H. L. FISH.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED MAY 19, 1906. RENEWED DEC. 31, 1917.

1,274,357. Patented July 30, 1918.

3 SHEETS—SHEET 1.

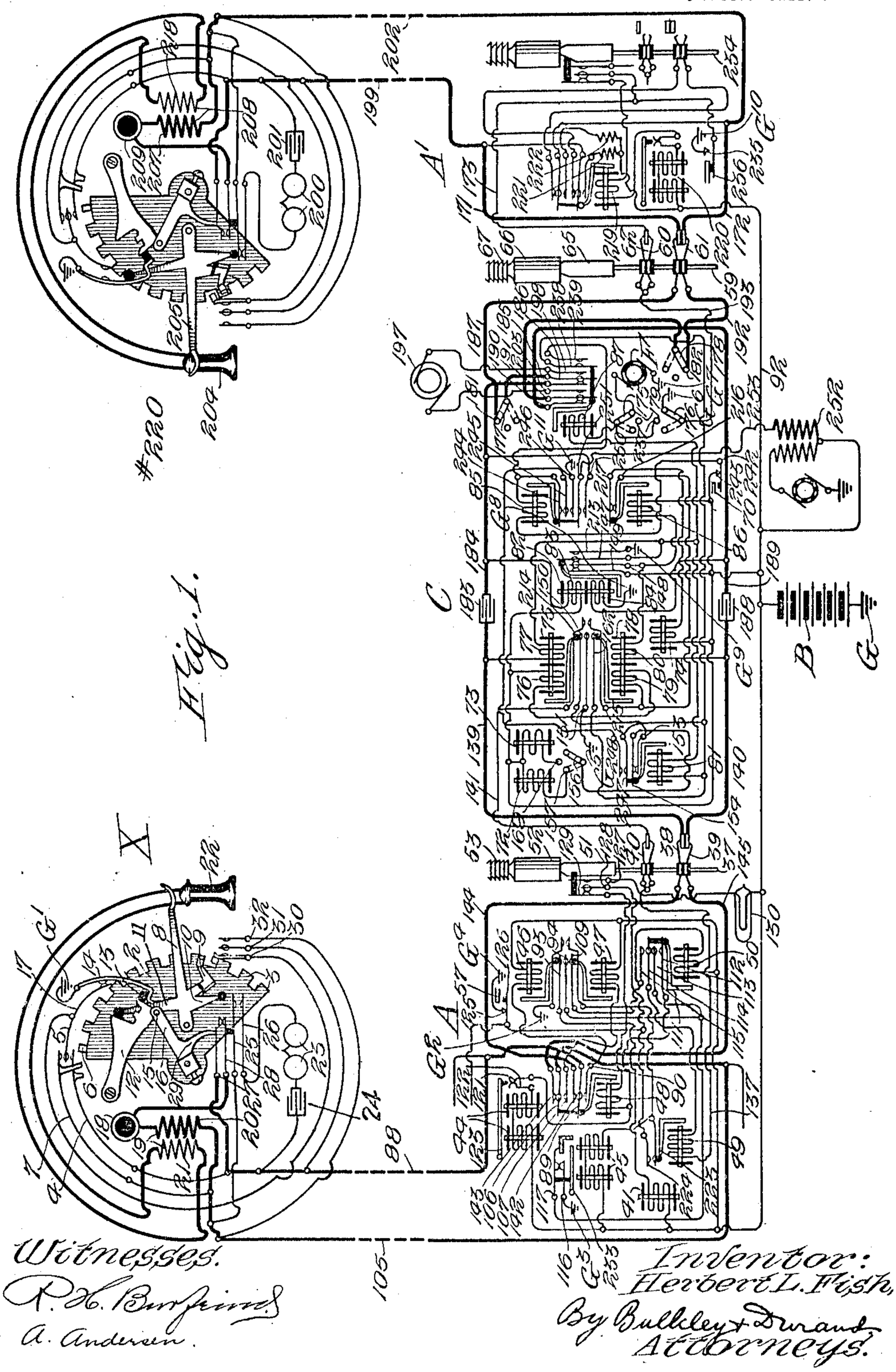

Fig. 1.

Witnesses.
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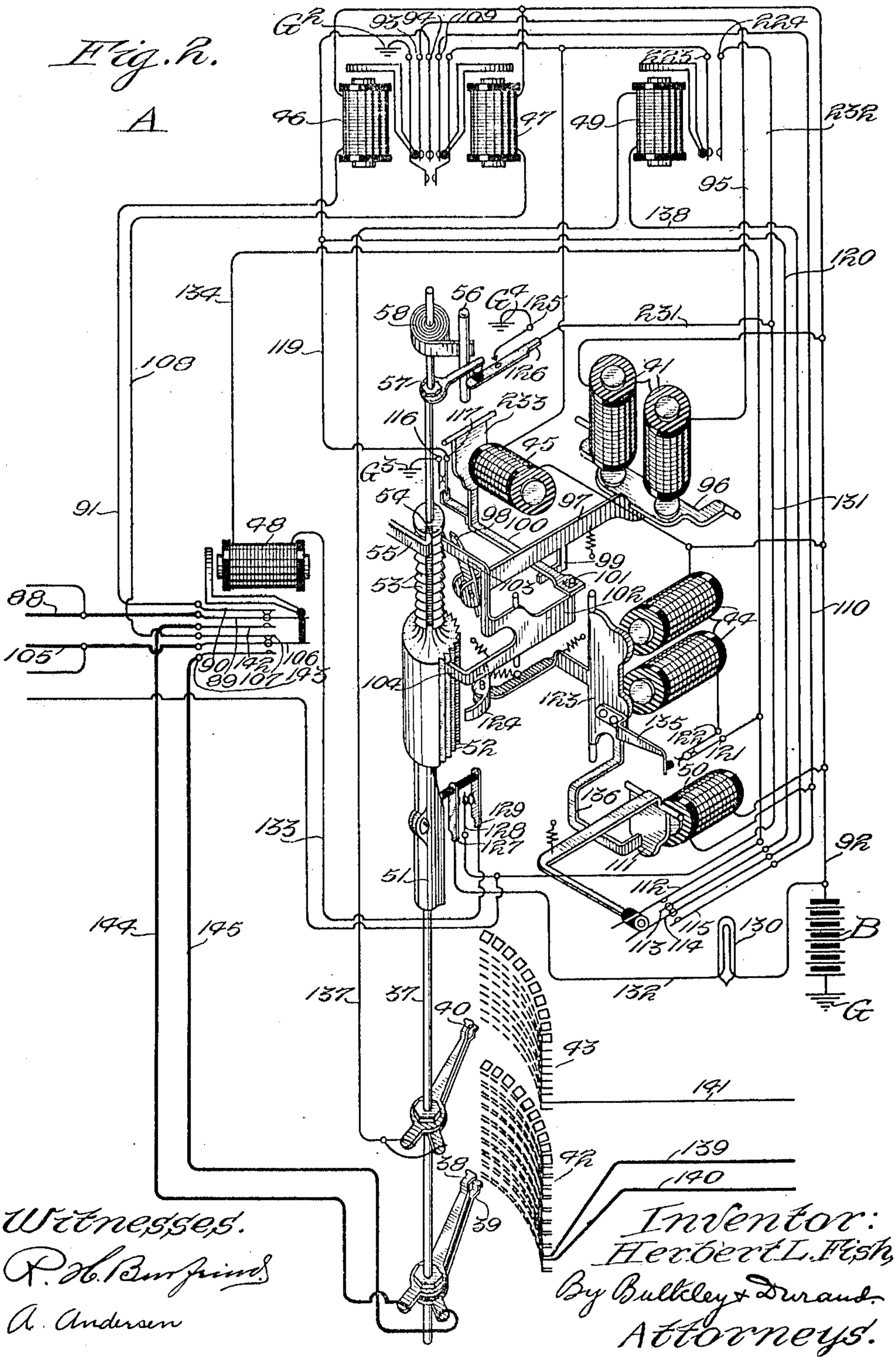
Fig. 2.



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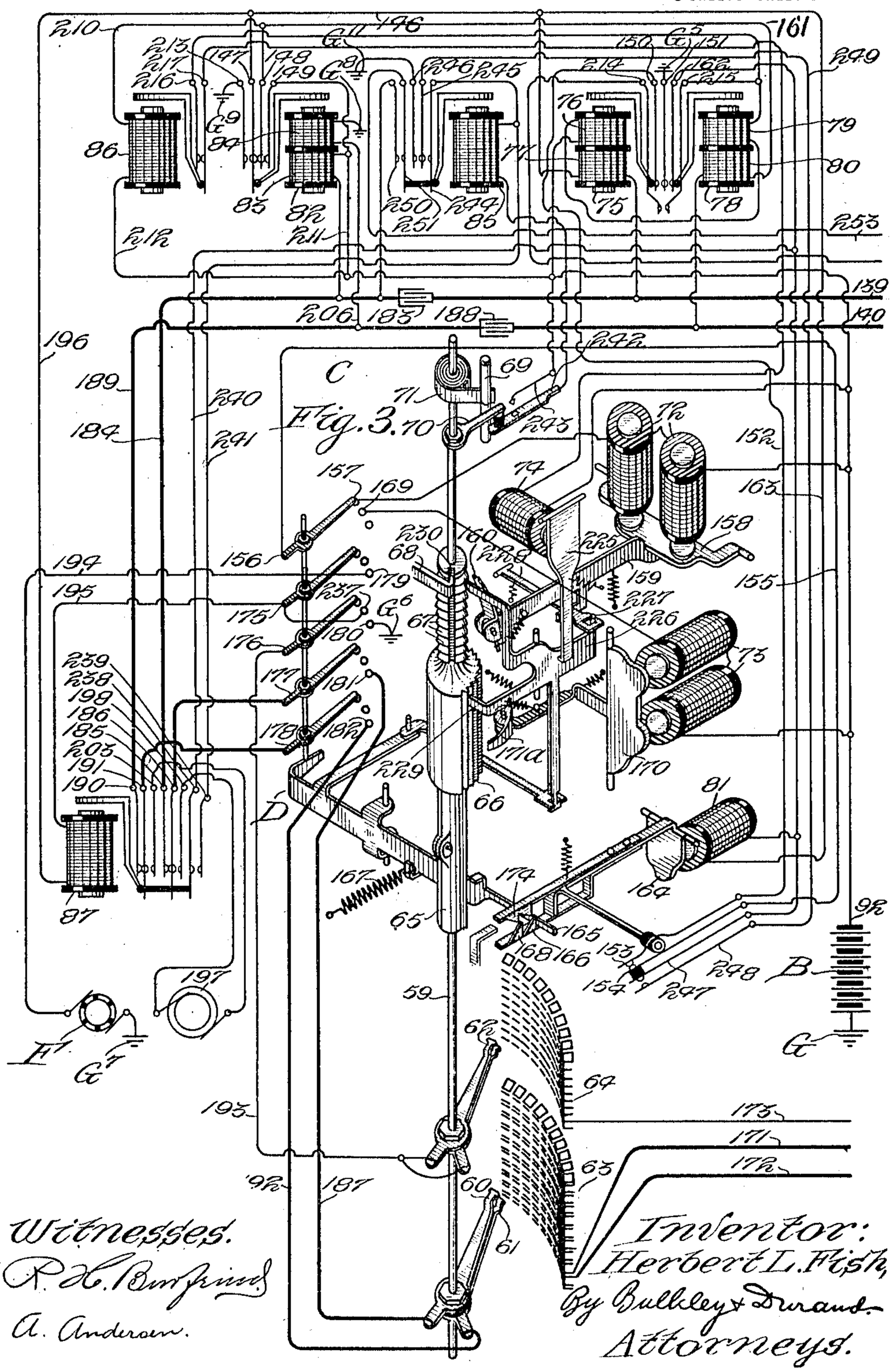

UNITED STATES PATENT OFFICE.

HERBERT L. FISH, OF BAKERSFIELD, CALIFORNIA, ASSIGNOR, BY MESNE ASSIGNMENTS, TO AUTOMATIC ELECTRIC COMPANY, A CORPORATION OF ILLINOIS.

AUTOMATIC TELEPHONE-EXCHANGE SYSTEM.

1,274,357. Specification of Letters Patent. Patented July 30, 1918.

Application filed May 19, 1906, Serial No. 317,697. Renewed December 31, 1917. Serial No. 209,796.

To all whom it may concern:

Be it known that I, HERBERT L. FISH, a citizen of the United States of America, and resident of Bakersfield, Kern county, California, have invented a certain new and useful Improvement in Automatic Telephone-Exchange Systems, of which the following is a specification.

My invention relates to telephone systems in general, but more particularly to automatic or semi-automatic telephone exchange systems, and especially to telephone systems in which electric current for both talking and switching purposes is supplied from a common battery or other centralized source of supply.

As will hereinafter more fully appear, my invention is in the nature of an improvement on the systems described in certain copending applications as follows: Serial No. 265,955, filed June 19, 1905, by Wilson L. Campbell, for improvement in automatic switching and telephone systems; Serial No. 258,508, filed May 2, 1905, by Talbot G. Martin, for improvement in automatic common battery telephone systems; Serial No. 312,156, filed April 17, 1906, by Talbot G. Martin, for improvement in telephone exchange systems; and Serial No. 292,911, filed December 22, 1905, by Herbert L. Fish, for improvement in common battery automatic telephone system and apparatus.

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

Special objects of my invention are the provision of an improved common battery connector; the provision of improved means and circuits for releasing the switches employed for establishing connection between subscribers' lines; the provision of improved means for preventing a third subscriber from releasing the switches temporarily employed between calling and called subscribers; the provision of improved circuits for supplying talking current to the substations of calling and called subscribers; the provision of improved means and circuits for giving a calling subscriber a busy-signal if the called line is busy; the provision of improved circuits for operating the automatic switching machinery by which a calling subscriber connects his line with that of the called subscriber; and the provision of certain details and combinations and features of improvement tending to increase the general efficiency and serviceability of a telephone exchange system of this particular character.

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

In the accompanying drawings, Figure 1 is a diagrammatic representation of a calling subscriber's station X connected with a called subscriber's station #220, said connection being maintained through the medium of certain central office switching apparatus comprising the first-selector A allotted to the calling subscriber's line, and a central battery B for providing all necessary current, an improved connector C, and a first-selector A^1 allotted to the called subscriber's line.

Fig. 2 is a diagrammatic perspective view of the first-selector A.

Fig. 3 is a similar view of the connector C.

It will be understood that the first-selectors A and A^1 are substantially the same.

In detail the apparatus is constructed as follows: The subscriber's station may be of any suitable, known or approved type. Said substation is provided with the well-known impulse-wheel 2 which has the usual vertical impulse-teeth 3 that are adapted to operate the vertical impulse-spring 4 in such manner that the said spring may be pressed intermittently against the ground-post 5 for the purpose of sending ground impulses to the vertical-line-conductor of the subscriber's line. Furthermore, the said impulse-wheel carries a rotary-impulse-tooth 6 which, after the vertical impulses are sent, so acts upon the rotary impulse-finger 7 that a ground impulse is then sent to the rotary side of the subscriber's line. The substation is provided, of course, with a suitable switch-hook 8. Said switch-hook has a number of cams 9, 10 and 11 for controlling certain appa-

ratus and circuits of the substation. The cam-arm 11 controls the so-called locking-cam 12 in such manner that when the switch-hook rises, and before the dial (which is not shown) is rotated, the insulating tip 13 upon the end of said locking-cam 12 (that normally rests in the position shown at substation #220) is driven to the inner edge of the angled section provided at the end of the so-called ground-spring 14, whereby when the dial is pulled down by the calling subscriber the pin 15 upon the end of the locking-dog 16 is able to pass beneath the said locking-cam to raise the said cam a trifle farther and thereby cause the said insulating tip 13 to fall behind the said angled section of the ground-spring 14, permitting said spring, therefore, to make electric contact with a ground-spring 17. The engagement of said ground-springs 14 and 17, upon the operation described, places the ground-post 5 in connection with the substation ground, whereby when the subscriber releases the dial after pulling it down as described, the vertical impulse-teeth 3 will then act first upon the vertical impulse-finger 4, and after that the rotary impulse-tooth 6 acts upon the rotary impulse-finger 7, as previously stated. The subscriber is, of course, provided with a transmitter 18 and an induction-coil 19, the primary winding 20 of which is connected (when the switch-hook is raised) in series with the transmitter 18 and across the subscriber's line; and the secondary winding 21 is connected in a local closed circuit in series with the receiver 22. Furthermore, the substation is provided with a ringer 23 that is normally bridged across the subscriber's line, when the switch-hook is down, in series with a condenser 24. When the switch-hook is down the cam-arm 10 maintains the switch-springs 25 and 26 in contact, whereby the said ringer is maintained across the line; but the spring 25 being depressed, two other springs 27 and 28 are kept normally separated, which, when the switch-hook rises, are normally closed while the said springs 25 and 26 spring apart. It will be noticed that the said springs 27 and 28 control the connection between the two conductors of the subscriber's line through the aforesaid transmitter 18, and through the primary winding 20 of the induction-coil 19. Even after the switch-hook is raised, since the finger 29 of the cam-dog 16 controls the engagement of the springs 27 and 28, and since the said cam-dog rotates in unison with the dial, and as long as the said dial is out of normal position, the springs 27 and 28 and, therefore, the subscriber's line-conductors are temporarily maintained apart. The means whereby the subscriber may release the central office switching apparatus, after said apparatus is once disturbed, comprises three release-springs 30, 31 and 32 so controlled by the cam-arm 9 that when the switch-hook descends the said springs are pressed into contact, whereby both sides of the subscriber's line are grounded simultaneously.

The first-selector A is of a well-known type. Said selector is provided with a switch-shaft 37 for carrying the line-wipers 38 and 39 and the private-wiper 40. Said shaft is operated vertically by the vertical-magnet 41 for raising the said wipers to any desired row or level of the line and private banks 42 and 43, respectively. Being raised, the shaft is rotated by the rotary-magnet 44. The release-magnet 45 is employed for restoring the switch after it has been operated. The vertical and rotary line-relays 46 and 47, the line-switching-relay 48, back-release-relay 49, and private-magnet 50 are for controlling said vertical, rotary and release magnets. The switch-shaft has, in addition to the details already described, the usual cam 51, the longitudinal teeth 52 for rotating the switch, and the circular teeth 53 for raising it. Associated with said circular teeth is the channel 54 normally occupied by the shaft-rest 55. The switch-shaft is maintained in normal position by the normal-post 56 and the normal-post-arm 57, against which post the said arm 57 is retained by the spring 58.

The connector C is also of a well-known type, and is structurally similar to the selector, but the circuits are quite different. Said connector like the selector is provided with a switch-shaft 59 and wipers 60, 61 and 62, to which latter are allotted the line and private banks 63 and 64, respectively. There is also the shaft-cam 65, the longitudinal teeth 66, the circular teeth 67, the shaft-rest 68, normal-post 69, normal-post-arm 70 and the coil-spring 71. Furthermore, the switch is provided with the usual vertical-magnet 72, the rotary-magnet 73 and the release-magnet 74. In addition, the connector has a number of auxiliary relays as follows: The vertical-line-relay 75 which is provided with two windings 76 and 77, the rotary-line-relay 78 which is also provided with two windings 79 and 80, the private-magnet 81, the back-bridge-relay 82 with two windings 83 and 84, the busy-lock-out-relay 85, the release-relay 86, and the ringer-relay 87. The said relays control circuits which will hereinafter be set forth.

The operations by which the subscriber at the calling station X establishes connection with the called subscriber #220 are as follows: He (the calling subscriber) removes his receiver from the switch-hook and then proceeds to operate the dial twice for the digits 2 and once for the digit 0. As soon as the dial is drawn down for the first digit 2 connection is established from the ground terminal G of battery B to the ground-post

5 by way of the ground-springs 14 and 17, when said springs come into contact in the manner described. As the impulse-wheel 2 returns to normal position, the vertical impulse-finger 4 is pressed against the said ground-post 5 twice in succession, thereby twice energizing the vertical-line-relay 46 of the first-selector A. Each time that the said relay is energized the circuit is closed from ground G^1 through the ground-springs 14 and 17 to the ground-post 5, thence to the vertical impulse-spring 4, vertical-line-conductor 88, line-switching-relay springs 89 and 90, conductor 91, vertical-line-relay 46 to the battery-lead 92, and through battery B to ground G. When the vertical-line-relay is energized the line-relay spring 93 is pressed onto the ground-spring 94 and a circuit is established each time through the vertical-magnet 41 for energizing said vertical-magnet. The current through the said vertical-magnet passes in its course from ground G^3 through the said springs 94 and 93 to the conductor 95, thence through the vertical-magnet 41 to the battery-lead 92, thence through battery B to ground G. Each time that the vertical-magnet 41 is energized it attracts the vertical-armature 96, which latter, through the medium of the vertical-arm 97, causes the vertical-pawl 98 to engage the circular teeth 53 and thereby raise the switch-shaft 37. It will be understood that at the first operation of the vertical-arm 97 the L-shaped piece 99 upon the under side of said vertical-arm lifts the release-link 100 from the lug 101 of the double-dog 102, whereby the said double-dog is caused to rotate so that the vertical and rotary dogs 103 and 104 are drawn against the circular and longitudinal teeth 53 and 52, respectively. Said vertical-dog 103 operates to hold the shaft at each vertical step in order that it may be raised in a well-known manner. When the shaft is raised two steps for reasons stated, the line and private wipers 38, 39 and 40 are raised to the second level of the banks 42 and 43, respectively, retaining the line-wipers opposite the first contact of the second level of the said line-bank 42, and the private-wiper 40 opposite the first contact of the second level of the private-bank 43, ready to be rotated into engagement with the contacts of said banks. The shaft being thus raised, and when the lug 6 of the impulse-wheel 2 engages and presses the rotary impulse-finger 7 against the ground-post 5, the rotary-line-relay 47 is then energized in turn. The circuit over which the energizing current passes may be traced from ground G^1 to the ground-post 5, thence to the rotary impulse-finger 7, rotary-line-conductor 105, line-switching-relay springs 106 and 107, conductor 108, vertical-line-relay 46 to the battery-lead 92, thence through battery B to ground G. When the said rotary-line-relay 47 becomes magnetized the spring 109 is pressed onto the ground-spring 94, and as a result the private-magnet 50 is also energized. The path of the current may be traced from ground G^3 through the springs 94 and 109 to the conductor 110, thence to the private-magnet 50 and battery-lead 92, and through battery B to ground G. As soon as the private-magnet 50 attracts its armature 111 the private-springs 112 and 113 that are normally open close into contact, the springs 113 and 114 that are normally engaged are forced apart, and the springs 114 and 115 are closed into contact. At the instant that the springs 112 and 113 come into contact the rotary-magnet 44 is energized through the following circuit: from ground G^3 through the springs 116 and 117 on the release-armature 233 to the conductors 119 and 120, private-springs 113 and 112 to the interrupter-springs 121 and 122, thence through the rotary-magnet 44 to the battery-lead 92 and through battery B to ground G. When the rotary-magnet 44 is magnetized it attracts its armature 123, whereby a number of operations are performed simultaneously. The rotary-pawl 124 is thrust into engagement with the first one of the longitudinal teeth 52 so that the shaft 37 is rotated one step. It should be stated that as soon as the switch-shaft 37 is raised the first step the switch-shaft springs 125 and 126 close into contact, the former of said springs being connected to ground G^4. As soon as the switch-shaft 37 is rotated, as described, the springs 127 and 128 controlled by the cam 51 separate and the spring 128 engages instead the spring 129. The object in maintaining the springs 127 and 128 normally closed, as described, is to provide a means whereby a lamp signal 130 is lighted whenever the switch-shaft 37 is raised, and whereby the said lamp signal will remain lighted as long as the switch-shaft 37 is raised but not rotated. The circuit for energizing said lamp 130 may be traced from ground G^4 through the switch-shaft off-normal springs 125 and 126, conductor 231 to the spring 128, thence through the spring 127, conductor 132 to the lamp 130, thence through battery B to ground G. In this way the switch attendant is always notified if a selector is off normal. As soon as the springs 127 and 128 come into contact, after the shaft 37 is rotated, the line-switching-relay 48 is short-circuited over the following circuit: from ground G^4 to the off-normal springs 125 and 126, conductor 231 to the cam-spring 128, thence to the spring 129, conductor 133 and line-switching-relay 48 to the conductor 134, thence through the private-springs 112 and 113 and conductor 120, release armature springs 117 and 116 to ground G^3. Assuming that the first nine trunks leading from the second level of the

line-bank 42 are busy the first nine contacts of the second level of the private-bank 43 will be connected to ground. Therefore, at the first step of the shaft 37 the private-wiper 40 engages a grounded contact. As the rotary-armature 123 strikes the rotary-magnet 44 the interrupter-finger 135 separates the interrupter-springs 121 and 122 and destroys the energizing circuit through the said rotary-magnet. By the time that this occurs the original energizing circuit for the private-magnet 50 has also been destroyed, since the rotary-line-relay 47 is energized only by a momentary impulse from the calling subscriber's station. But the rotary-armature-finger 136 prevents the private-armature 111 from regaining its normal position before the rotary-magnet 44 has completed its work. In the meantime, since the private-wiper 40 finds the first contact of the second level of the private-bank 43 grounded, a new energizing circuit is provided through the private-magnet 50. The current in this energizing circuit flows from ground G of the battery B and through whatever switch is occupying the first trunk, and through the bank-multipling conductors to the said ground private-contact, thence by way of the private-wiper 40, conductor 137, back-release-relay 49, conductor 138, private-springs 114 and 115 to the private-magnet 50, thence to the battery-lead 92 and through battery B to ground G. This circuit having once been established, it is then maintained as long as the private-wiper 40 is rotated into engagement with grounded private-contacts. Therefore, the original energizing circuit through the rotary-magnet 44 is not destroyed until after the said private-magnet is deënergized, as will be described. Therefore, when the interrupter-finger 135 destroys the energizing circuit through the rotary-magnet 44, as soon as the rotary-armature returns to normal position, the energizing circuit through the rotary-magnet is again established in order that the shaft 37 may be advanced another step. These operations continue until the private-wiper finds a non-grounded contact. The assumption being that only the tenth trunk is idle the wipers will be rotated into engagement with the tenth trunk. The vertical-wiper 38, therefore, will engage the vertical-trunk-conductor 139 and the rotary-wiper 39 will engage the rotary-trunk-conductor 140. At the same time the private-wiper 40 will establish connection with a trunk-release-conductor 141. The energizing circuit through the private-magnet 50 is thus destroyed so that the private-armature 111 is restored after the last operation of the rotary-armature 123. The private-springs 112 and 113 will, of course, be again separated so that the short-circuit across the line-switching-relay 48 is removed, and the said relay then instantly energized over the following circuit: from ground G^4 over the circuit as previously traced to the said line-switching-relay 48, thence over the conductor 134 and through the interrupter-springs 121 and 122 and through the rotary-magnet 44 to the battery-lead 92 and from battery B to ground G. In this circuit the current that flows is too small to magnetize the rotary-magnet 44 since the said line-switching relay 48 is of a very high resistance. For the same reason the back-bridge-relay 49 is not energized through the circuit previously described in series with the private-magnet 50. As soon as the line-switching-relay 48 pulls up, as just described, the line-switching-relay springs 89 and 106 are separated from the line-switching-relay springs 90 and 107 and pressed instead into contact with the springs 142 and 143. As a result the vertical and rotary line-relays 46 and 47 are cut off from the subscriber's line-conductors 88 and 105 and the said conductors are put in connection with the trunk-conductors 139 and 140, respectively, as follows: from the conductor 88 through the line-switching-relay springs 89 and 142, conductor 144, vertical-wiper 38 to the vertical-trunk-conductor 139, the rotary-line-conductor 105 to the line-switching-relay springs 106 and 143, conductor 145 and rotary-line-wiper 39 to the rotary-trunk-conductor 140. The subscriber's station is, therefore, put in connection with the connector C, as shown in Fig. 1. The subscriber upon operating his dial for the second digit grounds the vertical-line-conductor 88 first twice, and as a result the vertical-line-relay 75 is energized over the following circuit: from ground G^1 to the ground-post 5, thence over the vertical impulse-finger 4 to the vertical-line-conductor 88, line-switching-relay springs 89 and 142, conductor 144, vertical-line-wiper 38, vertical-trunk-conductor 139, vertical-line-relay winding 77, conductor 146, back-bridge-relay springs 147, 148 and 149 to the battery-lead 92 and through battery B to ground G. When the said relay 75 is energized the spring 150 is pressed onto the ground-spring 151, and as a result the vertical-magnet 72 is energized by a flow of current from ground G^5, through the said springs 151 and 150, conductor 152, private-springs 153 and 154, conductor 155, side-switch-wiper 156, contact-point 157, vertical-magnet 72 to the battery-lead 92, and through battery B to ground G. The said vertical-magnet then attracts the vertical-armature 158 and through the medium of the vertical-arm 159 causes the vertical-pawl 160 to engage the circular teeth 67, raising the shaft 59 two steps. The shaft being thus raised, the line-wipers 60 and 61 and the private-wiper 62 are raised to the second level opposite the first contact of the second level

of the line and private banks 63 and 64, respectively, in readiness to be rotated into engagement with the contacts of said banks. When the rotary-line-conductor 105 is grounded, the rotary-line-relay 78 of the connector C is energized in turn, and the current that passes through said relay flows over the following circuit: from ground G^1 to the ground-post 5, thence over the rotary impulse-finger 7 to the rotary-line-conductor 105, thence to the line-switching-relay springs 106 and 143 of the first-selector A to the conductor 145, rotary-line-wiper 39, rotary-trunk-conductor 140, winding 80 of the rotary-line-relay 78, conductor 161, back-bridge-relay springs 148 and 149 to the battery-lead 92, and through battery B to ground G. When the said rotary-line-relay becomes magnetized, the spring 162 is pressed onto the ground-spring 151, and as a result the private-magnet 81 is magnetized. The current through the said private-magnet may be traced from ground G^5 to the springs 151 and 162, private-magnet 81, conductor 163, back-bridge-relay springs 147, 148 and 149 to the battery-lead 92, and through battery B to ground G. When the private-magnet attracts its armature 164 the escapement-finger 165 of the side-switch D clears the escapement-tooth 166, and when the armature returns to normal position the retracting-spring 167 draws the side-switch into second position, with the said escapement-finger 165 resting between the teeth 166 and 168. After the side-switch D has passed to second position the subscriber operates his dial for the last digit of the number 220, and as a result the vertical-line-conductor 88 is grounded ten times. The vertical-line-relay 75 is again energized over the same circuit ten times, but instead of the vertical-magnet 72 being operated as a result the rotary-magnet 73 is energized. The change is due to the passage of the side-switch-wiper 156 onto the contact-point 169 after having left the contact-point 157. The rotary-magnet 73 is therefore energized ten times, the current flowing from ground G^5 to the side-switch-wiper 156, as in the previous case, but thence it passes onto the contact-point 169, through the rotary-magnet 73 to the battery-lead 92, and through battery B to ground G. The rotary-armature 170 is attracted ten times, so that the rotary-pawl 171^a by engaging the longitudinal teeth 66 rotates the shaft 59 ten steps, carrying the line-wipers 60 and 61 into engagement with the vertical and rotary normal-conductors 171 and 172, respectively, and the private-wiper 62 into engagement with the private-normal-conductor 173. As soon as the rotary-line-conductor 105 is grounded for the last time the rotary-line-relay 78 is again energized once so that the private-magnet 81 is energized in turn once more. The side-switch D, as soon as the escapement-finger 165 clears the escapement-teeth 168 and 174, is drawn into third position by the retracting-spring 167. The side-switch-wipers 175, 176, 177 and 178 then pass into engagement with the contact-points 179, 180, 181 and 182. When the side-switch-wipers 177 and 178 engage the contact-points 181 and 182 the subscriber's extended line-conductors 139 and 140 are placed in connection with the normal-conductors 171 and 172, respectively. The circuits are as follows: from the conductor 139, through the condenser 183, conductor 184, ringer-relay springs 185 and 186, side-switch-wiper 177, contact-point 181, conductor 187, vertical-line-wiper 60 to the vertical-normal-conductor 171, then from the rotary-trunk-conductor 140 through the condenser 188, conductor 189, ringer-relay springs 190 and 191, side-switch-wiper 178, contact-point 182, conductor 192 to the rotary-line-wiper 61, thence to the rotary-normal-conductor 172. As soon as the side-switch-wiper 176 engages the grounded contact-point 180 a guarding potential is established at the private-wiper 62, whereby no other subscriber may be able to call in upon the seized line. The circuit over which said potential is established is as follows: from ground G^6 to the contact-point 180, thence to the side-switch-wiper 176, conductor 193 and private-wiper 62 to the tenth contact of the second level of the private-bank 64. Not only is the said guarding potential established but an energizing current is sent through the ringer-relay 87 from the ground G^7 through a circuit interrupter F, conductor 194 to the contact-point 179, thence through the side-switch-wiper 175, conductor 195, ringer-relay 87, conductor 196, springs 147, 148 and 149 to the battery-lead 92, and through battery B to ground G. Each time that a circuit is closed through the circuit-interrupter F the ringer-relay 87 pulls up and bridges the ringer-generator 197 across the normal-conductors 171 and 172 that lead to the called subscriber's station. The circuit may be traced from the ringer-generator 197, through the ringer relay springs 198 and 186, side-switch-wiper 177, vertical-line-wiper 60, vertical-normal-conductor 171, vertical-line-conductor 199, condenser 201, ringer 200 to the rotary-line-conductor 202, thence to the rotary-normal-conductor 172, rotary-line-wiper 61, contact-point 182, side-switch-wiper 178, ringer-relay-springs 191 and 203, back to the ringer-generator 197. When the subscriber at the substation #220 responds he removes his receiver 204 from the switch-hook 205 and thereby closes connection across the telephone line-conductors 199 and 202. An energizing circuit is, therefore, closed through the back-bridge-relay 82. The current may be traced from ground G^8 through the wind-

ing 84, through the conductor 206, conductor 189, ringer-relay-springs 190 and 191, side-switch-wiper 178, contact-point 182, rotary-line-wiper 61, conductor 172, rotary-line-conductor 202, primary winding 207 of the induction-coil 208, transmitter 209 to the vertical-line-conductor 199, thence to the vertical-normal-conductor 171, wiper 60, contact-point 181, side-switch-wiper 177, ringer-relay-springs 186 and 185, conductor 184 to the winding 83 of the coil 82, thence to the battery-lead 92, and through battery B to ground G. It should be noticed that the release-relay 86 is normally short-circuited as follows: from the said relay 86 to the conductor 210, springs 148 and 149 of the relay 82, conductor 211 and conductor 212 back to the said relay 86. However, as soon as the back-bridge-relay 82 pulls up, the said short-circuit is removed when the springs 148 and 149 are separated by the relay 82. When the said relay 82 becomes magnetized as stated, not only is the short-circuit removed from the relay 86 but the spring 147 is shifted from normal connection with the battery-lead 92 into connection with the spring 213 and, therefore, with ground G^9. As soon as the springs 147 and 213 come into contact the ringer-relay 87 is short-circuited so that it will be impossible for said relay to be further energized. The short-circuit extends from ground G^9 through the springs 213 and 147, conductor 196, ringer-relay 87, side-switch-wiper 175, contact-point 179, conductor 194, interrupter F to ground G^7. Furthermore, talking battery current is established on the line of the calling subscriber over the following circuit: from the same ground G^9 and through the springs 213 and 147, conductor 146, winding 77 of the vertical-line-relay 75, vertical-trunk-conductor 139, first-selector-wiper 38, line-switching-relay-springs 142 and 89, vertical-line-conductor 88, transmitter 18, primary winding 20 of the induction-coil 19, rotary-line-conductor 105, line-switching-relay-springs 106 and 143, wiper 39, rotary-trunk-conductor 140, winding 80 of the rotary-line-relay 78, conductor 210, release-relay 86 to the battery-lead 92, and through battery B to ground G. In this circuit not only is the transmitter of the calling subscriber provided with battery current, but the vertical, rotary and release relays 75, 78 and 86, respectively, are also energized. When the said line-relays energize or pull up the trunk-release-springs 214 and 215 are pressed into contact, and when the release-relay 86 is energized the springs 216 and 217 are separated. It will be noticed that the release-magnet 74 is in a circuit that comprises the said springs 216 and 217 and the springs 214 and 215, and that the trunk-release-conductor 141 that leads to the first-selector A is connected to ground G^3, as previously described, and if at any time the said springs 214 and 215 are closed into contact simultaneously with the springs 216 and 217, the said release-magnet 74 will be energized. The energizing circuit would be from the said ground G^3 at the first-selector, thence through the release-armature-springs 116 and 117, conductor 119, private-springs 113 and 114, conductor 138, back-release-relay 49, conductor 137, private-wiper 40, trunk-release-conductor 141, trunk-relase-springs 214 and 215, springs 216 and 217 to the release-magnet 74, thence to the battery-lead 92 and through battery B to ground G. Therefore, since while the subscribers are talking the line-relays 75 and 78 are energized, as described, it is necessary to have the said release-circuit open at some point, which point appears between the said release-relay-springs 216 and 217. After the subscribers have established connection with each other they may converse over the following circuit: from the transmitter 209 to the primary winding 207 of the induction-coil 208, rotary-line-conductor 202, rotary-normal-conductor 172, wiper 61, contact-point 182, side-switch-wiper 178, ringer-relay-springs 191 and 190, condenser 188, rotary-trunk-conductor 140, wiper 39, line-switching-relay-springs 143 and 106, rotary-line-conductor 105, primary winding 20 of the induction-coil 19, transmitter 18, vertical-line-conductor 88, line-switching-relay-springs 89 and 142, wiper 38, vertical-trunk-conductor 139, condenser 183, ringer-relay-springs 185 and 186, side-switch-wiper 177, contact-point 181, wiper 60, vertical-normal-conductor 171, vertical-line-conductor 199 back to the transmitter 209. The said primary windings 207 and 20, respectively, being provided with their allotted secondary windings 218 and 21 (the said secondary windings being connected in series with the receivers 204 and 22, respectively), the conversation may then be carried on between the subscribers in a well-known manner. The guarding potential previously described for the private-wiper 62 not only protects the called line from further seizure, but causes an energizing circuit to be established through the bridge-cut-off-relay 219 of the called first-selector A^1. The circuit may be traced from ground G^6 through the side-switch-wiper 176 to the private-wiper 62, thence over the private-normal-conductor 173, line-switching-relay 219, rotary-magnet 220 to the battery B and to ground G. The object in energizing said line-switching-relay is to disconnect the line-relays 221 and 222 from across the talking line, for reasons well known. After the subscribers are through talking either subscriber, by hanging up his receiver, may restore the switches by simply opening up his line. It will be noticed that as soon as the talking current is

established on the line of the calling subscriber, and as soon as the trunk-release-springs 214 and 215 come in contact, a flow of current is established through the windings 76 and 79 of the line-relays 75 and 78 in series. The flow of current will be from ground G^3, as previously described, and over the same circuit to the trunk-release-spring 215, thence through the windings 79 and 76 to the battery-lead 92, and through battery B to ground G. Therefore, if the calling subscriber hangs up his receiver first—and although he will destroy the energizing circuit previously described that includes his transmitter and the windings 77 and 80 of the line-relays 75 and 78 and the release-relay 86—the line-relays 75 and 78 will not be deënergized because of the circuit established through the windings 76 and 79; but the release-relay 86 will be deënergized and the only open contact in the release-circuit that has been described is closed as soon as the springs 216 and 217 come into contact. As a result the release-magnet 74 in series with the back-release-relay 49 of the first-selector A will be energized. The release-armature 225 will be attracted, the double-dog 226 will then be struck by the said release-armature, and the lug 227 will then be engaged by the aperture on the end of the release-link 228. The shaft 59 will be deprived of its locking-dog 229 and the coil-spring 71 will rotate the said shaft to normal rotary position until the shaft-rest 68 finds the aperture 230, at which time the shaft will fall to normal vertical position. The back-release-relay 49 of the first-selector A being energized the springs 223 and 224 are pressed into contact and an energizing circuit is, therefore, established through the release-magnet 45 of the said selector A. The current through the said magnet 45 flows from ground G^4 through the switch-shaft-springs 125 and 126, conductors 231 and 232, back-release-relay-springs 224 and 223 to the release-magnet 45, thence to the battery-lead 92 and through battery B to ground G. Upon becoming energized the release-magnet 45 attracts the release-armature 233, thrusting the release-link 100 over the lug 101. As soon as the said release-armature 233 is attracted the springs 116 and 117 are pulled apart so that the energizing circuit comprising the back-release-relay 49 and release-magnet 74 of the connector is broken, and at the same time the energizing circuit through the windings 76 and 79 of the vertical and rotary line-relays 75 and 78, respectively, is also destroyed. Evidently the line-relays 75 and 78 and the release-magnet 74 of the connector will regain their normal conditions. The back-release-relay 49 of the selector A is also energized, for the reasons stated, and when deënergized the circuit through the release-magnet 45 is also broken, which latter then permits the release-armature 233 to be drawn into normal place by the spring 117, or by any other suitable spring. The release-armature 233, upon returning, withdraws the locking-dog 104 from the circular teeth 52, permitting the switch-shaft 37 to be rotated to normal rotary position by the spring 58, at which time the shaft-rest 55 finds the slot 54, and the shaft 37 then drops to normal vertical position, separating the off-normal springs 125 and 126 and the cam-springs 128 and 129. The line-switching-relay 48 is then restored and as a result the vertical and rotary line-relays 46 and 47 are brought back into connection with their respective line-conductors 88 and 105. If the called suberiber restores his receiver before the calling subscriber he will break the circuit that energizes the back-bridge-relay 82. Said relay upon deënergizing will permit the springs 147, 148 and 149 to pass into contact and thereby short-circuit the release-relay 86. Furthermore, the spring 147 leaves the spring 213, and the circuit for providing the calling subscriber with talking battery current is thereby cut off. Although the said talking current is cut off from the subscriber's line, and although as a result the windings 77 and 80 of the relays 75 and 78 are deprived of current, the said line-relays 75 and 78 are energized because of the circuit that is maintained through the windings 76 and 79 and over the trunk-release-conductor 141, as previously described. Therefore, the trunk-release-springs 214 and 215 are retained together even after the back-bridge-relay 82 deënergizes. However, as soon as the release-relay 86 permits the springs 216 and 217 to come into contact the release circuit through the release-magnet 74 and the back-release-relay 49 is again closed with the result already described. If the line of the called subscriber #220 is busy at the time that a subscriber calls there will be a guarding potential at the tenth contact of the second level of the private-bank 64, which contact corresponds to the line of the said subscriber #220. The line may be busy either from being called or from calling. If the subscriber #220 is calling the guarding potential will be established when the switch-shaft 234 rises and permits the springs 235 and 236 to come into contact. The circuit over which the guarding potential is established is as follows: from ground G^{10} through the springs 235 and 236 to the trunk-release-conductor 173 and to the said contact-point. If the subscriber has been called there will be another connector set on the line of the subscriber #220 and a guarding potential will be established from the ground terminal similar to the ground terminal G^6, through a side-switch-

wiper similar to the side-switch-wiper 176, and through a private-wiper 62 to the said contact. If the tenth contact of the second level of the private-bank 64 is grounded at the instant that the private-wiper 62 is rotated onto the said contact an energizing circuit is closed through the ringer-relay 87 from ground G of battery B to the said contact, thence to the private-wiper 62 through the side-switch-wiper 176, contact-point 237 to the side-switch-wiper 175, thence over the conductor 195 to the ringer-relay 87, conductor 196, back-bridge-relay-springs 147, 148 and 149 to the battery-lead 92 and through battery B to ground G. As soon as the ringer-relay 87 pulls up the springs 238 and 239 are pressed into contact. Furthermore, as soon as the calling subscriber grounds the rotary-line-conductor 105 for the last time, the rotary-line-relay 78 is energized over the usual circuit, and when the springs 151 and 162 are pressed together the private-magnet 81 is also energized. At the same time that the private-magnet 81 is energized the busy lock-out relay 85 is also energized from ground G^5 through the springs 151 and 162, conductor 240, springs 238 and 239, conductor 241 to the relay 85, thence through the switch-shaft-springs 242 and 243 (which are in contact) to the battery-lead 92 and through battery B to ground G. As soon as the relay 85 is energized the springs 244, 245 and 246 close and at the same time the private-magnet closes the springs 247 and 248. As a result the energizing circuit for the private-magnet 81 is shifted from ground G^5 to ground G^{11} as follows: from ground G^{11} through the springs 246 and 245, conductor 249, private-springs 248 and 247 to the private-magnet 81 and conductor 163, springs 147, 148 and 149 to the battery-lead 92 and through battery B to ground G. Also the energizing circuit for the busy lock-out relay 85 is shifted from ground G^5 to ground G^{11}, the new circuit being as follows: from ground G^{11} through the springs 246, 245 and 244 through the said coil 85, switch-shaft-springs 242 and 243 to the battery-lead 92, and from battery B to ground G. As a result the private-magnet 81 and the relay 85 will be locked, so to speak, over energizing circuits controlled by relays 81 and 85, as described. Therefore, when the rotary-line-relay 78 deënergizes and the spring 162 leaves the spring 151 the separation will produce no effect upon the private and busy lock-out magnets 81 and 85. Not only does the busy lock-out relay 85 control the springs 244, 245 and 246, but the springs 250 and 251 are also pressed into contact and a busy signaling circuit thereby established through the receiver of the calling subscriber. The busy current may be generated in a suitable coil 252, for instance (Fig. 1), which current will then flow from the said coil to the conductor 253, thence through the springs 251 and 250 and through the condenser 183 to the vertical-trunk-conductor 139, vertical-line-wiper 38 of the selector A, conductor 144, line-switching-relay-springs 142 and 89, vertical-line-conductor 88, through the transmitter 18 and primary winding 20 of the induction-coil 19 to the rotary-line-conductor 105, thence to the line-switching-relay-springs 106 and 143 of the selector A, conductor 145, rotary-line-wiper 39 and rotary-trunk-conductor 140 to the winding 80 of the rotary-line-relay 78, thence by way of the conductor 161 and through the springs 148 and 149 to the battery-lead 92, and through battery B to ground G. The current passing through the winding 20 of the induction-coil 19 at the substation X induces a current into the secondary winding 21, which coil being in series with the receiver 22 sends the current through the said receiver. The subscriber upon hearing the busy-signal will understand that the line is busy and will restore his receiver, whereby the switch-hook cam-arm 9 forces the release-springs 30, 31 and 32 into contact, grounding the vertical and rotary line-conductors 88 and 105 simultaneously. The ground connection to the vertical-line-conductor 88 is from ground G^1 through the ground-springs 14 and 17 to the release-spring 30, thence to the spring 31 and to the said conductor 88. To the rotary-line-conductor 105 the connection is from ground G^1 to the release-spring 30, thence through the springs 31 and 32 to the rotary-line-conductor 105. Grounding the vertical and rotary line-conductors 88 and 105 simultaneously sends a flow of current through the windings 77 and 80 of the vertical and rotary line-relays 75 and 78 of the connector C over circuits that are already known. The said relays 75 and 78 will, of course, be energized so that the trunk-release-springs 214 and 215 will be brought together, establishing a circuit (previously described) through the release-magnet 74 from ground G^3 at the first-selector A, through the springs 116 and 117, private-springs 113 and 114 to the back-release-relay 49, thence to the private-wiper 40, trunk-release-conductor 141 to the trunk-release-springs 214 and 215, thence through the release-relay-springs 216 and 217 to the release-magnet 74, thence through said magnet to battery-lead 92 and through battery B to ground G. From the trunk-release-spring 215 a flow of current is also established through the windings 79 and 76 of the relays 75 and 78 over circuits that have been previously described. The release-magnet 74 of the connector, being magnetized, will release the switch-shaft 59 and

side-switch D, as already described, and the back-release-relay 49 will pull up and energize the release-magnet 45 of the selector A. The switch-shaft 59 in falling to its lowest position, through the medium of the normal-post-arm 70, separates the switch-shaft-springs 242 and 243. Said springs being included in the energizing circuit through the busy lock-out relay 85, the said relay will then deënergize, at which time the springs 244, 245 and 246 will separate to deenergize in turn, as a result, the private-magnet 81. As soon as the release-armature 233 of the release-magnet 45 pulls up, the release-circuit through the last-named windings 76 and 79 will be broken, producing no effect; but when the subscriber's switch-hook descends far enough to permit the release-springs 30, 31 and 32 to separate an energizing circuit through the windings 77 and 80 of the line-relays 75 and 78 will also be destroyed, and the trunk-release-springs 214 and 215 separated as a result. The release-magnet 74 and back-release-relay 49 will be deënergized, restoring the connector and the selector in a manner that is well known.

The resistances of the relays and magnets of the connector may be varied to any suitable degree, but good results are obtained when the vertical-magnet 72, rotary-magnet 73 and release-magnet 74 are wound to 60 ohms; the windings 76 and 79 of the line-relays 75 and 78 to 350 and 250 ohms, respectively; the windings 77 and 80 of the said relays 75 and 78 to 500 ohms each; the busy lock-out relay 85 to 350 ohms; the private-magnet 81 to 350 ohms; the release-relay 86 to 100 ohms; the windings 83 and 84 of the back-bridge-relay 82 to 350 ohms each; and the ringer-relay 87 to 500 ohms. It will be evident, when a connector is locked on a busy line, that since the side-switch-wipers 177 and 178 are not in connection with the contact-points 181 and 182 the calling subscriber cannot hear any conversation that may be going on between the subscriber #220 and any other subscriber and, in fact, he cannot interfere with the subscriber #220 at all.

In an automatic system a number of substations, like the substations X and #220, are often bridged across the same line, and if when two subscribers are communicating (for instance as when the subscriber X is communicating with the subscriber #220) one of the other subscribers on the same line with the subscriber X should take off his receiver and begin to operate his dial he would ground the vertical and rotary line-conductors 88 and 105 through the transmitter 18 and primary winding 20 of the substation X. Ordinarily, in automatic telephone systems of the class herein described, if both line-conductors 88 and 105 are grounded simultaneously, the switching apparatus is released; but in my improved system such grounding of the line-conductors will not produce such undesirable results. Grounding the rotary-line-conductor 105, while the subscribers are talking, has no effect upon the release-relay 86, and it is only by operating the said relay that the subscribers on the line leading to the substation X can release the switches. The release-relay 86 will remain energized when the rotary-line-conductor 105 is grounded over the following circuit: from ground to the said rotary-line-conductor, thence through the winding 80 of the rotary-line-relay 78, conductor 210 to the said release-relay 86, thence to battery B. Grounding the vertical-line-conductor 88 simply cuts the flow of current through the winding 77 of the vertical-line-relay 75, which produces no result of significance. In a similar way, if a subscriber on the line leading to the substation #220 should ground both line-conductors 199 and 202, the back-bridge-relay 82 would remain energized, having one of its windings (namely the winding 84) short-circuited; but the other winding 83 would still receive current from the vertical-line-conductor 199. The subscribers upon the called line can only release the switches by operating first the back-release-relay 82, and since this cannot be done by grounding the line-conductors the switches will not be released.

The selectors herein referred to may be of the general type disclosed in Patent No. 815,321, issued March 13, 1906. The connectors referred to may be of the general type disclosed in Patent No. 815,176, issued March 13, 1906.

From the foregoing it will be seen that I provide an improved automatic telephone exchange system in which the connection between calling and called subscribers' lines cannot be released by accidental grounds on the lines. In other words, it is the opening of a subscriber's telephone line which accomplishes the release, and this may be done by either the calling subscriber or the called subscriber, and a ground on either line will not produce a premature release of the established connection. Current for talking purposes is supplied through improved circuits and apparatus to the substations of calling and called subscribers when any two substations are connected together. The line-relays of the connectors have line and local circuits, and current is furnished through both the local and the line circuits from the single common battery, as explained.

I do not, however, limit myself to the exact construction shown and described, as

various modifications for obtaining the foregoing and other useful ends will be obvious to those skilled in the art.

What I claim as my invention is:—

1. In a telephone exchange system, the combination of a calling telephone line, a called telephone line, automatic switching machinery for connecting the two lines, means for grounding a telephone line to release the switching machinery before the called subscriber answers, and means for opening a telephone line circuit to release the switching machinery after the called subscriber answers.

2. In a telephone exchange system, the combination of a calling telephone line, a called telephone line, automatic switching machinery for connecting the two lines together, means for grounding the calling line to release the switching machinery before the called subscriber answers, and means for opening the circuit of either telephone line to release the switching machinery after the called subscriber answers.

3. In a telephone exchange system, the combination of a calling telephone line, a called telephone line, automatic switching machinery for connecting the two lines together, means for grounding a telephone line to release the switching machinery before the called subscriber answers, and means for opening up the circuit of either telephone line to release the switching machinery after the called subscriber answers.

4. In a telephone exchange system, the combination of a connector provided with line-relays 75 and 78, said line-relay 75 provided with a couple of windings 76 and 77, said relay 78 provided with a couple of windings 79 and 80, a circuit including said windings 76 and 79 in series, a battery B permanently connected in said circuit, a trunk release spring 215 connected in said circuit, a coöperating trunk release spring 214, a local energizing circuit including said relays 75 and 78 and controlled by said trunk release springs, a trunk release conductor 141 included in said local energizing circuit, a ground terminal at the end of said trunk release conductor, said relays 75 and 78 energized until the said ground connection is broken, the said local energizing circuit being independent of the control of the connector, line-conductors 139 and 140, the windings 77 and 80 being normally bridged in series across the said line-conductors and normally connected to the battery B at a point between them, and means for grounding the line-conductors 139 and 140 to energize the relays 75 and 78, for the purpose set forth.

5. In a telephone exchange system, the combination of a connector provided with a release-relay, means for normally short-circuiting said relay, a back-bridge-relay controlling said means, a battery, and a rotary-line-relay provided with a winding, said short-circuit connected in series with said winding when the back-bridge relay is energized, and at a point between said relay and battery.

6. In a telephone exchange system, the combination of a release-relay, a pair of line-relays provided with windings, an energizing circuit including the windings of said release and line relays, substation springs also included in said energizing circuit, a release-circuit comprising a release-magnet, and a back release-relay controlled by the said release-relay, said release relay deënergized when the springs are separated, and the said release-circuit closed and the release magnet and back-release relay energized when said springs are separated.

7. In a telephone exchange system, the combination of a closed circuit comprising a release-magnet and a trunk release conductor, trunk release springs, together with release-relay springs, said circuit provided with a normally open switch-point between the trunk release springs, and with a normally closed switch-point at the said relay springs, said circuit closed by closure of connection between the trunk-release springs, and the release-relay springs, as set forth.

8. In a telephone exchange system, the combination of a connector provided with a busy lock-out relay having an energizing circuit, switch-shaft springs normally controlling said circuit, ringer-relay springs normally controlling said circuit, and a rotary-line-relay normally controlling said circuit.

9. In a telephone exchange system, the combination of a connector provided with a ringer-relay, means including a back-bridge-relay for short-circuiting said ringer-relay, connections for extending the short-circuit through ground, the short-circuit through ground closed when the springs of said relay are closed together.

10. In a telephone exchange system, the combination of a connector provided with a ringer-relay, a private-wiper, a grounded private-bank contact, means for energizing said ringer-relay as soon as the said wiper strikes the said grounded private-bank contact, a side-switch, an energizing circuit for said relay, a side-switch-wiper, and back-bridge-relay springs, and an energizing circuit including the grounded private-bank contact, the said private-wiper, the said side-switch-wiper and said back-bridge-relay springs.

11. In a telephone exchange system, the combination of a connector provided with a busy lock-out relay, a private-magnet, a line-relay, a ringer-relay, a private-wiper, a side-switch, a busy line, means for energizing the ringer-relay when the private-wiper

finds the busy line, and means for simultaneously energizing the lock-out relay and said private magnet when the rotary-line-relay is energized after the energizing of the ringer-relay.

12. In a telephone exchange system, the combination of a connector provided with a busy lock-out relay, an energizing circuit for said relay, controlled by the relay itself, a switch-shaft, springs operated by the shaft, and means for retaining the relay energized until the springs are opened by the switch-shaft.

13. In a telephone exchange system, the combination of a connector provided with a private-magnet having a plurality of energizing circuits, a line-relay controlling one of said circuits, private springs, and a busy lock-out relay controlling another of said circuits, a switch-shaft, springs operated by the shaft, and means for simultaneously energizing the private magnet and the lock-out relay until the switch-shaft separates the springs operated thereby.

14. In a telephone exchange system, a side switchless selector provided with a line-relay, ground-spring, release-armature springs, and a private magnet spring normally connected to ground through said release-armature springs.

15. In a telephone system, automatic switches, a three-wire trunk connecting said switches, a release circuit including the third conductor of the trunk, one of said switches provided with a pair of line relays having windings included in said release circuit, and means for supplying talking current over the other two wires of said trunk to the station of the calling subscriber.

16. In a telephone system, a trunk-selector, a three-wire trunk leading from said selector, an automatic switch allotted to the other end of said trunk, a line relay for said automatic switch, a trunk-release circuit including a winding of said line relay in series with the third wire of said trunk, and means for supplying talking current over the other two wires of said trunk to the station of the calling subscriber.

17. In a telephone system, an automatic trunk selector, a three-wire trunk leading from said selector, a connector allotted to the other end of said trunk, a called telephone line temporarily seized by said connector, line relays for said connector, a trunk-release circuit including a winding of said line relays in series with the third wire of said trunk, and means for supplying talking current over the other two wires of said trunk to the station of the calling subscriber.

18. In a telephone system, automatic switches including an automatic trunk selector, line relays for said automatic switches, a trunk-release circuit for said selector, and a trunk conductor and a line relay winding of another automatic switch included in said circuit and excluded from the talking circuit.

19. In a telephone exchange system, the combination of a calling telephone line, a called telephone line, automatic switching machinery for connecting the two lines together, said machinery comprising banks of line terminals, line wipers adapted to cooperate with said terminals in making connections, said terminals arranged in rows, means for moving the wipers in one direction while out of contact with said terminals, means for moving the said wipers in another direction while in contact with the terminals of a selected row, and means for opening the circuit of either telephone line to release the switching machinery.

20. In a telephone exchange system, a progressively movable automatic switch, an off-normal signal, a circuit for said signal, a shaft, a cam on said shaft, springs directly controlled by said shaft and springs controlled through the medium of said cam, said springs contained in the said circuit whereby the said signal is controlled by the shaft both directly and through the cam.

21. In a telephone system, two lines connected through the medium of trunking apparatus and a common battery connector switch, a double wound line relay associated with said connecting circuit, release means in said connector controlled through the medium of said line relay by opening either line independent of the other line.

22. In a telephone system, two lines connected through the medium of trunking apparatus and a common battery connector switch, a double wound line relay associated with said connecting circuit, release means in said connector controlled from either line through the medium of said line relay when either line is opened, said lines being separated during the connection by a condenser on each side, said line relay being connected with the line on one side of the condensers.

23. In a telephone system, an automatic switching apparatus for connecting one talking circuit with another, a release circuit associated with said talking circuit and separate therefrom, said switching apparatus provided with line relays having windings in the release circuit and windings connected to the talking circuit.

24. In a telephone system, an automatic switching apparatus for connecting one talking circuit with another, a release circuit associated with said talking circuit, said switching apparatus provided with line relays having windings in the release circuit and windings connected to the talking circuit, the windings in the release circuit being in series.

25. In a telephone system, an automatic

switching apparatus for connecting one talking circuit with another, a release circuit associated with said talking circuit, said switching apparatus provided with line relays having windings in the release circuit and windings connected to the talking circuit, said automatic switching apparatus comprising a connector switch and said line relays being located in said connector, the windings in the release circuit being in series.

Signed by me at Chicago, Cook county, Illinois, this 30th day of April, 1906.

HERBERT L. FISH.

Witnesses:
EDWARD D. FALES,
R. H. BURFEIND.