No. 866,639. PATENTED SEPT. 24, 1907.

E. D. FALES.

AUTOMATIC TELEPHONE RELEASE.

APPLICATION FILED FEB. 9, 1907.

2 SHEETS—SHEET 1.

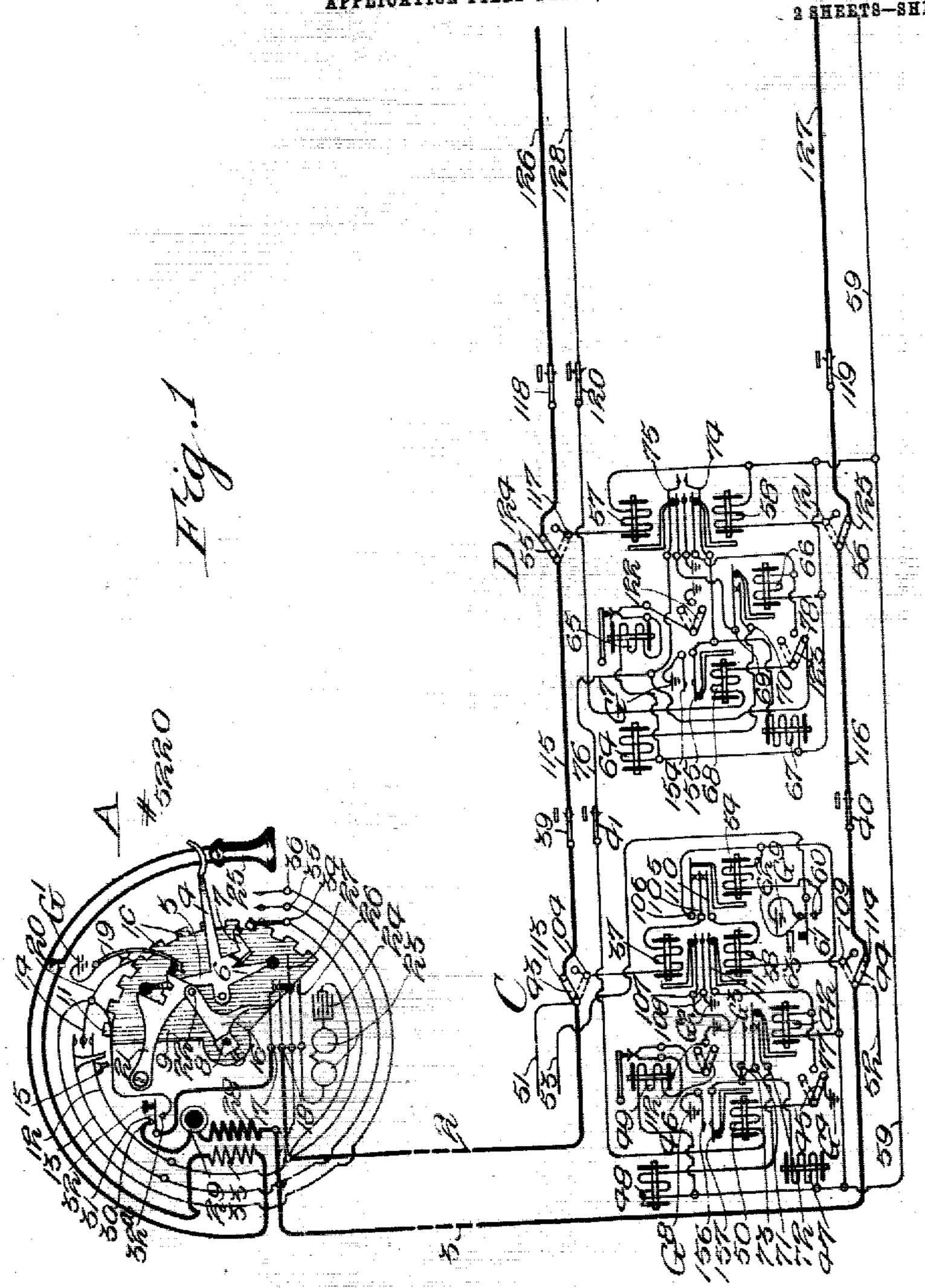

Fig. 1.

Witnessed.
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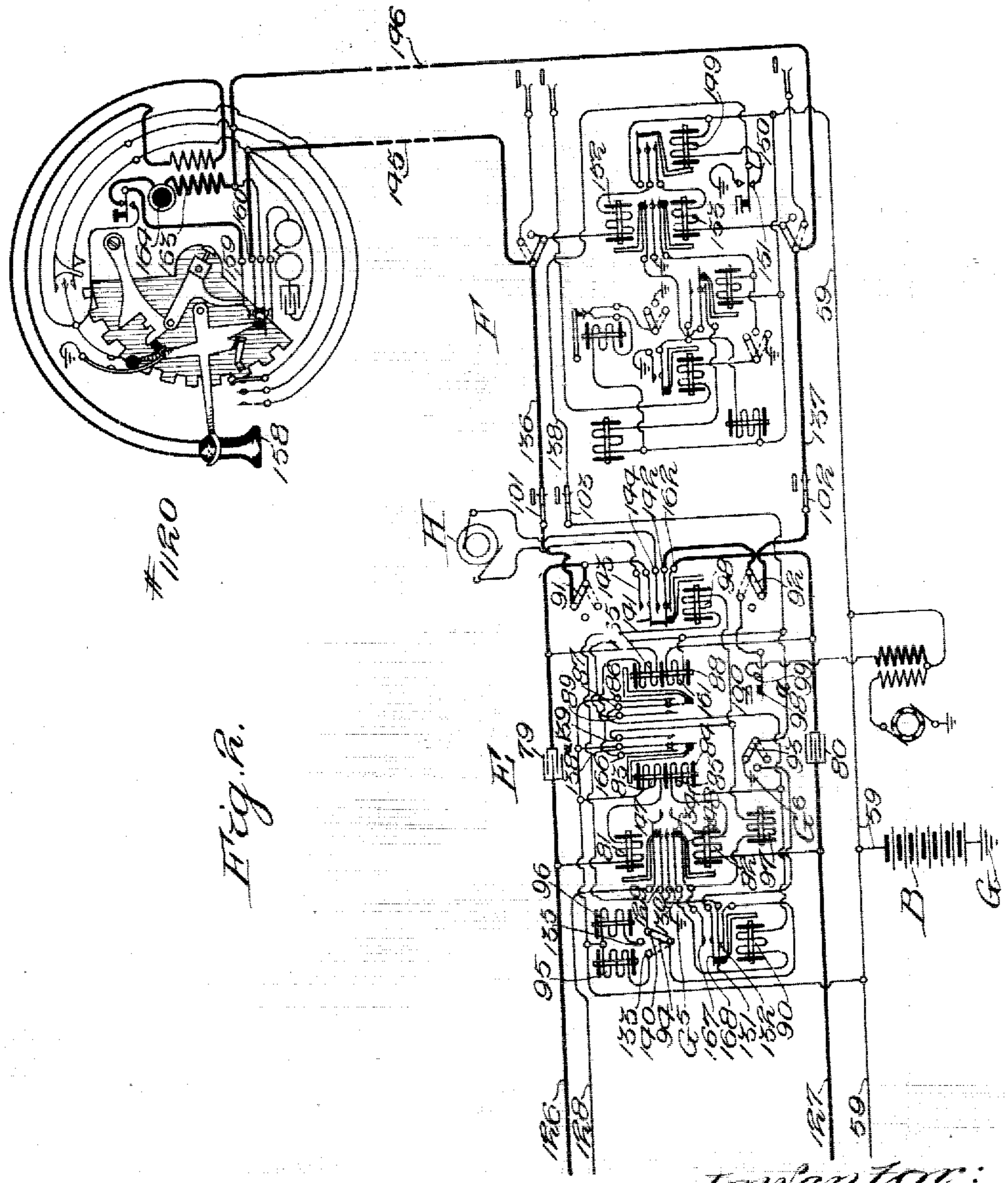

Fig. 2.

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UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE RELEASE.

No. 866,639. Specification of Letters Patent. Patented Sept. 24, 1907.

Application filed February 9, 1907. Serial No. 356,576.

To all whom it may concern:

Be it known that I, EDWARD D. FALES, a citizen of the United States of America, and a resident of Chicago, Cook county, Illinois, have invented a certain new and useful Improvement in Automatic Telephone Release, of which the following is a specification.

My invention relates to automatic or semiautomatic telephone exchange systems in general, but more particularly to those systems in which electrically-propelled and step-by-step-actuated switching machines are employed—such, for example, as selectors for making connection with idle trunk lines, and connectors for completing connection directly with the called subscribers' lines—and especially to systems of this kind in which the so-called trunk-release is employed between switches, whereby the selectors, or automatic trunking switches, are released over third or additional trunk conductors. In these trunk-release systems it has been customary, prior to my invention, to include only two switches in each trunk-release circuit—that is to say, to run a trunk-release circuit back from the connector and through the release relay of the second-selector, and to then run another trunk-release circuit back from the second-selector and through the first-selector, the said release relay controlling the release circuit through the first-selector. With this arrangement it is obvious that the closure of one release circuit is contingent upon the closure of the one ahead of it, and that the release of a long line of automatic switches in this manner is of a progressive and step-by-step character, as the switches are not released simultaneously. With my improved arrangement, however, as herein disclosed, the release relays of all the selectors or trunking switches are connected in series with the release magnet of the connector, so that only one long trunk-release circuit is employed, regardless of the number of selectors or automatic switches between the calling subscriber and the connector. In other words, and as herein disclosed, the said trunk-release circuit extends from the non-grounded pole of the battery through the release magnet of the connector, thence back through the release relay of the second-selector, through the release relay of the first-selector, and then to ground, whereby the selectors are all released simultaneously upon the hanging up of the subscriber's telephone receiver, which act on the part of the subscriber effects a closure of the trunk-release circuit at the connector, thus bringing the battery and the release magnet of the connector into a trunk-release circuit in which they are in series with the release relays of all the selectors. In this way the release of any and all automatic switches necessary for establishing connection through the exchange from a calling subscriber's line to a called subscriber's line is greatly improved, as the release is thereby made practically instantaneous.

The system in connection with which I have elected to illustrate my invention is of the common battery type, and of that kind in which first selectors are employed as individual switches for the telephone lines, and in the accompanying drawings, Figures 1 and 2 show diagrammatically an established connection between two automatic subscribers of an automatic telephone system embodying the principles of my invention.

In Fig. 1 A designates the substation of the calling subscriber, which substation is adapted to send electrical impulses, for operating the central office switches, from the central battery B. As thus illustrated, the automatic switching apparatus in the central office comprises first-selector, second selector and connector switches, one first-selector being allotted to each subscriber's line.

At C (Fig. 1) is shown the first-selector allotted to the calling substation A. At D is shown a second-selector with which the first-selector C has established connection. At E is shown a connector-switch with which the second-selector D has in turn established connection, and at F is shown the first-selector allotted to the line of the called subscriber #1120.

The central battery B is shown with its positive terminal preferably grounded at G, while the substation A is shown with a ground connection at G'. It is through the said ground connection G' that the subscriber at substation A closes circuits for transmitting impulses to operate the central office apparatus.

The substation may be of any suitable or approved type, means being provided to enable the subscriber to transmit impulses over his line conductors 2 and 3, in a predetermined manner, as will be more fully described. The said substation must be adapted to send impulses for operating the switches for the purpose of establishing the connection. It must be adapted to send impulses for operating the signaling devices of the system, whereby a call-signal may be given to the desired subscriber. Furthermore, the substation must be adapted to transmit impulses for restoring the switches to their normal condition after the subscriber has brought them into use. The substation A is diagrammatically shown, but is sufficiently clear to enable those versed in the art to understand my invention. For example, it is provided with a switch-hook 4, which, as shown, is equipped with the cam-arms 5, 6 and 7. Through the medium of these arms the said switch-hook is adapted to control certain mechanical devices and certain circuits which are more or less conveniently

controlled thereby. The telephone is, of course, provided with a suitable dial having finger-holes with the proper numbers, by means of which finger-holes the subscriber is guided in making a call. The said dial, although not shown, is mounted on the shaft 8, which shaft rigidly carries a so-called impulse wheel 9 provided on its circumference with so-called vertical impulse teeth 10 and one rotary impulse tooth 11. The said teeth are adapted to control and operate a couple of springs 12 and 13, known as the vertical and rotary impulse springs, respectively. Located between the said impulse springs there is a ground post 14 which, after the switch-hook has been raised and the dial rotated, is in electrical connection with the substation ground G'. By operating the dial the subscriber also operates, as a result, the impulse wheel 9, which latter is adapted to engage, through the medium of the vertical impulse teeth 10, the vertical impulse spring 12, whereby the said spring 12 is carried onto the ground post, when the dial is allowed to return, a number of times, depending upon the number of teeth 10 that have passed beyond the lug 15 of the said spring 12. After the vertical impulse spring is thus operated, whereby ground impulses are delivered to the vertical line conductor 2, the rotary impulse tooth 11 always engages the rotary impulse spring 13 once, just before the dial comes to a stop, whereby the said spring 13 is also carried into contact with the ground post 14, and whereby one ground impulse is delivered to the rotary line conductor 3. Rigidly secured to the shaft 8 there is a dog-like cam 16 which is provided with a finger, by means of which the primary circuit springs 17 and 18 are kept closed while the dial is in normal position, but while the dial is rotating—that is, at all times when the dial is out of normal position—the springs 17 and 18 are kept separated, so that the ground impulses that are delivered to either line conductor will not pass to the other. The shaft 8 has attached to it any suitable spring, such as a clock spring, whereby the dog 16 is maintained in the normal position shown at A, and whereby when the dial is rotated the said clock spring is wound up to a certain extent in order to insure the return of the dial and other parts located on the shaft 8 to normal position. When the receiver is on the switch-hook the latter is maintained in such a position that the insulating tip shown on the end of the cam-arm 5 holds the ground spring 19 away from the ground spring 20, at the same time holding the said spring in such condition that the insulating tip shown on the end of the so-called locking cam 21 is retained in front of the angled terminal of the spring 19, as shown at substation #1120, so that when a subscriber answers, the ground springs 19 and 20 are still retained separated by the said insulating tip, and are prevented from coming into contact until after the dial has been rotated, at which time the pin 22 on the end of the dog 16 raises the locking cam 21, so as to drive the insulating tip to the position shown at substation A. It will be understood that while the receiver is on the switch-hook, and since the cam 5 is out of engagement with the locking cam 21, the latter is retained in front of the pin 22 to prevent the shaft 8 from being turned. However, when the receiver is removed from the switch-hook the cam-arm 5 strikes the locking cam 21, raising the latter sufficiently to clear the pin 22, so as to permit the dog 16 that carries said pin to rotate, but not sufficiently to disengage the insulating tip on the end of the locking cam 21 from the ground spring 19. When the dial is rotated, however, the pin 22, by striking the rounded terminal of the lower end of the dog 21, raises the latter a trifle farther, whereby the ground springs 19 and 20 are brought into contact. The object of this construction—that is, in maintaining the ground springs apart until a subscriber has begun to make a call—is to prevent the accidental grounding of the line conductors 2 or 3, or both, when subscribers are simply answering a call.

The substation is further provided with the usual bell 23 which is normally bridged across the line conductors in series with the condenser 24 while the receiver 25 is on the switch-hook, and therefore while the cam 6 maintains the ring circuit springs 26 and 27 in contact. While the said receiver circuit springs are in contact, the primary circuit springs 17 and 18 are, of course, separated in order that all the current will pass through the ringer when the substation is being signaled. In the primary circuit (the telephone being a common battery telephone) the primary winding 28, the transmitter 29, and the signaling springs 30 and 31 are in series, and are always thrown across the line while the springs 17 and 18 are in contact. The spring 31 is, as shown, controlled by a button 32, whereby said spring 31 may be pressed onto the contact 32ª, which latter is connected with ground G' whenever the ground springs 19 and 20 are in contact. As shown, the receiver is in a closed circuit with the secondary winding 33, which latter, together with the primary winding 28, form the induction-coil at the substation. The telephone is further provided with the so-called release springs 34, 35 and 36 which are controlled by the cam-arm 7 and adapted to be pressed into contact by said arm 7 whenever the switch-hook is caused to descend. The length of time which the said release springs are maintained in contact in order that they may work effectively may be regulated in any suitable manner. It will be understood, of course, that the switch-hook is also provided with a spring, whereby when the receiver is removed the switch-hook is caused to rise to perform the operations that are assigned to it.

The selector C may be of the trunk-release type, and the one herein shown is similar to the one described in United States Patent No. 815,321, granted to Keith, Erickson & Erickson on March 13, 1906. As is well known, it comprises the vertical and rotary line relays 37 and 38, the relay 37 being provided for causing the vertical movement of the switch-shaft (not shown) that carries the line wipers 39 and 40 and the private wiper 41. The rotary line relay 38 is used for operating the private magnet 42, which magnet in turn controls the so-called side switch that comprises the side switch wipers 43, 44, 45 and 46. As is well known, the side switch, in the course of the operation of the selector, is adapted to assume three positions, namely the normal position known as the first position, the second position at which time the shaft is rotated, and the third position at which time the line conductors are extended into connection with the line wipers 39 and 40, and with whatever trunk line conductors the said wipers may have stopped in engage-

ment. The line relays 37 and 38 are, furthermore, adapted, while the side switch is in first or second position, to energize the release magnet 47, if they are energized simultaneously when the side switch is in first or second position. It will be understood, of course, that the vertical line relay 37, when a connection is being made, operates to energize the vertical magnet 48, which latter directly operates to raise the switch-shaft in a longitudinal or vertical direction. After the shaft has been thus raised by the vertical magnet, the rotary magnet 49, as soon as the side switch wiper 46 passes to third position, operates to rotate the shaft wipers along the bank level to which said wipers have been previously raised by the vertical magnet 48. After the side switch has once passed to third position the line relays 37 and 38, as is well known, are disconnected from the line conductors 2 and 3, and the switch can only be relased through the medium of the so-called back-release relay 50. When once the switch C has established connection with the switch D, the said relay 50 can only be controlled from the latter switch. The selector C is, furthermore, provided with so-called normal line conductors 51 and 52 which terminate in the banks of connector switches of the hundred to which the substation A belongs. If it is assumed that the substation A is #5220 the said normal conductors will lead to banks of the connector switches of the second hundred of the fifth thousand—that is, connectors that take care of all subscribers between 200 and 299. Together with the said normal conductors there runs a third or private normal conductor 53 over which the line #5220 is made busy at the connector banks while the subscriber at substation A is calling, and over which the so-called bridge-cut-off relay 54 is energized when the line #5220 is called, in order that the relays 37 and 38 may be disconnected from each other.

The selector D is identical with the selector C, except that there are no normal line conductors terminating in the side switch wipers 55 and 56, such as the normal line conductors 51 and 52 that terminate in the side switch wipers 43 and 44. Furthermore, there is no bridge-cut-off relay such as the bridge-cut-off relay 54 of the selector C, and the line relays 57 and 58 connect directly with the non-grounded battery lead 59 instead of through bridge-cut-off relay springs, as the line relays 37 and 38 of the selector C do. Necessarily, the private normal conductor does not appear in the selector D, and, furthermore, the shaft springs, such as the shaft springs 60, 61 and 62 which are controlled by the normal post arm 63 of the shaft of the selector C, are done away with. Of course the vertical magnet 64 will be recognized, as well as the rotary magnet 65, private magnet 66, the release magnet 67, and the back-release relay 68. There is another difference in the said selector D which will at once be apparent, and that is that the private magnet 66 has only two springs 69 and 70, which correspond to the springs 71 and 72 of the selector C; but the spring 73 of the private magnet 42 of the selector C does not appear in the switch D, which spring 73 is connected with the release magnet 47, as shown. In the selector D, however, the release magnet is connected with the so-called trunk-release spring 74 which is controlled by the rotary line relay 58, and which spring is adapted to engage the spring 75 which is controlled by the vertical line relay 57, whereby when both line relays 57 and 58 energize simultaneously, the release magnet 67 of the selector D is connected with the third or trunk-release conductor 76, and with the back-release relay 50, and through said relay to ground at the selector C, when the latter is connected with the selector D. It will be noticed that in the selector C the side switch contact point 77, which the side switch wiper 45 engages when the side switch is in third position, is connected directly to ground. In the selector D the corresponding side switch contact point—namely the contact point 78—, instead of being connected directly to ground, is connected directly to the third or trunk-release conductor 76, and this particular difference in the selector D is one of the features of my invention.

In mechanical structure the connector E is very much the same as the selector, and is a modified form of the connector disclosed in United States Patent No. 815,176, granted March 13, 1906, to Keith, Erickson & Erickson, the modification being that the connector E has been adapted to common battery work, while the connector of said patent is for local battery work. In the said connector E the condensers 79 and 80 will be recognized at once, which condensers are inserted one on each side of the talking line. In front of said condensers the vertical and rotary line relays 81 and 82 will also be recognized, and in this particular connector the vertical line relay 81 is connected with the non-grounded battery lead 59 through a winding 83 of a differential relay 84, while the rotary line relay 82 is connected through a second winding 85 of the said differential relay 84 with the non-grounded battery lead 59. It will be noticed, however, that this connection is made through the springs 86 and 87 of the so-called back-bridge relay 88, which is a double-wound relay, the spring 86 of which is permanently connected with the non-grounded battery lead 59, while the spring 87 is adapted to be shifted from the said spring 86 onto a spring 89 which, when the connector side switch passes to third position, is connected to ground. The connector side switch is, as usual, controlled by the private magnet 90, which side switch comprises the wipers 91, 92, 93 and 94. Said side switch, like the side switches of the selectors, has, of course, a first, second and third position. The said connector is, furthermore, equipped with the usual vertical magnet 95, the rotary magnet 96, the release magnet 97, and the ringer relay 98. In the connector, as is well known, both vertical and rotary magnets 95 and 96 are operated by the vertical line relay 81, while the rotary line relay 82 controls only the private magnet 90. Both line relays 81 and 82 are, however, adapted to conjointly control the release magnet 97. The differential relay 84 energizes whenever the vertical or rotary line relay 81 or 82 is energized alone; but if current passes through the windings 83 and 85 of the differential relay in series, it will not energize, but it will energize when current passes through both of said windings in multiple. The back-bridge relay 88, although double-wound, does not perform in the connector the functions of a differential relay, but is adapted to energize when the called subscriber answers, for the purpose of shifting the spring 87 from main to grounded battery in order to supply the calling subscriber with talking battery current. The connector is, furthermore, provided with a couple of off-normal springs 98[a]

and 99 through which the busy-signaling circuit is closed, which springs are controlled by the normal post arm 100 of the connector switch shaft, which latter is not shown but which, as is well known, carries the vertical and rotary line wipers 101 and 102 and the private wiper 103.

The selector F of the called line is, it will be understood, the same as the selector C of the calling subscriber, and the substation #1120 is the same as substation A.

In order that the invention may be more fully understood, a description of the mode of operation will now begiven.

Assuming that the subscriber at substation A wishes to call the subscriber at substation #1120, he removes his receiver 25 from the switch-hook 4 and then proceeds to operate the dial once for each digit of the number 1120. When the dial is operated in accordance with the first digit 1 the impulse wheel 9, through the medium of its vertical and rotary impulse teeth, operates to ground first the vertical line conductor 2 once and the rotary line conductor 3 once. When the dial is operated for the second digit 1 the line conductors 2 and 3 are again grounded once and once, respectively. For the third digit 2 the conductor 2 is grounded twice and the conductor 3 once, and for the last digit 0 the conductor 2 is grounded ten times and the conductor 3 once. The impulses corresponding to the first digit 1 are, of course, directed to the selector C. The impulse to the vertical line conductor 2 causes the vertical line relay 37 to be energized by a flow of current from the substation ground G' through the ground springs 19 and 20 to the ground post 14, thence to the vertical impulse spring 12, vertical line conductor 2, side switch wiper 43, first-position contact point 104 to the line relay 37, thence through said relay and through the bridge-cut-off relay springs 105 and 106 to the battery lead 59, and through battery B to ground G. The line relay 37 presses the line relay springs 107 and 108 into contact, whereby a flow of current is sent through the vertical magnet 48 from ground G^2, through the said springs 108 and 107, private magnet springs 71 and 72, vertical magnet 48 to the battery lead 59, and through battery B to ground G. In a manner well understood, the switch shaft is raised one step, whereby the shaft wipers 39, 40 and 41 are raised to the first bank level opposite the first trunk line thereof. The selector C being thus operated, the impulse to the rotary line conductor 3 causes the rotary line relay 38 to energize by a flow of current from ground G' to the ground post 14, and through the rotary impulse spring 13 to the rotary line conductor 3, thence through the side switch wiper 44, contact point 109 to the rotary line relay 38, thence through said relay and through the bridge-cut-off relay springs 110, 105 and 106 to the battery lead 59, and through battery B to ground G. The said line relay 38 operates to close connection between the springs 111 and 108, whereby a flow of current is sent through the private magnet 42 from ground G^2 through said springs 108 and 111, through said private magnet 42 to the battery lead 59, and through battery B to ground G. The private magnet being thus operated permits the side switch to trip to second position, at which time the side switch wiper 46 engages the grounded contact point 112, whereby a circuit is established through the rotary magnet 49 from ground G^3, through said rotary magnet to the battery lead 59, and through battery B to ground G. The rotary magnet then begins to rotate the shaft, which latter then carries the private wiper 41 onto the first contact of the first level of the private bank. If the trunk line leading from the first bank terminal of the first bank level is busy, the private wiper 41 will find the private contact grounded, since there is a selector similar to the selector C in connection with the first trunk line of the first level, the private side switch wiper of which selector, similar to the side switch wiper 45, is in third position and in engagement with a grounded contact point similar to the contact point 77. Evidently, then, the guarding potential is established at the private bank contact, through the described occupying selector, by way of the back-release relay of said selector, similar to the back-release relay 50. Therefore, as soon as the private wiper 41 engages the said grounded contact, an energizing circuit is established through the private magnet 42 that again energizes said private magnet and locks the side switch in second position in order to hold the energizing circuit for the rotary magnet 49 until after the shaft wipers have been carried beyond the last busy trunk line and into engagement with some idle trunk line. This energizing circuit for the private magnet extends from the grounded private bank contact through the private wiper 41, and through the back-release relay 50 to the side switch wiper 45, thence (since said side switch wiper is in second position) through the private magnet 42 to the battery lead 59, and through battery B to ground G. As soon as the private wiper 41 has been advanced by the rotary magnet 49 beyond the last busy or grounded private bank contact, the circuit through the private magnet 42 is again broken, at which time the side switch of the selector is permitted to pass to third position, at which instant the energizing circuit is broken through the rotary magnet 49, and the line conductors 2 and 3 are extended to the line wipers 39 and 40 as soon as the side switch wipers 43 and 44 engage the contact points 113 and 114. The line wipers 39 and 40 having previously engaged the trunk conductors 115 and 116, the subscriber is, therefore, directly connected with the second-selector D, to which selector the impulses corresponding to the second digit are directed for operating said selector, in the same manner that the selector C was operated. It will also be understood that as soon as the side switch wiper 45 passes to third position, into contact with the grounded contact point 77, a guarding potential is established at the private wiper 41 by way of the back-release relay 50 for protecting the seized line from interference, which guarding potential is, of course, communicated to the private bank contact engaged by the private wiper 41, and thence to all other private bank contacts connected in multiple therewith. It is assumed, of course, that the said trunk conductors 115 and 116, and also the third or trunk-release conductor 76, are the conductors of the first idle trunk line which the selector C has seized.

The ground impulse to the vertical line conductor 2 for the second digit 1 energizes the vertical line relay 57 by a flow of current from ground G' to the line conductor 2, to the side switch wiper 43, to the line wiper 39, side switch wiper 55, contact point 117, through said line relay 57 to the battery lead 59, and through bat-

tery B to ground G. The line relay 57, therefore, operates the vertical magnet 64, whereby the line wipers 118 and 119 and the private wiper 120 are brought opposite the first contacts of the first levels of their respective banks. When the rotary impulse comes over the rotary line conductor 3 the rotary line relay 58 is in turn energized by a flow of current from ground G′ to the conductor 3, side switch wiper 44, line wiper 40, side switch wiper 56, contact point 121 to the rotary line relay 58, and through said relay to battery lead 59, thence through battery B to ground G. The said rotary line relay 58, of course, operates the private magnet 66, which in turn operates the side switch from first to second position. When the side switch is thus tripped to second position, the circuit is closed through the rotary magnet 65, when the side switch wiper 122 engages the second-position grounded contact, whereby the shaft is rotated until an idle trunk line is found. It is to be noticed that if the first trunk line is busy, as was assumed in connection with the selector C, the first contact of the first level of the private bank will be connected to ground, there being, of course, some other selector similar to the selector D on the trunk line which is protected by the said first private bank contact. The connection to ground from the said bank contact will be the same as that established by the selector D when the side switch passes to third position and, therefore, when the side switch wiper 123 engages the contact point 78. This circuit is as follows: From the private wiper 120 through the back-release relay 68 to the side switch wiper 123, contact point 78, trunk-release conductor 76, back-release relay 50 of the selector C, side switch wiper 45, contact point 77 to ground G^4. It will be noticed, therefore, that the guarding potential for first-selector trunks as well as for second-selector trunks is provided from the first-selector ground terminal G^4; the guarding potential for the first-selector private wiper 41 being established through the back-release relay 50, and for the private wiper 120 through the back-release relays 50 and 68. Therefore, when the selector private wiper 120 is rotated onto the first contact of the first level of the private bank (which contact it is assumed is grounded, as explained), an energizing circuit is reëstablished through the private magnet 66 which maintains the side switch of the selector D in second position until the wipers are carried onto an idle trunk line, at which time the energizing circuit for the private magnet 66 breaks and the latter permits the side switch to pass to third position.

As soon as the side switch wipers 55 and 56 engage the contact points 124 and 125, the trunk conductors 115 and 116 are in turn placed in connection with the line wipers 118 and 119 and, therefore, with the trunk conductors 126 and 127 in engagement with which said wipers have stopped. Furthermore, when the side switch wiper 123 engages the contact point 78, the trunk-release conductor 76 is put in connection with the private wiper 120 through the back-release relay 68, thereby placing the said private wiper 120 in connection with ground G^4 at the selector C; and this connection establishes a guarding potential at the said private wiper 120, which is communicated to the engaged private bank contact and to all other private bank contacts in multiple therewith, whereby the trunk line the conductors 126 and 127 of which have been temporarily seized is protected from interference. Leading from the engaged private bank contact there is, of course, the third or trunk-release conductor 128 which, like the conductors 126 and 127, extends to the connector E. The subscriber's station having been thus placed in connection with the connector E, the impulses corresponding to the last two digits—namely 2 and 0—are directed to the connector E. The two ground impulses delivered to the vertical line conductor 2, of course, energize the vertical line relay 81 of the connector E and also the differential relay 84, the latter to no consequence for the time being. The circuit extends from the substation ground G′ to the conductor 2, to the trunk conductor 115 and to the trunk conductor 126, thence through the line relay 81, and through the winding 83 of the differential relay 84 to the battery lead 59, thence through battery B to ground G. Said relay by pressing the springs 129 and 130 into contact energizes the vertical magnet 95 by a flow of current from ground G^5 through the said springs 130 and 129, and through the springs 131 and 132 to the side switch wiper 94, contact point 133 to the vertical magnet 95, thence to the battery lead 59, and through battery B to ground G. The connector switch shaft is, therefore, raised one step each time that the line conductor 2 is grounded (twice in all), corresponding to the digit 2, whereby the wipers 101, 102 and 103 are raised opposite the first contact of the second level of their banks. The ground impulse delivered to the rotary line conductor 3, of course, energizes the rotary line relay 82, and incidentally the differential relay 84, by a flow of current from ground G′ to the line conductor 3, trunk conductor 116, trunk conductor 127 to the line relay 82, thence through the winding 85 of the differential relay 84, and through the springs 87 and 86 of the back-bridge relay 88 to the battery lead 59, thence through battery B to ground G. Said relay 82, by pressing the springs 134 and 130 into contact, energizes the private magnet 90 by a flow of current through ground G^5, through said springs 130 and 134 to the private magnet 90, thence through the back-bridge relay springs 87 and 86 to the battery lead 59, and through battery B to ground G. The connector side switch is, therefore, tripped to second position, and the side switch wiper 94 shifted onto the contact point 135, whereby the following impulses to the vertical line conductor 2, corresponding to the last digit 0, will, through the vertical line relay 81, effect to operate the rotary magnet 96. The ten impulses to the said conductor 2, of course, operate the line relay 81 ten times, which in turn operates the rotary magnet 96 ten times by sending a flow of current each time from ground G^5 to the side switch wiper 94, contact point 135, through the rotary magnet 96 to the battery lead 59, and through battery B to ground G. The shaft is, of course, rotated ten steps, whereby the wipers 101 and 102 are placed in contact with the normal conductors 136 and 137, and the private wiper 103 in contact with the private normal conductor 138. The last impulse to the rotary line conductor 3, of course, operates the rotary line relay 82 a second time, which latter in turn operates the private magnet 90 and trips the connector side switch to third position, thereby extending the trunk conductors 126 and 127 into electrical connection with the normal conductors 136 and 137 through the condensers 79 and 80.

Having thus established connection, the calling subscriber then presses his signaling button 32, which operates to ground the vertical line conductor 2 from ground G' through the ground springs 19 and 20 to the contact point 32^a, to the spring 31 and to the vertical line conductor 2. The vertical line relay 81 is, of course, again energized, and the differential relay 84 is also energized, as already explained. Said relays 81 and 84 then operate at the same time, the relay 81 to close the line relay springs 129 and 130, and the differential relay 84 to close the springs 138^a and 139, whereby, since the side switch wiper 94 is in third position and in engagement with the contact point 140, an energizing circuit is established for the ringer relay 98 from ground G^5 through the springs 130 and 129 to the side switch wiper 94, through the contact point 140, ringer relay 98, and through the springs 139 and 138^a to the battery lead 59, thence through battery B to ground G. Said relay 98 then operates to carry the springs 141 and 142 into engagement with the springs 143 and 144, whereby the ringer generator H is bridged across the line conductors 145 and 146 of the called substation for signaling the subscriber. If said subscriber does not answer, the subscriber at substation A hangs up his receiver and causes the release springs 34, 35 and 36 to be pressed into contact, whereby the line conductors 2 and 3 are grounded simultaneously from the substation ground G' to the release spring 36, and through the springs 35 and 34 to the said conductors 3 and 2. As a result the line relays 81 and 82 of the connector E are energized simultaneously, and the differential relay 84 is also energized. As a result the trunk-release springs 147 and 148 of the connector are pressed into contact, whereby the release magnet 97, in series with the back-release relay 68 of the selector D, and in series with the back-release relay 50 of the selector C, is energized, said back-release relays 68 and 50 energizing also. As soon as the release magnet 97 energizes, the connector side switch and switch shaft are restored, and the energizing circuit for the bridge-cut-off relay 149 is broken, said circuit being established as soon as the connector establishes connection with the selector F. The said energizing circuit is, of course, established from ground G^5 through the side switch wiper 93 (which is now in third position) to the private wiper 103, private normal 138, switch shaft spring 150, contact point 151 to the bridge-cut-off relay 149, and through said relay to the battery lead 59, thence through battery B to ground G. When said relay 149 energizes, the vertical and rotary line relays 152 and 153 of the selector F are disconnected from each other and from the battery lead 59. At the same time that the release magnet 97 of the connector restores the connector switch shaft and side switch, as stated, the back-release relay 68 of the selector D presses the release springs 154 and 155 into contact, whereby an energizing circuit is established through the release magnet 67 of the selector D from ground G^7 through the said springs 154 and 155, and through the release magnet 67 to the battery lead 59, thence through battery B to ground G. Said release magnet, upon energizing, attracts its armature and sets the releasing apparatus in readiness to restore the switch D as soon as the ground connections to the line conductors 2 and 3 are broken. Similarly, the back-release relay 50, upon energizing, presses the springs 156 and 157 into contact, whereby the release magnet 47 of the selector C is energized by a flow of current from ground G^8 through said springs 156 and 157, and through the release magnet 47 to the battery lead 59, thence through battery B to ground G. The release relay 50, of course, upon energizing, puts the releasing apparatus in readiness to restore the switch C, as has been described in connection with the switch D. As soon as the ground connection to the line conductors 2 and 3 is broken, the line relays 81 and 82 and the differential relay 84 at the connector E deënergize, whereby the trunk-release circuit that comprises the release magnet 97 of the connector, the back-release relay 68 of the selector D, and the back-release relay 50 of the selector C is broken. In this way the connector switch E is fully restored. The release magnet 67 of the selector D fully restores said switch D, and the release magnet 47 of the switch C likewise upon deënergizing fully restores said switch C. However, if the called subscriber does answer, as soon as he removes his receiver 158, the switch-hook rises and the primary circuit springs 159 and 160 close in contact, whereby a circuit is established for energizing the back-bridge double-wound relay 88 of the connector E. Said energizing circuit may be traced from the side switch ground G^6 at said connector to the side switch wiper 93, through the winding 161 of the back-bridge relay 88, through the ringer relay springs 162 and 142, side switch wiper 92, line wiper 102, normal conductor 137, line conductor 146, primary winding 163, transmitter 164, primary circuit springs 159 and 160, vertical line conductor 145, vertical normal conductor 136, line wiper 101, side switch wiper 91, winding 165 of the back-bridge relay 88, through the differential relay springs 166 and 138^a to the battery lead 59, and through battery B to ground G. The said relay 88, upon energizing, and as previously explained, shifts the spring 87 from the non-grounded battery spring 86 onto the spring 89, which spring, since the side switch wiper 93 is in third position, is connected to ground G^6. Therefore, the calling subscriber is provided with talking battery current which flows from ground G^6 through the said springs 89 and 87, winding 85 of the differential relay 84, rotary line relay 82, rotary trunk conductor 127, trunk conductor 116, rotary line conductor 3, through the primary winding 28 at the substation A and transmitter 29 back to the vertical line conductor 2, thence to the trunk conductor 115 and to the trunk conductor 126, passing thence to the vertical line relay 81 and winding 83 of the differential relay 84 to the battery lead 59, and through battery B to ground G. Of course, the line relays 81 and 82 of the connector energize, but the release of the switches is prevented, since the differential relay 84 does not energize. After the subscribers are through talking the calling subscriber may release by hanging up his receiver, at which time the line conductors 2 and 3 are grounded, as already explained. The vertical line relay 81 of the connector, being connected to main battery through the winding 83 of the differential relay 84, remains energized after such grounding; but the grounding of the rotary line conductor 3 first operates to effect a short-circuiting of the rotary line relay 82, whereby said relay is deënergized, and a short-circuiting of the winding 85 of

the differential relay 84, whereby the said differential relay is energized by the current in the winding 83. As a result the differential relay springs 166 and 138[a] are separated, and therefore the double-wound back-bridge relay 88 deënergizes, which latter then operates to restore the springs 86 and 87 into contact, thus restoring the rotary line relay 82 and the winding 85 of the differential relay 84 to normal connection with the battery lead 59. As a result the rotary line relay 82 is reënergized, and the winging 85 of the differential relay 84 carries current in such direction as to assist the winding 83 in its operation. As a result the vertical and rotary line relays 81 and 82 and the differential relay 83 are energized simultaneously. The result of this condition is that the switches are all released, as described, at the instant that the ground is removed from the line conductors 2 and 3.

It will be understood that the calling lines as well as called lines are protected by guarding potentials. The calling line #5220, for example, is protected at the instant that the switch shaft, upon rising, permits the off-normal spring 61 to engage the contact point 62, at which time the private normal conductor 53 is placed in connection with ground G[9] in order to prevent any calling subscriber from molesting the substation A after the selector C has operated as described. On the other hand, a called line is protected by a guarding potential established by the connector that calls. For example, the line #1120 is protected by a guarding potential which is established by the private wiper 103 when the side switch wiper 93 engages the side switch contact point that is connected with ground G[8]. This guarding potential is, of course, communicated to the private bank contact which is engaged by the said private wiper 103, which guarding potential is, furthermore, used for energizing the bridge-cut-off relay 149 of the selector of the called line, as already explained. This guarding potential is also communicated to all contact points in multiple with the contact that is engaged by the private wiper 103. If the connector E attempts to connect with a busy line the private wiper 103 will meet a grounded contact point while the side switch wiper 93 is in second position, and while the private magnet 90 is energized, and, therefore, while the springs 167 and 168 are in contact. A release circuit is therefore established through the release magnet 97 from the said grounded private bank contact which restores the connector switch. The calling subscriber will then, upon finding out that the line is busy, ground the line conductors 2 and 3 as before, which will operate to release the switches, as in the case described where the called subscriber did not answer. It will be understood, of course, that this release occurs at the instant that the subscriber sends in the last impulse to the rotary line conductor 3.

From the foregoing it will be seen that I advantageously connect the release relays of all the selectors, or automatic switches, directly in series with the release magnet of the connector, in one long trunk-release circuit extending through all of the switches and including the battery. The release relays of the selectors each have a local release circuit to control, but by energizing all of the release relays simultaneously, the release thereby effected between calling and called telephone lines is practically instantaneous, as one selector, or automatic switch, does not wait for the other in releasing. It is obvious that the resistance of the various relays and magnets can be changed or varied in accordance with different requirements. The battery is preferably of fifty volts, and with the system as shown I find that good results are obtained when the relays and magnets are given the following resistances: The release magnet 97 of the connector sixty ohms; the release magnet 47 of the selector C and the release magnet 67 of the selector D sixty ohms each; the back-release relay 50 of the selector C and the back-release relay 68 of the selector D one-half ohm each. It will be understood, of course, that all of the relays, switches and other circuit-closing devices, or impulse-transmitting devices, are suitably adjusted to close the different circuits for the proper length of time, or to send the required electrical impulses, so as to obtain the desired results and the described mode of operation.

From the description that has preceded it will be evident that the calling subscriber may release the switches even before he has completed a call. He may release the switches at any time, for example, while the side switch of the selector C is in third position and before the side switch of the selector D has passed to third position. In that case, when the line conductors 2 and 3 are grounded simultaneously, the line relays 57 and 58 of the selector D energize simultaneously, carrying the springs 74 and 75 into contact, and thus establishing a release circuit comprising the release magnet 67 of the selector D and the back-release relay 50 of the selector C. The current in this release circuit will flow from ground G[4] at the selector C through the back-release relay 50, trunk-release conductor 76, through the springs 75 and 74 to the release magnet 67, thence to the battery lead 59, and through battery B to ground G. Of course, the release magnet 67 will at once energize, and also the back-release relay 50, which will in turn cause the release magnet 47 to energize. Both release magnets 47 and 67 will remain in readiness to release the switches as soon as the ground is removed from the line conductors 2 and 3, as is well understood. At that instant the relays 57 and 58 will deënergize, destroying the energizing circuits for the magnet 67 and the release relay 50, which latter (namely the release relay 50), upon deënergizing, in turn breaks the energizing circuit of the release magnet 47, thus bringing about the release.

What I claim as my invention is:—

1. In a telephone exchange system, the combination of a calling telephone line, a called telephone line, a connector for completing connection with the called line, trunk lines and a plurality of trunking switches for extending connection from the calling line to the said connector, a grounded trunk-release circuit suitably controlled at the connector and extending through and including all of the said automatic switches in series, and a battery for energizing said release circuit.

2. In a telephone exchange system, a plurality of selectors and a connector, each selector provided with a release relay, said connector provided with a release magnet, and a trunk-release circuit including said magnet and relays in series with each other, together with a source of current for energizing said magnet and relays.

3. In a telephone exchange system, the combination of a first-selector, a second-selector, a connector, a trunk-release circuit extending from the connector to the said selectors, a talking circuit excluding said release circuit, electromagnets for said connector and selectors, said

electromagnets included in series in said release circuit, release mechanism controlled by said electromagnets, and a source of current for inclusion in said release circuit to energize said electromagnets.

4. In a telephone exchange system, the combination of a calling telephone line, a called telephone line, an automatic connector for completing the connection directly with the called line, trunk lines and a plurality of trunking switches for extending connection from the calling line to the said connector, switch mechanism by which the calling subscriber controls the operations of said connector and trunking switches, one of said trunking switches being individual to the calling telephone line, a trunk-release circuit controlled at the connector and extending through all of said trunking switches, and a source of current for energizing said release circuit.

5. In a telephone exchange system, the combination of an automatic switch, a telephone line, means including a plurality of switches for extending connection from the said telephone line to the said automatic switch, a trunk-release circuit controlled at the automatic switch and including the said switches in series with each other, and a source of current for energizing said circuit to release the automatic switch and switches.

6. In a telephone exchange system, the combination of a calling telephone line, a called telephone line, a connector for completing connection with the called line, trunk lines and a plurality of trunking switches for extending connection from the calling line to the said connector, a grounded trunk-release circuit suitably controlled at the connector and extending through and including all of the said automatic switches in series, a battery for energizing said release circuit, and subscribers' telephone transmitters receiving talking current from said battery.

7. In a telephone exchange system, a plurality of selectors and a connector, each selector provided with a release relay, said connector provided with a release magnet, a trunk-release circuit including said magnet and relays in series with each other, together with a source of current for energizing said magnet and relays, and a subscriber's telephone transmitter receiving talking current from said source.

8. In a telephone exchange system, the combination of a first-selector, a second-selector, a connector, a trunk release circuit extending from the connector to the said selectors, a talking circuit excluding said release circuit, electromagnets for said connector and selectors, said electromagnets included in series in said release circuit, release mechanism controlled by said electromagnets, a source of current for inclusion in said release circuit to energize said electromagnets, and a subscriber's telephone transmitter receiving talking current from said source.

9. In a telephone exchange system, the combination of a calling telephone line, a called telephone line, an automatic connector for completing the connection directly with the called line, trunk lines and a plurality of trunking switches for extending connection from the calling line to the said connector, switch mechanism by which the calling subscriber controls the operations of said connector and trunking switches, one of said trunking switches being individual to the calling telephone line, a trunk-release circuit controlled at the connector and extending through all of said trunking switches, a source of current for energizing said release circuit, and subscribers' telephone transmitters receiving talking current from said source.

10. In a telephone exchange system, the combination of an automatic switch, a telephone line, means including a plurality of switches for extending connection from the said telephone line to the said automatic switch, a trunk-release circuit controlled at the automatic switch and including the switches in series with each other, a source of current for energizing said circuit to release the automatic switch and switches, and a subscriber's telephone transmitter receiving talking current from said source.

11. The improved serial trunk-release for a plurality of trunk selectors or automatic switches, substantially as shown and described.

Signed by me at Chicago, Cook county, Illinois, this 1st day of February, 1907.

EDWARD D. FALES.

Witnesses:
F. H. DRURY,
JENNIE NORBY.