T. G. MARTIN.

TELEPHONE REPEATER SYSTEM.

APPLICATION FILED APR. 16, 1910. RENEWED MAY 2, 1913.

1,136,912.

Patented Apr. 20, 1915.

3 SHEETS—SHEET 1.

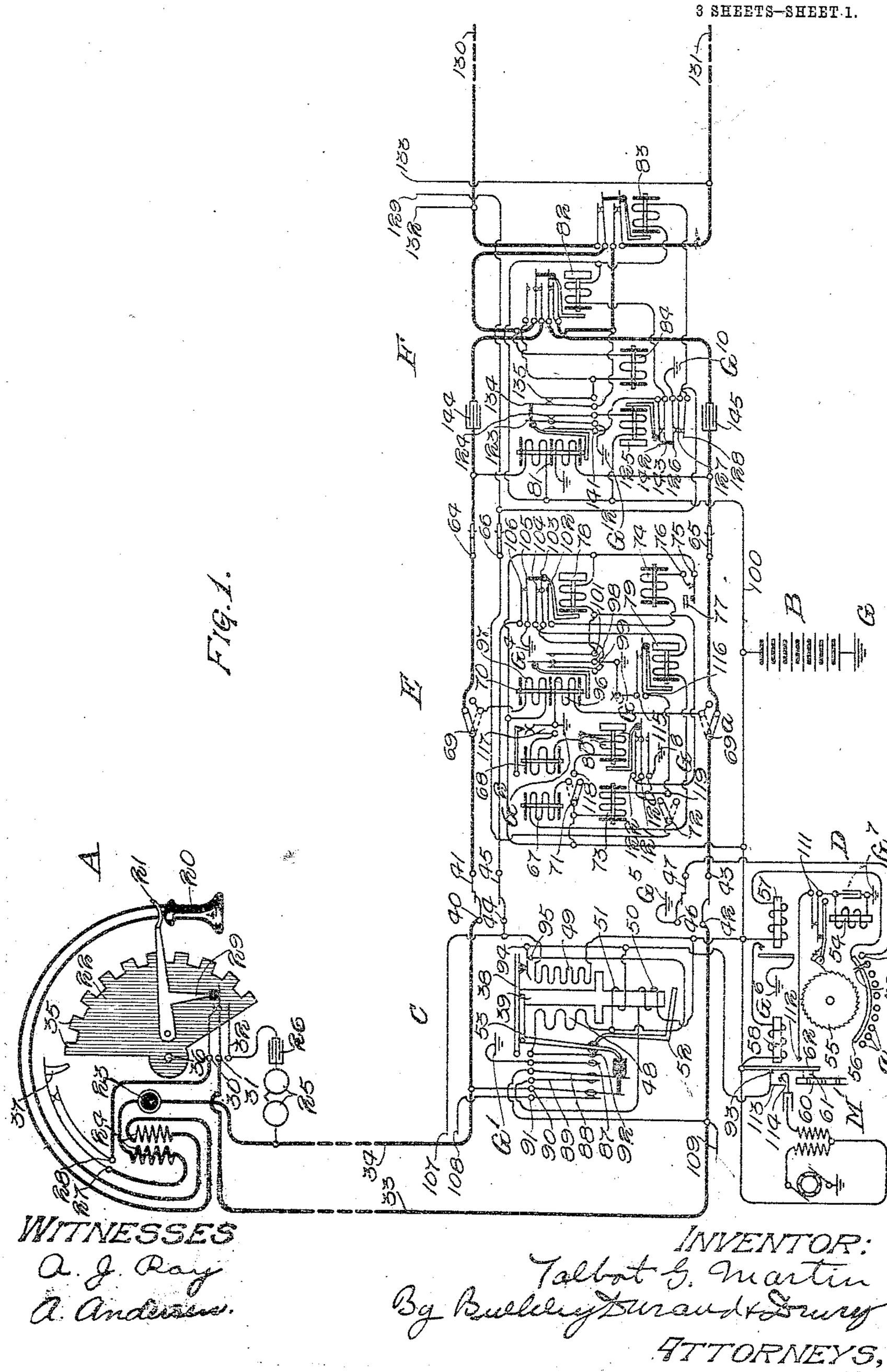

FIG. 1.

WITNESSES
A. J. Ray
A. Anderson.

INVENTOR:
Talbot G. Martin
By Bulkley Burand & Drury
ATTORNEYS,

T. G. MARTIN.

TELEPHONE REPEATER SYSTEM.

APPLICATION FILED APR. 16, 1910. RENEWED MAY 2, 1913.

1,136,912.

Patented Apr. 20, 1915.

3 SHEETS—SHEET 2.

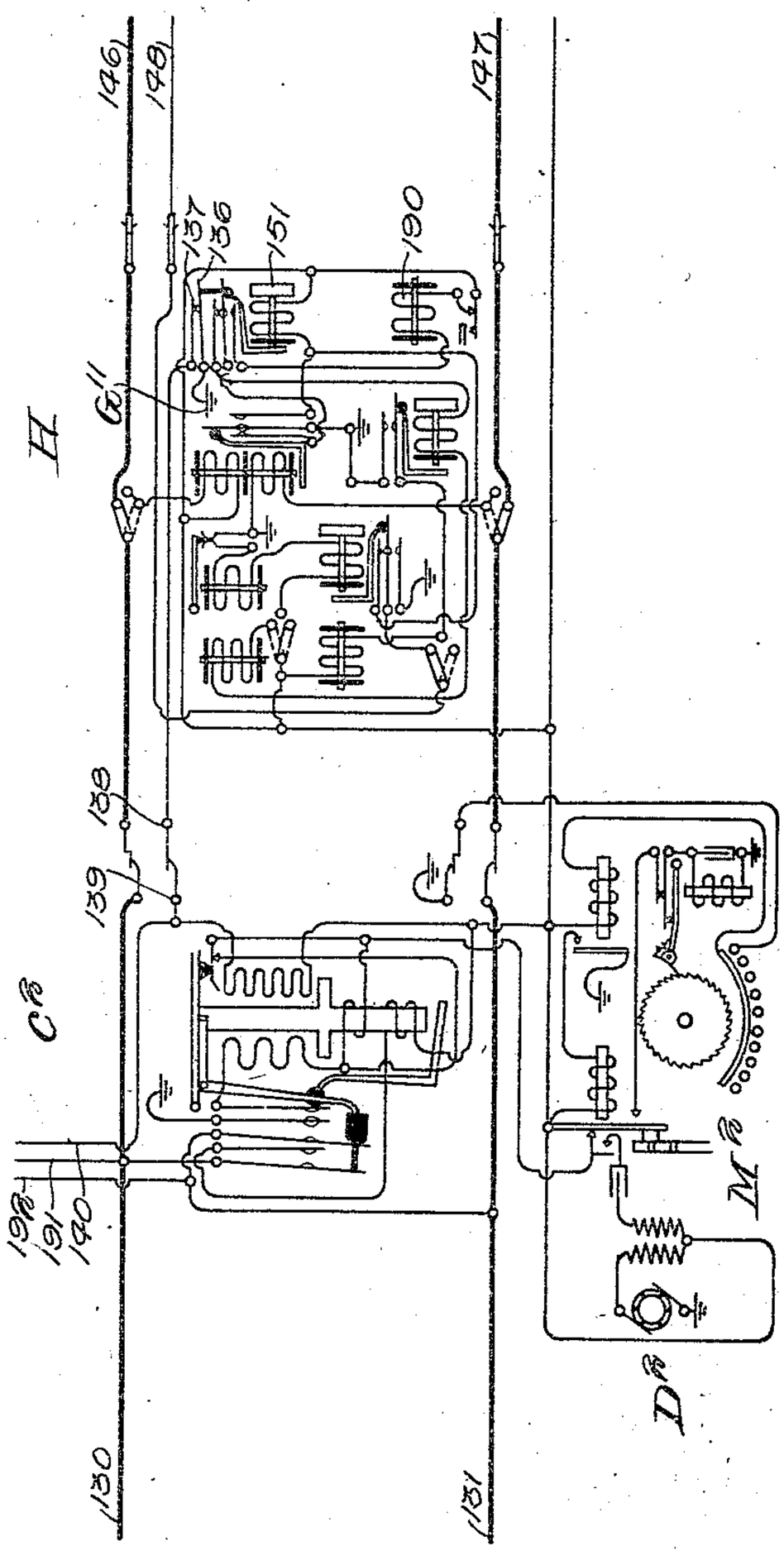

Fig. 2.

WITNESSES
A. J. Ray
A. Andersen

INVENTOR:
Talbot G. Martin
By Bulkley Durand & Dury
ATTORNEYS.

T. G. MARTIN.

TELEPHONE REPEATER SYSTEM.

APPLICATION FILED APR. 16, 1910. RENEWED MAY 2, 1913.

1,136,912.

Patented Apr. 20, 1915.

3 SHEETS—SHEET 3.

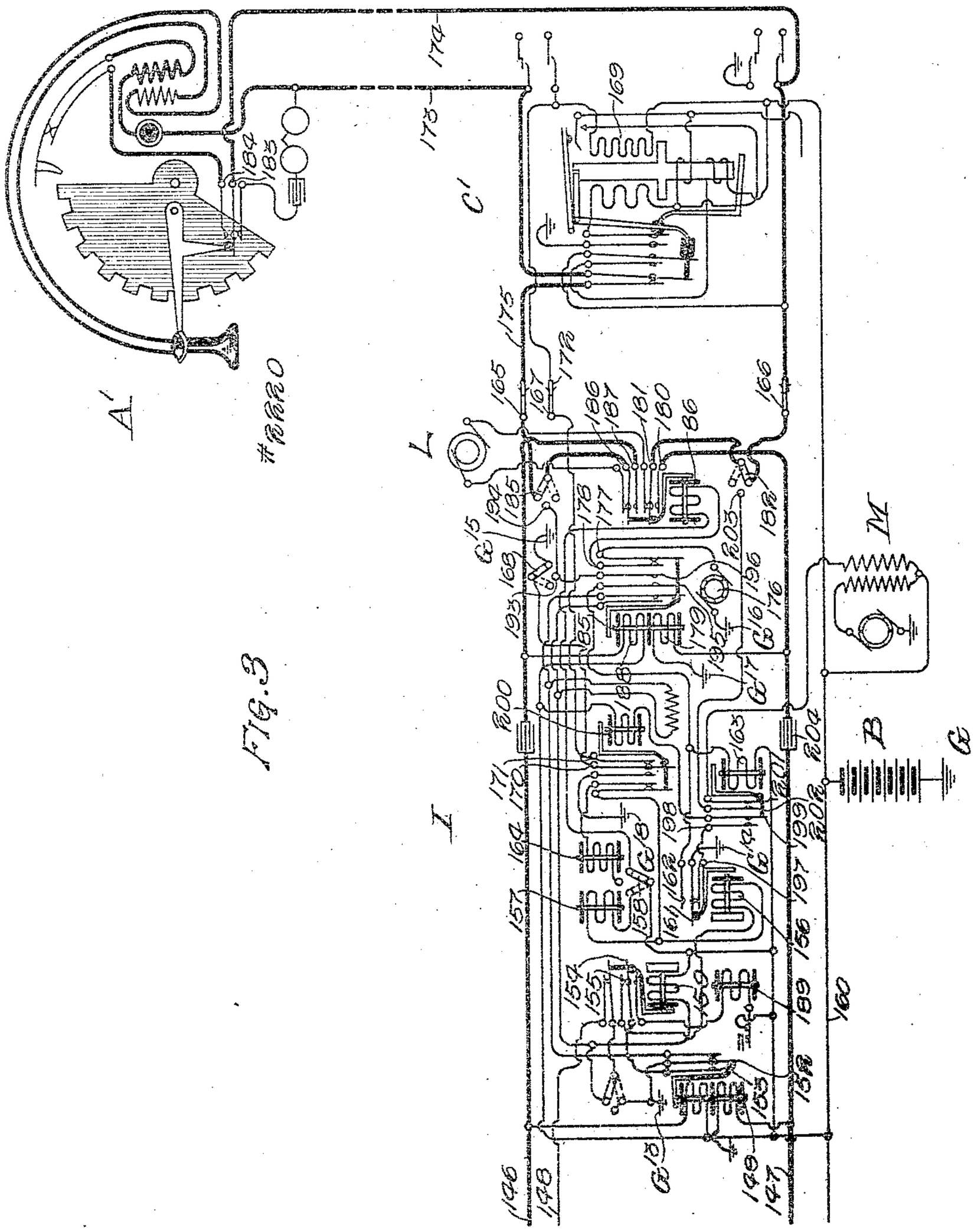

FIG. 3

WITNESSES
A. J. Ray.
A. Andersen

INVENTOR:
Talbot G. Martin
By Bulkley Durand & Drury
ATTORNEYS,

UNITED STATES PATENT OFFICE.

TALBOT G. MARTIN, OF CHICAGO, ILLINOIS, ASSIGNOR TO AUTOMATIC ELECTRIC COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

TELEPHONE REPEATER SYSTEM.

1,136,912. Specification of Letters Patent. Patented Apr. 20, 1915.

Application filed April 16, 1910, Serial No. 556,383. Renewed May 5, 1913. Serial No. 765,133.

To all whom it may concern:

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

My invention relates to telephone systems of that particular character in which automatic trunking is employed in the establishment of a talking connection between calling and called substations.

It relates more especially to systems of this kind in which a trunk line is provided at each end with a non-numerical trunking switch—that is to say, a switch that operates without reference to any digit of the called number, as distinguished from a first or second or third selector, which latter are switches that always operate in accordance with some digit of the called number.

The object of my invention is to provide a system of this kind in which the said trunk line is not only equipped at each end with a non-numerical trunking switch, whereby a trunking connection may be established from either end of the trunk line to permit the latter to be used for extending calls in either direction, but is also provided with a repeater at each end thereof, each repeater being adapted to control the non-numerical trunking switch at the other end of the trunk line. In a system embodying the principles of my invention it is possible, therefore, to employ a subscriber's calling mechanism for directly controlling one of said repeaters to operate the non-numerical trunking switch at the other end of the trunk line, and to thereafter control the same repeater for the purpose of operating one or more selectors or a connector, or other automatic switching machinery, for the purpose of completing the connection to the called line, or for the purpose of extending the connection to some other point in the system. In a similar way a call can be extended over the same trunk line in the opposite direction through the medium of the other repeater and the other non-numerical trunking switch, which repeater and switch are, of course, located at opposite ends of said trunk line. It will be seen, therefore that this application is in the nature of an improvement on my co-pending applications Serial Numbers 319,255, filed May 29th, 1906, 339,838, filed October 20th, 1906, 392,687, filed September 13th, 1907 and 394,984, filed September 28th, 1907.

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

In the accompanying drawings Figures 1, 2 and 3 taken together show a complete circuit connection established between a calling substation A (Fig. 1) and a called substation A' (Fig. 3) in a system embodying the principles of my invention.

In Fig. 1 there is shown a subscriber's substation A, the line conductors of which are connected to an individual or line switch C at the central office. A number of line switches C are controlled by a common mechanism D called a master switch. At E is shown a so-called first selector switch. At F is shown a repeater for repeating impulses to a distant exchange represented in Figs. 2 and 3.

In Fig. 2 there is shown a line switch C^2, a master switch D^2 and selector switch H which are similar to the switches C, D and E, respectively, Fig. 1, but situated in a distant exchange. The trunk line between the two exchanges is a two-way trunk, i. e., it may be used to extend a connection in either direction. In addition to the apparatus shown, the trunk is provided at the second exchange with a repeater similar to the repeater F (Fig. 1). At the first exchange the trunk line is also provided with a line switch similar to the switch C^2 (Fig. 2). In other words, both ends of the trunk line between exchanges are exactly alike.

In Fig. 3 there is shown a connector switch for completing connection with a group of substations of which substation A' is a member. The line of substation A' is connected to a line switch C' similar to that of substation A. At L a ringer generator is shown and at bl a busy signaling machine is represented. As shown, each exchange is provided with a battery B having one terminal grounded. There need be but one battery, however, but preferably each exchange has a separate one.

The automatic substations A and A' may be of any suitable or approved type. As here shown, the substation A comprises a receiver 20, switch hook 21, impulse wheel

22, transmitter 23, induction coil 24, ringer 25, condenser 26 and impulse springs 27 and 28. The switch hook controls the substation circuits through the medium of the cam arm 29 and springs 30, 31 and 32. When the receiver is on the hook the arm 29 maintains spring 31 in contact with spring 32, thus bridging the ringer 25 and condenser 26 in series across the line conductors 33 and 34. When the receiver is removed the hook is forced upward by a spring (not shown), allowing the spring 31 to disengage spring 32 and come into engagement with spring 30. By this action the circuit of the ringer 25 is opened and a bridge consisting of the transmitter 23, primary winding of induction coil 24, and impulse springs 27 and 28 is closed across the line conductors 33 and 34. The impulse wheel 22 carries upon its periphery the impulse teeth 35, and is secured to a shaft 36 to which there is also secured a dial (not shown) provided with finger holes. When the dial is rotated forward a certain number of teeth, corresponding to the digit called, are advanced past the cam 37 upon the end of the spring 27, but with no effect upon said spring. When the dial is released it and the impulse wheel are returned to normal position by a spring (not shown). As each tooth passes the cam 37 during this backward motion the spring 27 is forced out of engagement with the spring 28 to open the bridge across the line.

The line switch C and master switch D are of the general type disclosed in British Letters Patent No. 26,301 of 1906, and in the *Western Electrician* of Chicago, Illinois, of January 25, 1908. As here shown, the line switch C consists essentially of a plunger (not shown) attached to a plunger arm 38, and a magnet 39. When the plunger arm 38 is attracted by the magnet 39 the plunger is forced into a bank of springs and forces the springs 40, 42, 44 and 46 into contact with the springs 41, 43, 45 and 47, respectively. The magnet 39 is composed of four windings, a pull-in winding 48, a cut-off winding 49, a line winding 50 and an auxiliary winding 51. The magnetic circuit of the windings 48 and 49 is separate from that of the windings 50 and 51. The pull-in winding 48 is for the purpose of attracting the plunger arm 38 to force the plunger into the bank. The circuit of the winding 48 is controlled by the calling subscriber through the medium of the line winding 50 and armature 52. The winding 51 prevents the armature 52 from falling back immediately upon the deënergization of the winding 50. The cut-off winding 49 is provided for the purpose of holding the plunger arm 38 in an operated position and for operating the cut-off armature 53. If the winding 49 is energized while the armature 53 and plunger arm 38 are in an operated position, both the armature and plunger arm will be held in this position after the winding 48 is deenergized; but if the winding 49 is energized while the armature 53 and plunger arm 38 are in normal position, only the armature 53 will be operated, as the winding 49 is not as strong as winding 48. Although only one set of springs 40, 41, 42, 43, 44, 45, 46 and 47 is shown, each line switch C is provided with a bank comprising a number of such sets of springs, each set forming the terminal of a trunk line leading to a selector switch E. Each trunk is multipled through the corresponding bank contacts of a group of switches C. The plungers normally rest in locking engagement with a plunger shaft (not shown) and through the medium thereof are always held opposite an idle trunk terminal by the master switch D.

The master switch D consists essentially of a motor magnet 54 which operates the ratchet wheel 55, a bank of contacts comprising a number of individual contacts *a* and one common segment 56, a busy trunk relay 57 and a locking relay 58. The wiper 59 is adapted to always keep some one of the individual contacts *a* in electrical connection with the common segment 56. By means of a suitable mechanical connection the rotary motion of the ratchet wheel 55 is transmitted to the plunger shaft to give said shaft a reciprocating motion to move the idle plungers back and forth in front of the bank contacts. To the plunger shaft there is also secured a cam 60 having in its surface a number of circular openings which are engaged by the pin 61 on the armature 62. The openings in the cam 60 are so spaced that the pin 61 can engage an opening only when the plungers that are in locking engagement with the plunger shaft are directly in front of a trunk terminal.

The selector switch E is of the general type disclosed in United States Letters Patent No. 815,321, granted March 13, 1906, to Keith, Erickson and Erickson, but as here shown is adapted to operate in conjunction with a two-wire system—*i. e.*, a system in which there is no ground at the substation. Among other details the selector comprises a set of wipers 64, 65 and 66 carried upon a shaft (not shown) which has a vertical motion controlled by the vertical magnet 67 and a rotary motion controlled by the rotary magnet 68. The usual side switch, comprising the wipers 69, 69ª, 71 and 72, is controlled by the private magnet 73. The operation of the switch is controlled by the calling subscriber through the medium of the double-wound line relay 70. The release magnet 74 is normally disconnected from the battery by the separation of springs 75 and 76, which are held out of engagement by the arm 77 as long as the switch shaft is in its lowest position. The relays 78, 79

and 80 are relays that deënergize slowly after their energizing circuits have been broken. The selector is provided with the so-called connector release—*i. e.*, the mechanism is restored immediately upon the energization of the release magnet rather than by its deënergization, as shown in the said selector patent.

The repeater F is adapted to receive impulses from the substation and to repeat them over the trunk conductors to a distant exchange. Among other details the repeater comprises a double-wound line relay 81 which is similar to the relay 70 of the selector E. A slow-acting relay 82 is provided to open the circuit through the repeater while it is operating. The repeater is normally disconnected from the trunk, but is connected therewith by the relay 83 as soon as a selector switch engages the terminals of that trunk. The impedance coil 84 is provided for the purpose of furnishing a bridge across the line to prevent the switches of the second exchange from releasing, and yet forms a barrier to prevent the talking currents from passing from one side of the line to the other.

The connector I (Fig. 3) is of the general type disclosed in United States Letters Patent #815,176, granted March 13, 1906, to Keith, Erickson and Erickson, and, like the selectors, is modified to operate in a two-wire system. The general features of the connector are very similar to those of the selectors, the main difference between them being in the circuits. The connector is provided with a double-wound back-bridge relay 85 through which the called substation may be provided with talking battery current. A ringer relay 86 is provided for the purpose of connecting the ringer generator L with the called line after connection has been completed therewith.

In order to give a clearer understanding of my invention I will describe the complete operation of establishing a connection between substations A and A′. The number of the substation A′ will be assumed to be 2220.

When the hook switch springs 30 and 31 come into engagement upon the removal of the receiver at substation A, a circuit is closed through the line winding 50 of the line switch C. The circuit extends from ground G′ through springs 87 and 88, line conductor 33, substation springs 31 and 30, impulse springs 28 and 27, primary winding of induction coil 24, transmitter 23, line 34, springs 90 and 89, thence through the winding 50 to battery lead 100. The winding 50, upon energizing, attracts the armature 52, which operates to close a circuit through the pull-in winding 48. This circuit extends from ground G′ through springs 87 and 92, windings 48 and 51, contact point 93 and armature 62 to the battery lead 100. The winding 48, upon energizing, operates to draw down the plunger arm 38 and cut-off armature 53. In its attracted position the armature 53 forces the springs 88 and 90 out of engagement with the springs 87 and 89, respectively, and forces the spring 90 into engagement with spring 91. The engagement of springs 90 and 91 is without function at this time. The disengagement of springs 88 and 90 from springs 87 and 89 disconnects the ground G′ and winding 50 from the line conductors 33 and 34. The armature 52 does not fall back immediately upon the deënergization of winding 50, but remains held up for an instant by the current flowing through winding 51 in series with winding 48. When the plunger arm 38 is attracted by the magnet 39 it operates to force the plunger into the bank and to force springs 94 and 95 into engagement. The engagement of springs 94 and 95 short-circuits the winding 51, thus causing the said winding to deënergize slowly to allow the armature 52 to fall back. When the armature 52 returns to normal position it breaks the circuit of the winding 48, allowing it to deënergize, not, however, before the winding 49 has been energized as follows: When the bank springs 40 and 42 are forced into engagement with the springs 41 and 43, respectively, the line connection is extended to the selector E, causing its line relay 70 to become energized. The energizing circuit of relay 70 extends from ground G^2 through winding 96, side switch wiper 69^a, bank springs 43 and 42, thence over line 33 to and through substation A and back over line 34, through bank springs 40 and 41, side switch wiper 69 and winding 97 to battery lead 100. The relay 70, upon energizing, forces spring 98 into engagement with spring 101, thereby closing an energizing circuit extending from ground G^3 through the relay 78 to the battery lead 100. The relay 78, upon energizing, shifts the spring 103 out of engagement with the spring 102 and into contact with the spring 104, and forces the spring 105 into engagement with the spring 106. The engagement of springs 105 and 106 closes a circuit extending from ground G^4 through relay springs 105 and 106, bank springs 45 and 44 and winding 49 of magnet 39 to battery lead 100. This circuit is closed through the winding 49 before the winding 48 is deënergized, and serves to maintain the armature 53 and plunger arm 38 in their operated positions. By the operation of relay 78 a ground potential is also extended from ground G^4 through the bank springs 45 and 44 and over the private normal conductor 107 to the connector private bank contacts of the calling line. This ground potential at the connector private bank contacts pre-

vents the busy line from being seized for connection by said connectors over the conductors 108 and 109.

When the bank springs 46 and 47 are forced into engagement by the line switch plunger an energizing circuit is closed through the busy trunk relay 57. This circuit extends from ground G^5 through bank springs 46 and 47, master switch bank contact 110 (which corresponds to the trunk seized), wiper 59, segment 56 and relay 57 to battery lead 100. The relay 57, upon energizing, operates to close a circuit extending from ground G^6 through the locking relay 58. The relay 58, upon energizing, withdraws the pin 61 from the opening in the cam 60 and closes an energizing circuit through the motor magnet 54. This circuit extends from ground G^7 through magnet 54, interrupter springs 111, contact point 112 and armature 62 to battery lead 100. Since this circuit includes the interrupter springs 111, the motor magnet 54 will continue to operate in a manner similar to that of a buzzer as long as the armature 62 engages contact point 112. The continued operation of magnet 54 rotates the ratchet wheel 55 to move all idle plungers that are in locking engagement with the plunger shaft away from the trunk just seized. When the plunger shaft has moved a short distance the wiper 59 passes off of the contact 110 and allows the relays 57 and 58 to deënergize. The armature 62 cannot fall back immediately upon the deënergization of relay 58, because the cam 60 has also been moved and the opening formerly engaged by pin 61 has been moved out of register therewith. The master switch will then continue to operate until the next opening passes under the pin 61, when the armature 62 will be allowed to drop back to open the circuit of magnet 54 and to lock the plunger shaft, with the idle plungers standing in front of the next trunk. If the first trunk after the one seized by the line switch C had been busy, however, the wiper 59 would have found the corresponding contact grounded; consequently the relays 57 and 58 would have remained energized while the next opening was passing under pin 61 and the plungers would have been moved past the busy trunk to an idle one. During the time the master switch is operating, the armature 62 is disengaged from the contact point 93 and springs 113 and 114 are allowed to engage. By this arrangement the pull-in winding 48 of all switches which are controlled by the master switch D are disconnected from battery to prevent the operation of any switch while its plunger is in motion, and any subscriber attempting to make a call at this time will receive the busy signal. The busy signaling current passes from the machine M' through the windings 51 and 48 to ground G' if a subscriber attempts to make a call when the master switch is rotating. The current passing through winding 51 produces an induced current in winding 50 which is connected with the line.

The foregoing are the operations that follow immediately upon the removal of the receiver at the calling substation and before the calling device is operated for the first digit. When the substation calling device is operated for the first digit 2 the bridge across the line conductors 33 and 34 is opened twice by the separation of impulse springs 27 and 28. The opening of the bridge across the line momentarily breaks the energizing circuit of the line relay 70 of the selector E. The relay 70, upon deënergizing, permits the spring 98 to disengage spring 101 and engage spring 99. Since the relay 78 is slow acting it does not have time to deënergize during the momentary opening of its circuit by the springs 98 and 101. The engagement of springs 98 and 99 closes a circuit extending from ground G^8 through springs 98 and 99, 103 and 104, private magnet relay 79, vertical magnet 67 and side switch wiper 71 to battery lead 100. Since the digit called is 2 the vertical magnet receives two impulses over this circuit and operates to raise the shaft wipers 64, 65 and 66 two steps to a position opposite the second row or level of bank contacts. The private magnet relay 79, which is included in the energizing circuit of the vertical magnet, is energized by the first impulse, and, being a slow-acting relay, remains energized until all the impulses for the first digit have been delivered. The relay 79, upon energizing, operates to close a circuit extending from ground G^3 through springs 115 and 116 and private magnet 73 to battery lead 100. When the relay 79 deënergizes after the last impulse has been delivered to the vertical magnet, this energizing circuit through the private magnet is broken, allowing said magnet to deënergize to trip the side switch from first to second position. The movement of side switch wiper 71 from first to second position disconnects the battery from the vertical magnet 67 and closes a circuit through the rotary magnet 68. This circuit extends from ground G^2 through interrupter springs 117, rotary magnet 68, relay 80, contact point 118 and side switch wiper 71 to battery lead 100. The rotary magnet energizes upon the completion of this circuit and attracts its armature, which operates to rotate the wipers one step onto the terminals of the first trunk of the second level, to press down the armature of the private magnet 73, and to open the circuit of its own magnet at the interrupter springs 117. When the rotary magnet circuit is thus opened its armature falls back and, if the first trunk is not already in use, the private magnet armature

falls back, allowing the side switch to pass from second to third position. If, however, the first trunk engaged by the wipers 64, 65 and 66 is busy the private bank contact which is engaged by the wiper 66 will be grounded, as will be explained later. When the wiper 66 thus engages the grounded contact of a busy trunk a circuit is closed extending from said grounded contact through wiper 66, side switch wiper 72, contact point 119 and private magnet 78 to battery lead 100. The private magnet energizes upon the completion of this circuit, preventing its armature from dropping back to release the side switch to third position when the rotary magnet deënergizes. Since the side switch is locked in second position, the rotary magnet will be energized again to rotate the wipers a second step as soon as the interrupter springs 117 are permitted to engage. The rotary magnet will thus continue to advance the wipers step by step until the wiper 66 engages the non-grounded contact of an idle trunk, whereupon the private magnet 78 deënergizes and permits the side switch to pass to third position. As soon as the side switch wiper 71 leaves second position it opens the circuit of the rotary magnet 63 so prevent its further operation. The relay 80, which is included in the energizing circuit of the rotary magnet, is a slow acting relay and, consequently, remains energized for an instant after the wipers have been rotated the last step. Thus, at the instant the side switch wiper 72 engages its third-position contact point a guarding potential is extended from ground G^{5} through springs 120 and 121, side switch wiper 72 and shaft wiper 66 to the selector private bank contacts corresponding to the seized trunk. When the side switch wipers 69 and 69^{a} reach third position the line connection is extended through the shaft wipers 64 and 65 to the repeater F, causing its line relay 81 to be energized in the same manner in which the relay 70 was first energized. The relay 81, upon energizing, closes a circuit extending from ground G^{11} through springs 123 and 124 and relay 125 to battery lead 100. The relay 125, upon energizing, extends another ground potential from ground G^{12} to the selector private bank contacts of the trunk, and as soon as the relay 80 of the selector E deënergizes, a new circuit is closed through the relay 78. This circuit extends from ground G^{12} through the springs 126 and 127, shaft private wiper 66, side switch wiper 72, springs 121 and 122 of relay 80, and through relay 78. This new holding circuit through the relay 78 is closed before the said relay has time to deënergize after its former circuit is broken by the deënergization of the relay 70, when the side switch passes to third position. It is evident that the relay 78 must be slower than the relay 80, the only function of which is to provide a guarding potential for the seized trunk until the relay 125 has time to operate.

When the connection is first completed with the repeater F, and ground is connected with the private bank contact which is engaged by the wiper 66, a circuit is completed extending over conductor 129 and through the cut-off winding of the line switch connected to the trunk conductors 130 and 131 over the conductors 132 and 133. The cut-off winding of the line switch, upon energizing, operates to disconnect the line switch from the trunk. It is evident that as soon as the relay 125 is energized, as previously explained, a circuit is closed through the relay 83. The relay 83, upon energizing, operates to connect the repeater F with the trunk conductors 130 and 131, and, since the relay 81 is also energized, the impedance coil 84 is bridged across the trunk through springs 134 and 135. When the bridge is thus closed across the trunk the line switch C^{2} at the distant exchange operates in precisely the same manner as the line switch C to extend the connection to a selector switch H. After the connection has been extended to the selector a guarding ground potential extends from ground G^{11} through the relay springs 136 and 137 and bank springs 138 and 139 to conductor 140, which leads to a private bank contact in each selector switch at the second exchange which has access to the trunk conductors 130 and 131. When the substation calling device is operated for the remaining digits of the desired number the separation of the impulse springs 27 and 28 allows the relay 81 of the repeater F to deënergize. Each time the relay 81 deënergizes the spring 123 momentarily disengages spring 124 and engages spring 141, and spring 134 disengages spring 135. The operation of springs 134 and 135 opens the bridge across the trunk conductors 130 and 131, thus repeating the impulses from the substation to the switches of the distant exchange. Since the relay 125 is slow acting it does not have time to deënergize during the momentary separation of springs 123 and 124; consequently the engagement of springs 123 and 141 closes a circuit through the relay 82. This circuit extends from ground G^{12} through springs 123 and 141, 142 and 143 of relay 125, and through relay 82 to battery lead 100. The relay 82 is energized by the first impulse for each digit, and, being slow acting, remains in its operated position until all the impulses for the digit are delivered. In its energized position the relay 82 operates to disconnect the trunk conductors 130 and 131 from the condensers 144 and 145, and to short-circuit

the impedance coil 84 to prevent its interference with the operation of the switches at the other exchange.

When the substation calling device is operated for the second digit 2 the repeater F operates in the manner explained to repeat two impulses over the conductors 130 and 131 to the selector H. The selector H operates in the same manner as the selector E to extend the connection over the trunk conductors 146 and 147 to the connector I. When the connection is thus extended to the connector the line relay 149 and release relay 150 are energized and operate to close a holding circuit through the release relay 151 of the selector H in the same manner that the relays 81 and 125 of the repeater closed a holding circuit through the relay 78 of the selector E.

When the substation calling device is operated for the third digit 2 the repeater F operates to repeat two impulses to the line relay 149 of the connector I. Each time the relay 149 deënergizes a circuit is closed extending from ground G^{13} through springs 152 and 153, 154 and 155, private magnet relay 156, vertical magnet 157 and side switch wiper 158 to battery lead 160. The vertical magnet receives two impulses over this circuit and operates to raise the shaft and wipers two steps. The relay 156 is energized in series with the vertical magnet and operates to close a circuit from ground G^{14} through springs 161 and 162 and private magnet 163 to battery lead 160. The relay 156 is slow acting, like the relay 79 of the selector E, and does not have time to deenergize until after the last impulse has been delivered to the vertical magnet, when the said relay operates to open the circuit of the private magnet 163. The private magnet thereupon deënergizes and causes the side switch to pass to second position. The movement of side switch wiper 158 from first to second position transfers the battery connection from the vertical magnet 157 to the rotary magnet 164.

When the calling device is operated for the last digit 0 ten impulses are repeated to the connector I. The operation of the relay 149 in response to these impulses serves to transmit ten impulses through the relay 156 and rotary magnet 164 in the same manner in which the previous impulses were transmitted to vertical magnet. The rotary magnet 164 operates to rotate the wipers ten steps, while the relay 156 operates in the same manner as for the previous digit to close the circuit of the private magnet 163 and to open it again after all the impulses are delivered. This operation of the private magnet causes the side switch to pass to third position, thus extending the connection to the line #2220 upon whose terminals the wipers 165 and 166 have been placed by the operation of the vertical and rotary magnets. When the side switch wiper 168 engages its third-position contact point a guarding potential is established at the connector private bank contacts of the called line, and an energizing circuit is closed through the cut-off winding 169 of the line switch C'. This circuit extends from ground G^{15} through side switch wiper 168, springs 170 and 171, private wiper 167, private bank contact 172 and cut-off winding 169 to battery lead 160. The winding 169, upon energizing, operates to disconnect the switch C' from the lines of substation A and to connect the line 173 with the connector bank contacts over the normal conductor 175.

When the side switch wiper 158 of the connector passes from the second to third position it disconnects the battery from the rotary magnet 164 and closes a circuit through the ringer relay 86. This circuit extends from ground G^{16} through the interrupter 176, springs 177 and 178, relay 86 and side switch wiper 158 to battery lead 160. The relay 86, upon energizing, operates to disconnect the calling and called lines and to bridge the ringer generator L across the called line. Since the circuit of the ringer relay 86 includes the interrupter 176, the said relay is energized only intermittently so as not to ring the bells at the called substation continuously.

When the called subscriber removes his receiver from the switch hook, or as soon thereafter as the ringer relay 86 deënergizes, if it happens to be energized at the time, the called substation is provided with talking current. The path over which this talking current flows extends from ground G^{17} through winding 179 of the back-bridge relay 85, ringer relay springs 180 and 181, side switch wiper 182, shaft wiper 166, line 174, springs 183 and 184 (which are closed by the removal of the receiver from the hook), thence through the substation impulse springs, primary winding of the induction coil, transmitter, and back over conductors 173 and 175, wiper 165, side switch wiper 185, relay springs 186 and 187 and winding 188 of relay 85, the battery lead 160. Since both windings of relay 85 are included in the circuit just traced, the said relay energizes, and by separating the springs 177 and 178 prevents the further energization of the ringer relay 86. The two subscribers may now carry on an uninterrupted conversation over the heavy conductors shown in the drawings.

After a conversation is completed the central office apparatus is released by the return of the receiver to the switch hook at the calling substation. When the receiver at the substation A is replaced upon the switch hook the consequent separation of springs 30 and 31 breaks the energizing circuit of the

relay 81 of the repeater F. The relay 81, upon deënergizing, opens the bridge across the trunk conductors 130 and 131 and breaks the energizing circuit of the relay 125. The relay 125 deënergizes after a short time and opens the circuits of the cut-off relay 83 and of the release relay 78 of the selector E and cuts off the ground from the conductor 129 leading to the cut-off winding of the line switch which belongs to the trunk conductors 130 and 131. When the release relay 78 of the selector E deënergizes it breaks the holding circuit of the winding 49 of the line switch C and closes an energizing circuit through the release magnet 74 of the selector E. The deënergization of the winding 49 allows the plunger of the line switch C to be restored to normal position, thus disconnecting the lines 33 and 34 from the selector E. The circuit which is closed through the release magnet 74 of the selector by the deenergization of relay 78 extends from ground G^3 through springs 98 and 99, 103 and 102, magnet 74 and off-normal springs 76 and 75 to battery lead 100. The magnet 74, upon energizing, operates to immediately release the mechanism of the selector to allow it to be restored to normal position. As soon as the switch shaft reaches its lowest position the springs 75 and 76 are separated to disconnect the battery from the magnet 74 to allow it to deënergize.

The opening of the bridge across the trunk lines 130 and 131 by the deënergization of the repeater relay 81 allows the line relay 149 of the connector I to deënergize to destroy the holding circuits of the release relays 150 and 151 of the switches I and H, respectively. The relays 150 and 151, upon deënergizing, complete the energizing circuits of the release magnets 189 and 190 of their respective switches in the same manner as explained for the selector F. The relay 151, upon deënergizing, also breaks the energizing circuit of the holding winding of the line switch C^2 and removes the guarding potential from the conductor 140, which leads to the private bank contacts of the selector switches which have access to the trunk, over the conductors 191 and 192. The deenergization of the cut-off winding of the switch C^2 allows the said switch to be restored to normal position, and all the apparatus employed in the connection is ready for another call.

The foregoing is an explanation of the manner in which connection is completed with an idle line. It will now be explained how the calling subscriber is given the busy signal in case the line called is already in use. It has been seen that whenever a line is busy, either by reason of having made a call or by having been called, there is present a guarding ground potential upon the corresponding private bank contact in the bank of each connector which has access to the line. Consequently, at the instant the connector wipers are rotated onto the contacts of a busy line, a circuit is closed extending from the guarded private bank contact through the private wiper 167, springs 171 and 170, side switch wiper 168, contact point 193, contact point 194, side switch wiper 185, ringer relay springs 186 and 187, and winding 188 of the relay 85 to battery lead 160. The relay 85 energizes upon the closure of this circuit, and, by forcing the spring 195 into engagement with the spring 196, closes a locking circuit through the private magnet 163 independent of the relay 156. This locking circuit extends from the grounded bank contact to the contact point 193, as before traced, and thence through the springs 196 and 195 and through the magnet 163 to the battery lead 160. When the private magnet relay 156 deënergizes, with the private magnet thus locked, the side switch remains in second position and a circuit is closed extending from ground G^{14} through the springs 161 and 197, 198 and 199 and relay 200 to the battery lead 160. The relay 200, upon energizing, disconnects the rotary magnet 164 from the impulse spring 153 and shifts the holding ground of relay 85 and magnet 163 from the private bank contact to ground G^{18} to prevent the completion of the connection in case the guarding ground should be removed. As long as the side switch thus remains locked in second position the calling subscriber receives a busy signal over a circuit extending from the battery lead 160 through the busy machine M, private magnet springs 201 and 202, contact point 203, side switch wiper 182, ringer relay springs 181 and 180, condenser 204, thence over the heavy conductors shown in Figs. 2 and 1 to and through substation A and back over the other side of the line, thence through the upper winding of the connector line relay 149 to the starting point. The switches are released from this position by the hanging up of the receiver at the calling substation in practically the same manner as when a complete connection is established.

When the trunk lines 130 and 131 are used to extend a connection in the opposite direction, the operation is identical with that above explained, except that the repeater at the right-hand end of the trunk and the line switch at the left-hand end are used instead of the repeater F and line switch C^2. It is always the repeater that is situated in the exchange in which the call originates that is used.

From the foregoing it will be seen that I provide a trunk line having a non-numerical trunking switch at each end thereof, and that each switch is controlled by a repeater. Preferably these repeaters are allotted to the

trunk line and located at opposite ends thereof. In this way the repeater at one end of the trunk line may be controlled to operate the non-numerical trunking switch at the other end of said line. In a similar manner the other repeater and non-numerical trunking switch may be controlled to extend a connection over the trunk line in the opposite direction. The arrangement is such, as explained, that the operation of the repeater at one end of the trunk line does not disturb the normal condition of the trunking switch at the same end of the trunk line, but simply controls the switch at the other end thereof. When the trunk line is seized at one end it is then automatically made busy at both ends thereof, so that any other calling subscriber must then use some other trunk. The repeaters, it will be seen, control the operation of the non-numerical trunking switches for extending calls, and also control the release of the connection after the subscribers are through talking.

What I claim as my invention is:—

1. In a telephone system, a two-way trunk line, a non-numerical trunking switch for each end of said line, a repeater at one end of said trunk line adapted to control the switch at the other end thereof, and trunks, each switch adapted to automatically select idle trunks.

2. In a telephone system, a two-way trunk line, a non-numerical trunking switch for each end of said line, a repeater at one end of said trunk line adapted to control the switch at the other end thereof, instrumentalities operative to make either end of the line busy when the other end is seized, and trunks, each switch adapted to automatically select idle trunks.

3. In a telephone system, a two-way trunk line, a non-numerical trunking switch for each end of said line, a repeater at one end of said trunk line adapted to control the switch at the other end thereof, each switch adapted to automatically extend a trunking connection from said line in the direction of the called subscriber, numerical trunking switches for seizing either end of said trunk line, and instrumentalities operative to render either end of said trunk line busy when the other end is seized.

4. In a telephone system, a two-way trunk line, a non-numerical trunking switch for each end of said line, a repeater at one end of said trunk line adapted to control the switch at the other end thereof, instrumentalities operative to make both ends of said trunk line busy when either end thereof is seized, and trunks, each switch adapted to automatically select idle trunks.

5. In a telephone system, a two-way trunk line, a non-numerical trunking switch for each end of said line, a repeater at one end of said trunk line adapted to control the switch at the other end thereof, each switch adapted to automatically extend a trunking connection from said line in the direction of the called subscriber, numerical trunking switches for seizing either end of said trunk line, and instrumentalities operative to render both ends of said trunk line busy when either end thereof is seized.

6. In a telephone system, a set of two-way trunks, a set of non-numerical trunking switches for the said trunks at one end thereof, a master switch for said set of trunking switches, repeaters for the said trunks adapted to control said switches, another set of non-numerical switches for said trunks at the other end thereof, and another master switch for said last-mentioned set of trunking switches.

7. In a telephone system, a trunk line, another trunk line, a non-numerical trunking switch for automatically connecting one trunk line with the other, means including a repeater for controlling said switch over a complete metallic line circuit, and automatic means for seizing either end of said first-mentioned trunk line.

8. In a telephone system, a trunk line, an automatic switch for seizing one end of said trunk line, another trunk line, a non-numerical trunking switch for automatically connecting the first trunk line with the second trunk line, the first trunk line having a repeater for controlling said trunking switch, means for successively controlling said switches over complete metallic line circuits, and means for automatically seizing the other end of said first-mentioned trunk line.

9. In a telephone system, a two-way trunk line, switches for automatically extending connection from either end thereof in the direction of the called subscriber, automatic switches for seizing either end of said trunk line, and means including repeaters for controlling said switches over complete metallic line circuits.

10. In a telephone system, a two-way trunk line, automatic switches for extending connection from either end thereof in the direction of the called subscriber, repeaters for said trunk line adapted to control said switches, other automatic switches for seizing either end of said trunk line, and means by which all of said switches are controlled over complete metallic line circuits.

11. In a telephone system, a trunk line, a first selector operative in accordance with the first digit of the called number to seize one end of said trunk line, a second selector operative in accordance with the second digit of the called number to extend the connection in the direction of the called subscriber, a non-numerical trunking switch for automatically extending connection from the said trunk line to the second selector,

and means including repeaters whereby said switch and second selector are controlled over complete metallic line circuits.

12. In a telephone system, a two-way trunk, an automatic switch for including said trunk in a calling connection in one direction, another automatic switch for including said trunk in a calling connection in the other direction, an automatic switch controllable over the two sides of the trunk line in series for completing the call in one direction, another automatic switch controllable over the two sides of the trunk line in series for completing the call in the other direction, and a repeater for one end of said trunk.

13. In a telephone system, a two-way trunk line, an automatic switch for extending connection from one end of said trunk line, another automatic switch for extending connection from the other end of said trunk line, each switch controllable over the two sides of the trunk line in series, and a repeater for one end of said trunk.

14. In a telephone system, a two-way trunk line, a non-numerical trunking switch for each end of said line, a repeater for each end of said trunk line, each repeater adapted to control the switch at the other end of the trunk line, and trunks, each switch adapted to automatically select idle trunks.

15. In a telephone system, a two-way trunk line, a non-numerical trunking switch for each end of said line, a repeater for each end of said trunk line, each repeater adapted to control the switch at the other end of the trunk line, instrumentalities operative to make either end of the line busy when the other end is seized, and trunks, each switch adapted to automatically select idle trunks.

16. In a telephone system a two-way trunk line, a non-numerical trunking switch for each end of said line, a repeater for each end of said trunk line, each repeater adapted to control the switch at the other end of the trunk line, each switch adapted to automatically extend a trunking connection from said line in the direction of the called subscriber, numerical trunking switches for seizing either end of said trunk line, and instrumentalities operative to render either end of said trunk line busy when the other end is seized.

17. In a telephone system, a two-way trunk line, a non-numerical trunking switch for each end of said line, a repeater for each end of said trunk line, each repeater adapted to control the switch at the other end of the trunk line, instrumentalities operative to make both ends of said trunk line busy when either end thereof is seized, and trunks, each switch adapted to automatically select idle trunks.

18. In a telephone system, a two-way trunk line, a non-numerical trunking switch for each end of said line, a repeater for each end of said trunk line, each repeater adapted to control the switch at the other end of the trunk line, each switch adapted to automatically extend a trunking connection from said line in the direction of the called subscriber, numerical trunking switches for seizing either end of said trunk line, and instrumentalities operative to render both ends of said trunk line busy when either end thereof is seized.

19. In a telephone system, a set of two-way trunks, a set of non-numerical trunking switches for the said trunks at one end thereof, a master switch for said set of trunking switches, another set of non-numerical switches for said trunks at the other end thereof, another master switch for said last-mentioned set of trunking switches, and a repeater for each end of each trunk adapted to control said switches.

20. In a telephone system, a two-way trunk line, switches for automatically extending connection from either end thereof in the direction of the called subscriber, automatic switches for seizing either end of said trunk line, and means comprising repeaters for controlling all of said first-mentioned switches over complete metallic line circuits.

21. In a telephone system, a two-way trunk line, automatic switches for extending connection from either end thereof in the direction of the called subscriber, other automatic switches for seizing either end of said trunk line, and means by which all of said switches are controlled over complete metallic line circuits, including repeaters for the opposite end of said trunk line.

22. In a telephone system, a two-way trunk, an automatic switch for including said trunk in a calling connection in one direction, another automatic switch for including said trunk in a calling connection in the other direction, an automatic switch controllable over the two sides of the trunk line in series for completing the call in one direction, another automatic switch controllable over the two sides of the trunk line in series for completing the call in the other direction, and a repeater for each end of said trunk.

23. In a telephone system, a two-way trunk line, an automatic switch for extending connection from one end of said trunk line, another automatic switch for extending connection from the other end of said trunk line, each switch controllable over the two sides of the trunk line in series, and a repeater for each end of said trunk.

24. In a telephone system, a trunk line, a repeater at each end of said trunk line, a non-numerical switch at each end of said trunk line, means for controlling one repeater to operate the switch at the other end

of the trunk line, and means for controlling the other repeater to operate the other switch.

25. In a telephone system, a trunk line, a repeater at each end of said trunk line, a non-numerical switch at each end of said trunk line, means for controlling one repeater to operate the switch at the other end of the trunk line, and means for controlling the other repeater to operate the other switch, each repeater being controlled by a metallic line circuit.

26. In a telephone system, a trunk line, a repeater at each end of said trunk line, a non-numerical switch at each end of said trunk line, means for controlling one repeater to operate the switch at the other end of the trunk line, and means for controlling the other repeater to operate the other switch, each repeater having means for controlling the two sides of the trunk line in series.

27. In a telephone system, a trunk line, a non-numerical switch associated with each end of said trunk line for extending connection from said trunk line, other automatic switches for extending a connection to said trunk line, a repeater for one end of said trunk line adapted to repeat impulses over said trunk, a cut-off relay for said non-numerical switches, and means for energizing the cut-off relay of the non-numerical switch associated with the end of the trunk seized when said automatic switches seize one end of said trunk.

28. In a telephone system, a trunk line, means for seizing one end of said trunk line, a repeater and a non-numerical switch associated with each end of said trunk, a cut-off relay for each of said non-numerical switches, and means for energizing one of said relays when said trunk is seized.

29. In a telephone system, a trunk line, a non-numerical switch associated with each end of said trunk line for extending connection from said trunk line, other automatic switches controllable over a metallic circuit for extending a connection to said trunk line, a repeater for one end of said trunk line adapted to repeat impulses over said trunk, a cut-off relay for said non-numerical switches, and means for energizing the cut-off relay of the non-numerical switch associated with the end of the trunk seized when said automatic switches seize one end of said trunk.

30. In a telephone system, a trunk line, means controllable over a metallic circuit for seizing one end of said trunk line, a repeater and a non-numerical switch associated with each end of said trunk, a cut-off relay for each of said non-numerical switches, and means for energizing one of said relays when said trunk is seized.

31. In a telephone system, a two-way trunk line, a non-numerical switch at either end of said trunk line for selecting idle trunks extending therefrom, a repeater at one end of said trunk line controlling the non-numerical switch at the other end thereof, a pair of condensers in said trunk line, and means for disconnecting said condensers from said trunk line when said repeater is operating.

32. In a telephone system, a two-way trunk line, a non-numerical switch at either end of said trunk line for selecting idle trunks extending therefrom, a repeater at one end of said trunk line controlling the non-numerical switch at the other end thereof, a pair of condensers in said trunk line, and a slow-acting relay adapted to be energized when said repeater is operating to disconnect said condensers from said trunk line.

33. In a telephone system, a two-way trunk line, a non-numerical switch at either end of said trunk line for selecting idle trunks extending therefrom, a repeater at one end of said trunk line controlling, over a metallic circuit, the non-numerical switch at the other end thereof, a pair of condensers in said trunk line, and means for disconnecting said condensers from said trunk line when said repeater is operating.

34. In a telephone system, a two-way trunk line, a non-numerical switch at either end of said trunk line for selecting idle trunks extending therefrom, a repeater at one end of said trunk line controlling, over a metallic circuit, the non-numerical switch at the other end thereof, a pair of condensers in said trunk line, and a slow-acting relay adapted to be energized when said repeater is operating to disconnect said condensers from said trunk line.

35. In a telephone system, a trunk line, a repeater and an automatic non-numerical line switch connected to one end of said trunk, and a repeater and a non-numerical line switch connected to the opposite end of said trunk.

36. In a telephone system, a two-way trunk line, an automatic line switch at each end of said trunk for extending connection from said end, and a repeater at each end of said trunk.

Signed by me at Chicago, Cook county, Illinois, this 29th day of March, 1910.

TALBOT G. MARTIN.

Witnesses:

EDWARD D. FALES,

ARTHUR J. RAY.