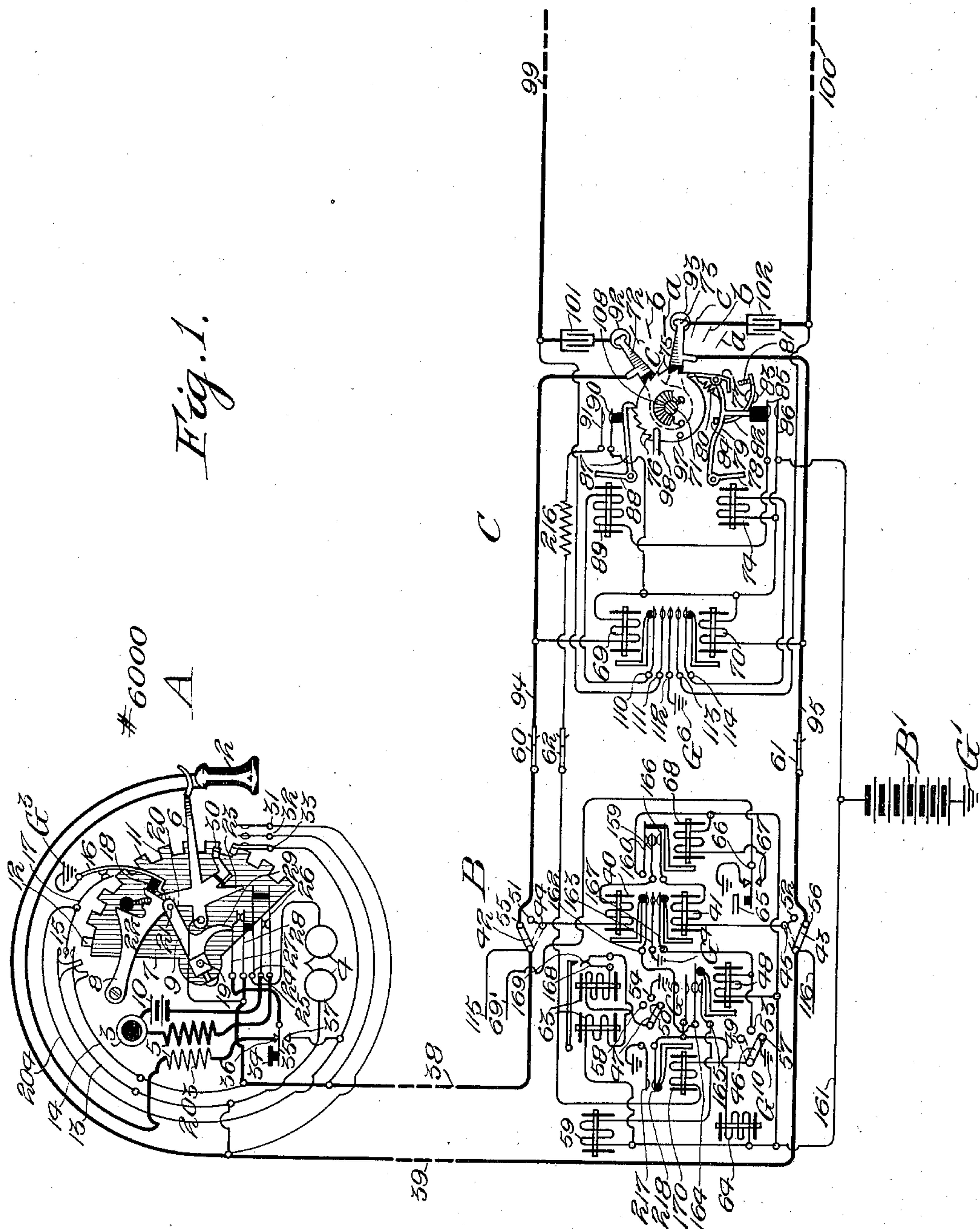


J. ERICKSON.
 TELEPHONE EXCHANGE APPARATUS AND SYSTEM.
 APPLICATION FILED JULY 19, 1906. RENEWED JAN. 2, 1918.

1,275,142.

Patented Aug. 6, 1918.

2 SHEETS—SHEET 1.



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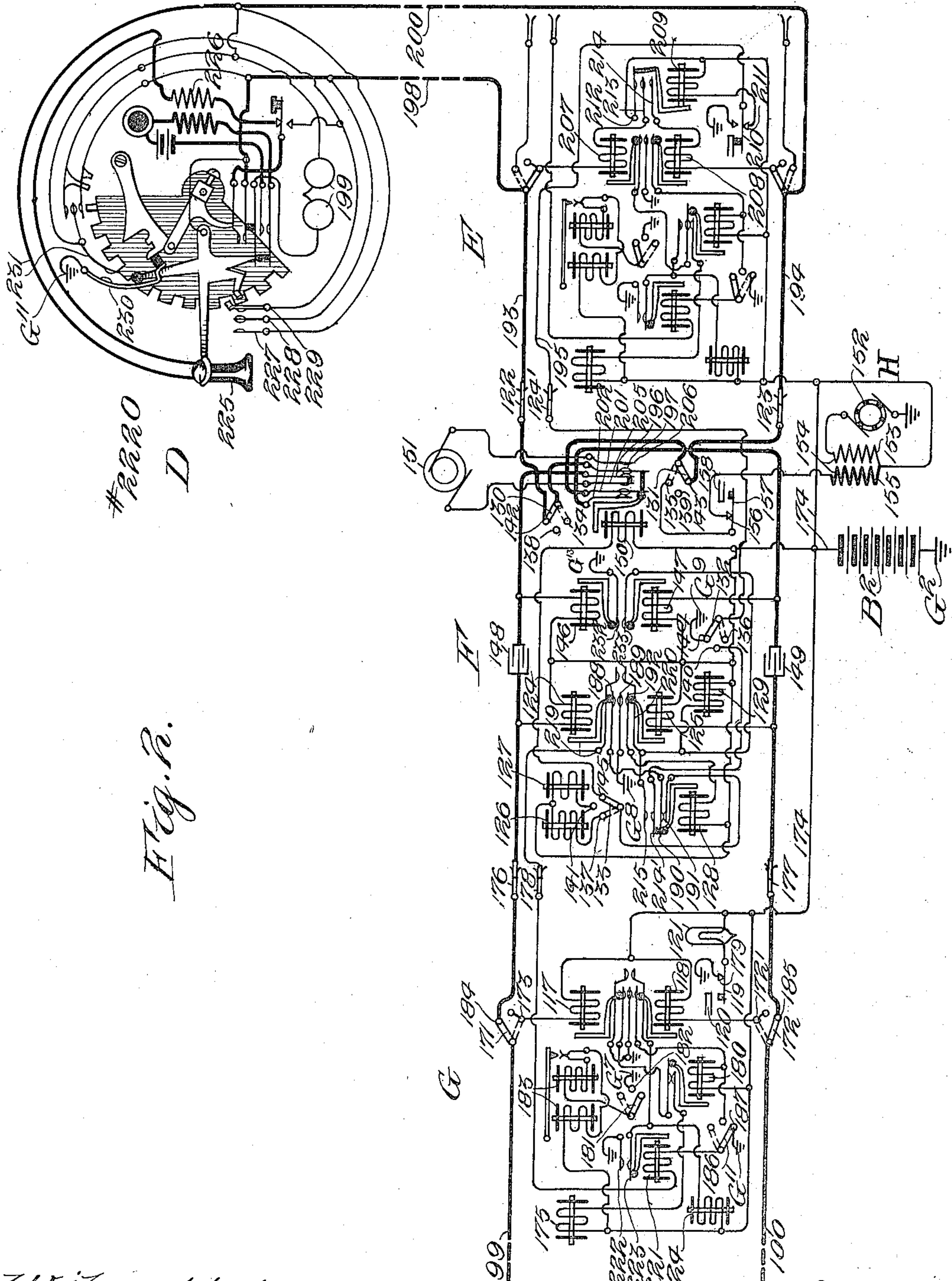


Fig. 2.

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UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE APPARATUS AND SYSTEM.

1,275,142.

Specification of Letters Patent.

Patented Aug. 6, 1918.

Application filed July 19, 1906, Serial No. 326,931. Renewed January 2, 1918. Serial No. 210,071.

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 automatic or semi-automatic telephone systems, and more especially to automatic telephone exchange systems in which electrically-propelled and step-by-step-actuated switching machines are employed at the exchange or central station, together with suitable calling devices at the subscribers' stations for controlling the said switching machines, whereby the calling subscriber may, by using his calling device for transmitting electrical impulses over his telephone line, automatically extend connection from his telephone line to the line of the called subscriber, and in which provision is made for then automatically producing an audible call-signal at the station of the called subscriber, as well as for automatically disconnecting and restoring the switching machinery after the subscribers are through talking, all without the assistance of operators at the exchange or central station.

For example, my invention is applicable to automatic telephone exchange systems of that particular character in which selectors are employed for trunking from the calling telephone line to a group of automatic connector-switches, which automatic connector-switches are employed for establishing the final connection directly with the called subscribers' lines, each connector being adapted to respond to the electrical impulses representing the last two digits of any called number, and the selectors being adapted to respond to all other electrical impulses representing the other digits of any called number, it being usual to provide as many different classes of selectors as there are digits in addition to the last two of any called number, as, for example, and assuming that each called number contains four digits, there will be first selectors for making trunking connections in accordance with the first digit of any called number, and second-selectors for establishing trunking connections in accordance with the

second digit of any called number, each second-selector being adapted to automatically pick out or select a non-busy connector, which latter will then make the final connection in accordance with the last two digits of the called number, providing, of course, that the called line is not busy, for should this be the case the connector will then refuse to establish connection with the called line, and a busy signal will be transmitted to the calling subscriber.

My invention is an improvement on the apparatus and system of my co-pending application Serial No. 326,450, filed July 16, 1906. In the present application the claims are limited to a repeater which controls a circuit separate from the talking circuit for releasing. In said prior application the repeater therein disclosed operates in conjunction with bridging selectors—that is to say, selectors having line relays which are allowed to remain bridged across the talking circuit during conversation, for the purpose of permitting these relays to be used in releasing the switches after the subscribers are through talking. In this application, however, I have disclosed and claimed a repeater having provisions for closing a trunk release circuit back over a third trunk conductor, in the direction of the calling subscriber, and through the first-selector or other automatic switch, thus making it possible to combine a repeater with selectors or other switches having line relays which can be cut off from the talking circuit during conversation.

Generally stated the object of my present invention is the provision of an improved construction and arrangement for permitting the cutting off of the bridged line relays of automatic switches in a system in which repeaters are employed for repeating or relaying switch operating electrical impulses from one section of a line circuit to another, as well as for transmitting voice-currents from one section of the circuit to another, and in which each repeater is provided with means for releasing a selector or other switching machine located ahead of it in the talking circuit—that is to say, back toward the calling subscriber—and in which each connector is provided with means for releasing any selector or other switch included between it and the repeater, thus

making it possible to leave the line relays of only the repeater and the connector bridged across the talking circuit during conversation between the subscribers.

5 Special objects of my present invention are the provision of a repeater having a relay provided with normally open switch contacts included in a trunk release circuit extending back over a third trunk conductor
10 to a selector or other automatic switch included in the circuit between the repeater and the calling subscriber's line, whereby the energizing of said relay will release or restore the said selector or other switch; the
15 provision of a repeater having a relay provided not only with the said normally open switch contacts for closing the trunk release circuit, but also with means for mechanically releasing the line wipers or other
20 circuit closing devices of the said repeater, whereby the energizing of said relay not only releases and restores the said selector or other switch included in the circuit between the repeater and the calling subscriber's
25 line; but also effects a release or restoration of the repeater itself; and the provision of certain details and features of improvement and combinations tending to increase the general efficiency and serviceability of
30 an automatic telephone exchange system of this particular character.

To the foregoing and other useful ends, my invention consists in matters herein-after set forth and claimed.

35 In the accompanying drawings, Figure 1 is a diagram showing a subscriber's line connecting the substation A (#6000) with its allotted first-selector B, and with the repeater C.

40 Fig. 2 shows in diagram a called substation D (#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 the central exchange or office #1, and Fig. 2 represents the apparatus at a second central office which will be designated as #2.

50 Figs. 1 and 2 taken together show a system embodying the principles of my invention and represent a temporarily established connection between the subscribers A and D.

It will be noticed that the apparatus is shown in an operative condition, maintaining the connection between the two sub-
55 stations. Each exchange or 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
60 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.

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
70 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. 75
The substation ground G³ is permanently connected to the ground spring 16, which latter is normally held away from the ground spring by the insulating tip 18 upon
80 the end of the cam latch 8. Said insulating tip normally rests opposite the 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
85 (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
90 arm 20 removes the ground spring 16 from the insulating tip 18 so that the cam latch 8 falls in front of the pin 21, on the end of the cam dog 9, so that it becomes impossible to rotate the dial. When the receiver
95 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
100 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 remains there, and out
105 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
110 16. The extreme end of the cam latch 8, which is engaged by the cam dog pin 21, is not angled but rounded off in such a 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
115 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
120 on the hook the cam 23 on the latter engages the spring 24 and thereby closes the ringer 4 across the line. By depressing the spring the said cam arm 23 not only closes the substation ringing circuit, but by separating
125 the springs 25 and 26 opens the local 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 130

is closed, the ringer is off the line, 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 subscribers' line conductors simultaneously when it becomes desirable to release the central office switching apparatus. The signaling button 34 has the office 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 G^3 and the 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, by hanging up his receiver he presses the release-springs 31, 32 and 33 into contact for a moment, grounds the subscribers' 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 described in Patent No. 815,321. Normally the subscribers' vertical and rotary line conductors 38 and 39 terminate, respectively, in the vertical and rotary line relays 40 and 41. The connection is maintained through the side switch wipers 42 and 43, respectively, the former being normally in engagement with the contact point 44, and the latter 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 and the rotary 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 and 47 engage, respectively, with the contact points 44, 45, 49 and 58; in the second position they rest on the contact points 51, 52, 53 and 54, respectively; and in the third position in engagement with the contact points 55, 56, 57 and 50, respectively. Through the medium of the vertical line relay 40, while the side switch is in first or second position, 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 relay 41, while the side switch is in first or second position, 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 while the side switch is in first or second position. If the side switch passes to third position, however, since the selector B is of the trunk release type, the said selector is controlled through the next switch with which a connection has been established and through the private wiper 62. The switch-shaft of the selector B carries a so-called normal post arm 65 which, when the shaft is in normal position, presses the spring 66 onto the contact point 67 and thereby makes a connection between the bridge-cut-off-relay 68 and the private normal conductor 69' that 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 B¹. It is necessary to thus disconnect said relays from battery, because if not the ringing current finds a path through the said relays, thus causing some danger from 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. Whenever the selector-switch B is operated, however, the spring 66 engages the grounded contact point just above it and thus grounds the private normal conductor 69' and the private bank contact of the connector banks corresponding to the number of the substation A, so that no calling subscriber may be able to call in upon substation A's line after a calling operation has once been started.

The repeater C is of the general type shown in my said application Serial No. 326,450. The spring 91 is provided in connection with a coil 216, from which latter the trunk release conductor leads to the private bank of the first-selector B, and to all other private banks in multiple therewith. The spring 91 is adapted to engage the spring 90, which latter has the retracting means for restoring the armature 88. Said spring 90 is connected to the non-grounded terminal of battery B¹ for purposes hereinafter described. The said 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 being adapted to be normally engaged by the rotary pawl 77. The rotary magnet 74 is provided with an armature 78, which latter is provided with an arm 79 upon the end of which the pawl 77 is pivotally mounted. A retracting-spring 80 is adapted to always maintain a tension on the pawl 77 in the direction of the longitudinal teeth 75. A suitable adjustable stop 81 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 five longitudinal teeth 75 for rotating the

shaft 71. The pawl 77 rests against the second tooth when the shaft 71 is in normal position. It is not absolutely necessary that there should be four steps, as the shaft may be arranged to be provided with only three or two or any suitable number of steps, depending upon the size of the exchange and the number of digits in the number to be secured by the repeater. The number of steps necessary to carry the wipers 72 and 73 to their respective bank contacts 92 and 93 may be readily changed, by adjusting the position of the stop 98 with respect to the stop pin 97. 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 said ratchet 87 also controls a couple of springs 90 and 91, the former of which acts as a retracting means for maintaining 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 in any suitable manner to form a bank. Normally the wipers are out of engagement with the said bank contacts, since the shaft is maintained in 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 in the arrangement shown in Fig. 1 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 line *a*, the first position by *b*, the second position by *c*, and the third 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 94 and 95 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 electric connecting apparatus. The repeater as a whole is built upon a suitable base (not shown), the mechanism itself being assembled upon a frame (not shown) that is attached to the base. The condensers are usually packed between the base and the frame. The switch-shaft 71 is retained in normal position by any suitable means, such as the coil-spring 108. The line relays 69 and 70 control the springs 110, 111, 112, 113 and 114 which are included in certain circuits to be 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.

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 the calling subscribers make connection with the substation A. There is, of course, no necessity for such conductors in the second-selector and they are therefore omitted. There is also no necessity 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 are, respectively, connected directly to the battery. There is also no requirement 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, as is well known, are very much the same, although there is some material difference in the circuits. The connector-switch shaft, like the shaft of the selectors, 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 relay 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 in turn controls circuits of the vertical and rotary magnets 126 and 127 and of 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 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 into 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 trunk connection between the two exchanges may be arranged 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, for convenience, 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; and it will 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 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 the 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 not only to the first-selector but to all the switches.

The operation in detail is as follows: To call the number 2220 the subscriber at sub-station 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 result the vertical line relay 40 of the first-selector B is energized twice, the current in each case flowing 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, side switch wiper 42, contact point 44, 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, 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 a level in which are 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 in turn energized. 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 side switch wiper 43, contact point 45 to 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 back-release-relay 170, 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 passing 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, respectively, engage the contact points 55 and 56 the subscribers' 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 57 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 upon 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 B¹ to ground G¹. The operation 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 G⁶ through the springs 112, 113 and 114 to the rotary magnet 74 and to the battery lead 161, thence through battery B¹ to ground G¹. The rotary magnet 74 upon energizing attracts its armature 78 and thus operates the pawl 77 to rotate the shaft 71 one step at the same time the springs 85 and 86 are pressed into contact, but just at this stage of the call the operation has no effect. The vertical trunk conductor 99 terminates in the side switch wiper 171 of the second-selector G, and the rotary trunk conductor 100 terminates in the side switch wiper 172 of the said selector. Therefore, grounding the vertical trunk conductor 99 twice, as described in the preceding, operates the vertical line relay 117, the current flowing from ground G⁶ at the repeater C through the line relay springs 112 and 111 to the vertical trunk conductor 99, thence through the side switch wiper 171, contact point 173, vertical line relay 117 to the battery lead 174, and through battery B² to ground G². 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 that 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 G⁶ at the repeater C through the springs 112 and 113 to the rotary trunk conductor 100, through the side switch wiper 172, contact point 172', rotary line relay 118 to the battery lead 174, thence through battery B² to ground G². 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 G⁷ through the side switch wiper 181, rotary magnet 183 and its allotted interrupter springs to the battery lead 174 and through battery B² to ground G². When the rotary magnet operates, the side switch is 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 subscribers' line conductors are extended to the connector F, is directed to the 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 G⁶ 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 B² to ground G². 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 G⁸ 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 B² to ground G². 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^6 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, substituting 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 0. 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 operates the rotary magnet 127 each time. The circuit through the said rotary magnet extends from ground G^6 to the side switch wiper 133, thence through the contact point 141 to the said rotary magnet 127 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 conductors 193 and 194 continuing 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 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. The 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 latter. 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 extends from ground G^0 through the side switch wiper 132 to the private wiper 124', conductor 195, thence through the switch shaft springs 210 and 211 to the bridge-cut-off-relay 209, thence 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 ground G^0 through 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 the number of his line. Digressing for a moment it will be assumed 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, as is shown, in turn causes the energization of the private magnet 128, which latter then presses the springs 214' and 215 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, private springs 214' and 215, 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 131, ringer relay springs 201 and 202, condenser 149 to the calling subscriber's rotary line conductor 39 over circuits that have been described, through the receiver 2 back to the vertical line conductor 38, thence to the vertical trunk conductor 99 and to the vertical line relay 124 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. 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 of the springs 110, 111, 112, 113 and 114 are pressed into contact. As a result 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 G^0 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 B^1 to ground G^1 . When the ratchet magnet 89 forces the springs 90 and 91 into contact an energizing circuit is established through the back-release-relay 170 of the first-selector B. Current in this circuit passes from ground G^{10} at the first-selector B, side switch contact point 57, side switch wiper 46, back-release-relay 170, private wiper 62, resistance coil 216 of the repeater C, springs 91 and 90 to the battery lead 161, thence through battery B^1 to ground G^1 . The back-release-relay 170 upon magnetizing presses the springs 217 and 218 in contact, setting up in turn, as a result, a magnetizing circuit through the release-magnet 64 of the first-selector B. As soon as the rotary magnet 74 of the repeater C and the ratchet magnet 89 attract their armatures, 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, and thus force the trunk release springs 219 and 220 into contact. As a result an energizing circuit is established through the release-magnet 129 of the connector, in series with the back-release-relay 221 of the second-selector G. This release

circuit extends from ground G^{11} at the second-selector G to the contact point 187, side switch wiper 186, back-release-relay 221, private wiper 178, trunk release springs 219 and 220 of the connector F, release-magnet 129 to the battery lead 174 and through battery B^2 to ground G^2 . The connector release-magnet and back-release-relay of the second-selector G energize simultaneously, the former, as is well known, releasing the connector-shaft and side switch at once. The back-release-relay 221, however, upon energizing presses the springs 222 and 223 into contact, thereby energizing the release-magnet 224 of the second-selector in the same manner that the release-magnet 64 of the first-selector B was energized. As soon as the subscribers' release-springs 31, 32 and 33 disengage, the line relays 69 and 70 of the repeater C deenergize, and the rotary magnet 74 and the ratchet magnet 89 of the repeater C deenergize, which ratchet magnet upon permitting the springs 91 and 90 to separate destroys the energizing release circuit that leads to the selector B, at which time the selector B is fully restored. The removal of the ground connection from the trunk conductors 99 and 100 causes the deenergization of the vertical and rotary relays 124 and 125 of the connector F. When the said connector relays 124 and 125 deenergize the trunk release springs 219 and 220 separate, and as a result the energizing circuit through the back-release-relay 221 of the second-selector G and through the release-magnet 129 of the connector F is destroyed. The connector F is thus left fully restored. The deenergization of the back-release-relay 221 of the selector G causes the deenergization of the release-magnet 224, which latter, as is well known, then causes the restoration of the selector switch shaft and side switch. The calling subscriber thus restores all the switching apparatus which he originally brought into use. However, if the line is not busy, and the called subscriber answers, by removing his receiver 225 from the switch-hook he thus bridges his secondary circuit, which includes the said receiver and the secondary winding 226 of his induction-coil, across the line. The calling and called subscribers are thus connected for conversation over the heavily marked conductors shown in Figs. 1 and 2, which conductors have already been pointed out. After the subscribers are through communicating the calling subscriber may destroy the established connection by hanging up his receiver 2 and grounding as a result the vertical and rotary line conductors 38 and 39 simultaneously, as already described. As a result the line relays 69 and 70 of the repeater C become energized simultaneously. Said relays in turn, as has been described, ground the trunk conductors 99 and 100, when the

springs 111, 112 and 113 are pressed into contact, thus in turn causing the energization of the line relays 124 and 125 of the connector F. The connector-switch, of course, is thus released in the same manner described in connection with the release when the calling subscriber receives the busy signal. There is one slight difference, however, and that is that the connector switch shaft which is now rotated first returns to normal rotary position and then falls to normal vertical position, as is well known. 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 and the energizing circuit for the bridge-cut-off-relay 209 is destroyed. As a result the line relays 207 and 208 of the selector E regain their normal condition and return under the control of the substation D. The release-magnet 129 of the connector F, of course, energizes in series with the back-release relay 221 of the selector G, as previously pointed out, which latter relay 221 in turn energizes the release-magnet 224; so that as soon as the relays 124 and 125 deenergize the back-release-relay 221 also deenergizes, as well as the release-magnet 224, with the result that the selector G is also restored. The simultaneous energization of the repeater line relays 69 and 70 causes the simultaneous energization of the rotary and ratchet magnets 74 and 89, respectively, and the establishment of a release circuit through the back-release-relay 170 of the first-selector B when the springs 90 and 91 of the repeater C are brought into contact. The said back-release-relay 170 in turn causes the energization of the release-magnet 64, but the circuit of the said release-magnet is also broken when the release-springs 31, 32 and 33 separate, and, of course, when the line relays 69 and 70 deenergize. The final result is that the switching apparatus involved in establishing connection is all restored to normal condition ready for another call.

The back release is provided in order that the called subscriber may not remain helplessly tied up, so to speak, while the bridge-cut-off-relay 209 is energized, should he desire, before the calling subscriber releases, to break the established connection and make an independent call. If he should desire to acquire control of his first-selector E, after establishing connection between the ground springs 230 and 231, by operating the dial, he may ground his line conductors 198 and 200 simultaneously by restoring his receiver 225 and thus pressing the release-springs 227, 228 and 229 into contact. As a result an energizing circuit will be set up through the vertical back-bridge-relay 146

and the rotary back-bridge-relay 147 of the connector F. The energizing circuit through the vertical back-bridge-relay may be traced from ground G^{11} through the springs 230 and 231 to the ground release-spring 229, thence over the vertical line conductor 198 through the ringer relay springs 197 and 196 and vertical back-bridge-relay 146 to the battery lead 174, thence through battery B^2 to ground G^2 . Through the rotary back-bridge-relay the current at the same time flows from the ground release-spring 229 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 through battery B^2 to ground G^2 . The said relays 146 and 147 upon energizing simultaneously force the springs 232 and 233 into contact, establishing an energizing circuit for the release-magnet 129 from ground G^{13} through the springs 232 and 233, release-magnet 129 to the battery lead 174, thence through battery B^2 to ground G^2 . The release-magnet of the connector F is thus energized, the wipers 122, 123 and 124' disconnected from the first-selector E and the energizing circuit through the bridge-cut-off-relay 209 destroyed, leaving the first-selector E and the connector F fully restored, the former being returned to the control of the calling subscriber. The calling subscriber may then, by grounding his line conductors 38 and 39, upon hanging up his receiver, restore the remaining switches B, C and G. 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 any of the switches or in any other position where the repetition of impulses and the transmission of voice-currents is required, as described in the preceding.

The resistance of the coils 69, 70, 74, 89 and 216 may be of any suitable character, but good results are obtained when the coils 69 and 70 are wound to a resistance of five hundred ohms each, and the coils 74, 89 and 216 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 exchange to which the called subscriber belongs may be so great that ordinarily the resistance of the lines would be too great to successfully operate, directly, the relays and magnets of the switches in the distant exchange, and too great for a satisfactory use of three-conductor trunk lines. 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 where the exchanges are not so far apart the trunk conductors 99 and 100 may be made of material which is cheaper even if of comparatively high resistance, such as iron, instead of making it necessary to use copper for the trunk lines between the exchanges. If for any reason it should be desirable to have two repeaters, 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 employed. 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, as it may be used to transmit impulses between switches wherever 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 disconnected circuit between the local trunk conductors 94 and 95 that connect the repeater C with the banks of the selector B and the outgoing 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. Better results are obtained by this form of construction.

From the foregoing it will be seen that the repeater relay 89 has the double function of closing a trunk release circuit back over a third trunk conductor to the first-selector B, and of mechanically releasing or restoring the line wipers 72 and 73 to normal position. With this arrangement the bridged line relays of the selectors can be cut off from the talking circuit during use of same for conversational purposes, and at such time the only relays left across the circuit are those of the repeater and the connector. When the subscribers are through talking the release is initiated over the line circuit by energizing the line relays of the repeater, and this in turn grounds both of the trunk line conductors 99 and 100, causing a simultaneous energizing of the line relays of the connector. This, of course, as explained, enables the connector to close a trunk release circuit extending back to the second-selector G, and enables the repeater to in turn close a trunk release circuit extending back to the first-selector B. In other words, the connector releases itself and the second-selector, and the repeater releases itself and the first-selector. With such an arrangement three trunk line conductors are necessary between the first-selector and the repeater, and between the

second-selector and the connector, but only two conductors are necessary between the repeater and the second-selector, while only two bridges are retained for releasing purposes, namely the line relay bridges of the repeater and the connector.

What I claim as my invention is:—

1. In a telephone exchange system, the combination of a telephone line circuit extending between calling and called subscribers' substations, an automatic switch provided with relay means temporarily disconnected from said circuit, a repeater provided with means for repeating or relaying electrical impulses from one portion of said circuit to another, means in said repeater for closing connection between the said portions of the line circuit, an electromagnet for releasing said circuit-closing means in the repeater, a trunk release circuit extending between the automatic switch and the repeater, normally open contacts included in the repeater and controlled by said electromagnet, said contacts controlling the continuity of said trunk release circuit, and means for supplying electrical current for operating said automatic switch and repeater.

2. 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, a second 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, said first releasing means comprising circuits between the switches separate from the talking circuit.

3. 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 second means and circuits for operating the said mechanisms from said repeater in response to said impulse sending means, one of said release circuits involving a conductor separate from the talking circuit.

4. In a telephone system, a telephone line

means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater responsive to said impulses for operating said second switch, and means for connecting said telephone line with said switch line after the second switch is operated, releasing devices in said second switch and in said first switch and circuits for operating the same controlled from said repeater in response to said impulse sending means, one of said release circuits involving a conductor separate from the talking circuit.

5. 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 electromagnetic 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 second means and circuits for operating the said mechanisms from said repeater in response to said impulse sending means, one of said release circuits involving a conductor separate from the talking circuit.

6. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, electromagnetic means in said repeater responsive to said impulses for operating said second switch, and means for connecting said telephone line with said switch line after the second switch is operated, releasing devices in said second switch and in said first switch and circuits for operating the same controlled from said repeater in response to said impulse sending means, one of said release circuits involving a conductor separate from the talking circuit.

7. 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 progressively movable means for connecting said telephone line with said switch line after the switch is operated, releasing mechanisms in said switch and in said second means and circuits for operating the said mechanisms from said repeater in response to said impulse sending means, one of said release circuits involving a conductor separate from the talking circuit.

8. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater responsive to said impulses for operating said second switch, and progressively movable means for connecting said telephone line with said switch line after the second switch is operated, releasing devices in said second switch and in said first switch and circuits for operating the same controlled from said repeater in response to said impulse sending means, one of said release circuits involving a conductor separate from the talking circuit.

9. 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, 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 mechanism in said switch, releasing mechanism in said second means, a first release circuit for operating said first releasing mechanism, a second release circuit for operating said second releasing mechanism, said release circuits controlled from said repeater in response to said impulse sending means, said second release circuit being separate from the talking circuit.

10. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater responsive to said impulses for operating said second switch, and means for connecting said telephone line with said switch line after the second switch is operated, a releasing device in said second switch, a releasing device in said first switch, a first release circuit for controlling said first releasing device, a second release circuit for controlling said second releasing device, both of said releasing devices being controlled from the repeater responsive to said impulse sending means, said second release circuit being separate from the talking circuit.

11. In a telephone system, a telephone line, means for sending impulses over said line, a repeater, means for connecting said lines with said repeater, a switch, a line connecting said switch with said repeater, electromagnetic 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 mechanism in said switch, releasing mechanism in said second means, a first release circuit for operating said first releasing mechanism, a second release circuit for operating said second releasing mechanism, said release circuits controlled from said repeater in response to said impulse sending means, said second release circuit being separate from the talking circuit.

12. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, electromagnetic means in said repeater responsive to said impulses for operating said second switch, and means for connecting said telephone line with said switch line after the second switch is operated, a releasing device in said second switch, a releasing device in said first switch, a first release circuit for controlling said first releasing device, a second release circuit for controlling said second releasing device, both of said releasing devices being controlled from the repeater responsive to said impulse sending means, said second release circuit being separate from the talking circuit.

13. 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, means in said repeater responsive to said impulses for operating said switch, and progressively movable means for connecting said telephone line with said switch line after the switch is operated, releasing mechanism in said switch, releasing mechanism in said second means, a first release circuit for operating said first releasing mechanism, a second release circuit for operating said second releasing mechanism, said release circuits controlled from said repeater in response to said impulse sending means, said second release circuit being separate from the talking circuit.

14. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater responsive to said impulses for operating said second switch, and progressively movable means for connecting said telephone line with said switch line after the second switch is operated, a releasing device in said second switch, a releasing device in said first switch, a first release circuit for controlling said

first releasing device, a second release circuit for controlling said second releasing device, both of said releasing devices being controlled from the repeater responsive to said impulse sending means, said second release circuit being separate from the talking circuit.

15. 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 inductively said telephone line with said switch line after the switch is operated, releasing mechanisms in said switch and in said second means and circuits for operating the said mechanisms from said repeater in response to said impulse sending means, one of said release circuits involving a conductor separate from the talking circuit.

16. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater responsive to said impulses for operating said second switch, and means for connecting inductively said telephone line with said switch line after the second switch is operated, releasing devices in said second switch and in said first switch and circuits for operating the same controlled from said repeater in response to said impulse sending means, one of said release circuits involving a conductor separate from the talking circuit.

17. 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 electromagnetic means in said repeater responsive to said impulses for operating said switch, and means for connecting inductively said telephone line with said switch line after the switch is operated, releasing mechanisms in said switch and in said second means and circuits for operating the said mechanisms from said repeater in response to said impulse sending means, one of said release circuits involving a conductor separate from the talking circuit.

18. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, electromagnetic means in said repeater responsive to said impulses for operating said second switch, and means for

connecting inductively said telephone line with said switch line after the second switch is operated, releasing devices in said second switch and in said first switch and circuits for operating the same controlled from said repeater in response to said impulse sending means, one of said release circuits involving a conductor separate from the talking circuit.

19. 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 progressively movable means for connecting inductively said telephone line with said switch line after the switch is operated, releasing mechanism in said switch and in said second means and circuits for operating the said mechanisms from said repeater in response to said impulse sending means, one of said release circuits involving a conductor separate from the talking circuit.

20. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater responsive to said impulses for operating said second switch, and progressively movable means for connecting inductively said telephone line with said switch line after the second switch is operated, releasing devices in said second switch and in said first switch and circuits for operating the same controlled from said repeater in response to said impulse sending means, one of said release circuits involving a conductor separate from the talking circuit.

21. 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, means in said repeater responsive to said impulses for operating said switch, and means for connecting inductively said telephone line with said switch line after the switch is operated, releasing mechanism in said switch, releasing mechanism in said second means, a first release circuit for operating said first releasing mechanism, a second release circuit for operating said second releasing mechanism, said release circuits controlled from said repeater in response to said impulse sending means, said second release circuit being separate from the talking circuit.

22. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting

said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater responsive to said impulses for operating said second switch, and means for connecting inductively said telephone line with said switch line after the second switch is operated, a releasing device in said second switch, a releasing device in said first switch, a first release circuit for controlling said first releasing device, a second release circuit for controlling said second releasing device, both of said releasing devices being controlled from the repeater responsive to said impulse sending means, said second release circuit being separate from the talking circuit.

23. 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, electromagnetic means in said repeater responsive to said impulses for operating said switch, and means for connecting inductively said telephone line with said switch line after the switch is operated, releasing mechanism in said switch, releasing mechanism in said second means, a first release circuit for operating said first releasing mechanism, a second release circuit for operating said second releasing mechanism, said release circuits controlled from said repeater in response to said impulse sending means, said second release circuit being separate from the talking circuit.

24. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, electromagnetic means in said repeater responsive to said impulses for operating said second switch, and means for connecting inductively said telephone line with said switch line after the second switch is operated, a releasing device in said second switch, a releasing device in said first switch, a first release circuit for controlling said first releasing device, a second release circuit for controlling said second releasing device, both of said releasing devices being controlled from the repeater responsive to said impulse sending means, said second release circuit being separate from the talking circuit.

25. 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, means in said repeater responsive to said impulses for operating said switch, and progressively movable means for con-

necting inductively said telephone line with said switch line after the switch is operated, releasing mechanism in said switch, releasing mechanism in said second means, a first release circuit for operating said first releasing mechanism, a second release circuit for operating said second releasing mechanism, said release circuits controlled from said repeater in response to said impulse sending means, said second release circuit being separate from the talking circuit.

26. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater responsive to said impulses for operating said second switch, and progressively movable means for connecting inductively said telephone line with said switch line after the second switch is operated, a releasing device in said second switch, a releasing device in said first switch, a first release circuit for controlling said first releasing device, a second release circuit for controlling said second releasing device, both of said releasing devices being controlled from the repeater responsive to said impulse sending means, said second release circuit being separate from the talking circuit.

27. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater responsive to said impulses for operating said second switch, and means for connecting said telephone line with said switch line after the second switch is operated, releasing devices in said second switch and in said first switch and circuits for operating the same controlled from said repeater in response to said impulse sending means.

28. 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 electromagnetic 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 mechanism in said switch and in said second means and circuits for operating the said mechanisms from said repeater in response to said impulse sending means.

29. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater,

means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, electromagnetic means in said repeater responsive to said impulses for operating said second switch, and means for connecting said telephone line with said switch line after the second switch is operated, releasing devices in said second switch and in said first switch and circuits for operating the same controlled from said repeater in response to said impulse sending means.

30. 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, means in said repeater responsive to said impulses for operating said switch, and progressively movable means for connecting said telephone line with said switch line after the switch is operated, releasing mechanism in said switch and in said second means and circuits for operating the said mechanisms from said repeater in response to said impulse sending means.

31. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater responsive to said impulses for operating said second switch, and progressively movable means for connecting said telephone line with said switch line after the second switch is operated, releasing devices in said second switch and in said first switch and circuits for operating the same controlled from said repeater in response to said impulse sending means.

32. 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, 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 mechanism in said switch, releasing mechanism in said second means, a first release circuit for operating said first releasing mechanism, a second release circuit for operating said second releasing mechanism, said release circuits controlled from said repeater in response to said impulse sending means.

33. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater

responsive to said impulses for operating said second switch, and means for connecting said telephone line with said switch line after the second switch is operated, a releasing device in said second switch, a releasing device in said first switch, a first release circuit for controlling said first releasing device, a second release circuit for controlling said second releasing device, both of said releasing devices being controlled from the repeater responsive to said impulse sending means.

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 connecting said switch with said repeater, electromagnetic 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 mechanism in said switch, releasing mechanism in said second means, a first release circuit for operating said first release mechanism, a second release circuit for operating said second releasing mechanism, said release circuits controlled from said repeater in response to said impulse sending means.

35. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, electromagnetic means in said repeater responsive to said impulses for operating said second switch, and means for connecting said telephone line with said switch line after the second switch is operated, a releasing device in said second switch, a releasing device in said first switch, a first release circuit for controlling said first releasing device, a second release circuit for controlling said second releasing device, both of said releasing devices being controlled from the repeater responsive to said impulse sending means.

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 connecting said switch with said repeater, means in said repeater responsive to said impulses for operating said switch, and progressively movable means for connecting said telephone line with said switch line after the switch is operated, releasing mechanism in said switch, releasing mechanism in said second means, a first release circuit for operating said first releasing mechanism, a second release circuit for operating said second releasing mechanism, said release circuit controlled from said repeater in response to said impulse sending means.

37. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater responsive to said impulses for operating the second switch, and progressively movable means for connecting said telephone line with said switch line after the second switch is operated, a releasing device in said second switch, a releasing device in said first switch, a first release circuit for controlling said first releasing device, a second release circuit for controlling said second releasing device, both of said releasing devices being controlled from the repeater responsive to said impulse sending means.

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 connecting said switch with said repeater and means in said repeater responsive to said impulses for operating said switch, and means for connecting inductively said telephone line with said switch line after the switch is operated, releasing mechanisms in said switch and in said second means and circuits for operating the said mechanisms from said repeater in response to said impulse sending means.

39. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater responsive to said impulses for operating said second switch, and means for connecting inductively said telephone line with said switch line after the second switch is operated, releasing devices in said second switch and in said first switch and circuits for operating the same controlled 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 connecting said switch with said repeater and electromagnetic means in said repeater responsive to said impulses for operating said switch, and means for connecting inductively said telephone line with said switch line after the switch is operated, releasing mechanisms in said switch and in said second means and circuits for operating the said mechanisms from said repeater in response to said impulse sending means.

41. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a re-

peater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, electromagnetic means in said repeater responsive to said impulses for operating said second switch, and means for connecting inductively said telephone line with said switch line after the second switch is operated, releasing devices in said second switch and in said first switch and circuits for operating the same controlled from said repeater in response to said impulse sending means.

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 connecting said switch with said repeater, and means in said repeater responsive to said impulses for operating said switch, and progressively movable means for connecting inductively said telephone line with said switch line after the switch is operated, releasing mechanism in said switch and in said second means and circuits for operating the said mechanisms from said repeater in response to said impulse sending means.

43. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater responsive to said impulses for operating said second switch, and progressively movable means for connecting inductively said telephone line with said switch line after the second switch is operated, releasing devices in said second switch and in said first switch and circuits for operating the same controlled from said repeater in response to said impulse sending means.

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 connecting said switch with said repeater, means in said repeater responsive to said impulses for operating said switch, and means for connecting inductively said telephone line with said switch line after the switch is operated, releasing mechanism in said switch, releasing mechanism in said second means, a first release circuit for operating said first releasing mechanism, a second release circuit for operating said second releasing mechanism, said release circuits controlled from said repeater in response to said impulse sending means.

45. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said sec-

ond switch, means in said repeater responsive to said impulses for operating said second switch, and means for connecting inductively said telephone line with said switch line after the second switch is operated, a releasing device in said second switch, a releasing device in said first switch, a first release circuit for controlling said first releasing device, a second release circuit for controlling said second releasing device, both of said releasing devices being controlled from the repeater responsive to said impulse sending means.

46. 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, electromagnetic means in said repeater responsive to said impulses for operating said switch, and means for connecting inductively said telephone line with said switch line after the switch is operated, releasing mechanism in said switch, releasing mechanism in said second means, a release circuit for operating said first releasing mechanism a second release circuit for operating said second releasing mechanism, said release circuits controlled from said repeater in response to said impulse sending means.

47. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, electromagnetic means in said repeater responsive to said impulses for operating said second switch, and means for connecting inductively said telephone line with said switch line after the second switch is operated, a releasing device in said second switch, a releasing device in said first switch, a first release circuit for controlling said first releasing device, a second release circuit for controlling said second releasing device, both of said releasing devices being controlled from the repeater responsive to said impulse sending means.

48. 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, progressively movable means in said repeater responsive to said impulses for operating said switch, and means for connecting inductively said telephone line with said switch line after the switch is operated, releasing mechanism in said switch, releasing mechanism in said second means, a first release circuit for operating said first releasing mechanism, a second release circuit for operating said sec-

ond releasing mechanism, said release circuits controlled from said repeater in response to said impulse sending means.

49. In a telephone system, a telephone line, means for sending impulses over said line, a switch associated with said line, a repeater, means in said switch for connecting said line with said repeater, a second switch, a line connecting said repeater with said second switch, means in said repeater responsive to said impulses for operating said second switch, and progressively movable means for connecting inductively said telephone line with said switch line after the second switch is operated, a releasing device in said second switch, a releasing device in said first switch, a first release circuit for controlling said first releasing device, a second release circuit for controlling said second releasing device, both of said releasing devices being controlled from the repeater responsive to said impulse sending means.

50. An automatic telephone system comprising a plurality of electrically-propelled step-by-step switches, a repeater, a calling subscriber's line temporarily connected with a called subscriber's line through the medium of said switches, all except one of said switches having "line-relays" temporarily disconnected from the "line-conductors" with which they are normally connected, and said repeater apparatus, like one of said switches, having a pair of "line-relays" which remain bridged across the talking-circuit temporarily established between the two subscribers' stations, said repeater line relays being controlled by the calling subscriber to repeat impulses to the line relays of said switches during the establishment of the connection.

51. An automatic telephone system comprising selectors, connectors, a repeater, a calling subscriber's line temporarily connected with a called subscriber's line through the medium of said selectors and connectors, said "selector" or "selectors" having "line-relays" temporarily disconnected from the "line-conductors" with which they are normally connected, but said "connector" and repeater apparatus each having a pair of "line-relays" which remain bridged across the talking circuit temporarily established between the two subscribers' stations, said repeater line relays being controlled by the calling subscriber to repeat impulses to the line relays of the said selectors and connector during the establishment of the connection.

Signed by me at Chicago, Cook county, Illinois, this 16th day of July, 1906.

JOHN ERICKSON.

Witnesses:

ROY C. GIFFORD,
EDWARD D. FALES.