E. D. FALES.

AUTOMATIC TRUNKING SYSTEM.

APPLICATION FILED MAY 17, 1909.

1,248,834.

Patented Dec. 4, 1917.

3 SHEETS—SHEET 1.

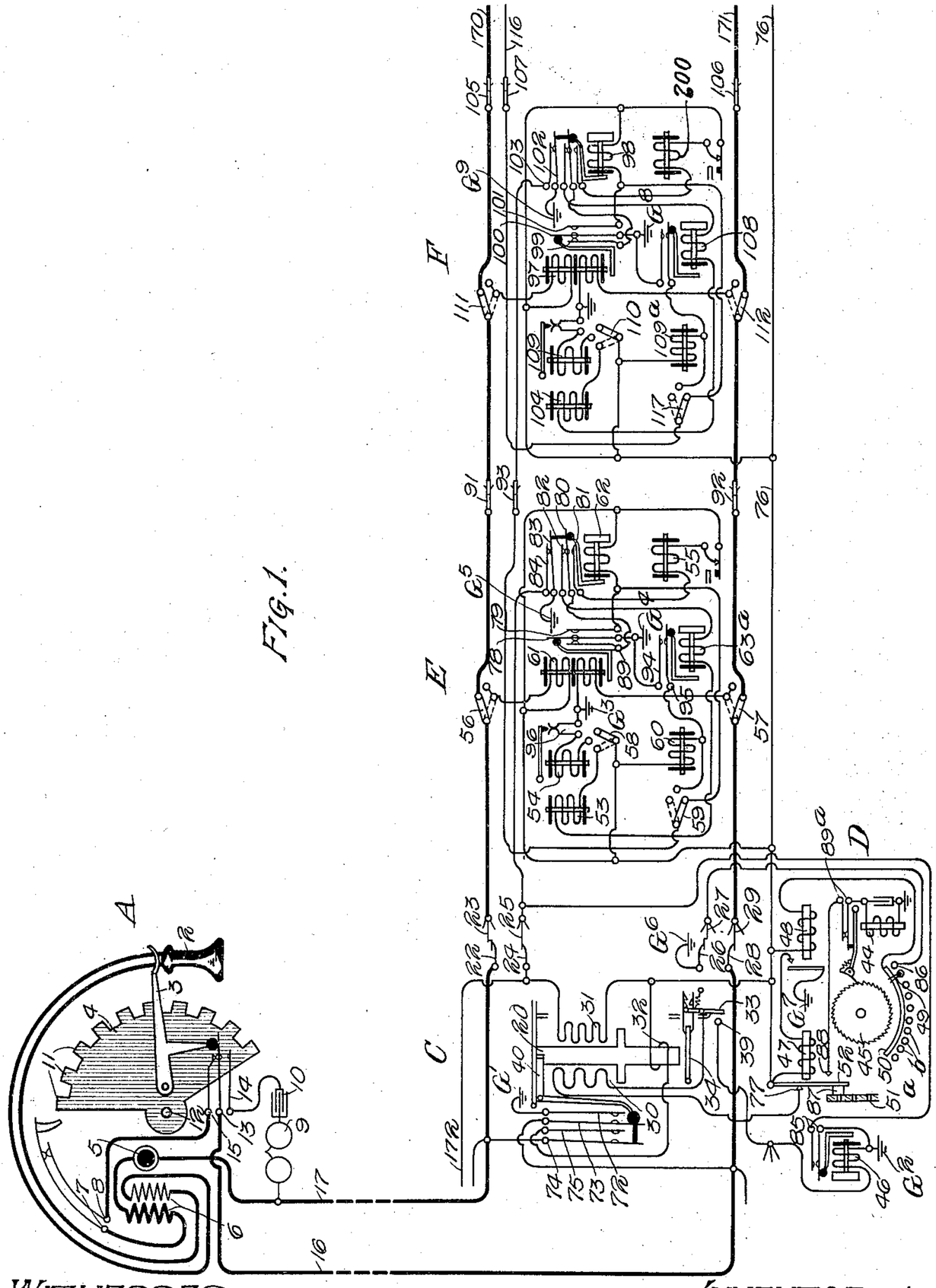

FIG. 1.

WITNESSES

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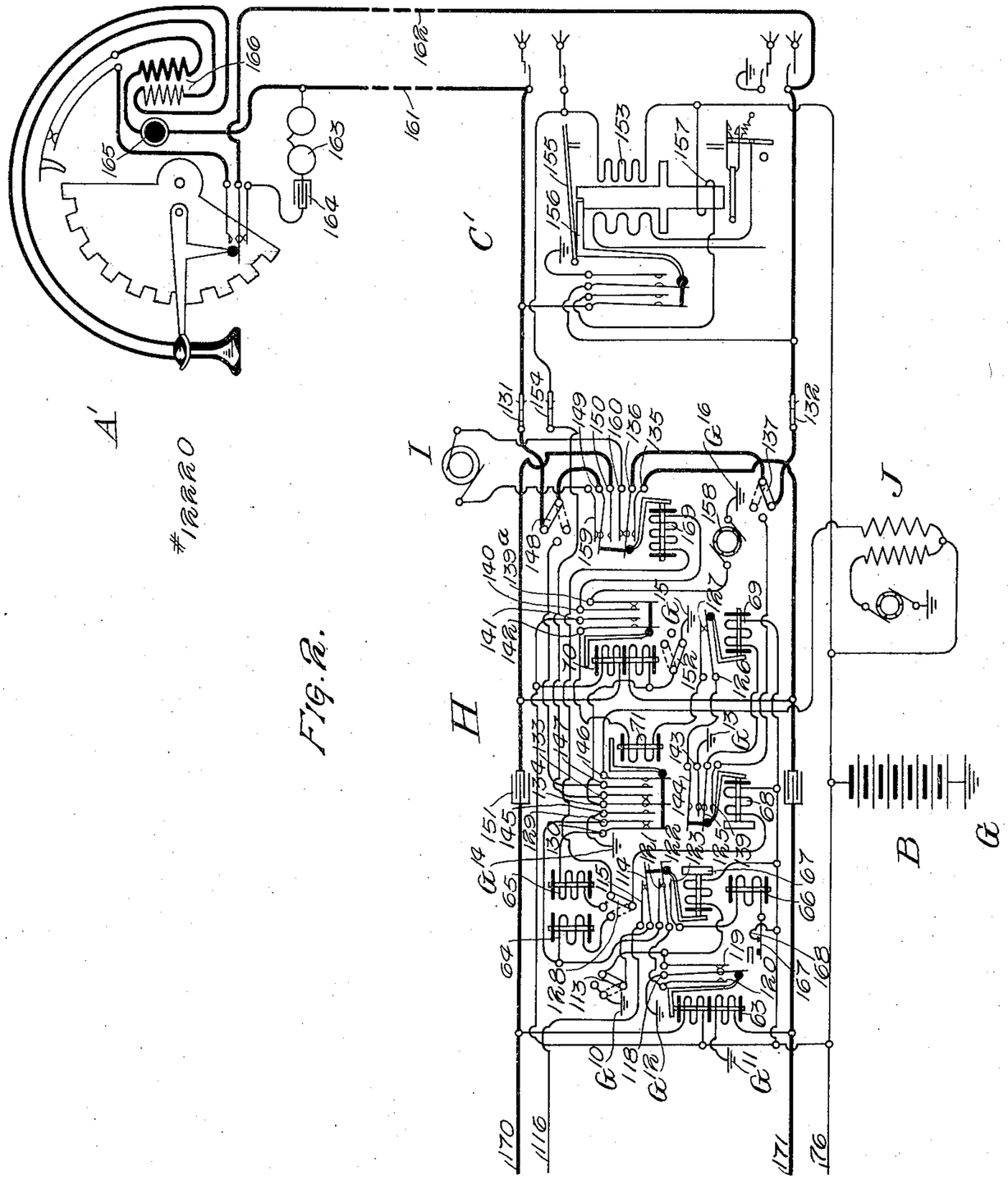

Fig. 2.

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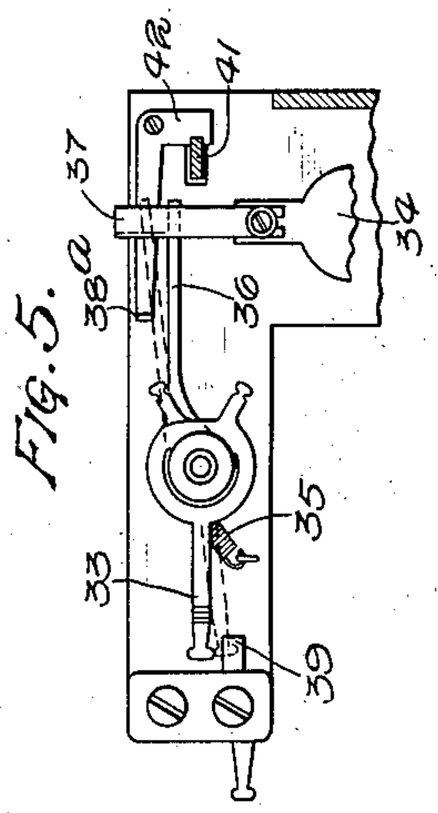

FIG. 5.

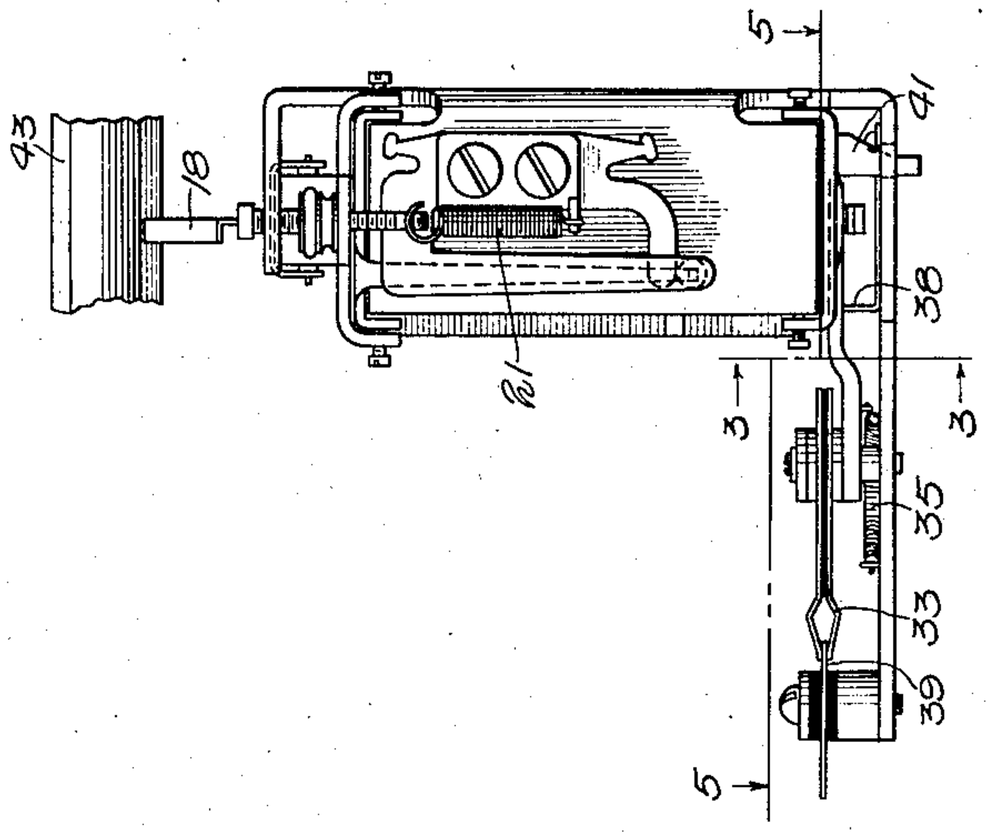

FIG. 4.

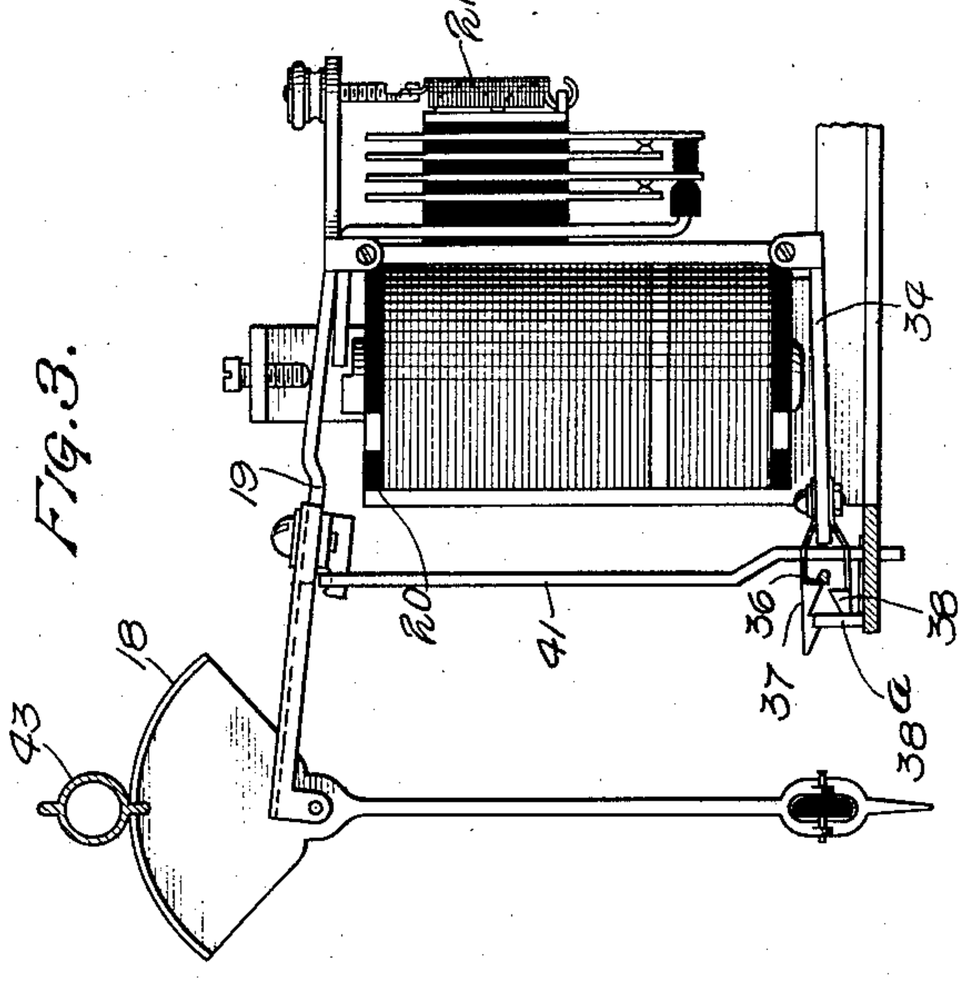

FIG. 3.

WITNESSES

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UNITED STATES PATENT OFFICE.

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AUTOMATIC TRUNKING SYSTEM.

1,248,834. Specification of Letters Patent. Patented Dec. 4, 1917.

Application filed May 17, 1909. Serial No. 496,591.

To all whom it may concern:

Be it known that I, EDWARD D. FALES, a citizen of the United States of America, and resident of La Grange, Cook county, Illinois, have invented certain new and useful Improvements in Automatic Trunking Systems, of which the following is a specification.

My invention relates to telephone exchange systems of that particular character in which the apparatus for extending a trunking connection in the direction of the called subscriber is controlled over the two sides of the line circuit in series. Heretofore in systems of this kind the arrangement has been such that the closure of the line circuit at the calling subscriber's substation, by the removal of the receiver from the switch hook, caused an automatic switch at the exchange or central station to seize an idle trunk line. Obviously, therefore, it was possible for a subscriber to take down his receiver, thereby causing connection to be made with a trunk line, and to then defer making the call for more or less time, thereby excluding the said trunk line from use by other subscribers. When the calling subscriber operates his calling mechanism the connection is then completed from the said trunk line to the called line. As stated, and during the interim between the removal of the receiver and the operation of the calling mechanism, the said trunk line could not be used by other subscribers, notwithstanding that the said calling subscriber was not actually using it for talking purposes. This tended to reduce the efficiency of the service, as while a subscriber who had taken off his receiver was waiting to make the call, the trunk line which he was thereby monopolizing for no useful purpose was not available for use by other subscribers.

The object of my invention is, therefore, the provision of an improved construction and arrangement whereby, in a system of this particular character, the removal of the receiver at the calling substation will not cause the subscriber's line switch or other similar mechanism to seize an idle trunk line, and whereby such seizure of the trunk line does not occur until the calling subscriber actually begins operating the calling mechanism, as by rotating the ordinary and well-known rotary dial, thus materially increasing the trunking efficiency of the exchange, and making it possible to give efficient service with a less number of trunks than was heretofore possible in a so-called two-wire system—that is to say, a system in which the automatic selecting and connecting mechanism at the exchange or central station is controlled over the two sides of the subscriber's line in series, there being no operating grounds at the substations.

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

In the accompanying drawings Figures 1 and 2 are a diagrammatic representation of a circuit connection established between a calling substation in Fig. 1 and a called substation in Fig. 2, in a system embodying the principles of my invention.

Figs. 3 and 4 are a side and front elevation, respectively, of my improved subscriber's individual or line switch.

Fig. 5 is a partial plan view of the switch shown in Figs. 3 and 4, showing features of my invention.

To the substation A (Fig. 1) there is allotted the individual line switch C. This line switch C, together with a number of other similar switches, is controlled by a common mechanism D, usually called a master switch. Accessible to the line switch C is the numerical switch E, commonly called a first selector. This first selector E is one of a group of selectors common to a group of line switches C. At F is shown a so-called second selector, which is one of a group of selectors common and accessible to a number of first selectors E. Accessible to a group of second selectors F are a number of connectors H, by which connection may be completed to a group of substations of which A′ is a member. To the substation A′ there is allotted at the exchange a line switch C′ similar to the line switch C of substation A. The line switch C′ is controlled by a master switch similar to D (Fig. 1). The line switches C and C′ may be controlled by the same master switches, or by different ones, depending upon whether or not the two substations A and A′ belong to the same group. At B is shown a battery, with one terminal grounded, for supplying current for operating the central station apparatus, and providing talking current for the connected substations.

Although the line switch C is shown with

only one set of trunk terminals, it is provided with a bank containing the terminals of a number of trunks, each leading to a selector E. Each trunk has a terminal in the bank of each line switch of the group. Likewise, the selectors E and F and the connector H are provided with a bank consisting of a number of terminals. To each of these terminals of the selector E may be connected a trunk, each leading to a second selector F, each trunk being multipled through the banks of a number of first selectors E. The banks of the second selectors F are similar to those of the first selectors E, the trunks therefrom leading to connector H.

In order to secure connection with the subscriber A′ (Fig. 2) the subscriber at A removes his receiver and operates his calling device once for each digit of the number of the substation A′. The first operation of the dial operates the line switch C, causing it to extend the connection from the line of substation A to a pre-selected trunk leading to an idle selector F. The master switch D then operates the remaining idle line switches to place them in such position that the next one that operates will not seize the trunk already occupied by C, but will make connection with an idle selector. The operation of the dial for the next digit advances the first selector E to a certain group of trunks, and then causes it to automatically pick out an idle one of this group of trunks, leading to a second selector F. In the same manner the operation of the calling device for the next digit carries the second selector to establish connection with an idle connector H. The operation of the calling device for the last two digits operates the connector H to complete the connection with the desired line.

The substation A′ (Fig. 1) may be of any suitable or approved type. As here shown, the substation comprises a receiver 2, switch hook 3, impulse wheel 4, transmitter 5, induction coil 6, impulse springs 7 and 8, ringer 9 and condenser 10. When the receiver is on the hook it holds the hook down and thereby maintains the springs 13 and 14 in contact, thus bridging the ringer 9 and condenser 10 in series across the line conductors 16 and 17. When the receiver is removed from the hook, however, the switch hook is forced upward by a spring (not shown) which allows the spring 13 to leave spring 14 and engage spring 15. By this action the circuit of the ringer 9 is opened and a bridge, consisting of the impulse springs 7 and 8, primary winding of induction coil 6 and transmitter 5, is closed across the line conductors 16 and 17. The impulse wheel 4 carries on its periphery a number of impulse teeth 11, and is secured to a shaft 12, to which there is also secured a dial (not shown). When the dial is pulled down the impulse wheel is advanced a certain number of teeth, corresponding to the digit called, but with no effect on the impulse springs 7 and 8. When the impulse wheel is released, however, it is returned to normal position by a spring, and each tooth that passes the impulse springs forces them apart, thus sending a series of impulses to the exchange switching apparatus.

The line switch C, the mechanism of which is shown in Figs. 3, 4 and 5, consists essentially of a plunger 18 carried on a plunger arm 19, and a magnet 20. The plunger arm 19 is held in its normal position by the spring 21, but when the said arm is attracted by the magnet 20 the plunger 18 is thrust into the bank, forcing the springs 22, 23, 24, 25, 26, 27, 28 and 29 into contact in pairs, as indicated in Fig. 1. The magnet 20 is composed of three windings, a pull-in winding 30, a bridge-cut-off winding 31 and a line winding 32. The pull-in winding 30 is for the purpose of attracting the plunger arm 19 to thrust the plunger 18 into the bank. The circuit of the pull-in winding 30 is controlled by the wiper 33, the said wiper being in turn controlled by the calling subscriber through the medium of the line winding 32. The magnetic circuit of the line winding 32 is entirely independent of that of the windings 30 and 31, so that when the said winding 32 energizes it affects only the armature 34. The wiper 33 is held in normal position, against the tension of the spring 35 (Fig. 5), by the finger 36 resting against the rear tooth of the upper escapement spring 37. The lower escapement spring is so set that the rear edge of the tooth 38 is a short distance in advance of the upper tooth. If, now, the armature 34 is attracted the lower point of the tooth on the upper escapement spring rises above the arm 36, and the said arm moves out into engagement with the tooth 38. Now when the armature restores, the lower tooth comes down on top of the beveled edge of the finger 36, and the said finger escapes and flies out against the stop 38ª. The wiper 33 to which the finger 36 is secured accordingly moves over into contact with the contact 39, thereby closing an energizing circuit through the pull-in winding 30. With this escapement arrangement it is seen that the circuit through the pull-in winding is not closed until the line winding 32 has been energized and deënergized again. After the plunger arm has been once pulled down it may be held in its operated position by the cut-off winding 31. If the cut-off winding is energized while the plunger arm is in its normal position, only the cut-off armature 40 will be operated. To the under side of the plunger arm 19 is attached an arm 41 which projects through an opening in the lower part of the switch

frame. The lower end of this arm is beveled, as shown in Fig. 4, and bears against the lever 42. When the plunger arm is drawn down it forces the arm 41 downward also, and the beveled end striking the end of the lever 42 forces it outward. The other end of the lever 42 carries a vertical stop 38[a] which moves back and forces the finger 36 and wiper 33 back into normal position, when the other end of the lever 42 is forced outward by the arm 41. One end of the plunger 18 is broadened out into a fan like projection with a notch in its center. This notch normally engages the plunger shaft 43, so that the plungers may be moved from one trunk to another by the rotation of said shaft. The movement of the plunger shaft is controlled by the master switch D.

The master switch D consists essentially of a motor magnet 44 which operates the ratchet wheel 45, a bank of contacts *a* and the circuit controlling relays 46, 47 and 48. The master switch bank *a* is composed of a common segment 50 and a number of individual segments *b*, and a wiper 49 is provided for keeping some one of the individual segments always in electrical connection with the common segment 50. By means of a suitable mechanical connection the rotary motion of the ratchet wheel 45 is transmitted to the plunger shaft 43 to give the said shaft a reciprocating motion. To the plunger shaft is rigidly secured a cam 51, having on its surface a number of circular openings which are engaged by a pin 87 on the armature 52 when the relay 47 is de-energized, thereby locking the plungers in front of a trunk.

The selector switch E is of the general type shown in United States Letters Patent No. 815,321, issued 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. The selector E is provided with the usual vertical magnet 53, rotary magnet 54 and release magnet 55. The usual side switch is composed of the wipers 56, 57, 58 and 59, and is controlled by private magnet 60. The usual line relays are here combined in the double wound relay 61. Relay 62 controls the release circuit and relay 63[a] controls the private magnet circuit.

The second selector F is almost identical with the first selector E.

The connector H is of the type disclosed in United States Letters Patent #815,176, granted March 13, 1906, to Keith, Erickson and Erickson, but, like the second selectors E and F, is adapted to operate in conjunction with a two-wire system. Like the selectors, the connector has a double wound line relay 63, vertical magnet 64, rotary magnet 65, release magnet 66, private magnet 69, private magnet relay 68, release relay 67 and a side switch. In addition the connector is provided with a back-bridge relay 70, a busy locking relay 71 and a ringer relay 169. The line switch C′ and substation A′ are similar to the line switch C and substation A shown in Fig. 1.

Having given a general description of the apparatus involved in a connection between two subscribers, the method of establishing such a connection will be given in detail. With my invention one complete impulse is required to operate the line switch C before any impulses can be delivered to the numerical switching apparatus. This preliminary impulse may be produced in a number of different ways, but for the purpose of description I have assumed that an extra digit (1) is prefixed to the regular exchange number of the line. In order that the subscriber at substation A may call substation A′, the number of which has been assumed to be 12220, he removes his receiver from the hook and then operates his dial once for each of the five digits of the desired number.

As soon as the receiver 2 is removed from the switch hook the springs 13 and 15 engage, closing a bridge across the line conductors, as has already been explained. The closure of this bridge also closes a circuit through the line winding 32 of the line switch C. This circuit extends from ground G′ through springs 72 and 73, line conductor 16, thence through the springs 13 and 15, impulse springs 7 and 8, primary winding of induction coil 6, transmitter 5, line conductor 17, springs 74 and 75, and through line relay 32 to the battery lead 76, thence through the battery B to ground G. The energization of winding 32 has no effect other than to draw up the armature 34. The subscriber now operates the dial for the digit 1, whereby the impulse springs 7 and 8 are momentarily forced apart. When the springs 7 and 8 separate, the energizing circuit of the winding 32 is broken, and the armature 34 falls back, which allows the wiper 33 to engage the contact point 39 in the manner previously explained. As soon as the wiper 33 engages the contact 39 an energizing circuit is established through the pull-in winding 30, said circuit extending from ground G^2 through the slow-acting relay 46, contact 39, wiper 33, winding 30, contact point 77, armature 52 to the battery lead 76, and thence through battery B to ground G. Upon the energization of the winding 30 the plunger is thrust into the bank, and the cut-off armature 40 opens the circuit of the line winding 32 by separating springs 73 and 74 from springs 72 and 75. When the plunger enters the bank the bank springs 22, 24, 26 and 28 are forced into engagement with the springs 23, 25, 27 and

29, respectively. The engagement of springs 22 and 28 with springs 23 and 29 closes an energizing circuit from ground G^3 through the lower winding of relay 61 of the selector E, thence through the substation A and back through the upper winding of relay 61 to the battery B. The relay 61 energizes upon the closure of this circuit and closes an energizing circuit through the release relay 62. This circuit extends from ground G^4 through springs 78 and 79, and through relay 62 to battery B. The relay 62 thereupon energizes and shifts spring 80 from 81 into contact with 82, and also closes springs 83 and 84. The closure of springs 83 and 84 furnishes an energizing circuit from ground G^5 through the bank springs 25 and 24, and through the cut-off winding 31. This energizing of the winding 31 is for the purpose of holding the plunger arm 20 and cut-off armature 40 in their operated positions. The energization of the release relay 62 of the selector E also grounds the private normal conductor 172 for providing a guarding potential at the connector private bank contacts of the calling line to protect the said calling line from being called while it is busy. At the time the plunger arm 20 is pulled down the wiper 33 is restored by the arm 41, and opens the circuit of pull-in winding 30. To provide for the possibility of the pull-in winding circuit being opened before the relay 62 has time to close the circuit of the cut-off winding 31, the slow relay 46 is included in the energizing circuit of the winding 30. When the relay 46 energizes it closes the springs 85 into contact, thereby furnishing an energizing circuit through the winding 31 from ground G^2. The relay 46 is slow to deënergize and maintains the connection between the winding 31 and the ground G^2 for a short time after the circuit of the said relay and winding 30 is opened, thus giving the relays 61 and 62 of the selector E time to energize and supply a new holding ground before ground G^2 is cut off.

When the bank springs 26 and 27 are closed a connection is extended from ground G^6 to the master switch bank contact 86. When the idle plungers are opposite the trunk of selector E the wiper 49 is resting on the wiper 86, so that when ground comes on the contact 86 it energizes the relay 48 over the said wiper 49, common segment 50, through said relay 48 to battery B. The relay 48, upon energizing, closes an energizing circuit from ground G^7 through the locking relay 47 to battery B. The relay 47, upon energizing, attracts its armature, withdrawing the pin 87 from the opening in the cam 51 in which it is resting, and places said armature in contact with contact point 88. The engagement of the armature 52 with contact point 88 establishes an energizing circuit for the motor magnet 44. The energizing circuit of the motor magnet includes the interrupter springs 89^a, so that the magnet 44 operates like a buzzer to give the wheel 45 a continuous rotary motion, moving the idle plungers and the wiper 49 away from the trunk just seized. As soon as wiper 49 leaves the contact 86, the relay 48 and, consequently, the relay 47 deënergize. The energizing circuit of the motor magnet, however, is not broken immediately upon the deënergization of relay 47, because the previously mentioned opening in the cam 51 has passed out of register with the pin 87, so that the armature 52 cannot fall back. After the deënergization of relay 47, the master switch continues to operate until the next opening in the cam 51 passes under the pin 87, when the armature 52 falls back, opening the circuit of the motor magnet 44 and locking the plunger shaft with its engaged plungers opposite an idle trunk. If the next trunk after the one seized had been idle, the wiper 49 would have found the corresponding bank contact grounded, the relay 48 would not have deenergized and the plungers would have been carried onto the next trunk which was idle. When the armature 52 of the relay 47 pulls up, it leaves the contact 77, and thereby disconnects the battery from the pull-in winding of all the line switches which it controls; therefore, no line switch can be operated while its master switch is moving. This prevents a line switch from operating before its plunger has reached an idle trunk.

The calling subscriber is now ready to operate his calling device for the second digit (2). As the impluse wheel 4 returns to normal for this digit, the impulse springs 7 and 8 are forced apart twice, thus allowing the relay 61 of the selector E to deënergize twice. Each time the relay 61 deenergizes, the spring 78 leaves spring 79 and engages spring 89. The relay 62 is slow to deënergize and the time during which the springs 78 and 79 are separated is so short that the relay 62 does not return to its normal position while the impulses are being sent in. Each time the spring 78 engages the spring 89 an energizing circuit is closed from ground G^4 through springs 78 and 89, through springs 80 and 82, through relay 63^a, vertical magnet 53, and side switch wiper 58 (in first position) to battery B. The vertical magnet responds to the two impulses and operates to raise the switch shaft and wipers 91, 92 and 93 two steps. The relay 63^a energizes upon the first impulse but, being slow to deënergize does not have time to return to its normal position until after all the impulses for the second digit are completed. The energization of the relay 63^a completes an energizing circuit from ground G^4 through the

private magnet 60. After the last impulse the relay 63ª deënergizes, allowing the springs 94 and 95 to separate and open the circuit of the private magnet. When the private magnet deënergizes, it allows the side switch to pass from first to second position, whereby a circuit is closed through the rotary magnet 54. This circuit extends from ground G³ through interrupter springs 96, rotary magnet 54 and side switch wiper 58 to battery. The rotary magnet energizes upon the completion of this circuit, rotates the shaft wipers one step and opens its own circuit at the interrupter springs 96. Also, when the rotary magnet energizes, its armature presses down the private armature, and when the rotary armature falls back, the private armature also restores (if the first trunk is idle) and allows the side switch to pass into third position. If the first trunk is busy, however, the private wiper 93 finds a grounded contact, said ground being supplied by some other occupying switch. When the private wiper 93 thus strikes a grounded contact, it forms a locking circuit for the private magnet 60, through the side switch wiper 59 in second position. The private magnet thus locks the side switch in second position, and the rotary magnet continues to rotate the shaft step by step until the wiper 93 finds a non-grounded contact, when the private magnet is allowed to deënergize, and the side switch passes to third position, as before explained. As soon as the side switch passes to third position, the circuit of the rotary magnet is opened by the wiper 58, the line relay 61 is cut off of the line by the wipers 56 and 57, and the connection is extended through to the second selector F. As soon as the connection is extended to the second selector F, the line relay 97 energizes and closes an energizing circuit for the relay 98. This circuit extends from ground G⁸ through springs 100 and 101, and through the relay 98 to battery. The relay 98, upon energizing, extends a connection from ground G⁹ through springs 102 and 103, private wiper 93, side switch wiper 59 in third position, and through the relay 62 to battery. This circuit maintains the relay 62 energized after the cutting off of the ground G⁴ upon the deënergization of relay 61, when it is cut from the line.

When the calling device is operated for the third digit (2), the line relay 97 of the second selector F responds, and the second selector operates in the same manner as explained for the first selector E, to extend the connection to an idle connector H, which has access to the group of lines of which A′ is a member. Thus, when the two impulses for the third digit are sent in, the vertical magnet 104 is energized twice to raise the shaft wipers 105, 106 and 107 two steps. The relay 108 is energized by the first impulse and closes the energizing circuit of the private magnet 109ª. After the last impulse the private magnet deënergizes, and allows the side switch to pass to second position, thus closing the circuit of the rotary magnet 109. The rotary magnet then operates to rotate the shaft wipers onto the terminals of an idle trunk leading to a connector H, after which the side switch passes to third position, opening the circuit of the rotary magnet 109 at the wiper 110. Also, when the side switch wipers 111 and 112 pass from second to third position, the line relay 97 is cut off from the line, and the connection from the substation A is extended to the connector H over the line wipers 105 and 106, and conductors 170 and 171.

When the connection is thus extended to the connector, the double wound line relay 63 energizes and closes an energizing circuit through the release relay 67. As soon as the release relay 67 energizes, it furnishes a new circuit for maintaining the release relay 98 of the selector F energized after the relay 97 deënergizes. This circuit extends from ground G¹⁰ through side switch wiper 113, relay springs 114 and 115, conductor 116, private wiper 107 of selector F, side switch wiper 117 in third position, and through relay 98 to the battery lead 76. The energizing circuit of the line relay 63 of the connector H extends from ground G¹¹ through the lower winding of the said relay to conductor 171, thence over the heavy conductors in Fig. 1, through the switches F, E and C, through the substation A, thence back through switches C, E, and F, and through the upper winding of relay 63 to the battery lead 76. The circuit which is closed through the relay 67 by the relay 63 extends from ground G¹² through springs 118 and 119, and relay 67 to the battery lead 76, thence through the battery B to ground G. When the relay 67 energizes, it completes a connection via springs 122 and 121, between the vertical magnet 64 and the spring 120 of the relay 63, whereby impulses may be transmitted to the vertical magnet 64.

The switches are now in position to receive impulses for the fourth digit (2). The two impulses for this digit cause the relay 63 to deënergize twice, whereby the spring 118 engages spring 120 twice, thus sending two impulses through the vertical magnet 64 in series with the private magnet relay 68. The relay 67 is slow acting, like the relays 98 and 62 of the selectors E and F, and consequently does not deënergize while the impulses are being delivered to the vertical magnet. The private magnet relay 68, like the relays 108 and 63ª of the selectors F and E, is energized by the first impulse and

remains in its operated position until after the last impulse. By the closure of springs 143 and 125 the relay 68 closes an energizing circuit from ground G^{13} through the private magnet 69 to battery. The private magnet 69, upon energizing, places the springs 126 and 127 in contact, without any effect at this time, however. After the last impulse, the private magnet relay 68 deenergizes and opens the circuit of the private magnet 69. When the private magnet deënergizes, the side switch passes from first to second position. The movement of the side switch wiper 128 from first to second position disconnects battery from the vertical magnet 64 and connects the rotary magnet 65 with the battery B through the private magnet relay 68. When the calling device is operated for the last digit (0), the relay 63 responds ten times, and sends ten impulses from ground G^{12} through springs 118, 120, 122, 121, 129 and 130, rotary magnet 65, side switch wiper 128, and relay 68 to battery. These ten impulses to the rotary magnet cause the shaft wipers 131, 132 and 154 to be rotated onto the tenth contacts of the second bank level, which are the contacts of the desired line #12220. The private magnet 69 is energized during the time the impulses are coming in, in the same manner as when the vertical magnet was operated. When the private magnet deënergizes, upon the cessation of the impulses, the side switch passes to third position and completes the connection between the two substations. If the called line is busy, however, when called, the private magnet cannot deënergize, but locks the side switch in second position, thus preventing the completion of the connection. The manner in which the side switch is thus locked is as follows: Whenever a line is busy, either having made a call or having been called, a guarding ground potential is placed upon all of the connector bank contacts of that line. Thus if the called line is busy, the private wiper 154 finds the contact which it encounters grounded. This ground is extended via springs 133 and 134 of relay 71, lower winding of relay 70, ringer relay springs 135 and 136, side switch wiper 137 in second position to the spring 139 of the private magnet relay 68. The private magnet relay springs are so adjusted that, as the relay deënergizes, the spring 125 engages spring 139 before it leaves the spring 143. Thus, when the relay 68 deënergizes after the last impulse to the rotary magnet, a new circuit is closed from spring 139 through the private magnet 69 to battery, thus holding the said magnet in its operated position, and the side switch can not pass to third position. Since the lower winding of the back bridge relay 70 is included in the new holding circuit of the private magnet, the said relay 70 energizes, separating springs 139^a and 140, and closing springs 141 and 142. When the relay 68 deënergizes, the springs 143 and 144 again engage, whereby a circuit is closed from ground G^{13} through springs 143, 144, 126 and 127, busy locking relay 71, and springs 142 and 141 to the battery B. The relay 71 energizes upon the closure of this circuit and, by the engagement of springs 145 and 134, furnishes a new locking ground for the private magnet 69, independently of the ground at the private bank contact. Also, when the relay 71 energizes while the side switch is yet in second position, the calling subscriber is given a busy signal over a circuit as follows: from the battery lead 76 through the secondary winding of the busy signaling machine J, through springs 146 and 147, side switch wiper 148, ringer relay springs 149 and 150, thence through the condenser 151 and over the heavy conductors, through the switches F, E and C, through the receiver of the called substation, thence back through the switches C, E and F, and through the winding of coil 63 to ground, and thence through the battery B to the starting point. When the calling subscriber hears this busy signal he hangs up his receiver, and the switching mechanism is restored in a maner which will be explained later. If the called line is not busy, the private wiper 154 does not find its contact grounded and, consequently, the circuit of the private magnet 68 is opened when the relay 68 falls back, after the last impulse to the rotary magnet, and the side switch passes to third position. When the side switch wiper 152 reaches its third position contact point, a guarding ground is placed upon the private wiper 154 and, consequently, upon all the private bank contacts of the called line, and an energizing circuit is closed through the bridge-cut-off winding 153 of the line switch C'. This energizing circuit extends from ground G^{15} through side switch wiper 152, relay springs 133 and 134, private wiper 154, and through the winding 153 to battery. The winding 153, upon energizing, is not strong enough to operate the plunger arm 155 from its normal position, but pulls down the cut-off armature 156, thereby cutting off the line winding 157 from the called line. When the side switch wiper 128 reaches third position, a circuit is closed from ground G^{16} through the interrupter 158, relay springs 139^a and 140, ringer relay 169, side switch wiper 128, and private magnet relay 68 to the battery lead 76. The relays 169 and 68 are intermittently energized over this circuit by the interrupter 158. The relay 68 causes the energization of the private magnet, of course, whenever it energizes, but the operation of these two at this time is without function. Each time that the ringer relay

is energized, however, the connection between the calling and called lines is opened by the springs 149, 150, 135 and 136, and the ringer generator I is bridged across the called line. The circuit over which the bell at the called substation is rung extends from the generator I through the ringer relay springs 159 and 149, side switch wiper 148, line wiper 131, line conductor 161, ringer 163, condenser 164, conductor 162, line wiper 132, side switch wiper 137, relay springs 136 and 160 to the other terminal of the generator I. In response to the signal the subscriber at substation A′ removes the receiver from the switch hook, whereby the circuit of the ringer 163 is opened, and the transmitter 165 and primary winding of the induction coil 166 are bridged across the line conductors 161 and 162. The first time the ringer relay deënergizes, after the talking set is bridged across the talking conductors of the called substation, that substation is provided with talking battery current over the following circuit: from ground G^{15} through the side switch wiper 152, lower winding of the back-bridge relay 70, ringer relay springs 135 and 136, side switch wiper 137, thence through the substation and back through the side switch wiper 148, relay springs 149 and 150, and through the upper winding of relay 70 to battery. The relay 70, being included in the circuit just traced, energizes and operates the springs 139^a and 140, thereby opening the circuit of the ringer relay 169, so that the said relay cannot again energize after the called subscriber answers.

After a connection has been completed, or after the connector has been locked on a busy called line, the release of all the switches is initiated by the return of the receiver to the hook at the calling substation. When the receiver at substation A is thus restored the circuit of the relay 63 of the connector H is opened by the separation of the substation springs 13 and 15, due to the downward movement of the switch hook. When the circuit of the relay 63 is opened the said relay deënergizes and allows the springs 118 and 119 to separate, whereby ground is disconnected from the release relays 67 and 98 of the connector H and selector F, respectively. This is strictly true only when releasing after a complete connection. When releasing from a busy line the side switch wiper 113 of the connector is still in second position, and, consequently, the ground is not cut off from the release relay of the second selector F until the relay 67 of the connector deënergizes and permits the springs 114 and 115 to separate. When the relay 67 deënergizes, after the deënergization of the line relay 63, a circuit is closed through the release magnet 66 as follows: from ground G^{12} through springs 118 and 120, 122 and 123, through the magnet 66 and off-normal springs 167 and 168 (which are closed as long as the switch shaft is away from its normal position) and to battery. When the release magnet energizes, it restores the connector to its normal position, and when the shaft reaches normal, it forces the off-normal springs 167 and 168 apart, leaving the release magnet 66 deënergized. The release of the connector also removes the guarding ground from the private bank contacts of the called line and opens the energizing circuit of the cut-off winding 153 of the line switch C′.

When the relay 98 of the selector F deënergizes, it cuts off the ground from release relay 62 of the selector E and closes the circuit of the release magnet 200, which releases the selector F in the same manner as described for the connector H. The cutting off of the ground from the release relay 62 of the selector E allows the relay 62 to deënergize, whereby the circuit of the release magnet 55 of selector E is energized, and the said selector is restored in the same way as the connector H. The deënergization of the relay 62 also cuts off the holding ground from the cut-off winding 31 of the switch C, whereby the plunger arm 20 and cut-off armature 40 are allowed to return to normal position. The return of the plunger arm withdraws the plunger from the bank, thereby disconnecting the calling line from selector E and removing the guarding potential from the master switch bank contact 86. The restoration of the cut-off armature 40 restores the line winding 32 to the line of substation A.

From the foregoing it will be seen that I provide a metallic line-circuit-controlled automatic telephone exchange trunking system in which provision is made for preventing removal of the receivers at the substations from causing seizure of idle trunks at the exchange or central station. By a metallic circuit I mean a circuit that includes both sides of the subscriber's line in series for controlling the trunking and other switches of the system, as distinguished from a system in which operating grounds are employed at the substations, such systems being commonly known as three-wire systems. The normally open switch contacts 33 and 39 constitute means for preventing actuation of the subscriber's line switch when the receiver is removed from the switch hook at the substation. The mechanism for closing this normally open switch point constitutes means for bringing the subscriber's line switch under substation control, whereby an idle trunk line may be seized or temporarily appropriated for talking purposes. As the normally open switch point 33—39 is closed, in response to the opening of the line circuit, subsequent to the initial closure thereof by the removal of the receiver, it follows

that here is a line switch for trunking purposes that is responsive to the opening of the line circuit—that is to say, which is actuated from normal position by the opening of the line circuit at the substation.

The subscriber may take down his receiver, and may then hang up the same without seizing a trunk, because the seizure of a trunk is dependent upon the opening and immediate closure of the line circuit at the substation. By taking down and then hanging up his receiver the calling subscriber simply causes his line switch to engage a trunk and then release the same, inasmuch as the substation circuit must remain closed in order to keep the first selector relay energized and the trunk thereby retained in connection with the calling line.

What I claim as my invention is:—

1. In a telephone system, a plurality of trunks, selecting and connecting mechanism, a subscriber's line, means for controlling said mechanism over the two sides of the line in series, to obtain connection with an idle trunk, means for preventing actuation of said mechanism by the initial closure of the line, when the subscriber calls, and means operated by the initial closure of the line and the subsequent opening of the same for operating said mechanism, whereby connection with an idle trunk is effected.

2. In a telephone system, a line circuit, a non-numerical switch allotted to said circuit, controllable over the two sides thereof in series, means for preventing actuation of said switch by the initial closure of said circuit, and means operated by the initial closure of the circuit and the subsequent opening of the same for operating said switch, whereby a non-numerical switching operation is effected.

3. In a telephone system, a line, a plurality of trunks, a switch individual to said line, controllable over the two sides thereof in series, for connecting the line with an idle trunk, means for preventing the initial closure of the line from actuating said switch, a calling mechanism, and means responsive to the initial closure of the line, and to the subsequent opening of the same by the calling subscriber, for operating said switch, whereby connection with an idle trunk is effected.

4. In a telephone system, a line, a switch therefor provided with a controlling magnet, trunks adapted to be seized by said switch, and means whereby said magnet is energized and said switch thereby operated to seize a trunk in response to the opening of the line after the initial closure thereof.

5. In a telephone system, the combination of a line, a plunger attached thereto, a magnet for operating the plunger, a circuit for energizing said magnet to actuate the plunger, a normally open switch in said circuit, a circuit for energizing said magnet to operate the switch, said switch adapted to close said circuit in response to the opening of the line after the initial closure thereof, a plurality of trunks, and means whereby operation of the plunger connects the said line with an idle trunk.

6. In a telephone system, trunk lines, a main switch for seizing idle trunks, an auxiliary switch for controlling said main switch, and mechanical connection whereby operation of the main switch to seize a trunk serves to restore the auxiliary switch to normal.

7. In a telephone system, a main switch, an auxiliary switch, a magnet common to said switches, a line circuit for energizing the magnet to operate the auxiliary switch, a circuit for said magnet controlled by the auxiliary switch, and mechanical connection whereby actuation of the main switch serves to restore the auxiliary switch to normal.

8. In a telephone system, subscribers' lines and switches individual thereto, trunk lines and means for operating said switches to complete connections from said subscribers' lines to said trunk lines by the initial opening of the line after the initial closure thereof.

9. In a telephone trunking system, subscribers' lines, a non-numerical switch individual thereto and operated over the two sides of the line in series, numerical switches for extending connection from a calling to a called subscriber's line, said numerical switches adapted to be operated by a varying number of impulses, depending upon the digit of the called subscriber, means whereby the non-numerical switch selects an idle trunk extending to a numerical switch, and means for rendering the system inoperative for trunking in response to the taking down of a receiver by any calling subscriber.

10. In a telephone system, a line, a switch therefor provided with a controlling magnet having two windings, and means whereby the closing and opening of a circuit through one winding closes a circuit through the second winding thereof.

11. In a telephone system, line switches, a master switch therefor, trunk-release conductors extending from the line switches, and selectors for said conductors, said line switches having an operating magnet provided with a winding, a slow-acting relay, a circuit for energizing said relay and winding in series, and means operated by said relay to put ground on the trunk-release conductors, as set forth.

12. In a telephone system, subscribers' lines, line switches individual thereto, a master switch controlling said line switches, a

slow-acting relay for said master switch, a trunk-release conductor, and means for energizing said relay to thereby place ground on the trunk-release conductor.

13. In a telephone system, line switches, a master switch therefor, trunk-release conductors extending from said line switches, an operating relay for said line switch, and a relay controlling a circuit through the trunk-release conductors for said master switch, said relays connected in series, said controlling relay being slow acting.

14. In a telephone system, a subscriber's line, a non-numerical switch individual to said line, means for extended connection to said line, and means for preventing said non-numerical switch from operating to close a circuit when the called subscriber answers, and if the subscriber on said line retains his receiver off the hook until after the calling subscriber hangs up his receiver to release the connection.

15. In a telephone system, a subscriber's line, a progressively movable switch associated with said line for connecting said line with another line, means for extending connection from another calling line to said first line, and automatic means for preventing said progressively movable switch from operating to close a circuit when connection is made with the called line, and for preventing the operation of said progressively movable switch if the calling line is disconnected from the called line while the apparatus of the called subscriber is still across the line.

16. In a telephone system, a calling and a called line, a line switch for each line including a line relay normally bridged across the line and a trip magnet controlled thereby, means for cutting off the line relay on the called line when connection is extended thereto, and means for preventing said trip magnet of the called line switch energizing when the connection is disconnected before the called subscriber hangs up his receiver.

17. In a telephone system, a called line, a line switch therefor, a circuit associated with said line switch, means for establishing a connection with said called line, and means for preventing said line switch from operating to close said circuit either during said connection or after said connection is released until the called subscriber hangs up his receiver.

18. In a telephone system, a called line, a line switch therefor, a circuit associated with said line switch, means for establishing a connection with said called line, and means for preventing said line switch from operating to close said circuit either during said connection or at the time said connection is released by the calling subscriber.

19. In a telephone system, a called line, a line switch therefor, a circuit associated with said line switch, means for establishing a connection with said called line, and means for preventing said line switch from operating to close said circuit either during said connection or as a result of the called telephone being across the line, at the time said connection is released by the calling subscriber.

20. In a telephone system, a called line, a line switch therefor, a circuit associated with said line switch, means for establishing a connection with said called line, and means for preventing said line switch from operating to close said circuit either during said connection or as a result of the called line being closed at the time said connection is released by the calling subscriber.

Signed by me at Chicago, Cook county, Illinois, this 7th day of May, 1909.

EDWARD D. FALES.

Witnesses:
J. NORBY,
CLARENCE E. TAYLOR.