. A description of this operation is as follows: If the called subscriber is busy the private bank contact 126 (which is, of course, one of a number of private bank contacts connected in multiple) is grounded. Therefore, when the private magnet relay 113 falls back after having been energized in series with the rotary magnet 123, and, of course, after the connector has stopped on the called line, an energizing circuit is established through the lower winding of the back-bridge relay 153. This circuit extends from the grounded private bank contacts 126 of the busy called line to the private wiper 116, through the springs 140 and 139 of the auxiliary relay 156, through the lower winding of the relay 153 to the positive side of the talking circuit, thence through the ringer relay springs 157 and 158 and the side switch wiper 129 (in second position), thence through the springs 118 and 119 of the private magnet relay 113 (this relay being now deënergized) and through the private magnet 122 to the battery lead 21. The private magnet 122 having been energized up to this point, due to the contact between the springs 120 and 119 of the private magnet relay 113 while it was energized, is held energized even after the relay 113 falls back. It should be explained that the private magnet 122 has no opportunity to fall back while the relay 113 is deënergizing, because the spring 119 engages the spring 118 before it leaves the grounded spring 120, and the spring 118 is, of course, as just described, now connected with the private wiper 116, which in turn is connected with the grounded private bank contact. The private magnet 122 therefore continues to hold the springs 159 and 160 in contact, and as a result (as soon as the back-bridge relay 153 energizes due to the flow of current through its lower winding) the auxiliary relay 156 is energized by current flowing from ground G^9 at the private magnet relay 113, through the springs 120 and 121 and through said springs 159 and 160 to the said relay 156, thence through the back-bridge relay springs 154 and 155 to the battery lead 21. The relay 156 upon energizing shifts the energizing circuit for the private magnet 122 and for the back-bridge relay 153 by moving the spring 139 out of engagement with the spring 140 and into engagement with the grounded spring 161. During this change, however, the circuit is not interrupted; the only effect is that the private wiper 116 is disconnected from ground, and, therefore, no matter how long the connector F stays on the called line said line will not be made busy at this connector. In order to prevent the calling subscriber from further rotating the connector F after it has once stopped on a busy line, the springs 162 and 163 are provided on the auxiliary relay 156 for opening the circuit of the rotary magnet 123. This auxiliary relay is also provided with the springs 164 and 165 for sending a busy signal current to the calling subscriber when the connector finds a busy line. It will be seen from the operation described that the relay 156 sets up a locking circuit for the private magnet 122. This locking circuit is maintained until the calling subscriber releases. After the calling subscriber has established connection with the called subscriber, or after he gets the busy signal, he may release the apparatus brought into use by him by hanging up his receiver. This act opens the line circuit—that is, it separates the positive and negative sides of the line at the telephone, which operation initiates the release. As-

suming that the calling and called subscribers are connected, when the calling subscriber opens up his line circuit, as explained, the line relay 101 of the connector deënergizes. The result is that the springs 103 and 104 separate and the release relay 105 deënergizes also. This relay upon deenergizing permits the springs 106 and 107 to close into normal contact, and since now the line relay springs 103 and 102 are also in contact, an energizing circuit is established through the release magnet 166. This circuit extends from ground G^7 through the said springs 103 and 102, and 107 and 106, through the release magnet 166 and through the off-normal springs 167 and 168 (which were closed in contact upon the first vertical step of the shaft) to the battery lead 21. The release magnet 166 upon energizing withdraws the supports from the switch shaft which, under the force of a spring, rotates out of engagement with the bank contacts and then of its own weight falls to normal. Upon reaching this point the off-normal springs 167 and 168 are again separated, thereby breaking the energizing circuit of the release magnet. This release magnet 166, upon attracting its armature, not only restores the switch shaft as explained, but also drives the side switch back into normal position. This has the effect of finally restoring all of the circuits of the connector to normal, whether the connector has established connection with a called line or whether the connector F is locked on a busy line. In the event that the connector is connected with a called line the restoration of the said switch causes the holding circuit for the bridge-cut-off winding 138 of the line switch C′ of the called line to be broken, thereby restoring the line switch C′ of the called line to normal condition. If the connector is locked on a busy line, the act of restoring the said switch, among other things, causes the circuit of the auxiliary relay 156 to be broken, thereby disconnecting the busy signaling apparatus from the line. The deënergizing action of the relay 105 not only causes the restoration of the connector F, with the result described, but, by separating the springs 109 and 110, causes the restoration of the remaining apparatus. The separation of these two springs 109 and 110 breaks the energizing circuits for the release relays 111 and 63 of the second and first selectors E and D. Upon deënergizing, the release relay 111 of the selector E closes the energizing circuit for the release magnet 169. Normally the circuit of this magnet is open at the off-normal springs 170 and 171, but these springs are brought into contact at the first vertical step of the switch shaft 88. The energizing circuit for the said release magnet 169 extends from ground G^{13} through the line relay springs 172 and 173, and through the release relay springs 174 and 175 to the release magnet 169, thence through said magnet and through the off-normal springs 170 and 171 to the battery lead 21. The release magnet 169 upon energizing causes the release of the switch shaft of the selector in the same manner as the switch shaft of the connector was released, at the same time restoring the side switch to normal position. Of course, when the switch shaft reaches normal the energizing circuit for the release magnet 169 is broken by the separation of the springs 170 and 171. In the same manner, the release relay 63 of the first selector D causes the release of said switch at the instant that the release relay springs 67 and 68 come into contact. The circuit, of course, in this instance, extends from ground G^4 through the line relay springs 61 and 60 and through said release relay springs 67 and 68, release magnet 176 and off-normal springs 177 and 178 to the battery lead 21. It will be seen that, upon deënergizing, the release relay 63 breaks the retaining circuit for the line switch C by separating the springs 64 and 65. The result is, of course, that the armature 29 of the line switch is restored and the bank springs 30 and 31 are disconnected, as well as the bank springs 32 and 33, the springs 34 and 35 and the springs 36 and 37. It should be understood that the plunger armature 29 of the line switch C does not return into engagement with the plunger shaft controlled by the master switch H until the master switch H advances to a position where the master switch wiper 46 engages the bank contact 45 corresponding to the trunk which the line switch C has been using. It is not until after this occurs that the plunger attached to the plunger armature 29 is advanced from the trunk terminating in the selector D (Fig. 4). This advancement occurs when the master switch H moves upon the initiation of a call by some other subscriber of the same group. If the subscriber A should make a call before the master switch has reached such a point, the armature 29 will cause the plunger to again close the same set of bank springs 30, 31, etc., thereby extending connection to the same first selector D again.

It should be stated that the release mechanism of the selectors E and D, as well as of all the other selectors shown herein, is so arranged that the shaft and side switch are restored to normal position immediately upon the energization of the release magnet, rather than by its deënergization, as shown in said selector Patent No. 815,321. This type of release mechanism is the same as is employed on the connector switches shown herein and as disclosed in said Patent No. 815,176.

Referring again to Fig. 1, if the subscriber A desires to establish connection with the subscriber A^2 of the second hundred in the second thousand, whose line terminates in a district office, the operation is as follows: Upon removing his receiver the subscriber A operates his line switch C, which places subscriber A in connection with a first selector, first selector D, for example. The subscriber A then operates his dial, sending in two impulses in order to reach the second thousand. In so doing, the shaft of the first selector is raised to the second level, to which are connected the second selectors, from which latter the connectors of the second thousand are accessible, among these the connectors of the second hundred group, where the desired subscriber is located. The selector D then automatically rotates and establishes connection with an idle second selector, second selector E, for example. The subscriber A again operates his dial and sends in two impulses, thereby raising the switch shaft of the second selector E to the second hundred level. In this level the switch automatically rotates and picks out a trunk line running to the two-hundred district station, which trunk contains a repeater I (Fig. 6). This trunk, it will be assumed, terminates in a connector F', the same in all respects as the connector F (Fig. 5) but for the omission of the springs 109 and 110 and the side switch wiper 130. The subscriber now operates his dial for the last two digits of the called subscriber's number, which, it will be assumed, is 2220. In that event the dial is now again operated, first to send in two impulses and then to send in ten impulses. Referring to Figs. 4, 5 and 6, it will be seen that the extension of the call to the repeater I (Fig. 6) by way of the line switch C, first selector D and second selector E is the same as the extension of the call to the connector F, where subscriber #2320 was called, with this exception: that in this instance the second selector E is raised to the second level, in which level it is assumed that the wipers 89, 90 and 91 stop on the contacts of the trunk conductors 179, 180 and 181, in connection with the repeater I (Fig. 6), in which event it establishes connection with the connector F'. It will be seen that in this connection the repeater I has to supply the holding or retaining circuit for preventing the release relays 111 and 63 of the selectors E and D from deënergizing. This holding circuit is established just as soon as the second selector E extends connection to the repeater I. It will be seen that this repeater I is provided with a line relay 182, which line relay energizes in the same manner as the line relay 101 of the connector F—that is, this relay 182 having one side connected to ground and the other side to non-grounded battery, an energizing circuit is therefore established through the telephone as usual. Upon energizing, this relay 182 shifts the springs 183 and 184 into engagement with the springs 185 and 186. The closure of contact between the springs 183 and 185 sets up an energizing circuit for the slow-acting relay 187, which in turn, by pressing the springs 188 and 189 into contact, closes the holding circuit for the release relays 111 and 63 referred to. It will be understood that the conductors 190 and 191 (to the right of the condensers 192 and 193) terminate in the connector F', as already explained. In describing this connection the connector F will be substituted for the connector F', since, with the exception noted, the two are alike, and telephone A^2 is substituted for the telephone A' because these two are also alike.

With this understanding, then, it will be seen that the conductor 190 will be connected to the conductor 95, and that the conductor 191 will be connected to the conductor 96; but, as already stated, the conductor 97 is omitted when the connector F acts as the connector F'. It will be seen, therefore, that as soon as the line relay 182 of the repeater I presses the springs 184 and 186 into contact, the line relay 101 will be energized, shifting the spring 103 onto the spring 101 and energizing the relay 105. The operation of this relay 105 has already been explained, it being seen that in the present connection the springs 109 and 110 are to be ignored. Having extended his connection to the connector F, the subscriber A is now ready to operate his dial in accordance with the last two digits of the number desired, namely the digits 2 and 0. In response to the two impulses corresponding to the digit 2 the relay 182 of the repeater I responds twice, which in turn, by operating the springs 184 and 186, operates the line relay 101 of the connector. The connector, of course, responds to raise the shaft two steps. The subscriber now operates his dial, sending in the last impulses (ten in number) and causing the line relay 182 of the repeater to respond, which relay in turn operates the line relay 101 of the connector in a similar manner. The result is that the connector is rotated and carried into engagement with the desired line. If the called line is idle the subscriber thereof will be signaled, and when he answers the signaling current will be cut off, as already explained. If the called subscriber should be busy the relay 156 will operate to lock the side switch in second position and to send a busy signal current to the calling subscriber. It will be seen (in the operation of the repeater I) that the relay 187, being a slow-acting relay, does not permit its armature to fall back while the impulses are being transmitted. However, when a calling subscriber hangs up his receiver to re-

lease, he opens his line circuit and thereby permits the line relay 182 of the repeater to fall back which remains deënergized for a sufficient length of time to permit the relay 187 to also deënergize. When the line relay 182 separates the springs 184 and 186, the line relay 101 of the connector also deënergizes, causing the release of the connector switch in a manner already explained. Of course, the relay 187, by separating the springs 188 and 189, breaks the energizing circuit for the release relays 111 and 63 of the selectors E and D, thereby causing the release of these switches and of the line switch C in a manner already explained.

Referring again to Fig. 1, if the subscriber A wishes to call the subscriber A^3 in the 3200 district office he does it in exactly the same manner as he calls the subscriber No. 2220—that is, the subscriber A operates his line switch C, establishes connection with a first selector D; the first selector D then operates to raise the switch shaft to the third level for reaching the third thousand, establishing connection with a second selector E'. The second selector E' is then operated to raise the wipers to the second or two-hundred level, in which level connection is made with a connector F^2 in the 3200 district office. This connector is operated through the repeater I' to establish connection with the desired subscriber A^3. It will be seen that in this 3200 district two separate groups of connectors have access to the subscribers. The reason for this difference is that local subscribers, as will be later described, establish their connections locally—that is, they do not have to operate the selectors in the main exchange. If, however, the subscribers in this district wish to call subscribers anywhere else the switches at the central office must be operated.

If the subscriber A wishes to establish connection with the automatic subscribers J or the manual subscribers K in the private branch board L of the 2100 group he must do so through an operator's board. This board is indicated by a square divided into two sections. In the upper section are shown two groups of circles indicating the subscribers' multiples on the right, and trunk jacks to the main exchange on the left. In the lower section are shown two groups of circles, the group on the right indicating the subscribers' line signals and jacks and on the left line signals and jacks of incoming trunks. If the subscriber A wishes to call the automatic subscriber A^4 of the automatic group in the private branch exchange he operates his line switch C, establishes connection with a selector D, which latter is operated to raise the wipers to the second level, by way of which level connection is made with a second selector in the second thousand, second selector E, for example. The second selector E is then raised to the first level and rotated to establish connection with an idle rotary connector in the first hundred, rotary connector M (Fig. 17), for example. This rotary connector is then raised to the second level and rotated over a group of trunks running to the private branch exchange board L (#2121), each trunk of which group terminates in a jack *c* (Fig. 9). When the rotary connector finds an idle one of these trunks, the operator at the district board L is signaled. The operator may then connect the calling subscriber with any one of the subscribers of this board, whether manual or automatic, and if the subscriber A wants the subscriber A^4 the operator simply connects the subscriber A^4 with the trunk over which she has been signaled through the cord N, thereby completing the connection. Referring to Figs. 4, 5, 9 and 17, a more detailed description of the connection is as follows: The operation of the line switch C, first selector D and the second selector E, through which connection is established with the rotary connector M, is already understood, having already been described, and no further description need be made up to this point. From this point on the operation is as follows: The second selector E (Fig. 4) having been raised to the first level and having been rotated into connection with the trunk conductors 194, 195 and 196, and the connection having thus been extended to the rotary connector (Fig. 17), the line relay 197 is energized through the telephone A in the same manner as the line relay 101 of the connector F (Fig. 5) was energized. This relay, upon energizing, operates like the line relay of the connector F to separate the springs 198 and 199, carrying the latter into engagement with the spring 200. The effect of placing the springs 199 and 200 in contact is to energize the slow-acting release relay 201, which relay is similar to the relay 105 of the connector F. This relay 201 upon energizing separates the springs 202 and 203, carrying the latter into engagement with the spring 204, and at the same time pressing the springs 205 and 206 into contact. By coming into contact, the springs 205 and 206 close the holding circuit through the trunk-release conductor 195 for the release relays 111 and 63 of the selectors E and D to prevent their release. The subscriber is now ready to send in the first set of impulses for raising the switch shaft of the rotary connector to the desired level. In this instance the number of impulses will be two, since it will be assumed that the number of the subscriber at the private branch board L is 2121. These impulses operate the line relay 197 twice, which relay, operating like the line relay of the connector F (Fig. 5), sends two impulses to the vertical magnet

207. Of course, the slow-acting relay 201 does not deënergize during the transmission of these two impulses. It will be seen that the slow-acting private magnet relay 208 is in multiple with the vertical magnet 207. Therefore, at the first impulse through the magnet 207 the relay 208 also energizes and, being slow-acting, remains energized until after the impulses have been delivered through the magnet 207. The relay 208 upon energizing presses the springs 209 and 210 into contact, thereby closing an energizing circuit for the private magnet 211. This private magnet remains energized as long as the relay 208 remains energized, but deenergizes when all of the impulses to the vertical magnet 207 have been sent in, for the purpose of permitting the side switch to trip to second position. The switch shaft having been raised to the second level, the subscriber is now ready to operate his dial in accordance with the last digit 1. When he does so the line relay 197 falls back once, thereby sending an impulse from ground G^{14} through the line relay springs 199 and 198, and through the release relay springs 203 and 204 to the private magnet springs 212 and 213, through the rotary magnet 214, through the side switch wiper 215, thence to the battery lead 21 and to battery B. At the same time the impulse passes through the slow-acting relay 208 over another branch, causing this relay to energize and remain energized as long as the impulses are coming in. As in the previous instance, this relay 208 again energizes the private magnet 211 by pressing the springs 209 and 210 into contact, which private magnet 211 remains in readiness to trip the side switch to third position. This impulse, of course, also energizes the rotary magnet 214. The object in allowing the impulse that energizes the rotary magnet to pass first through the private magnet springs 212 and 213 is to insure a long enough impulse to the rotary magnet, which would not be long enough if it had to wait until the relay 208 energized. It is assumed there are nine contacts running from the second level of the rotary connector M to the private branch board L. Upon rotating the shaft, the rotary magnet 214 advances the private wiper 216 into engagement with the first private bank contact of the second level. If the first trunk running to the private branch is busy, the private wiper 216 will strike ground; and since the side switch is in second position the auxiliary private magnet relay 217 is energized through the side switch wiper 218. The relay 217 upon energizing presses the springs 219 and 220 into contact, thereby closing a new energizing circuit for the private magnet 211 from ground G^{15} through said springs 219 and 220. As long as the private wiper 216 continues to find a busy trunk the relay 217 will continue to remain energized; and, therefore, the private magnet 211 will continue to remain energized and thus maintain closed the energizing circuit for the rotary magnet 214, which advances the line wipers 221 and 222 from trunk to trunk until an idle one is found. As soon as such a trunk is found the energizing circuit of the relay 217 is broken, and the private magnet 211 will permit the side switch to pass to third position, thereby extending connection from the calling subscriber to the operator at the branch board L. Referring to the slow-acting relay 208, it will be seen that the energizing circuit for the magnet 214 (through the medium of which the shaft and wipers are propelled in their search for an idle trunk) comprises the interrupter springs 223, private magnet springs 224 and 225 and the springs 226 and 227 of the slow-acting relay 208. Further, it will be seen that the primary or preliminary energizing circuit for the rotary magnet 214, after the private magnet 211 is energized, is maintained through the springs 227 and 288 of the same relay 208. Connection having been extended to the operator at the private branch board L, this operator is signaled by current sent out over the selected trunk, the conductors 229 and 230 of which are shown in Figs. 17 and 9. The current for signaling this operator flows from ground G^{15} through the side switch wiper 218 (in third position), through the lower winding of the coil 231, through the ringer relay springs 232 and 233, through the side switch wiper 234 (in third position), line wiper 222 to the trunk conductor 230 (positive side), springs 235 and 236, signal relay 237, jack springs 238 and 239, trunk conductor 229 (negative side), line wiper 221, through the side switch wiper 237^a, ringer relay springs 240 and 241, back over the upper winding of the relay 231 to the battery lead 21. As a result of establishing this circuit the double-wound back bridge relay 231 of the rotary connector M energizes in series with the line signal relay 237 at the operator's board. The result of energizing the relay 231 is that the energizing circuit for the ringer relay 242, which would have been established if an ordinary subscriber's line had been called, is prevented from being established. Of course, the result of energizing the signal relay 237 is that the operator is signaled by the glowing of the lamp 243. Upon receiving the signal the operator inserts the plug *b* into the jack *c*, thereby cutting off the relay 237 and substituting the coil 244 in the cord N for the coil 237, thus maintaining the energizing circuit of the double-wound relay 231 in the rotary connector M. It should be stated that the battery B in Fig. 17 is of higher voltage than the battery B'; there-

fore, there will be a flow of current through the upper winding of the relay 231 at the connector M and through the upper winding of the relay 244 at the cord circuit N sufficient to energize both of these relays. Of course, when the relay 244 energizes it attracts its armature and opens the circuit of the front supervisory lamp 245. After plugging in, the operator throws the key *d*, thereby bridging the talking set *e* across the line, and asks the calling subscriber the desired number. It will be seen that the talking circuit extends over the heavily marked conductors and includes the condensers 246 and 247 in the cord circuit N, as well as the condensers 248 and 249 in the connector M. The calling subscriber may then call for the subscriber A^4 (Fig. 9), giving the name of the party desired or the local number, as, for example, #22, which number it is assumed is the local number of subscriber A^4. The operator thereupon restores the key *d* and inserts the plug *b'* into the jack *c'* and, after doing so, presses the ringing key *d'*, thereby signaling the subscriber A^4. Upon restoring the ringing key *d'* the calling and called lines will be left connected, and when the called subscriber A^4 removes his receiver he will be in readiness to answer the calling subscriber. It will be seen that as soon as the plug *b'* is inserted in the jack *c'* a circuit is established for the relay 252^a from ground G^{16} to the sleeve 251, thence to the sleeve 252 of the plug *b'* and through the relay 252^a to battery. The relay 252^a, upon energizing, operates to complete a circuit from ground G^{27} through its armature, contacts of the back supervisory relay 253, through the lamp 250 to the battery B'. As soon as the called subscriber removes his receiver, however, the relay 253 energizes and causes the lamp 250 to be put out, thereby giving the signal to the operator that the called subscriber has answered. After the subscribers are through talking the subscriber A may hang up the receiver, thereby causing the line relay 197 of the rotary connector M to deënergize. As a result thereof the slow-acting release relay 201 also deënergizes, thereby permitting the springs 202 and 203 to fall into contact and at the same time separating the springs 205 and 206. Since at the first vertical movement of the switch shaft of the connector M the off-normal springs 254 and 255 were brought into contact and the energizing circuit for the release magnet 256 was partially closed, it follows that the closure of contact between the springs 202 and 203 now causes the said release magnet 256 to energize. This release magnet energizes in the manner described in connection with the connector F (Fig. 5), there being no difference in the general principles of operation between the switches M and F, thus restoring the switch shaft and side switch of the connector M. Of course, the separation of the springs 205 and 206 of the relay 201 causes the release relays 111 and 63 of the second selector E and of the first selector D, respectively, to deënergize, thereby bringing about the restoration of both of these switches, as well as of the line switch C, as already explained. When the connector M disconnects from the trunk conductors 229 and 230, the relay 244 at the cord N deënergizes and permits the lamp 245 to energize, thereby giving the operator the disconnect signal. Likewise, when the subscriber A^4 hangs up his receiver the relay 253 deënergizes and the lamp 250 lights, giving the operator the back disconnect signal. Upon receiving these signals the operator withdraws the plugs from their jacks. It should be explained that had the rotary connector M found all of the trunks to the board L busy, the switch would have rotated beyond all of these trunks and would have stopped with the wiper 221 on the bank contact 257. Upon stopping, the side switch would have passed to third position and an energizing circuit would have been set up for the busy relay 258. The flow of current in this circuit would be from ground G^{17} through the said relay 258, bank contact 257 and wiper 221, through the side switch wiper 237^a, ringer relay springs 240 and 241, upper winding of the relay 231 to the battery lead. The relay 258 upon energizing will press the springs 259 and 260 into contact, thereby connecting the busy signaling apparatus *f* with the calling line through the condenser 249 on the positive side of the line, and giving the calling subscriber the busy signal. The calling subscriber, of course, upon receiving the busy signal, will release the connector in the manner already explained. It is obvious that had the calling subscriber A desired to connect with either of the subscribers A^5 or A^6 at the branch exchange L (Fig. 9), the operator would have connected with the line called for instead of with the line of subscriber A^4. The operation would have been the same.

Had the subscriber A desired to connect with the office O or with the office P in the 2100 group, the lines running to which (as shown in Fig. 1) terminate directly in the bank contacts of the rotary connector M, and of the other rotary contacts in the same group, the only difference between this connection and the connection when the operator at the branch exchange L was called would be that the rotary connector would have been raised to some other level corresponding to the office O, or to the level corresponding to the office P; and that the called subscriber would have been automatically rung. It is to be understood that each

of the offices O and P is provided with a number of trunks, just as the office L was provided with a number of trunks. Assuming that the subscriber A desires to call the office P, the number allotted to which, it will be assumed, is 2131, the rotary connector M, after being raised to the third level and started rotating, will continue to rotate until an idle line is found, for example, the line terminating in the telephone A^7. Upon finding an idle line the connector M stops rotating, as already described, and its side switch passes to third position. The telephone of the subscriber A^7 is, of course, the same as the telephone of the subscriber A' (Fig. 5) and, therefore, as soon as the connector stops on this line the energizing circuit for the ringer relay 242 is set up. This energizing circuit is, as shown, an intermittent one, under the control of the interrupter 261. Each time that the ringer relay 242 energizes, the ringer generator 262 is thrown across the line of the called subscriber A^7 and, therefore, the bell at that station is rung. As soon as the called subscriber answers, the line circuit is, of course, closed, as already explained, and as a result the back-bridge relay 231 energizes, cutting off the ringing current. As soon as the subscribers are through talking the calling subscriber, by hanging up his receiver, will release the apparatus in a manner already explained. The subscriber A^8 (group 0) would be called by raising the connector M to the first level instead of to the third, assuming the number of the office O is 2111.

If the subscriber A had decided to call any one of the subscribers in the 3100 district office, subscriber A^9, for example, he would establish his call in much the same manner as with the subscriber A^2. Assuming that the number of the subscriber A^9 is 3120, the subscriber A would remove his receiver, operate his line switch C and establish connection with the first selector D, for example. (See Fig. 1). The selector D will then be raised to the third level, thereby extending the connection to the second selector E', for example. The second selector E' is in turn operated and raised to the first level, thereby obtaining connection with one of the connectors in the 3100 district office, connector F^3, for example. The connector F^3 is in turn operated and raised to the second level, being then rotated into engagement with the tenth contact, which is the terminal of the line #3120. In the 3100 district office there are both automatic and manual subscribers, as indicated by the letters J and K, and the connection might just as easily have been made with one of the manual subscribers as with one of the automatic subscribers, since both classes of subscribers have their lines terminating in the connectors indicated, among which is the connector F^3 already referred to. Connection having been established, the release is the same as in the case when the subscriber A^2 was called. It will be seen that the connection with the subscriber #3120 is made through a repeater I^2, indicated by the trunks running to the 3100 district exchange, just as the connection to the subscriber A^2 was made through the repeater I.

If the subscriber A desires to establish connection with a subscriber in the 3311 private branch exchange L' (Fig. 1), subscriber A^{10}, #3311—*n*, for example, the operation is as follows: He removes his receiver and thereby operates his line switch C to establish connection with a first selector, selector D, for example. The first selector D is then operated and raised to the third level, thereby extending the connection to a group of second selectors in the 3000 division, the second selector E', for example. Having established connection with the second selector E', this switch is operated to raise its shaft and wipers to the third level, thereby extending the connection to a rotary connector in the 3300 level, rotary connector M', for example. It will be understood that this rotary connector M' is in all respects like the rotary connector M shown in Fig. 17. This rotary connector is then operated to raise its wipers to the first level, from which level, as indicated, a number of trunk lines run to the operator's board in the 3311 branch exchange. As indicated, these trunks terminate in cords of the character shown in Fig. 16. As soon as the rotary connector M' stops on one of these cords, cord N', for example, the disconnect signal coil 264 energizes in series with the back-bridge double-wound coil of the rotary connector. Since the rotary connectors M' and M are identical, in order to save space reference will be made to the rotary connector M (Fig. 17) in this connection instead of connector M'. This double-wound back-bridge coil of the rotary connector (see coil 231, Fig. 17), upon energizing, as already explained, opens the energizing circuit of the ringer relay (see relay 242), thereby preventing ringing current from passing to the cord circuit N' when connection is made with such a cord. At the same time the signal relay 265 at the cord circuit N' energizes and attracts its armature, closing a signaling circuit through the signal lamp 266 from the battery, through the said lamp 266 and conductors 267 and 268 to the lamp and contact 269 and to ground G^{18}. Upon seeing the signal the operator throws the key d^4 and bridges her talking set on the line. The operator then inquires the number desired of the calling subscriber, whereupon the calling subscriber gives the name of the local subscriber, subscriber A^{10}, #3311—*n*, for example. The

substation A^{10} is the same as the substation A^{15} (Fig. 11), with the exception that the contacts 641, 642 and 630 are omitted. Upon learning the number desired the operator inserts the plug b^2 into the jack c^2 Fig. 1, (see jack c^8, Fig. 11) of the subscriber A^{10} (Fig. 11), thereby completing the connection. Upon lifting the plug the operator permits the springs 271 and 272 to separate, thus putting out the lamp 266. When she plugs into the jack c^2, Fig. 1, (see c^8, Fig. 11), the single-wound relay 314 and the differential relay 275 pull up. The energizing circuit for these two relays may be traced from ground G^{19} through the springs 632 and 631, through the relay 314, through the sleeve 313 of the jack c^2, thence through the sleeve of the plug b^2 and through the left-hand winding of the relay 275 to battery. The relay 314 upon energizing shifts the spring 315 away from the spring 633 and into engagement with the grounded spring 316. The separation of the springs 315 and 633 breaks the energizing circuit of the relay 628 in order to prevent this relay from energizing under any conditions while the relay 314 is energized. The pressing into contact of the springs 315 and 316 closes an energizing circuit through the bridge-cut-off winding 318 of the line switch C^3. When the relay 275 pulls up it attracts its armature and puts ground on the conductor for the purpose of energizing the relay 609^a and lighting the lamp 609. When the called subscriber answers, the relay 608 energizes in the usual manner, thereby bridging the upper winding of the relay 608^a across the trunk conductors 605 and 606 in multiple with the winding 264. The relay 608^a, upon energizing, connects its lower winding in multiple with the lamp 609, thereby forming a locking circuit for itself and shunting the lamp sufficiently to cause it to cease to glow. After the subscribers are through talking the calling subscriber may release all of the automatic apparatus brought into use by hanging up his receiver in the manner already described, thereby giving the operator the disconnect signal through the medium of the lamp 610. Upon receiving the disconnect signal the operator withdraws the plug b^2 from the jack, restoring the circuit of the line A^{10} and then, by permitting the plug b^2 to assume its normal position, presses the springs 271 and 272 together. Thus far it has been shown how the subscriber A of Fig. 1 may call any other subscriber in the same figure. It will now be shown how the subscriber A may call any of the subscribers of Fig. 2. The subscriber A may desire to call any of the subscribers, subscriber A^{11}, for example, connected with the tollboard L^3 in Fig. 2, three groups of such subscribers being shown and indicated by the letter K. In calling any one of these subscribers the subscriber A (in the same manner as already explained in the call between subscribers A and A^{10}) establishes connection with any one of the rotary connectors in the 3300 group, the rotary connector M', for example. This rotary connector is then operated to raise the shaft wipers to the third level, assuming that the number of the tollboard is 3331. The rotary connector M' automatically rotates to establish connection with any one of the trunks running to the tollboard 3331 which may be idle. Each one of these trunks terminates in a jack c^3 (Fig. 12). Upon receiving the signal the operator inserts the answering plug b^3 of the cord N^2 (Fig. 12) into the jack c^3, and then throws the key d^3 to talking position and inquires the number desired. Upon learning the number of the subscriber desired the operator inserts the calling plug b^4 into the multiple jack c^4 of the subscriber A^{11}, #3331—n, and rings the subscriber desired. It will be understood that the back-bridge coil of the rotary connector (see back-bridge coil 231, Fig. 17) pulls up through the coils 276^a and 276 of the cord circuit. After the subscribers are through talking the calling subscriber, by hanging up his receiver, releases the automatic apparatus and gives the operator the front disconnect signal at the cord N^2, and the back disconnect signal is given when the called subscriber hangs up. These signals are given through the medium of the relays 277 and 278. Referring to the tollboard in Fig. 2, it will be seen that four horizontal sections are indicated, sections L, B, A and M. The division L is intended to indicate the subscribers' line signals; the division B is intended to indicate the line signals coming from an A-operator, in which case the operator at the tollboard is acting as a B-operator; the section A is the section of multiple jacks, the trunks leading from which terminate in automatic switches; the section M is a multiple section, there being indicated the multiple jacks of subscribers. This arrangment is carried out on all boards shown.

If the subscriber A wishes to obtain connection with any of the subscribers connected to the board L^3, subscriber A^{12} (Figs. 2 and 12), for example, he removes his receiver, operates his line switch C^1, operates the first selector D to the fourth level and extends connection to a second selector E^2 (Fig. 1), assuming that the subscribers connected with the board L^3 are in the 4000 group, from which second selector connection is extended to a connector having access to the group of subscribers of the board L^3, among which is the one desired. The normals of all the subscribers of the board L^3, it is assumed, are contained in the cables 280^a. It will be understood that if the sub-

scribers connected with the board L^3 are not more than one hundred in number they may be taken care of with one group of connectors; but if the number of subscribers is greater, additional groups of connectors are required, which groups are reached from separate levels of the second selectors, such as selector E^2. Assuming that the number of the subscriber desired by the subscriber A in this particular instance is 4120, the first selector D is raised to the fourth level, from which level connection is established to a second selector E^2. The second selector is then raised to the first level and connection extended to a connector, connector F^4, for example. This connector, it will be understood, is in all respects the same as the connector F (Fig. 5). The connector F^4 is then operated to raise its wipers to the second level, after which it is rotated to establish connection with the last line in that level, thereby completing connection with the line #4120. When the connector F^4 connects with this line #4120 its shaft wipers (see wipers 115, 116 and 117) will stop in engagement with the bank contacts 280, 281 and 282. The negative line wiper 115 (taking the connector F for the connector F^4) will therefore be in engagement with the normal contact 280, the positive wiper 117 with the contact 281 and the private wiper 116 with the contact 282. Through the medium of the private wiper 116 the connector switch grounds the private bank contact 282, with the result that the relay 284 is energized. Upon attracting its armature this relay presses the springs 285 and 286 into contact. The closure of contact between the springs 285 and 286 closes an energizing circuit through the cut-off relay 287 of the subscriber's line. Upon energizing, the cut-off relay 287 attracts its armatures 288 and 289, disconnecting these armatures from the line conductors 290 and 291. The armature 288, however, is carried into engagement with the contact 292, which is of no significance at this time. As soon as the connection is thus made with the desired telephone the connector F sends ringing current out to the called telephone line from the ringer generator 135 each time that the ringer relay 131 is energized, as a result of the action of the interrupter 132. This ringing current, of course, reaches the called line through the line wipers 115 and 117 and through the bank contacts 280 and 281, thence to the line conductors 290 and 291. The called subscriber, in answering, closes his line circuit through the transmitter 293, thereby causing the back-bridge coil 153 to energize and cut off the ringing current. After the subscribers are through talking the calling subscriber will, by hanging up his receiver, release all of the automatic switches and break the connection; and as soon as the connector switch leaves the bank contacts 280, 281 and 282 the line equipment of the subscriber A^{12} is restored to normal. By referring to the line equipment shown in Fig. 12, it will be seen that the auxiliary relay 284, by pressing the springs 285 and 286 into contact, as explained, not only causes the energization of the relay 287, but also provides a guarding potential at the sleeves 295. It will be seen that the relay 284 connects with the non-grounded battery through the jack springs 298, 299, 300 and 301. The object in providing these springs is to disconnect the relay 284 from battery whenever a plug is inserted in a jack, in order to prevent the relay 284 from energizing. This may also be done by adding two normally closed springs to the relay 287, and connecting the relay 284 to battery through them instead of through the springs 298, 299, 300 and 301 (see Fig. 12^a). With this arrangement the relay 284 energizes only when an automatic switch grounds the private bank contact 282. By referring to Fig. 14, one of the line circuits A^{13} of the subscribers K (whose line terminates in line switches such as the line switch C^2, Fig. 2) will be seen. Had the subscriber A called the subscriber A^{13}, #4320, (Fig. 14), for example, instead of the subscriber A^{12} (Fig. 12), the wipers of the connector F^5 would have stopped on the normal bank contacts 302, 303 and 304 corresponding, respectively, to the bank contacts 280, 281 and 282. By grounding the private bank contact 304 the connector switch will cause the energization of the bridge-cut-off winding 305 of the line switch C^2, whereby the bridge-cut-off armature 306 is attracted, separating the springs 307 and 308 from the springs 309 and 310 and pressing the spring 307 into engagement with the spring 311. By this operation the line switch is rendered inoperative for the time being and connection is extended to the called subscriber's line. The subscriber A^{13} is signaled just as the subscriber A^{12} was signaled, and when he responds by removing his receiver the closure of the line circuit cuts off the ringing current, as already explained. After the subscribers are through talking the calling subscriber, by hanging up his receiver, restores all of the automatic switches and therefore breaks the connection. As soon as the connector switch is disconnected from the bank contacts 302, 303 and 304 (Fig. 14) the line switch C^2 is restored to normal position.

If the subscriber A desires to establish connection with any one of the manual toll subscribers whose lines terminate in the toll-board L^4 (Fig. 3), subscriber A^{14}, for example, whose number it will be assumed is 3321—*n*, the operation is as follows: Assuming the number of the subscriber desired in the board L^4 to be 3321, by removing his

receiver the subscriber A operates his line switch C and establishes connection with the first selector D. He then operates his dial, raising the wipers to the third level and establishes connection with the second selector E′. The dial is again operated to raise the wipers of the selector E′ to the third level, establishing connection with a rotary connector M′. The dial is now again operated twice, first to raise the shaft to the second level and then to rotate it one step to switch the wipers into this level. In this level the rotary connector picks out an idle trunk terminating in the tollboard L^4. This trunk terminates at the board L^4 in a jack e^5 exactly like the jack e^3 (Fig. 12). Upon receiving the signal the tollboard operator answers in the usual manner (as when the plug b^3 was inserted in the jack e^3) through the cord circuit N^4, which cord circuit is exactly the same as the cord circuit N^2 (Fig. 12). It will be understood that since the cords N^2 and N^4 are identical, the reference characters used for cord N^2 will be used as reference characters for the cord N^4. Upon ascertaining the number desired, the operator then completes the call as usual by plugging into the multiple jack of the desired line, just as the plug b^4 of the cord N^2 was inserted in the jack e^4 of the line A^{11}. The subscriber A^{14} is then signaled and the subscribers left to communicate with each other. When the subscribers are through talking the calling subscriber, by hanging up his receiver, releases all the automatic switches and thereby gives the operator at the cord N^4 the disconnect signal. Also, upon hanging up his receiver the called subscriber gives the operator the disconnect signal, whereupon the operator takes down the cord. If the subscriber A desires connection with one of the subscribers in the private branch exchange L^5 (Fig. 3), as, for example, with subscriber A^{15}, connection is established with the tollboard operator L^4 by calling the number 3321, as in the previous instance. Upon receiving the signal the operator ascertains the number desired. Upon learning that the subscriber A^{15}, #3321—n, of the private branch exchange L^5 is desired, she extends connection to a cord N^5 at the board L^5, which cord is exactly like the cord N^3 (Fig. 13). As usual, this cord is assigned over the order wire Q (Figs. 12 and 13), and connection is extended by inserting the plug b^4 in the jack e^7. This last operator then completes the connection with subscriber A^{15} by inserting the plug b^6 in the jack e^8 of the desired subscriber. The telephone and line equipment of the subscribers A^{10} and A^{15} are also the same. When the operator plugs into the jack e^8 non-grounded battery is supplied at the sleeve 313, which battery causes the relay 311 to energize. This relay upon energizing presses the springs 315 and 316 into contact, thereby supplying ground to the private normal conductor 317 for making the line A^{15} busy to all other local subscribers. This ground connection to the conductor 317 causes the bridge-cut-off winding 318 of the line switch C^3 to energize, whereupon the bridge-cut-off armature 319 is attracted, rendering the line switch C^3 inoperative for the time being. After the subscribers are through talking, if the calling subscriber hangs up his receiver he releases the automatic apparatus and therefore breaks the connection to the tollboard L^4. The operator thereupon receives the disconnect signal on the calling side of the cord circuit N^4 (see lamp 320 at the cord N^2, Fig. 12). When the called subscriber hangs up he in turn gives the A-operator at the board L^4 a disconnect signal in the usual manner by lighting the lamp 321 (Fig. 12) at the A-cord N^4 through the B-cord N^5 at the branch exchange L^5. When the operator sees both signals she takes down the cord N^4, thereby giving the operator N^5 at the exchange L^5 the disconnect signal in the usual manner through the lamp 322. Upon receiving this signal the B-operator takes down the cord N^5. If the subscriber A wishes to call one of the subscribers at the manual board L^6 (Fig. 3) whose lines terminate directly in the board L^6, he calls the toll operator L^4 as before. Upon receiving the signal the toll operator answers through the cord N^4, for example, and upon ascertaining the subscriber desired, subscriber A^{16}, #3321—n, for example, she plugs into the multiple jack e^9 (exactly like the jack e^4) at the tollboard L^4. It will also be understood that the equipment of the subscriber A^{16} is the same as the equipment of the subscriber A^{11} shown in Fig. 12, and it will also be understood that this subscriber, as well as all other subscribers of the same kind, have multiples not only in the board L^4, but also in the board L^6, as indicated in Fig. 3.

If the subscriber A wishes to establish connection with one of the manual subscribers in Fig. 3 associated with the board L^5, the lines of which terminate in line switches in district apparatus, the subscriber A^{17}, #3321—n, for example, he establishes connection with the tollboard L^4 as before. Upon receiving the signal at the jack e^3 (Fig. 12) the operator answers the call through the cord N^4, for example, and upon ascertaining that the subscriber A^{17} is desired she extends the call through the jack e^{10} to the secondary switch C^4 (Fig. 15) and to the cord N^6. The result is the same as when the plug b^4 of the cord N^2 is inserted in the jack e^{10}, which is as follows: Upon inserting the plug b^4 into the jack e^{10} (Fig. 15) the secondary line switch C^4 is operated to

establish connection with a trunk running to the board L^7 (Fig. 3). The line switch C^4 is operated by the energization of the pull-in magnet 323. The energizing circuit may be traced from ground G^{25} (Fig. 12) through the coil 324, conductor 325, sleeve 326 of the plug b^4, sleeve 327 of the jack c^{19}, conductor 328, through the magnet 323, springs 329 and 330, through the springs 331 and 332 to the battery lead 21, thence through battery to ground G^{20}. The pull-in magnet 323 upon energizing forces the bank springs 333 and 334, springs 335 and 336, springs 337 and 338 and springs 339 and 340 into contact. At the same time the relay 323 shifts the spring 329 which it controls from the spring 330 and into engagement with the spring 341. It will be seen that by this operation of the spring 329 the energizing circuit of the magnet 323 is shifted, so that the connection from the spring 329, instead of going directly to battery, passes through the resistance coil 342 before reaching battery. The object in throwing this resistance 342 is to cut down the amount of current through the coil 323 after it has once pulled up. It should be stated that the springs 330, 329 and 341 are so adjusted that the spring 329 engages the spring 341 before it leaves the spring 330. The energizing circuit for the magnet 323, as shown, includes the relay 324. This relay energizes in series with the magnet 323 of the secondary line switch C^4 and, upon energizing, presses the springs 343 and 344 into contact for lighting the back supervisory lamp 321. It is to be understood also that the switch C^4 as well as all other similar switches in the same group (see group g, Fig. 3) are controlled by the same master switch H′ (not shown in Fig. 3). The master switch H′, of course, maintains the switch C^4 opposite an idle trunk line while the switch C^4 is not in use. In this particular instance it is assumed that the particular trunk line held for the line switch C^4 at the time it is operated, as described, was the trunk line the conductors 345 and 346 of which are shown in Fig. 15, and it is also assumed that at the time the switch C^4 operated, the master switch wiper was resting on the contact 347 of the master switch bank, which contact corresponds to the trunk line last referred to. Under these conditions it will be seen that when the bank springs 337 and 338 are pressed into contact an energizing circuit is closed through the relay 348 from ground G^{21} through the springs 338 and 337, through the contact 347, master switch wiper 349 and segment 350 to the relay 348, thence to battery. The relay 348 upon energizing in turn closes an energizing circuit for the relay 351, which relay upon energizing unlocks the plunger shaft, as already explained in connection with the master switch H shown in Fig. 4, and closes the energizing circuit for the motor magnet 352. In this manner the master switch H′ is operated and continues to operate until it finds another idle trunk line in the same group. Like the banks of the other line switches in this system the bank of the line switch C^4 is provided with ten sets of bank springs similar to the set 333—340, as indicated at R in Fig. 15. As indicated at R, the spring 335 of the set shown (333—340) is connected with a spring in the adjoining set, similar to the spring 336 of the set shown, said spring being indicated by the number 353; likewise, the spring in this second set, indicated by the number 354 and corresponding to the spring 335 of the set shown, and so on. In the last set the spring 356 corresponding to the spring 335 of the set shown is connected to ground. With this arrangement, therefore, it will be seen that when all of the trunks are in use the spring 336 of the set shown will be grounded, and the relay 357 will, therefore, become energized. Upon energizing, this relay presses the springs 358 and 359 into contact, as a result lighting all of the lamps 360. It should be explained that one of these lamps is provided at the board of every operator who has access to the trunks of the group g (Fig. 3), and will indicate to this operator that she should not plug into the jack corresponding to this group. It is obvious that as soon as at least one of the ten trunks is cleared, all of the lamps 360 will go out again. By the closure of connection between the springs 333 and 334 on one side, and the springs 339 and 340 on the other, the talking circuit is extended from the line switch C^4 to the B-board circuit N^6, which is the same as the cord N′ (Fig. 16) with the exception that in this case the conductors 605, 606 and 607 of the cord N′ terminate in the springs 333, 339 and 337 (Fig. 15), respectively. As soon as the springs 337 and 338 close, the relay 265 (Fig. 16) is energized and the operator signaled, as already explained. Upon receiving the signal the operator inquires for the number desired and completes the connection with the desired subscriber as follows: She inserts the plug of the cord N^6 (see the plug b^2 of the cord N′, Fig. 16) into a jack c^{19} (Figs. 3 and 14). A line runs from this jack to a connector F^9. This connector is in all respects the same as the connector F (Fig. 5). The operator then throws the key d^5 (Fig. 16), thereby connecting her calling device with the connector F^9. The operator then, by operating her calling device, completes the connection with the desired subscriber A^{17}, the number of which subscriber may be any number of two digits. When the conversation is completed the call-

ing subscriber, by hanging up his receiver, causes the switches C, D, E′ and M′ to be released. The release of the connector M′ destroys the energizing circuit of the calling supervisory relay (relay 277, Fig. 12) of the cord N^4 at the manual board L^4. The relay 277, upon deënergizing, removes the shunt from the lamp 320, causing it to glow and thereby give the operator a disconnect signal. The operator thereupon removes the plugs b^3 and b^4. The removal of the plug b^4 releases the switch C^4 and causes the calling supervisory relay of the cord N^6 (relay 264, Fig. 16) to deënergize. The relay 264, upon deënergizing, removes the shunt from the lamp 610, which thereupon gives the B-operator a disconnect signal. The removal of the plug b^2 restores the cord N^6 and permits the connector F^9 to release.

If the subscriber A^2 (Fig. 1) desires to call the subscriber A (see Fig. 1) he removes his receiver and operates his line switch C^5, thereby establishing connection with a first selector D′. Assuming that the number of the subscriber A is 1320, the first selector D′ is raised to the first level, thereby establishing connection with the second selector E^3. The second selector is then raised to the third level, establishing connection with the connector F^6, which connector is then operated to reach the desired line #1320. After extending connection to one of the switches in the central office, such as the first selector D′, the subscriber A^2 may set up a connection with any of the other subscribers in exactly the same manner as connection was completed between subscriber A and the other subscribers.

If the subscriber A^3 desires connection with the subscriber A the operation is a little different. Referring to Figs. 1, 7 and 8, when the subscriber A^3 (Fig. 7) removes his receiver he operates the line switch C^6 the same as usual, but instead of establishing connection directly with the first selector, as heretofore, connection is established with a trunk having associated with it a special connector switch F^7 (Fig. 8) and a secondary line switch C^7. It will be seen that in the district exchange, where the line of subscriber A^3 terminates, the line switch C^6 is located in one group, while the secondary line switch C^7 is a member of a separate group. Further, it will be seen that the master switches controlling these two groups, namely the master switches H^2 and H^3 (not shown in Fig. 1 but shown in Figs. 7 and 8), are associated in a particular manner, as will more fully appear. When the line switch C^6 operates, the springs 505 and 506 are pressed into contact, as well as the springs 507 and 508, the springs 509 and 510 and the springs 511 and 512. The closure of contact between the springs 509 and 510 performs the usual function of driving the master switch H^2 on, and in this case supplies ground to the conductor 513 which leads to the connector F^7. The closure of contact between the springs 507 and 508 connects the bridge-cut-off winding 514 of the line switch C^6 with the conductor 515, also running to the connector F^7. The closure of contact between the springs 505 and 506 on one side, and the springs 511 and 512 on the other side, of the talking circuit operates to energize the line relay 516 of the connector F^7. This line relay is much the same as the line relays of the connectors already described. Upon energizing, this relay operates to shift the spring 517 from the spring 518 and into engagement with the spring 519, and at the same time presses the springs 520 and 521 into contact. The closure of contact between the springs 520 and 521 is for the purpose of bridging the coil 522 across the conductors 523 and 524 leading to the secondary switch C^7, whereby when the secondary switch C^7 operates and extends connection through the conductors 525 and 526 to a switch at the main exchange, such, for example, as the first selector D^5 (see the first selector D, Fig. 4), the switch at the end of the trunk line at the main exchange may be prevented from releasing after it has been operated. Furthermore, these springs are for the purpose of operating the said first selector and any of the switches with which connection may be established through the conductors 523 and 524. In other words, the line relay 516 at the connector F^7 is in the nature of a line relay in a repeater, and the springs 520 and 521 are to the repeating apparatus what the springs 4 and 5 are to the telephone A (Fig. 4). The closure of contact between the springs 517 and 519 performs the function of energizing the slow-acting relay 527, which relay in turn performs the double function of maintaining the bridge-cut-off winding 514 of the line switch C^6 energized for holding the line switch C^6 in connection with the trunk conductors 528 and 529, and of tripping or operating the secondary line switch C^7. The energizing circuit for the relay 527 is as follows: Starting from ground G^{22} at the line switch C^6 (Fig. 7) the current flows through the bank springs 509 and 510 to the conductor 513, thence through the line relay springs 517 and 519 to and through the slow-acting relay 527, thence through the springs 531 and 530 of the relay 532 to the conductor 533, thence through the springs 534 and 535 of the master switch H^3 to the battery lead 21. The relay 527, upon energizing, presses the springs 536 and 537 into contact, thereby closing a circuit by way of the conductor 515 through the bridge-cut-off winding 514 of the line switch C^6 already referred to. At the same time an impulse is sent through the conductor 538 from ground G^{23} for en-

ergizing the operating magnet 539 of the secondary switch C^7. After leaving the conductor 538 this ground impulse passes through the springs 541 and 540 of the relay 532, thence through the conductor 542 and through the springs 543 and 544 of the line switch C^7, and through the magnet 539 to battery. When the magnet 539 operates, the spring 544 is separated from the spring 543, which in turn leaves the spring 545. This spring 544 is then carried into engagement with the spring 546. The object in separating the springs 543 and 545 when the secondary switch C^7 operates is to prevent the release relay 547 of the connector F^7 from energizing, which relay, by remaining deenergized, in turn maintains the energizing circuit of the vertical magnet 548 open. The object of this arrangement is to prevent the connector switch F^7 from operating while the line relay 516 is acting as a repeater, and operating the apparatus with which the secondary switch C^7 has made connection. The connector F^7 is for the purpose of establishing local connections, and when a local connection is to be made the secondary switch C^7 automatically releases, in a manner to be explained. It will be seen that, upon energizing, the secondary switch C^7 extends the talking circuit from the conductors 523 and 524 to the conductors 525 and 526 by carrying the springs 549 and 550 into engagement on one side, and the springs 551 and 552 on the other side. At the same time the springs 553 and 554 are carried into engagement, as well as the springs 555 and 556. The closure of contact between the springs 555 and 556 has the effect of advancing the master switch H^3, just as explained in connection with the line switch C^6. As soon as the circuit is extended from the conductors 523 and 524 to the trunk conductors 525 and 526, the line relay of the first selector switch in which these trunk conductors terminate pulls up, and at the same time the relay 522 at the connector F^7 pulls up in series therewith. Assuming that connection has been extended to a first selector D^5 (see Fig. 1), the relay 522 will energize in series with the line relay of the first selector D^5. In order to simplify the drawings, reference will be made to the first selector D (Fig. 4) whenever any detailed description of the selector D^5 is necessary. Furthermore, the numerals already applied to the selector D will be used. With this understanding, then, it will be seen that the springs 550 and 552 of the secondary switch C^7 (Fig. 8) will coincide with the springs 31 and 37 in Fig. 4. The energizing circuit, therefore, to which reference was last made may be traced as follows: from ground G^3 (Fig. 4) through one winding of relay 57 to the conductor 526 (Fig. 8), through the springs 552 and 551, conductors 524 and 557, springs 520 and 521 of the relay 516, conductor 558, coil 522 to the conductor 523, springs 549 and 550, conductor 525 (Fig. 8) to the coil 57 (Fig. 4), thence to battery. As soon as his circuit is established the relay 522 energizes and shifts the spring 559 from the spring 560 and into engagement with the spring 561. By separating the springs 559 and 560 the energizing circuit of the slow-acting relay 562 just to the left of the relay 522 is opened for the time being, while the closure of circuit between the springs 559 and 561 energizes the coil 532 and locks the pull-in magnet 539 of the secondary switch C^7 in an energized circuit, holding it there. Upon thus energizing, the relay 532 shifts the spring 531 into engagement with the spring 563, thereby shifting the energizing circuit for the slow-acting relay 527 from the control of the master switch H^3 by way of the conductor 533, thus making it impossible for the master switch to interfere with the action of this relay 527 as long as the relay 532 is energized. By shifting the spring 541 into engagement with the spring 564, the relay 532 provides a locking circuit for itself under the control of the relay 527. The calling subscriber is now ready to operate his dial to call the subscriber A, whose number is 1320. At the first operation of the dial one impulse is transmitted, and the line relay 516 of the connector F^7 operates once. In operating, the springs 520 and 521 are operated once, with the result that the relay 522 of the connector F^7 operates once in synchronism with the line relay 57 of the first selector. The first selector shaft is, of course, raised one step, and then automatically rotated to establish connection with the second selector, second selector E^3 (Fig. 1), for example. When the relay 522 at the connector F^7 operates in this instance, it energizes the slow-acting relay 562 by sending a flow of current from ground G^{22} (Fig. 7) at the line switch C^6, thence through the conductor 513 and through the springs 517 and 518 of the line relay 516, through the springs 559 and 560 of the relay 522, to and through the slow-acting relay 562 to battery through the bank springs 553 and 554 of the secondary switch C^7. This relay 562 upon energizing opens the circuits of the condensers 565 and 566, and at the same time short-circuits one of the windings of the relay 522, thereby reducing the resistance in the operating circuit of the first selector. The former operation in regard to the condensers is performed through the medium of the springs 568, 569, 570 and 571. The second operation is performed through the medium of the springs 572 and 573. The subscriber is now ready to operate his dial for the second time for the digit 3, operating the apparatus at the connector F^7 just as in the last instance—

that is, for the digit 1—the only difference being that now the second selector is operated instead of the first selector, and in the same way, after connection is extended to the desired connector, the remaining impulses are transmitted. It will be understood that after each series of impulses the slow-acting relay 562 of the connector F^7 falls back. It is obvious that the operation of extending a connection to any other subscriber in the system is the same as the operation described in connection with the subscriber A, after the connection has been extended to the first selector. It will be seen that while the impulses are being transmitted, the secondary switch C^7 is held in operated condition by the see-saw action of the line relay 516 and the relay 522—that is, while these relays are deënergized the pull-in magnet 539 is held by the ground G^{22} at the line switch C^6 (Fig. 7), and while they are energized the magnet 539 is held by the ground G^{24}. After the subscribers are through talking, if the calling subscriber hangs up his receiver the line relay 516 of the connector F^7 deënergizes, and as one result the spring 517 separates from the spring 519 and returns to normal. By thus separating, these springs break the energizing circuit of the slow-acting relay 527. This relay, upon deënergizing, permits the springs 536 and 537 to separate, thereby removing ground from the trunk conductor 515 and permitting the line switch C^6 to be restored. As soon as the bank springs 509 and 510 disengage at the said switch C^6 the ground is removed from the trunk conductor 513, and as a result the magnet 539 of the switch C^7 deënergizes, together with the relay 512. Upon falling back the line relay 516 at the same time separates the springs 520 and 521, thereby causing the release of the first selector and of any other switches to which connection may have been extended therefrom. Obviously, then, when the calling subscriber hangs up his receiver all of the apparatus is restored to normal. Although the subscriber A^3 may call another subscriber in the same group by going through the main exchange, the connector F^7 and other such connectors associated therewith are provided, whereby the subscriber A^3 may call another subscriber in the same group, subscriber A^{24} (Fig. 1), for example, by a direct connection as follows: It should now be explained that the subscribers in the group to which the subscriber A^3 belongs must have two numbers. They must be known by one number to all subscribers not in that group, while these subscribers must know each other by a different number—that is, the subscriber A^3 cannot call the subscriber A^{24} by the direct connection indicated if he calls the same number that the subscriber A would call to get subscriber A^{24}. To the subscriber A, and to all other subscribers not in the same group with the subscriber A^3, these last subscribers are in the 3200 group; but for the purpose of direct connection these subscribers are known among themselves by numbers in the 500 group, for example—that is, this number 500 is arbitrarily selected in this instance for that purpose. Assuming, therefore, that the local number for the subscriber A^{24} is 520, the operation is as follows: In making the call the calling subscriber A^3 removes the receiver and operates his line switch C^6 and obtains connection finally with the first selector D^5 (Fig. 1) through the secondary switch C^7. The subscriber is then ready to operate his dial for the digit 5, raising the shaft and wipers of the first selector D^5 to the fifth level. It should now be explained that all of the contacts on the fifth level of the first selectors in this group—that is, in the same group with the first selector D^5—are open; and when the first selector D^5 is raised and rotated into this level, this first selector D^5 as well as the secondary switch C^7 automatically release as follows: As soon as the side switch of the first selector D^5 passes to third position the relay 522 in the connector F^7 deënergizes for the reason that the trunk conductors 525 and 526 now terminate in an open circuit. As a result this relay permits the spring 559 to disengage from the spring 561, thereby breaking the energizing circuit of the pull-in magnet 539 of the secondary switch C^7. The result is that the switch C^7 is restored. The calling subscriber is now ready to operate his dial for the second digit 2. In doing so he operates the line relay 516 twice, thereby sending two impulses through the vertical magnet 548 as follows: from ground G^{22} at the line switch C^6, conductor 513, springs 517 and 518, conductor 574, springs 575 and 576 (which are now in contact, since the relay 547 is now energized), slow-acting private magnet relay 577, vertical magnet 548, side switch wiper 578 to battery. It will be understood that the relay 547 becomes energized as soon as the pull-in magnet 539 of the switch C^7 deënergizes and permits the springs 544 and 545 to engage, as previously explained. The magnet 539 is not operatively energized in series with the relay 547 on account of the comparatively high resistance of said relay. The impulses thus transmitted to the vertical magnet 548 operate to raise the shaft and wipers to the second level in the usual manner; and as soon as the last impulse is transmitted the private magnet relay 577 deënergizes, permitting the side switch to pass to second position. It will be seen that at the instant the relay 577 is energized, the springs 579 and 580 close an energizing circuit through the private magnet 581. The private magnet, of course,

draws up and remains in readiness to trip the side switch to second position as soon as the relay 577 releases it. The subscriber is now ready to operate his dial for the last digit 0, at which time he sends in ten impulses. These impulses, of course, operate the line relay 516, which in turn operates the rotary magnet 582. The rotary magnet 582 is energized in series with the private magnet relay 577 just as the vertical magnet 548 is energized, and it follows that the private magnet 581 is again energized as soon as the impulses begin to come in. After all of the impulses have come in the relay 577 deënergizes and the private magnet 581 permits the side switch to pass to third position. As soon as the side switch passes to third position the ringer relay 583 begins to operate under the action of the interrupter 584. As a result the called subscriber is automatically rung, periodically, by the ringer generator 585. When the called subscriber answers, the double-wound back-bridge coil 586 energizes, one of its functions being to separate the springs 587 and 588, thereby removing a short-circuit from across the relay 589, which thereupon energizes and opens the energizing circuit of the ringer relay 583. The energizing circuit of this relay 589 is the same circuit which maintains the coil 547 energized. In other words, these two coils are energized in series as a result of the line relay 516 being energized—that is, as a result of the springs 518 and 519 being in contact, and also as a result of the pull-in magnet 539 of the line switch C^7 being deënergized. If the called subscriber had been busy the connector would have been locked on a busy line with the side switch in second position, just as was described in connection with the connector F (Fig. 5), giving the calling subscriber the busy signal.

If the subscriber A^4 should desire to establish connection with the subscriber A the operation is as follows: He removes his receiver and signals the operator by energizing the relay 590 (Fig. 9) and lighting the lamp 591. The operator responds by inserting the plug b into the jack c' and ascertaining the number desired. Upon being given the number of some subscriber with whom connection must be made through the main exchange, the operator throws the key d^6 and inserts the plug b' into a suitable jack c^{11} (see Fig. 1), the trunk running from which terminates in the line switch C^8, in all respects similar to the line switch C (Fig. 4). The line switch C^8 is operated and connection is extended to a first selector D^3, which is operated in the usual manner. The jack c^{11} is, of course, a simple two-conductor jack. The line switch is automatically tripped, of course, as soon as the jack is inserted, as described above, since the act of throwing the key d^6 has thrown the telephone of the subscriber A^4 across the line. The subscriber then proceeds to make his own call automatically, the condensers 246 of the cord N (Fig. 9) having been short-circuited by the operator upon throwing the key d^6. The subscriber may then complete his call in the same manner as above explained for the other subscribers. After the subscribers are through talking the calling subscriber A^4 hangs up his receiver. He gives the operator the disconnect signal through the lamp 245, at the same time releasing the connection. If the subscriber A^6 desires to obtain connection with another subscriber through the main exchange, the operation would be almost the same, with the exception that the operator would have thrown the key d^6 in the reverse direction, thus leaving the condensers 246 in the circuit, and bridging her calling device e across the line. The operator then proceeds to establish the connection herself. When the subscriber answers, the key d^6 is restored, leaving the subscribers connected. After the subscribers are through talking the operator will receive the disconnect signal when the relay 244 deënergizes. If all the substations at the board L are manual, the cord N^2 (Fig. 12) can be used instead of the cord N with corresponding line-signaling apparatus.

If the subscriber A^5 had desired connection with the local subscriber A^5 (Figs. 1 and 9) the connection would, of course, have been completed by the local operator through the medium of any suitable cord circuit, the cord circuit N^7, for instance.

If the subscriber A^8 (Fig. 1) wishes to make a call the operation is just the same as when the subscriber A is calling.

If the subscriber A^9 (Fig. 10) wishes to make a call through the main exchange he removes his receiver and signals the operator through the medium of the relay 592 and the lamp 593. The operator inserts the cord N^8 and ascertains the number desired. Had the number desired been that of a local subscriber, such as the subscribers A^{19} or A^{18}, for example, the connection would have been completed with the cord N^8; but since the call is for some other subscriber the operator inserts the plug b^7 of the cord N^9 into the jack c^{12}. As soon as this is done the relay 594 pulls up, and by closing the contacts 595 and 596, and at the same time the contacts 597 and 598, the calling subscriber A^9 is given a through connection, whereby he may complete his own call. After the connection is completed the calling subscriber hangs up his receiver and breaks the energizing circuit of the relay 599. Upon falling back, this relay closes an energizing circuit through the lamp 600 from ground G^{25} (just above the relay 594) through the armature 601 and armature 602 to the lamp

600 and to battery. Upon receiving the signal the operator withdraws the cord. It is understood that the act of hanging up by the calling subscriber also releases the central office apparatus. It will be seen that with the equipment provided at the branch exchange (Fig. 10) containing the subscribers A^9 and A^{18}, those subscribers provided with manual equipment cannot make calls to the central office. Even should the operator attempt to establish such a connection she will find it impossible to do so, for the reason that the relay 594 cannot be energized when inserted into the jack of the subscriber A^{18}.

If the subscriber A^{10} (Fig. 1) wishes to make a call he removes his receiver and operates the line switch C^9. This line switch C^9 is in all respects like the line switch C^3 (Fig. 11). Also, it may be stated that the telephone and line equipments of the subscriber A^{10} (Fig. 1) are the same as those of subscriber A^{15} (Fig. 11), with the exception that the bank contacts 641, 642 and 630 may be omitted; and in describing the operation of the telephone A^{10} reference will be made to Fig. 11. The line switch C^9, upon operating, extends connection to a first selector D^{14} (Fig. 1), in all respects like the selector D (Fig. 4). From thence on, the operation in establishing connection with any other subscriber is the same as that described in connection with the calling subscriber A.

Referring to Fig. 3, if the subscriber A^{14} wishes to call any of the subscribers whose lines terminate directly in the boards L^6 and L^4 (subscriber A^{16}), for example, the connection is set up by the operator at the board L^4 over the normals indicated by the cable 603. If the subscriber A^{14} had desired to establish connection with another subscriber whose line terminates only in the board L^4, subscriber A^{20}, for example, the connection would be made over the normals indicated by the cable 604. Had the subscriber A^{14} desired to establish connection with the subscriber A^{15}, his operator would signal the operator at the exchange L^5 over an order wire Q (indicated in Fig. 13 but not shown in Fig. 3); and after having been assigned a trunk the connection is extended to the exchange L^5 through cords similar to the cords N^2 and N' (Figs. 12 and 13), whereupon the operator at the exchange L^5 will complete the connection, in a manner already explained, through the medium of the cord N^5. Had the subscriber A^{14} desired to establish connection with the subscriber A^{17} the operator at the board L^4, after being signaled, would extend the subscriber's line through the jack c^{10} (Figs. 3 and 15), for example, through a secondary switch C^4 to a cord N^3 (Fig. 3), for example, similar to the cord N', in a manner already explained. The operator at the board L^7 then completes the connection to the subscriber A^{17} in the same way as when subscriber A called subscriber A^{17}. If the subscriber A^{14} desires to establish connection with one of the subscribers whose lines terminate in the board L^3, he removes his receiver, signals the operator at the board L^4 and the operator, through the medium of a cord N^4 similar to the cord N^2 (Fig. 12), ascertains the number desired. After learning that the subscriber A^{14} desires connection with the subscriber A^{12}, the operator at the board L^4 inserts the plug b^4 into the jack c^{13} (Fig. 3), similar in all respects to the jack c^{10}, the line running from which terminates in a secondary switch C^{10} of the group g^2. This secondary switch C^{10} is in all respects the same as the secondary switch C^4 of the group g, and when it operates it extends connection through one of the trunks in the cable 611 to a B-cord N^{19} at the board L^3. This cord N^{19} is in all respects the same as the cord N' (Fig. 16). Upon receiving the signal, by the operation of the relay 265 and lighting of the lamp 266 of the cord, the operator completes the connection with the desired subscriber A^{12} (Fig. 12) in the usual manner. When the conversation is completed, the called subscriber, by hanging up his receiver, breaks the circuit of the relay 608, which latter falls back and lights the A-operator's lamp 321 (Fig. 12), giving the disconnect signal. Of course, when the A-operator withdraws the cord circuit N^2 from the trunk the secondary switch C^4 is released, and the relay 264 at the cord circuit N' (Fig. 16) deënergizes, thereby removing the shunt from around the lamp 610 and permitting this lamp to light. As soon as the B-operator receives the signal she also withdraws the plug b^2 and restores the cord circuit. In a similar manner connection might have been made with the subscriber A^{13} at the board L^3. It is obvious that in both cases the act of inserting the plug of the B-cord into the desired line will operate to energize the cut-off winding (see the winding 287 and the winding 305 shown in Fig. 14) of the line switch C^2. If the subscriber A^{14} wishes to call one of the subscribers at the toll board L^2 (Fig. 2), subscriber A^{11}, for example, the operation is as follows: Upon removing his receiver the subscriber A^{14} signals the operator at the board L^4. This operator plugs in with a cord N^4, for example, onto the calling line and ascertains the number desired, just as in the last instance where subscriber A^{14} called subscribers A^{12} and A^{13}. The operator then plugs into the jack c^{13} and thereby extends connection to the cord N^{19} of the board L^3 through one of the secondary switches of the group g^2 (Fig. 3), secondary switch C^{10}, for example. Upon ascertaining that the sub-

scriber desired is at the tollboard L^2, the operator at the board L^3 inserts the plug of the cord N^{12} (see plug b^2, Fig. 16), which is identical with the cords N^6 and N', into the jack c^{25} at the board L^3. The jack c^{25}, it should be explained, is identical with the jack c^{10} (Fig. 15) and, upon inserting the plug b^3 (Fig. 16) into the jack c^{25} a secondary switch C^{11} of the group g^3 is operated to extend connection to a second B-cord N^{13}, in all respects similar to the cords N^6 and N^8 (Figs. 3 and 13). The operator at the board L^2, upon receiving the signal, ascertains the number desired and finally plugs into the line of the desired subscriber A^{11}. The release here is the same as in the previous instance. If the subscriber A^{14} desires to establish connection with any one of the subscribers in the automatic exchange (Fig. 1), the operation is as follows: He signals the operator at the board L^4, who answers through the medium of a cord circuit N^4, for example; and upon learning that an automatic subscriber in Fig. 1 is desired she inserts the calling end of the cord N^4 into the jack c^{14}, for example. By doing so connection is extended by way of one of the conductors in the cable 612 to one of the line switches in the 4300 group, the line switch C^{12}, for example. This line switch, upon operating, extends connection to the first selector D^6, for example. From this point on the operator at the board L^4 may extend the connection to any subscriber desired by operating her calling device after throwing her calling key. (See key d^{10}, Fig. 12). When the calling subscriber hangs up he signals the operator L^4, who restores her cord and automatically restores all the apparatus.

If the subscriber A^{11} (Fig. 2) at the tollboard L^2 wishes to call another subscriber of the same tollboard, subscriber A^{25}, for example, the operation is the same as when the subscriber A^{14} calls the subscriber A^{20} at the tollboard L^4 (Fig. 3). If the subscriber A^{11} wishes to call any subscriber at the board L^3, subscriber A^{12}, for example, the operation is as follows: He signals the operator at the tollboard L^2, which operator answers through the medium of the cord N^2 (Fig. 12). The operator then inserts the other end b^4 of the cord into the multiple c^{15} of the desired subscriber, which multiple is contained in the cable 280^a. Had the subscriber A^{13} been called the operation would have been the same.

If the subscriber A^{11} wishes to establish connection with one of the subscribers at the board L^6, the line of which subscriber terminates directly in this board, subscriber A^{16}, for example, the operation is as follows: The subscriber A^{11} removes the receiver, signals the operator at the board L^2, who answers through the medium of the cord N^2. Upon learning the number desired the operator inserts the plug b^4 of the cord N^2 into the jack c^{16}, which is in all respects the same as the jack c^{10} (Fig. 15.) As a result one of the secondary switches, switch C^{13}, for example, of the group g^4 is operated, extending connection through one of the conductors of the cable 613 to a B-cord, cord N^{14}, for example, at the board L^6. This cord N^{14} is in all respects similar to the cords N^6 and N'. Upon learning that the subscriber A^{16} is desired the operator completes the connection by plugging into the jack c^{17} of the desired subscriber (see Fig. 12). When the subscribers are through talking the A-operator is given the disconnect signal in the usual manner, which operator then takes down her cord, thereby giving the operator at the board L^6 the disconnect signal. This second operator, upon taking down her cord, restores the remaining apparatus. Had the subscriber A^{11} desired connection with one of the subscribers associated with the board L^7 (Fig. 3), the line of which terminates in one of the district stations L^8, such as subscriber A^{17}, the operation is as follows: The operator at the board L^2 is signaled and she responds by again plugging into a jack, such as the jack c^{16}. A secondary switch, such as the secondary switch C^{13}, is operated, thereby extending connection to the board L^6 and to the cord N^{14}, for example. Upon learning the number desired the operator inserts the plug of the B-cord N^{14} into a jack c^{18}, extending connection to and operating a second secondary switch, secondary switch C^4, for example, of the group g, which in turn operates to extend the connection to the cord circuit N^6 at the board L^7. On receiving the signal the operator inquires the number desired and completes connection the same as when subscriber A called subscriber A^{17}. When the calling subscriber hangs up his receiver he gives the operator at the tollboard L^2 the disconnect signal. Upon taking down the connection this operator gives the operator at the board L^6 the disconnect signal, who in turn gives the operator at the board L^7 the disconnect signal. Upon taking down the connection the operator at the board L^7 automatically releases the connector F^9. If the subscriber A^{11} desires to establish connection with a subscriber at the tollboard L^4, subscriber A^{14}, for example, the operation is as follows: He obtains connection with the cord N^{14} at the board L^6, just as in the previous instance, through the cord N^2. Upon ascertaining that the subscriber at the tollboard L^4 is desired the operator at the board L^6 inserts the plug of the cord N^{14} into a jack c^{20}, thereby extending connection to and operating a secondary switch C^{14} of the group g^5. This jack c^{20} is, of course, the same as the jack c^{10}, and the line switch C^{14} is the same as the line

switch C^4. The line switch C^{14}, upon operating, extends connection to a B-cord N^{15}, at the same time giving the operator at the board L^4 a signal. The cord N^{15} is, of course, the same as the cords N^6 and N'. Upon receiving the signal the operator completes the connection with the subscriber A^{14}, as desired. If the subscriber A^{11} wishes to establish connection with one of the subscribers at the private branch exchange L^5 (Fig. 3) the operation is as follows: The subscriber initiates the call and the operator at the board L^2 extends the connection to the board L^6 through the cord circuit N^2, the jack e^{16} and the secondary switch C^{13} to the cord N^{14}, for example. The operator at the board L^6 then connects the cord N^{14} with the jack e^{21}, for example, thereby extending connection to the cord N^5 at the private branch exchange L^5. Upon learning what number at the exchange A^{15} is desired the operator at the exchange L^5 plugs into the jack e^8 of the desired subscriber and completes the connection. (See Fig. 11). After the subscribers are through talking the disconnect signal is given in the usual manner, as heretofore described. If the subscriber A^{11} wishes to establish connection with any one of the automatic subscribers shown in Fig. 1 the operation is as follows: The subscriber signals the operator at the tollboard L^2 who, through the medium of the cord N^2, connects the subscriber A^{11} with the jack e^{22}, for example. As soon as the operator establishes connection with this jack one of the line switches in the 4300 group (Fig. 1), the line switch C^{15}, for example, is operated. This line switch extends connection to a first sector, selector D^6, for example. From this point on the connection is completed by the operator through the medium of her calling device, in a manner already explained, for calls to the automatic exchange from the board L^4 (Fig. 3). If the subscriber A^{12} (Fig. 2) wishes to call subscriber A^{13} (same figure) the connection is completed by an operator at the board L^3 in the usual manner through the medium of the ordinary cord, such as the cord N^2. If the subscriber A^{12} desires to establish connection with subscriber A^{11} (Fig. 2) at the tollboard L^2 he removes his receiver and signals the operator at the board L^3 who, through the medium of a cord similar to the cord N^2, ascertains the number desired and plugs into a jack, such as the jack e^{25}, thereby extending connection to and operating a secondary switch, such as the secondary switch C^{11}, in the group g^3. Connection is thereby extended to a B-cord, such as the cord N^{13} at the tollboard L^2, and the operator signaled. This operator completes the connections in the usual manner, as already explained. When the subscribers are through talking the operator at the board L^3 receives the disconnect signal. If the subscriber A^{12} wishes to establish connection with one of the subscribers in Fig. 3 whose lines terminate in the board L^6, subscriber A^{16}, for example, the operation is the same as the operation in calling the subscriber A^{11}, with the exception that the operator at the board L^3, instead of plugging into the jack e^{25}, plugs into the jack e^{23}, for example, thereby extending connection through the board L^6 by way of one of the line switches of the secondary group g^4, similar in all respects to the line switch C^{13}. In this manner the operator at the board L^6 is signaled at the cord N^{14}, for example. The operator at the board L^6 then completes the connection. When the subscribers are through talking the operator at the board L^3 receives the disconnect signal. If the subscriber A^{12} desires to establish connection with one of the subscribers of the board L^7 (Fig. 3), connection is extended in the same manner to the board L^6, and from the board L^6 connection is extended to the board L^7 by way of a secondary line switch of the group g, for example. The operator at the board L^7, upon receiving the signal, inquires the number desired and completes the connection automatically in a manner already explained. When the calling subscriber hangs up, the operator at the board L^3 receives the disconnect signal, and she in turn gives the disconnect signal to the operator at the board L^6, the operator at the board L^6 in turn giving the disconnect signal to the operator at the board L^7. By taking down the cord automatically the operator at the board L^7 restores the connector switch F^9 at the district exchange. If the subscriber A^{12} desires to establish connection with one of the subscribers of the tollboard L^4 (Fig. 3), connection is extended from the board L^2 to the board L^4 in the same manner as when the subscriber A^{11} called the subscriber A^{14} through the secondary switches of the group g^4 in Fig. 2 and g^5 in Fig. 3, for example. Upon receiving a signal at the cord N^{15}, for example, the operator at the board L^4 completes the connection. The act of disconnecting is accomplished in a manner similar to that already described. If the subscriber A^{12} desires to establish connection with the subscriber A^{15} at the private branch exchange L^5 (Fig. 3), connection is extended to the board L^6 in the same manner as in the previous call, and at the board L^6 the operator establishes connection with a cord N^5, for example, at the exchange L^5 by plugging into a jack, such as the jack e^{-1}. The operator at the board L^5 completes the connection in the usual manner. If the subscriber A^{12} desires to establish connection with the automatic exchange in Fig. 1 the operation is as follows: Connection is extended from the board L^3 to the board L^2 through an A-cord at the

board L^3, and the B-cord at the board L^2 (with which connection is made) is then plugged into a jack, such as the jack c^{22}, thereby extending connection to a line switch in the 4300 group (Fig. 1), such as the line switch C^{15}. This line switch operates to extend connection to a first selector D^6, and from this point on the connection is completed automatically by the B-operator at the board L^2. Upon hanging up his receiver the calling subscriber gives the operator at the board L^3 the disconnect signal. This operator then signals the operator at the board L^2, who in turn, by taking down her cord, automatically releases the apparatus shown in Fig. 1.

When the subscriber A^{13} (Fig. 2) calls, the method of operation is exactly the same as when the subscriber A^{12} was calling after signaling the operator at the board L^3. The only difference is in signaling the operator at the board L^3. This operation is accomplished as follows, reference being made to Fig. 14. When the subscriber A^{13} removes his receiver he operates the line switch C^2 in the usual manner. This line switch, upon operating, extends connection from the subscriber to the trunk conductors 614 and 615, thereby establishing an energizing circuit for the relay 616 from ground G^{26} on one side and through the lower winding of the relay 616, conductor 615, springs 620 and 619, through the telephone A^{13} to the other side, thence through the springs 618 and 617 to the conductor 614, then through the upper winding of the relay 616 and signal relay 620^a to battery. The relay 620^a upon energizing in turn energizes the relay 621, which signals the operator. The relay 616 upon energizing presses the springs 622 and 622^a into contact, thereby setting up the holding circuit for the winding 305 of the line switch C^2. The operator, upon answering, inserts the plug b^3 (Fig. 12) into the jack c^{24}. As soon as this is done the relay 623 energizes, drawing up the armatures 624 and 624^a, thus leaving the trunk between the subscriber and the cord clear. From this point on the process of calling is the same as when the subscriber A^{12} is calling.

If the subscriber A^{15} (Fig. 3) wishes to establish connection with a local subscriber, subscriber A^{26}, for example, the operation is as follows: He removes his receiver and operates his line switch C^3 (see Fig. 11). By this operation connection is extended to a rotary connector M^2. This rotary connector is only rotary on one level, the tenth level, for example. On all other levels it is a simple two-wire connector, just as the connector F (Fig. 5). Connection having thus been extended through the line switch C^3, which is in all respects the same as the line switch C, the subscriber is ready to complete the connection by operating the dial twice to connect with the desired subscriber A^{26}. Assuming that the number of the subscriber A^{26} is 22, the shaft of the connector M^2 is raised two steps and then rotated two steps. The operation of this connector is controlled by the line relay 625. This line relay, as in the connector F, upon energizing, energizes the slow-acting release relay 626. This relay 626 puts ground on the trunk-release conductor 627 and on the private normal conductor 317. Grounding this private normal conductor energizes the auxiliary relay 628 which, upon energizing, puts a non-grounded battery potential on the ring 313 by pressing the springs 629 and 629^a into contact. This guarding potential at the ring 313 is for the usual purpose of giving an operator the busy signal. At the same time the relay 628 breaks the energizing circuit of the auxiliary relay 314 to prevent any possible energization of said relay as long as there is ground on the conductor 317. Maintaining ground on the conductor 317 also maintains a guarding potential at the multiple connector bank contact 630 for making the line busy to any connector switch, such as another connector switch in the same group with the connector M^2, and of the same character. It may be well to state here that the line A^{15} may be made busy if an operator inserts a plug of a cord circuit, such as the cord circuits N', N^2 or N^3, into the jack c^8. By so doing the relay 314 is energized by a flow of current from the non-grounded battery at the cord through the relay 314, through the springs 631 and 632 to ground. This relay 314, upon energizing, separates the spring 315 from the spring 633, thereby breaking the energizing circuit of the relay 628 to prevent this coil from energizing. At the same time the spring 315 is carried into engagement with the grounded spring 316 for putting a guarding potential on the connector private bank contact 360, and for energizing the bridge-cut-off winding 318 of the line switch C^3. The subscriber A^{15} having extended his connection to the connector M^2, as explained, by operating the line relay 625 after the slow-acting relay 626 is energized, operates the vertical magnet 634 just as the vertical magnet 112 of the connector F was operated, and during this operation energizing the slow-acting private magnet relay 635. This relay 635, of course, energizes the private magnet 636, which remains ready to put the side switch in second position as soon as the relay 635 deënergizes. These two magnets 635 and 636 are, of course, duplicates of the magnets 113 and 122 of the connector F. After the side switch passes to second position the subscriber operates his dial for the second digit, again operating the line relay 625, which now operates the rotary magnet

637 in series with the relay 635. The rotary magnet 637, being operated twice, advances the wipers 638, 639 and 640 of the connector into engagement with the multiple contacts of the desired subscriber #22, which contacts are the same as the contacts 641, 642 and 630 shown at the left of the line switch C^3. If the called subscriber should be busy the connector side switch is locked in second position just as the connector F (Fig. 5), giving the calling subscriber the busy signal. When the subscriber A^{15} hangs up his receiver he opens the line circuit and thereby causes the deënergization of the line relay 625. This in turn permits the relay 626 to deënergize, thereby causing the energization of the release magnet 642^a and the deënergization of the winding 318 of the line switch C^3. This, of course, causes the release of the apparatus. If the subscriber A^{15} desires to establish connection with a subscriber in some other part of the system he must operate his dial to raise the connector shaft to the tenth level by sending in ten impulses, and after the side switch trips to second position he must transmit one additional impulse for rotating the wipers into engagement with the first contacts of the tenth level, contacts 643, 644 and 645, for example. If the private contact 644 should be busy it would be found grounded. This grounded potential will serve to maintain the interrupter relay 646 and the private magnet 636 energized, for the reason that the switch shaft has closed the springs 647 and 648 in contact and because the side switch is in second position. As soon as the relay 646 energizes, the springs 649 and 650 are pressed into contact, thereby connecting the interrupter 651 with the rotary magnet 637. This interrupter continues to operate the rotary magnet 637 as long as the private wiper 639 continues to meet grounded private bank contacts, such as the contact 644. As soon as an idle trunk is found, however, the relay 646 and the magnet 636 deënergize, with the result that the connector is stopped and the side switch is passed to third position. This connector M^2 now acts like the rotary connector M (Fig. 17). It will be seen, therefore, that the double-wound back-bridge coil 652 and the coils 653 and 654 have their corresponding parts in the coils 231, 242 and 258 of the connector M. The trunk line on which the rotary connector M^2 stops terminates in a jack, such as the jack c^3 (Fig. 12) described in connection with the rotary connector M. As soon as the rotary connector M^2 stops on this trunk the operator at the board L^5 is signaled. She answers by inserting the answering plug of a cord, such as the cord N^2, into the jack c^3 and then inserts the calling plug of the cord into a jack, thus signaling the operator at the board L^6. From this point on connection to any other subscriber in the system is completed in the manner described in connection with the calls by subscriber A^{17}.

If the subscriber A^{16} wishes to make a call the operation is as follows: If, for example, another subscriber whose line terminates in the same board, subscriber A^{21}, for example, is wanted, the operation is the same as when two manual subscribers, whose lines terminate in the same board, are calling each other. For this purpose any one of the well-known cord circuits may be used, for example, cord circuit N^2 (Fig. 12). If the subscriber A^{16} wishes to call the subscriber A^{17}, for example, the operator at the board L^6 is signaled, who then completes the connection to the board L^7 by way of one of the secondary switches, such as the secondary switch C^4 of the group g (Fig. 3). From this point on the operator at the board L^7 completes the connection in the manner explained. There is no difference in the process of establishing connection between subscribers A^{16} and A^{17} and subscribers A^{14} and A^{17}. If the subscriber A^{16} wishes to call the subscriber A^{14} (Fig. 3) he signals the operator at the board L^6, who answers with an A-cord N^2 (Fig. 12). The operator at the board L^6 then plugs into a jack c^{25} and extends connection to the board L^4 by operating a secondary switch C^{10}, through which connection is extended over one of the trunk conductors in the cable 625 to a B-cord at the board L^4, B-cord N^{16}, for example, in all respects similar to the cord N′ (Fig. 16). The operator then completes the connection by plugging into the line of the desired subscriber. When the subscribers are through talking the operator at the board L^6 receives the disconnect signal, and when she takes down the cord she gives the operator at the board L^4 the disconnect signal. If the subscriber A^{16} wishes to establish connection with the subscriber A^{15} (Fig. 3) he signals the operator at board L^6, who, after answering, extends the connection to the board L^5 by plugging into a jack, jack c^{21}, for example. By this operation the connection is extended to the B-cord N^5, for example, from which point the connection is completed by plugging into the jack of the desired line. If the subscriber A^{16} desires to establish connection with the subscriber A^{12} (Fig. 2) he signals his operator, who extends connection to the board L^3 through a secondary switch in the group g^2 (Fig. 3). The secondary switch is in all respects the same as the secondary switch C^{10}. This is done by the operator at the board L^6 plugging into a jack, such as the jack c^{26}. Connection is in this manner extended by way of the trunks in the cable 611 to a cord in the board L^3, the cord N^{19}, for example. At

this board the connection is completed by plugging into the jack of the desired line. Connection with the subscriber A^{13} would be established in exactly the same manner. If subscriber A^{16} wishes to establish connection with the subscriber A^{11} he signals his own operator at the board L^6, who in turn extends connection to a cord, cord N^{19}, for example, at the board L^3 through a secondary switch, just as in the previous instance. Through the medium of this cord the operator at the board L^3 extends connection to the board L^2 through a secondary switch in the group g^3, for example, by plugging into a jack c^{25}, for example. At the board L^2 the connection is completed in the usual manner. If the subscriber A^{16} wishes to establish connection with any one of the subscribers in the automatic section (Fig. 1) he signals his operator, who extends connection to the board L^4 in the same manner as when the subscriber A^{14} was to be called. At the board L^4 the cord N^{16}, instead of being connected with the multiple jack of the subscriber A^{14}, is inserted in a jack c^{14}, for example, thereby extending connection to a line switch in the 4300 group, line switch C^{15}, for example, which upon operating extends connection to a first selector D^6. From this point on the connection is completed by the operator at the board L^4, as in previous instances already described.

From the foregoing it will be seen that I provide for the establishment of various kinds of connections in a two-wire system, which connections were heretofore not possible in a system of this particular kind, and that I have thereby materially increased the efficiency of a two-wire system, especially a system in which many connections, if possible at all, must be made either manually or more or less semi-automatically, owing to the fact that some lines terminate in manual apparatus, while other lines terminate in automatic apparatus, and for other reasons, as hereinbefore fully explained.

What I claim as my invention is:—

1. A telephone system comprising automatic switches, line circuits for said switches, one of said switches being a connector, a line relay individual to and controlling said connector for finding the called line, means for energizing said relay over two sides of the line circuit in series, said called line having a jack, and a line signal associated with said jack.

2. A telephone system comprising automatic switches, line circuits for said switches, one of said switches being a connector, a line relay individual to and controlling said connector for finding the called line, means for energizing said relay over two sides of the line circuit in series, a non-numerical trunking switch for said called line for use only when said called line is used as a calling line, a jack for said called line, and means for using said jack to call the line manually.

3. A telephone system comprising automatic switches, line circuits for said switches, one of said switches being a connector, a line relay individual to and controlling said connector for finding the called line, means for energizing said relay over two sides of the line circuit in series, means whereby said line may also be called manually, and means whereby said line may call only manually.

4. A telephone system comprising a manual line, a semi-automatic line, means for calling the semi-automatic line automatically, a cord circuit, devices for connecting each line with said cord circuit, an automatic switch, means for controlling said automatic switch over the two sides of a calling line in series, said cord circuit being provided with mechanism for indicating to the operator that both the calling and called subscribers have signaled for a disconnection.

5. A telephone system comprising a cord circuit, a plug for said cord circuit, said plug being provided with a sleeve, a relay, a connection between the said sleeve and the middle point of the winding of said relay, a source of current having one pole grounded and the other pole permanently connected with one terminal of said winding, a ground connection for the other terminal of said winding, and a circuit controlled by said relay.

6. In a telephone system, a trunk jack, an automatic switch individual thereto, a set of trunks leading from said automatic switch, a cord circuit plug, said switch comprising means responsive to the insertion of said plug into said jack for automatically connecting the latter with an idle trunk, selectors and connectors for said system, means for controlling said selectors and connectors over the two sides of a calling line in series, and other lines, each of said other lines being adapted to be called through the medium of said selectors and connectors, or through the medium of said plug, depending upon the character of the call.

7. In a telephone system, a set of trunk jacks, plugs associated with said jacks, a plurality of trunks, means responsive to the insertion of a plug in said jacks for automatically connecting the latter with idle trunks, only a portion of said trunks being accessible through the medium of any one jack, signals associated with said jacks, means for automatically displaying the signal of a jack when all of the trunks accessible therefrom are in use, selectors and connectors for said system, means for controlling said selectors and connectors over the two sides of a calling line in series, other

lines, each of said other lines being adapted to be called through the medium of said selectors and connectors, or through the medium of said plug, depending upon the character of the call.

8. A telephone system comprising automatic switches, line circuits for said switches, a line relay individual to and controlling each of said switches, and means for energizing said relay over two sides of the line circuit in series, a manual switchboard, a subscriber's line adapted to be called either automatically or manually, a line signal for said line, means for manually answering a call from said line to connect one or more automatic switches therewith, and means by which the subscriber on said line then controls the said switch or switches to find the line of the desired subscriber.

9. A telephone system comprising automatic switches, line circuits for said switches, a line relay individual to and controlling each of said switches, and means for energizing said relay over two sides of the line circuit in series, a manual switchboard, a subscriber's line adapted to be called either automatically or manually, trunks leading to said switchboard, and non-numerical switching means for automatically selecting an idle trunk in response to a call from said line.

10. In a telephone exchange system, a plurality of subscribers' lines terminating at a manual switchboard, with associated signal devices whereby a calling line may attract the attention of an operator, a number of first-selector switches less than the number of lines, auxiliary switches associated therewith and containing multiple terminals for the lines, operators' connective means and terminal devices for the selector switch circuits upon the manual switchboard manually controlled to connect a calling line with an idle first selector switch, means thereafter controlled by the subscribers for setting and releasing the switches, clearing-out signals associated with the operator's circuits to indicate the desire of connected subscribers for disconnection, line circuits for said switches, a line relay individual to and controlling each of said switches, and means for energizing said relay over two sides of the line circuit in series, substantially as described.

11. In a telephone exchange system, a plurality of subscribers' lines, manual connective terminals therefor, signal devices associated therewith and becoming active in response to subscribers' calls, automatic switches containing terminals of the same lines, operators' connective circuits for connecting a calling line with an idle switch, means controlled by the subscribers for setting and releasing the switches, clearing-out signals connected with said connective circuits, line circuits for said switches, a line relay individual to and controlling each of said switches, and means for energizing said relay over two sides of the line circuit in series, substantially as described.

12. In a telephone exchange system, subscribers' lines with manual connective circuits and automatic switches for interconnecting them, each line having an answering terminal manually accessible only, one or more calling terminals in the automatic switches, said switches being subdivided into classes and groups, certain groups in each class containing multiple terminals for switches of the next class, and the switches of the last class containing the said line terminals, said manual connective circuits adapted to initiate connection between lines through the successive classes, means whereby the continuity of a connection may thereafter be controlled by the subscribers, line circuits for said switches, a line relay individual to and controlling each of said switches, and means for energizing said relay over two sides of the line circuit in series, substantially as described.

13. In a telephone exchange system, subscribers' lines having manually accessible answering terminals, and automatically accessible calling terminals, two or more sets of link or trunk circuits each containing automatic switch adapted to be successively operated to reach said calling terminals, together with operators' cord circuits for interconnecting the first set of links or trunks with calling subscribers' lines, means controlled by the subscribers for setting and releasing said switches, line circuits for said switches, a line relay individual to and controlling each of said switches, and means for energizing said relay over two sides of the line circuit in series, substantially as described.

14. In a telephone exchange system, a plurality of subscribers' lines, first selector switches less in number than the number of lines, means whereby said switches may be manually switched to be brought under control of calling lines, becoming thereby individual line switches for the time being, as to both setting and releasing, auxiliary switches in groups containing the terminals of the same lines, together with connections from said auxiliary switches brought to and controllable by and through the first selector switches, line circuits for said switches, a line relay individual to and controlling each of said switches, and means for energizing said relay over two sides of the line circuit in series, substantially as described.

15. In a telephone exchange system, a plurality of subscribers' lines, first selector switches in number less than the number of lines, means whereby said switches may

be manually brought under control of calling lines, becoming thereby individual line switches for the time being, auxiliary switches in groups containing the terminals of corresponding groups of trunks, connector switches connected thereto, and containing terminals of the same subscribers' lines in groups, means whereby the said switches may be controlled through the trunks and their accompanying circuits to reach the wanted subscribers' lines, and for purposes of restoration to normal, line circuits for said switches, a line relay individual to and controlling each of said switches, and means for energizing said relay over two sides of the line circuit in series, substantially as described.

16. The combination in a telephone system of subscribers' lines, a manual switchboard and automatic switches containing respectively answering and calling terminals for said lines, operators' cord circuits for interconnecting the calling lines and switches, means controlled by the subscribers for both setting and releasing said switches, line circuits for said switches, a line relay individual to and controlling each of said switches, and means for energizing said relay over two sides of the line circuit in series, substantially as described.

17. In a telephone system, a cord circuit, a plug for said cord circuit, said plug provided with a sleeve contact, a supervisory signal, and a relay for controlling said signal, said relay upon energization adapted to display said signal, the mid point of the winding of said relay being connected to the sleeve of said plug.

18. In a telephone system, a cord circuit, a plug provided with a sleeve contact for said cord circuit, a relay and a permanent connection from said sleeve through a winding on said relay to ground, and a connection from said sleeve through a winding on said relay to battery.

19. In a telephone system, a cord circuit, a plug for said cord circuit, said plug provided with a sleeve contact, a supervisory signal for said cord circuit, and a pair of relays in said cord for controlling said signal, the winding of one of said relays being connected at a point between its ends with said sleeve contact.

20. In a telephone system, a cord circuit, a plug for said cord circuit, said plug provided with a sleeve contact, a relay having a middle point of its winding connected to said sleeve contact, a supervisory signal, means for displaying said signal upon said relay being energized, a second relay, and means controlled thereby to extinguish said signal.

21. In a telephone system, a cord circuit, a plug for said cord circuit, a trunk circuit provided with a jack to receive said plug, a relay associated with said plug, the middle point of said relay connected to a contact on said plug, and one terminal permanently connected to ground and the other permanently connected to battery, and means for energizing said relay by placing battery or ground on the opposite end of said trunk circuit.

22. In a telephone system, a cord circuit, a plug for said cord circuit, a sleeve contact for said plug, a trunk circuit provided with a jack to receive said plug, a relay, the middle point of said relay connected to said contact on said plug, and one terminal permanently connected to ground and the other permanently connected to battery, and means for energizing said relay by placing battery or ground on the opposite end of said trunk circuit.

23. In a telephone system, automatic switches, line circuits for said switches, a line relay individual to and controlling each of said switches, and means for energizing said relay over two sides of the line circuit in series, a manual switchboard, a subscriber's line adapted to be connected with said line circuits, means for calling said line automatically, a jack for manually calling said line, means for placing a busy test on said jack when said line is called automatically, and non-numerical switching means for automatically selecting an idle trunk in response to a call from said line.

24. In a telephone system, automatic switches, line circuits for said switches, a line relay individual to and controlling each of said switches, and means for energizing said relay over two sides of the line circuit in series, a manual switchboard, a subscriber's line adapted to be connected with said line circuits, means for calling said line automatically, a jack for manually calling said line, means for preventing automatic connection when said line is connected manually, and non-numerical switching means for automatically selecting an idle trunk in response to a call from said line.

25. In a telephone system, automatic connecting means, said means comprising switches, a line relay individual to and controlling the operation of each of said switches, and means for energizing said relay over both sides of the line in series, manual connecting means, and means for preventing operation of one of said means when the other is operated.

26. In a telephone system, a plurality of lines, a plurality of operators' positions, individual answering terminals at one of said operators' positions for certain of said lines, common answering terminals distributed among a plurality of operators' positions for other of said lines, means whereby said other lines may establish connection with

one of said common answering terminals, said means comprising switches, a line relay individual to and controlling the operation of each of said switches, and means for energizing said relay over both sides of the line in series.

27. In a telephone system, a plurality of lines, a plurality of operators' positions, individual answering terminals at one of said operators' positions for certain of said lines, common answering terminals distributed among a plurality of operators' positions for other of said lines, and an automatic selecting switch individual to each of said other lines for extending connection to one of said common answering terminals, said means comprising switches operated over both sides of the line in series.

28. In a telephone system, a plurality of telephone lines, a plurality of automatic switches divided into groups and provided with bank contacts in which said telephone lines terminate, a manual switchboard divided into a plurality of sections, a plurality of link circuits for each group of switches extending to manually-controlled terminals at different sections of said switchboard, automatically-operated selecting switching mechanism associated with the telephone lines and the answering ends of the link circuits for connecting said link circuits with calling lines, a line relay individual to and controlling the operation of said mechanism, and means for energizing said relay over both sides of the line in series.

29. In a telephone system, a called line, an A operator's board, a B-operator's board, automatic switches for extending connection from said B operator's board to the called line, a signal on said A operator's board, and means controlled by said B operator to operate said signal when said automatic switches attempt to make connection with a busy line.

30. In a telephone system, a calling line, an A-operator's board, a B operator's board, automatic switches for extending connection from said B operator's board to the called line, a visual signal on said A operator's board, and means controlled by said B operator for intermittently operating said signal when said automatic switches attempt to make connection with a busy line.

Signed by me at Chicago, Cook county, Illinois, this 11th day of March, 1910.

EDWARD D. FALES.

Witnesses:

ARTHUR J. RAY,

J. E. COOLEY.