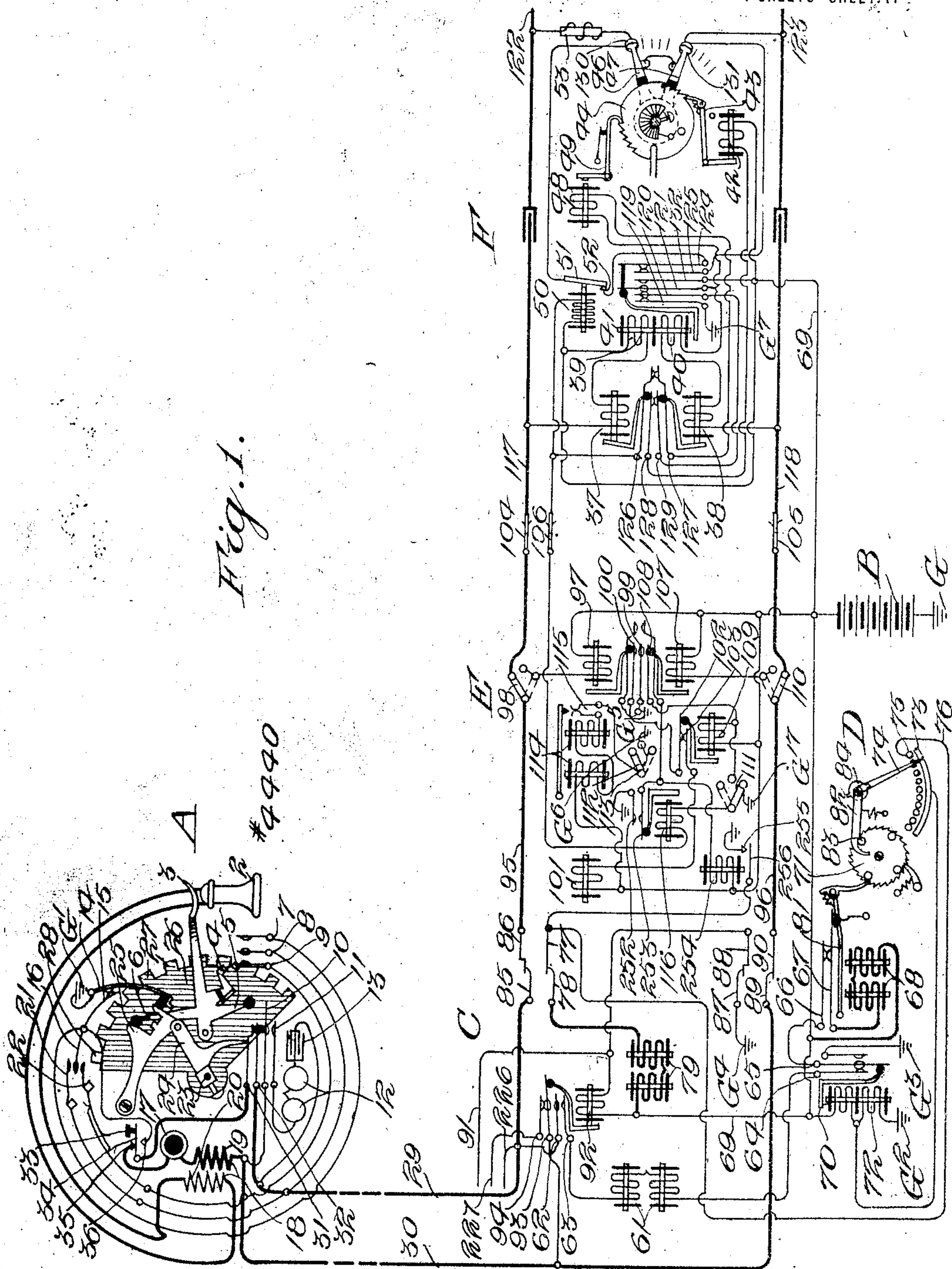


1,238,039.

Patented Aug. 21, 1917.

4 SHEETS—SHEET 1.



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4 SHEETS—SHEET 2.

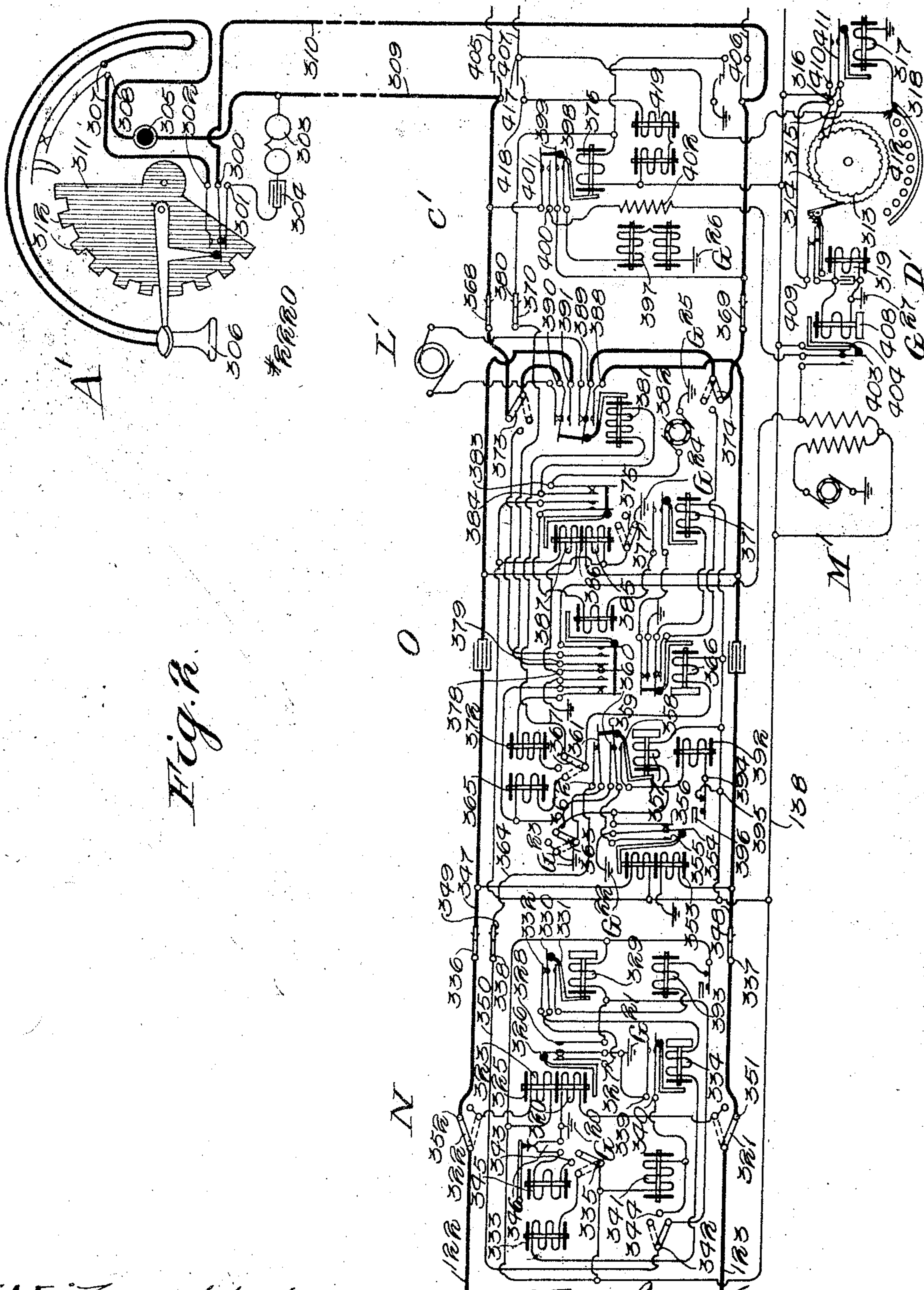


Fig. 2.

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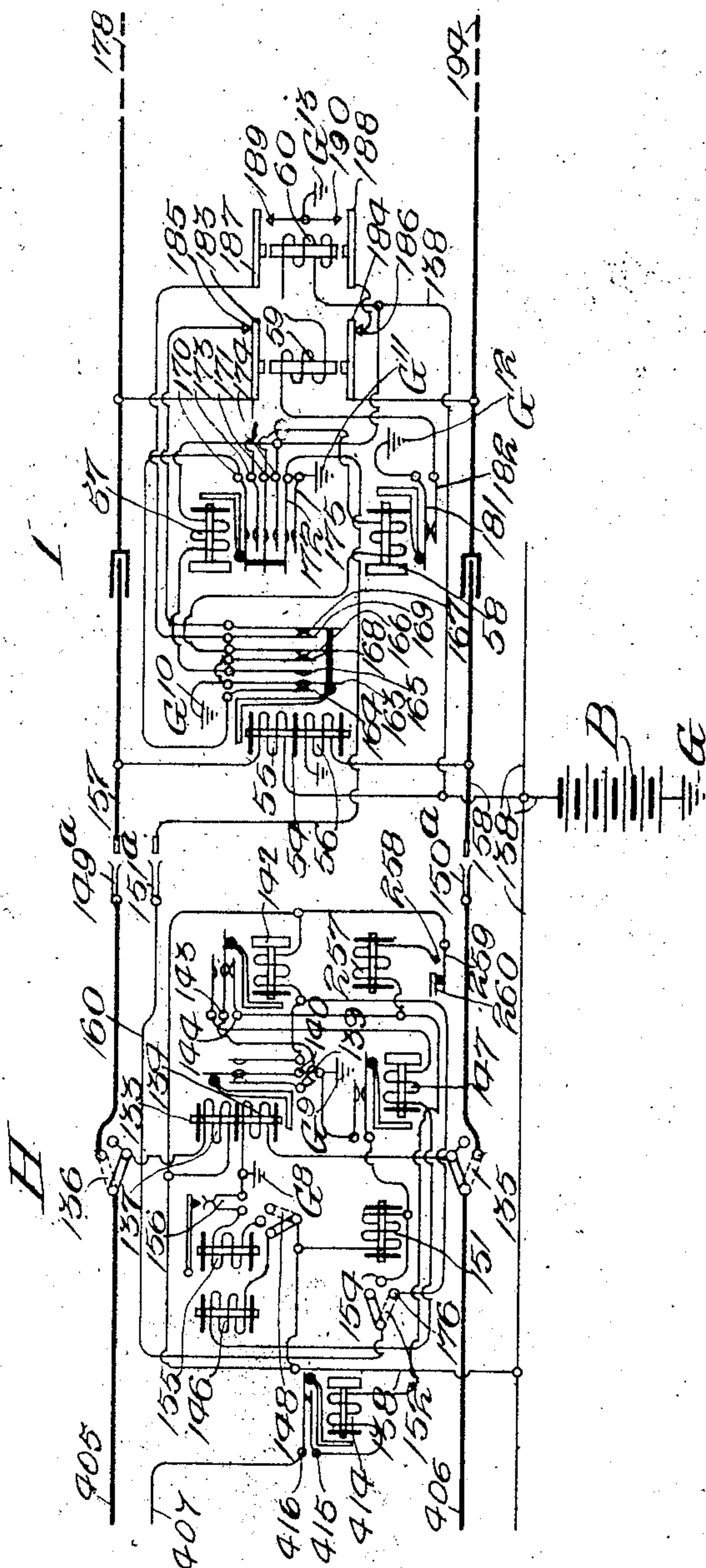
T. G. MARTIN.
TELEPHONE EXCHANGE AUTOMATIC TRUNKING SYSTEM.
APPLICATION FILED MAR. 1, 1910.

1,238,039.

Patented Aug. 21, 1917.

4 SHEETS—SHEET 3.

Fig. 3.



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4 SHEETS—SHEET 4.

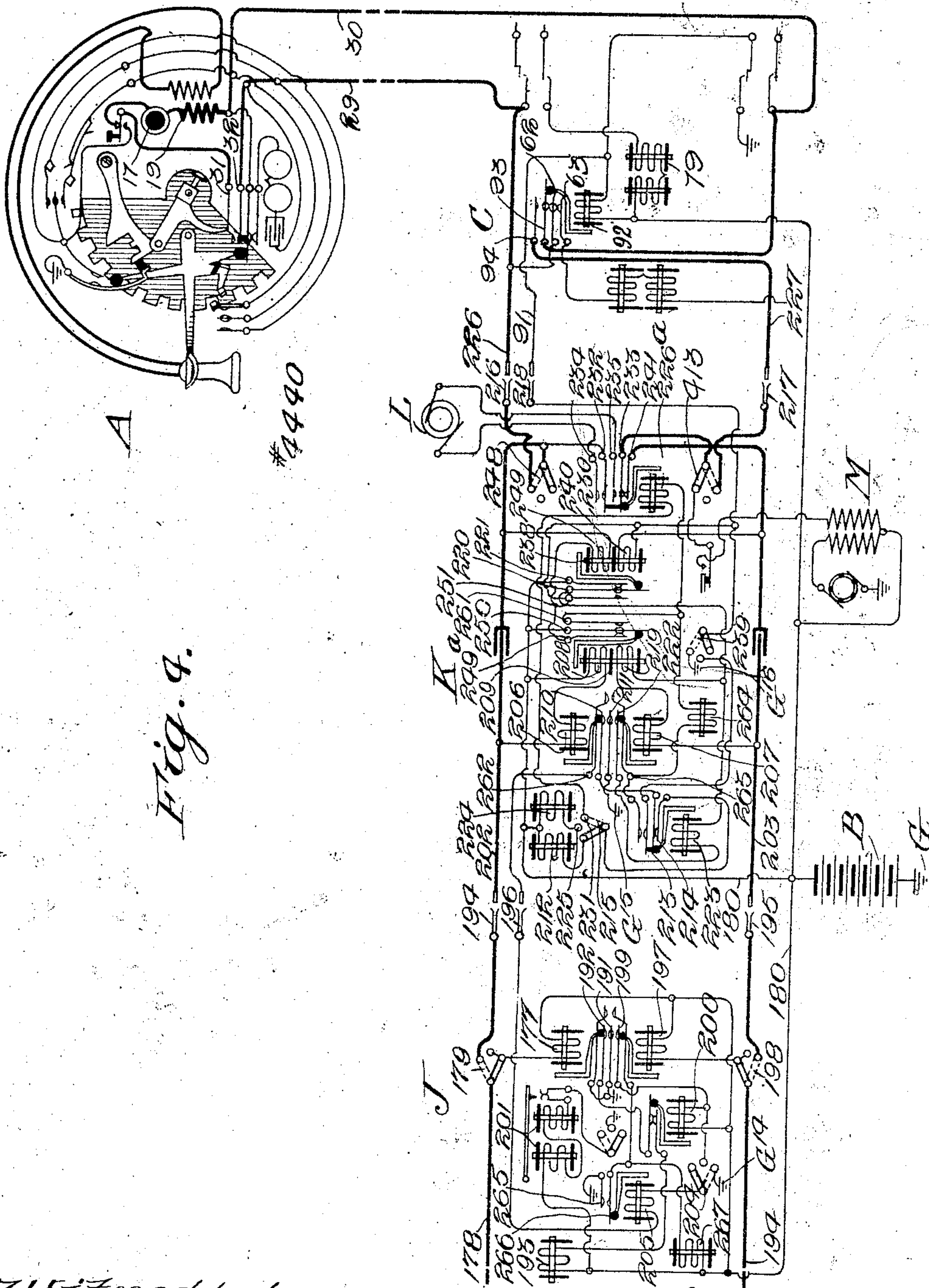


Fig. 4.

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UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE AUTOMATIC TRUNKING SYSTEM.

1,238,039.

Specification of Letters Patent.

Patented Aug. 21, 1917.

Application filed March 1, 1910. Serial No. 546,581.

To all whom it may concern:

Be it known that I, TALBOT G. MARTIN, a citizen of the United States of America, and resident of Chicago, Cook county, Illinois, have invented a certain new and useful Improvement in Telephone-Exchange Automatic Trunking Systems, of which the following is a specification.

My invention relates to automatic or semi-automatic telephone exchange systems in general, but more particularly to those in which provision is made for enabling a subscriber of one exchange to call a subscriber of another exchange, which exchanges are of different character. For example, automatic telephone exchanges may be of the three-wire type—that is to say, of that character in which an operating ground is provided at the substation of each telephone line, and in which the automatic switches at the exchange or central station are responsive to calling devices which control the ground connections at the substations. Again, systems of this kind may be of the two-wire type—that is to say, of the kind in which no operating grounds are employed at the substations of the telephone lines, and in which the automatic switches at the exchange or central station are controlled over the two sides of the telephone line in series. It some times happens that a necessity arises for efficient service between a three-wire system and a two-wire system, and in such case special provision must be made for taking care of calls from one exchange to the other.

Generally stated, the object of my invention is the provision of improved means for trunking between systems or exchanges of different types, whereby a subscriber of one system may call a subscriber of the other system, and vice versa, with the same, or substantially the same, facility and efficiency that a subscriber of either exchange would call another subscriber of the same exchange.

A special object is to provide an improved construction and arrangement whereby trunking may be carried on from a three-wire to a two-wire system, as above defined.

Another object is to provide an improved construction and arrangement whereby trunking may be effected from a two-wire to a three-wire system, as above defined.

Another object is the provision of a re-

peater for use in trunking from a three-wire to a two-wire system, as above defined, which repeater is adapted to receive the calling impulses transmitted over the three-wire line circuit, and to then repeat and transmit the same over the two-wire line circuit to the other exchange.

Another object is the provision of a repeater for use in trunking from a two-wire to a three-wire system, as above defined, which repeater is adapted to receive the calling impulses transmitted over the two-wire line circuit, and to then repeat and transmit the same over the three-wire line circuit to the other exchange.

Another object is to provide an improved construction and arrangement whereby a calling subscriber may signal the called subscriber by an additional movement of the dial at the substation of the calling line.

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

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

In the accompanying drawings, which show a telephone system embodying the principles of my invention, Figure 1 shows diagrammatically automatic central office switching apparatus of the usual type. A represents a subscriber's substation, while at C the line switch allotted to the line conductors of substation A is shown. The master switch D controls the line switches of the group of which the line switch C is a member. E indicates a first selector switch and F represents one of my improved repeaters.

Fig. 2 represents automatic central office switching apparatus of a two-wire system, viz., a system in which a ground connection is not employed at the subscriber's station for operating switches. At N is shown a first selector switch, while at O a connector is represented. A central office ringer generator L' and busy signaling machine M' are also shown. To the line conductors of substation A' there is allotted the line switch C' which is controlled by the master switch D'.

Fig. 3 also represents automatic central

office apparatus of a two-wire system. H indicates a first selector switch, while at I is shown another of my improved repeaters for relaying impulses to another exchange.

Fig. 4 shows additional central office switching apparatus of the three-wire system shown in Fig. 1. J represents a selector switch, while K indicates a connector. A central office ringer generator L and a busy signaling machine M are also shown. The substation A and line switch C are the same as the substation A and line switch C of Fig. 1, reproduced here for the sake of clearness.

For the purpose of explanation it is assumed that the three-wire apparatus of Figs. 1 and 4 belongs to one exchange, while the two-wire apparatus of Figs. 2 and 3 belongs to a second exchange. For the purpose of furnishing current for operating the switches and for talking purposes a number of batteries B are shown, each having one terminal grounded. There may, however, be but one battery, or preferably, if the exchanges are some distance apart, one battery may be provided for each exchange office.

Figs. 1 and 2 taken together represent diagrammatically the central office apparatus involved in establishing a connection from the substation A to the substation A'. Fig. 1 represents a connection extended from substation A through a three-wire exchange to a two-wire exchange in Fig. 2, where the connection is completed with the substation A'.

Figs. 3 and 4 represent central office apparatus by means of which the substation A' may obtain connection with the substation A. The apparatus shown in Figs. 1 and 2 is shown operated, while that of Figs. 3 and 4 is shown in its normal position.

The substation A may be of any suitable or approved type. The one in connection with which I have elected to illustrate my invention comprises, among other details, a receiver 2 and switch hook 3 for controlling the substation circuits, which controlling operations are accomplished through the medium of any suitable means, such as the cam-arms 4, 5 and 6. As the switch hook is lowered the cam-arm 4 momentarily presses the release springs 7, 8 and 9 into engagement, whereby the substation line conductors may be grounded simultaneously. When the switch-hook is down the cam-arm 5 maintains a contact between the springs 10 and 11, thereby bridging the ringer 12 in series with the condenser 13 across the line. The substation ground circuit is normally broken between the ground springs 14 and 15 by the cam-arm 6, but when said springs are together, then ground potential is provided from the battery to the ground post 16 and to the release spring 7, as is usually the case in telephones of this type. The said

substation comprises the usual transmitter 17, induction-coil 18 having the primary winding 19 and secondary winding 20. Being an automatic substation it is provided with the usual vertical and rotary impulse springs 21 and 22. Said substation is, of course, provided with a dial (not shown) which is secured to the shaft 23, together with the locking dog 24. Furthermore, there is a locking cam 25 that locks the dog 24 while the receiver is on the switch hook to prevent rotation of the dial. For operating the impulse springs 21 and 22 the substation is provided with an impulse wheel 26 that is secured to the shaft 23, which impulse wheel carries on its periphery the so-called vertical impulse teeth 27, and one rotary impulse tooth 28. Furthermore, the rotary impulse spring 22 is of such construction that, when the dial is turned forward for the first digit, the rotary impulse tooth 28 momentarily presses the said impulse spring onto the ground post 16, whereby the rotary line conductor 30 is given a preliminary impulse for operating the line switch C. The said impulse teeth are so arranged that when the dial is drawn down the impulse spring 21 is not carried into contact with the ground post 16; but as the dial returns, first the vertical teeth engage the vertical impulse spring 21, and after they have completed their work the rotary impulse tooth operates the rotary impulse spring 22. In this operation the subscriber's vertical line conductor 29 is first given a number of ground impulses, and then the rotary line conductor 30 is given one ground impulse. It will be seen that as long as the dial is out of normal position the dog 24 permits the primary circuit springs 31 and 32 to separate, thus preventing the impulses that are delivered to either line conductor from passing to the other. Means whereby a subscriber may signal a called subscriber comprises the push-button 33 which, when pressed, carries the spring 34 out of engagement with the contact point 35 and into engagement with the contact point 36, whereby the vertical line conductor 29 is grounded.

The substation A' is of the same general type as the substation A, but is modified somewhat in order to operate in a two-wire system. In the substation A', when the receiver is removed from the switch hook, the spring 300 is permitted to disengage spring 301 and to engage spring 302. By this action the circuit through the ringer 303 and condenser 304 is opened, and a bridge consisting of the transmitter 305, receiver 306 and impulse springs 307 and 308 is closed across the line conductors 309 and 310. As the impulse wheel 311 returns to normal position after the dial has been rotated to call a number, the teeth 312 force the impulse spring 307 out of engagement with the

spring 308, thus momentarily opening the bridge across the line a number of times, corresponding to the digit called.

The line switches C and C' are similar to the line switches disclosed in British Patent No. 26,301 of 1906, *Western Electrician* of Chicago, Ill., of Jan. 25, 1908, and the *American Telephone Journal* of Chicago, Ill., of June 6, 1908, the switch C' being modified slightly to operate in a two-wire system. The master switch D is similar in operation and construction to the master switch shown in the above publications.

The master switch D' is of the same general type as the master switch D, but of a somewhat different construction. In the master switch D' several steps of the ratchet wheel 313 are required to rotate the plunger shaft sufficiently to carry the idle plungers from one trunk to another. Rigidly secured to the ratchet wheel 313 there is a notched wheel 314 composed preferably of insulating material. This notched wheel 314 controls a couple of springs 315 and 316. The notches in the wheel 314 are so spaced that the springs 316 and 315 may separate only when the plungers that are in locking engagement with the plunger shaft are in a position directly in front of a trunk terminal. When a line switch operates the circuit of the motor magnet 319 is first closed by the relay 317, which is energized through the wiper 318. As soon as the ratchet wheel 313 is rotated one step the springs 315 and 316 are forced into engagement. The motor magnet will then continue to operate until the plungers reach the next trunk, when the spring 315 drops into the next notch of the wheel 314, thus opening the circuit of the motor magnet 319, since in the meantime the circuit of relay 317 has been broken by the wiper 318. The plunger shaft is so connected with the ratchet wheel 313 that a continued rotary motion of said wheel gives to the shaft a reciprocating motion to move the plungers back and forth in front of the trunk terminals. After the plungers reach the limit of their travel in one direction they are moved successively past the trunks in the reverse direction.

The selector switches E, N, H and J are of the general type shown in United States Letters Patent #815,321, issued March 13, 1906, to Keith, Erickson and Erickson. In this instance the usual bridge-cut-off relay and normal conductors are omitted. The selector switches H and N are modified and arranged to operate in connection with a two-wire system, while the switches E and J operate in conjunction with the usual system employing a ground at the subscriber's substation.

The connector switch K is of the general type of connector switch shown in United States Letters Patent #815,176, issued

March 13, 1906, to Keith, Erickson and Erickson, and is, as usual, connected to the ringer generator L and busy signaling machine M. The connector O is of the same general type as the connector K, being modified somewhat, however, to operate in a two-wire system. In the connector O the operation of the ringer relay for bridging the terminals of the ringer generator across the called line is not contingent upon the calling subscriber pressing a signaling button, but operates automatically when the side switch passes to third position. After the called subscriber answers, however, the energizing circuit through the ringer relay is broken.

The repeater F is adapted to receive impulses from a three-wire central office or substation, and to repeat these impulses to operate switches in a two-wire exchange—that is, the repeater F is the connecting link between a three-wire and a two-wire exchange, and comprises the usual vertical and rotary line relays 37 and 38 connected in series with the windings 39 and 40 of the differential relay 41. The rotary magnet 42 is provided with an armature 43 for rotating the ratchet wheel 44. Secured to the same shaft with the ratchet wheel 44 are the wiper arms 46 and 47. The rotary magnet 42 is so arranged that each time the dial reaches normal position the rotary magnet 42 energizes and the armature 43 moves the ratchet wheel 44 in its advanced position. When the armature pawl 49 is attracted, the ratchet wheel is then free to restore to normal position. The relay 50, upon energizing, attracts its armature 51 into contact with the contact point 52, thereby bridging the impedance coil 53 across the outgoing trunk conductors.

The repeater I (Fig. 3) is adapted to receive impulses from a two-wire substation and to repeat these impulses to the switches of a three-wire exchange (Fig. 4). The repeater I, then, is the connecting link between the two-wire exchange and the three-wire exchange in the same manner in which the repeater F is the connecting link between the three-wire and two-wire central offices. The repeater I comprises the usual double-wound line relay 54 comprising the windings 55 and 56, which are bridged between the battery terminals and the trunk conductors. The slow acting relay 57 controls certain circuit connections, as will be explained. The slow relay 58 controls the energizing circuit of the quick and slow acting release relays 59 and 60. By "slow acting" is meant that, when the relay is energized and in an operated position, the said relay will remain in its operated position for a short time after the energizing circuit is broken.

A clearer understanding of my improved repeaters may be had from an explanation of their operation when employed by one sub-

scriber to establish connection with another. Assume, for example, that the subscriber at substation A (Fig. 1) desires to call the subscriber at substation A' (Fig. 2), the number of which latter is assumed to be 2220. To call the number 2220 the calling subscriber operates the dial in the usual manner for each digit of the desired number. When the dial is turned forward for the first digit 2 a preliminary impulse energizes the trip magnet 61 of the line switch C. This preliminary impulse occurs when the rotary impulse tooth 28 momentarily presses the rotary impulse spring 22 onto the ground post 16, thereby closing an energizing circuit extending from the substation ground G' through the cooperating ground springs 14 and 15, ground post 16, rotary impulse spring 22 to the rotary line conductor 30, bridge-cut-off springs 93 and 63, trip magnet 61, through the motor magnet relay springs 64 and 65, interrupter springs 66 and 67, through the winding of the motor magnet 68 to the battery lead 69. The trip magnet 61 has a comparatively high resistance and does not permit sufficient current to flow to operate the motor magnet 68. As soon as the trip magnet is energized its armature is attracted and the plunger thrust into an idle bank terminal. When the plunger enters the bank terminal an energizing circuit is closed through the motor magnet relay 70 of the master switch. The motor magnet 68 in turn energizes and operates to rotate the ratchet wheel 71, thereby placing the idle plungers opposite the next idle bank terminal. The circuit through the relay 70 extends from ground G² through the winding 72 to the common segment 73 of the master switch bank, through the wiper 74 to the individual segment 75 (which corresponds to the trunk terminal just engaged), conductor 76, line switch bank springs 77 and 78, through the winding of the release magnet 79 to the battery lead 69, thence through battery B to ground G. The release magnet 79 is not energized over this circuit on account of the comparatively high resistance of relay 70. The motor magnet, upon energizing, attracts its armature 81, whereby the pawl upon the end of the armature 81 engages the ratchet wheel 71 and rotates the latter one step. When the armature 81 is attracted against the magnet cores the interrupter springs 66 and 67 disengage, thereby breaking the energizing circuit of the motor magnet 68. The cam arm 82, being in engagement with the pin 83, is operated to advance the plunger shaft 84 and, consequently, all idle plungers that may be in normal position one step to another bank terminal. Also, the master switch bank wiper 74 is carried from the contact 75, which corresponds to the trunk line engaged, to another contact corresponding to the bank terminal before which the idle plungers are now resting. At the instant that the plunger enters the bank terminal the following bank springs are pressed into contact: 85 and 86, 87 and 88, 89 and 90, and 77 and 78. The engagement of the springs 87 and 88 establishes a positive guarding potential, which is transmitted by the private normal conductor 91 to the connector private bank contact corresponding to the line of substation A. This potential projects the line to the calling subscriber from being called by another while the protected line is in use. Also, when the springs 87 and 88 engage, an energizing circuit is established through the bridge-cut-off relay 92 to the battery lead 69, thence through battery B to ground G. This relay, upon energizing, operates to break the contact between the springs 62, 63 and 93 and to carry the spring 93 into contact with the spring 94. The disengaging of the springs 62, 63 and 93 disconnects the subscriber's line conductors 29 and 30 from the line switch trip magnet 61. The guarding potential at the master switch bank for protecting the trunk line conductors 95 and 96 from being seized by another line switch extends from the battery lead 69, through the release magnet 79 and bank springs 78 and 77 to the individual contact 75. The closure of connection between the springs 85 and 86 extends the subscriber's vertical line conductor 29 to the trunk line conductor 95. In a similar manner the engaging of the bank springs 89 and 90 extends the subscriber's rotary line conductor 30 to the trunk line conductor 96. The trunk line conductors 95 and 96 terminate in the first selector switch E and, now, when the dial returns to normal position for the first digit, the vertical line relay is energized a number of times depending upon the digit called. The digit called being 2 the vertical impulse spring 21 is pressed onto the ground post 16 twice, thereby closing an energizing circuit each time through the vertical line relay 97 of the first selector E. This circuit extends from the substation ground G' through the ground post and impulse spring 21 to the vertical line conductor 29, bank springs 85 and 86, side switch wiper 98, vertical line relay 97 to the battery lead 69, thence through battery B to ground G. Each time that the vertical line relay 97 energizes, the springs 99 and 100 are pressed into contact, thereby closing a circuit through the vertical magnet 101 extending from ground G² through the springs 99 and 100, private magnet springs 102 and 103, vertical magnet 101 to the battery lead 69, thence through battery B to ground G. The vertical magnet is thereby energized twice and the shaft and shaft wipers 104, 105 and 106 are raised one step at a time until the shaft wipers

are carried up two steps opposite the bank level in which are located the terminals of trunk lines leading to the repeater F. Immediately following the last vertical impulse the rotary impulse spring 22 is pressed onto the ground post 16, thereby energizing the rotary line relay 107 of the first selector E. The rotary line relay energizes and places the springs 108 and 99 in contact, whereby an energizing circuit is closed through the private magnet 109. The private magnet, as is well known, controls the side switch wipers 98, 110, 111 and 112. The private magnet 109, upon energizing and deenergizing, permits the side switch wipers to engage their respective contacts of the second position. When the side switch wiper 112 engages the contact point 113 an energizing circuit is closed through the rotary magnet 114, said circuit extending from ground G^a through the side switch wiper 112, interrupter springs 115 and windings of the rotary magnet 114 to the battery lead 69, thence through battery B to ground G. The rotary magnet, upon energizing, operates to rotate the shaft wipers 104, 105 and 106 into engagement with the first bank contact of the second level. If the first contact is busy a positive guarding potential is present at the private bank contact, and as soon as this contact is engaged by the shaft private wiper 106, an energizing circuit is established through the private magnet 109 from the grounded private bank contact to the private wiper 106, through the back-release relay 116, side switch wiper 111 (bearing in mind that the side switch is still in second position), through the private magnet 109 to the battery lead 69, thence through battery B to ground G. This new energizing circuit maintains the private magnet in an energized position, thereby locking the side switch in second position until the private wiper 106 passes onto a contact at which there is no guarding potential. At that moment the energizing circuit through the private magnet is broken and the said magnet deenergizes, permitting the side switch to pass to third position, whereby the energizing circuit through the rotary magnet is broken. Furthermore, when the side switch passes to third position a guarding potential is established at the private bank contact corresponding to the trunk line engaged. This potential extends from ground G^a through the side switch wiper 111, back-release relay 116 to the shaft wiper 106 which engages the private bank contact. This guarding potential also provides an energizing circuit for the relay 50 extending from ground through the side switch wiper 111 to the private wiper 106, through the relay 50 to the battery lead 69, thence through battery B to ground G. The relay 50 there-

upon energizes and closes the armature 51 in contact with the point 52, thereby bridging across the trunk conductors 122 and 123 the impedance coil 53 in series with the springs 124 and 125. Although the relay 116 is included in this circuit it does not operatively energize, because it has a low resistance, while that of relay 50 is comparatively high. The engagement of the side switch wipers 98 and 110 with their third-position contact points extends the connection from the calling line through the shaft wipers 104 and 105 to the repeater F. An energizing circuit is immediately established through the line relays 37 and 38 and the windings 39 and 40 of the double-wound coil 41. This circuit extends from ground G^a through the springs 119, 120 and 121, through the winding 40 in series with the rotary line relay 38 to the conductors 118, 96 and 30, thence through the subscriber's substation to the vertical line conductor 29, trunk conductors 95 and 117, through the vertical line relay 37 in series with the winding 39 of the relay 41 to the battery lead 69, thence through battery B to ground G. The relay 41 being wound differentially does not operatively energize; the line relays 37 and 38, however, operate and press the springs they control into contact. The engagement of the springs 126 and 127 at this time produces no result. The engagement of the springs 128 and 129, however, provides an energizing circuit for the rotary magnet 42 extending from ground G^a through the springs 119 and 120, through the springs 129 and 128, rotary magnet 42 to the battery lead 69, thence through battery B to ground G. The rotary magnet 42 thereupon energizes and attracts its armature 43, thus rotating the ratchet wheel 44 one step. It should be stated in connection with the repeater F that each time the repeater F is operated the rotary magnet 42 deenergizes and energizes once for each digit called. Hence, when the ratchet wheel 44 is given four steps the wipers 46 and 47 are carried into engagement with the contact points 130 and 131, thereby providing a new bridge across the trunk conductors 122 and 123. Of course, it will be understood that this bridge connection is not complete until the last digit of the desired number is called. The subscriber's line conductors 29 and 30 having been extended to the trunk conductors 117 and 118, the vertical line relay 37 is operated when the dial returns to normal position for the second digit 2. The energizing circuit through the vertical and rotary line relays 37 and 38 in series is broken at the substation A between the springs 31 and 32 when the dial is turned for the second digit 2. The rotary line relay 38 restores to normal position, but the vertical line relay 37 is energized twice on the

return motion of the dial. The energizing circuit extends from the ground G' through the ground springs 14 and 15, ground post 16 and impulse spring 21 to the conductor 5 95, as explained, side switch wiper 98, shaft wiper 104 to the winding of the vertical line relay 37, winding 39 of the differential relay 41 to the battery lead 69, thence through battery B and to ground G. The winding 10 39 being included in this circuit, the differential relay 41 operatively energizes. The operation of the vertical line relay 37 at this time, however, is without effect. The relay 41, upon energizing, carries the 15 springs 121 and 124 out of engagement with the springs 120 and 125; also, the spring 121 is carried into contact with the spring 132. This disengagement of the springs 124 and 125, as will be seen, opens the bridge across 20 the trunk conductors 122 and 123. When the bridge including the impedance coil 53 is closed across the trunk line conductors 122 and 123, an energizing circuit is provided for the line relay 325 of the selector switch 25 N (Fig. 2). This circuit extends from ground G^{20} through the winding 320, side switch wiper 321, trunk conductor 123 to the contact point 131, then through the springs 125 and 124, contact point 52, armature 51, 30 contact point 130, impedance coil 53, trunk conductor 122, side switch wiper 322, winding 323 to the battery lead 138, thence through battery B to ground G. The relay 325 thereupon energizes and carries the 35 spring 326 out of engagement with the spring 327 and into engagement with the spring 328, thereby closing an energizing circuit through the slow acting relay 329 extending from ground G^{21} through the 40 springs 326 and 328, slow acting relay 329 to the battery lead 138, thence through battery B to ground G. The slow acting relay 329 in turn operates to carry the spring 330 out of engagement with the 45 spring 331 and into engagement with the spring 332. This is the condition of the selector switch N, after the bridge has been closed at the repeater F prior to the sending of the impulses for the second digit. Now, 50 when the differential relay 41 of the repeater F operates for the second digit and opens the bridge circuit between the springs 124 and 125 twice, the energizing circuit for the line relay 325 of the selector N 55 (Fig. 2) is broken twice, and the spring 326 falls back into contact with the spring 327 twice, thereby closing an energizing circuit through the vertical magnet 333 twice. This circuit extends from ground G^{21} 60 through the springs 326 and 327, springs 330 and 332, private magnet relay 334, vertical magnet 333, side switch wiper 335 to the battery lead 138, thence through battery B to ground G. The vertical magnet there- 65 upon operates to carry the shaft wipers 336, 337 and 338 two steps in a vertical direction, opposite the first contact of the second bank level. After the impulses for the second digit have been sent, the differential relay springs 124 and 125 again resume 70 their normal positions, thereby closing an energizing circuit for the line relay 325 of the selector N. The relay 325 returns to its energized position, with the spring 326 in contact with the spring 328, thereby 75 again establishing an energizing circuit for the relay 329. The relay 329, being slow acting, remains in its energized position while the impulses are being sent. The private magnet relay 334, which is also slow 80 acting, being included in series in the energizing circuit of the vertical magnet 333, operatively energizes on the first impulse and closes the springs 339 and 340 in contact. The engagement of these springs pro- 85 vides an energizing circuit for the private magnet 341 extending from ground G^{21} through the springs 339 and 340, private magnet 341 to the battery lead 138, thence through battery B to ground G. The pri- 90 vate magnet relay 334 deenergizes after the last vertical impulse, since this energizing circuit is no longer maintained after the springs 326 and 327 disengage. Hence, the springs 339 and 340 restore to normal posi- 95 tion, whereby the energizing circuit for the private magnet 341 is in turn broken, which private magnet now deenergizes and permits the side switch to pass from first to second position, whereby the side switch 100 wipers 335 and 342 engage the contact points 343 and 344, respectively. It should be explained that when the dial returns to normal position after being operated for the second digit 2, the springs 31 and 32 at the 105 station A again close in contact, thereby providing the series energizing circuit for the vertical and rotary line relays 37 and 38 in series with the windings 39 and 40 of the differential relay 41. The engagement of 110 the springs 128 and 129 again closes an energizing circuit for the rotary magnet 42, thereby giving the ratchet wheel 44 a second step. The closure of contact between the side switch wiper 335 and the contact point 115 343 provides an energizing circuit for the rotary magnet 345 from ground G^{20} to the interrupter springs 346, rotary magnet 345, contact point 343, side switch wiper 335 to the battery lead 138, thence through battery 120 B to ground G. The said rotary magnet then operates to rotate the shaft wipers 336, 337 and 338 of the selector N into engagement with the first contact of the second level of the selector banks, from which con- 125 tact it is assumed the trunk line conductors 347, 348 and 349 lead to the connector O. If the first trunk line is busy, however, and the wipers have to pass over busy contacts, then, as soon as the private wiper 338 en- 130

gages the first private bank contact the private magnet 341 again energizes, locking the side switch in second position. The energizing circuit for the said private magnet extends from grounded terminal G of the battery B through the connector switch of the busy trunk (not shown), through the private wiper 338, conductor 350, private magnet 341 to the battery lead 138, thence through battery B to ground G. The private magnet 341, upon thus becoming energized, locks the side switch wiper 335 in engagement with the contact point 343, whereby the rotary magnet 345 will be energized step by step until the wipers are carried beyond the last busy trunk line. At the instant that the private wiper leaves the last busy contact point, the energizing circuit through the private magnet 341 is destroyed and, as a result, the selector side switch passes to third position. If, however, there are no busy trunk lines, the private magnet 341 releases the side switch to third position as soon as the shaft wipers are carried into engagement with the first trunk line. As soon as the side switch passes to third position, as stated, the subscribers' line conductors 29 and 30 are extended to the trunk conductors 347 and 348 which, in this case, it is assumed lead to the connector O. The extending of the line occurs, of course, as soon as the side switch wipers 321 and 322 engage the contact points 351 and 352, respectively. When the trunk line conductors 122 and 123 are thus extended to the connector O an energizing circuit is established for the line relay 353 in the same manner in which the energizing circuit was established through the line relay 325 of the selector switch N when the subscribers' line conductors were extended to the repeater F. The relay 353, upon energizing, operates to shift the spring 354 out of engagement with the spring 355 into engagement with the spring 356. The engagement of the springs 354 and 356 provides an energizing circuit for the slow acting relay 357 extending from ground G²² to the springs 354 and 356, relay 357 to the battery lead 138, thence through battery B and to ground G. The relay 357, upon energizing, operates to carry the spring 359 out of engagement with the spring 358 and into contact with the spring 360, and to force the spring 361 into engagement with the spring 362. When the springs 361 and 362 engage, a new energizing circuit is established through the slow acting release relay 329 of the selector switch N. This circuit extends from ground G²³ through the side switch wiper 363, springs 361 and 362, private trunk conductor 364, shaft wiper 338, conductor 350, side switch wiper 342, through the winding of the slow acting release relay 329 to the battery lead 138, thence through battery B to ground G.

The engagement of the springs 361 and 362 also provides a guarding potential from ground G²³ to the private bank contact corresponding to the connector O for protecting it against seizure by another calling selector switch. When the dial is turned for the third digit 2 the repeater F is operated, as previously explained, and the differential relay 41 in turn opens the bridge across the trunk conductors 122 and 123 twice, as before, whereby the energizing circuit of the line relay 353 is in turn broken twice. The relay 353, upon deenergizing twice, twice closes the circuit through the vertical magnet 365 and private magnet relay 366. This circuit extends from ground G²² through the springs 354 and 355, springs 359 and 360, vertical magnet 365, side switch wiper 367 and relay 366 to the battery lead 138. Since the digit called is 2 the vertical magnet receives two impulses over this circuit and operates to raise the shaft and wipers 368, 369 and 370 two steps. The private magnet relay 366 operates in the same manner as the private magnet relay 334 of the selector N to close the circuit of the private magnet 371 while the vertical magnet is operating. After all the impulses for the third digit are delivered, the relay 366 deenergizes and breaks the circuit of the private magnet 371. The magnet 371, upon deenergizing, permits the side switch to pass from first to second position. The movement of the side switch wiper 367 from first to second position breaks the connection between the vertical magnet 365 and the relay 366, and connects the rotary magnet 372 with the battery through the relay 366.

The operation of the calling device for the last digit 0 causes the repeater F to operate in the manner explained to repeat ten impulses to the connector or line relay 353. Since the side switch wiper 367 is in second position the deenergization of the relay 353 for this last series of impulses closes a circuit through the rotary magnet 372 and relay 366. Since the last digit is 0 the rotary magnet receives ten impulses, causing it to rotate the wipers ten steps out to the terminals of the desired line #2220. The private magnet relay 366 operates in the same manner as for the previous digit, causing the private magnet 371 to trip the side switch to third position after all the impulses have been delivered to the rotary magnet. The engagement of the side switch wipers 373 and 374 with their third-position contact points extends the connection through the wipers 368 and 369 to the lines of the called substation. The engagement of the side switch wiper 375 with its third-position contact point provides a guarding potential at the connector private bank contacts of the called line, and closes an energizing circuit through the cut-off relay 376 of the line

- switch C'. This circuit extends from ground G²⁴ through the contact point 377, side switch wiper 375, springs 378 and 379, private wiper 370, bank contact 380 and relay 376 to the battery lead 138. The relay 376, upon energizing, disconnects the switch C' from the called line to prevent the operation of the switch when the called subscriber answers.
- 10 When the side switch wiper 367 of the connector engages its third-position contact point a circuit is closed through the ringer relay 381. This circuit extends from ground G²⁵ through the interrupter 382, springs 383 and 384, ringer relay 381, side switch wiper 367 and relay 366 to the battery lead 138. The ringer relay 381, upon energizing, operates to disconnect the calling line and to bridge the generator L' across the called line to signal the called subscriber. Since the circuit of the ringer relay 381 includes the interrupter 382 the relay will be energized only intermittently, so as not to ring the bells at the substation A' continuously.
- 20 When the subscriber at substation A' removes his receiver in response to the signal a bridge is closed across the line through the transmitter and receiver, as previously explained. When this bridge is closed across the line, or as soon thereafter as the ringer relay 381 deenergizes, the substation is provided with talking battery current over a circuit extending from ground G²⁴ through the side switch wiper 377, winding 385 of the back-bridge relay 386, ringer relay springs 388 and 389, side switch wiper 374, shaft wiper 369, line conductor 310, thence through the substation A' and back over the line 309, wipers 368 and 373, springs 390 and 391 and through the winding 387 of the relay 386 to the battery lead 138. The relay 386 is energized by the closure of this circuit and, by separating the springs 383 and 384, prevents further energization of the relay 381 after the called subscriber has answered. The talking circuit between the two connected substations is shown in heavy lines in Figs. 1 and 2.
- 50 When the dial returns to its normal position after the last digit 0 the rotary magnet 42 of the repeater F operates to carry the wipers 46 and 47 into engagement with the contact points 130 and 131, thereby bridging the impedance coil 53 across the trunk conductors 122 and 123, independent of the circuit through the springs 124 and 125 of the differential relay 41. This provision is made so that the subscriber at substation A may not interfere with a connection once established by pressing his signaling button and thereby energizing the vertical line relay 37 and the differential relay 41, whereby the bridge across the line conductors 122 and 123 would be broken, and the switches might be released if the button was pressed for too long a time. With the impedance coil 53 bridged across the trunk line conductors 122 and 123, independent of the operating relays, this exigency is provided for.
- The release of the central office switching apparatus occurs when the calling subscriber restores his receiver to the switch hook, whereby the cam arm 4 presses the release springs 7, 8 and 9 into contact simultaneously, thereby grounding the line conductors 29 and 30. The ground to the line conductors 29 and 30 unbalances the differential relay 41, whereby the said relay now energizes and presses the spring 121 into engagement with the spring 132. By this operation a new energizing circuit is established through the rotary line relay 38 in series with the winding 40, since the spring 121 is now connected with the battery lead 69 instead of ground G'. When the contact between springs 119 and 120 is broken the circuit through the rotary magnet 42 is opened, thus allowing the armature 43 to drop back from the ratchet wheel 44, leaving the said wheel in position to return to its normal position when the armature 49 is withdrawn by the magnet 48. When the spring 121 engages the spring 132 and the relays 37 and 38 are also energized, an energizing circuit is established through the relay 48 extending from ground G' through the side switch wiper 111 of the selector switch E, back-release relay 116, shaft wiper 106, through the springs 126 and 127, relay 48 to the springs 132 and 121, to the battery lead 69, thence through battery B to ground G. The relay 48 thereupon energizes and attracts its armature 49 out of engagement with the ratchet wheel 44. The ratchet wheel thereupon restores to normal position. The back-release relay 116 of the selector E, being included in this circuit, also operatively energizes and presses the springs 252 and 253 into contact, whereby an energizing circuit is established through the release magnet 254 of the selector switch E. The release magnet 254 energizes and in turn closes an energizing circuit through the release magnet 79 of the line switch C. This circuit extends from ground through the contact point 255, spring 256, bank springs 77 and 78, release magnet 79 to the battery lead 69, thence through battery B to ground G. All of the relays and magnets thus energized attract their respective armatures and remain in readiness to restore their respective switches when the ground connection to the line conductors 29 and 30 is broken upon the disengagement of the release springs 7, 8 and 9. When the first selector E restores to normal position the shaft wipers 104, 105 and 106 disengage from the bank contacts, and the energizing circuit through the relay 50 of the repeater F is broken.

The armature 51 therefore disengages from the contact point 52, which prevents the closure of the bridge across the trunk when the relay 41 again deenergizes.

5 The opening of the bridge across the trunk conductors 122 and 123 by the restoration of the wipers 46 and 47 of the repeater F permits the line relay 353 of the connector O to deenergize and open the energizing circuits of the release relays 357 and 10 329 of the switches O and N, respectively. Although it has not been previously mentioned, it is evident that after the connector side switch reaches third position the holding ground of the release relay 329 of the 15 selector N is shifted from ground G^{25} to ground G^{22} through the wiper 363 and springs 354 and 356. Thus, the deenergization of the relay 353 breaks the circuit of 20 both release relays, as stated. When the relays 357 and 329 deenergize they close the energizing circuits of the release magnets 392 and 393, respectively. The circuit of the connector release magnet 392 extends 25 from ground G^{22} through springs 354 and 355, 359 and 358, magnet 392 and off normal springs 394 and 395 to battery lead 138. The release magnet 392, upon energizing, releases the mechanism of the connector O, 30 allowing it to be restored to normal position. When the switch shaft reaches its lowest position the arm 396 forces the spring 394 out of engagement with the spring 395 to permit the magnet 392 to be deenergized. 35 The selector N is restored in the same manner as the connector O. When the connector releases it destroys the energizing circuit of the cut-off relay 376 of the line switch C' to allow it to be restored to the line of 40 substation A'. The central office switching mechanism is thus restored to normal position and remains in readiness to be used by another calling subscriber.

The foregoing is a description of how a 45 subscriber of a three-wire exchange may obtain connection with a subscriber of a two-wire exchange. It will now be explained how a call proceeds in the opposite direction, or how the subscriber at substation A' can 50 call substation A (#4440). The engagement of the springs 300 and 302 at substation A', upon the removal of the receiver, closes an energizing circuit through the trip magnet 397 of the line switch C'. This circuit extends from ground G^{26} through the 55 magnet 397, springs 398 and 399, line 310, springs 300 and 302, impulse springs 308 and 307, receiver 306, transmitter 305, line 309, springs 401 and 400, resistance 402 and 60 springs 403 and 404 to battery lead 138. The trip magnet 397, upon energizing, causes the switch C' to operate in the same manner as explained for the switch C to extend the connection over the trunk conductors 405 and 65 406 to the selector H (Fig. 3). The opera-

tion of the switch C' also closes a circuit through the master switch relay 317 in the same manner in which the circuit was closed through the winding 72 of the relay 70 of master switch D (Fig. 1). The relay 317, upon energizing, closes an energizing circuit through the relay 408 and motor magnet 319. This circuit extends from ground G^{27} through relay 408 and magnet 319 in multiple, interrupter springs 409 and springs 75 410 and 411 of relay 317 to battery lead 138. Since this circuit includes the interrupter springs 409 the motor magnet 319 begins to operate in a manner similar to that of a 80 buzzer to give the ratchet wheel 313 a continuous step by step motion to move the idle plungers away from the trunk just seized. As soon as the wheel 313 moves one step the notched wheel 314 forces spring 315 into engagement with spring 316 to maintain the 85 circuit of the motor magnet 319, independent of relay 317. When the master switch has advanced a short distance farther, the wiper 318 leaves the contact 412, but the motor magnet continues to operate until the spring 90 315 drops into the next notch of the wheel 314 and disengages spring 316, by which time the plungers will have reached a position directly in front of the next trunk. If 95 the next trunk is busy, however, the relay 317 remains energized, when the wiper 318 passes onto the next contact and causes the plungers to be carried past the busy trunk to the next one which is idle. The relay 408 is energized when its circuit is first closed by relay 100 317, but being slow acting does not have time to deenergize during the momentary interruption of its circuit at the springs 409 while the magnet 319 is operating. Thus, the relay 408 is energized during the entire time 105 the master switch is rotating, and operates to disconnect the battery from the trip magnets 397 of all line switches C', and connects the busy signaling machine M' with the idle lines through the resistance 402 and 110 springs 400 and 401. Thus, any subscriber who attempts to make a call while his master switch is operating will not only be unable to operate his line switch, but will receive the busy signal as well. 115

When the connection is extended to the selector H by the line switch C' the line relay 133 is energized over a circuit extending from ground G^8 through winding 134, side switch wiper 135, trunk conductor 406, line 120 310, through substation A' and back over line 309, trunk 405, side switch wiper 136 and winding 137 to battery lead 138. The relay 133, upon energizing, closes a circuit through the release relay 142 in the same 125 manner explained for the relay 329 of selector N. When the calling device is operated for the first digit (4) four impulses are transmitted to the line relay 133. The selector H operates in the same manner as 13

explained for the selector N, except that since the digit called is 4 the shaft is raised four steps by the vertical magnet 146, after which the rotary magnet 155 automatically rotates the wipers 149^a, 150^a and 151^a onto the terminals of an idle pair of trunk conductors 157 and 158 leading to a repeater I. The private magnet relay 147 operates in the same manner as the relay 334 of the selector N to cause the private magnet 151 to trip the side switch from first to second position after the vertical magnet has operated.

At the instant the connection is extended to the repeater I by the selector H the relay 54 is energized in the same manner as was the relay 133 of the selector H when the connection was first extended to it by the line switch C'. The relay 54, upon energizing, operates to shift the spring 163 out of engagement with the spring 164 and into engagement with the spring 165, and to force the springs 166 and 167 out of engagement with the springs 168 and 169, respectively. The engagement of the springs 163 and 165 closes a circuit extending from ground G¹⁰ through springs 163 and 165 and relay 57 to battery lead 138. The relay 57, upon energizing, forces springs 170, 171 and 172 into engagement with the springs 173, 174 and 175, respectively, whereby the spring 164 of relay 54 is connected with the vertical trunk conductor 178, relay 58 is connected with battery lead 138, and a holding circuit is closed through the release relay 142 of the selector H. This circuit extends from ground G¹¹ through the springs 175 and 172, private wiper 151^a, conductor 160, side switch wiper 152, contact point 176 and relay 142 to the battery lead 138.

When the calling device is operated for the second digit 4 the bridge across the line conductors 309 and 310 is opened four times, each time allowing the relay 54 of the repeater to deenergize and permit the springs 163, 166 and 167 to return to normal position momentarily. The engagement of the springs 163 and 164 closes an energizing circuit for the vertical line relay 177 of the selector switch J (Fig. 4). This circuit extends from ground G¹⁰ through the springs 163 and 164, springs 170 and 173 to the vertical trunk conductor 178, side switch wiper 179 (Fig. 4), vertical line relay 177 to the battery lead 180, thence through battery B to ground G. Also, when the spring 166 engages the spring 168 an energizing circuit is closed through the slow acting relay 58 extending from ground G¹⁰ through the springs 166 and 168, relay 58, springs 171 and 174 to the battery lead 138, thence through battery B and to ground G. The relays 57 and 58, being slow acting, remain in their operative position until all of the impulses for the third digit have been sent. The relay 58, upon energizing, operates to close the springs 181 and 182 in contact, whereby a circuit is closed through the release relays 59 and 60. This circuit extends from ground G¹² through the springs 181 and 182, quick-acting release relay 59 in series with the slow-acting release relay 60 to the battery lead 138, thence through battery B to ground G. The relay 59, upon energizing, attracts its armatures 183 and 184 out of engagement with the contact points 185 and 186. The relay 60, upon energizing, attracts its armatures 187 and 188 into engagement with the grounded contact points 189 and 190. This is the condition of the repeater I while the impulses for the second digit 4 are being transmitted. The vertical line relay 177, upon being energized four times, operates to close the springs 191 and 192 in contact, thereby in turn closing an energizing circuit through the vertical magnet 193, whereby the shaft wipers 194, 195 and 196 are carried four steps in a vertical direction opposite the first contact of the second level of the selector bank. After the dial at substantiation A⁴ returns to normal position for the second digit 4, the springs 166 and 168 remain out of engagement, thereby breaking the energizing circuit for the slow acting relay 58. The slow acting relay 58 in turn restores to normal position, permitting the springs 181 and 182 to disengage, thereby breaking the energizing circuit for the release relays 59 and 60. When this occurs the armatures 183 and 184 of the quick acting relay 59 immediately restore to normal position in engagement with the contact points 185 and 186, respectively. The armatures 187 and 188 of the slow acting relay 60, however, remain in contact with the points 189 and 190, respectively, for a moment. This operation produces a ground impulse for the rotary trunk line conductor 194, thereby providing an energizing circuit for the rotary line relay 197 of the selector switch J. No ground impulse, however, is transmitted to the vertical trunk line conductor 178, since the springs 167 and 169 are disengaged. The energizing circuit for the rotary line relay 197 extends from ground G¹³ through the contact point 190 and armature 188, contact point 186 and armature 184 to the rotary trunk line conductor 194, side switch wiper 198 (Fig. 4), through the rotary line relay 197 to the battery lead 180. The rotary line relay 197, upon energizing, presses the springs 199 and 191 into contact, thereby closing an energizing circuit through the private magnet 200, which operates as usual to trip the side switch wipers from first to second position, whereby an energizing circuit is established through the rotary magnet 201. The rotary magnet 201 now operates to rotate the shaft wipers 194, 195 and 196 in a rotary direction to select an idle trunk line leading to a connector

switch K. After the rotary magnet ceases to operate, and the side switch wipers pass to third position, a guarding potential is established at the private bank contact engaged by the shaft wiper 196 for protecting the seized trunk line conductors 202 and 203 against seizure by any other calling subscriber. This potential extends from ground G^{14} to the side switch wiper 204, back-release relay 205 to the shaft private wiper 196, which latter engages the private bank contact corresponding to the trunk line conductors 202 and 203. The operation of the dial for the last two digits is effective in operating the vertical and rotary line relays 206 and 207 of the connector switch K. The operation of the substation calling device for the third digit 4 again opens the bridge across the line four times, thereby in turn operating the line relay 54 of the repeater I four times, as explained. The relay 54 operates to send four ground impulses to the vertical trunk line conductor 178, which are effective in closing an energizing circuit for the vertical line relay 206 of the connector switch K. This circuit extends from ground G^{10} at the repeater I to the springs 163 and 164, springs 170 and 173 to the trunk conductor 178, side switch wiper 179 (Fig. 4), shaft wiper 194, trunk conductor 202, vertical line relay 206, winding 208 of the differential relay 209 to the battery lead 180, thence through battery B to ground G. The winding 208 being included in this circuit, the relay 209 operatively energizes, but its operation at this time is without effect. The relay 206 thereby closes the springs 210 and 211 into contact, whereby four impulses are transmitted to the vertical magnet 212 over a circuit extending from ground G^{15} through the springs 211 and 210, springs 213 and 214 to the side switch wiper 215 and vertical magnet 212 to the battery lead 180, thence through battery B and to ground G. The shaft wipers 216, 217 and 218 are thereby raised to the fourth level opposite the first contact. When the dial returns to rest after having sent the four impulses, the line relay 54 of the repeater I returns to its normal energized position and again breaks the energizing circuit for the slow acting relay 58, when the springs 166 and 168 disengage. The springs 181 and 182 again operate, as before, permitting the release relays 59 and 60 to restore to normal position, whereby a rotary impulse is transmitted to the rotary trunk conductor 194, as previously explained. This impulse provides an energizing circuit for the rotary line relay 207 extending from ground G^{13} to the trunk conductor 194, as stated, through the side switch wiper 198, shaft wiper 195, trunk conductor 203 to the rotary line relay 207 and winding 219 of the differential relay 209, through the springs 220 and 221 to the battery lead

180, thence through battery B to ground G. The winding 219 being included in this circuit, as is the winding 208 in the circuit of the vertical line relay 206, the differential relay 209 operatively energizes, but its operation at this time is also without effect. The rotary line relay, upon energizing, presses the springs 222 and 211 into contact, thereby closing an energizing circuit for the private magnet 223 from ground G^{15} through the springs 211 and 222, winding of the private magnet 223, springs 220 and 221 to the battery lead 180, thence through battery B to ground G. The private magnet 223 now operates to permit the side switch wipers to pass from first to second position. When the dial is turned for the last digit 0 the vertical line relay 206 of the connector K is operated ten times, in the manner previously explained. When the vertical line relay operates for the last digit, however, an energizing circuit is established through the rotary magnet 224 instead of through the vertical magnet 212, since the side switch wiper 215 is now in second position, in engagement with the contact point 225. This circuit extends from ground G^{15} through the springs 211 and 210, private magnet springs 213 and 214, side switch wiper 215, contact point 225, winding of the rotary magnet 224 to the battery lead 180, thence through battery B to ground G. The rotary magnet now operates to rotate the shaft wipers 216, 217 and 218 ten steps in a rotary or circular direction and into engagement with the bank contacts comprising the terminals of the normal conductors 226, 227 and 91 of the line of substation #4440. When the line relay 54 of the repeater I returns to its energized position the circuit to the relay 58 is broken, and the release relays 59 and 60 again operate to provide an energizing circuit for the rotary line relay 207, as before explained. The rotary line relay 207 operates in turn to close an energizing circuit through the private magnets 223, which also operates and permits the side switch wipers to pass from second to third position. When the side switch wiper 215 reaches third position the ringer relay 226^a is placed under the control of the vertical relay 206 and at the same time the connection is completed with the called line by the side switch wipers 248 and 413. The engagement of the side switch wiper 239 with its third-position contact point provides a guarding potential for the connector private bank contacts of the called line and closes an energizing circuit for the cut-off relay 92 of the line switch C. This circuit extends from ground G^{16} through the side switch wiper 239, private wiper 218, connector private bank contacts of the called line, conductor 91 and relay 92 to battery. The relay 92, upon energizing, disconnects the trip magnet 61 from the called

line, and by closing the contact between the springs 93 and 94 connects the line conductor 30 with its connector bank contacts.

In order to signal the called substation, the calling subscriber again operates his calling device, preferably for the digit 0. The repeater I responds to this operation of the calling device to again repeat a series of ground impulses to the vertical trunk conductor 178. The vertical relay 206 and differential relay 209 respond to these impulses in the usual manner, but in this instance the engagement of springs 211 and 210 closes an energizing circuit for the ringer relay 226^a. This circuit extends from ground G¹⁵ through springs 211 and 210, 213 and 214, side switch wiper 215, contact point 231, relay 226^a and springs 261 and 250 to battery lead 180. The relay 226^a, upon energizing, operates to disconnect the calling line and to bridge the ringer generator L across the called line to ring the bells at substation A. The rotary impulse following this last series of vertical impulses causes the operation of the rotary relay 207 and private magnet 223 in the usual manner, but this operation is without effect, because the side switch has already reached the limit of its travel.

When the called subscriber removes his receiver in response to the signal the springs 31 and 32 engage, thereby closing a circuit over which the substation A receives talking current. This circuit extends from ground G¹⁶ at the connector K through the side switch wiper 239, winding 240 of relay 238, ringer relay springs 241 and 233, wiper 217, conductor 227, springs 94 and 93, line 30, primary winding 19, transmitter 17, springs 31 and 32, line 29, conductor 226, wiper 216, side switch wiper 248 and winding 249 of the relay 238 to the battery lead 180. The relay 238 is energized by this talking current, but has no utility at this time.

After the conversation is completed the central office apparatus is released by the restoration of the receiver at the calling substation, as in the previous case, but in a slightly different manner. When the springs 300 and 302 at substation A' are separated by the switch hook the circuit of the line relay 54 of the repeater I is broken. This relay, upon deenergizing, permits the springs 163, 166 and 167 to restore to normal position, thereby closing an energizing circuit through the relay 58 extending from ground G¹⁰ to the springs 168 and 166, relay 58, springs 171 and 174 to the battery lead 138, thence through battery B to ground G. The relay 58 thereupon energizes and closes the springs 181 and 182 into contact, whereby the circuit through the release relays 59 and 60 is again established. When the springs 163 and 165 disengage, the energizing circuit for the slow acting relay 57 becomes broken and this relay in turn restores

to normal position, permitting the springs 170, 171 and 172 to disengage from the springs 173, 174 and 175. This disengagement of the springs 172 and 175 breaks the energizing circuit through the slow acting release relay 142 of the selector switch H. The spring 143 therefore returns to normal engagement with the spring 144, whereby an energizing circuit is established through the release magnet 257 of the switch H. This circuit extends from ground G⁹ through the springs 139 and 140, springs 143 and 144, release magnet 257, contact point 258, normal spring 259 to the battery lead 138. The release magnet thereupon energizes and restores the selector side switch and switch shaft to normal position. When the switch shaft reaches normal position the normal arm 260 carries the spring 259 out of engagement with contact point 258, thereby breaking the energizing circuit of the release magnet 257. The engagement of springs 143 and 144 closes a second circuit extending from ground G⁹ through springs 139 and 140, 143 and 144, relay 414, springs 415 and 416, conductor 407, bank springs 417 and 418 and release magnet 419 of the line switch C' to the battery lead 138. Both the magnet 419 and the relay 414 are energized over this circuit, the magnet 419 placing the mechanism of switch C' in position to be released by the subsequent deenergization of said magnet, while the relay 414 opens the circuit through itself and the magnet 419. The magnet 419 thereupon deenergizes, allowing the line switch C' to be restored to normal position. The circuit of the magnet 419 is not again closed when the relay 414 deenergizes, because bank springs 417 and 418 are then separated. The relay 414 is made slow acting to prevent its deenergization before the switch C' has released.

The disengagement of springs 171 and 174 of the repeater relay 57 opens the circuit through the slow acting relay 58 which, after a moment, deenergizes, thus permitting the springs 181 and 182 to restore to normal position. The opening of springs 181 and 182 breaks the circuit through the release relays 59 and 60. Relay 59 immediately deenergizes, while the slow acting relay 60 remains energized for a moment, thus grounding the vertical and rotary trunk line conductors 178 and 194 simultaneously and thereby providing an energizing circuit for the vertical and rotary line relays 206 and 207 simultaneously. The energizing circuit for the vertical line relay extends from ground G¹³ to the contact point 189, armature 187, springs 169 and 167, contact point 185 and armature 183, the trunk line conductor 178, side switch wiper 179 (Fig. 4), vertical line relay 206, winding 208 to the battery lead 180, thence through battery B to ground G. The ground to the rotary

line conductor 194 extends from ground G^{13} to the armature and contact points of the release relays, as before explained, to the trunk conductor 194, side switch wiper 198 (Fig. 4), conductor 203, rotary relay 207, through the winding 219 of the relay 209, through the springs 220 and 221 to the battery lead 180, thence through battery B to ground G. The vertical and rotary line relays thereupon energize, and also the differential relay 209, since the windings 208 and 219 do not oppose one another when thus carrying current. The spring 250 is therefore shifted out of engagement with the spring 249^a and into engagement with the spring 261. It will be seen that the closure of the above circuit for the rotary relay is dependent upon the back-bridge relay 238 being deenergized. If the called subscriber has not hung up his receiver, the circuit of this relay will be broken by the separation of the springs 249 and 250 of the relay 209, which is energized through its winding 208 as soon as the vertical trunk conductor 178 is grounded by the repeater I. The vertical and rotary line relays 206 and 207, upon energizing simultaneously, press the trunk-release springs 262 and 263 into contact, thereby closing an energizing circuit through the release magnet 264 extending from ground G^{14} at the selector switch J to the side switch wiper 204, back-release relay 205, shaft private wiper 196, through the springs 262 and 263, release magnet 264, differential relay springs 261 and 250 to the battery lead 180, thence through battery B to ground G. The release magnet 264, upon energizing, operates to restore the connector side switch wipers and switch shaft wipers to normal position. The release relay 205 of the selector switch J, being included in this release circuit, also operatively energizes and presses the springs 265 and 266 into contact, thereby providing a circuit for the release magnet 267. The release magnet 267 energizes and remains in readiness to release the selector switch J when the energizing circuit for the release relay 205 is broken. The slow acting release relay 60 of the repeater I, after a moment, is restored to normal position, thereby disconnecting the trunk conductors 178 and 194 from ground G^{13} . All of the release relays and magnets thus involved in a release are restored, leaving the central office apparatus in normal position and in readiness to be used by another calling subscriber.

From the foregoing it will be seen that I provide efficient means for carrying on trunking from a three-wire to a two-wire system, and vice versa, and that this is accomplished through the medium of the repeaters F and I, as previously explained. As herein disclosed, these repeaters are employed in connection with automatic con-

nectors for finding the called lines, and in combination with means whereby a calling subscriber may, without the assistance of an operator, extend connection to said automatic connectors. In other words, and as herein disclosed, no switchboard operators are necessary, as the connection from a calling line to a called line is entirely automatic. It will be understood, however, that I do not limit myself to this particular kind of a system, as these repeaters F and I may be employed in other systems, and in conjunction with manual apparatus, without departing from the spirit of my invention.

It will also be seen that, with my improved construction and circuit arrangement, the calling subscriber signals the called subscriber when the call is from a two-wire subscriber to a three-wire subscriber by an additional movement of the dial at the calling substation.

For the purpose of this application I desire to define the meaning of certain terms or expressions as follows: By a "three-wire line circuit", or "three-wire automatic subscriber's telephone line", I mean a line which must be grounded at the substation thereof in order to control the automatic switching apparatus at the exchange or central station. By a "two-wire line", or "two-wire line circuit", or equivalent expression, I mean a line the two sides of which are necessarily employed in series to control the automatic apparatus at the exchange or central station, no ground being employed at the substation of said line. By the expression "repeater" I mean a mechanism of any suitable character which is adapted to receive calling impulses, and to then repeat or transmit duplicates of said impulses in the direction of the called subscriber.

What I claim as my invention is:—

1. In a telephone system, means for transmitting calling impulses, and a repeater for receiving and repeating said impulses, said repeater provided with parallel voice-current conductors, a step-by-step-operated switching mechanism, said mechanism responsive to said impulses, and means operated by said mechanism to form a bridge between said voice-current conductors.

2. In a telephone system, means for transmitting calling impulses, and a repeater for receiving and repeating said impulses, said repeater provided with parallel voice-current conductors, a ratchet mechanism, a relay for operating said ratchet mechanism, responsive to said impulses, and means whereby a plurality of actuations of said mechanism will close a bridge between said voice-current conductors.

3. In a telephone system, means for transmitting calling impulses, and a repeater for receiving and repeating said im-

pulses, said repeater provided with parallel voice-current conductors, a step-by-step operated switching mechanism, said mechanism responsive to said impulses, means operated by said mechanism to form a bridge between said voice-current conductors, and means including a release magnet for restoring said mechanism to normal position.

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

5. In a telephone system, means for transmitting calling impulses, a pair of relay coils for receiving said impulses, a pair of slow-acting relays controlled by said first-mentioned relay coils, a second pair of relays controlled in series by one of said slow-acting relays, and a ground connection controlled by one of said second pair of relays.

6. In a telephone system, means for transmitting calling impulses, a repeater for receiving and repeating said impulses, an automatic switch whereby the calling subscriber connects with said repeater, said repeater provided with parallel voice-current conductors, a step-by-step-operated switching mechanism, said mechanism responsive to said impulses, and means operated by said mechanism to form a bridge between said voice-current conductors.

7. In a telephone system, means for transmitting calling impulses, a repeater for receiving and repeating said impulses, an automatic switch whereby the calling subscriber connects with said repeater, said repeater provided with parallel voice-current conductors, a ratchet mechanism, a relay for operating said ratchet mechanism, responsive to said impulses, and means whereby a plurality of actuations of said mechanism will close a bridge between said voice-current conductors.

8. In a telephone system, means for transmitting calling impulses, a repeater for receiving and repeating said impulses, an automatic switch whereby the calling subscriber connects with said repeater, said repeater provided with parallel voice-current conductors, a step-by-step-operated switching mechanism, said mechanism responsive to said impulses, means operated by said mechanism to form a bridge between said voice-current conductors, and means including a release magnet for restoring said mechanism to normal position.

9. In a telephone system, means for transmitting calling impulses, a repeater for receiving and repeating said impulses, an automatic switch whereby the calling subscriber connects with said repeater, said repeater provided with parallel voice-current conductors, a ratchet mechanism, a relay for operating said ratchet mechanism, responsive to said impulses, means whereby a plurality of actuations of said mechanism will close a bridge between said voice-current conductors, and means including a release magnet for restoring said mechanism to normal position.

10. In a telephone system, means for transmitting calling impulses, a repeater having a pair of relay coils for receiving said impulses, slow-acting relays controlled by said first-mentioned relay coils, relays controlled in series by one of said slow-acting relays, a ground connection controlled by one of said last-mentioned relays, and an automatic switch whereby the calling subscriber connects with said repeater.

11. In a telephone system, means for transmitting calling impulses, and a repeater for receiving and repeating said impulses, said repeater provided with parallel voice-current conductors, a step-by-step-operated switching mechanism, said mechanism responsive to said impulses, means operated by said mechanism to form a bridge between said voice-current conductors, and an automatic switch for finding the called subscriber's line.

12. In a telephone system, means for transmitting calling impulses, and a repeater for receiving and repeating said impulses, said repeater provided with parallel voice-current conductors, a ratchet mechanism, a relay for operating said ratchet mechanism, responsive to said impulses, means whereby a plurality of actuations of said mechanism will close a bridge between said voice-current conductors, and an automatic switch for finding the called subscriber's line.

13. In a telephone system, means for transmitting calling impulses, and a repeater for receiving and repeating said impulses, said repeater provided with parallel voice-current conductors, a step-by-step-operated switching mechanism, said mechanism responsive to said impulses, means operated by said mechanism to form a bridge between said voice-current conductors, means including a release magnet for restoring said mechanism to normal position, and an automatic switch for finding the called subscriber's line.

14. In a telephone system, means for transmitting calling impulses, and a repeater for receiving and repeating said impulses, said repeater provided with parallel voice-current conductors, a ratchet mechanism, a relay for operating said ratchet mechanism,

responsive to said impulses, means whereby a plurality of actuations of said mechanism will close a bridge between said voice-current conductors, means including a release magnet for restoring said mechanism to normal position, and an automatic switch for finding the called subscriber's line.

15. In a telephone system, means for transmitting calling impulses, relay coils for receiving said impulses, slow-acting relays controlled by said first-mentioned relay coils, relays controlled in series by one of said slow-acting relays, a ground connection controlled by one of said controlled relays, and an automatic switch for finding the called subscriber's line.

16. In a telephone system, a three-wire circuit, a two-wire circuit, means for transmitting calling impulses, and means for repeating said impulses from the three-wire circuit to the two-wire circuit.

17. In a telephone system, a calling telephone line, an automatic switch, means for controlling said switch by grounding the said telephone line at the substation thereof, a called telephone line, another automatic switch, a repeater between said automatic switches, a metallic line circuit over the two sides of which said repeater controls the said last-mentioned automatic switch during the progress of the call from the calling line to the called line, and means whereby the subscriber of said called line may call the subscriber of said calling line, said means including one or more automatic switches controllable over the two sides of the called line in series when the latter is used as a calling line.

18. In a telephone system, an automatic switch, a line circuit for said switch, means for controlling said switch by grounding first one side and then the other of said line circuit, a second automatic switch, a trunk line circuit for said second automatic switch, a repeater adapted to control the said second automatic switch over the two sides of the trunk line circuit in series, and means for connecting the first automatic switch with the said repeater.

19. In a telephone system, a three-wire automatic subscriber's line, a two-wire automatic subscriber's line, and means including a repeater for extending connection from the three-wire line to the two-wire line.

20. In a telephone system, a two-wire automatic subscriber's line, a three-wire automatic subscriber's line, and means including a repeater for extending connection from the two-wire line to the three-wire line.

21. In a telephone system, an automatic switch, a line circuit for said switch, means for controlling said switch over the two sides of said line circuit in series, a repeater, means for connecting said switch with the said repeater, a second automatic switch,

and a trunk line circuit for said second automatic switch, said repeater adapted to control the said second switch by grounding first one side and then the other of said trunk line.

22. In a telephone system, a calling telephone line, an automatic switch, means for controlling said automatic switch over the two sides of said telephone line in series, a repeater, means for connecting the said switch with the said repeater, a second automatic switch, a trunk line circuit for said second automatic switch, a called telephone line, and one or more other automatic switches controllable by grounding the called line at the substation thereof when this line is to be used as a calling line said repeater being provided with means for grounding the said trunk line to control the second automatic switch during the progress of the call from the first-mentioned telephone line to the other telephone line.

23. In a telephone system, a circuit, means for grounding said circuit to transmit calling impulses over the same, another circuit, and means for receiving said impulses and repeating the same over the two sides of said second circuit in series.

24. In a telephone system, a trunk line, means for transmitting impulses, a repeater for repeating said impulses, said repeater including a double-wound relay bridged across said trunk line, a pair of slow-acting relays controlled by said double-wound relay, another pair of relays controlled by said slow-acting relays, an outgoing trunk line, and means controlled by said second pair of relays for repeating impulses over said outgoing trunk.

25. In a telephone system, a line circuit, a trunk circuit, means for transmitting impulses by grounding first one side and then the other of said line circuit, and a repeater for receiving said impulses and for repeating them over two sides of the trunk circuit in series, said repeater comprising a pair of line relays and a double-wound relay, each of said line relays being connected in series with one winding of said double-wound relay.

26. In a telephone system, a line circuit, a trunk circuit, means for transmitting impulses by grounding first one side and then the other of said line circuit, a repeater for receiving said impulses and for repeating them over two sides of the trunk circuit in series, said repeater comprising a pair of line relays and a double-wound relay, each of said line relays being connected in series with one winding of said double-wound relay, a step-by-step switch, and a release relay therefor, said release relay being connected in series with one of said line relays.

27. In a telephone system, a line circuit, a calling device, a step-by-step switch, means

for operating said calling device to transmit impulses over said line circuit, means for operating said step-by-step switch upon the return of said calling device to normal position, and a normally open bridge across said circuit controlled by said switch.

28. In a telephone system, a line circuit, a trunk circuit, a switch for extending a connection from said line circuit to said trunk circuit, a bridge across said trunk circuit, a step-by-step switch for controlling normally open contacts in said bridge, a relay for controlling said bridge at another point, and means for energizing said relay when connection is extended to said trunk circuit.

29. In a telephone system, a line circuit, a trunk circuit, a switch for extending a connection from said line circuit to said trunk circuit, a repeater for repeating impulses from said trunk to a second trunk, a bridge across said second trunk circuit, a step-by-step switch for controlling normally open contacts in said bridge, a relay for controlling said bridge at another point, and means for energizing said relay when connection is extended to said trunk circuit.

30. In a telephone system, a pair of trunk circuits, a repeater for receiving impulses from the first of said trunks and repeating them to the second, said repeater including a pair of line relays, a step-by-step switch, an operating magnet therefor controlled by said line relays, and a bridge across said second trunk controlled by said switch.

31. In a telephone system, a pair of trunk circuits, a repeater for repeating impulses from the first of said trunks and repeating them to the second, said repeater including a pair of line relays, a step-by-step switch, an operating magnet therefor controlled by said line relays, a bridge across said second trunk controlled by said switch, and means for operating said switch when the impulse-transmitting means returns to normal position.

32. In a telephone system, a repeater, circuits, an automatic switch for connecting the circuits with the repeater, means for sending impulses first over one circuit and then over the other, an auxiliary circuit associated with the repeater, and means in the repeater for receiving said impulses and repeating them to the said auxiliary circuit over both sides of the auxiliary circuit in series.

33. In a telephone system, a repeater, circuits, an automatic switch for connecting the circuits with the repeater, means for sending impulses first over one circuit and then over the other, an auxiliary circuit associated with the repeater, and means in the repeater for receiving said impulses and repeating them to the said auxiliary circuit.

and means in said repeater for holding said auxiliary circuit closed after the impulses.

34. In a telephone system, a repeater, circuits, an automatic switch for connecting the circuits with the repeater, means for sending impulses first over one circuit and then over the other, an auxiliary circuit associated with the repeater, and means in the repeater for receiving said impulses and repeating them to the said auxiliary circuit, and a bridge controlled by said repeater for closing the auxiliary circuit.

35. In a telephone system, a repeater, circuits, an automatic switch for connecting the circuits with the repeater, means for sending impulses first over one circuit and then over the other, an auxiliary circuit associated with the repeater, and means in the repeater for receiving said impulses and repeating them to the said auxiliary circuit, an automatic switch connected with said auxiliary circuit and operated by said impulses, means in said switch for releasing the same controlled over said auxiliary circuit, and means in said repeater for preventing the release of said switch.

36. In a telephone system, a repeater, circuits, an automatic switch for connecting the circuits with the repeater, means for sending impulses first over one circuit and then over another, another automatic switch for extending the connection beyond said repeater, a circuit in said other switch for controlling the operation thereof, and means in said repeater for receiving said impulses and repeating them over both sides of said controlling circuit in series.

37. In a telephone system, a repeater, circuits, an automatic switch for connecting the circuits with the repeater, means for sending impulses first over one circuit and then over another, another automatic switch for extending the connection beyond said repeater, a circuit in said other switch for controlling the operation thereof, means in said repeater for receiving said impulses and repeating them to said controlling circuit, and means in said repeater for holding said controlling circuit closed after the impulses.

38. In a telephone system, a repeater, circuits, an automatic switch for connecting the circuits with the repeater, means for sending impulses first over one circuit and then over another, another automatic switch for extending the connection beyond said repeater, a circuit in said other switch for controlling the operation thereof, means in said repeater for receiving said impulses and repeating them to said controlling circuit, and a bridge controlled by said repeater for closing said controlling circuit.

39. In a telephone system, a repeater, circuits, an automatic switch for connecting

the circuits with the repeater, means for sending impulses first over one circuit and then over another, another automatic switch for extending a connection beyond said repeater, a circuit for said other switch, means in said repeater for receiving said impulses and repeating them to the circuit in said other switch while the connection is being extended beyond said repeater, and means in
 10 said repeater for holding the circuit in said other switch closed after the impulses.

40. In a telephone system, a repeater, circuits, an automatic switch for connecting the circuits with the repeater, means for
 15 sending impulses first over one circuit and then over another, another automatic switch for extending a connection beyond said repeater, a circuit for said other switch, means in said repeater for receiving said impulses
 20 and repeating them to the circuit in said other switch while the connection is being extended beyond said repeater, and a bridge controlled by said repeater for closing the circuit in said other switch.

25 41. In a telephone system, means for transmitting calling impulses and a repeater for receiving and repeating said impulses, said repeater provided with parallel voice current conductors, step-by-step switch
 30 operated mechanism, said mechanism responsive to said impulses, and means oper-

ated by said mechanism to form a bridge between and individual to said voice current conductors.

42. In a telephone system, means for
 35 transmitting calling impulses, a repeater for receiving and repeating said impulses, an automatic switch whereby the calling subscriber connects with said repeater, said repeater provided with parallel voice current
 40 conductors, a step-by-step switch operated mechanism, said mechanism responsive to said impulses, and means operated by said mechanism to form a bridge between and individual to said voice current conductors.
 45

43. In a telephone system, means for transmitting calling impulses and a repeater for receiving and repeating said impulses, said repeater provided with parallel voice current conductors, a step-by-step
 50 switch operated mechanism, said mechanism responsive to said impulses, means operated by said mechanism to form a bridge between and individual to said voice current conductors, and an automatic switch for finding
 55 said subscriber's line.

Signed by me at Chicago, Cook county, Illinois, this 7 day of Feb., 1910.

TALBOT G. MARTIN.

Witnesses:

EDWARD D. FALES,
 ARTHUR J. RAY.