

A. E. KEITH.
TELEPHONE SYSTEM.
APPLICATION FILED JUNE 28, 1911.

1,185,510.

Patented May 30, 1916.
6 SHEETS—SHEET 1.

FIG. 1.

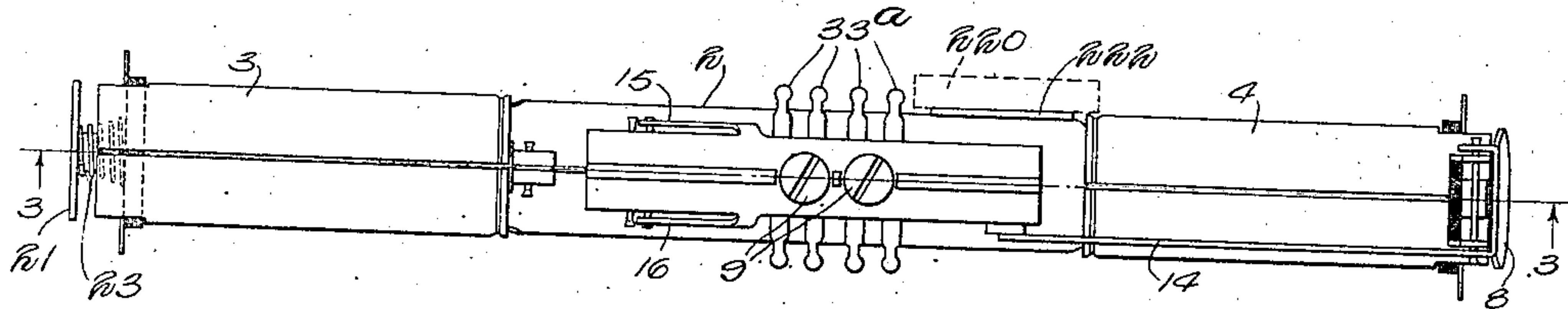


FIG. 2.

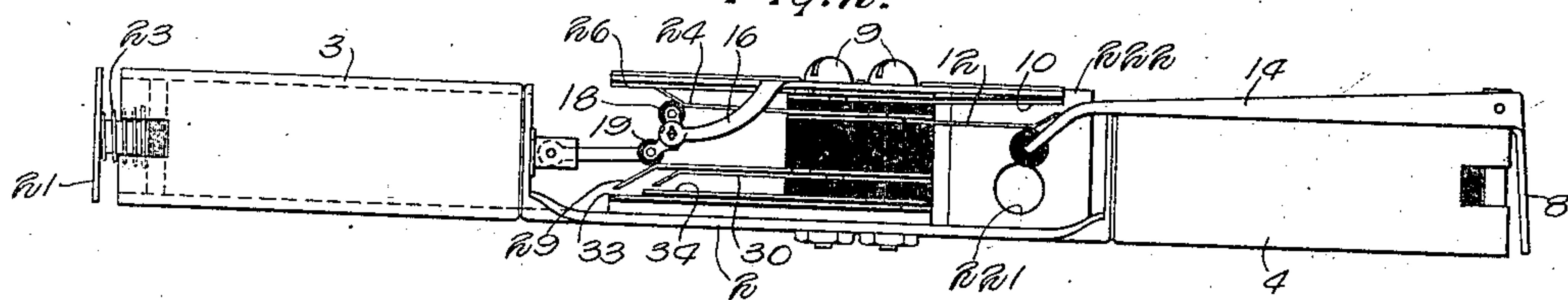


FIG. 3.

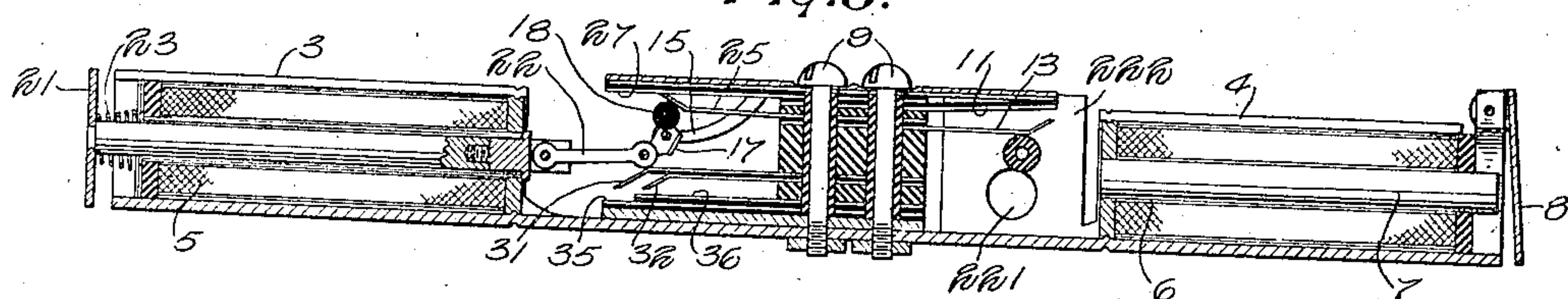
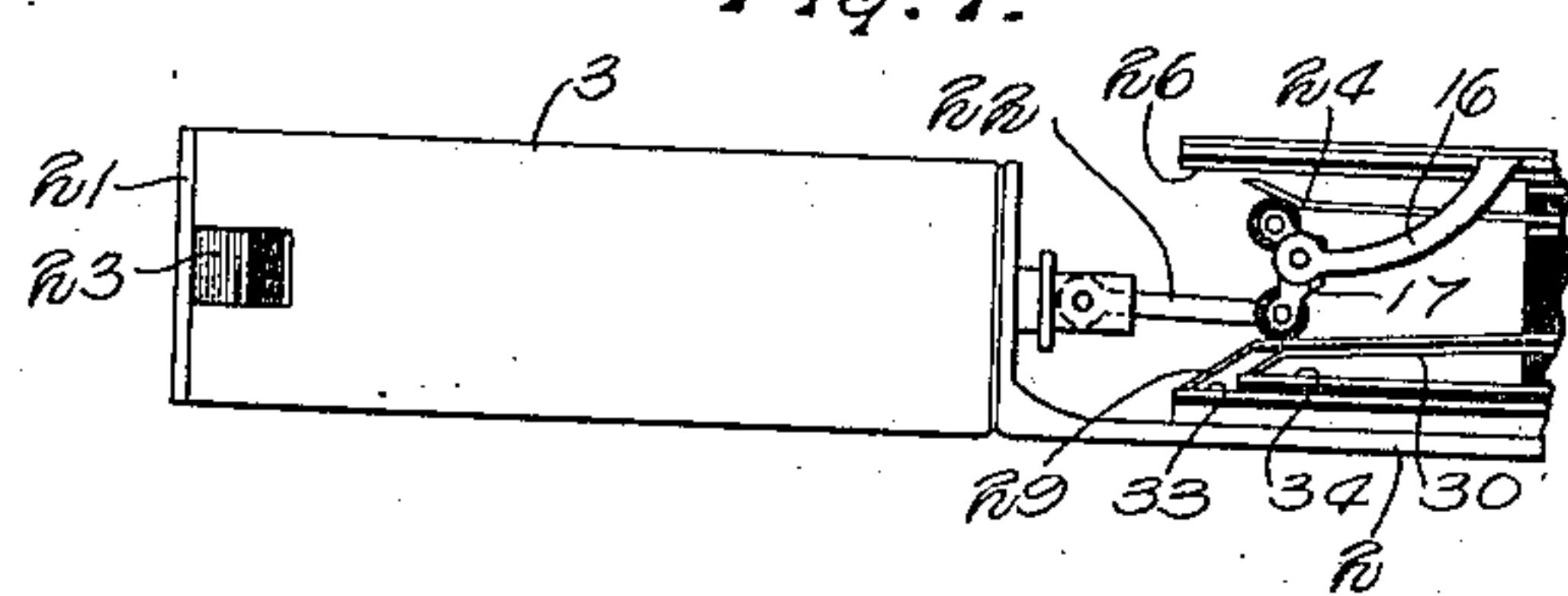


FIG. 4.



WITNESSES

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6 SHEETS—SHEET 2.

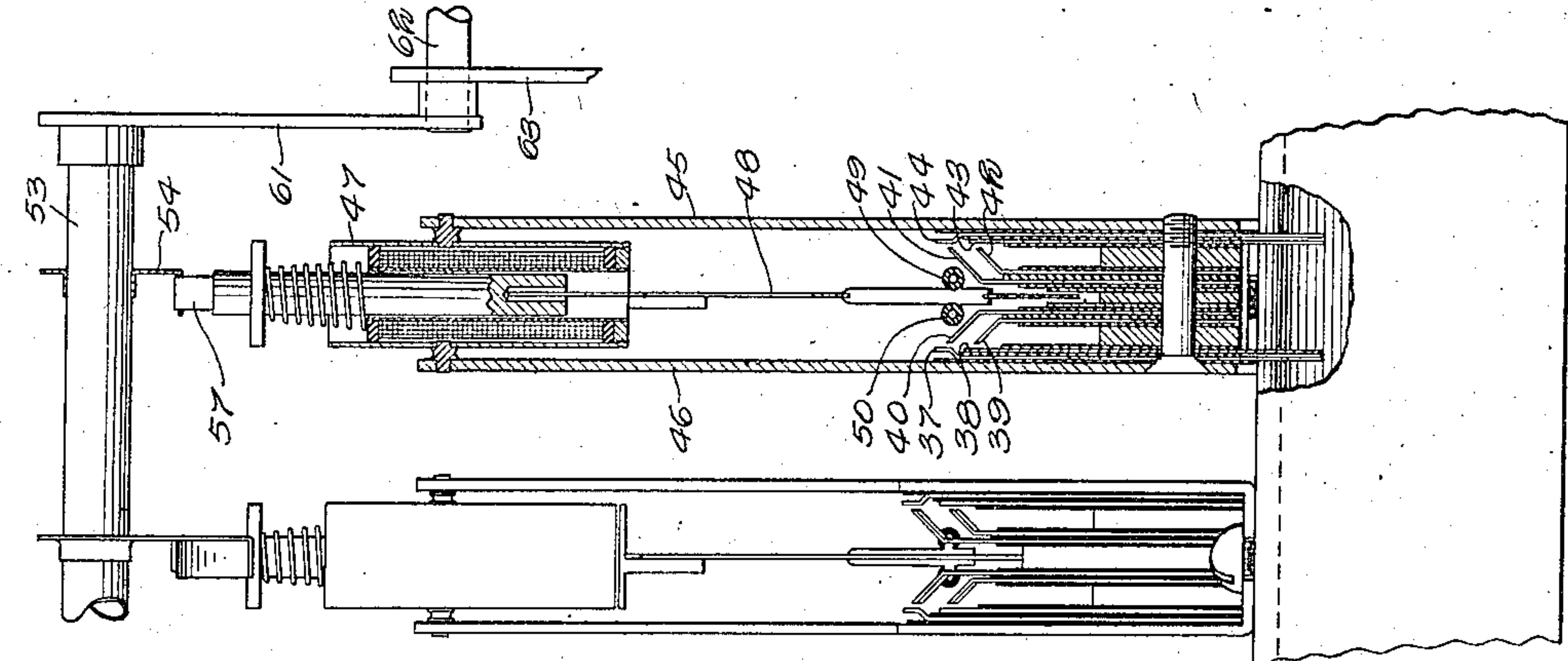


Fig. 6.

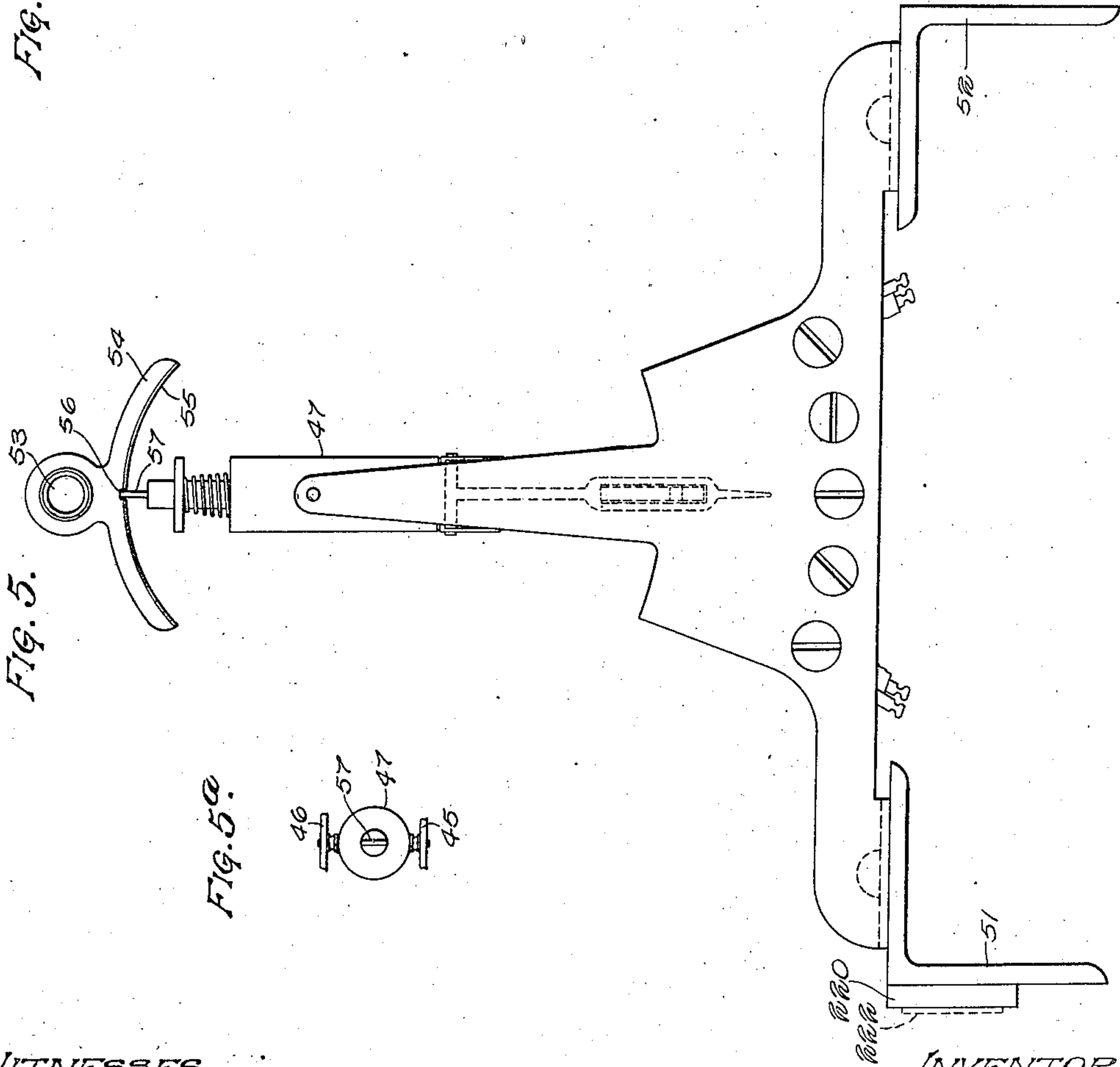
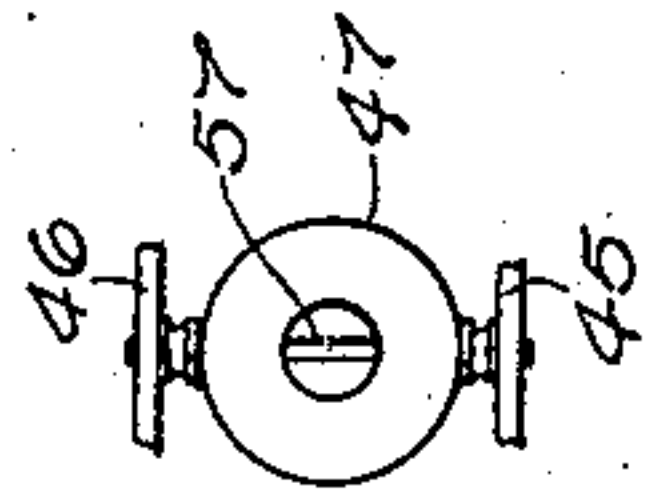


Fig. 5.

Fig. 5a.



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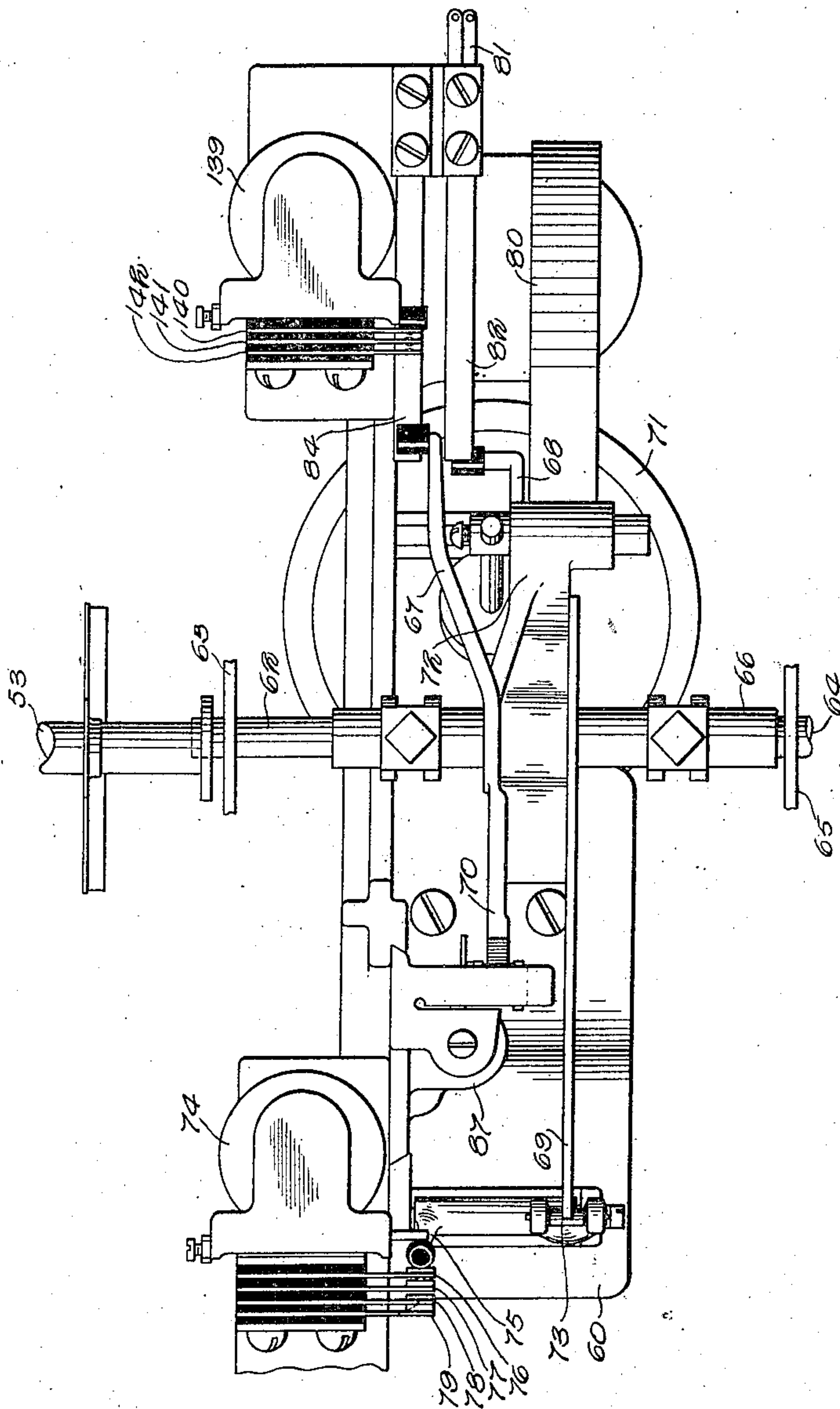
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FIG. 7.



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6 SHEETS—SHEET 4.

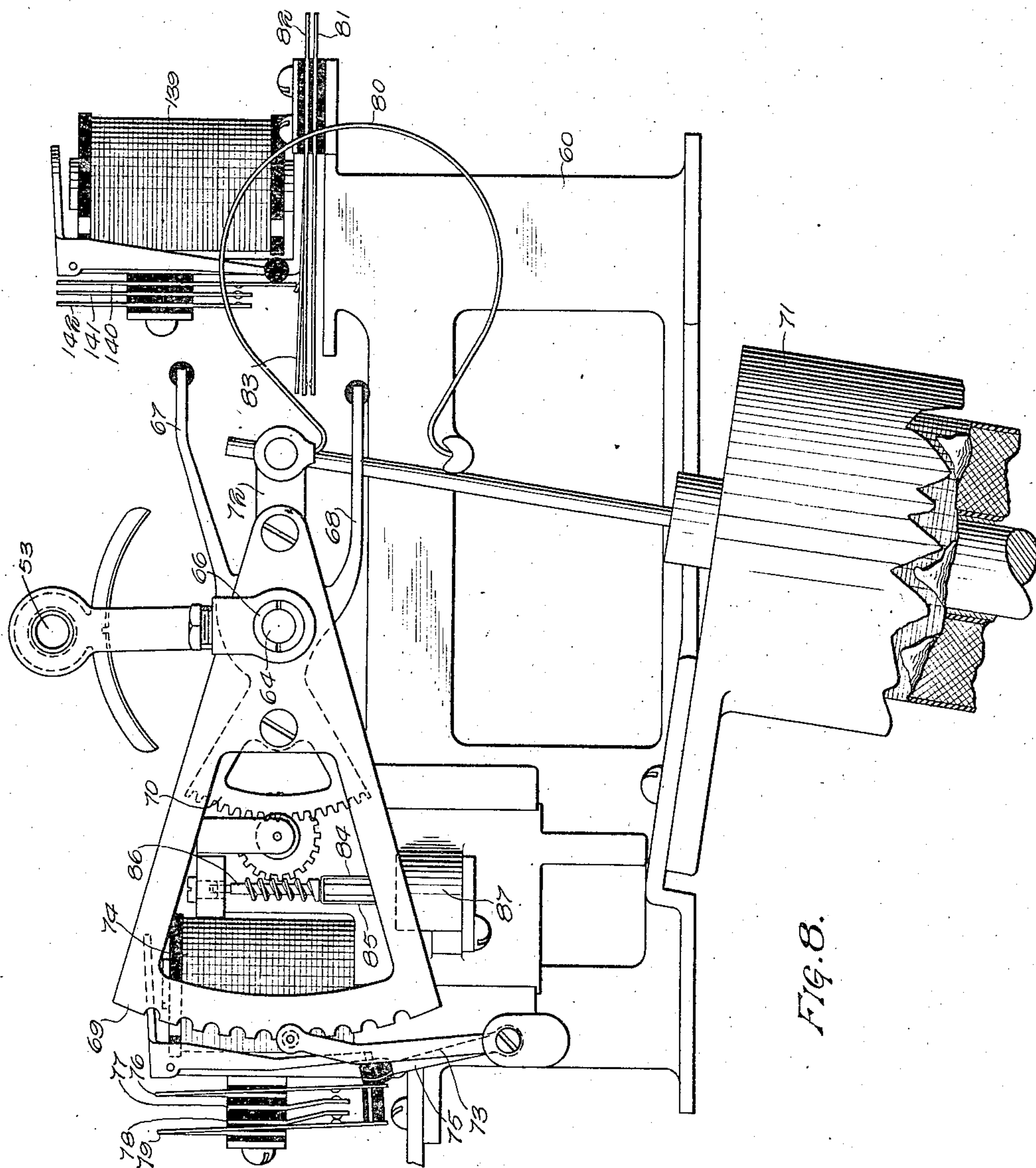


FIG. 8.

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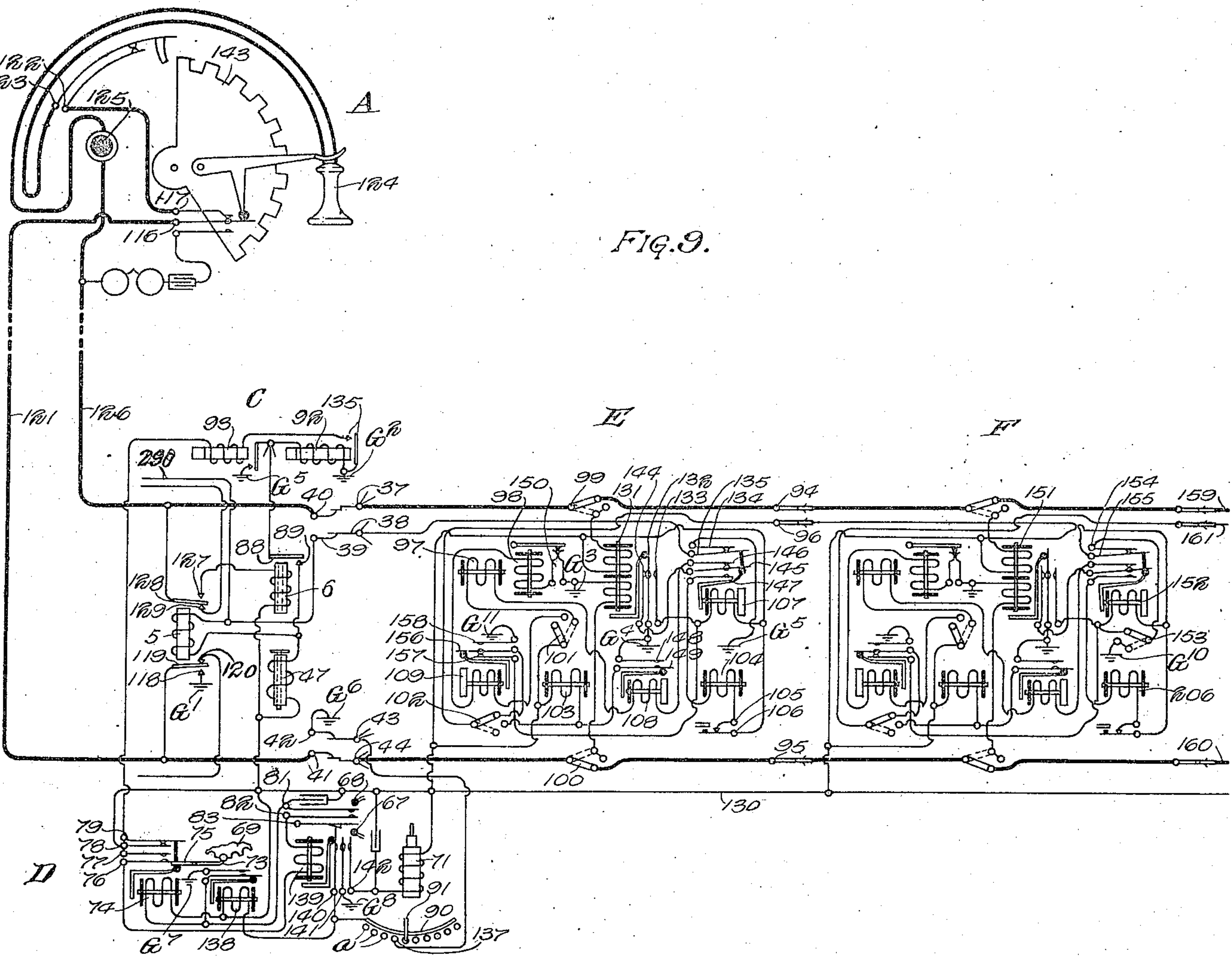
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6 SHEETS—SHEET 5.

FIG. 9.



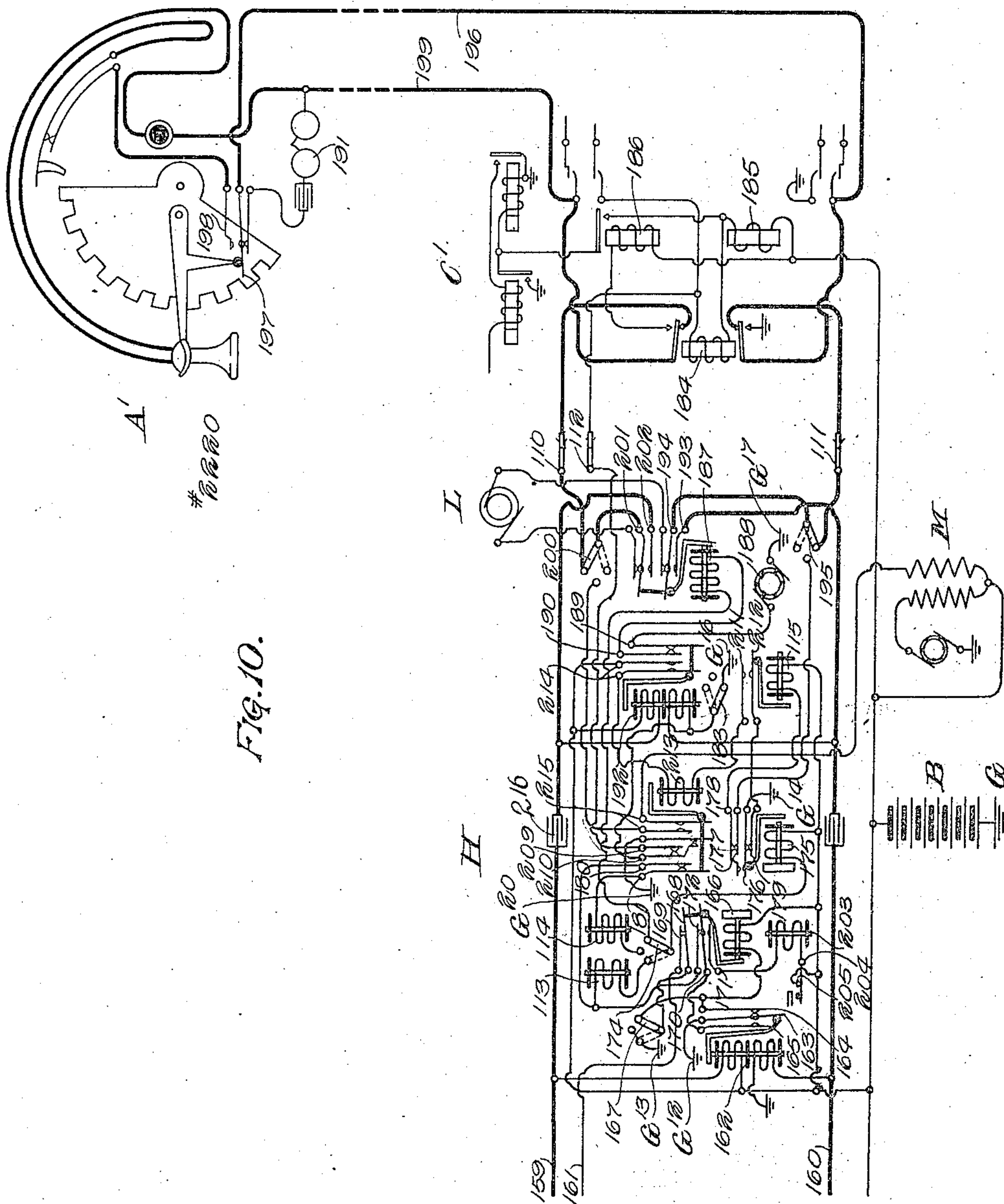
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6 SHEETS—SHEET 6.



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TELEPHONE SYSTEM.

1,185,510.

Specification of Letters Patent.

Patented May 30, 1916.

Application filed June 28, 1911. Serial No. 635,697.

To all whom it may concern:

Be it known that I, ALEXANDER E. KEITH, a citizen of the United States of America, and resident of Hinsdale, Dupage county, Illinois, have invented certain new and useful Improvements in Telephone Systems, of which the following is a specification.

My invention relates in general to automatic or semi-automatic telephone systems, and more particularly to that type of system known as the "line switch system"—that is, one in which line switches are employed which are individual to the subscribers' lines for the purpose of selecting an idle trunk, which trunk may extend to a first selector or the like.

Among the objects of my invention are to provide an improved construction for the line switch, and to provide a line switch in which the operating magnet is movable with the operating plunger in the selecting operation of the switch.

A further object is to provide an improved and simplified construction of master switch, which master switch controls a group of line switches, and to provide a master switch which has a continuous selecting motion and a continuous return motion, as distinguished from a step-by-step motion.

These and other objects of my invention will be more clearly understood by reference to the accompanying drawings, in which similar reference characters refer to similar parts, and in which—

Figure 1 is a top view of my improved combined line and cut-off relay. Fig. 2 is a side view of the same. Fig. 3 is a section taken on the line 3—3 of Fig. 1. Fig. 4 is a view of one of the relays in its operated position. Fig. 5 is a side view of one of the subscribers' individual switches. Fig. 5^a is a top view of the solenoid 47 in Fig. 5. Fig. 6 is a view showing two of the switches, showing how they are mounted relatively to each other, one of them being shown in section. Fig. 7 is a side view of the master switch. Fig. 8 is a top view of the same. Figs. 9 and 10 taken together show a complete connection between the calling and called substations in a system embodying the principles of my invention.

The construction of the combined line and cut-off relays shown in Figs. 1, 2, 3 and 4 is as follows: In these figures, 3 and 4 are

two metal tubes joined by a flat strip 2. The strip 2 and the tubes 3 and 4 are formed out of a single piece of metal which is punched out of a flat sheet and formed into the proper shape. The tubes form casings for the relay windings 5 and 6. The winding 6 has a stationary core 7 and the pivoted armature 8. The winding 5 is provided with a movable plunger, to the end of which there is secured a flat disk or armature 21. As shown, each relay controls two sets of springs placed side by side. These springs are mounted on the strip 2 between the windings 5 and 6, and are held in place between suitable insulating bushings by the bolts 9. The springs controlled by the winding 6 consist of two stationary springs 10 and 11 placed along side of each other and two movable springs 12 and 13. When the winding is energized, the armature 8 is attracted, and, through the medium of the arm 14, forces the springs 12 and 13 into contact with the springs 10 and 11. The relay 5 controls a set of normally closed springs and a set of normally open springs. Journaled between the arms 15 and 16 there is a small lever 17 provided with the bushings 18 and 19. The lever 17 is connected with the plunger of the relay 5 by a short link 22. When the winding is deenergized, the plunger is held in its retracted position, as shown in Figs. 2 and 3, by the spring 23. In this position, the bushing 18 on the lever 17 forces the springs 24 and 25 into contact with the springs 26 and 27. When the winding is energized, the plunger is forced to the right and the lever 17 is rocked into the position shown in Fig. 4. In this position, the springs 24 and 25 are permitted to separate from the springs 26 and 27, and the springs 29, 30, 31 and 32 are forced into contact with the springs 33, 34, 35 and 36, respectively. The contact springs of the relays are provided with suitable terminals 33^a (Fig. 1) by means of which electrical connections may be made therewith. It will be understood, of course, that although I have shown and described one particular spring combination for these relays, any suitable arrangement of springs may be used without departing from the spirit of the invention—that is, the number of springs controlled by either relay may be either increased or decreased as desired. It will be seen that the ends of the movable springs

of these relays are bent outward. When they are forced into contact with the stationary springs, there is a tendency to straighten out the movable springs, thereby lengthening them slightly. This causes a slight rubbing motion between the movable springs and the stationary springs. This serves to keep the contact surfaces bright and clean, thereby insuring a good contact without the use of platinum contact points.

The subscriber's individual switch shown in Figs. 5 and 6 is, in general principles, very similar to that disclosed in British Patent No. 26,301 of 1906, and in the *American Telephone Journal* of New York, N. Y., of June 6, 1908. Each switch is provided with a number of sets of contact springs similar to the set 37, 38, 39, 40, 41, 42, 43 and 44. These sets of springs are arranged on the arc of a circle and are clamped between the plates 45 and 46 and are separated from each other by suitable insulating bushings. Pivoted between the plates 45 and 46 there is a solenoid 47. To the lower end of the movable core of the solenoid there is attached a plunger 48, the point of which projects downward between the contact springs of the switch. To the lower end of the plunger 48 there are attached two small bushings 49 and 50. When the plunger is retracted, these bushings are high enough to just pass over the top of the contact springs as the solenoid is moved about its pivots. When the solenoid is energized, its plunger is drawn downward, forcing the bushings 49 and 50 against the springs 40 and 41 of whichever group of springs the plunger is then opposite, and as the plunger continues to move downward the springs 39, 40, 41 and 42 are forced into contact with the springs 38, 37, 44 and 43, respectively. A number of these line switches are mounted side by side upon a frame comprising a pair of angle irons 51 and 52 (Fig. 5). Above these switches, and parallel with these angle irons, there extends a rotatable shaft 53. On the shaft 53, opposite each of the individual switches, there is a member 54. The member 54 is provided with a curved flange 55. In the center of this flange there is a notch 56. On the upper end of the plunger of the solenoid 47 there is a small flat projection 57 which is adapted to normally engage the notch 56 in the flange 55. Thus the plungers of all the individual switches are normally locked with the shaft 53 and, through the medium thereof, may be moved back and forth in front of their respective banks of contact springs. When a line switch is operated, however, its plunger passes out of control of the shaft 53. If, when a line switch returns from its operated to its normal position, the shaft 53 is not standing in the same position in which

it was when the line switch was operated, the projection 57 on the top of the plunger of the line switch will not engage the notch 56, but will strike somewhere on the smooth surface of the cam 55. During the subsequent movements of the shaft 53 the line switch will then remain stationary, with its plunger standing in front of the group of contacts from which it was just disengaged, until the shaft returns to the position in which it was when that particular switch was operated. When the shaft reaches this position, the projection 57 drops into the notch 56 and the plunger will again become locked with the shaft. The movement of the shaft 53 is controlled by a master switch such as shown in Figs. 7 and 8, and in a manner to be hereinafter described.

To each of the line switches there is allotted one of the combined line and cut-off relays, as shown in Fig. 1. These relays are mounted vertically, opposite their respective switches, upon a strip 220 which is secured to the angle iron 51 (Fig. 5). The relays are secured to the strip 220 by a screw which passes through the hole 221 in the rectangular piece 222 (Figs. 1, 2 and 3).

The master switch shown in Figs. 7 and 8 is assembled upon a base or frame 60 which is adapted to be mounted upon the angle irons 51 and 52 (Fig. 5) midway of their length, with an equal number of line switches on either side of it. On the end of the shaft 53 (Figs. 6 and 7) there is a downwardly projecting link 61, to the lower end of which there is secured a short shaft 62. The end of the shaft 62 is supported by a bearing in the stationary support 63. The line switches on the other side of the master switch are provided with a plunger shaft similar to the shaft 53, and which in turn is connected with a shaft 64 which is similar to the shaft 62. The shaft 64 passes through a bearing in the support 65. For simplicity, the supports 63 and 65 are omitted in Fig. 8. The shafts 62 and 64 are firmly clamped together by means of a divided hollow shaft 66, through which the ends of the shafts 62 and 64 pass and to which they are securely fastened. Firmly secured to the shaft 66 there are two arms 67 and 68, a notched cam 69 and a geared segment 70. The shaft 66 is also connected with the plunger of a solenoid 71 by means of an arm 72. Adapted to register with the notches in the cam 69 there is a locking dog 73 which is controlled by the armature of the relay 74 through the medium of the arm 75. The relay 74 also controls the contact springs 76, 77, 78 and 79. When the relay 74 is energized, the dog 73 is disengaged from the cam 69 and the shaft 66 is then free to rotate. If the solenoid is not energized, the shaft will be rotated in a counter-clockwise direction by the spring 80. When the

solenoid is energized, it rotates the shaft 66 in a clockwise direction against the tension of the spring 80. In its normal operation the shaft 66 is rotated in either direction only far enough to carry the last notch in the cam 69 past the dog 73. The motion of the shaft 66 is transmitted to the plunger shaft 53 and the corresponding shaft on the other side of the master switch to give them an oscillating motion about the shafts 62 and 64 as an axis. This oscillatory motion of the plunger shafts moves the plungers 48 of the line switches back and forth in front of their bank springs. There is a notch in the cam 69 for each set of springs in the banks of the line switches, and the notches are so spaced that when the dog 73 is in engagement with any one of them, the plungers of the line switches that are in engagement with the plunger shaft will be in line with the corresponding sets of springs in their banks. The arm 68 of the master switch is adapted to force the spring 81 into contact with the spring 82 when the upper notch in the cam 69 reaches a position just below that in which it registers with the dog 73. The arm 67 is adapted to depress the spring 83 when the shaft 66 is rotated far enough to bring the lowest notch of the cam 69 slightly above the end of the dog 73. In order to operate the springs at the proper time, the arms 67 and 68 may be adjusted by bending, or they may be provided with adjusting screws or other well-known means of adjustment. The speed of the operation of the master switch is controlled by a governor comprising a pair of weighted springs 84 and 85 secured to a shaft 86 which is geared to the segment 70. As the master switch operates, the shaft 86 rotates and causes the ends of the springs 84 and 85 to fly outward and rub on the inside of a stationary cup 87 to produce a braking action.

In Fig. 9 there is shown a substation A to the line conductors of which there is allotted at the central office one of the subscriber's individual switches shown in Figs. 5 and 6. In these figures the line switch is represented diagrammatically by one of the sets of springs 37—44 and the solenoid 47. As has been explained, each line switch is provided with a number of such sets of springs. Each of these sets forms the terminal of a trunk line leading to a selector switch E. Each trunk line is connected in multiple with the corresponding set of springs in the banks of all the line switches which are controlled by the same master switch. The subscribers' line conductors are connected in multiple with the springs 40 and 41 of all the sets in its own line switch. This trunking arrangement is the same as described in British Patent No. 26,301 of 1906.

To each subscriber's line there is also allotted one of the combined line and cut-

off relays 6 and 5, shown in Figs. 1 to 4, inclusive. The line relay 5 has only a single pair of contact springs 88 and 89. The cut-off relay 6 has two groups of springs, each of which is represented by an armature and a front and back contact. In reality each group would consist of a pair of springs, such as 24 and 26, on the upper side of the relay (Fig. 2) and another pair of springs, such as 29 and 33, on the lower side. By connecting the springs 24 and 29, these two pairs of springs form the equivalent of a simple make-and-break device, as represented in Fig. 9.

At D there is shown a master switch of the type shown in Figs. 7 and 8 for controlling the group of line switches to which the switch C belongs. In addition to the parts already described, the master switch is provided with a suitable bank of contacts comprising a common segment 90 and an individual contact *a* for each trunk line to which the switches C have access. The wiper 91 is secured to the master switch shaft and is adapted to keep the common segment 90 in electrical contact with the individual contact corresponding to the trunk line before which the plungers are being held by the master switch.

The two relays 92 and 93 shown just above the line switch C are common to the entire group of switches controlled by the master switch D. These relays are slow-acting—that is, slow to deenergize. This slow action may be obtained by placing a ring of copper around one end of the core of the relay.

The selector switch E is of the general type disclosed in United States Letters Patent No. 815,321, granted March 13, 1906, to Keith, Erickson & Erickson, being modified somewhat, however, in order to operate in a two-wire system. As herein represented, the selector comprises the usual wipers 94, 95 and 96 carried upon a shaft (not shown) which has a vertical motion controlled by the vertical magnet 97 and a rotary motion controlled by the rotary magnet 98. The usual side switch comprising the wipers 99, 100, 101 and 102 is controlled by the private magnet 103 in the usual and well-known manner. The usual means of releasing the switch are provided in the release magnet 104. The springs 105 and 106 are permitted to close only when the switch shaft is raised one or more steps from its lowest position. The relays 107, 108 and 109 are slow acting relays. The shaft will release immediately upon the energization of its release magnet, rather than by its deenergization as shown in the said selector patent No. 815,321. The selector F is essentially the same as the selector E.

The connector H (Fig. 10) is of the general type disclosed in United States Letters Patent No. 815,176, granted March 13, 1906,

to Keith, Erickson & Erickson, but, like the selector, is modified to operate in a two-wire system. This connector comprises the usual wipers 110, 111 and 112 carried upon a vertically and rotatably movable shaft, which is controlled by a vertical magnet 113 and rotary magnet 114 and the usual side switch, which latter is controlled by the private magnet 115 in the usual manner. At L there is shown a ringing current generator and at M a busy signaling machine is represented. A battery B having one terminal grounded at G is shown for supplying current for operating the switches and for talking purposes. The connector H is represented as having obtained connection with the line of substation A', which line is provided with the line switch C', in all respects similar to the line switch C (Fig. 9).

In order to give a clearer understanding of my invention, I will explain in detail how the subscriber at substation A may obtain connection with the subscriber at substation A', the number of which will be assumed to be #2220. Upon removing his receiver from the switch hook, the subscriber at substation A permits the spring 116 to engage the spring 117, whereby a circuit is completed extending from ground G' through the springs 118 and 119 of the cut-off relay 5, line 121, springs 116 and 117, 122 and 123; receiver 124, transmitter 125, line 126, springs 128 and 127 and line winding 6 to the battery lead 130, thence through the battery B to ground G. The relay 6, upon energizing, completes the circuit from ground G² through the slow acting relay 92, springs 88 and 89 of the relay 6 and the solenoid 47 of the line switch to the battery lead. The relay 92 is energized over this circuit, but it has a comparatively high resistance and does not permit sufficient current to flow through the solenoid 47 to cause it to operate. The relay 92, upon energizing, completes a circuit from ground G² through the armature 135 and its front contact, relay 93 and the springs 79 and 78 to the battery lead 130. The relay 93, upon energizing, connects the ground G⁵ with the solenoid 47 direct, without interposed resistance. The solenoid is thereupon operatively energized. The relays 92 and 93 are slow acting and therefore maintain the circuit of the solenoid 47 long enough to cause it to operate, even though the relay 92 is short-circuited by the energization of the relay 93. The solenoid 47, upon energizing, forces the plunger of the line switch into the set of bank springs before which it is resting, forcing them into contact in pairs, as has been already described. The engagement of the springs 40 and 41 with the springs 37 and 44, respectively, extends the line connection to the first selector E, whereupon its line

relay 131 becomes energized over a circuit extending from ground G³ through the lower winding of said relay, side switch wiper 100, springs 44 and 41, line 121, thence through the substation A and back over the other side of the line, through the springs 40 and 37, side switch wiper 99 and the upper winding of the relay 131 to the battery lead. The relay 131, upon energizing, completes a circuit extending from ground G⁴ through the springs 132 and 133 and relay 107 to the battery lead. The relay 107, upon energizing, completes a circuit from ground G⁵ through the springs 134 and 135, 38 and 39, cut-off relay 6 and the solenoid 47. This circuit energizes the relay 6 and provides a holding circuit for the solenoid 47. The relay 5, upon energizing, disconnects the line relay from the line.

When the springs 42 and 43 are forced into contact by the plunger of the line switch, a circuit is closed from ground G⁶ through said springs, master switch bank contact 137 (which is assumed to be the contact belonging to the trunk line leading to the selector E), wiper 91, common segment 90 and relay 138 to the battery lead. The relay 138, upon energizing, completes a circuit through the relay 74. The relay 74, upon energizing, separates the springs 79 and 78, closes the contact between the springs 77 and 76 and withdraws the locking dog 73 from the cam 69. As soon as the cam is unlocked, the spring 80 (Fig. 8) begins to rotate the master switch shaft 66, thereby causing the plunger shaft 53 to move the plungers of all of the idle line switches which are in engagement therewith away from the trunk line just seized by the switch C. Of course, the switch C becomes disengaged from the plunger shaft when it operates, and is therefore not affected by the movement of the plunger shaft. After the plungers have been moved a short distance, the master switch wiper 91 passes off the contact 137, which allows the relay 138 to deenergize and break the circuit of the relay 74. The relay 74 thereupon allows the dog 73 to drop back and engage the next notch in the cam 69, which stops the master switch and the plunger shaft with the plungers resting in front of the next trunk line—that is, provided this trunk line is idle. If this trunk line is busy, however, the wiper 91 will find the next contact grounded, which will cause the relays 138 and 74 to remain energized, while the next opening in the cam 69 is passing the dog 73, and the plungers will be carried past the busy trunk to an idle one. If the plungers of the line switches are being held in front of the last trunk and this trunk becomes seized by some line switch, or if this trunk is busy when the plungers arrive opposite it, the master switch will start to move the idle plungers on past this trunk, but

after they have moved a short distance the arm 68 forces the spring 81 into contact with the spring 82. This closes a circuit from ground G⁷ through the springs of the relay 138 (said relay being energized because the wiper 91 is in engagement with the guarded contact of the last trunk, which is assumed to be busy), springs 81 and 82, relay 139 and springs 76 and 77 to battery. The relay 139 thereupon energizes, forcing the springs 140, 141 and 142 into contact, in which position said springs become locked by the coöperation of the lug on the top of the spring 83 with the spring 140. The engagement of the springs 141 and 140 completes a circuit from ground G⁸ through the said springs and through the relay 138 to maintain the relay 138 energized regardless of the wiper 91. The engagement of the springs 141 and 142 completes a circuit through the solenoid of the master switch. The solenoid, upon energizing, rotates the shaft 66 (Fig. 8) in a clockwise direction, thereby causing the plunger shaft 53 to carry the plungers of the idle line switches back to the position opposite the first trunk. When the plungers reach this position, the arm 67 depresses the spring 83, which allows the spring of the relay 139 to restore to normal position, thereby breaking the circuit of the solenoid 71 and the relay 138. The relay 138, upon deenergizing, allows the relay 74 to deenergize, which permits the dog 73 to drop into the cam 69 and lock the master switch with the plungers standing opposite the first trunk. From the above it is evident that the master switch operates to advance the plungers of the idle line switches whenever any one of said switches is operated. Thus, when a switch is released from its operated position, the notch 56 (Fig. 5) in the member 54 will have moved out of register with the projection 57 on the end of the plunger of the solenoid 47, and the projection 57 will come into contact with the flat projection or flange 55. During subsequent movements of the master switch, this particular line switch will remain stationary, in front of the trunk line from which it was just disengaged, until the plunger shaft returns to the position in which it was resting when this switch was operated, whereupon the projection 57 will drop into the notch 56 and this line switch will again become locked with the plunger shaft. If a second call is sent in over this line switch after it has been released, and before the projection 57 engages the notch 56, the line switch will engage the same trunk line from which it was last released. During the operation of the master switch, it will be seen that the springs 78 and 79 of the relay 74 are open. Thus, if any subscriber removes his receiver to make a call at this time, he will be unable to close a circuit through the relay 93, and therefore will

be unable to operate his line switch. This is to prevent the operation of the line switches while their plungers are being moved from one trunk to another.

The foregoing are the operations that take place upon the removal of the receiver at the calling substation. The calling subscriber now operates his calling device for the digits of the number 2220. This calling device is represented diagrammatically in the drawings by the impulse springs 122 and 123 and an impulse wheel 143. The impulse wheel 143 is controlled by the calling subscriber through the medium of a dial (not shown) provided with finger holes. When the dial is operated for the first digit 2 of the desired number, the impulse springs 122 and 123 are separated twice momentarily. Each time the springs 122 and 123 are separated, the energizing circuit of the line relay 131 of the selector E is broken, allowing said relay to be momentarily deenergized. Since the relay 107 of the selector is slow acting, it does not have time to deenergize during the momentary interruption of its circuit at the springs 132 and 133. Consequently the engagement of the springs 132 and 144 closes an energizing circuit through the vertical magnet 97. This circuit extends from ground G⁴ through the springs 132 and 144, springs 145 and 146, private magnet relay 108, vertical magnet 97 and the side switch wiper 101 to the battery lead 130. Since the digit called is 2, the vertical magnet receives two impulses over this circuit and operates to raise the switch shaft and wipers two steps to a position opposite the second row or level of bank contacts. The private magnet relay 108, which is included in the energizing circuit of the vertical magnet, is energized with the first impulse, but being a slow acting relay does not have time to deenergize until the last impulse for the digit is transmitted. In its energized condition the relay 108 operates to close a circuit extending from ground G⁴ through the springs 148 and 149 and private magnet 103 to the battery lead 130. When the relay 108 deenergizes, after the last impulse is transmitted to the vertical magnet, this circuit through the private magnet is broken. The private magnet thereupon deenergizes and allows the side switch to pass to second position. The movement of the side switch wiper 101 from first to second position disconnects the battery from the vertical magnet 97 and completes an energizing circuit through the rotary magnet 98. This circuit extends from ground G³ through the interrupter springs 150, rotary magnet 98, relay 109 and side switch wiper 101 to the battery lead 130. Upon the closure of this circuit the rotary magnet attracts its armature, which operates to rotate the shaft wipers one step, to press down the armature of the pri-

vate magnet 103 and to open the circuit of its own magnet at the interrupter springs 150. When the circuit of the rotary magnet is thus opened, its armature falls back and, if the first trunk line upon which the wipers have just been rotated is not already in use, the private magnet armature also falls back and permits the side switch to pass to third position. If, however, the first trunk line of the second level is already busy, the private wiper 96 finds the first contact which it engages provided with a guarding ground potential. When the wiper 96 thus engages the grounded contact, a locking circuit is completed through the side switch wiper 102 (in second position) and the private magnet 103 to battery lead 130. The private magnet thus becomes energized and locks the side switch in second position. As long as the side switch remains thus locked, the rotary magnet continues to operate in a manner similar to that of a buzzer to rotate the selector wipers step by step until an idle trunk line is found. When the private wiper 96 engages the non-grounded contact of an idle trunk, the private magnet 103 deenergizes and permits the side switch to pass to third position, thereby breaking the circuit of the rotary magnet. The movement of the side switch wipers 99 and 100 from second to third position disconnects the line relay 131 from the line and extends the line connection through the shaft wipers 94 and 95 to the second selector F. The line relay 151 in the selector F then becomes energized in the same manner in which the relay 131 of the selector E was energized when the connection was first extended to that selector.

The energization of the relay 151 serves to close an energizing circuit through the slow acting relay 152 in the same manner in which the circuit of the relay 107 of the selector E was closed by the relay 131. The relay 152, upon energizing, extends a guarding potential from ground G^{10} through the side switch wiper 153 and springs 154 and 155 to the private bank contacts of the seized trunk in the banks of all of the selectors E which have access to this trunk. A circuit also extends from the ground G^{10} through the said selector private bank contacts, private wiper 96, side switch wiper 102, springs 156 and 157 and relay 107 to the battery lead 130. This circuit prevents the relay 107 from deenergizing after its former circuit is broken by the deenergization of the relay 131 when the side switch of the selector E passes to third position. A short period of time elapses between the time when the side switch of the selector E passes to third position and the time when the relay 152 energizes to extend a guarding potential back to the first selector private bank contacts from the ground G^{10} . During

this interval the trunk line leading to the selector F is guarded by a ground potential extending from ground G^{11} through the springs 158 and 156, side switch wiper 102 and private wiper 96 to the private bank contacts. It will be remembered that the relay 109 is included in the operating circuit of the rotary magnet 98 and, since it is a slow acting relay, it remains energized for an instant after the rotary magnet is energized for the last time. Thus the relay 109 is already energized when the side switch reaches third position, and a guarding potential is extended from ground G^{11} in the manner described. The relay 109 is quicker than the relay 107 and thus deenergizes in time to close the new energizing circuit for the relay 107 before it has time to deenergize.

The calling subscriber now operates his calling device for the second digit 2. The second selector F operates in response to the impulses for this digit in the same manner as explained for the selector E, and extends connection to an idle connector H over the trunk lines 159 and 160. When the connection is thus extended to the connector H, its line relay 162 becomes energized in the same manner that the selector line relays are energized. The relay 162, upon energizing, operates to complete a circuit extending from ground G^{12} through the springs 163 and 164 and the slow acting relay 166 to the battery lead 130. The relay 166, upon energizing, extends the guarding potential from ground G^{13} through the side switch wiper 167, springs 168 and 169 and conductor 161 to all of the selector private bank contacts which belong to the trunk line leading to the connector H. The energization of the relay 166 of the connector also provides a new holding circuit for the release relays 152 and 107 of the selectors F and E, respectively.

The calling subscriber now operates his dial for the third digit 2, momentarily separating the substation impulse springs 122 and 123 in the same manner as described for the first digit. Each time the impulse springs are separated for the third digit, the energizing circuit for the connector line relay 162 is broken momentarily. Since the relay 166 of the connector is slow acting it does not have time to deenergize during the momentary deenergizations of the relay 162. Consequently, the engagement of the springs 163 and 165 completes an energizing circuit through the vertical magnet 113. This circuit extends from ground G^{12} through the springs 163 and 165, springs 170 and 172, vertical magnet 113, side switch wiper 174 and private magnet relay 175 to the battery lead 130. The vertical magnet receives two impulses over this circuit and operates to raise the shaft wipers 110, 111 and 112

two steps. The private magnet relay 175 operates in the same manner as the private magnet relay 108 of the selector E to close the circuit of the private magnet 115 while the vertical magnet is operating. The circuit through the private magnet extends from ground G^{14} through the springs 176 and 178 and private magnet 115 to the battery lead 130. This circuit is broken shortly after the last impulse is delivered to the vertical magnet, whereupon the private magnet deenergizes and permits the side switch to pass to second position. The movement of the side switch wiper 174 from first to second position transfers the battery connection from the vertical magnet 113 to the rotary magnet 114. The connector is then in position to receive impulses for the last digit 0. The operation of the substation calling device for this digit breaks the energizing circuit of the relay 162 ten times. Each time the relay 162 deenergizes it completes a circuit extending from ground G^{12} through the springs 163, 165, 170 and 172, springs 180 and 181, rotary magnet 114, side switch wiper 174 (in second position) and relay 175 to the battery lead 130. The rotary magnet 114 receives ten impulses over this circuit and operates to rotate the wipers ten steps onto the contacts of the line No. 2220. The private magnet relay 175 is energized by the first impulse to the rotary magnet and again closes the circuit of the private magnet 115. The circuit of the relay 175 is not opened long enough to permit it to deenergize until after the last impulse has been delivered to the rotary magnet. The relay 175 then deenergizes and breaks the circuit of the private magnet 115 which, if the called line is not already busy, in turn deenergizes and permits the side switch to pass to third position, whereby connection is completed between the calling and called lines. The side switch wiper 183 (in third position) extends a guarding potential from ground G^{16} through the private wiper 112 to the connector private bank contacts of the called line, and also provides an energizing circuit for the cut-off relay 184 of the line switch C'. The energizing circuit of the relay 184 also includes the solenoid 185, but the resistance of the relay 184 is high enough to prevent sufficient current from flowing to operate the solenoid. Although this current is not strong enough to operate the line switch, it is sufficient to hold it in its operated position, as explained in connection with the line switch C of the calling line. The relay 184, upon energizing, cuts off the line relay 186 and connects the called line with its connector bank contacts. When the side switch wiper 174 of the connector reaches third position, the energizing circuit is established for the ringer relay

187. This circuit extends from ground G^{17} through the interrupter 188, springs 189 and 190, relay 187, side switch wiper 174 and relay 175 to the battery lead 130. Since this circuit includes the interrupter 188, the relay 187 is energized only intermittently. Each time the relay 187 is energized it operates to disconnect the calling line from the called line and to bridge the generator L across the called line to ring the bell 191. When the called subscriber removes his receiver, or as soon thereafter as the relay 187 deenergizes, if it happens to be energized at the time, the called substation is provided with talking battery current from the central office. The circuit over which this talking current flows extends from ground G^{16} through the side switch wiper 183, lower winding of the relay 192, ringer relay springs 193 and 194, side switch wiper 195, shaft wiper 111, line 196, hook switch springs 197 and 198, substation impulse springs, receiver and transmitter, line 199, shaft wiper 110, side switch wiper 200, ringer relay springs 201 and 202, upper winding of the back bridge relay 192 to the battery lead 130. When the connector back bridge relay 162 is energized, it breaks the circuit of the ringer relay 187 at the springs 189 and 190 to prevent further application of ringing current to the called line.

After the conversation is completed, the release of the central office apparatus is initiated by the hanging up of the receiver at the calling substation. When the receiver 124 is restored to the switch hook, the springs 116 and 117 are separated, thereby breaking the energizing circuit through the connector line relay 162. The relay 162, upon deenergizing, breaks the holding circuits of the release relays 166, 152 and 107 of the switches H, F and E, respectively. It will be seen that when the side switch wiper 167 of the connector passed from second to third position, the holding ground of the release relays 152 and 107 of the selector switches was transferred from ground G^{13} to ground G^{12} through the springs 164 and 163, so that the circuits of all of the release relays are controlled at this time by the connector line relay. When the relay 166 of the connector deenergizes, it completes a circuit from ground G^{12} through the springs 163 and 165, springs 170 and 171, release magnet 203 and off normal springs 204 and 205 to the battery lead 130. The energization of the magnet 203 immediately restores the mechanism of the connector to normal position, thereby breaking the connection with the called line and allowing the relay 184 of the called line to deenergize. The deenergization of the release relays 107 and 152 of the selectors E and F closes the circuits of their respective release magnets. The energizing cir-

cuit for the release magnet 104 of the selector E extends from ground G^4 through the springs 132 and 144, springs 145 and 147, magnet 104 and off normal springs 105 and 106 to the battery lead 130. The circuit of the release magnet 206 of the selector F is similar to that just traced for the magnet 104. The energization of the magnets 104 and 206 restores the mechanism of their respective switches to normal position. When the shafts of the switches E, F and H reach their lowest positions, the energizing circuits of their respective release magnets are broken by the separation of the off normal springs. The deenergization of the release relay 107 of the selector E also opens the holding circuit of the relay 5 and solenoid 47 in the line switch C, whereupon its plunger returns to normal position and all of the apparatus employed in the connection is left in readiness for another call.

The foregoing is an explanation of how connection is completed with an idle line. It will now be explained how the calling subscriber is given a busy signal in case the called line is in use. It has been explained how the connector private bank contacts of the called line are provided with a guarding potential. It will be evident that the calling line is also provided with a guarding potential extending from ground G^5 at the selector E, through the springs 134 and 135, springs 38 and 39 and conductor 290, which leads to the connector private bank contacts of the substation A. Thus, whenever the private wiper 112 of the connector engages the contact of a busy line, a ground potential is extended from the grounded private bank contact of said line through said wiper, springs 209 and 210, lower winding of the relay 192, springs 193 and 194 and side switch wiper 195 (in second position) to the spring 177 of the private magnet relay 175. Thus, when the relay 175 deenergizes after the last digit is called, the circuit of the private magnet is not opened, but is shifted from ground G^{14} to the ground at the private wiper by the engagement of the springs 177 and 178. The relay 192 thereupon becomes energized, because its lower winding is included in the holding circuit of the private magnet, and a circuit is closed from ground G^{14} through the springs 176 and 179 of the relay 175, springs 212 and 211, relay 213 and springs 214 to battery. The relay 213, upon energizing, shifts the holding circuit of the private magnet 115 and relay 192 from the private wiper to ground G^{20} . Since the private magnet does not deenergize, the side switch remains locked in second position without completing connection with the busy line and the busy signaling machine M is connected with the calling line through

the springs 215, side switch wiper 200 (in second position), springs 201 and 202 and condenser 216.

While I have shown my invention in connection with a full automatic system in which first and second selectors and connectors are employed, it will be readily understood that my improved form of line and master switch is equally as well adapted for use in a semi-automatic system—that is, a system in which the connection between the subscribers is established in part by means of a manual operator.

What I claim as my invention is:—

1. In a telephone system, a plurality of subscribers' lines, trunk lines, a line switch for each subscriber's line for selecting idle trunks, and a master switch for controlling a group of said line switches, said master switch having a continuous selecting motion and a continuous non-selecting return motion.

2. In a telephone system, a group of trunk lines, a plurality of line switches for selecting idle trunks, a master switch for controlling a group of said line switches, and a spring in which energy is stored up for supplying the entire operating power for said master switch.

3. In a telephone system, a group of trunk lines, a plurality of line switches for selecting idle trunks, a master switch for controlling a group of said line switches, means for operating said master switch, and a solenoid for restoring said switch and operating means to operative position.

4. In a telephone system, a group of trunk lines, a plurality of line switches for selecting idle trunks, a master switch for controlling a group of said line switches, a solenoid magnet, a spring, said master switch having a continuous selecting motion controlled by said spring, and a non-selecting return motion controlled by means of said solenoid magnet.

5. In a telephone system, a group of trunk lines, a plurality of line switches for selecting idle trunks, a master switch for controlling a group of said line switches, a spring under tension for operating said master switch, a cam provided with a series of notches, a dog adapted to engage with said notches normally preventing operation of said master switch, and means for releasing said dog to permit the operation of said master switch.

6. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch for connecting with an idle trunk, an operating magnet for said switch, and means for moving said magnet in the operation of said switch.

7. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch for connecting with

an idle trunk, and a solenoid magnet for controlling the operation of said switch, the said magnet adapted to be moved during such operation.

8. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch for connecting with an idle trunk, said switch including a plurality of sets of contacts, an operating plunger adapted to engage any one of said sets of contacts, and a solenoid for operating said plunger, said plunger being connected directly to the core of said solenoid.

9. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch for connecting with an idle trunk, a pivoted operating plunger for said switch, and an operating magnet the core of which is connected directly to said plunger.

10. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch for connecting with idle trunk, a plurality of sets of normally separated contacts, an operating plunger adapted to engage with any one of said sets, and an operating magnet, said plunger being connected directly to the armature of said magnet, said magnet being pivoted and adapted to rotate in the selecting operation of said switch.

11. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch having a plunger for connecting with an idle trunk, and an operating magnet for said switch provided with an operating winding, said switch adapted to be maintained in its operated position by the continued energization of said operating winding.

12. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch having a plunger for connecting with an idle trunk, a line relay permanently connected to battery, an operating magnet controlled by said relay, an operating winding therefor, and means for maintaining said switch in operative position by the continued energization of said operating winding.

13. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch for connecting with an idle trunk, an operating magnet therefor, a high resistance relay adapted to be included in circuit with said operating magnet, and means for short-circuiting said relay to permit the operation of said magnet.

14. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch for connecting with an idle trunk, an operating magnet therefor, a slow acting relay adapted to be connected in circuit with said operating magnet, a second relay controlled by said first-men-

tioned relay, and means controlled by said second relay for short-circuiting said first-mentioned relay to thereby permit the operation of said operating magnet.

15. In a telephone system, a plurality of subscribers' lines, a plurality of trunk lines extending therefrom, a line switch allotted to each of said subscribers' lines for selecting an idle trunk line, a master switch for controlling a group of said line switches, an operating magnet including an operating winding for operating said line switch, said switch being adapted to be maintained in operative position through the continued energization of said operating winding, and means for rendering an idle line switch inoperative while its master switch is operating.

16. In a telephone system, a plurality of subscribers' lines, a plurality of trunk lines extending therefrom, a line switch allotted to each of said subscribers' lines for selecting an idle trunk line, a master switch for controlling a group of said line switches, a line relay permanently connected to battery, an operating magnet for said line switch controlled by said line relay, means whereby said switch is maintained in operative position through the continued energization of said operating magnet, and means for rendering an idle line switch inoperative while its master switch is operating.

17. In a telephone system, a plurality of subscribers' lines, a plurality of trunk lines extending therefrom, a line switch allotted to each of said subscribers' lines for selecting an idle trunk line, a master switch for controlling a group of said line switches, an operating magnet therefor, a relay adapted to be included in the circuit of said operating magnet to prevent the operation thereof, a second relay adapted to short-circuit said first-mentioned relay to permit the operation of said operating magnet, and means for opening the circuit of said second relay when the master switch is in operation.

18. In a telephone system, a subscriber's line, a line switch therefor, a solenoid magnet controlling the operation of said line switch, a line relay for controlling said solenoid magnet, and a cut-off relay adapted to be energized to cut off said line relay from the line, said cut-off relay and line relay being combined in a single unitary structure.

19. In a telephone system, a plurality of subscribers' lines, trunk lines, a line switch for each subscriber's line for connecting with idle trunks, means for controlling said line switch over two sides of the subscriber's line in series, and a master switch for controlling a group of said line switches, said master switch having a continuous selecting motion and a continuous non-selecting return motion.

20. In a telephone system, a line circuit

a group of trunk lines, a plurality of line switches for selecting idle trunks, means for controlling said line switches over two sides of the line circuit in series, a master switch
5 for controlling a group of said line switches, and a spring in which energy is stored up for supplying the entire operating power for said master switch.

21. In a telephone system, a line circuit,
10 a group of trunk lines, a plurality of line switches for selecting idle trunks, means for controlling said line switches over two sides of the line circuit in series, a master switch for controlling a group of said line switches,
15 a solenoid magnet, and means to control said master switch through the medium of said magnet.

22. In a telephone system, a line circuit, a group of trunk lines, a plurality of line
20 switches for selecting idle trunks, means for controlling said line switches over two sides of the line circuit in series, a master switch for controlling a group of said line switches, means for operating said master switch, and
25 a solenoid for restoring said switch and operating means to operative position.

23. In a telephone system a line circuit, a group of trunk lines, a plurality of line
30 switches for selecting idle trunks, means for controlling said line switches over two sides of the line circuit in series, a master switch for controlling a group of said line switches, and a solenoid magnet, said master switch having a continuous selecting motion controlled by a spring, and a non-selecting return motion controlled by means of said
35 solenoid magnet.

24. In a telephone system, a line circuit, a group of trunk lines, a plurality of line
40 switches for selecting idle trunks, means for controlling said line switches over two sides of the line circuit in series, a master switch for controlling a group of said line switches, a spring under tension for operating said
45 master switch, a cam provided with a series of notches, a dog adapted to engage with said notches normally preventing operation of said master switch, and means for releasing said dog to permit the operation of said
50 master switch.

25. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch for connecting with an idle trunk, an operating magnet for said
55 switch, means for moving said magnet in the operation of said switch, and means for controlling said magnet over two sides of the line circuit in series.

26. In a telephone system, a subscriber's
60 line, a plurality of trunk lines extending therefrom, a line switch for connecting with an idle trunk, a solenoid magnet for controlling the operation of said switch, the said magnet adapted to be moved during

such operation, and means for controlling
65 said magnet over two sides of the line circuit in series.

27. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch for connecting with
70 an idle trunk, said switch including a plurality of sets of contacts, an operating plunger adapted to engage any one of said sets of contacts, a solenoid for operating said plunger, said plunger being connected di-
75 rectly to the core of said solenoid, and means for controlling said switch over two sides of the line circuit in series.

28. In a telephone system, a subscriber's line, a plurality of trunk lines extending
80 therefrom, a line switch for connecting with an idle trunk, a pivoted operating plunger for said switch, an operating magnet the core of which is connected directly to said plunger, and means for controlling said
85 switch over two sides of the line circuit in series.

29. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch for connecting with
90 an idle trunk, a plurality of sets of normally separated contacts, an operating plunger adapted to engage with any one of said sets, an operating magnet, said plunger being connected directly to the armature of
95 said magnet, said magnet being pivoted and adapted to rotate in the selecting operation of said switch, and means for controlling said switch over two sides of the line circuit in series. 100

30. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch for connecting with an idle trunk, an operating magnet for said
105 switch provided with an operating winding, said switch adapted to be maintained in its operated position by the continued energization of said operating winding, and means for controlling said switch over two sides of the line circuit in series. 110

31. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch for connecting with an idle trunk, a line relay permanently connected to battery, an operating magnet controlled by said relay, an operating winding therefor, means for maintaining said switch in operative position by the continued energization of said operating winding, and means for controlling said switch over two
120 sides of the line circuit in series.

32. In a telephone system, a subscriber's line, a plurality of trunk lines extending therefrom, a line switch for connecting with an idle trunk, an operating magnet therefor,
125 a high resistance relay adapted to be included in circuit with said operating magnet, means for short-circuiting said relay to

permit the operation of said magnet, and means for controlling said switch over two sides of the line circuit in series.

33. In a telephone system, a subscriber's
5 line, a plurality of trunk lines extending therefrom, a line switch for connecting with an idle trunk, an operating magnet therefor, a slow acting relay adapted to be connected in circuit with said operating magnet, a
10 second relay controlled by said first-mentioned relay, means controlled by said relay

for short-circuiting said first-mentioned relay to thereby permit the operation of said operating magnet, and means for controlling said switch over two sides of the line circuit 15 in series.

Signed by me at Chicago, Cook county, Illinois, this 16th day of June, 1911.

ALEXANDER E. KEITH.

Witnesses:

ARTHUR J. RAY,
E. D. FALES.