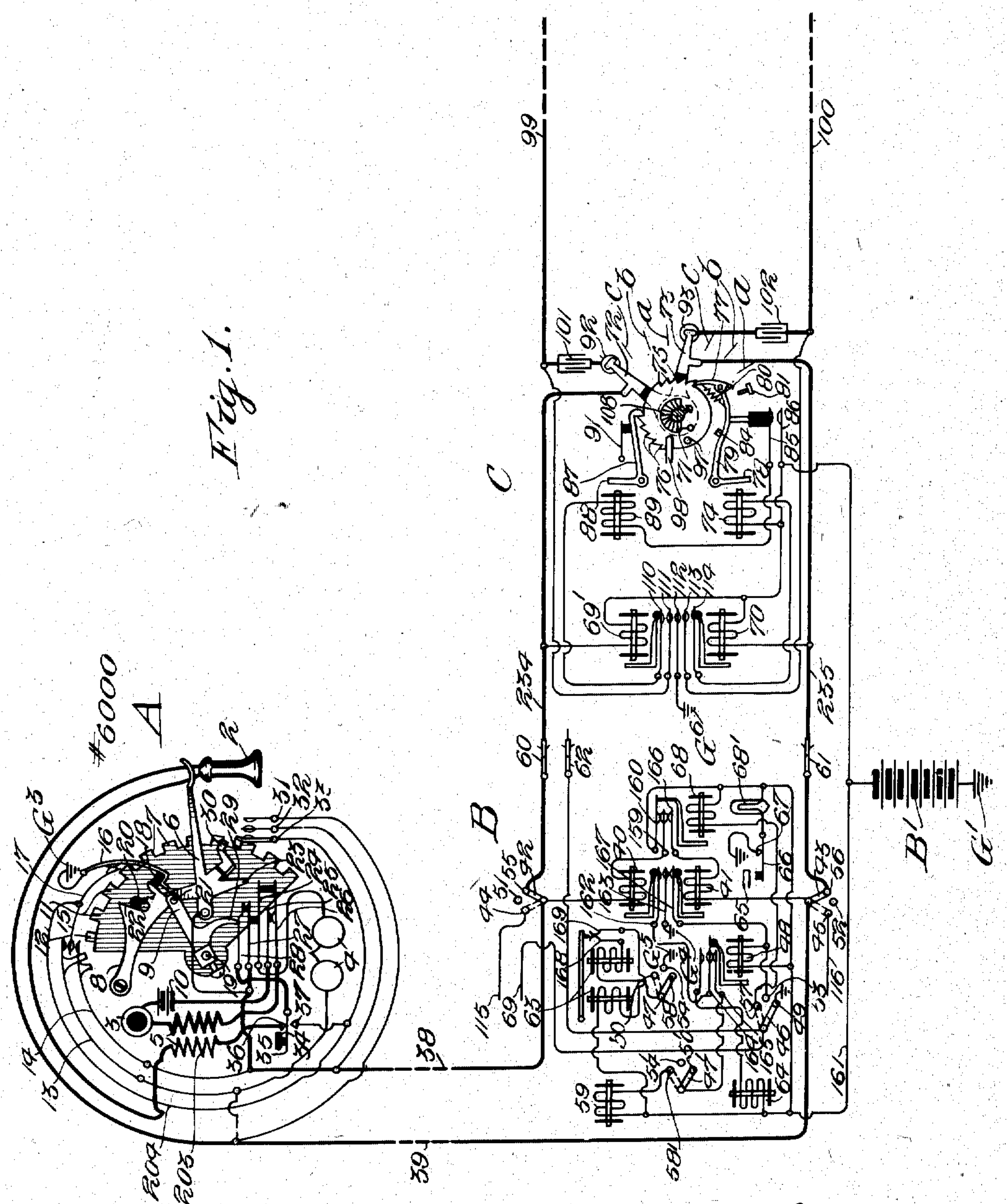


J. ERICKSON.
 TELEPHONE EXCHANGE APPARATUS AND SYSTEM.
 APPLICATION FILED JULY 16, 1906. RENEWED JAN. 2, 1918.

1,275,141.

Patented Aug. 6, 1918.
 3 SHEETS—SHEET 1.



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3 SHEETS—SHEET 2.

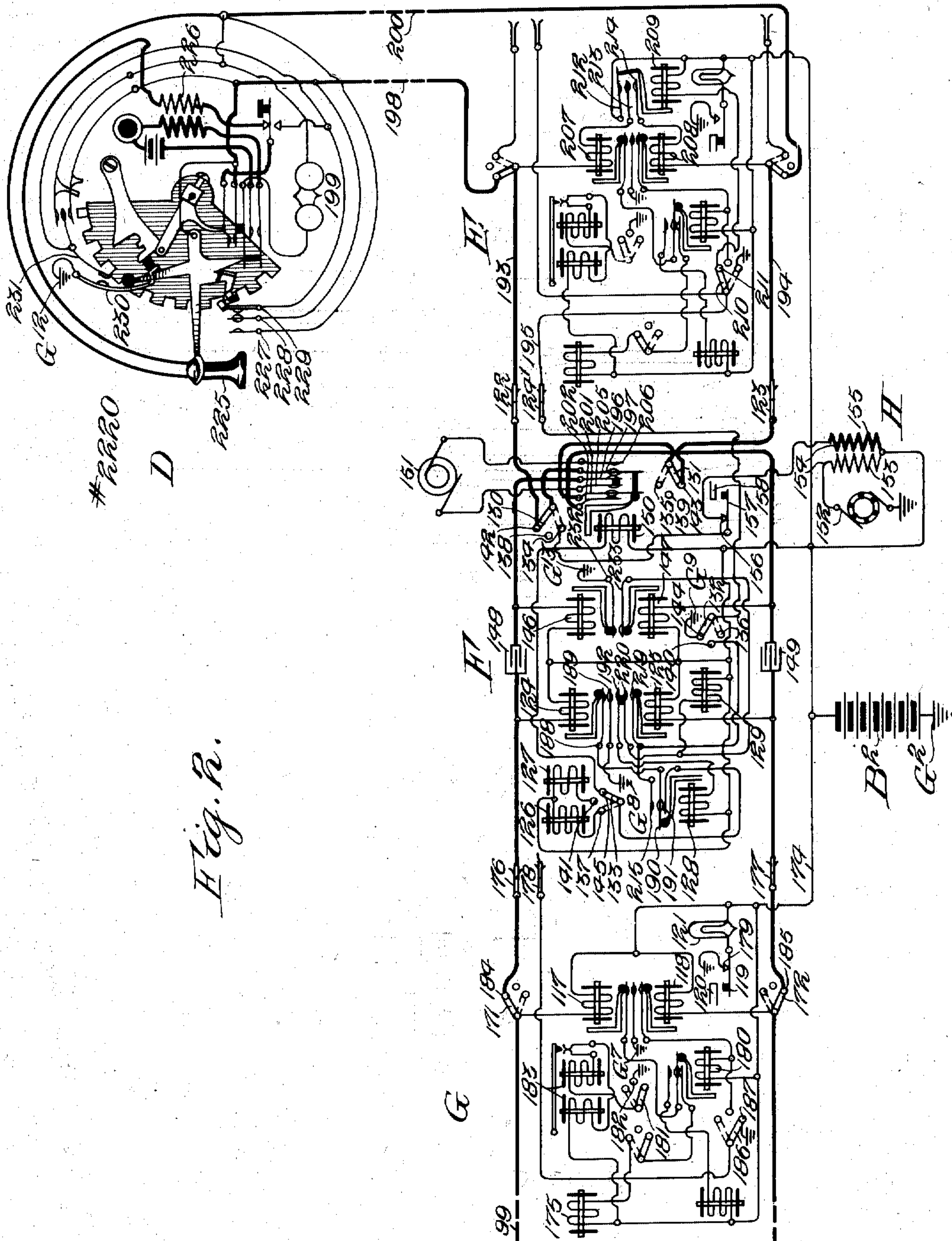


Fig. 2.

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3 SHEETS—SHEET 3.

Fig. 3.

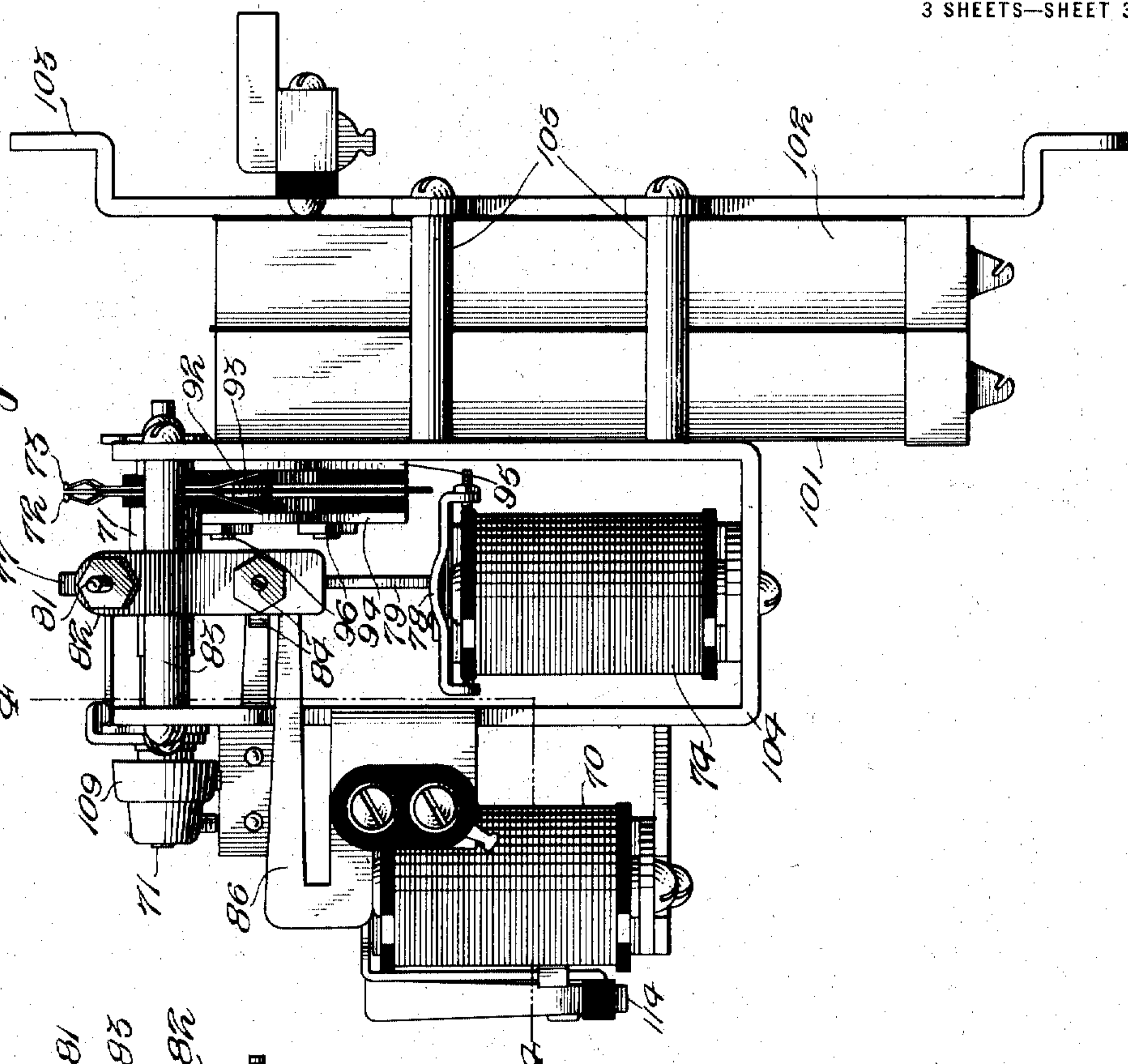
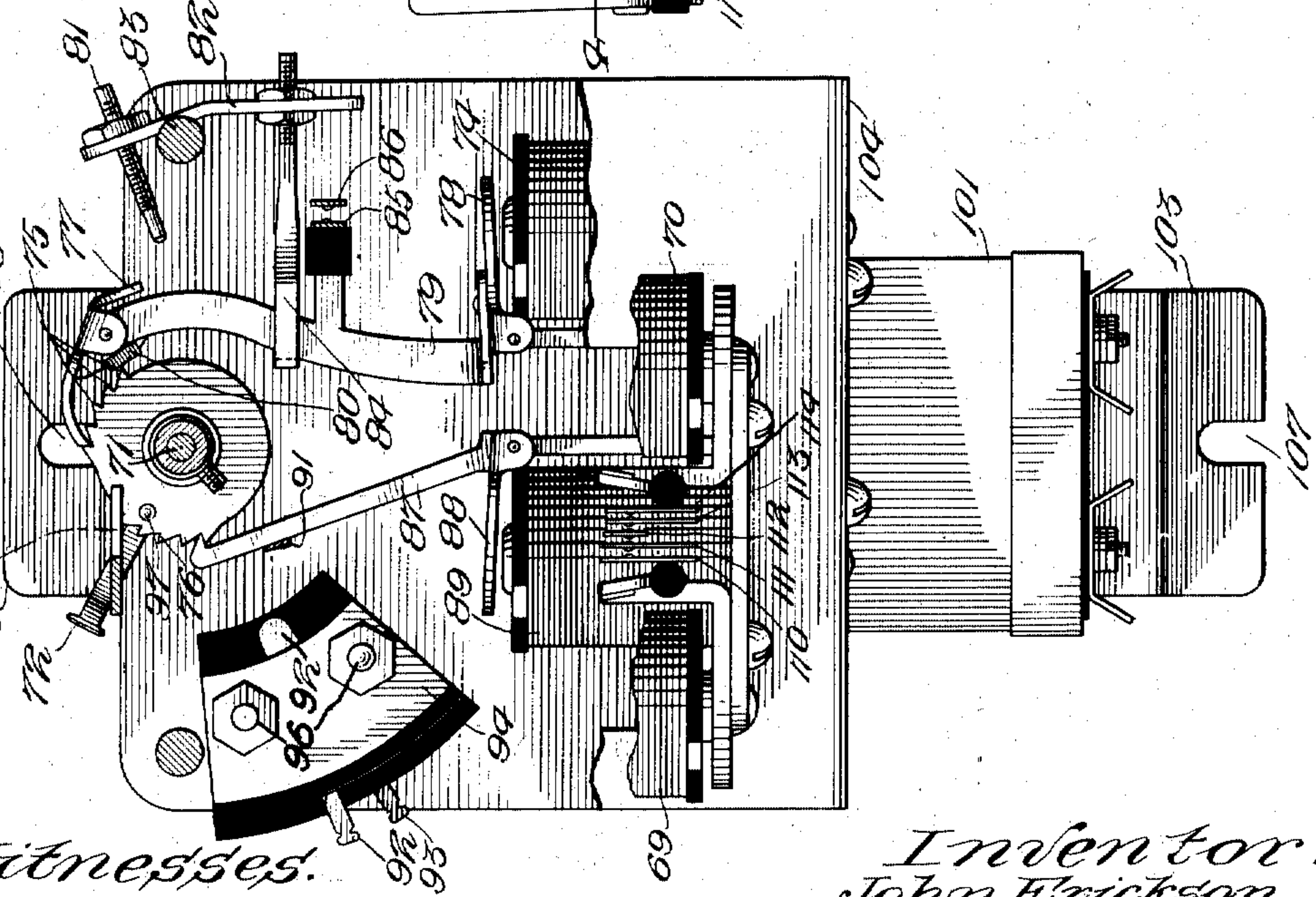


Fig. 4.



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UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE APPARATUS AND SYSTEM.

1,275,141.

Specification of Letters Patent.

Patented Aug. 6, 1918.

Application filed July 16, 1906, Serial No. 326,450. Renewed January 2, 1918. Serial No. 210,070.

To all whom it may concern:

Be it known that I, JOHN ERICKSON, 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 Apparatus and Systems, of which the following is a specification.

My invention relates to telephone systems in general, but more particularly to automatic or semi-automatic telephone exchange systems, and especially to systems in which electrically-propelled and step-by-step-actuated switching machinery is employed at the exchange or central station, and adapted to respond to electrical impulses transmitted over the telephone lines from the subscribers' substations.

For example, my invention is applicable to automatic telephone exchange systems of that particular type in which automatic selectors and connectors are employed at the exchange or central station, and in which the subscribers' stations are equipped with electrical impulse transmitters or calling devices for controlling the operations of the said selectors and connectors, thus making it possible for any calling subscriber to first control and operate one or more selectors for the purpose of trunking through the exchange to the group of connectors at which the called subscriber's line terminates, and to finally control and operate a connector for the purpose of completing the desired connection directly with the called subscriber's line. In such a system the said selectors and connectors are automatically restored to normal condition by the hanging up of one of the subscriber's telephones, as, for example, by restoration of the calling subscriber's receiver to the usual switch-hook. It will also be understood that in such a system provision is made for producing an audible call-signal at the substitution of any called subscriber.

Generally stated the object of my invention is the provision of an improved and highly efficient telephone exchange system.

Special objects are the provision of an improved construction and arrangement whereby the electrical impulses necessary for operating one or more automatic switches will not traverse the entire line circuit between such switches and the calling subscriber, but will only travel a portion of

such distance, a so-called repeater then being relied upon to duplicate or repeat such impulses in the balance of the circuit extending to the switch or switches, this arrangement being particularly advantageous and desirable in systems where, owing to the length of the lines, or to the distance between exchanges having trunking connection between them, it would be difficult to obtain satisfactory results by directly controlling the switch or switches from the station of the calling subscriber; the provision of an improved construction and arrangement whereby means are provided for repeating or duplicating both voice currents and switch-operating electrical impulses from one to another of two inductively connected sections of a line circuit extending between calling and called subscriber's lines; the provision of an improved construction and arrangement for enabling a calling subscriber of one automatic exchange to complete connection with the line of a called subscriber of another automatic exchange, and to then, after conversation is terminated between the two subscribers, automatically release all automatic switches, such as individual switches, selectors and connectors, that may have been brought into use for establishing and retaining the desired connection between the two subscribers' lines; the provision of a trunk line which is normally open at a point between its two ends, and which is provided with a repeater adapted to close the said normally open gap therein, as well as with means for dividing the trunk line into two inductively connected sections, and for repeating both voice currents and switch-operating electrical impulses from one to the other of the two inductively connected trunk sections; and the provision of certain details and features of improvement and novel combinations tending to increase the general efficiency and improve the service 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, Figure 1 is a diagram showing a subscriber's line connecting the substation A, or #6000, with its allotted first-selector B and the repeater C.

Fig. 2 shows in diagram a called substation D, or #2220, a first-selector E allotted

to the called line, a connector-switch F and a second-selector G.

Fig. 1 represents the apparatus at one central office #1, and Fig. 2 represents the apparatus at a second central office which will be designated as central office #2.

Figs. 1 and 2 taken together represent an established connection between the subscribers A and D, embodying the principles and features of my invention.

It will be noticed that the apparatus is shown in an operative condition maintaining the connection between the two substations.

Each central office has its own battery; the central office #1 having its battery B¹ with its positive terminal preferably grounded at G¹, and the central office #2 having its battery B² with its positive terminal preferably grounded at G². These batteries may be of any suitable voltage but good results are obtained when they are built to give a pressure of from 50 to 55 volts.

Fig. 3 is a side elevation of the repeater-switch.

Fig. 4 is a front elevation of Fig. 3 with a section through the line 4—4 removed.

The substation may be of any suitable or approved type. The substation shown in Fig. 1 is, as usual, provided with a receiver 2, transmitter 3, ringer 4, induction-coil 5, switch-hook 6, impulse wheel 7, cam latch 8 (for normally locking the dial), a cam dog 9 and a battery 10. The impulse wheel 7 is, of course, provided with a set of vertical impulse teeth 11 and a rotary impulse tooth 12 for operating, respectively, the vertical impulse finger 14 and the rotary impulse finger 13 with respect to the ground post 15. The substation ground G³ is permanently connected to the ground spring 16, which latter is held normally away from the ground spring by the insulating tip 18 upon the end of the cam latch 8, said insulating tip normally resting upon the bent angled terminal of the ground spring 16, as shown at substation D, Fig. 2. It will be understood, of course, that in the subscriber's dial (which is not shown, but which may be of any suitable or approved type), the impulse wheel 7 and the cam dog 9 are all rigidly secured to the shaft 19. While the receiver is on the switch-hook the switch-hook cam-arm 20 removes the ground spring 16 from the insulating tip 18 so that the cam latch falls in front of the pin 21 on the end of the cam dog 9, whereby it becomes impossible to rotate the dial. When the receiver is removed, however, the switch-hook is raised by a suitable spring (not shown) and the cam-arm 20 by engaging the face 22 of the cam latch 8 raises the latter sufficiently to permit the pin 21 to pass under the cam latch when the dial is sufficiently rotated. It will be understood, however, that the ground spring 16, when the

cam-arm 20 leaves its normal position, falls against the insulating tip 18 and there remains out of engagement with the other ground spring 17 until the dial is rotated, since the cam-arm 20 does not raise the cam latch 8 sufficiently to permit the tip 18 to clear the angled section on the end of the ground spring 16. The extreme end of the cam latch 8 which is engaged by the cam dog pin 21 is not angled, but is rounded off in such manner that when the dial is rotated the pin 21 slides beneath the said rounded section and raises the cam latch 8 a trifle more, so that the insulating tip 18 may now leave the ground spring 16, permitting the latter to engage the ground spring 17 and thus establish connection between ground G³ and the ground post 15. When the receiver is on the hook the cam 23 engages the spring 24 and thereby closes the ringer 4 across the line. By depressing the spring 24 the said cam-arm 23 not only closes the substation ringing circuit, but also by separating the springs 25 and 26, opens the primary circuit, and by separating the springs 27 and 28 opens the secondary circuit for removing the receiver 2 from across the line. When the switch-hook is up, the primary circuit is closed, and the secondary circuit comprising the receiver 2 is bridged across the line. However, while the dial is being operated and, therefore, while the cam 29 of the cam dog 9 is out of normal position, the secondary circuit is opened up at the point between the springs 27 and 28 so that no electric impulses that may be delivered to either of the subscribers' line conductors individually shall pass through the receiver to the other side of the line. The switch-hook cam 30 is provided for controlling the release-springs 31, 32 and 33, which release-springs are pressed into contact, grounding the subscriber's line conductors simultaneously when it becomes desirable to release the central office switching apparatus. The signaling button 34 has the function of controlling the spring 35 that normally rests in engagement with the contact-point 36, but from which it is separated and carried into engagement with the ground contact 37, whereby only the vertical side of the subscriber's line may be grounded when he signals. With this apparatus, the subscriber, when he wishes to make a call, removes his receiver from the switch-hook and thereby disconnects the ringer from across the line, closes his local talking circuit and connects his secondary circuit across the line. He then operates his dial once for each digit of the number he is to call. At the operation of the dial for the first digit connection is made between the substation ground G³ and ground post 15, and the secondary circuit is opened between the springs 27 and 28 at the forward motion of the dial. At the return motion of

the dial the subscriber's vertical line conductor is grounded a number of times equal to the numerical value of the first digit, and then the rotary side of the line is grounded once, and then the secondary circuit is again closed between the springs 27 and 28. At the second operation of the dial the secondary circuit is again opened at the same point at the forward motion of the dial and at the return motion of the dial the vertical line conductor is grounded a number of times equal to the numerical value of the second digit, then the rotary side of the line is grounded once and then the secondary circuit is again closed. Each succeeding operation of the dial accomplishes the same result accomplished by the second operation of the dial. The number having been called the signaling button 34 is pressed, whereby the secondary circuit is opened between the spring 35 and contact point 36, and the vertical side of the line is grounded when the spring 35 engages the contact point 37. If the called subscriber is not busy the pressing of the signaling button rings the called subscriber's substation bell, but if he is busy a busy signal will be sent back to the calling subscriber. When a subscriber is through he then, by hanging up his receiver, presses the release-springs 31, 32 and 33 into contact for a moment, grounds the telephone line conductors simultaneously for a moment, and thus restores all the switching apparatus that has been brought into service by him.

The first-selector may be of any suitable or approved type, such as the selector shown in Patent No. 831,875. The subscribers' vertical and rotary line conductors 38 and 39 terminate, respectively, in the vertical and rotary line relays 40 and 41. The side switch wipers 42 and 43 are, respectively, connected with the line conductors 38 and 39, the former wiper being normally in engagement with the contact point 44 and the latter wiper with the contact point 45. The side switch, as is well known, comprises besides the side switch wipers 42 and 43 the private side switch wiper 46, the rotary magnet side switch wiper 47, and the vertical magnet side switch wiper 47'. The side switch is controlled by the private magnet 48, and in the normal or first position of the side switch the side switch wipers 42, 43, 46, 47 and 47' engage, respectively, with the contact points 44, 45, 57, 50 and 58'; in the second position they rest on the contact points 51, 52, 53, 54 and 54', respectively; and in the third position in engagement with the contact points 55, 56, 49, 58 and 50', respectively. Through the medium of the vertical line relay 40, the subscriber controls the vertical magnet 59, which latter operates vertically the switch-shaft (not shown) that carries the line wipers 60 and 61 and the private wiper 62. Through the medium of the rotary line re-

lay 41, the subscriber controls the private magnet 48 and, therefore, the side switch. When the side switch is in second position the rotary magnet 63 is energized and the switch-shaft that carries the wipers 60, 61 and 62 is operated in a rotary direction. The vertical and rotary line relays 40 and 41 provide the means by which the release-magnet 64 is controlled by the subscriber. The switch-shaft of the selector B carries a so-called normal post arm 65 which, when the shaft is out of normal position, permits the spring 66 to engage the contact point 67 and thereby close a connection through the off-normal lamp 68'. The private normal conductor 69 leads to the connector private bank, and by way of said private normal conductor the bridge-cut-off-relay 68 is energized whenever any subscriber calls the substation A. The said bridge-cut-off-relay controls the connection between the vertical and rotary line relays 40 and 41 and the battery B'. It is necessary to thus disconnect said relays from battery because otherwise the ringing current finds a path through the said relays, thus causing some danger of interference. Also, it is desirable to remove the bridge from across the line that is formed through the line relays 40 and 41 in series.

The repeater C, like the selector B, is provided with a vertical line relay 69' and a rotary line relay 70, through the medium of which the said repeater is controlled. The said repeater is provided with a shaft 71 which carries a pair of wipers 72 and 73 and which is operated by a rotary magnet 74. The shaft carries two sets of longitudinal teeth 75 and 76, the former adapted to be normally engaged by a rotary pawl 77. The rotary magnet 74 is provided with an armature 78 which is provided with an arm 79 upon the end of which the pawl 77 is pivotally mounted. A retracting-spring 80 is adapted always to maintain a tension on the pawl 77 in the direction of the longitudinal teeth 75. A suitable adjustable stop 81, Fig. 3, is mounted upon a cross member 82 that is secured to the post 83. The said stop limits the stroke of the armature 78 toward the core of the magnet 74. Another stop 84 also mounted upon the cross member 82 limits the motion of the armature 78 in the opposite direction. The said arm 79 controls a couple of springs 85 and 86, the former of which may be of heavy spring material and answers as a retracting force for restoring the armature 79 to normal condition, and for rotating the shaft 71 at the same time. It will be noticed that there are only enough longitudinal teeth 75 for rotating the shaft 71 four steps. It is not absolutely necessary that there should be four, as the shaft may be arranged to be provided with only three or two or any suitable number, depending upon the size of the exchange and the num-

ber of digits in the number to be secured by the repeater. It should be understood that by adjusting the stop 98 relatively to the stop pin 97, the number of steps necessary to cause the wipers 72 and 73 to engage their corresponding bank contacts may be readily changed. In the illustration in Fig. 1, it is only necessary to advance the shaft three steps to carry the wipers 72 and 73 into engagement with the contacts 92 and 93, respectively. At each step of the shaft 71 the latter is retained by a ratchet 87 upon the armature 88 that is controlled by a ratchet magnet 89. The spring 91 maintains the ratchet 87 in engagement with the longitudinal teeth 76. When the subscriber starts to release, the rotary magnet 74 and the ratchet magnet 89 must then be energized simultaneously so that the pawl 77 and ratchet 87 may be simultaneously disengaged from the shaft 71. The wipers 72 and 73 are adapted to engage the bank contacts 92 and 93 which are clamped between the plates 94 and 95 by screws 96, and which form a small bank. Normally the wipers are out of engagement with the said bank contacts, since the shaft is maintained in a normal position determined by the adjustment of the pin 97 located on the upper side of the shaft, and a stop member 98. The normal position of the shaft is such that it takes three steps to carry the wipers into engagement with the bank contacts 92 and 93. The normal position of the wipers is shown in Fig. 1 by the lines *a*, the second position by *b*, the third position by *c*, and the fourth position by the bank contacts themselves. When the repeater is located in the circuit, as shown in Fig. 1, and used as a terminal to a trunk line leading to another exchange the local trunk conductors that connect the repeater C with the proper first-selector bank contacts terminate in the wipers 72 and 73, and the trunk conductors 99 and 100 that lead to the other exchange terminate in the condensers 101 and 102, respectively, or in any other suitable inductive apparatus. The repeater as a whole is built upon a suitable base 103, the mechanism itself being assembled upon a frame 104 that is attached to the base 103 by means of bolts 105. Between the base 103 and the frame 104 the condensers 101 and 102 are held in position in any suitable manner. The base is provided with a slot 106 on the upper side and another slot 107 on the under side, through which slots screws are passed to secure the switch to a frame or board in any suitable locality. The switch-shaft 71 is retained in normal position by any suitable means, such as the coil-spring 108 that is inclosed within the casing 109, Fig. 3. The line-relays 69' and 70 control the springs 110, 111, 112, 113 and 114 which are included in certain circuits to be hereinafter described. In a system in which

the subscribers' numbers have four digits the trunk conductors 99 and 100 that lead from the repeater C to the central office #2 terminate in a second-selector G.

The second-selector G is the same as the first-selector B with the exception that there are no normal conductors such as the normal conductors 115 and 116 that lead to the connector-banks and over which calling subscribers make connection with the station A. There is no use for such conductors in the second-selector and they are, therefore, omitted. There is also no use in the second-selector for such a relay as the bridge-cut-off-relay 68 of the first-selector B and it is, therefore, omitted and the vertical and rotary line relays 117 and 118, respectively, are connected directly to the battery. There is also no use for a private normal conductor such as the private normal conductor 69, and the spring 119 controlled by the normal post arm 120 is connected through an off-normal lamp 121 for indicating when the second-selector is off normal. Whenever the switch-shaft is raised the normal post arm 120 clears the spring 119, which latter then passes into contact with the grounded contact just above it and thus establishes an energizing circuit through the lamp 121 from ground to the battery.

The connector switch F may also be of any suitable or approved type, such as the connector described in Patent No. 815,176. The mechanical details of the selector and connector are, as is well known, very much the same, although there is some material difference in the circuits. The connector-switch shaft, like the shaft of the selector, and which is not shown, carries the usual line wipers 122 and 123 and the private wiper 124'. The connector-switch is also controlled by the calling subscriber through the medium of the vertical and rotary line relays 124 and 125. The vertical line relay 124 directly controls the vertical magnet 126 and also the rotary magnet 127. The office of the said vertical magnet 126 is to give the shaft and the shaft wipers their vertical movement, and the rotary magnet 127 imparts to the said shaft a rotary or circular movement. The rotary line relay 125 controls the private magnet 128, which latter under certain conditions controls in turn the vertical and rotary magnets 126 and 127 and the release-magnet 129, and also the side switch wipers 130, 131, 132 and 133, all of which are shown. The said side switch, like the side switch of the first-selector, has a normal or first position, a second position and a third position. In normal position the respective side switch wipers engage the contact points 134, 135, 136 and 137; in second position the contact points 138, 139, 140 and 141, and in the third position the contact

points 142, 143, 144 and 145. The release-magnet 129 is also controlled by the line relays 124 and 125 conjointly, and by the back-bridge-relays 146 and 147 conjointly. Like the repeater the connector divides the circuit that passes through it into two sections by the use of the condensers 148 and 149. The connector has in addition a ringer relay 150 by means of which the ringer generator 151 is bridged across the terminals of the called line to signal the called subscriber. Each exchange also has a busy signaling apparatus H of any suitable design, as for example an interrupter 152 in series with a secondary winding 153 of an induction-coil 154, whereby a busy signaling current is induced in the primary winding 155 of the said induction-coil 154. Said primary winding 155 is connected to the contact point 156 against which the switch shaft spring 157 is allowed to press when the normal post arm 158 is raised.

The first-selector E of the called line is the same as the first-selector B and needs, therefore, no description. The substation D is also the same as substation A.

The connection between the two exchanges may be made in any convenient manner and I do not confine myself to any particular arrangement, since the system herein disclosed is variable. If it is assumed that the maximum number of subscribers to be accommodated at each exchange is five thousand, then the first five levels of the first-selectors of exchange #1 may be devoted to local connections, and the last five levels to trunk connections to exchange #2, each of which trunk connections, of course, comprising a repeater similar to the repeater C. The reverse would be the arrangement for exchange #2, as in that exchange the first five levels would be devoted to trunk operations to exchange #1 and the last five levels to local connections. I do not limit myself to this arrangement even when the maximum number to be accommodated at each exchange is not to exceed five hundred. It will also be understood, of course, that all of the switches may be arranged in groups. For example, the first-selectors of the same group have all similar bank contacts connected in multiple. If each group consists of one hundred first-selectors there will be one hundred banks. Therefore, if any one of the selectors of a given hundred connect with the repeater C a guarding potential will be established at the contact engaged by the private wiper 62, and at all other private bank contacts in multiple, so that all other selectors of that group, if they make a call, will pass over the trunk that leads to the repeater C without interfering with the connection. The same grouping arrangement, as is well known, applies to the central office #2 as well, and to all the switches.

The operation in detail is as follows: To call the number 2220 the subscriber at substation A, as previously described, operates the dial once for each digit. The first operation of the dial results in the vertical line conductor 38 being grounded twice, and as a further result the vertical line relay 40 of the first-selector D is energized twice, the current flowing in each case from ground G^3 through the ground springs 16 and 17 to the ground post 15, thence through the vertical impulse finger 14 to the vertical line conductor 38, vertical line relay 40, bridge-cut-off-relay springs 159 and 160 to the battery lead 161 and from battery B^1 to ground G^1 . Each time that the vertical line relay 40 is energized the line relay springs 162 and 163 are pressed into contact and an energizing circuit is thereby established through the vertical magnet 59. Current through the said magnet flows from ground G^4 through the springs 163 and 162, private springs 164 and 165, side switch wiper 47', contact point 58', vertical magnet 59 to the battery lead 161 and through battery B^1 to ground G^1 . The vertical magnet 59 then operates to raise the shaft for placing the wipers 60, 61 and 62 opposite the level containing the contact points at which the trunk line conductors that lead to the repeater C terminate. When the rotary line conductor 39 is grounded the rotary line relay 41 is energized in turn. The current through said relay flows through ground G^3 to the ground post 15, then through the rotary impulse finger 13 to the rotary line conductor 39, thence through the rotary line relay 41, bridge-cut-off-relay springs 166, 159 and 160 to the battery lead 161, thence through battery B^1 to ground G^1 . The rotary line relay in turn magnetizes the private magnet 48 by establishing a circuit through the line relay springs 167 and 163. The current for energizing the private magnet flows from ground G^4 through the line relay springs 163 and 167 to the private magnet 48, thence through battery lead 161 and through battery B^1 to ground G^1 . The private magnet 48 then operates to release the side switch from first to second position, and as a result a circuit is closed through the rotary magnet 63 when the side switch wiper 47 engages the contact point 54. The current through the rotary magnet flows from ground G^5 to the contact point 54, thence through the side switch wiper 47, one coil of rotary magnet 63, interrupter springs 168 and 169, another coil of rotary magnet 63 to the battery lead 161, thence through battery B^1 to ground G^1 . The rotary magnet is energized step by step and the wipers 60, 61 and 62 are advanced in like manner over busy contact points until the wipers find the first idle trunk line which, it is assumed, is the trunk line that leads to the repeater C. As long as the

private wiper 62 is passing over busy contact points the private magnet 48 is retained energized and the side switch is locked in second position, as is well known, until all guarded points are passed. The current through the private magnet, while the private wiper 62 is passing over busy contacts, flows from the grounded terminal G^1 of the battery B^1 through the occupying switch to the private wiper 62, thence through the side switch wiper 46, contact point 53, private magnet 48 to the battery lead 161, thence through battery B^1 to ground G^1 . At the instant that the private magnet 48 deenergizes, after the private wiper passes over busy contacts, the side switch is tripped into third position, or if there are no busy contacts to be passed over, the rotary magnet 63, as is well known, trips the side switch to third position with the result that as soon as the side switch wipers 42 and 43 engage the contact points 55 and 56, respectively, the subscriber's line conductors 38 and 39 are extended to the repeater C. Also, since the side switch wiper 46 at the same time engages the contact point 49 a guarding potential is established at the private wiper 62 to protect the seized trunk line that leads from the repeater C from being molested by any other switch. The second operation of the dial, since the line is now extended, is directed to the repeater C. Grounding the vertical line conductor 38 twice energizes the vertical line relay 69' twice, the current in this case flowing from ground G^3 to the ground post 15, thence through the vertical impulse finger 14 to the vertical line conductor 38, side switch wiper 42 of the selector B, vertical line wiper 60, vertical line relay 69' of the repeater C to the battery lead 161 and through battery B^1 to ground G^1 . Each time that the said vertical line relay 69' is energized the springs 110, 111 and 112 are pressed into contact. The spring 110 connects through the ratchet magnet 89 to the spring 85, at which spring the circuit is open, so that the operation of the spring 110 at this time is not of any consequence, but the closure of contact between the springs 111 and 112 grounds the vertical trunk conductor 99. This, of course, occurs each time that the vertical line relay 69' is operated. Grounding the vertical trunk conductor 99 in turn operates the switches at the exchange #2, which operation will be considered in due time. When the subscriber grounds the rotary line conductor 39 he energizes the rotary line relay 70 of the repeater C, the current flowing from ground G^3 to the ground spring 15, thence to the rotary impulse finger 13, rotary line conductor 39, first-selector side switch wiper 43, contact point 56, rotary line wiper 61, rotary line relay 70 to the battery lead 161, thence through battery B^1 to ground G^1 . The op-

eration of the rotary line relay causes the line relay springs 114, 113 and 112 to be pressed together. The closure of the contact between the springs 113 and 112 sends a ground impulse to the rotary trunk conductor 100 for operating the switches at the second exchange and the effect of thus grounding the rotary trunk conductor will be considered hereinafter. The establishment of connection between the springs 114 and 112, through the intervening spring 113, energizes the rotary magnet 74 of the repeater C. The current passes from ground G^6 through the springs 112, 113 and 114 to the rotary magnet 74 to the battery lead 161, thence through battery B^1 to ground G^1 . The rotary magnet 74 upon energizing attracts its armature 78 and thus disengages the pawl 77 from the teeth 75 and closes contact between springs 85 and 86. Upon the deenergization of magnet 74 armature 78 is pushed back by the spring 85 and pawl 77 rotates the shaft 71 one step; but just at this stage of the call such operation has no effect. The vertical trunk conductor 99 terminates in the vertical line relay 117 of the second-selector G and the rotary trunk conductor 100 terminates in the rotary line relay 118 of the said selector. Connected to said conductors, respectively are also the side switch wipers 171 and 172. Therefore, grounding the vertical trunk conductor 99 twice, as described in the preceding, operates the vertical line relay 117, the current flowing from ground G^6 at the repeater C through the line relay springs 112 and 111 to the vertical trunk conductor 99, thence through the vertical line relay 117 to the battery lead 174 and through battery B^2 to ground G^2 . The vertical line relay 117 in turn operates the vertical magnet 175, as described in connection with the first-selector B, so that the shaft wipers 176, 177 and 178 are raised to the level with the contacts from which a trunk line leads to the connector F. As soon as the switch-shaft rises the normal post arm 120 permits the switch shaft spring 119 to engage the contact point 179 so that the off-normal lamp 121 flashes up and indicates that the said switch is in use. The grounding of the rotary trunk conductor 100 in turn energizes the rotary line relay 118, which latter in turn energizes the private magnet 180 for a moment and permits the side switch to escape from first to second position. The current through the said rotary line relay 118 flows from ground G^6 at the repeater C through the springs 112 and 113 to the rotary trunk conductor 100, through the rotary line relay 118 to the battery lead 174, and through battery B^2 to ground G^2 . As soon as the side switch wiper 181 engages the contact point 182 an energizing circuit is established through the

rotary magnet 183, which latter operates to rotate the shaft in the same manner that the rotary magnet of the first-selector B operates. The current through the said rotary magnet 183 flows from ground G^7 through the side switch wiper 181, rotary magnet 183 and its allotted interrupter springs to the battery lead 174, and through battery B^2 to ground G^2 . When the rotary magnet operates, the side switch is then tripped into third position, or if the wipers are carried over busy contacts the side switch does not pass to third position until the private magnet 180 deenergizes. As soon as the side switch passes to third position the side switch wipers 171 and 172 upon engaging the contact points 184 and 185, respectively, extend the trunk line conductors 99 and 100 to the connector F at the same time that the side switch wiper 186 engages the contact point 187 and a guarding potential is established at the private wiper 178 for preventing other switches from establishing connection with the connector F. The third operation of the dial, since the subscriber's line conductors are extended to the connector F, is directed to the repeater for the purpose of operating said connector. When the vertical line conductor 38 is grounded twice the vertical line relay 69' of the repeater C is again operated twice, whereby the vertical trunk conductor 99 is again grounded twice. Grounding the vertical trunk conductor 99 energizes the vertical line relay 124 of the connector. The current through said relay flows from ground G^6 to the vertical trunk conductor 99, thence through the side switch wiper 171, contact point 184, vertical line wiper 176 to the vertical line relay 124, thence to the battery lead 174 and from battery B^2 to ground G^2 . The vertical line relay 124 in turn presses the line relay springs 188 and 189 into contact and as a result the magnet 126 is operated. The current through said magnet flows from ground G^8 to the springs 189 and 188, private springs 190 and 191, side switch wiper 133, contact point 137, vertical magnet 126 to the battery lead 174 and through battery B^2 to ground G^2 . The vertical magnet 126, as usual, operates to raise the switch-shaft. Being operated twice the shaft is raised two steps and the shaft wipers 122, 123 and 124' are carried to a level in which the line of the subscriber #2220 is located. When the rotary line conductor 39 is grounded once the rotary line relay 70 of the repeater C is energized once as before, and as a result the rotary magnet 74 of the repeater C is again operated once and the shaft 71 rotated another step and the wipers 72 and 73 carried to a position marked by the lines c. At the same time the rotary trunk conductor 100 is grounded once, causing the rotary line relay 125 of the connector

F to be operated. The current flows through the rotary relay 125 from ground G^6 to the rotary trunk conductor 100, thence to the side switch wiper 172 of the second selector G, contact point 185, rotary line wiper 177, rotary line relay 125 to the battery lead 174, thence through battery B^2 to ground G^2 . The rotary line relay 125 in turn energizes the private magnet 128 upon pressing the line relay springs 192 and 189 into contact. The current through said private magnet passes from ground G^8 through the springs 189 and 192, private magnet 128 to the battery lead 174, thence through battery B^2 to ground G^2 . The private magnet being operated momentarily causes the side switch to pass from first to second position. As a result the side switch wiper 133 shifts into engagement with the contact point 141, substituting the rotary magnet 127 for the vertical magnet 126, subjecting the former to the control of the vertical line relay 124. The fourth operation of the dial causes the vertical line conductor 38 to be grounded again, the vertical line relay 69' of the repeater C to be energized again, and the vertical trunk conductor 99 to be grounded again (each ten times), since the fourth digit is the digit O. Each time that the vertical trunk conductor 99 is grounded the vertical line relay 124 of the connector F is operated over circuits that have been pointed out, but instead of operating in turn the vertical magnet 126 it each time operates instead the rotary magnet 127. The circuit through the said rotary magnet extends from ground G^8 to the side switch wiper 133, thence through the contact point 141 to the said rotary magnet 127 and to the battery lead 174 and through battery B^2 to ground G^2 . The switch shaft is thus rotated step by step until the wipers 122, 123 and 124' are carried into engagement with the normal conductors 193, 194 and 195 that reach to the first-selector E of the called line. The former conductors 193 and 194 extend to the called subscriber's line and to the substation #2220. Grounding the rotary line conductor 39 for the last time energizes the rotary line relay 70 of the repeater C, which latter in turn causes the energization of the rotary magnet 74, whereby the shaft 71 is rotated another step and the wipers 72 and 73 carried into engagement with the contact points 92 and 93, respectively. At the same time the rotary trunk conductor 100 is grounded once. Grounding the rotary trunk conductor 100 energizes the rotary line relay 125 of the connector F, the energization of which relay causes either the release of the connector-switch, if the called line is busy, or the release of the side switch from second to third position, if the line is not busy, which latter operation places the side switch wipers 130 and 131 in engagement with the contact

points 142 and 143, thus placing the calling subscriber's line in connection with the called subscriber's line through the condensers 148 and 149. This connection is marked by heavy lines in Figs. 1 and 2. It will be assumed, first, that the energization of the rotary line relay 125 produces the latter result—that is, releases the connector side switch to third position. It will be noticed that the calling subscriber's vertical line conductor 38 extends through the vertical side switch wiper 42 and the vertical line wiper 60 of the first-selector B to the vertical wiper 72 of the repeater C, which latter being now in engagement with the contact point 92 extends the circuit through the condenser 101 to the vertical trunk conductor 99, thence through the side switch wiper 171 and vertical line wiper 176 of the second-selector G to the connector condenser 148, thence through the ringer relay springs 196 and 197, side switch wiper 130 to the vertical line wiper 122, normal conductor 193, called subscriber's vertical line conductor 198 through the substation ringer 199 to the rotary line conductor 200 and back to the rotary normal conductor 194, line wiper 123, side switch wiper 131, ringer relay springs 201 and 202, condenser 149, line wiper 177, and side switch wiper 172 of the second-selector G, rotary trunk conductor 100, condenser 102, contact point 93 and rotary wiper 73 of the repeater C, rotary line wiper 61 and side switch wiper 43 of the first-selector B to the rotary line conductor 39, thence through the receiver 2, secondary winding 203 of the induction-coil 5 back to the vertical line conductor 38.

To signal the called subscriber the calling subscriber presses his signaling button 34, thereby grounding the vertical line conductor 38 over a circuit that extends from ground G^3 through the ground springs 16 and 17, conductor 204, contact point 37, spring 35 to the vertical line conductor 38. As a result the vertical line relay 69' of the repeater C is energized, which latter then grounds the vertical trunk conductor 99, causing in turn the energization of the vertical line relay 124 of the connector F. Said relay 124, since the side switch wiper 133 is in third position, causes the ringer relay 150 to become magnetized. The current through said ringer relay flows from ground G^3 to the side switch wiper 133, thence through the ringer relay 150 to the battery lead 174, and through battery B^2 to ground G^2 . The ringer relay upon attracting its armature forces the ringer relay springs 201 and 197 onto the ringer relay springs 205 and 206, thus breaking the connection between the calling subscriber and the called subscriber, and throwing the ringer generator 151 across the called subscriber's line for ringing the bell 199 at the station of the lat-

ter. In order to prevent the ringing current from interfering with the line relays 207 and 208 of the called first-selector E the bridge-cut-off-relay 209 is energized as soon as the connector side switch wiper 132 engages the grounded contact point 144. The circuit through said bridge-cut-off-relay flows from ground G^3 through the side switch wiper 132 to the private wiper 124', conductor 195, side switch wiper 210, contact point 211, thence through to the bridge-cut-off-relay 209 to the battery lead 174 and through battery B^2 to ground G^2 . The said relay 209 upon energizing separates the springs 212, 213 and 214, thereby breaking the connection between the said relays 207 and 208 and battery lead, and between each other, leaving the line clear at the selector E. The same circuit that connects the side switch wiper 132 with the connector private wiper 124' is used for establishing a guarding potential that protects the seized line from interference by some other subscriber.

Busy lines are protected as described by guarding potentials. The calling line is protected by guarding potential established at the connector banks from the selector B of the calling line and the called line is protected by a guarding potential established by the connector. In either case if the line is busy, therefore, there is a guarding potential at the private bank contact that corresponds to his number. Assume, for example, that the called line #2220 is busy at the time that the rotary line relay 125 of the connector F is energized. The said relay then presses the springs 219 and 220 into contact. As a result the release-magnet 129 is placed in connection with the private wiper 124', which latter has been previously rotated onto a grounded contact. As a result there is sent a flow of current through the release-magnet 129 from the private wiper 124' to the side switch wiper 132, which is now in second position, contact point 140, springs 219 and 220, release-magnet 129 to the battery lead 174 and through battery B^2 to ground G^2 . As a result the release-magnet becomes magnetized and the connector-switch is released and restored to normal condition. Then when the subscriber presses his signaling button and grounds the vertical line conductor 38 he energizes the vertical line relay 69' at the repeater C, grounds the vertical trunk conductor 99 and energizes the vertical line relay 124 of the connector. Since the side switch is now in first position, the connector having been released, the vertical magnet 126 is energized and the switch-shaft is raised so that the switch-shaft springs 157 and 156 close connection. A circuit is thus established from the busy coil 155 of the busy machine H through the switch-shaft springs 156 and 157, side switch wiper 130, ringer relay

springs 197 and 196, condenser 148 to the calling subscriber's vertical line conductor 38 over circuits that have been described, through the receiver 2 back to the rotary line conductor 39, thence to the rotary trunk conductor 100 and to the rotary line relay 125 of the connector to the battery lead 174 and back to the busy coil 155. The calling subscriber upon hearing the busy signal releases his switching apparatus at the central office. It will be noticed that during the building up of the connection between the substation A and the connector F the line relays 40 and 41 of the first-selector B and the line relays 117 and 118 of the second-selector G are retained across the line. It follows, therefore, that even after the selector B establishes connection with the repeater C the line relays 40 and 41 become energized, respectively, when the line conductors 38 and 39 are grounded. The energization of said relays is of no consequence, however, after the side switch passes to third position. The same is true of the second selector G after the side switch passes to third position. It will be shown, however, that in a bridging system the said selectors B and G are dependent for their release upon the operation of their line relays when the line conductors 38 and 39 are grounded simultaneously. The release occurs when the calling subscriber restores his receiver 2 and thus presses the release-springs 31, 32 and 33 into contact, and thus simultaneously grounds the vertical and rotary line conductors 38 and 39 for a moment. Grounding the vertical and rotary line conductors 38 and 39 simultaneously energizes the vertical and rotary line relays 69' and 70 of the repeater C at the same time, whereby all the springs 110, 111, 112, 113 and 114 are pressed into contact. As a result the line relays 40 and 41 of the selector B energize over known circuits at the same time. Also, the rotary magnet 74 is magnetized, the ratchet magnet 89 is magnetized, and the vertical and rotary trunk conductors 99 and 100 are grounded simultaneously. The circuit through the rotary magnet 74 is known. The energizing circuit through the ratchet magnet 89 extends from ground G² through the springs 112, 111 and 110 to the ratchet magnet 89, thence through the springs 85 and 86 to the battery lead 161 and through battery B¹ to ground G¹. As soon as the rotary magnet 74 of the repeater C and the ratchet magnet 89 attract their armatures together the switch-shaft 71 and wipers 72 and 73 are restored to normal condition by the tension of the retracting spring 108. The vertical and rotary trunk conductors 99 and 100 being grounded at the same time, as previously stated, cause the vertical and rotary line relays 124 and 125 of the connector F to energize at the same time. As a re-

sult an energizing circuit is established through the release-magnet 129 of the connector. This release circuit extends from ground G² at the connector F to the springs 189 and 188, private springs 190 and 215 to the springs 219 and 220, release-magnet 129 to the battery lead 174 and through battery B² to ground G². The connector release-magnet thus energizes, releasing the connector-shaft and side switch at once. As soon as the subscriber's release-springs 31, 32 and 33 disengage the line relays 40 and 41 of the selector B deenergize, releasing the selector B. Also, the line relays 69' and 70 of the repeater C deenergize and as a result the rotary magnet 74 and the ratchet magnet 89 of the repeater C deenergize, leaving the repeater C fully restored and removing the ground connection from the trunk conductors 99 and 100. The removal of the ground connection from the trunk conductors 99 and 100 causes the deenergization of the vertical and rotary relays 117 and 118 of the selector G and of the line relays 124 and 125 of the connector F. As soon as the line relays 117 and 118 of the selector G deenergize, the said switch G becomes restored; also, the deenergization of the line relays 124 and 125 of the connector F leave the said switch fully restored.

The called subscriber answers by removing his receiver 225, bridges his secondary circuit, including said receiver and the secondary winding 226 in series, across the called subscriber's line. The subscribers thus become connected over the heavily marked conductors, shown in Figs. 1 and 2, which conductors have been pointed out. After they are through communicating the calling subscriber may destroy the connection by hanging up his receiver 2, thus grounding the vertical and rotary line conductors 38 and 39 simultaneously as before. As a result the line relays of the first-selector B and the line relays 69' and 70 of the repeater C become energized simultaneously, as previously described, when the calling subscriber released after receiving the busy signal. The line relays 69' and 70 of the repeater C in turn ground the trunk conductors 99 and 100 simultaneously, thus causing in turn the energization of the line relays of the second-selector G and the connector F, as before. The connector-switch is, of course, thus released, as previously described, with the exception that in this case, since the switch-shaft is rotated, the shaft first rotates to normal position and then falls to its normal place. As soon as the shaft of the connector F is released from engagement with the trunk line leading to the called selector E the private wiper 124' breaks connection with the private normal conductor 195, restoring as a result the bridge-cut-off-relay 209 of the first-selector

E, whereby the line relays 207 and 208 return to their normal condition under the control of the substation D. As soon as the release-springs 31, 32 and 33 separate the ground connection to the conductors 38 and 39 is removed and as a result the first-selector B is restored, and the repeater C is restored, which latter then removes the ground from the trunk conductors 99 and 100, and as a result permitting the selector G and connector F to regain their full normal condition. If the called subscriber should desire to use his selector E before the calling subscriber A restores the switches he must first ground his line conductors 200 and 198 simultaneously by pressing the release-springs 227, 228 and 229 together after the ground springs 230 and 231 have come into contact. As a result an energizing circuit is established through the back-bridge-relays 146 and 147 of the connector F from ground G^{12} through the springs 230 and 231 to the ground release-spring 229, thence to the vertical line conductor 198 by one path through the ringer relay springs 197 and 196, through the vertical back-bridge-relay 146 to the battery lead 174, thence through battery B^2 to ground G^2 . Over another branch the current passes from ground release spring to the rotary line conductor 200, thence through the ringer relay springs 201 and 202 and through the rotary back-bridge-relay 147 to the battery lead 174, and from battery B^2 to ground G^2 . The said relays 146 and 147, upon energizing simultaneously, force the springs 232 and 233 together and thus establish a circuit from ground G^{13} through the said springs 232 and 233 and through the release-magnet 129 to the battery lead 174, and thence through battery B^2 to ground G^2 . The connector F is then released, the wipers 122, 123 and 124' disconnected from the first-selector E, leaving the first-selector E and connector F fully restored. Having been restored the selector E may be used by the subscriber at substation D. The calling subscriber may then, by grounding his vertical line conductors 38 and 39, upon hanging up his receiver restore the remaining switches B, C and G in a manner that is already known. It will be evident from the structure and description of the repeater C that the said switch is adapted to be inserted in any part of the circuit between either the substation and the selector B, or between the second-selector G and connector F, or in any other position, for the repetition of impulses.

The resistance of the coils 69', 70, 74 and 89 may be of any suitable character, but good results are obtained when the coils 69' and 70 are wound to five hundred ohms each, and the coils 74 and 89 to sixty ohms each.

Obviously with the use of my repeater the

subscribers of two different exchanges, which may be a considerable distance apart, may easily obtain connection with each other, notwithstanding the fact that the distance between the calling exchange and the apparatus of the exchange to which the called subscriber belongs may be so great that ordinarily the resistance of the line would be too great to successfully operate, directly, the relays and magnets of the switches in the distant exchange. Under such conditions the repeater C acts as a relay station for the switch-operating impulses that originate in the calling substation. It will be evident, then, that even where the exchanges are not so far apart the trunk conductors 99 and 100 may be made of material which is of comparatively high resistance, such as iron, instead of making it necessary to use copper for the trunk lines. In a system where for any reason it were desirable to have two repeaters, one after the other, for example, one at the end of the trunk line as shown in Fig. 1, and one at the other end of the same trunk line, in place of the second-selector G, there is no reason why such an arrangement should not be made. My repeater, it will be evident from its construction, is adapted to be thus arranged in the circuit. It is not even necessary that the repeater should be used to transmit impulses from one exchange to the other, but may be used to transmit impulses between switches no matter where they may be located.

The hub of the repeater C that carries the longitudinal teeth 75 and 76 may, if desired, be either riveted to the shaft or secured thereto by means of a screw or other device. The object in providing a normally open circuit between the local trunk conductors 234 and 235 which connect the repeater C with the banks of the selector B, and the trunk conductors 99 and 100, is to preclude the impulses which operate the relays 69' and 70 from discharging through the condensers 101 and 102 and thus perhaps affecting the relays at the second-selector G, before the relays 69' and 70 operate to ground the trunk conductors 99 and 100.

From the foregoing it will be seen that I provide a pair of repeater relays, such as the relays 69' and 70, which are adapted to be used in successively controlling a selector and a connector. In other words, the second-selector G and the connector F are successively responsive to the electrical ground impulses established in the trunk line by the energizing of the said repeater line relays. It will be seen that the repeater C is individual to one end of a trunk line, while the second-selector G is individual to the other end of the same trunk line. By placing the said repeaters in the trunk lines it will be seen that the number of repeaters

need only be substantially ten per cent. of the total number of subscribers. The first-selector B, or other suitable individual line switches, may be controlled directly by the
 5 subscriber's electrical impulse transmitter or calling device, but after the first trunk selection is made the calling subscriber then controls the second-selector and connector through the medium of the repeater C—that
 10 is to say, the calling subscriber simply operates the relays of the said repeater, and these repeater relays then correspondingly ground the trunk line at the other side of the condensers or other inductive connec-
 15 tions by which the repeater divides the trunk line into inductively connected sections. In this way the distance between the two exchanges—that is to say, the distance between the repeater C and the second-
 20 selector G—can be considerably reduced, and at the same time, notwithstanding the large amount of total resistance included in the line circuit between the second exchange and the calling subscriber, the necessary
 25 switching operations will be performed with accuracy and certainty at the second exchange. Of course, as previously stated, the said repeater can be employed for directly controlling and operating all automatic
 30 switches necessarily employed in establishing connection between the calling and called lines. Preferably, however, the said repeaters are interposed between the first and second selectors, or at least between the
 35 subscribers' individual switches and the selectors.

What I claim as my invention is:—

1. In a telephone exchange system, an automatic switch, a line running to said switch,
 40 a repeater in said line, provided with relays for controlling the operation of said automatic switch, and a subscriber's calling device for transmitting electrical impulses to operate said repeater, said automatic switch
 45 provided with relays responsive to the electrical impulses transmitted by the said repeater relays, said repeater provided with parallel line circuit conductors each having
 50 means for closing said gaps simultaneously with the transmission of the last impulse necessary for completing connection between the telephone lines of the calling and called subscribers.

55 2. In a telephone exchange system, an automatic switch, a line running to said switch, a repeater in said line, provided with a relay for controlling the operation of said automatic switch, and a subscriber's calling de-
 60 vice for transmitting electrical impulses to operate said repeater, said automatic switch provided with a relay responsive to the electrical impulses transmitted by the said repeater relay, said repeater provided with
 65 parallel line circuit conductors each having

a normally open gap therein, and automatic means for closing said gaps simultaneously with the transmission of the last impulse necessary for completing connection between the telephone lines of the calling and called
 70 subscribers.

3. In a telephone exchange system, the combination of a trunk line, an automatic switch at the end of said line, a repeater at the other end of said trunk line, provided
 75 with means for transmitting electrical impulses to said automatic switch, a plurality of telephone lines to which the said trunk line is common, a subscriber's calling device for each telephone line, provided with means
 80 for transmitting electrical impulses to operate said repeater, automatic means responsive to said electrical impulses, adapted for connecting any calling telephone line with the repeater end of the trunk line, and a central
 85 source of current for operating the said instrumentalities, said automatic switch provided with electromagnetic means responsive to said electrical impulses transmitted by the repeater, said repeater provided with
 90 parallel line circuit conductors each having a normally open gap therein, and automatic means for closing said gaps simultaneously with the transmission of the last impulse necessary for completing connection between
 95 the telephone lines of the calling and called subscribers.

4. In a telephone exchange system, the combination of a line circuit, a repeater in said circuit, adapted for repeating switch
 100 operating electrical impulses from one section thereof to another, an automatic switch adapted to receive the electrical impulses transmitted by said repeater, means for controlling or operating said repeater, and a
 105 central source of operating current, said circuit being provided with a normally open gap at the said repeater, and said repeater being provided with automatic means for closing said gap after the operation of said
 110 automatic switch.

5. In a telephone exchange system, the combination of a line circuit, automatic switches, a repeater in said circuit adapted for repeating switch operating electrical impulses
 115 from one section of said circuit to another, means for controlling said repeater, and a source of operating current, said repeater provided with a rotary step-by-step switch mechanism for controlling the continuity of
 120 said circuit.

6. In a telephone exchange system, the combination of a line circuit, a repeater in said line circuit, a source of operating current, said repeater provided with line wipers,
 125 a rotary magnet for operating said line wipers, and a rotary relay for controlling the energizing of said rotary magnet, whereby the said wipers are rotated one step each time the rotary relay is energized.
 130

7. In a telephone exchange system, the combination of a line circuit, a repeater in said circuit, adapted for repeating electrical impulses from one section of said circuit to another, and a source of operating current, said repeater provided with a rotary step-by-step switch mechanism controlling the continuity of said circuit, a release-magnet, and a pair of line relays adapted to be energized simultaneously to energize the release-magnet and thereby effect a release of the said switch mechanism.

8. In a telephone system, a line, an impulse transmitter in said line, a repeater associated with said line, a switch and a second line extending from said repeater to said switch, said repeater comprising means responsive to the impulses from said impulse transmitter for repeating said impulses over the second line to operate said switch, and means for connecting said first and second lines after the switch is operated.

9. In a telephone system, a line, an impulse transmitter in said line, a repeater associated with said line, a switch and a second line permanently connecting said repeater with said switch, said repeater comprising means responsive to the impulses from said impulse transmitter for repeating said impulses over the second line to operate said switch, and means for connecting said first and second lines after the switch is operated.

10. In a telephone system, a line, an impulse sender associated with said line, a repeater associated with said line, another line associated with said repeater, a switch associated with said second line, said repeater having an electromagnetic impulse repeating device responsive to the impulse sender for repeating impulses to the second line for operating said switch, and means for connecting said first and second lines after the switch is operated.

11. In a telephone system, a plurality of lines, means for sending impulses over said lines, a repeater, means for making said repeater accessible to any one of said lines and for connecting said repeater with one of said lines, a switch and a line connecting said switch and repeater, said repeater having means responsive to impulses from the connected line for repeating the impulses to said second line for operating said switch, and means for connecting said first and second lines after the switch is operated.

12. In a telephone system, a plurality of lines, means for sending impulses over said lines, a repeater, means for making said repeater accessible to any one of said lines and for connecting said repeater with one of said lines, a switch and a line connecting said switch and repeater, said repeater having an electromagnetic impulse repeating device responsive to the impulses transmit-

ted over the connected line for repeating impulses to said second line for operating said switch, and means for connecting said first and second lines after the switch is operated.

13. In a telephone system, a line, an impulse transmitter in said line, a repeater associated with said line, a switch and a second line extending from said repeater to said switch, said repeater comprising means responsive to the impulses from said impulse transmitter for repeating said impulses over the second line to operate said switch, and progressively movable means for connecting said first and second lines after the switch is operated.

14. In a telephone system, a line, an impulse transmitter in said line, a repeater associated with said line, a switch and a second line permanently connecting said repeater with said switch, said repeater comprising means responsive to the impulses from said impulse transmitter for repeating said impulses over the second line to operate said switch, and progressively movable means for connecting said first and second lines after the switch is operated.

15. In a telephone system, a line, an impulse sender associated with said line, a repeater associated with said line, another line associated with said repeater, a switch associated with said second line, said repeater having an electromagnetic impulse repeating device responsive to the impulse sender for repeating impulses to the second line for operating said switch, and progressively movable means for connecting said first and second lines after the switch is operated.

16. In a telephone system, a plurality of lines, means for sending impulses over said lines, a repeater, means for making said repeater accessible to any one of said lines and for connecting said repeater with one of said lines, a switch and a line connecting said switch and repeater, said repeater having means responsive to impulses from the connected line for repeating the impulses to said second line for operating said switch, and progressively movable means for connecting said first and second lines after the switch is operated.

17. In a telephone system, a plurality of lines, means for sending impulses over said lines, a repeater, means for making said repeater accessible to any one of said lines and for connecting said repeater with one of said lines, a switch and a line connecting said switch and repeater, said repeater having an electromagnetic impulse repeating device responsive to the impulse transmitted over the connected line for repeating impulses to said second line for operating said switch, and progressively movable means for connecting said first and second lines after the switch is operated.

18. In a telephone system, a line, an impulse transmitter in said line, a repeater associated with said line, a switch and a second line extending from said repeater to said switch, said repeater comprising means responsive to the impulses from said impulse transmitter for repeating said impulses over the second line to operate said switch, means for connecting said first and second lines after the switch is operated, and means for disconnecting the first and second lines.

19. In a telephone system, a line, an impulse transmitter in said line, a repeater associated with said line, a switch and a second line permanently connecting said repeater with said switch, said repeater comprising means responsive to the impulses from said impulse transmitter for repeating said impulses over the second line to operate said switch, means for connecting said first and second lines after the switch is operated, and means for disconnecting the first and second lines.

20. In a telephone system, a line, an impulse sender associated with said line, a repeater associated with said line, another line associated with said repeater, a switch associated with said second line, said repeater having an electromagnetic impulse repeating device responsive to the impulse sender for repeating impulses to the second line for operating said switch, means for connecting said first and second lines after the switch is operated, and means for disconnecting the first and second lines.

21. In a telephone system, a plurality of lines, means for sending impulses over said lines, a repeater, means for making said repeater accessible to any one of said lines and for connecting said repeater with one of said lines, a switch and a line connecting said switch and repeater, said repeater having means responsive to impulses from the connected line for repeating the impulses to said second line for operating said switch, means for connecting said first and second lines after the switch is operated, and means for disconnecting the first and second lines.

22. In a telephone system, a plurality of lines, means for sending impulses over said lines, a repeater, means for making said repeater accessible to any one of said lines and for connecting said repeater with one of said lines, a switch and a line connecting said switch and repeater, said repeater having an electromagnetic impulse repeating device responsive to the impulses transmitted over the connected line for repeating impulses to said second line for operating said switch, means for connecting said first and second lines after the switch is operated, and means for disconnecting the first and second lines.

23. In a telephone system, a line, an impulse transmitter in said line, a repeater associated with said line, a switch and a

second line extending from said repeater to said switch, said repeater comprising means responsive to the impulses from said impulse transmitter for repeating said impulses over the second line to operate said switch, means for connecting said first and second lines after the switch is operated, and means for releasing said switch controlled by said repeater.

24. In a telephone system, a line, an impulse transmitter in said line, a repeater associated with said line, a switch and a second line permanently connecting said repeater with said switch, said repeater comprising means responsive to the impulses from said impulse transmitter for repeating said impulses over the second line to operate said switch, means for connecting said first and second lines after the switch is operated, and means for releasing said switch controlled by said repeater.

25. In a telephone system, a line, an impulse sender associated with said line, a repeater associated with said line, another line associated with said repeater, a switch associated with said second line, said repeater having an electromagnetic impulse repeating device responsive to the impulse sender for repeating impulses to the second line for operating said switch, means for connecting said first and second lines after the switch is operated, and means for releasing said switch controlled by said repeater.

26. In a telephone system, a plurality of lines, means for sending impulses over said lines, a repeater, means for making said repeater accessible to any one of said lines and for connecting said repeater with one of said lines, a switch and a line connecting said switch and repeater, said repeater having means responsive to impulses from the connected line for repeating the impulses to said second line for operating said switch, means for connecting said first and second lines after the switch is operated, and means for releasing said switch controlled by said repeater.

27. In a telephone system, a plurality of lines, means for sending impulses over said lines, a repeater, means for making said repeater accessible to any one of said lines and for connecting said repeater with one of said lines, a switch and a line connecting said switch and repeater, said repeater having an electromagnetic impulse repeating device responsive to the impulses transmitted over the connected line for repeating impulses to said second line for operating said switch, means for connecting said first and second lines after the switch is operated, and means for releasing said switch controlled by said repeater.

28. In a telephone system, a line, an impulse transmitter in said line, a repeater associated with said line, a switch and a

second line extending from said repeater to said switch, said repeater comprising means responsive to the impulses from said impulse transmitter for repeating said impulses over the second line to operate said switch, progressively movable means for connecting said first and second lines after the switch is operated, means for releasing said switch controlled by said repeater, and means for releasing said progressively movable means to disconnect the first and second lines.

29. In a telephone system, a line, an impulse transmitter in said line, a repeater associated with said line, a switch and a second line permanently connecting said repeater with said switch, said repeater comprising means responsive to the impulses from said impulse transmitter for repeating said impulses over the second line to operate said switch, progressively movable means for connecting said first and second lines after the switch is operated, means for releasing said switch controlled by said repeater, and means for releasing said progressively movable means to disconnect the first and second lines.

30. In a telephone system, a line, an impulse sender associated with said line, a repeater associated with said line, another line associated with said repeater, a switch associated with said second line, said repeater having an electromagnetic impulse repeating device responsive to the impulse sender for repeating impulses to the second line for operating said switch, progressively movable means for connecting said first and second lines after the switch is operated, means for releasing said switch controlled by said repeater, and means for releasing said progressively movable means to disconnect the first and second lines.

31. In a telephone system, a plurality of lines, means for sending impulses over said lines, a repeater, means for making said repeater accessible to any one of said lines and for connecting said repeater with one of said lines, a switch and a line connecting said switch and repeater, said repeater having means responsive to impulses from the connected line for repeating the impulses to said second line for operating said switch, progressively movable means for connecting said first and second lines after the switch is operated, means for releasing said switch controlled by said repeater, and means for releasing said progressively movable means to disconnect the first and second lines.

32. In a telephone system, a plurality of lines, means for sending impulses over said lines, a repeater, means for making said repeater accessible to any one of said lines and for connecting said repeater with one of said lines, a switch and a line connecting said switch and repeater, said repeater having an electromagnetic impulse repeating device re-

sponsive to the impulses transmitted over the connected line for repeating impulses to said second line for operating said switch, progressively movable means for connecting said first and second lines after the switch is operated, means for releasing said switch controlled by said repeater, and means for releasing said progressively movable means to disconnect the first and second lines.

33. In a telephone system, a telephone line, means for sending impulses over said line, a repeater, means for connecting said line with said repeater, a switch, a line extending from said repeater to said switch, another switch, electromagnetic means in said repeater responsive to said impulses for operating said switches to build a line connection from the repeater to a second telephone line and to signal said second telephone line, and means in said repeater for connecting the first line with the switch line after the first switch is operated whereby a connection is established between the first line and the second line.

34. In a telephone system, a telephone line, means for sending impulses over said line, a repeater, means for connecting said line with said repeater, a switch, a line extending from said repeater to said switch, another switch, electromagnetic means in said repeater responsive to said impulses for operating said switches to build a line connection from the repeater to a second telephone line and to signal said second telephone line, and progressively movable means in said repeater for connecting the first line with the switch line after the first switch is operated whereby a connection is established between the first line and the second line.

35. In a telephone system, a telephone line, means for sending impulses over said line, a repeater, means for connecting said line with said repeater, a switch, a line extending from said repeater to said switch, another switch, electromagnetic means in said repeater responsive to said impulses for operating said switches to build a line connection from the repeater to a second telephone line and to signal said second telephone line, means in said repeater for connecting the first line with the switch line after the first switch is operated whereby a connection is established between the first line and the second line, and means for releasing said switches controlled by said repeater.

36. In a telephone system, a telephone line, means for sending impulses over said line, a repeater, means for connecting said line with said repeater, a switch, a line extending from said repeater to said switch, another switch, electromagnetic means in said repeater responsive to said impulses for operating said switches to build a line connection from the repeater to a second telephone line and to signal said second telephone line, progres-

sively movable means in said repeater for connecting the first line with the switch line after the first switch is operated whereby a connection is established between the first line and the second line, and means for releasing said switches controlled by said repeater.

37. In a telephone system, a telephone line, means for sending impulses over said line, a repeater, means for connecting said line with said repeater, a switch, a line extending from said repeater to said switch, another switch, electromagnetic means in said repeater responsive to said impulses for operating said switches to build a line connection from the repeater to a second telephone line and to signal said second telephone line, means in said repeater for connecting the first line with the switch line after the first switch is operated whereby a connection is established between the first line and the second line, means for releasing said switches controlled by said repeater, and releasing means for disconnecting the first line from the said first switch.

38. In a telephone system, a telephone line, means for sending impulses over said line, a repeater, means for connecting said line with said repeater, a switch, a line extending from said repeater to said switch, another switch, electromagnetic means in said repeater responsive to said impulses for operating said switches to build a line connection from the repeater to a second telephone line and to signal said second telephone line, progressively movable means in said repeater for connecting the first line with the switch line after the first switch is operated whereby a connection is established between the first line and the second line, means for releasing said switches controlled by said repeater, and releasing means for disconnecting the first line from said first switch.

39. In a telephone system, a telephone line, means for sending impulses over said line, a repeater, means for connecting said line with said repeater, a switch, a line connecting said switch with said repeater and means in said repeater responsive to said impulses for operating said switch, and means for connecting said telephone line with said switch line after the switch is operated, releasing mechanisms in said switch and in said last means and circuits for operating the said mechanisms from said repeater in response to said impulse sending means.

40. In a telephone system, a telephone line, means for sending impulses over said line, a repeater, means for connecting said line with said repeater, a switch, a line extending from said repeater to said switch, another switch, electromagnetic means in said repeater responsive to said impulses for operating said switches to build a line connection from the repeater to a second telephone line and to

signal said second telephone line and means in said repeater for connecting inductively the first line with the switch line after the first switch is operated whereby a connection is established between the first line and the second line.

41. In a telephone system, a telephone line, means for sending impulses over said line, a repeater, means for connecting said line with said repeater, a switch, a line extending from said repeater to said switch, another switch, electromagnetic means in said repeater responsive to said impulses for operating said switches to build a line connection from the repeater to a second telephone line and to signal said second telephone line, and progressively movable means in said repeater for connecting inductively the first line with the switch line after the first switch is operated whereby a connection is established between the first line and the second line.

42. In a telephone system, a telephone line, means for sending impulses over said line, a repeater, means for connecting said line with said repeater, a switch, a line extending from said repeater to said switch, another switch, electromagnetic means in said repeater responsive to said impulses for operating said switches to build a line connection from the repeater to a second telephone line and to signal said second telephone line, means in said repeater for connecting inductively the first line with the switch line after the first switch is operated whereby a connection is established between the first line and the second line, and means for releasing said switches controlled by said repeater.

43. In a telephone system, a telephone line, means for sending impulses over said line, a repeater, means for connecting said line with said repeater, a switch, a line extending from said repeater to said switch, another switch, electromagnetic means in said repeater responsive to said impulses for operating said switches to build a line connection from the repeater to a second telephone line and to signal said second telephone line, progressively movable means in said repeater for connecting inductively the first line with the switch line after the first switch is operated whereby a connection is established between the first line and the second line, and means for releasing said switches controlled by said repeater.

44. In a telephone system, a telephone line, means for sending impulses over said line, a repeater, means for connecting said line with said repeater, a switch, a line extending from said repeater to said switch, another switch, electromagnetic means in said repeater responsive to said impulses for operating said switches to build a line connection from the repeater to a second telephone line and to signal said second tele-

phone line, means in said repeater for connecting inductively the first line with the switch line after the first switch is operated whereby a connection is established between
 5 the first line and the second line, means for releasing said switches controlled by said repeater, and releasing means for disconnecting the first line from the said first switch.

45. In a telephone system, a telephone
 10 line, means for sending impulses over said line, a repeater, means for connecting said line with said repeater, a switch, a line extending from said repeater to said switch, another switch, electromagnetic means in
 15 said repeater responsive to said impulses for operating said switches to build a line connection from the repeater to a second telephone line and to signal said second telephone line, progressively movable means in
 20 said repeater for connecting inductively the first line with the switch line after the first switch is operated whereby a connection is established between the first line and the second line, means for releasing said
 25 switches controlled by said repeater, and releasing means for disconnecting the first line from said first switch.

46. In a telephone exchange system, the combination of one exchange, another ex-
 30 change, a trunk line connecting the two exchanges, an automatic switching machine at one end of said trunk line, a pair of relays at the other end of said trunk line, means by which the energizing of said relays severs
 35 the trunk line, and means by which a calling subscriber employs said relays for controlling said automatic switching machine.

47. In a telephone exchange system, the combination of a trunk line, an automatic
 40 switch at one end of said trunk line, a pair of relays at the other end of said trunk line, means by which the trunk line is severed by the energizing of said relays, and means by which a calling subscriber employs said
 45 relays for controlling said automatic switch.

48. In a telephone exchange system, a first-selector, means therein having one motion to select groups and another motion to connect with a line in any selected group,
 50 a second-selector, a trunk line connecting the first-selector with the second-selector, a repeater provided with relays controlling the continuity of the trunk line connection between the two selectors, a calling subscriber's
 55 telephone line connected with said first-selector, a calling device by which the subscriber controls the first-selector, by which the second-selector is controlled through the medium of the repeater relays, a source of operating
 60 current, said repeater relays provided with normally open contacts and a ground connection for grounding the trunk line when the relays are energized.

49. In a telephone exchange system, the
 65 combination of one exchange, another ex-

change, a trunk line connecting the two exchanges, an automatic switching machine at one end of said trunk line, means therein having one motion to select groups and another motion to connect with a line in any
 70 selected group, a pair of relays at the other end of said trunk line, means by which the energizing of said relays severs the trunk line, and means by which a calling subscriber employs said relays for controlling said
 75 automatic switching machine.

50. In a telephone exchange system, the combination of a trunk line, an automatic switch at one end of said trunk line, means therein having one motion to select groups
 80 and another motion to connect with a line in any selected group, a pair of relays at the other end of said trunk line, means by which the trunk line is severed by the energizing of said relays, and means by which
 85 a calling subscriber employs said relays for controlling said automatic switch.

51. An automatic telephone system comprising a plurality of electrically-propelled step-by-step switches, a calling subscriber's
 90 line having a calling device, said line temporarily connected with a called subscriber's line through the medium of said switches, the latter controlled and operated through the medium of said calling device at the
 95 calling subscriber's station, said switches including a pair of "line-relays" adapted to remain bridged across the talking circuit temporarily established for carrying on conversation between the two subscribers, and
 100 also including a pair of repeating relays which remain bridged across the said talking-circuit and through the medium of which the calling impulses transmitted by the calling subscriber are repeated in the
 105 windings of the said first-mentioned relays, means operated by battery current and under the control of any calling subscriber for admitting alternating current onto any called subscriber's line and thereby produc-
 110 ing an audible signal at the latter's station.

52. An automatic telephone system comprising a plurality of electrically-propelled step-by-step switches, a calling subscriber's
 115 line having a calling device, said line temporarily connected with a called subscriber's line through the medium of said switches, the latter controlled and operated through the medium of said calling device at the calling
 120 subscriber's station, a pair of "line-relays" adapted to remain bridged across the talking-circuit temporarily established for carrying on conversation between the two subscribers, and also including a pair of repeating relays which remain bridged across
 125 the said talking circuit and through the medium of which the calling impulses transmitted by the calling subscriber are repeated in the windings of the said first mentioned relays, and means whereby a subscriber may
 130

momentarily establish the live or charged ground circuits necessary in calling the number of another subscriber.

53. An automatic telephone system comprising a plurality of electrically propelled step-by-step switches, a calling subscriber's line having a calling device, said line temporarily connected with a called subscriber's line through the medium of the said switches, the latter controlled and operated through the medium of said calling device at the calling subscriber's station, said switches including a pair of "line-relays" adapted to remain bridged across the talking circuit temporarily established for carrying on conversation between the two subscribers, and also including a pair of repeating relays which remain bridged across the said talking circuit and through the medium of which the calling impulses transmitted by the calling subscriber are repeated in the windings of the said first mentioned relays, and means whereby a calling subscriber may momentarily establish the live or charged ground circuits necessary in automatically effecting a disconnection between subscribers' stations after the conversation is terminated.

54. An automatic telephone system comprising a plurality of electrically propelled step-by-step switches, a calling subscriber's line having a calling device, said line temporarily connected with a called subscriber's line through the medium of said switches, the latter controlled and operated through the medium of said calling device at the calling subscriber's station, said switches including a pair of "line-relays" adapted to remain bridged across the talking circuit temporarily established for carrying on conversation between the two subscribers, and also including a pair of repeating relays which remain bridged across the said talking circuit and through the medium of which the calling impulses transmitted by the calling subscriber are repeated in the windings of the said first mentioned relays, and means whereby a called subscriber may momentarily establish the live or charged ground circuits necessary in automatically effecting a disconnection between subscribers' lines after the conversation is terminated.

55. In a telephone exchange system substantially is disclosed, the combination of a connector provided with a line-conductor, a condenser in said line-conductor, a switch-wiper in said line-conductor, a bank of line-contacts adapted to be engaged by said switch-wiper, a single normally-open switch-point in the line-conductor between said condenser and switch-wiper, said wiper normally insulated from battery and ground, and subscribers' impulse transmitters or calling devices for transmitting to the exchange or central station the electrical impulses rep-

resenting the number of any called subscriber.

56. An automatic telephone system comprising a plurality of electrically propelled step-by-step switches, a calling subscriber's line having a calling device, said line temporarily connected with a called subscriber's line through the medium of said switches, the latter controlled and operated through the medium of said calling device at the calling subscribers' station, the apparatus as a whole including a pair of "line-relays" adapted to remain bridged across the talking-circuit temporarily established for carrying on conversation between the two subscribers, and also including a pair of repeating-relays which remain bridged across the said talking circuit and through the medium of which the calling impulses transmitted by the calling subscriber are repeated in the windings of said first-mentioned relays.

57. In a telephone system, a trunk line, a pair of condensers therein, a pair of relays permanently bridged across the trunk line at one side of said condensers, a battery having one pole permanently connected to the bridge at a point between said relays, a second pair of relays, another battery having one pole normally connected with both sides of said trunk line through the medium of the second pair of relays, each battery having its other pole grounded, and means for grounding the trunk line by the energizing of said first-mentioned pair of relays, to energize the said last-mentioned pair of relays, the said last-mentioned pair of relays being bridged across the trunk line at the other side of said condensers, said trunk line having continuous parallel sides.

58. In a telephone system, a trunk line, a condenser in each side of said trunk line, a relay permanently bridged across the trunk line at one side of said condensers, another relay permanently bridged across the trunk line at the other side of said condensers, and means by which the energizing of the first-mentioned relay causes the energizing of the said last-mentioned relay, said trunk line having continuous parallel sides.

59. In a telephone system, a trunk line having continuous parallel sides, a condenser in each side of said trunk line, one or more relays permanently bridged across the trunk line at one side of said condensers, one or more relays responsive to said first-mentioned relays, connected with the trunk line at the other side of said condensers, and switching means controlled over the trunk line by said last-mentioned relays.

60. In a telephone system, a trunk line having continuous parallel sides, re-active connections in said trunk line, one or more relays permanently bridged across the trunk line at one side of said re-active connections,

one or more relays responsive to said first-mentioned relays, connected with the trunk line at the other side of said re-active connections, and switching means controlled
5 over the trunk line by said last-mentioned relays.

61. In a telephone system, a trunk line having continuous parallel sides, a re-active connection in each side of said trunk line,
10 one or more relays permanently bridged across the trunk line at one side of said re-active connections, one or more relays responsive to said first-mentioned relays, connected to said trunk line at the other side
15 of said re-active connections, means for energizing the first-mentioned relay or relays to control the said last-mentioned relay or relays over the trunk line, and automatic switching machinery controlled by
20 said last-mentioned relay or relays.

62. In an automatic telephone system, a trunk line, a repeater in said trunk comprising only two relays, a line circuit for said repeater, and a selector switch adapted to
25 be controlled by said repeater.

63. In a telephone system, a trunk line, a pair of condensers therein, a pair of relays permanently bridged across the trunk line at one side of said condensers, a battery having
30 one pole permanently connected to the bridge at a point between said relays, a second pair of relays, another battery having one pole normally connected with both sides of said trunk line through the medium of
35 the second pair of relays, a switch having vertical motion to select groups and rotary motion to find a line in any selected group, controlled by said second pair of relays, each battery having its other pole grounded, and
40 means for grounding the trunk line by the energizing of the said first-mentioned pair of relays, to energize the said last-mentioned pair of relays, the said last-mentioned pair of relays being bridged across the trunk line
45 at the other side of said condensers, said trunk line having continuous parallel sides.

64. In a telephone system, a trunk line, a condenser in each side of said trunk line, a relay permanently bridged across the trunk
50 line at one side of said condensers, another relay permanently bridged across the trunk line at the other side of said condensers, a

switch having vertical motion to select groups and rotary motion to find a line in any selected group, controlled by said second relay, and means by which the energizing of the first-mentioned relay causes the energizing of the said last-mentioned relay, said trunk line having continuous parallel
55 sides. 60

65. In a telephone system, a trunk line having continuous parallel sides, a condenser in each side of said trunk line, one or more relays permanently bridged across the trunk line at one side of said condensers, one or
65 more relays responsive to said first-mentioned relays, connected with the trunk line at the other side of said condensers, and a switch having vertical and rotary selecting motions controlled by said second relay or
70 relays.

66. In a telephone system, a trunk line having continuous parallel sides, reactive connections in said trunk line, one or more relays permanently bridged across the trunk
75 line at one side of said reactive connections, one or more relays responsive to said first-mentioned relays and connected with the trunk line at the other side of said reactive connections, and a switch having vertical
80 and rotary selecting motions controlled by said second relay or relays.

67. In a telephone system, a trunk line having continuous parallel sides, a reactive connection in each side of said trunk line, one or more relays permanently bridged
85 across the trunk line at one side of said reactive connections, one or more relays responsive to said first-mentioned relays and connected to said trunk line at the other
90 side of said reactive connections, means for energizing the first-mentioned relay or relays to control the said last-mentioned relay or relays, and automatic switching machinery having vertical motion to select
95 groups and rotary motion to find a line in any selected group.

Signed by me at Chicago, Cook county, Illinois, this 14th day of July, 1906.

JOHN ERICKSON.

Witnesses:

E. A. MELLINGER,
Edw. D. HALES.