J. G. BLESSING & B. D. WILLIS.

AUTOMATIC TELEPHONE SWITCH.

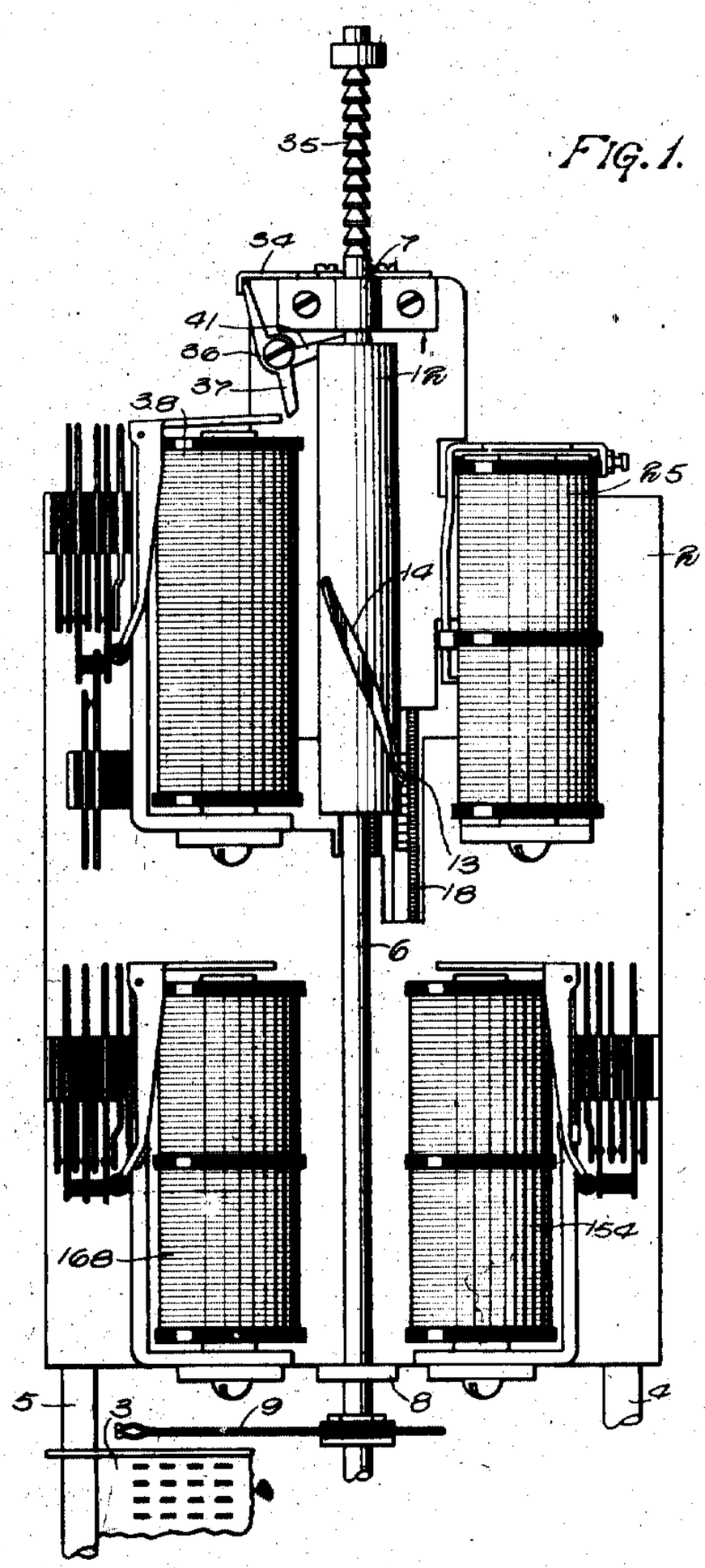
APPLICATION FILED MAR. 16, 1912.

1,256,511.

Patented Feb. 19, 1918.

5 SHEETS—SHEET 1.

FIG. 1.



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5 SHEETS—SHEET 2.

FIG. 5.

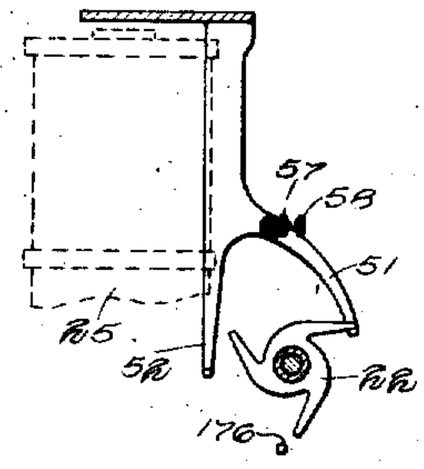

FIG. R.

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5 SHEETS—SHEET 3.

FIG. 3.

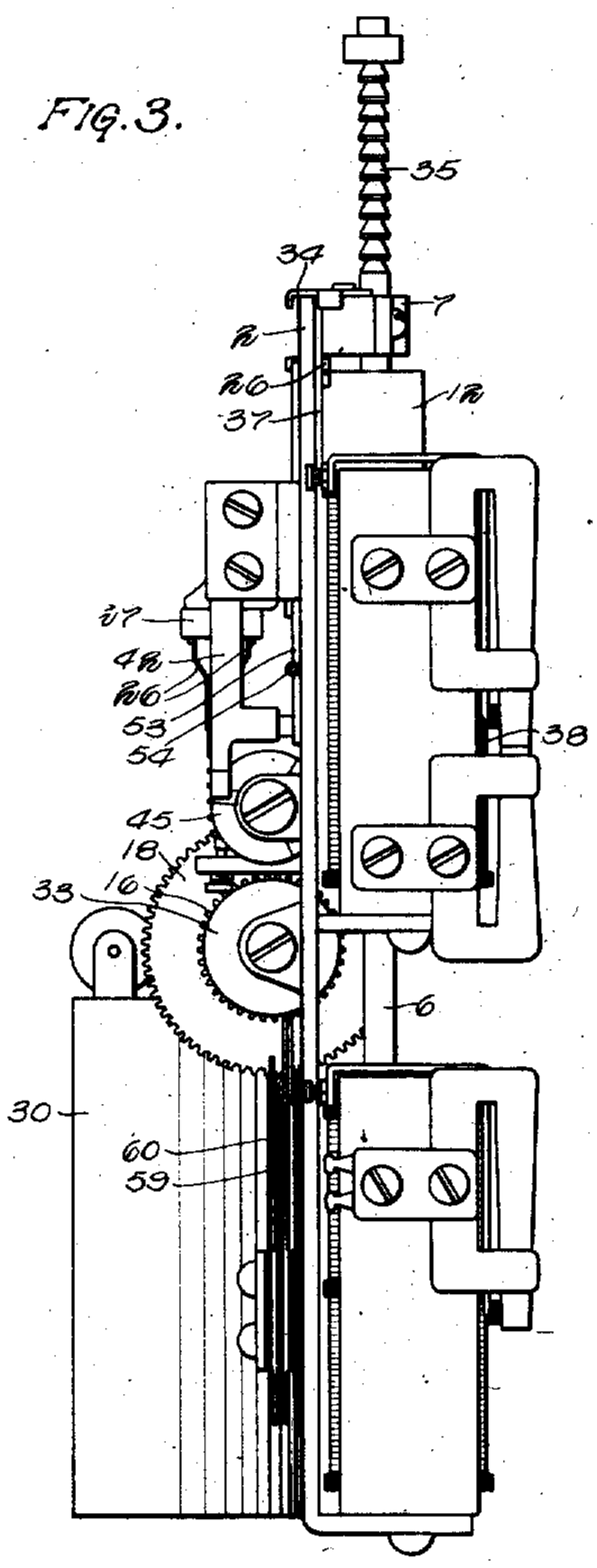
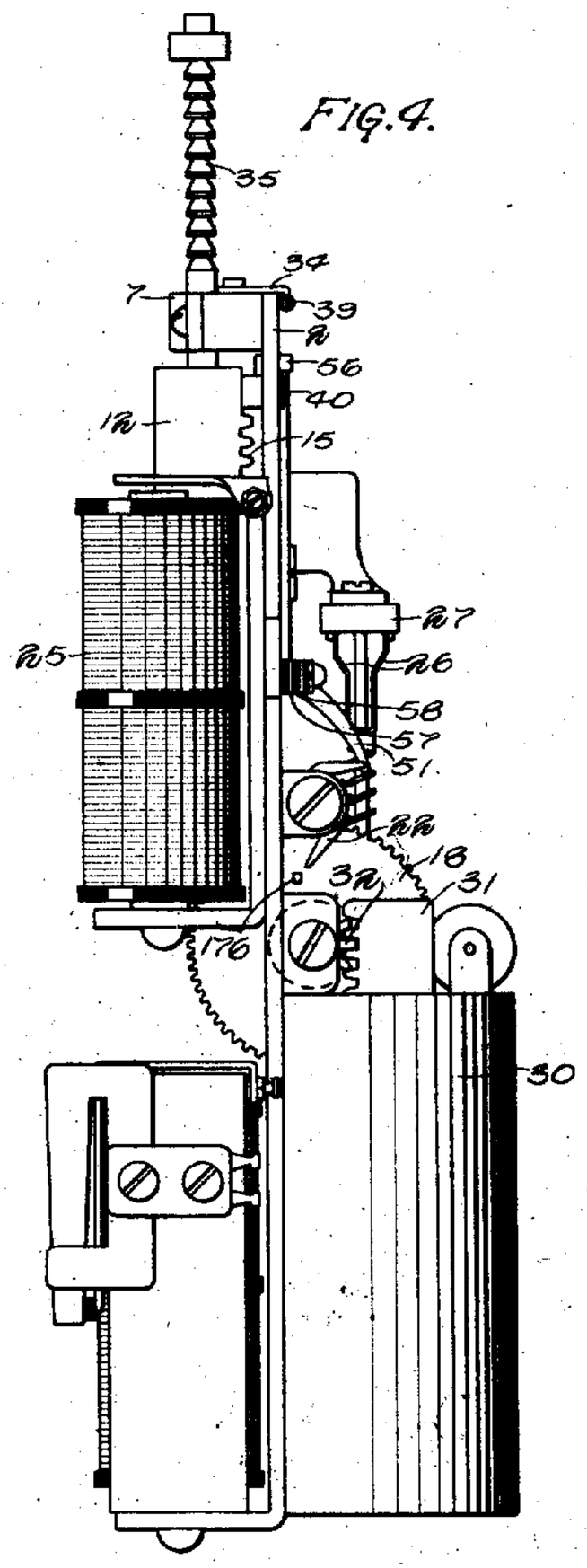


FIG. 4.



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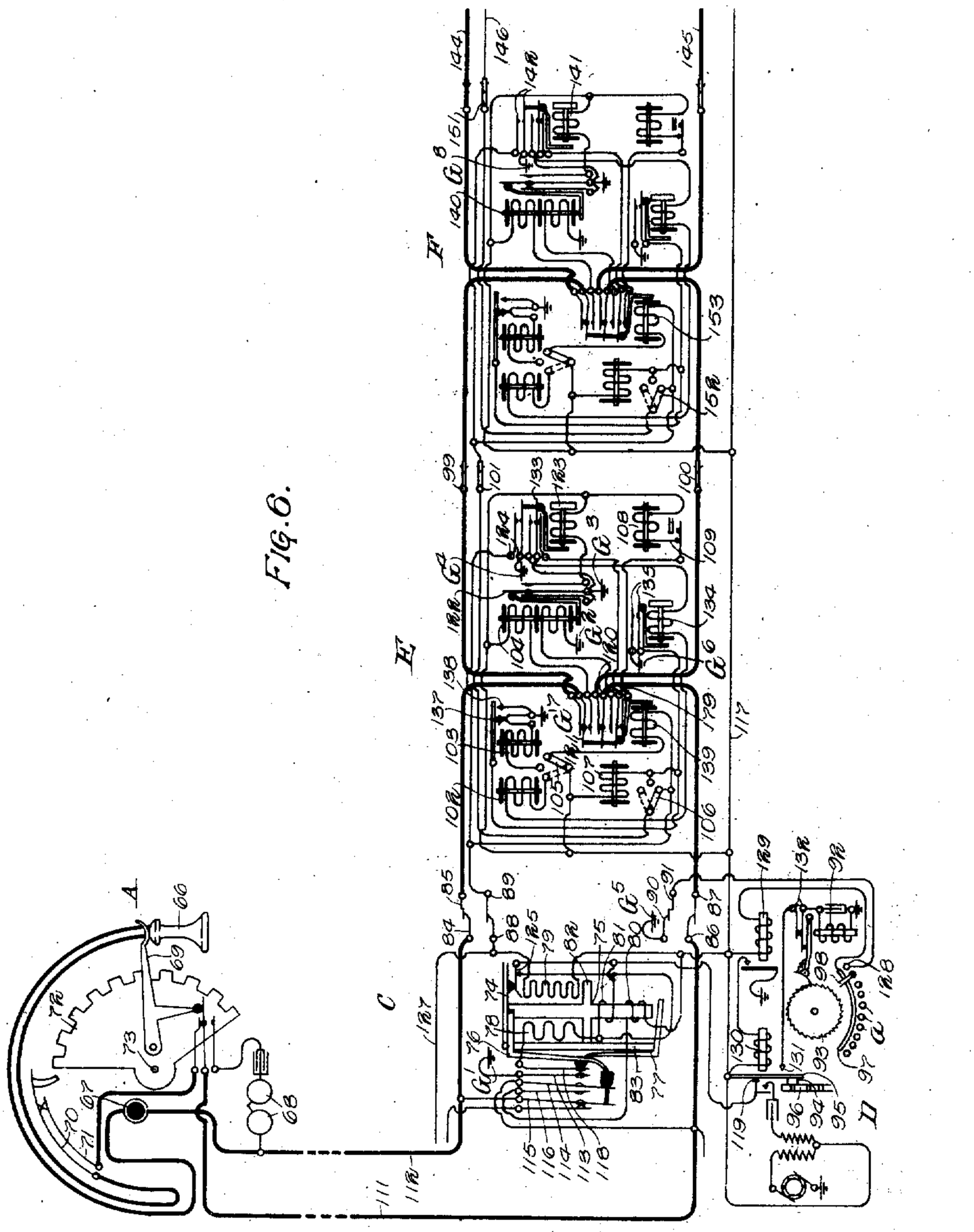
5 SHEETS—SHEET 4.

FIG. 6.



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5 SHEETS—SHEET 5.

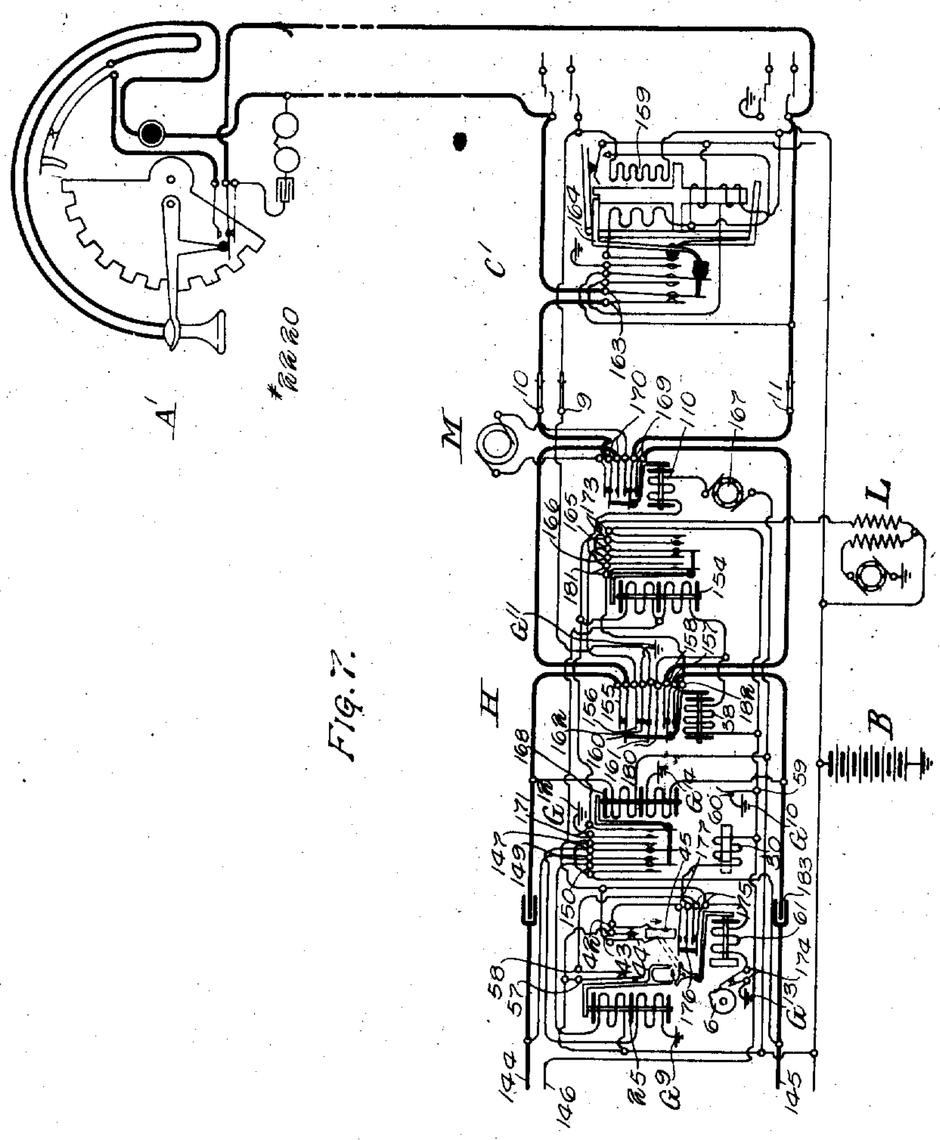

Fig. 7.

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UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE-SWITCH.

1,256,511. Specification of Letters Patent. Patented Feb. 19, 1918.

Application filed March 16, 1912. Serial No. 684,110.

To all whom it may concern:

Be it known that we, JOHN G. BLESSING and BERNARD D. WILLIS, citizens of the United States of America, and residents of Chicago, Cook county, Illinois, have invented certain new and useful Improvements in Automatic Telephone-Switches, of which the following is a specification.

Our invention relates to automatic or semi-automatic telephone systems, and more particularly to an improved automatic switch and circuits for operating the same.

The objects of our invention are to devise a switch which is capable of being operated at a very high rate of speed, and one in which there is very little wear upon the operating parts. The speed of operation of the ordinary step-by-step switches is limited by the speed at which the armatures of the operating magnets which control the operating pawls vibrate. In our improved switch, however, the only parts which operate intermittently in synchronism with the operating impulses are the line relay and a small escapement wheel. These parts are made very light and can, therefore, be operated very rapidly. The shaft, however, of our switch moves with a uniform motion, which motion is controlled by the intermittent operation of the line relay. The motion of this shaft is controlled by a governor, while the motion of the line relay and the escapement is uncontrolled, whereby the line relay and escapement operate with a greater rapidity than the operating shaft.

A further object of our invention is to devise a switch having vertical and rotary motion, the vertical selecting motion of which is downward instead of upward, as in the usual type of Strowger switch.

Another object of our invention is to devise a switch in which the power for the selecting operation of the switch is supplied from an operating spring, and one in which the same source of power is used to control the downward and rotary motions of the switch. Heretofore it has been necessary to apply separate operating means for operating the switch in its two selecting motions, but in our improved switch we provide a single operating means which normally tends to move the switch wipers in a vertical direction, and when prevented from moving them in this direction tends to rotate the wipers.

These and other objects of our invention will be more readily understood by reference to the accompanying drawings, in which we have illustrated our invention in connection with a full automatic two-wire system comprising line switches, first and second selectors and connectors, and in which—

Figure 1 is a front elevation of a switch embodying the principles of our invention.

Fig. 2 is a rear view.

Figs. 3 and 4 are side views of the same.

Fig. 5 is a detail view of a portion of the apparatus.

Figs. 6 and 7 show a complete connection between a calling and a called substation.

The switch shown in Figs. 1, 2, 3 and 4 resembles the switches shown in United States Letters Patent Nos. 815,321 and 815,176, granted March 13, 1906, to Keith, Erickson and Erickson, in that it comprises a bank of contacts which are adapted to be engaged by a set of wipers carried upon a shaft or spindle which is capable of both vertical and rotary motion. In the above figures, 2 represents a plate upon which the various parts are mounted. The banks 3 (only a portion of one of which is shown in Fig. 1) are mounted upon rods 4 and 5 attached to the lower end of the plate 2. These banks may be of any suitable construction and usually comprise ten horizontal rows of contacts with ten contacts in each row. The shaft 6 is mounted in the bearings 7 and 8 upon the front of the plate 2. On the lower end of the shaft there is shown one wiper 9. It will be understood that there may be a plurality of wipers attached to the shaft and a separate bank of contacts provided for each wiper. Loosely mounted upon the shaft 6 there is a cylinder 12. There is a pin 13 on the shaft 6 which extends through a slot 14 in the cylinder. On the back of the cylinder 12 there is a series of gear teeth 15 which mesh with a gear wheel 16 on a shaft 17. Loosely mounted on the shaft 17 there is a gear wheel 18 which meshes with a pinion 19 on a second shaft 20. On the side of the wheel 18 is a pawl which is adapted to engage a ratchet on the shaft 17, so that the wheel 18 is forced to rotate with the shaft in one direction but not in the other. Loosely mounted upon the shaft 20, but connected therewith by the spring 21, is an escapement wheel 22. A pin 23 projects hori-

zontally from the face of the wheel 22 into the path of a pin 24 on the shaft 20. The escapement lever of the escapement wheel 22 is controlled by the relay 25, as shown in Fig. 5. Secured to the shaft 20 there is also a gear wheel which engages a worm gear of a governor comprising a pair of weighted springs 26 and a stationary cup 27. As the shaft 20 rotates, the springs 26 revolve and their ends fly out and rub on the inside of the cup 27, thereby producing a braking action to limit the speed of operation of the switch. On the back of the plate 2 there is a solenoid 30, the plunger 31 of which is provided with gear teeth which mesh with the pinion 32 on the shaft 17. On the top of the plate 2 there is a sliding catch 34 which is adapted to engage the teeth 35 on the upper end of the shaft 6. This catch is normally held out of engagement with these teeth, against the tension of the spring 39, by a pin 40 on the back of the cylinder 12, which pin engages the arm 41 of the lever 36. When the cylinder 12 is lowered, the arm 37 of the lever 36 engages the armature of the relay 38 and still holds the catch 34 out of engagement with the teeth on the shaft until the relay 38 is energized. On the back of the switch there is a set of springs 42, 43 and 44 which are controlled by a disk 45, composed of insulating material, upon the shaft 20. This disk has notches in its sides which, when they are opposite the springs 42 and 44, permit them to come into contact with the spring 43. When the relay 25 is deënergized—that is, when the escapement wheel 22 is held by the engagement of one of its arms with the arm 51 of its escapement lever—, the shaft 20 is held in position for the spring 42 to engage a notch in the disk 45. When, however, the relay 25 is energized and the escapement wheel 22 is held by the engagement of one of its fingers with the arm 52 of the escapement lever, the disk 45 is held in position for the spring 44 to drop into one of the notches in its side of the disk. Although one of the notches normally stands opposite the spring 42, said spring is held out of engagement with the spring 43 by the lever 53 and the spring 54. On the back of the switch there is a slow acting relay 61, the armature of which is adapted to engage the escapement wheel 22 to lock the mechanism when the relay 61 is energized.

Besides controlling the escapement wheel 22, the relay 25 also controls a pair of contact springs 57 and 58. The springs 59 and 60 are controlled by a pin on the wheel 16 in such a manner that they are closed whenever said wheel is out of normal position.

In general, the operation of the switch shown in Figs. 1, 2, 3 and 4 is as follows: The cylinder 12 is normally held in its upper position, as shown in the drawings, against gravity and the tension of a spring 33 on the shaft 17, by the engagement of one of the fingers of the wheel 22 with the arm 51 of its escapement lever, whereby the whole mechanism is locked. The shaft 6, being free, rests with the pin 13 at the bottom of the slot 14, in which position the wiper 9 (Fig. 1) rests three steps above the upper row of contacts in the bank 3 and two steps out of line with the first contacts. When connection is extended to the switch, the relay 25 is energized, thereby allowing the escapement wheel 22 to advance one step, or one-sixth of a revolution, when one of its arms will come into contact with the arm 52 of the escapement lever. This allows the shafts 20 and 17 to rotate a corresponding amount, permitting the cylinder 12 and the shaft 6 to descend one step. When the cylinder is thus lowered, the pin 40 (Fig. 2) strikes the lug 55 on the upper end of the lever 53, forcing it out so that the projection 56 on the arm 41 (Fig. 1) drops behind it and holds the lower end of the lever 53 out of engagement with the spring 42; but since the shaft 20 has been rotated, the spring 42 rests on the flat surface of the disk 45 and out of engagement with the spring 43. Upon the first movement of the switch the pin in the wheel 16 permits the springs 59 and 60 to close. If now, the relay 25 be deënergized momentarily a number of times, the escapement wheel 22 will be permitted to rotate step by step. As soon as the wheel 22 advances the first step, the pin 23 leaves the pin 24 and unlocks the shaft 20. The shafts 17 and 20, therefore, begin to rotate to lower the cylinder 12 and the shaft 6. Since the escapement wheel 22 is rotated on the shaft 20 by the spring 21, it advances instantly whenever the relay 25 is energized or deënergized. The shaft 20 is, however, controlled by the governor springs 26, so that it rotates more slowly that the wheel 22. Therefore, if the relay 25 is energized and deënergized rapidly, the pin 24 will not be able to catch up with the pin 23, and the shaft 20 will rotate continuously to lower the shaft 6 with a uniform motion as long as the relay 25 is operating. The spaces between the rows of contacts in the banks 3 are equal to the distance through which the shaft is lowered by the steps of the escapement wheel 22—that is, the relay 25 must be deënergized and energized again in order to permit the shaft to be lowered the distance between successive rows of contacts. Therefore, when the mechanism finally comes to rest, with the relay 25 in an energized position, the wiper 9 will be standing opposite the row of bank contacts which correspond to the number of times the relay 25 has been deënergized. During the time the shaft 20 is rotating to permit the cylinder 12 to be lowered, the notches in the disk 45 pass the end of the

springs 42 and 44 so rapidly that these springs do not have a chance to drop into contact with the spring 43. When, however, the mechanism comes to rest, with the relay 25 energized, the spring 44 drops into a notch and into engagement with the spring 43. This energizes the relay 38, which releases the lever 36 and permits the catch 34 to be drawn into engagement with the teeth 35. If, now, the relay 25 be again deënergized rapidly a number of times, the cylinder 12 will be again lowered in the same manner as previously explained. Since the catch 34 is in engagement with the teeth 35, the shaft 6 cannot descend with the cylinder and will therefore be caused to rotate, due to the action of the slot 14 on the pin 13. This slot is so shaped that when the shaft 6 cannot descend and the cylinder 12 is lowered, the movement of the cylinder, caused by the deënergization and energization of the relay 25, will rotate the shaft to carry the end of the wiper 9 a distance equal to the distance between successive contacts in the rows of the bank 3. Therefore, if the relay 25 is momentarily deënergized a number of times while the catch 34 is in engagement with the teeth 35, the wiper 9 will be rotated over the contacts in the row corresponding to the particular tooth 35 with which the catch 34 is in engagement, and the contact in the row upon which the wipers will come to rest will depend upon the number of times the relay 25 is deënergized. During this rotary operation, the spring 44 is held out of engagement with the spring 43 in the same manner as during the downward motion, and the spring 44 again engages the spring 43 when the shaft 20 comes to rest upon the termination of the rotary operation. It will be seen that when the shaft 17 rotates to permit the cylinder 12 to be lowered, it also raises the plunger of the solenoid 30 the same distance. In order to restore the apparatus to its normal position the solenoid 30 is energized, thereby pulling down the plunger 31 and restoring the shaft 17 to its normal position. During the restoration of the shaft 17, the wheel 18 remains stationary, due to the operation of the ratchet and pawl heretofore described.

In order to give a clearer understanding of our invention, we will describe in detail how a connection is extended from the substation A (Fig. 6) to the substation A′ (Fig. 7), in which the connector switch H (Fig. 7) is of the type of switches shown in Figs. 1, 2, 3 and 4. In Fig. 6 the line of the substation A is shown terminating at the central office in an individual or line switch C. At D there is shown a master switch for controlling a group of line switches C. The line switches of this group have common access to a number of trunk lines which lead to first selectors E. A number of first selectors have common access to a number of second selectors F (Fig. 7), which in turn have access to connector switches H by means of which connection may be completed with subscribers' lines. Associated with the connector H there are shown a ringing current generator M and a busy signaling apparatus L. At B a battery is shown having one terminal grounded. The automatic substation A may be of any suitable automatic common battery type. As herein shown it comprises the usual receiver 66, transmitter 67, ringer 68 and switch hook 69. Being an automatic substation it is also provided with an automatic calling device herein represented by a pair of impulse springs 70 and 71 and a toothed impulse wheel 72. The impulse wheel 72 is secured to a shaft 73 to which there is also attached a dial (not shown) provided with finger holes. Through the medium of the dial the subscriber may cause the impulse wheel 72 to separate the springs 70 and 71 any desired number of times to call any digit.

The line switch C, which is individual to the line of the substation A, and the master switch D are modified forms of the general type of line switch and master switch disclosed in British Patent No. 26,301 of 1906, but, however, of the particular type shown in British Patent No. 1,419 of 1910. As herein represented, the line switch C comprises, among other details, a plunger (not shown) attached to the end of the so-called plunger arm 74 which is controlled by the magnet 75. The magnet 75 also controls the relay armatures 76 and 77 and is composed of four windings, namely, a pull-in winding 78, a holding and cut-off winding 79, a line winding 80 and an auxiliary winding 81. The core of the magnet is provided near the center of its length with a lateral projection 82 by means of which the magnet is mounted upon the bracket 83, upon which latter the armatures 74, 76 and 77 are pivoted. With this method of mounting the magnet, the magnetic circuit of the windings 78 and 79 is maintained separate from that of the windings 80 and 81, so that the armatures at one end of the magnet are not affected by the energization of the windings upon the other end thereof. Of the windings upon the upper end of the magnet, only the winding 78 is strong enough to operate the plunger arm 74. The winding 79 is strong enough to operate the armature 76 and also to hold the plunger arm 74 in its operated position. When the plunger arm 74 is attracted by the magnet 75, the plunger of the switch is forced into a bank of contact springs, forcing the springs 84, 86, 88 and 90 into contact with the springs 85, 87, 89 and 91, respectively. Although only one set of springs (84—91) is shown, each line switch

C is provided with a number of such groups of springs, each group forming the terminal of a trunk line leading to a selector E. Each trunk line is multipled to the corresponding springs of all of the line switches of the group which is controlled by the master switch D.

The plungers of the line switches normally engage a so-called plunger shaft (not shown), and through the medium of the master switch D are normally maintained opposite the terminals of an idle trunk line. The master switch consists essentially of a motor magnet 92 for rotating the ratchet wheel 93. The ratchet wheel 93 is connected with the plunger shaft in such a manner that a rotary motion of the wheel imparts an oscillatory motion to the shaft to move the plungers back and forth in front of their trunk terminals. To the plunger shaft there is also secured a locking plate 96 provided with a number of openings adapted to be engaged by the pin 94 upon the end of the armature 95. The holes in this plate are so spaced that the pin 94 can engage one of them and allow the armature 95 to resume its normal position only when the idle plungers are directly opposite a trunk terminal. The master switch is also provided with a bank of contacts comprising a common segment 97 and one individual contact *a* for each trunk line to which the line switches have access. The wiper 98 always keeps the common segment 97 in contact with the individual contact of the trunk line before which the plungers are resting. The selector E is of the general type of selector switch disclosed in Patent No. 815,321 hereinbefore referred to. Among other details, the selector E comprises a set of wipers 99, 100 and 101 carried upon a vertically and rotatably movable shaft (not shown). The vertical movement is controlled by the vertical magnet 102 and the rotary movement is controlled by the rotary magnet 103. The usual vertical and rotary line relays are replaced by the double-wound line relay 104. The side switch, comprising the wipers 105 and 106, is controlled by the private magnet 107 in a manner well known in the art. Means for restoring the switch to normal position are provided in the release magnet 108. This magnet releases the switch immediately upon energization rather than by deënergization as shown in the said selector patent. The springs 109 are opened by the switch shaft whenever it is in its lowest position.

The selector F is the same as the selector E.

As has been previously explained, the connector H is the same as that shown in Figs. 1, 2, 3 and 4, portions of the mechanism being represented diagrammatically. As shown in Fig. 7, the connector is provided with three wipers, namely, a so-called private wiper 9 and two line wipers 10 and 11. A ringing relay 110 is shown also in Fig. 7. Since this relay has no connections with the mechanical parts of the switch, it may be mounted at any convenient place upon the frame.

The line switch C′ and the substation A′ are in all respects the same as the line switch C and the substation A.

When the subscriber at substation A removes his receiver preparatory to making a call, a bridge is closed across the line conductors 111 and 112 through the transmitter 67, receiver 66 and impulse springs 70 and 71, thereby closing a circuit through the line winding 80 of the line switch C. This circuit extends from ground G′ through the springs 113 and 114, line 111, telephone A, line 112, springs 115 and 116 and the winding 80 to the battery lead 117. The winding 80, upon energizing, attracts the armature 77, thereby closing a circuit from ground G′ through the springs 113 and 118, windings 78 and 81, contact 119 and the armature 95 to the battery lead 117. The winding 78, upon energizing, attracts the plunger arm 74 and cut-off armature 76. The plunger arm, upon being attracted, causes the plunger to close the springs 84—91 into contact in pairs as indicated. The closure of contact between the springs 84 and 85, and 86 and 87 extends the line connection to the first selector E, whereupon its line relay becomes energized over a circuit extending from ground G^2 through the lower winding of the relay 104, spring 120 and its back contact, line switch bank springs 87 and 86, thence to and through the telephone A and back over the other side of the line through the springs 84 and 85, spring 121 and its back contact and the upper winding of the relay 104 to the battery lead. The relay 104, upon energizing, completes a circuit from ground G^3 through the spring 122 and its front contact and the relay 123 to the battery lead. The relay 123, upon energizing, completes a circuit from ground G^4 through the springs 124, line switch bank springs 89 and 88 and the winding 79 to the battery lead. The winding 79, upon energizing, operates to hold the armatures 74 and 76 in their operated positions after the winding 78 is deënergized. The winding 78 is deënergized by the falling back of the armature 77, which occurs shortly after the line winding 80 is disconnected from the line by the operation of the cut-off armature 76. In order to delay the falling back of the armature 77 a short time so as to give the winding 79 a chance to become energized, the winding 81 is provided on the lower end of the magnet 75. This winding 81 is energized in series with the operating winding 78, and is short-circuited by the closure of the contact 125 when the plunger arm reaches its fully operated position. This momentary energization of

the winding 81, and the short-circuiting thereof, keeps the armature 77 attracted for an instant after the winding 80 is disconnected from the line. The energization of the relay 123 at the selector E also extends a guarding potential from ground G^4 through the springs 124, 89 and 88 and over the conductor 127 to the connector private bank contacts of all the connectors which have access to the line of substation A. The closure of the bank springs 90 and 91 of the line switch C completes a circuit from ground G^5 through the springs 90, and 91, contact 128 (which it is assumed corresponds to the trunk line leading to the selector E), wiper 98, segment 97 and the relay 129 to battery. The relay 129, upon energizing, closes a circuit through the relay 130. The relay 130 thereupon attracts its armature 95, withdrawing the pin 94 from the locking plate 96 and closing the circuit of the motor magnet 92 at the contact 131. Since the circuit of the motor magnet includes the interrupter springs 132, said magnet will operate in a manner similar to that of a buzzer as long as the contact 131 is closed, thereby rotating the ratchet wheel 93 step by step to advance the plungers of the idle line switches away from the trunk seized by the switch C. After the plungers have advanced a short distance, the wiper 98 is disengaged from the contact 128 and the relays 129 and 130 deënergize. The contact 131, however, remains closed until the next opening in the plate 96 passes under the pin 94, whereupon the armature 95 resumes its normal position, breaking the circuit of the motor magnet 92 and locking the plunger shaft. If the next trunk after the one seized by the line switch had been busy, the wiper 98 would have found a guarding potential upon the corresponding contact in the master switch bank, and the relays 129 and 130 would have remained energized while the next opening in the plate 96 was passing under the pin 94, and therefore the plungers of the idle line switches would have been carried past the busy trunk to an idle one.

The foregoing operations take place immediately upon the removal of the receiver at the calling substation. The calling subscriber now operates his calling device for the first digit of the number to be called, which will be assumed to be 2220. The operation of the calling device for the first digit 2 momentarily separates the substation impulse springs 70 and 71 twice. Each time these springs are separated the first selector line relay 104 deënergizes. Since the relay 123 is slow to deënergize, its armature does not have time to fall back during the momentary interruption of its circuit by the relay 104. Therefore, each time the relay 104 deënergizes a circuit is closed from ground G^3 through the spring 122 and its back contact, spring 133 and its front contact, relay 134, vertical magnet 102 and the side switch wiper 105 to the battery lead. The two impulses received over this circuit cause the vertical magnet to raise the shaft wipers 99, 100 and 101 two steps to a position opposite the second row or level of bank contacts. The relay 134, which is included in the operating circuit of the vertical magnet, when energized, closes a circuit from ground G^6 through the springs 135 and the private magnet 107 to battery. The relay 134, being slow acting, does not have time to deënergize until after the last impulse is delivered to the vertical magnet. When it does deënergize, the relay 134 breaks the circuit of the private magnet 107, which in turn deënergizes and permits the side switch to pass to second position. In second position the side switch wiper 105 completes a circuit from ground G^7 through the interrupter springs 137, rotary magnet 103 and the side switch wiper 105 to the battery lead. As long as the side switch remains in second position the rotary magnet operates in a manner similar to that of a buzzer to rotate the wipers step by step over the bank contacts of the second level, to which level they were raised by the vertical magnet. Each time the rotary magnet is energized it closes the contact 138, thereby completing a circuit from ground G^7 through the private magnet 107. If the first trunk line is idle, the first impulse through the private magnet steps the side switch to third position, thereby breaking the circuit of the rotary magnet and leaving the wipers standing upon the contacts of this first trunk. If this first trunk line is busy, however, the private wiper 101 finds its private bank contact grounded, and completes a holding circuit through the side switch wiper 106 (in second position) and the private magnet 107 to battery. This holding circuit through the private magnet causes the side switch to be locked in second position, whereupon the rotary magnet 103 continues to advance the wipers until an idle trunk is found, whereupon this holding circuit of the private magnet 107 is broken and the side switch passes to third position. The movement of the side switch wiper 105 from second to third position, besides breaking the circuit of the rotary magnet, closes the circuit of the line-switching relay 139. This circuit extends from ground G^4 at the relay 123 through the springs 124, relay 139 and the side switch wiper 105 to battery. The relay 139, upon energizing, disconnects the line relay 104 from the line and extends the line connection through the line wipers 99 and 100 to the second selector F, whereupon its line relay 140 becomes energized in the same manner in which the relay 104 was energized when the connection was first ex-

tended to the selector E. The relay 140, upon energizing, closes the circuit of the relay 141. The relay 141, upon energizing, completes a circuit extending from ground G^8 through the springs 142, private bank contact and private wiper 101 of the selector E, side switch wiper 106, thence through the relay 139 and the holding winding 79 of the line switch C in multiple to battery. This circuit just traced is for the purpose of maintaining the relays 139 and 79 energized after the relay 123 of the selector E is deënergized, which occurs shortly after the relay 104 is disconnected from the line by the relay 139.

The calling subscriber now operates his calling device for the second digit 2, whereupon the second selector F operates in the same manner as explained for the selector E to extend the connection over the trunk conductors 144 and 145 to the connector H (Fig. 7). The line relay 25 of the connector thereupon becomes energized over a circuit extending from ground G^9 through the lower winding of the relay 25, spring 147 and its back contact, trunk conductor 145, thence over the heavy conductors to and through the substation A, back over the other side of the line through the switches E and F, over the trunk conductors 144, springs 149 and 150 and the upper winding of the relay 25 to battery. The relay 25, upon energizing, permits the escapement wheel 22 to advance one step, as has been already explained, whereby the switch shaft 6 is lowered a short distance and the wheel 16 (Figs. 2 and 3) permits the springs 59 and 60 to come into contact. The closure of these springs provides a new holding circuit for the relays 153 and 139 of the switches F and E and the winding 79 of the line switch C. This circuit extends from ground G^{10} through the springs 60 and 59, conductor 146, private wiper 151 of the selector F, side switch wiper 152 and thence through the relays 153 and 139 and the winding 79 in multiple to battery. When the calling subscriber operates his calling device for the third digit 2, the line relay 25 of the connector is momentarily deënergized twice and then brought to rest in its energized position. As has already been explained, these two deënergizations of the relay 25 permit the switch shaft to be lowered a sufficient amount to bring the wipers 9, 10 and 11 opposite the second row or level of bank contacts, counting from the top. Also, as has been previously explained, the disk 45 rotates continuously during the downward movement of the shaft and at such a speed that the springs 42 and 44 do not have a chance to come into contact with the spring 43. After the impulses are delivered, however, the disk 45 comes to rest in a position in which the spring 44 drops into a notch and engages the spring 43. A circuit is thereby closed extending from ground G^{10} through the springs 60 and 59, relay 38, lower winding of the relay 154 and the springs 44 and 43 to battery. The relay 154 is not energized over this circuit, due to the comparatively high resistance of the relay 38. The relay 38 is energized, however, and releases the catch 34 (Fig. 1), allowing it to engage the teeth 35 in the shaft. Now, when the substation calling device is operated for the last digit 0, the line relay 25 is deënergized ten times, and since the shaft is locked against further vertical movement, it is forced to rotate in the manner heretofore explained to carry the wipers 9, 10 and 11 onto the tenth contacts of the second level, which are the contacts of the line desired. During this rotary operation the spring 44 is disengaged from the spring 43 and the relay 38 is allowed to deënergize. When, however, the disk 45 comes to rest after the last impulse is delivered, the spring 44 again engages the spring 43 and the relay 38 is again energized. The closure of the contact between the springs 155 and 156 and 157 and 158 of the relay 38 completes the line connection through the line wipers 10 and 11 to the called substation. The relay 38, upon energizing, also provides a guarding ground potential for the connector private bank contact of the called line and an energizing circuit for the ringing relay 110 and cut-off winding 159 of the line switch C'. The guarding potential for the private bank contact and the energizing circuit for the winding 159 extends from ground G^{11} through the springs 160 and 161, private wiper 9, thence to the connector private bank contacts of the called line and through the winding 159 to battery. The winding 159, upon energizing, attracts the armature 164, which operates to disconnect the switch C' from the called line and to close the normally open contact 163 in the talking circuit. The circuit for the ringing relay 110 extends from ground G^{11} through the springs 160 and 162, springs 165 and 166, relay 110 and the interrupter 167 to battery. The ringing relay 110, upon energizing, disconnects the calling from the called line, and connects the ringing generator M with the called line to signal the called subscriber. Since the circuit of the ringing relay contains the interrupter 167, the said relay is energized only intermittently so as not to ring the called subscriber continuously. When the talking circuit is bridged across the called line by the removal of the receiver at the substation A', or as soon thereafter as the relay 110 deënergizes, if it happens to be energized at the time, a circuit is closed through the back-bridge relay 168 of the connector. This circuit extends from ground G^{14} through the lower winding of the relay 168, springs 157 and 158, ringer

relay springs 169, wiper 11, thence to and through the substation A' and back over the other side of the line through the wiper 10, ringer relay springs 170, springs 156 and 155 and the upper winding of the relay 168 to battery. The closing of the springs 171 by the energizing of the relay 168 completes a circuit from ground G^{12} through the springs 171 and the upper winding of the relay 154 and springs 44 and 43 to battery. The relay 154, upon energizing, breaks the circuit of the ringing relay 110 at the springs 165 and 166, thereby cutting off the ringing current and allowing the two subscribers to carry on an interrupted conversation over the talking circuit outlined by heavy conductors in the drawings. The relay 154, upon energizing, closes a locking circuit for itself extending from ground G^{11} through the springs 160 and 162, 165 and 173 and the upper winding of the relay 154 to battery. The closure of this locking circuit prevents the relay 154 from falling back and again closing the energizing circuit of the ringing relay when the called subscriber hangs up. The springs 174 are closed as soon as the switch shaft begins to rotate. Therefore, when the springs 44 and 43 come into contact after the last digit is called, a circuit is closed from ground G^{13} through the springs 174, slow acting relay 61 and the springs 44 and 43 to the battery lead. The relay 61 thereupon energizes and locks the mechanism. This is for the purpose of preventing the shaft from being further rotated in case the calling subscriber should again operate his calling device for any reason. It will be seen that after the relay 61 in energized, a second circuit is closed extending from ground G^{13} through the springs 174, relay 61, springs 175 and the line relay springs 57 and 58 to battery. Therefore, if the calling device is again operated, the relay 61 will receive an impulse of current each time the line relay is energized, even though the springs 44 and 43 are separated. The relay 61, being slow acting, does not have time to deënergize between these impulses, and therefore the shaft remains locked.

It will be seen that when the back-bridge relay 168 is energized upon the response of the called subscriber, it interchanges the connections between the windings of the line relay and the conductors 144 and 145. This, it will be seen, reverses the direction of the current flowing in the calling line. This reversal of current may be used for the purpose of operating call register devices on the calling line, or for controlling supervisory signals in an operator's cord circuit in case the connection is a semi-automatic one.

The connection is released upon the termination of the conversation by the hanging up of the receiver at the calling telephone. The hanging up of the receiver permits the relay 25 to deënergize. This permits the disk 45 to rotate sufficiently to open the springs 44 and 43 and to permit the spring 42 to drop into the notch and engage the spring 43. The circuit of the relay 61 is also broken by the deënergization of the relay 25, and as soon as this relay deënergizes, a circuit is closed through the restoring solenoid 30. This circuit extends from ground G^{10} through the springs 60 and 59, solenoid 30, springs 176 and 177, 42 and 43 to battery. The solenoid, upon energizing, restores the mechanism of the connector to normal position, as has been already described. When the connector reaches its normal position, the springs 60 and 59 are separated, thereby breaking the circuit of the solenoid 30 and the holding circuit of the relays 153 and 139 of the selectors F and E and the winding 79 of the switch C. The winding 79, upon deënergizing, permits the plunger of the line switch to be restored to normal position. The deënergization of the relay 139 of the selector E completes a circuit extending from ground G^{3} through the spring 122 and its back contact, spring 133 and its back contact, springs 179 and 109 and the release magnet 108 to battery. The magnet 108, upon energizing, restores the selector to normal position, and when the switch shaft reaches its lowest position, the springs 109 are separated to allow the release magnet to deenergize. The selector F is released in the same manner as the selector E.

It having been explained how the connector H may connect with an idle line, it remains to be explained how the calling subscriber is given the busy signal in case the called line is busy. Whenever a line is busy, its connector private bank contacts are grounded. Therefore, when the wiper 9 strikes the contact of a busy line, a circuit is closed from the grounded private bank contact of said line through the springs 161 and 180, lower winding of the relay 154 and the springs 44 and 43 (when the disk 45 comes to rest) to battery. The closure of this circuit energizes the relay 154, and the relay 38 remains deënergized because it is short-circuited by the ground at the private bank contact of the busy line. Since the relay 38 is not energized, the connection is not completed between the calling and the called lines, and the closing of the contacts 181 at the relay 154 extends a connection from the busy signaling machine L through said springs 181, springs 182 and 157, condenser 183, thence to and through the substation A, thence back to the connector, through the lower winding of the line relay 25 to ground G^{9}, thence to the battery B and back to the other terminal of the busy signaling machine. The busy signaling current flowing over this circuit signifies to the

calling subscriber that the called line is busy. The relay 154, upon energizing, completes a locking circuit for itself through its upper winding in the same manner as explained when it was energized upon the response of the called subscriber. The locking of the relay 154 is for the purpose of preventing it from deënergizing and cutting on the ringing current in case the busy guarding potential should be removed from the called line before the calling subscriber A hangs up his receiver and releases the connection.

While we have shown and described one specific embodiment of our invention, it will be understood that we do not wish to limit ourselves to such exact construction, as many changes will readily suggest themselves to anyone skilled in the art. Furthermore, it is evident that our improved switch is equally well adapted for use in a semi-automatic system in which manual operators are employed for assisting in the establishing of connection between calling and called subscribers' lines.

What we claim as our invention is:—

1. In a telephone system, an automatic selecting switch provided with a shaft carrying wipers, said shaft having downward and rotary selecting motions, and circuits for operating the same.

2. In a telephone system, an automatic selecting switch having downward and rotary selecting motions, and means for controlling said switch over the two sides of a metallic talking circuit in series.

3. In a telephone system, lines divided into groups, an automatic switch having downward straight line motion to select groups and rotary motion to find a line in the selected group, and circuits for operating the same.

4. In a telephone system, lines divided into groups, an automatic switch having downward motion to select groups and rotary motion to find a line in the selected group, and means for controlling said switch over the two sides of a metallic talking circuit in series.

5. In a telephone system, an automatic switch including an element movable in two intersecting planes, means for moving said element by a continuous motion, step-by-step means for controlling the extent of operation of said movable element, and circuits for controlling said operation.

6. In a telephone system, an automatic switch including a movable element, means for moving said element by a continuous motion, and step-by-step means controlled over the two sides of a metallic talking circuit in series for controlling the extent of operation of said movable element.

7. In a telephone system, a subscriber's line, an automatic switch including arms movable in two intersecting planes, means on said subscriber's line for transmitting a varied number of impulses to control said switch, means for moving said arms by a continuous motion, and means controlled by said varying number of impulses for controlling the extent of motion of said arms.

8. In a telephone system, a subscriber's line, an automatic switch including movable arms, means on said subscriber's line for transmitting a varied number of impulses over the two sides of a metallic talking circuit in series to control said switch, means for moving said arms by a continuous motion, and means controlled by said varying number of impulses for controlling the extent of motion of said arms.

9. In a telephone system, an automatic switch including movable arms, means for moving said arms by a continuous motion in two intersecting planes, step-by-step means for controlling the extent of motion of said movable arms, and circuits for controlling said operation.

10. In a telephone system, an automatic switch including movable arms, means for moving said arms by a continuous motion in two intersecting planes, and step-by-step means controlled over a metallic circuit for controlling the extent of motion of said movable arms.

11. In a telephone system, an automatic switch including movable arms, means for moving said arms by a continuous motion downward, means for controlling the extent of said downward motion, means for then rotating the said arms by a continuous motion, and circuits for controlling said operation.

12. In a telephone system, an automatic switch, means for transmitting a varied number of impulses to operate said switch, movable arms for said switch, means for moving said arms downward by a continuous motion, means controlled by said impulses for determining the extent of motion of said arms, and means for then rotating said arms.

13. In a telephone system, an automatic switch, means for transmitting a varied number of impulses over a metallic circuit to operate said switch, movable arms for said switch, means for moving said arms downward by a continuous motion, means controlled by said impulses for determining the extent of motion of said arms, and means for then rotating said arms.

14. In a telephone system, an automatic switch including an operating shaft, means for controlling the operation of said shaft, and means for simultaneously operating said controlling means at one speed and said operating shaft at a second speed.

15. In a telephone system, an automatic switch, an operating shaft therefor, an es-

capement mechanism for controlling the operation of said shaft, means for operating said escapement mechanism at one speed, and means for operating said shaft at a second speed.

16. In a telephone system, an automatic switch, an operating shaft therefor, an escapement mechanism controlling the extent of operation of said shaft, a governor for controlling the speed of said shaft, whereby said escapement mechanism is adapted to operate at a higher rate of speed than said shaft, and means including electrical circuits for controlling the operation of said shaft.

17. In a telephone system, an automatic switch including a movable element having motion in two intersecting planes a single operating means for moving said element in both of said planes, and electrical circuits for controlling said operating means.

18. In a telephone system, an automatic switch including a movable element having motion in two intersecting planes, a single operating means for moving said element in both of said planes, and means for controlling said operating means over a metallic circuit.

19. In a telephone system, lines divided into groups, an automatic switch including a movable element having motion in one plane to select groups and motion in a plane at right-angles thereto to find a line in the selected group, and a single operating means for moving said element in both of said planes.

20. In a telephone system, lines divided into groups, an automatic switch including a movable element having motion in one plane to select groups and motion in a plane at right-angles thereto to find a line in the selected group, a single operating means for moving said element in both of said planes, and means for controlling said operating means over a metallic circuit.

21. In a telephone system, an automatic switch including a movable element having motion in two intersecting planes, a single spring for moving said element in both of said planes during the operation of said switch, and electrical circuits for controlling the operation of said switch.

22. In a telephone system, an automatic switch including a movable element having motion in two intersecting planes, a single spring for moving said element in both of said planes during the operation of said switch, and means for controlling said switch over a metallic circuit

23. In a telephone system, lines divided into groups, an automatic switch including a movable element having motion in one plane to select a group and motion in a plane at right-angles thereto to find a line in the selected group, and a single spring for moving said element in both of said planes during the operation of said switch.

24. In a telephone system, lines divided into groups, an automatic switch including a movable element having motion in one plane to select a group and motion in a plane at right-angles thereto to find a line in the selected group, a single spring for moving said element in both of said planes during the operation of said switch, and means for controlling said switch over a metallic circuit.

25. In a telephone system, an automatic switch including a movable element, operating means tending normally to operate said element in one direction, and operating the same in another direction when prevented from moving it in the first-mentioned direction, and electrical circuits for controlling the operation of said switch.

26. In a telephone system, an automatic switch including a movable element, and operating means controlled over a metallic circuit tending normally to operate said element in one direction, and operating the same in another direction when prevented from moving it in the first-mentioned direction.

27. In a telephone system, an automatic switch including a movable element, an operating spring normally tending to move said element in one direction, means controlled by said spring for moving said element in a direction at right-angles to said first-mentioned direction when motion in said direction is prevented, and electrical circuits for controlling the operation of said switch.

28. In a telephone system, an automatic switch including a movable element, an operating spring controlled over a metallic circuit normally tending to move said element in one direction, and means controlled by said spring for moving said element in a direction at right-angles to said first-mentioned direction when motion in said direction is prevented.

29. In a telephone system, lines divided into groups, an automatic switch including a movable element, and operating means tending normally to operate said element in one direction to select a group, and operating said element in another direction to find a line in a selected group when prevented from moving the element in the first-mentioned direction.

30. In a telephone system, an automatic switch including a movable element, an operating spring normally tending to move said element in a downward direction, means controlled by said spring for rotating said element when said downward motion is prevented, and electrical circuits for controlling the operation of said switch.

31. In a telephone system, an automatic

switch including a movable element, an operating spring normally tending to move said element in one direction by a continuous motion, means controlled by said spring for moving said element by a continuous motion in a direction at right-angles to said first-mentioned motion when motion in said direction is prevented, step-by-step means for controlling the extent of motion of said movable element, and electrical circuits for controlling the operation of said switch.

32. In a telephone system, an automatic switch including a movable element, an operating spring normally tending to move said element in a downward direction by a continuous motion, means controlled by said spring for rotating said element by a continuous motion when said downward motion is prevented, step-by-step means for controlling the extent of movement of said movable element, and electrical circuits for controlling the operation of said switch.

33. In a telephone system, an automatic switch including a movable element, a line relay therefor, and means for intermittently operating said line relay to cause said movable element to operate with a continuous motion.

34. In a telephone system, lines divided into groups, an automatic switch including a movable element, a line relay, and means for intermittently operating said line relay to cause said movable element to move with a uniform motion to select a group and to find a line in the selected group.

35. In a telephone system, an automatic switch including a movable element having motion in two intersecting planes, a single spring for moving said element in both of said planes, a magnet for returning said movable element to normal position, and electrical circuits for controlling said operations.

36. In a telephone system, lines divided into groups, an automatic switch including a movable element having motion in one plane to select groups and motion in a plane at right-angles thereto to find a line in the selected group, a single operating means for moving said element in both of said planes, and a magnet for returning said movable element to normal position.

37. In a telephone system, lines divided into groups, an automatic switch including a movable element having motion in one plane to select a group and motion in a plane at right-angles thereto to find a line in the selected group, a single spring for moving said element in both of said planes, and a magnet for returning said movable element to normal position.

38. In a telephone system, an automatic switch including a movable element, operating means tending normally to operate said element in one direction, and operating the same in apother direction when prevented from moving it in the first-mentioned direction, a magnet for returning said movable element to normal position, and electrical circuits for controlling said operations.

39. In a telephone system, an automatic switch including a movable element, an operating spring normally tending to move said element in one direction, means controlled by said spring for moving said element in a direction at right-angles to said first-mentioned direction when motion in said direction is prevented, a magnet for returning said movable element to normal position, and electrical circuits for controlling said operations.

40. In a telephone system, an automatic switch including an operating element movable in but one direction, a movable element controlled by said operating element and adapted to be moved first in one direction and then in a direction at right-angles to said first-mentioned direction by a single movement of said operating element, and electrical circuits for controlling said operations.

41. In a telephone system, an automatic switch, a movable cylinder for said switch, means for moving said cylinder longitudinally, a movable element controlled by said cylinder and adapted to be moved first in one direction and then in a direction at right-angles thereto by a single longitudinal movement of said cylinder, and electrical circuits for controlling said operations.

42. In a telephone system, an automatic switch, an operating shaft carrying contact arms, a cylinder mounted upon said shaft, means for moving said cylinder along said shaft, means controlled by said cylinder for first moving said shaft longitudinally and then rotating said shaft during a single longitudinal movement of said cylinder, and electrical circuits for controlling said operations.

43. In a telephone system, an automatic switch, an operating shaft carrying contact arms, a movable cylinder mounted upon said shaft, a spiral slot in said cylinder, a pin mounted upon said shaft and adapted to engage with said slot, means for moving said cylinder and shaft longitudinally, means for then preventing longitudinal movement of said shaft, whereby the longitudinal movement of the cylinder rotates said shaft through the medium of said pin and slot connection, and electrical circuits for controlling said operations.

44. In a telephone system, lines divided into groups, an automatic switch including an operating shaft, contact arms carried thereby, a cylinder mounted upon said shaft, means for moving said cylinder longitudinally, and means controlled by the longitudi-

nal movement of said cylinder to move said contact arms to first select groups and then to find a line in the selected group.

45. In a telephone system, lines divided into groups, an automatic switch including an operating shaft, contact arms carried thereby, a sleeve mounted upon said shaft, spring-operated means for moving said sleeve downward, means controlled by said downward movement of said sleeve to first move said operating shaft and contact arms carried thereby downward to select a group, and to then rotate said contact arms to find a line in the selected group, and a magnet for returning said shaft and contact arms to normal position.

46. In a telephone system, an automatic switch including an operating shaft, means for moving said shaft in a vertical and rotary direction, a catch for preventing said vertical movement, means for normally holding said catch out of engagement with said shaft, means for throwing said catch into engagement with said shaft when said shaft is brought to rest after moving from normal position, and electrical circuits for controlling said operations.

47. In a telephone system, an automatic switch, a notched disk, circuits controlling the operation of said switch, springs engaging the notched surfaces of said disk for controlling said circuits, means for rotating said disk at a high rate of speed during the operation of said switch to thereby prevent said controlling springs coming in contact except when said disk is at rest, and electrical circuits for controlling said operations.

48. In an automatic telephone exchange, the combination of a telephone line, an automatic switch, a bridge of the line at said switch including a magnet and a source of current, switching mechanism at the subscriber's station for producing either a continuous or an intermittent current in said magnet, means operated by intermittent current in the magnet to actuate the automatic switch to select the terminals of a called subscriber, a relay, means operated by continuous current in said magnet after the operation of said switch by said intermittent current for controlling said relay, a ringer relay controlled by said first-mentioned relay, a source of ringing current, and means controlled by said ringer relay for connecting the ringing current to the called subscriber's line.

49. In a telephone system, an automatic switch having a movable element, means for operating said element, a magnet, and mechanical connections between said movable element and the core of said magnet, whereby the operation of said magnet drives said movable element to normal position.

50. In a telephone system, an automatic selecting switch having an element having downward and rotary selecting motions, means for operating said switch, a magnet, and mechanical connections between the core of said magnet and said element, whereby said magnet operates to release said switch by moving said element to normal position.

51. In a telephone system, lines divided into groups, an automatic switch having an element having downward motion to select groups and rotary motion to find a line in the selected group, and a magnet operating to release said switch by moving said element to normal position.

52. In a telephone system, an automatic switch having a movable element, means for moving said element by a continuous motion, step-by-step means for controlling the extent of operation of said movable element, and a solenoid magnet for controlling the release of said switch.

53. In a telephone system, an automatic switch having a movable element, means for moving said element by a continuous motion, step-by-step means for controlling the extent of operation of said movable element, a solenoid magnet, and mechanical connections between the core of said solenoid and said movable element, whereby said solenoid controls the release of said switch.

54. In a telephone system, an automatic switch including movable arms, means for moving said arms by a continuous motion in two intersecting planes, step-by-step means for controlling the extent of motion of said movable arms, a solenoid magnet, and mechanical connections between the core of said magnet and said movable arms, whereby said solenoid controls the release of said switch.

55. In a telephone system, an automatic switch including a movable element having motion in two intersecting planes, a spring for moving said element in both of said planes, a solenoid magnet, and mechanical connections between the core of said magnet and said movable element, whereby said solenoid controls the release of said switch.

Signed by us at Chicago, Cook county, Illinois, this 9th day of March, 1912.

JOHN G. BLESSING.
BERNARD D. WILLIS.

Witnesses:
ARTHUR J. RAY,
ALBERT ANDERSEN.