E. D. FALES.

AUTOMATIC TELEPHONE RELEASE.

APPLICATION FILED FEB. 27, 1908. RENEWED MAY 16, 1918.

1,290,148.

Patented Jan. 7, 1919.

3 SHEETS—SHEET 1.

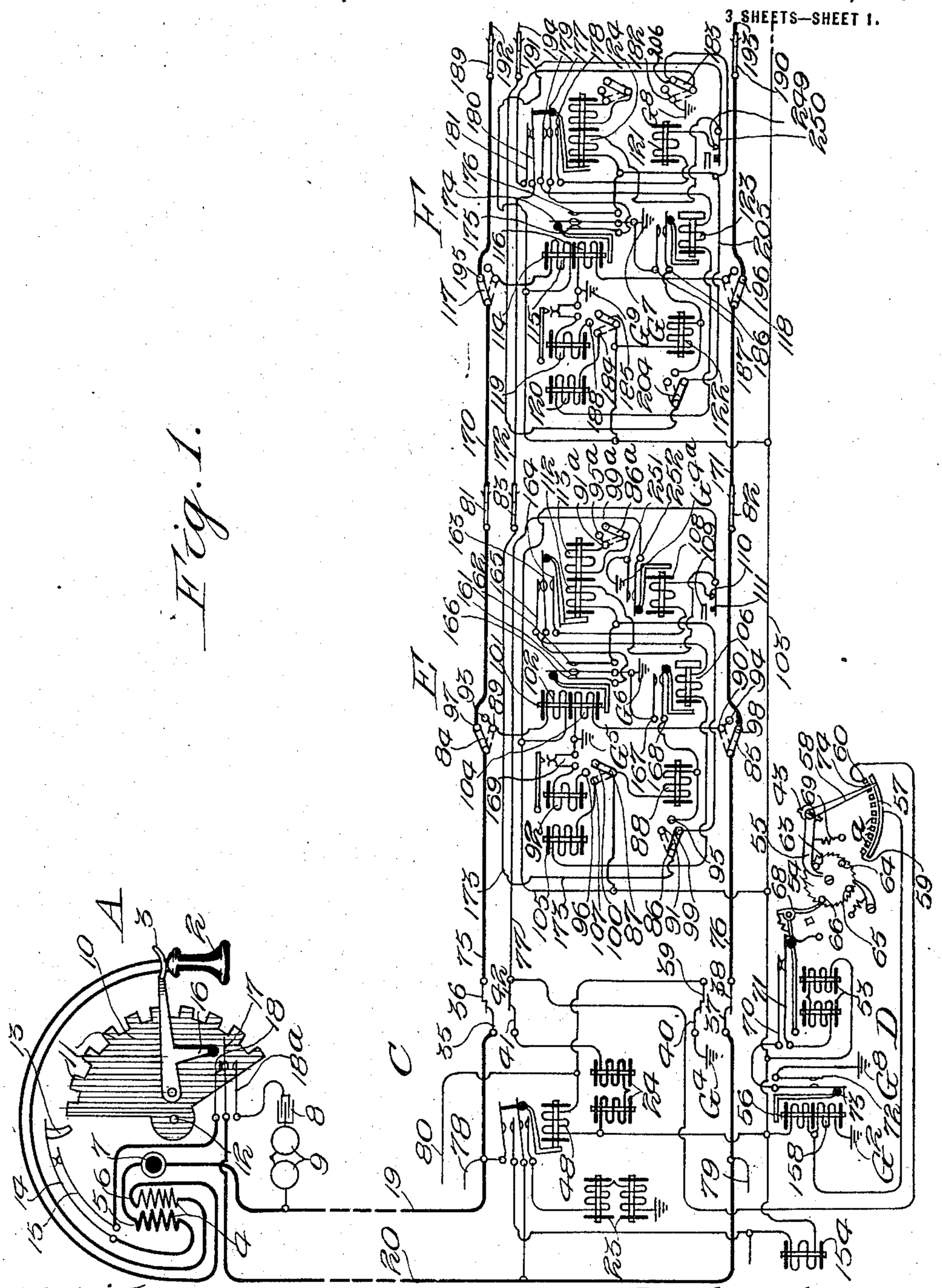

Fig. 1.

Witnesses.
R. H. Burfeind
A. B. Sperry,

Inventor:
Edward D. Fales,
By Bulkley Grau & Drury.
Attorneys.

NORRIS PETERS, INC., LITHO., WASHINGTON D. C.

E. D. FALES.

AUTOMATIC TELEPHONE RELEASE.

APPLICATION FILED FEB. 27, 1908. RENEWED MAY 16, 1918.

1,290,148.

Patented Jan. 7, 1919.

3 SHEETS—SHEET 2.

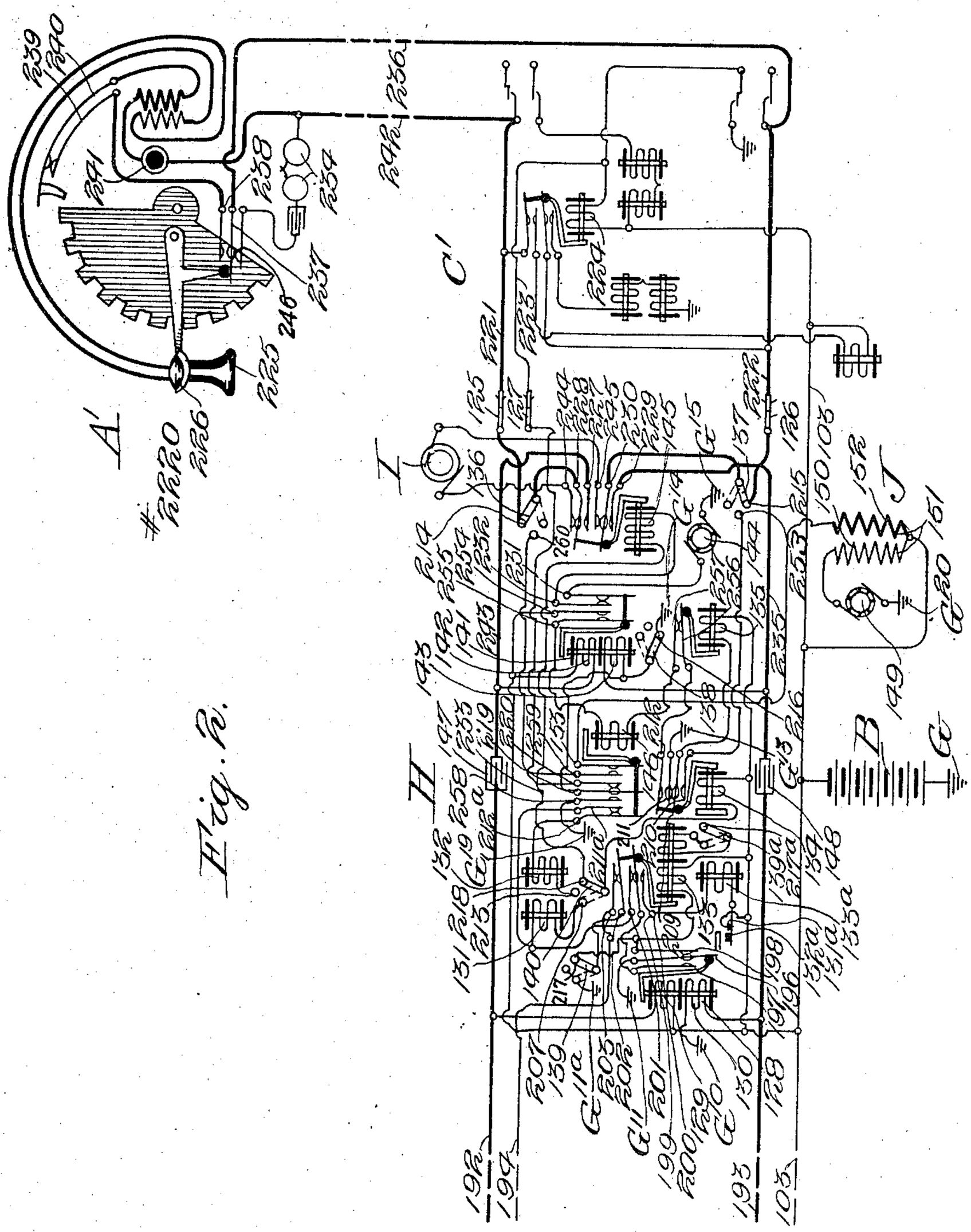

Fig. 2.

Witnesses.
P. H. Burfeind
A. B. Drury.

Inventor:
Edward D. Fales.
By Bulkley Brand & Drury
Attorneys.

NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

E. D. FALES.

AUTOMATIC TELEPHONE RELEASE.

APPLICATION FILED FEB. 27, 1908. RENEWED MAY 16, 1918.

1,290,148.

Patented Jan. 7, 1919.

3 SHEETS—SHEET 3.

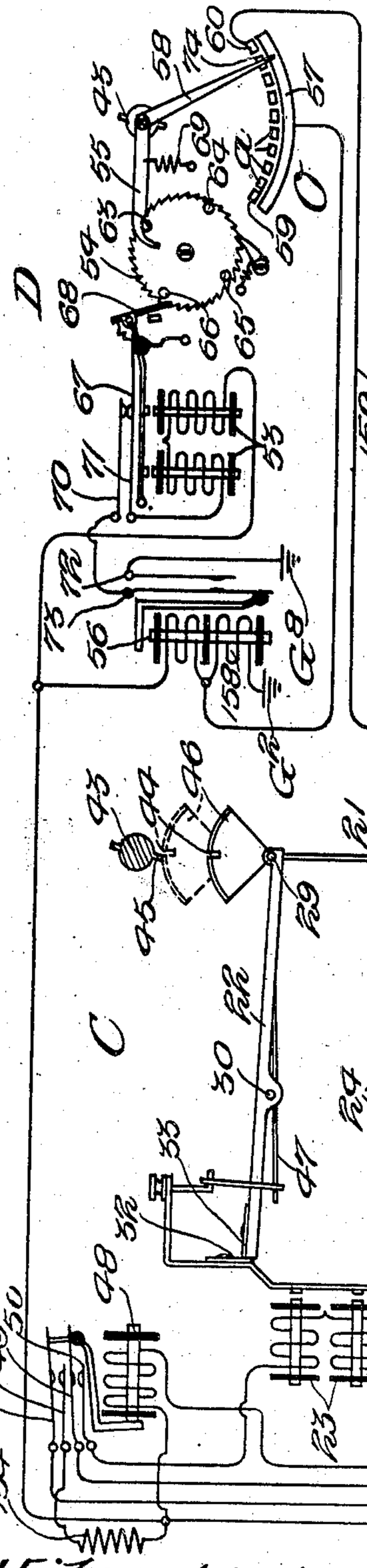

Fig. 3.

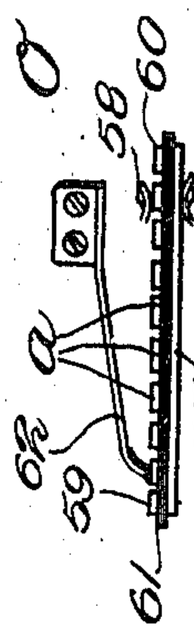

Fig. 4.

Witnesses.
P. H. Burfeind.
A. B. Sherry.

Inventor:
Edward D. Fales,
By Bulkley Duran & Drury.
Attorneys.

Norris Peters Inc., Litho. Washington D. C.

UNITED STATES PATENT OFFICE.

EDWARD D. FALES, OF WESTERN SPRINGS, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO AUTOMATIC ELECTRIC COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

AUTOMATIC TELEPHONE-RELEASE.

1,290,148. Specification of Letters Patent. Patented Jan. 7, 1919.

Application filed February 27, 1908, Serial No. 418,166. Renewed May 16, 1918. Serial No. 235,010.

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 Western Springs, Cook county, Illinois, have invented a certain new and useful Improvement in Automatic Telephone-Releases, of which the following is a specification.

My invention relates to automatic telephony of that particular character in which electrically-propelled and step-by-step-actuated switches are employed for extending connection from one point to another—such, for example, as from a calling subscriber's line to a called subscriber's line; and especially to systems of this kind in which the switches have vertical motion for selecting groups and rotary motion for connecting with a line in the selected group, which line may be either a trunk-line or the called subscriber's line, inasmuch as the trunk selectors and the connectors or final switches have the said vertical and rotary motion, as will hereinafter more fully appear.

Prior to my invention it has been proposed to release the automatic connection through the medium of what are called slow-acting relays—that is to say, relays which are sluggish or slow in deënergizing, the said relays being retained energized during use of the connection for talking purposes, so that immediately upon one of the subscribers hanging up his telephone, the said relays are deenergized, thus bringing about the release of the connection. These relays are made slow-acting to prevent their premature action—that is to say, to prevent them from being prematurely deënergized by the opening of the line circuit during the progress of the call, it being understood that these slow-acting relays were used in connection with what are called two-wire systems—that is to say, automatic telephone systems in which no operating grounds are employed at the subscribers' stations, and in which the operation of the switches and their return to normal is all accomplished over metallic circuits simply by opening and closing the line circuit at the calling substation. The said relays being slow-acting, in the manner specified, it follows that when they are once energized they remain so until one or the other of the two subscribers hangs up his receiver, for the reason that during the progress of the call the brief breaking or opening of the line circuit, during the transmitting of the impulses, does not operate to deënergize the said relays. It follows, however, that while these relays were slow-acting during the progress of the call, for the purpose of preventing a premature release of the switches, in the manner specified, it was also true that they were slow-acting when the time came to use them for releasing purposes, and for this reason it was found that the release of the switches was sluggish or slow in character. This was productive of some trouble, inasmuch as with a slow or sluggish release the subscriber would perhaps begin calling again before the connection for the previous call had been fully released.

Generally stated, therefore, the object of my invention is the provision of a slow-acting release relay arrangement which will prevent a premature release of any of the switches during the progress of the call, as heretofore, but which is also of such character that when the time comes for the release, then the said relays are quick-acting in character, thus insuring practically an instantaneous release as soon as the said relays are deënergized by the opening of the line at the subscriber's station, the system being two-wire in character, as previously explained, and as will hereinafter more fully appear.

It is also an object to provide certain novel details and features of improvement and combinations tending to increase the general efficiency and serviceability of the release for a two-wire telephone exchange system of this particular character.

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

In the accompanying drawing, Figure 1 represents a substation A and central office apparatus embodying the principles of my invention. The line of substation A terminates in the line switch C. At D is represented the master switch for controlling the line switches of the group of which C is a member. E represents diagrammatically a first-selector switch and F is a second-selector switch.

In Fig. 2 is shown diagrammatically a connector switch H, and at C′ is shown a

line switch allotted to the line of substation A'. A central battery B having its positive terminal preferably grounded at G provides battery current for operating and talking purposes.

Fig. 3 represents more fully the line switch C and the controlling master switch D.

Fig. 4 is a detail view of the master switch bank O.

In this system each subscriber's line is, of course, provided with a line switch similar to the line switch C, and one-hundred of these usually form a group. Also, to each such group there is allotted a group of first-selector switches in common. The first-selector switches may in turn be operated to first select any one of a number of groups of second-selectors, and then some one of the selector group which may be idle. The second-selector switches may in turn be operated to first select any one of a number of groups of connector switches, and then some one of the connectors of the selected group which may be idle. Each group of connector switches is also arranged to take care of one-hundred subscribers—that is, if any subscriber in the system wants to call another subscriber he must, through the medium of the first-selector and second-selector switches, pick out a certain group of connectors, any one of the connectors of which group is capable of establishing the final connection with the desired subscriber in a particular hundred.

The substations may be of any suitable or approved type. As shown, it will be seen that substation A is somewhat different from the usual automatic substation, substation A being arranged and modified to operate in connection with a two-wire system—that is, a system in which no ground connection is used at the subscriber's substation. Substation A, for example, comprises the usual receiver 2, switch-hook 3, induction coil 4 which consists of the primary winding 5 and secondary winding 6, transmitter 7, condenser 8, ringer 9 and impulse wheel 10 which has the usual impulse teeth 11. The impulse wheel 10 is secured to the shaft 12, to which shaft there is also secured the dial (not shown). When the dial is turned the impulse teeth 11 are adapted to engage the cam 13 upon the end of the spring 14, and thereby carry the latter out of engagement with the spring 15. Upon the switch-hook 3 is secured the cam 16 which, when the switch-hook is up, permits the springs 17 and 18 to engage, thereby bridging across the subscriber's line conductors 19 and 20 the primary circuit including the transmitter 7 in series with the primary winding 5; but when the switch-hook is lowered the spring 17 is carried out of engagement with the spring 18 and into engagement with the spring 18^a, whereby the ringer 9 in series with the condenser 8 is bridged across the line conductors 19 and 20 instead.

The line switch C (Fig. 3) comprises a plunger 21, plunger arm 22, trip magnet 23 and switch-release magnet 24, all of which are assembled upon a suitable base or frame (not shown). The said switch-release magnet is provided with an armature 25 that is pivoted on a pin 26 which rises from the base of the switch. The said armature carries pivotally secured on its end a second armature 27 that is controlled by the trip magnet 23. The pin 28 about which the armature 27 moves is carried on the end of the armature 25. The plunger 21 is pivotally secured by the pin 29 to the plunger arm 22, which latter is in turn pivoted by a pin 30 that rises from the switch frame (not shown). The lug 31 may be stamped from the frame, and is provided as a stop for the armature 25. Upon the armature 27 is secured the catch spring 32 which is adapted to normally engage the end 33 of the plunger arm 22. Furthermore, the said line switch is provided with a bank of terminals, usually ten in number, only one of which is shown at Q (Fig. 3). The said terminal Q is shown displaced from its true position with respect to the swing of the plunger 21, and the bushing 34 is correspondingly displaced, all for the purpose of making the illustration clearer. The terminal Q comprises the springs 35 and 36, 37 and 38, 39 and 40, and 41 and 42. These springs are normally disconnected from each other, but are driven into contact in the above-mentioned order when the plunger 21 enters the bank terminal Q. When the plunger 21 disengages from the bank terminal Q the said plunger may take one of two positions with relation to the plunger shaft 43—that is, the plunger may return to locked or sliding engagement with the shaft 43. When the plunger 21 is in locked engagement with the plunger shaft 43, the notch 44 is in engagement with the flange or web 45 of the shaft 43; and when in sliding engagement the fan-like tail-piece 46 rests in the position shown by the dotted lines in Fig. 3—that is, when the plunger shaft is operated the plunger 21 is not carried along with the locked plungers, but remains in the dotted position, the plunger shaft sliding upon the edge of the tail-piece 46. The general operation of the switch is as follows: The trip magnet 23 is energized when the receiver is removed from the switch hook and the armature 27 is attracted against the magnet cores. When the armature 27 is attracted the catch 32 slides out of contact with the end 33 of the plunger arm 22, and the said plunger arm 22, owing to the tension of the spring 47, moves about the pin 30 and thrusts the plunger 21 into the bank terminal Q; and when the trip magnet

again deënergizes, the trip armature 27 falls against the end 33 of the plunger arm 22, as shown. Furthermore, when the line switch operates and the plunger 21 is thrust into the bank terminal Q, the shaft 43 is advanced one step, as will be explained, to carry the locked plungers opposite the next idle trunk-line. The switch is restored when the release magnet 24 becomes energized, whereby the armature 25 is attracted, and, accordingly, the trip armature 27 is moved upwardly until the catch 32 slides over the end 33; then when the release magnet 24 becomes deënergized the armature 25 returns to normal position and remains at rest against the stop 31. Furthermore, since the plunger arm 22 is now in engagement with the armature 27, the said plunger arm is also moved about the pin 30, whereby the plunger 21 is removed from the terminal Q. Also, since the plunger shaft has advanced one step, the tail-piece 46 of the plunger 21 comes to rest in the position shown by the dotted line—that is, in sliding engagement with the plunger shaft 43; and as the said plunger shaft advances each time an idle trunk is seized, the plunger 21 is not advanced, but remains in this position opposite the trunk terminal from which it has last disengaged, since the slot 44 is not in engagement with the plunger shaft web 45. After all the trunk-lines have been successively seized, the shaft 43 then passes from its last position and moves toward its starting point, picking up the plunger 21, when the web of the said shaft over which the slot 44 normally rides arrives at the position in which the plunger 21 was originally released—that is, the plunger passes into locked engagement with the shaft when the slot 44 slips over the web of said shaft. From thence on the plunger 21 is carried in locked engagement by the shaft 43 until it is again released when another call is made. But if after the plunger is released, and before the shaft 43 returns to pick up said plunger, the switch C is again operated, the plunger 21 again engages the same terminal Q. The bridge-cut-off relay 48 is provided for controlling the springs 49, 50, 51 and 52, and, upon energizing, operates to shift the springs 49 and 51 out of engagement with the springs 50 and 52. When the springs are thus operated the trip magnet of the line switch C is disconnected from the substation line conductors.

The master switch D, which may be of any suitable or approved type, is provided for operating the plunger shaft 43 and for controlling certain circuits that will hereinafter be disclosed. It comprises the following details: a motor magnet 53 for operating the ratchet wheel 54, which latter is designed for operating the plunger shaft 43 through the medium of the cam 55, and a differential relay 56 for controlling the energizing circuit of the motor magnet 53. The said master switch also has a bank O comprising a plurality of individual contact segments *a* and a common metallic segment 57, as shown in Fig. 3. The wiper 58 is adapted to remain in constant engagement with the bank O, and to at all times, except when the wiper is passing from the extreme left contact 59 to the extreme right contact 60, maintain some one of the segments *a* in electrical connection with the common segment 57. As shown in Fig. 4 the individual segments *a* are separated from the common segment 57 by the insulating strip 61. The spring 62 is provided so that when the wiper is carried to the contact 60 on the extreme right, the upper part of the wiper 58 slides on the guide spring 62, thus preventing the wiper from placing any of the individual segments *a* in contact with the common segment 57, whereby some interference might be caused with the master switch. The wiper 58 is operated in a step-by-step manner by the ratchet wheel 54 through the medium of the cam member 55 rigidly secured to the said wiper 58, and is adapted to successively engage the pins 63, 64, 65 and 66 upon the said ratchet wheel 54. The motor magnet 53 is provided with an armature 67 upon the end of which there is suitably secured a pawl 68. Each time that the said magnet is energized the armature 67 is attracted against the magnet cores, and the pawl 68 engages a tooth on the ratchet wheel 54, thereby advancing the latter one step. It will be seen, therefore, that as the ratchet wheel 54 advances in a backward direction, the wiper 58 advances step by step from right to left, and when the pin 63, for example, clears the cam 55 the retracting spring 69 restores the wiper 58 to its first position at the right of the bank and in engagement with the first segment 60. The said motor magnet is provided with a couple of interrupter springs 70 and 71 that are included in the energizing circuit of the said motor magnet, which energizing circuit also comprises the springs 72 and 73 controlled by the differential relay 56. Therefore, whenever the differential relay is energized the springs 72 and 73 are pressed into contact, and the motor magnet 53 operates step by step as long as the differential relay 56 remains energized. Furthermore, it is assumed that the terminal Q of the line switch C is the first terminal of the line switch bank. While in normal locking engagement with the shaft 43, the plunger 21 is retained in front of said terminal by the plunger shaft 43 whenever the master switch wiper 58 is in engagement with the bank segment 60; but as the motor magnet 53 advances the wiper 58 onto the second segment 74, the said plunger and all idle plungers similarly engaging the shaft 43 are

carried opposite the next terminal of the line switch bank. It should be noted that in each line switch bank all of the springs 35 are permanently connected and may be composed of one common piece. The springs 36, however, are individual—that is, there is one separate and distinct spring for every bank set Q, there being ten in the bank. The springs 37, 39, 40 and 41, like the springs 35, are all common, and the springs 38 and 42, like the springs 36, are individual. For every bank terminal Q there is a trunk-line of three conductors 75, 76 and 77 leading to a selector; and there is also a normal trunk-line comprising the conductors 78, 79 and 80 leading to the connector banks. The subscriber's line conductors 19 and 20 terminate in the springs 35 and 37 which, as has been stated, are common springs. When the subscriber operates the line switch C, and the plunger 21 engages the terminal Q, the subscriber's line conductors 19 and 20 are extended to the vertical and rotary trunk conductors 75 and 76, and thence to the first-selector switch E.

The first-selector switch shown at E is of the general type described in United States Letters Patent No. 815,321, granted March 13, 1906, to Keith, Erickson & Erickson, and, as shown, is modified to adapt it to operate in connection with a two-wire system. Among other details it embodies the following features: The switch shaft (not shown) carries the vertical and rotary wipers 81 and 82, respectively, and the private wiper 83. The side switch is well known and comprises the side switch wipers 84, 85, 86, 86[a] and 87, which may be designated as the vertical, rotary and private side switch wipers, the secondary winding side switch wiper, and the rotary magnet wiper, respectively. The side switch is under the control of the private magnet 88, and when the side switch is in normal or first position the wipers 84, 85, 86 86[a] and 87 occupy the contact points 89, 90, 91, 91[a] and 107, respectively. In the second position the wipers rest on the contact points 93, 94, 95, 95[a] and 96, respectively, and in third position the contact points 97, 98, 99, 99[a] and 100 are engaged by their respective wipers. The windings of the usual vertical and rotary line relays are, in this case, combined into one double-wound relay 101 comprising the winding 102 which is connected with the battery lead 103, and also with the vertical trunk-line conductor when the side switch wiper 84 is in first or second position. The second winding 104 is connected to ground and also to the rotary trunk-line conductor when the side switch wiper 85 is in first or second position. Through the medium of this double-wound relay, and while the side switch is in first position, the subscriber controls the vertical magnet 105 which operates to raise the switch shaft and wipers 81, 82 and 83 vertically. This line relay 101 also controls the private magnet relay 106, which latter in turn controls the private magnet 88. As usual, the private magnet controls the side switch. While the side switch is in second position the rotary magnet 92, which operates to carry the switch shaft and wipers 81, 82 and 83 in a rotary direction, is energized. The release magnet 108 provides means for restoring the selector switch to normal position. Upon the switch shaft which carries the wipers 81, 82 and 83 there is mounted the arm 109 which, when the shaft is raised one or more steps, permits the spring 111 to engage the contact point 110, whereby the release magnet 108 is connected to the battery lead. The release relay 112 is provided for closing the energizing circuit of the release magnet 108 after the switch is operated. Said relay 112 is provided with a second winding 113 which is short-circuited when the side switch wiper 86[a] is in first or second position; but when the side switch wiper 86[a] passes to third position the short-circuit is broken. This arrangement is provided in order that the relay 112 may be a slow-acting relay when the selector E is operating, but when the switch is to be released, after the side switch passes to third position, the relay 112 is quick-acting. The relay 106 is a slow-acting relay—that is, it is provided with a copper shield so that when energized and when the energizing circuit is broken, the said relay remains in an operated position for a moment or so. In other words, it does not instantly return to normal position after the energizing circuit is broken.

The second-selector F (Fig. 1) is similar to the first-selector E and is provided with the usual double-wound line relay 114 having the windings 115 and 116 connected with the vertical and rotary side switch wipers 117 and 118 in the same manner in which the windings of the relay 101 of the selector switch E are connected to their vertical and rotary side switch wipers. Since like parts are similarly represented, the rotary magnet 119 and the vertical magnet 120 will be recognized and understood. The release magnet 121 is operated in the same manner in connection with the switch F that the release magnet 108 is operated in connection with the switch E. The private magnet 122 is controlled by the private magnet relay 123. The release relay 124 of the second-selector switch F performs the same function in connection with this switch as the release relay 112 performs in connection with the first-selector switch E. In the switch F the relay 123 is so arranged that it deënergizes slowly, the same as the relay 106 of the selector switch E.

The connector switch H (Fig. 2) is a

modified form of the connector switch disclosed in United States Letters Patent No. 815,176, granted March 13, 1906, to Keith, Erickson & Erickson. The connector switch shaft (not shown), like the selector switch shaft, carries the line wipers 125 and 126 and the private wiper 127. The connector switch is also controlled by the calling subscriber through the medium of a double-wound line relay 128. The line relay 128 is provided with the windings 129 and 130. One terminal of the winding 129 is connected to the battery lead, while the other terminal is connected with the vertical trunk-line conductor. The winding 130 is connected with ground and also with the rotary trunk-line conductor. This line relay 128 directly controls the vertical magnet 131. The purpose of the vertical magnet 131 is to give the shaft and shaft wipers a vertical motion, and the rotary magnet 132 imparts to the shaft and shaft wipers a rotary or circular motion. The connector switch is also provided with the slow-acting release relay 133, which is the same as the release relay 124 of the second-selector switch F. The private magnet relay 134, as usual, controls the private magnet 135, which latter controls the side switch wipers 136, 137, 138, 139, 139[a] and 140. The back-bridge relay 141, comprising the windings 142 and 143, serves as a means whereby the called subscriber is provided with battery current for talking purposes. As illustrated, my connector switch is of the automatic ringing type—that is, a signaling of the called subscriber is not dependent upon the calling subscriber pressing a signaling button when he calls a line; but as soon as connection is established with the desired line, the interrupter 144 intermittently closes an energizing circuit through the ringer relay 145, whereby the terminals of the ringer generator I are intermittently bridged across the normal conductors of the called line. The relay 146 is so arranged that if a busy line is called the connector side switch is locked in second position, and the calling subscriber is given the busy-signal. The means whereby the connector switch may be restored to normal position is provided by the usual release magnet 133[a] which, when the connector switch shaft is raised one or more steps, is connected to the battery lead through the normal springs 131[a] and 132[a]. By means of the condensers 147 and 148 the circuit through the connector switch is divided into two sections. The busy-signaling apparatus J comprises the interrupter 149 in series with the winding 150 of the induction coil 151. The winding 152 is connected with the spring 153, and when the relay 146 energizes, as will be explained, the busy-signaling apparatus is connected with the connector side switch wiper 136. The relay 133 of the connector, it will be seen, is similar to the relays 112 and 124 of the selector switches—that is, it is arranged with a secondary winding which is short-circuited when the side switch is in first or second position, thus making the relay slow-acting; but when the side switch passes to third position this short-circuit is removed and the relay then becomes quick-acting. It will be seen that it is necessary for the relays 112, 124 and 133 to be slow-acting when the side switch is in first and second position, but after the side switch passes to third position I find that it is desirable to have these relays quick-acting.

The operation of the system may be more clearly understood from an explanation of its operation in the course of establishing a connection. It will be assumed that the subscriber at substation A wishes to call the subscriber at substation A′ to which is allotted the number 2220. To call the number 2220 (substation A′, Fig. 2) the subscriber at substation A (Fig. 1) removes his receiver from the switch-hook and operates the calling device for each digit in the well-known manner—that is, when the receiver is removed from the switch-hook a preliminary impulse provides an energizing circuit for the trip magnet 23 of the line switch C, whereby the line switch C is operated to seize an idle trunk-line leading to a first-selector switch. The dial is then turned for the first digit, and upon returning to normal position operates the first-selector switch to establish connection with an idle trunk-line leading to a second-selector switch. In a similar manner, upon returning to normal position for the second digit, the dial operates the second-selector switch F to establish connection with an idle trunk-line leading to a connector switch. The impulses delivered by the dial for the last two digits are directed toward the connector H which operates to place the shaft wipers in connection with the contacts corresponding to the desired substation. The preliminary impulse for energizing the trip magnet 23 occurs when the receiver 2 is removed from the switch-hook 3 and the cam-arm 16 permits the spring 17 to engage the spring 18, thereby removing the ringer from across the line and bridging the primary circuit instead. When the primary circuit is thus bridged across the line, the energizing circuit for the trip magnet 23 is completed and extends from ground G′ (Fig. 3) through the trip magnet 23, through the springs 50 and 49, conductor 155 to the rotary line conductor 20 (Fig. 1), through the springs 17 and 18, impulse springs 15 and 14, primary winding 5, transmitter 7 to the vertical line conductor 19, thence through the conductor 156 (Fig. 3), springs 51 and 52, through the resistance coil 154 to the battery lead 103, thence

through battery B to ground G. As soon as the trip magnet 23 energizes, the armature 27 is attracted, and the plunger 21 is liberated and thrust into the bank terminal Q by the spring 47, assuming that the plunger 21 is opposite the terminal Q at the time. When the plunger 21 engages the bank terminal Q an energizing circuit is established through the motor magnet relay 56, which in turn operates to close an energizing circuit through the motor magnet 53 of the master switch D. The motor magnet then operates to advance all idle plungers that are in locking engagement with the shaft 43 opposite the next idle bank terminal similar to the terminal Q. The circuit through the relay 56 extends from ground G^2 through the winding 158 of the relay 56 to the common segment 57, thence through the wiper 58, through the segment 60, conductor 159, bank terminal springs 42 and 41, through the winding of the release magnet 24 to the battery lead 103, thence through battery B to ground G. Although this circuit includes the release magnet 24 the said magnet does not operatively energize, since the winding of the relay 56 is of a high resistance, while the winding of the release magnet 24 is comparatively low. The relay 56, upon energizing, operates to place the springs 72 and 73 in contact, whereby a circuit is completed through the motor magnet 53 extending from ground G^8 through the springs 72 and 73, motor magnet springs 70 and 71, through the winding of the motor magnet 53 to the battery lead 103, thence through battery B to ground G. The motor magnet 53, upon energizing attracts its armature 67, whereby the pawl 68 engages the rat het wheel 54, advancing the latter one step. When the armature 67 is attracted against the magnet cores, the springs 70 and 71 disengage, thereby breaking the energizing circuit through the motor magnet 53 and permitting the armature 67 to return to normal position. The cam 55 being in engagement with the pin 63 upon the ratchet wheel 54 is operated to advance the plunger shaft 43 (and consequently all idle plungers that may be in normal locked position with the shaft 43) opposite another terminal similar to the terminal Q, assuming the next succeeding trunk is idle. Consequently, the wiper arm 58 is carried from the contact point 60, which corresponds to the terminal Q, to the contact point 74, which latter corresponds to the terminal before which the advanced idle plungers are now resting. Suppose that nine subscribers have called and that the master switch has thus operated nine steps, carrying the wiper 58 to the last contact point 59. Now, when the motor magnet 53 operates for the next step, when the tenth subscriber calls, the wiper 58 passes back and drops into engagement with the contact point 60. If the first trunk is still busy the wiper 58 finds a battery potential on the contact 60, and an energizing circuit is established through the differential relay 56 which in turn operates to close an energizing circuit through the motor magnet 53. The current through the said relay 56 flows from the said contact 60 through the wiper 58 to the common segment 57, and through the winding 158 of the differential relay 56 to ground G^2. When this relay energizes it operates to close the circuit through the motor magnet 53, and the motor magnet then operates, as previously explained, to rotate the ratchet wheel 54 one step, and the master switch bank wiper 58 one step also and into engagement with the second segment 74. When thus advanced one step the plunger shaft 43 carries all idle plungers that are in locking engagement with said shaft opposite the first bank terminal, as previously explained. If there should still be a guarding potential at the bank segment 74 the differential relay 56 will remain energized, whereby the energizing circuit through the motor magnet 53 is again completed when the motor magnet springs 70 and 71 again engage, and as a result the motor magnet 53 is again operated, whereby the plunger shaft 43 and the master switch wiper 58 are advanced another step. This process continues as long as the wiper 58 continues to find segments with guarding potentials. As soon as an idle segment is found, however, the energizing circuit through the relay 56 is broken, at which time the said relay in turn breaks the energizing circuit for the motor magnet 53 until the next subscriber makes a call. At the instant that the plunger 21 enters the bank terminal Q the following springs are pressed into contact: 35 and 36, 37 and 38, 39 and 40, and 41 and 42. The engagement of the springs 39 and 40 closes a circuit through the cut-off relay 48 extending from ground G^4 through the springs 40 and 39, conductor 160, relay 48 to the battery lead 103, thence through battery B to ground G. The said relay, upon energizing, operates to carry the springs 49 and 51 out of engagement with the springs 50 and 52. When these springs disengage the coil 154 is disconnected from the vertical line conductor 19, and the trip magnet 23 is disconnected from the rotary line conductor 20. The engagement of the bank springs 39 and 40 also establishes a guarding potential by way of the normal conductor 80 to the connector private bank contacts corresponding to the line that terminates in the line switch C, to prevent any subscriber from calling the said line after the calling subscriber at substation A removes his receiver preparatory to making a call, as explained. Also, the closure of connection between the springs 41 and 42 establishes a guarding po-

tential at the master switch bank contact 60 over the following circuit: from battery B to the battery lead 103, thence through the winding of the release magnet 24, through the springs 41 and 42, conductor 159 to the said contact point 60. It will be understood that the bank terminal Q, being the first bank terminal of the line switch bank, corresponds to the first segment 60 of the master switch bank O and, therefore, to the trunk-line, the conductors 75, 76 and 77 of which terminate in the first-selector switch E. This guarding potential protects the seized trunk conductors 75, 76 and 77 from being seized by other plungers, as already explained. The closure of connection between the springs 35 and 36 extends the calling subscriber's vertical line conductor 19 to the vertical trunk conductor 75 and the side switch wiper 84 of the first-selector switch E. The closure of contact between the springs 37 and 38 in a similar manner extends the subscriber's rotary line conductor 20 to the rotary trunk conductor 76 and to the side switch wiper 85 of the selector E. The subscriber has thus established connection with the next selector switch, which is now operated by the impulses that are delivered when the dial returns to normal position for the first digit. When the subscriber's line conductors 19 and 20 are thus extended to the first-selector switch E an energizing circuit is established through the line relay 101, said circuit extending from ground G^5 through the winding 104 to the contact point 90, side switch wiper 85, trunk conductor 76, through the bank springs 38 and 37 to the rotary line conductor 20, through the springs 17 and 18, impulse springs 15 and 14, primary winding 5, transmitter 7 to the vertical line conductor 19, through the bank springs 35 and 36, trunk conductor 75, side switch wiper 84, contact point 89, through the winding 102 to the battery lead 103, thence through battery B to ground G. The relay 101, upon energizing, operates to place the springs 161 and 162 in contact, whereby an energizing circuit is established through the release relay 112, said circuit extending from ground G^6 through the springs 161 and 162, relay 112 to the battery lead 103, thence through battery B to ground G. The release relay 112, upon energizing, operates to carry the spring 163 out of engagement with the spring 164 and into engagement with the spring 165. This is the condition of the first-selector switch E when the subscriber operates the dial for the first digit. The first digit being 2, the impulse spring 14 is twice carried out of engagement with the impulse spring 15. As a result the energizing circuit through the line relay 101 is broken twice, and the spring 161 comes into contact with the spring 166 twice. After the two impulses are thus delivered the line relay 101 again energizes and carries the spring 161 into contact with the spring 162. As previously explained, the relay 112 is a slow-acting relay—that is, slow to deënergize; and when this energizing circuit is momentarily broken during the vertical impulses just delivered, the said relay does not deenergize, but remains in an operated position with the spring 163 in contact with the spring 165. Then when the spring 161 engages the spring 166 two impulses are transmitted to the vertical magnet 105, over a circuit extending from ground G^6 through the springs 161 and 166 to the springs 163 and 165, through the private magnet relay 106, through the winding of the vertical magnet 105, contact point 107, side switch wiper 87 to the battery lead 103, thence through battery B to ground G. The impulses being delivered, the vertical magnet 105 is thereby energized twice, and the shaft wipers are given two vertical steps in the well-known manner. It will be seen that the private magnet relay 106 is included in the energizing circuit of the vertical magnet 105. This relay also energizes, but being a slow-acting relay it energizes on the first impulse and remains so until all the impulses are transmitted. This relay, upon energizing, operates to close the springs 167 and 168 in contact, whereby an energizing circuit is established through the private magnet 88. This circuit extends from ground G^6 through the springs 167 and 168, private magnet 88 to the battery lead 103, thence through battery B to ground G. The private magnet relay 106 deënergizes after the last vertical impulse, since this energizing circuit is no longer maintained after the springs 161 and 166 disengage. Hence, the said relay deënergizes, permitting the springs 167 and 168 to disengage, whereby the energizing circuit through the private magnet 88 is in turn broken, which private magnet now deënergizes and permits the side switch to pass from first to second position, permitting the side switch wipers 86 and 87 to engage the contact points 95 and 96, respectively. The closure of contact between the side switch wiper 87 and the contact point 96 sets up an energizing circuit for the rotary magnet 92 from ground G^5 through the interrupter springs 169, through the winding of the rotary magnet 92, contact point 96, side switch wiper 87 to the battery lead 103, and through battery B to ground G. The said rotary magnet then operates to rotate the shaft wipers 81, 82 and 83 of the selector E into engagement with the first contact of the second level of the selector banks, from which contact it is assumed the trunk-line conductors 170, 171 and 172 lead to the second-selector switch E. If the first trunk-line is busy, however, and the wipers have to pass over

busy trunk-lines, then as soon as the private wiper 83 engages the first private bank contact, the private magnet 88 again energizes, locking the side switch in second position. The energizing circuit for said private magnet extends from the grounded terminal G of the battery B through an occupying switch (not shown), through the private wiper 83, thence through the conductor 173 to the side switch wiper 86, contact point 95, through the winding of the private magnet 88 to the battery lead 103, thence through battery B to ground G. The private magnet 88, upon thus becoming energized, locks the side switch wiper 87 in engagement with the contact point 96, whereby the rotary magnet 92 will be energized step by step until the wipers are carried beyond the last busy trunk-line. At the instant that the private wiper leaves the last busy contact point the energizing circuit through the private magnet 88 is destroyed, and as a result the selector side switch passes to third position. If, however, there are no busy trunk-lines, the private magnet 88 releases the side switch to third position as soon as the wipers are carried into engagement with the first trunk-line. As soon as the side switch passes to third position, as stated, the subscriber's line conductors 19 and 20 are extended to the conductors 170 and 171 which, in this case, it is assumed, lead to the second-selector switch F. The extending of the line occurs, of course, as soon as the side switch wipers 84 and 85 engage the contact points 97 and 98, respectively. When the subscriber's lines are thus extended to the selector switch F an energizing circuit is established through the line relay 114 in the same manner in which the energizing circuit was established through the line relay 101 of the selector E when the subscriber's line conductors 19 and 20 were extended through the line switch bank to the trunk conductors 75 and 76. The relay 114, upon energizing, operates to shift the spring 174 from the spring 175 to the spring 176. When the springs 174 and 176 engage, an energizing circuit is established through the release relay 124. This circuit extends from ground G^7 through the springs 174 and 176, through the relay 124 to the battery lead 103, thence through battery B to ground G. The relay 124, upon energizing, operates to shift the spring 177 from the spring 178 to the spring 179, and the springs 180 and 181 are also closed in contact. This operation of the second-selector switch F occurs at the instant that the side switch wipers 84 and 85 of the selector switch E pass to third position and extend the subscriber's line conductors 19 and 20 to the second-selector switch F. Therefore, when the second-selector switch thus operates, a guarding potential is established at the private wiper 83 for protecting the seized trunk-line conductors 170 and 171 against seizure by another calling first-selector. This guarding potential extends from ground G^8 to the contact point 182, side switch wiper 183, through the springs 181 and 180, conductor 172 to the contact engaged by the private wiper 83. Furthermore, when the first-selector switch E operates and the side switch passes to third position, a new energizing circuit is established through the release relay 112. This energizing circuit extends from ground G^8 at the selector switch F through the springs 181 and 180, conductor 172, shaft wiper 83, conductor 173, through the side switch wiper 86, contact point 99, to the battery lead 103, thence through battery B to ground G. The relay 112 thus remains in an operated position, with the spring 163 in engagement with the spring 165, but the line relay 101 returns to normal position when the side switch wipers 84 and 85 engage the contact points 97 and 98, respectively. The energizing circuit through the line relay 114 extends from ground G^9 through the winding 116 to the side switch wiper 118, thence through the conductor 171, conductor 76 and line conductor 20 through the primary circuit of the substation, through the vertical line conductor 19, thence through the trunk conductor 75, conductor 170, side switch wiper 117, through the winding 115 of the relay 114 to the battery lead 103, thence through battery B to ground G. When the dial returns to normal position for the second digit 2 this circuit through the line relay 114 is interrupted twice, when the impulse spring 14 is carried out of engagement with the spring 15 by the impulse teeth on the wheel 10. The circuit being interrupted twice, the said relay 114 momentarily deënergizes, thus permitting the spring 174 to engage the spring 175, whereby an energizing circuit is completed through the vertical magnet 120, said circuit extending from ground G^7 to the springs 174 and 175, springs 177 and 179, through the winding of the private magnet relay 123, through the winding of the vertical magnet 120, contact point 184, side switch wiper 185 to the battery lead 103, and through battery B to ground G. The private magnet relay 123 being included in this circuit, energizes, and since it is a slow-acting relay it remains in an operated position until the last vertical impulse is delivered, and the relay 114 remains energized with the spring 174 in contact with the spring 176, whereby the circuit through the private magnet relay and the vertical magnet 120 remains open. When the relay 123 energizes, the springs 186 and 187 are pressed into contact, thereby causing an energizing current to flow through the private magnet 122, the circuit extending from ground G^7 through the springs

187 and 186, through the winding of the private magnet 122 to the battery lead 103, thence through battery B to ground G. When the relay 123 deënergizes and breaks the energizing circuit through the private magnet 122, the private magnet deënergizes and permits the side switch to pass from first to second position. When the side switch wiper 185 passes to second position and into engagement with the contact point 188, an energizing circuit is established through the rotary magnet 119, which now operates (as explained in connection with the rotary magnet 92 of the selector switch E) to select an idle trunk-line leading to the connector switch. After the switch comes to rest with the side switch in third position, the shaft wipers 189, 190 and 191 are in engagement with the trunk conductors 192, 193 and 194, respectively, which lead to the connector switch H (Fig. 2). At the instant that the side switch wipers 117 and 118 pass to third position, into engagement with the contact points 195 and 196, the subscriber's line conductors are extended to the connector switch H, and an energizing circuit is established through the line relay 128, in the same manner in which the energizing circuit was established through the line relay 114 of the selector switch F when the side switch wipers of the first-selector passed to third position. The energizing circuit through the line relay 128 extends from ground G^{10} through the winding 130, trunk conductors 193, 171 and 76 to the line conductor 20, thence through the substation to the vertical line conductor 19, trunk conductors 75, 170 and 192, thence through the winding 129 to the battery lead 103, and through battery B to ground G. The line relay 128, upon energizing, operates to shift the spring 196 from the spring 197 to the spring 198, whereby an energizing circuit is established through the release relay 133, extending from ground G^{11} through the springs 196 and 198, relay 133 to the battery lead 103, thence through battery B to ground G. When the relay 133 energizes, the spring 199 is shifted out of contact with the spring 200 and into contact with the spring 201, and the spring 202 is shifted into engagement with the spring 203. This primary operation of the connector relays 128 and 133 occurs at the instant that the side switch wipers 117 and 118 of the selector F pass to third position and extend the subscriber's line conductors to the connector H. The engagement of the springs 203 and 202 establishes a guarding potential for protecting the trunk-line conductors 192, 193 and 194 against seizure by another line and second-selector. This potential extends from ground G^{11a} to the side switch wiper 139, springs 202 and 203, conductor 194 to the private bank contact engaged by the shaft wiper 191. Furthermore, when the side switch of the second-selector F passes to third position a new energizing circuit is established through the release relay 124, said circuit extending from ground G^{11a} at the connector switch to the conductor 194, through the shaft wiper 191, side switch wiper 204, conductor 205, through the release relay 124 to the battery lead 103, thence through battery B to ground G. Also, this same guarding potential established at the contact engaged by the private shaft wiper 191 is extended to the private bank contact engaged by the shaft wiper 83 of the first-selector E, when the side switch of the second-selector F passes to third position. The path over which this potential extends is as follows: from ground G^{11a} at the connector switch H (Fig. 2) to the side switch wiper 139, springs 202 and 203, conductor 194, shaft wiper 191, side switch wiper 204, conductor 205, contact point 206, side switch wiper 183, springs 181 and 180, conductor 172 to the bank contact engaged by the private wiper 83 of the selector switch E. The operation of the dial for the last two digits affects the connector switch, and when the dial is operated for the third digit 2 the impulse spring 14 is twice carried out of engagement with the spring 15, thereby momentarily deënergizing the line relay 128 twice, whereby the spring 196 twice engages the spring 197, thus sending two impulses to the vertical magnet 131 from ground G^{11} through the springs 196 and 197, springs 199 and 201, through the vertical magnet 131, contact point 207, side switch wiper 140, private magnet relay 134 to the battery lead 103, thence through battery B to ground G. The private magnet relay 134 energizes when the first impulse is delivered, and since the said relay is slow-acting it remains in an operated position until all the vertical impulses are sent. The vertical magnet, upon being energized, operates one step at a time to carry the shaft wipers 125, 126 and 127 two steps to a point opposite the second level. The relay 134, upon energizing, shifts the spring 209 out of engagement with the spring 210 and into engagement with the spring 211; also, the spring 212 is shifted out of engagement with the spring 211. When the springs 209 and 211 engage, an energizing circuit is established through the private magnet 135 from ground g^{13} through the springs 211 and 209, private magnet 135 to the battery lead 103, thence through battery B to ground G. The relay 134 being a slow-acting relay remains in an operated position while the vertical impulses are being sent; but after all the impulses are delivered, and the line relay 128 returns to its operated posi-

tion, the circuit through the relay 134 becomes broken, thus permitting the springs 212 and 209 to return to normal position. When the springs 209 and 211 disengage, the circuit through the private magnet 135 becomes broken, whereby the said magnet deenergizes, permitting the side switch to pass from first to second position. The calling subscriber now operates the calling device for the last digit 0, thereby transmitting ten impulses and operating the line relay 128 ten times. Each time that the line relay springs 196 and 197 engage, an energizing circuit is established through the rotary magnet 132 from ground G^{11} through the said springs 196 and 197 and through the springs 199 and 201, locking-relay springs 211^a and 212^a, through the rotary magnet 132 to the contact point 213, thence through the side switch wiper 140, and through the private magnet relay 134 to the battery lead 103, thence through battery B to ground G. Again the private magnet relay energizes, as in the previous case, remaining so until all the impulses are transmitted, thereby retaining the private magnet also energized. The rotary magnet 132 then operates to rotate the shaft wipers into engagement with the desired line #2220. If this line is busy at the time, the connector side switch will be locked in second position, in a manner to be described, and the calling subscriber is given a busy-signal, thus making it impossible to extend the calling line into connection with the called line. Before describing the results that follow when the connector finds a busy line, the description of how a connection is established will be completed. As soon as the line relay 128 ceases to operate for the last digit, the private magnet relay 134 deënergizes, as heretofore explained, permitting, in this instance, the side switch to pass to third position. The result is that the side switch wipers 136, 137, 138, 139, 139^a and 140 engage the contact points 214, 215, 216, 217, 217^a and 218, respectively. When the side switch wiper 138 engages the contact point 216 a guarding potential is completed at the private wiper 127 for protecting the seized line from outside interference while the connection is established. This guarding potential extends from ground G^{14} to the contact point 216, thence by way of the side switch wiper 138, locking relay springs 219 and 220 to the private wiper 127. Not only does this guarding potential prevent other connectors from arriving on the same line over multiples of the normal conductors 221, 222 and 223, but it also provides means for energizing the cut-off relay 224 of the line switch C′, whereby said switch C′ is prevented from operating when the called subscriber removes his receiver 225 from the switch-hook 226. It will also be seen that when the side switch passes to third position the trunk-release conductor 194 that runs between the second-selector and the connector is provided with guarding potential from ground G^{11} through the line relay springs 196 and 198, contact point 217, side switch wiper 139, release relay springs 202 and 203 to the trunk conductor 194. However, while the side switch is in first and second position a guarding potential for this trunk 194 is also provided from ground G^{11a}, but through the side switch wiper 139 direct. The reason for this is that the guarding potential from ground G^{11} is interrupted while the line relay 128 is operating, and there is some liability of some other selector similar to the selector F stopping on the same trunk-line. After the side switch passes to third position, however, there is no such liability, and the potential is provided from ground G^{11} through the line relay springs, as stated. Of course, when the side switch wipers 136 and 137 engage their third-position contact points 214 and 215, the calling subscriber's line is placed in connection with the called subscriber's line over the heavy conductors shown, passing through the ringer relay springs 227 and 228 on one side, and 229 and 230 on the other side. As soon as connection is thus established, the ringer relay 145 is energized over the circuit established when the side switch wiper 140 engages the contact point 218, the energizing current flowing from ground G^{15} through the interrupter 144, through the back-bridge relay springs 231 and 232, ringer relay 145, conductor 233, contact point 218, side switch wiper 140, private magnet relay 134 to the battery lead 103, thence through battery B to ground G. It will be seen that as the interrupter 144 revolves, the energizing circuit of the ringer relay 145 will be broken periodically so as not to ring the called subscriber continuously. It will be seen that each time that the ringer relay is energized the springs 228 and 230 are separated from the ringer relay springs 227 and 229, thereby breaking the calling line from the called line and pressing the springs 228 and 230 onto the springs 244 and 245, which are the terminals of the ringer generator I. As a result, ringing current is sent over the called line for energizing the bell 234 while the springs 237 and 246 are in contact. However, as soon as the called subscriber answers, the back-bridge relay 141 is energized by a flow of current from ground G^{14}, contact point 216, side switch wiper 138, winding 143 of the back-bridge relay 141, conductor 235, ringer relay springs 229 and 230, side switch wiper 137, contact point 215, rotary line wiper 126, rotary normal conductor 222, rotary line conductor 236, switch-hook springs 237 and 238, impulse

springs 239 and 240, transmitter 241, vertical line conductor 242, vertical normal conductor 221, vertical line wiper 125, contact point 214, side switch wiper 136, ringer relay springs 228 and 227, conductor 243, winding 142 of the back-bridge relay 141, thence to the battery lead 103, and through battery B to ground G. When the back-bridge relay 141 is energized, the energizing circuit for the ringer relay 145 is interrupted at a point between the springs 231 and 232, thus making it impossible for the ringer relay to energize as long as the called subscriber is on the line. The subscribers being thus connected they may communicate over the main talking conductors indicated by the heavy lines and including the condenser 147 at the connector H on one side, and the condenser 148 on the other side. After the subscribers are through talking, if the calling subscriber hangs up his receiver he opens up the line circuit at a point between the springs 17 and 18, thereby initiating the release of all of the switches. This release is brought about as follows: At the instant that the circuit is broken between the said springs 17 and 18 the double-wound line relay 128 and release relay 133 of the connector H deënergize. At the instant that the relay 133 and the line relay 128 deenergize the energizing circuit for the release magnet 133^a is closed at a point between the springs 199 and 200, and at another point between the springs 196 and 197. A flow of current is, therefore, set up from ground G^{11} through the springs 196 and 197, through the springs 199 and 200 to the release magnet 133^a, thence through said magnet to the off-normal spring 132^a, to the contact point 131^a and to the battery lead 103, thence through battery B to ground G. The release magnet instantly releases the connector switch shaft and side switch, thereby breaking the energizing circuit through the back-bridge relay 141, if the called subscriber has not in the meantime restored his receiver, and also the energizing circuit through the bridge-cut-off relay 224 of the called line switch C'. As soon as the connector switch shaft reaches its lowest position it breaks the circuit of the release magnet 133^a by separating the off-normal spring 132^a from the contact point 131^a, at which instant the release magnet of the connector is also restored. As previously explained, the relay 133 is quick-acting when the side switch is in third position; hence, the contact between the springs 199 and 200 is made at the same time the contact is made between the springs 196 and 197. Prior to this arrangement the relay 133 was slow-acting during the release, and some little time elapsed before the relay 133 returned to normal position and closed the circuit for the release magnet. With my new arrangement the release circuit is established immediately when the line relay deënergizes. The operation of the line relay 128 and of the relay 133 not only causes the release of the connector, as described, but also the release of the preceding switches, because the ground connection from ground G^{11} to the trunk-release conductor 194 is interrupted by both of these relays. Since the release relays 124 and 112 are dependent upon that ground for their energized condition, as already explained, it follows that they will fall back, with the following results: As soon as the release relay 124 of the second-selector F deënergizes, the spring 177 falls back into normal engagement with the spring 178, thereby closing an energizing circuit for the release magnet 121 from ground G^7 through the springs 174 and 175, through the springs 177 and 178 to the release magnet 121, thence to the contact point 249, off-normal spring 250 to the battery lead 103, thence through battery B to ground G. As soon as the release magnet 121 energizes, the second-selector side switch and switch shaft are restored, which switch shaft, upon reaching its lowest position, opens the release circuit at a point between the off-normal spring 250 and the contact point 249, whereby the release magnet 121 is restored also. When the release relay 112 of the selector E deenergizes, the springs 163 and 164 are brought into contact and as a result the energizing circuit for the release magnet 108 is closed. The energizing current for this release magnet 108 then flows from ground G^6 through the springs 161 and 166, through the said springs 163 and 164 to the release magnet 108, thence through said magnet to the contact point 110, off-normal spring 111 to the battery lead 103, thence through battery B to ground G. The release magnet, upon energizing, restores the first-selector side switch and switch shaft, which switch shaft, upon reaching its lowest position, opens the energizing circuit for the release magnet 108 at a point between the off-normal spring 111 and the contact point 110. Furthermore, when the release magnet 108 energizes and closes the springs 251 and 252 in contact, an energizing circuit is established through the release magnet 24 of the line switch C. This circuit extends from ground G^{4a} through the springs 251 and 252, conductor 77 to the bank springs 42 and 41, thence through the release magnet 24 of the line switch C to the battery lead 103, and through battery B to ground G. It will be seen that the release magnet will then energize and, as previously explained, cause the trip armature 27 to fall over the plunger arm 22, whereby the members 32 and 33 engage. (See Fig. 3.) As the release magnet deënergizes and separates the

springs 251 and 252 the release circuit is broken, which permits the release magnet 24 of the line switch C to deënergize, thereby withdrawing the plunger 21 from the bank terminal Q. As a result the bank springs 41 and 42, as well as the other bank springs of the line switch C, are separated, thus preventing any other action from the trunk After the switches are thus restored the calling subscriber can then proceed to make another call.

Returning now to that stage of the call where the calling subscriber was operating the connector switch in accordance with the last digit 0, it will be explained what takes place in the event that the desired line is busy. When the line #2220 is calling, or when it has been called by someone else, the private bank contacts in which the normal conductor 223 terminates are connected to ground. If another connector switch has called the line this guarding potential would be supplied through the connector switch from a ground terminal similar to the ground terminal G^{14} in the connector switch H, as already explained; but if the line switch C′ is calling, a guarding potential is established from the ground at the bank contacts of the line switch as shown in Fig. 1, thence to the private bank contact of the connector switch. In a similar manner the line switch C protects the calling line A when the bank springs 39 and 40 come into contact from ground G^4, from which latter connection is established through the said bank springs to the private normal conductor 80. Therefore, when the subscriber sends in the last impulse, the private wiper 127 is carried onto the grounded contact; and when the slow-acting relay 134 of the connector deënergizes, instead of the side switch tripping to third position, as in the case where the line is not busy, it is locked and the calling subscriber is then given a busy-signal. The method by which this side switch is locked is as follows: The slow-acting relay springs 209, 210 and 211 are so arranged that as the relay 134 deënergizes, the spring 209 engages the spring 210 before it leaves the spring 211, and in this way the private magnet 135 is prevented from deënergizing, because the spring 210 is connected with the private wiper 127 at the time over the following circuit: from the private wiper 127 to the locking relay spring 220, thence to the spring 219 and through the winding 143 of the back-bridge relay 141 to the talking line conductor 235, thence through the ringer relay springs 229 and 230 to the side switch wiper 137, contact point 253, (the side switch being in second position) to the slow-acting relay spring 210. Therefore, when the spring 209 engages the spring 210 the private magnet 135 is not deënergized, since the energizing circuit is maintained from the private wiper 127 to the said spring 210, as described, thence through the spring 209, and through the private magnet 135 to the battery lead 103, thence through battery B to ground G. The private magnet therefore remains energized, retaining the side switch in second position. It will be seen that at the same time the back-bridge relay 141 energizes in series with the private magnet 134 over this circuit from the private wiper 127. Therefore, the back-bridge relay 141, upon energizing, presses the springs 254 and 255 into contact thereby energizing the locking relay 146, over the following circuit: from ground G^{13} through the slow-acting relay springs 211 and 212, through the private magnet springs 256 and 257, through the said relay 146, and through the back-bridge relay springs 255 and 254 to the battery lead 103, thence through battery B to ground G. It will be seen that when the relay 146 energizes, the connection between the rotary magnet 132 and the line relay springs is broken at a point between the springs 211^a and 212^a. The object of this arrangement is to prevent the calling subscriber from further rotating the connector switch if he should attempt to operate his dial while receiving the busy-signal—that is, while the connector switch is locked in second position. It will also be seen that when the relay 146 energizes, the circuit for maintaining the private magnet 135 energized is shifted from the private wiper 127 to the spring 258, which latter is connected to ground G^{19}. The object of this arrangement is to prevent the side switch from unlocking and passing to third position if the switch that is maintaining the called line busy should be released while the calling subscriber A (Fig. 1) is receiving the busy-signal. It will be evident that if the ground G^{19} were not substituted for the ground at the private wiper 127, the private magnet 135 would deënergize if the switch that is supplying ground at the private wiper 127 should release. This would, of course, be undesirable. It will also be seen that the relay 146, upon energizing, closes the springs 259 and 153 in contact, thereby establishing the busy circuit as follows: from the secondary winding of the busy coil 151 through the springs 153 and 259 to the second-position side switch contact point 260, side switch wiper 136, ringer relay springs 228 and 227, through the condenser 147, through the substation A to the rotary side of the line, then over said rotary side back to the connector H, and through the winding 130 of the line relay 128 to ground G^{10}, thence to the interrupter ground G^{20}, through the interrupter 149 to the primary winding of the busy coil 151 back to the secondary winding. When the calling sub-

scriber receives the busy-signal he understands that the line is busy and hangs up his receiver. The line circuit is opened, as already explained, with the result that the relays 128 and 133 of the connector H deenergize, causing the release of the connector and all other switches, as heretofore explained. It will, of course, be seen that as soon as the side switch is restored the energizing circuit for the back-bridge relay 141 that includes the winding 143 thereof, and for the private magnet 135, is broken, when the side switch wiper 137 leaves the contact point 253. Now, since the energizing circuit of the lo king relay 146 is controlled by the back-bridge relay 141, the said locking relay is also deënergized, and the connector switch is left in a normal condition.

From the foregoing it will be seen that with my new release arrangement and after a connection has been fully established the release circuit for the release magnets of the various switches is established as soon as the calling subscriber restores his receiver to the switch-hook and deënergizes the line relay. Prior to this arrangement the release circuit in certain two-wire systems was not established until a slow-acting relay deënergized.

It will be seen that I provide an automatic trunking system having a release relay means adapted in part at least to remain slow-acting until the called line is found, and provided with means whereby such relay means is rendered quick-acting in its entirety upon the completion of the call, thus enabling the said relay means to prevent a premature release during the progress of the call, without rendering the release slow or sluggish when the time comes for disconnecting the two lines—that is to say, when the calling subscriber hangs up his receiver. Each release relay is provided with means, such as a coil closed upon itself, for rendering it slow-acting while there is danger of its being deënergized during the progress of the call; and is also provided with means, such as a switch in the closed circuit of said coil or winding, for making it quick-acting—that is, quick to deënergize—as soon as there is no longer any danger of its being deënergized by the brief breaking or opening of the line circuit at the calling substation, during the progress of the call. In this way, one relay after the other in succession is rendered quick-acting, in the manner specified, and as soon as the called line is found, and the side switch of the connector has passed to third position, then the last slow-acting release relay is made quick-acting, so that the entire slow-acting relay means has thus become a quick-acting relay means, the transition from slow-acting to quick-acting capacity on the part of the release having been accomplished automatically and progressively during the action of extending connection from the calling line to the called line. Upon the release, however, which may be initiated by the hanging up of the receiver at the calling substation, all of said relays then become re-transformed into slow-acting relays by the automatic closure of the circuits of their closed coils or windings, and each relay is then ready to serve in its capacity as a slow-acting relay for preventing the premature release of its allotted selector or connector during the progress of another call. Thus, as stated, I provide a release-relay means which remains slow-acting, in part at least, until the call is completed, but which is then adapted to serve throughout as a quick-acting relay means, so that the deenergizing will be instantaneous and the release practically simultaneous with the hanging up of the receiver at the subscriber's station.

It will be observed that the system includes switches having vertical motion for selecting groups, and rotary motion for connecting with a line in a selected group, as both the selectors and the connectors have vertical and rotary motion for this purpose. The selection of a trunk in a group selected by a calling subscriber is purely automatic, as the selector automatically picks out or selects the first idle trunk. The selection of the called line is, however, under the control of the calling subscriber, so that by means of the connector the calling subscriber first uses the vertical motion for selecting the desired group, and then uses the rotary motion for selecting and connecting with the particular line of the called subscriber.

What I claim as my invention is:—

1. In a telephone system, the combination of switches having vertical and rotary motion to extend connection to the called line, a release-relay means therefor, means for making said relay means slow-acting to prevent premature release before the called line is found, and means for making said relay means quick-acting for releasing purposes.

2. In a telephone system, an automatic switch, means for controlling the release of said switch, said means including a relay, and means for making said relay slow-acting during the call and quick-acting after the call.

3. In a telephone system, a series of release relays, switching means to be released thereby, means for normally rendering said relays slow-acting, and means progressively and successively rendering said relays quick-acting during the progress of the call.

4. In a telephone system, a switch, a release relay therefor, a trunk, a circuit for maintaining the said relay energized while the switch is searching for the trunk, another circuit over the trunk for energizing

the said relay after the trunk is found and seized, means for making the relay slow-acting during the search for the trunk, and means for making said relay quick-acting after the trunk is seized.

5. In a telephone system, the combination of subscribers' lines free from operating grounds at the substations thereof, whereby calls are transmitted from the substations over both sides of the line in series, an automatic switch, means for controlling the release of said switch, said means including a relay, and means for making said relay slow-acting during the call and quick-acting after the call.

6. In a telephone system, the combination of subscribers' lines free from operating grounds at the substations thereof, whereby calls are transmitted from the substations over both sides of the line in series, a series of release relays, switching means to be released thereby, means for normally rendering said relays slow-acting, and means progressively and successively rendering said relays quick-acting during the progress of the call.

7. In a telephone system, the combination of subscribers' lines free from operating grounds at the substations thereof, whereby calls are transmitted from the substations over both sides of the line in series, a switch, a release relay therefor, a trunk, a circuit for maintaining the said relay energized while the switch is searching for the trunk, another circuit over the trunk for energizing the said relay after the trunk is found and seized, means for making the relay slow-acting during the search for the trunk, and means for making said relay quick-acting after the trunk is seized.

8. In a telephone system, the combination of an automatic switch, means for controlling the release of said switch, said means including a relay, means for making said relay slow-acting during the call and quick-acting after the call, and means for initiating the release by opening the line at the calling substation.

9. In a telephone system, the combination of a series of release relays, switching means to be released thereby, means for normally rendering said relays slow-acting, means progressively and successively rendering said relays quick-acting during the progress of the call, and means for initiating the release by opening the line at the calling substation.

10. In a telephone system, the combination of a switch, a release relay therefor, a trunk, a circuit for maintaining the said relay energized while the switch is searching for the trunk, another circuit over the trunk for energizing the said relay after the trunk is found and seized, means for making the relay slow-acting during the search for the trunk, means for making said relay quick-acting after the trunk is seized, and means for initiating the release by opening the line at the calling substation.

11. In a telephone system having metallic telephone lines, an automatic switch, means for controlling the release of said switch, said means including a relay, means for making said relay slow-acting during the call and quick-acting after the call, and a common battery for supplying current over the metallic circuits for calling and talking purposes.

12. In a telephone system having metallic telephone lines, a series of release relays, switching means to be released thereby, means for normally rendering said relays slow-acting, means progressively and successively rendering said relays quick-acting during the progress of the call, and a common battery for supplying current over the metallic circuits for calling and talking purposes.

13. In a telephone system having metallic telephone lines, a switch, a release relay therefor, a trunk, a circuit for maintaining the said relay energized while the switch is searching for the trunk, another circuit over the trunk for energizing the said relay after the trunk is found and seized, means for making the relay slow-acting during the search for the trunk, means for making said relay quick-acting after the trunk is seized, and a common battery for supplying current over the metallic circuits for calling and talking purposes.

14. In a subscriber-operated telephone system, an automatic switch, means for controlling the release of said switch, said means including a relay, means for making said relay slow-acting during the call and quick-acting after the call, and calling mechanism requiring a separate manual operation thereof for each digit of the called number, adapted to transmit current for one digit and then come to rest before manual operation for the next digit.

15. In a subscriber-operated telephone system, a series of release relays, switching means to be released thereby, means for normally rendering said relays slow-acting, means progressively and successively rendering said relays quick-acting during the progress of the call, and calling mechanism requiring a separate manual operation thereof for each digit of the called number, adapted to transmit current for one digit and then come to rest before manual operation for the next digit.

16. In a subscriber-operated telephone system, a switch, a release relay therefor, a trunk, a circuit for maintaining the said relay energized while the switch is searching for the trunk, another circuit over the trunk for energizing the said relay after the trunk

is found and seized, means for making the relay slow-acting during the search for the trunk, means for making said relay quick-acting after the trunk is seized, and calling mechanism requiring a separate manual operation thereof for each digit of the called number, adapted to transmit current for one digit and then come to rest before manual operation for the next digit.

17. In a telephone trunking system in which the trunks are in groups, means for selecting a group, means for automatically selecting an idle trunk in a selected group, and a release-relay means slow-acting during the call and quick-acting after the call, said automatic means released thereby.

18. In a telephone trunking system in which the trunks are in groups, means for selecting a group, means for automatically selecting an idle trunk in a selected group, a series of release relays, said automatic means released thereby, means for normally rendering said relays slow-acting, and means progressively and successively rendering said relays quick-acting during the progress of the call.

19. In a telephone trunking system in which the trunks are in groups, means for selecting a group, and for then automatically selecting an idle trunk in a selected group, said means including a switch, a release relay therefor, a trunk, a circuit for maintaining the said relay energized while the switch is searching for the trunk, another circuit over the trunk for energizing the said relay after the trunk is found and seized, means for making the relay slow-acting during the search for the trunk, and means for making said relay quick-acting after the trunk is seized.

20. In a telephone trunking system in which the trunks are in groups, means for selecting a group, means for automatically selecting an idle trunk in a selected group, a release relay, said automatic means released thereby, a closed winding or coil thereon for making the same slow-acting to prevent premature release, and means for opening said winding or coil to make the said relay quick-acting for release purposes.

21. In a telephone trunking system, trunks divided into groups, automatic switches having motion in one plane to select groups and motion in a plane at right angles thereto to find a trunk in a selected group to extend connection to the called line, release relays for said switches, means for making said relays slow-acting to prevent premature release, and means for making said relays quick-acting for release purposes.

22. In a telephone system, an automatic switch, automatic electrically controlled means for controlling the release of said switch, said means including a relay, and means for making said relay slow-acting during the call and quick-acting after the call.

23. In a telephone system, a series of release relays, switching means to be released thereby, electromagnetic means for normally rendering said relays slow-acting, and automatic electrically controlled means progressively and successively rendering said relays quick-acting during the progress of the call.

24. In a telephone system, a switch, a release relay therefor, a trunk, a circuit for maintaining the said relay energized while the switch is searching for the trunk, another circuit over the trunk for energizing the said relay after the trunk is found and seized, electromagnetic means for making the relay slow-acting during the search for the trunk, and automatic electrically controlled means for making said relay quick-acting after the trunk is seized.

25. In a telephone system, the combination of subscribers' lines free from operating grounds at the substations thereof, whereby calls are transmitted from the substations over both sides of the line in series, an automatic switch, automatic electrically controlled means for controlling the release of said switch, said means including a relay, and means for making said relay slow-acting during the call and quick-acting after the call.

26. In a telephone system, the combination of a series of release relays, switching means comprising a progressively movable element to be released thereby, electromagnetically controlled means for normally rendering said relays slow-acting, automatic electrically controlled means progressively and successively rendering said relays quick-acting during the progress of the call, and circuit controlling means for initiating the release by opening the line at the calling substation.

Signed by me at Chicago, Cook county, Illinois, this 17th day of February, 1908.

EDWARD D. FALES.

Witnesses:

JENNIE NORBY,

ELLEN CLEGG.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."