J. ERICKSON.

MEASURED SERVICE TELEPHONE SYSTEM.

APPLICATION FILED MAY 5, 1911.

1,257,828.

Patented Feb. 26, 1918.

4 SHEETS—SHEET 1.

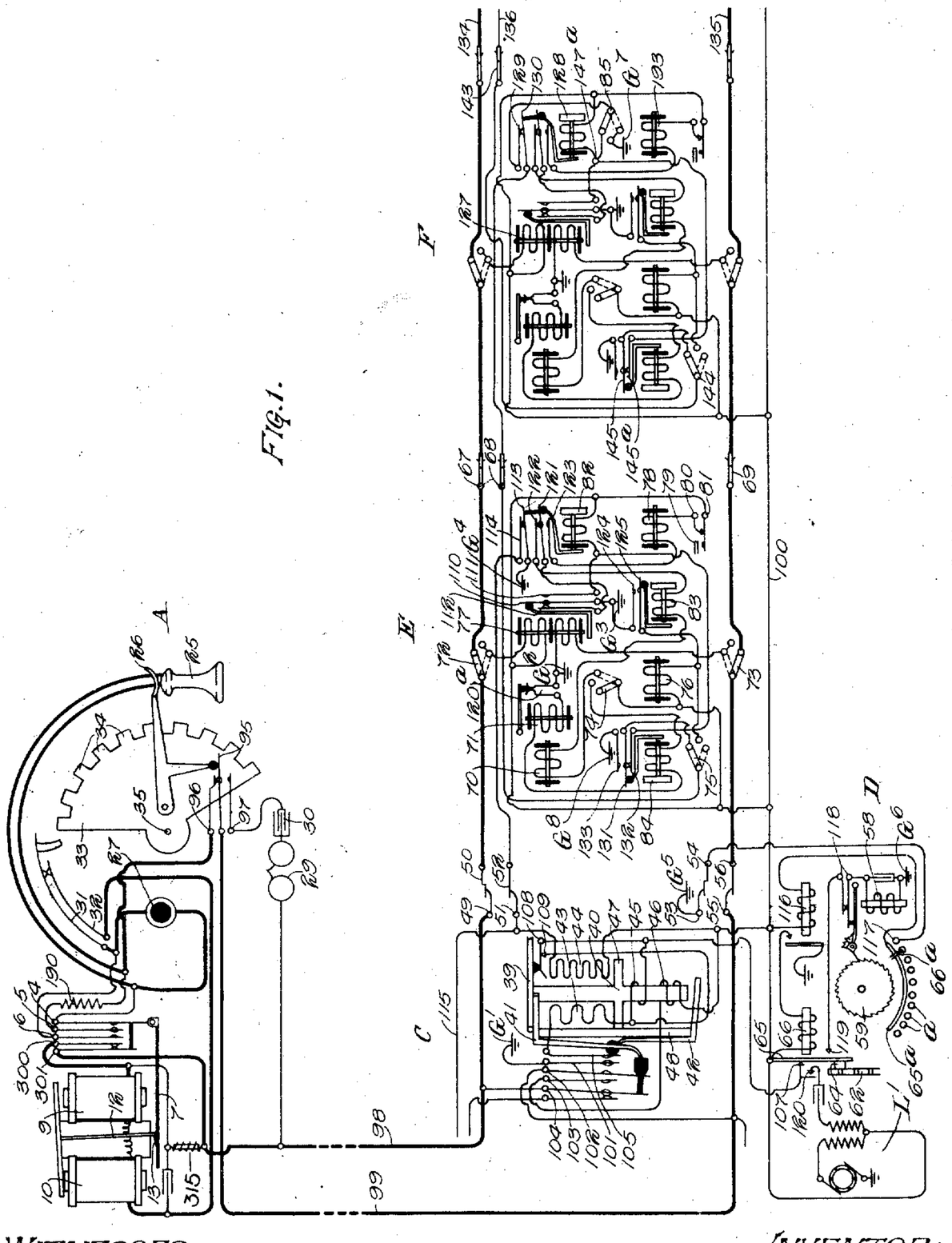

Fig. 1.

WITNESSES

A. Andersen.

A. J. Ray

INVENTOR:

John Erickson

By Bulkley & Durand

ATTORNEYS.

J. ERICKSON.

MEASURED SERVICE TELEPHONE SYSTEM.

APPLICATION FILED MAY 5, 1911.

1,257,828.

Patented Feb. 26, 1918.

4 SHEETS—SHEET 2.

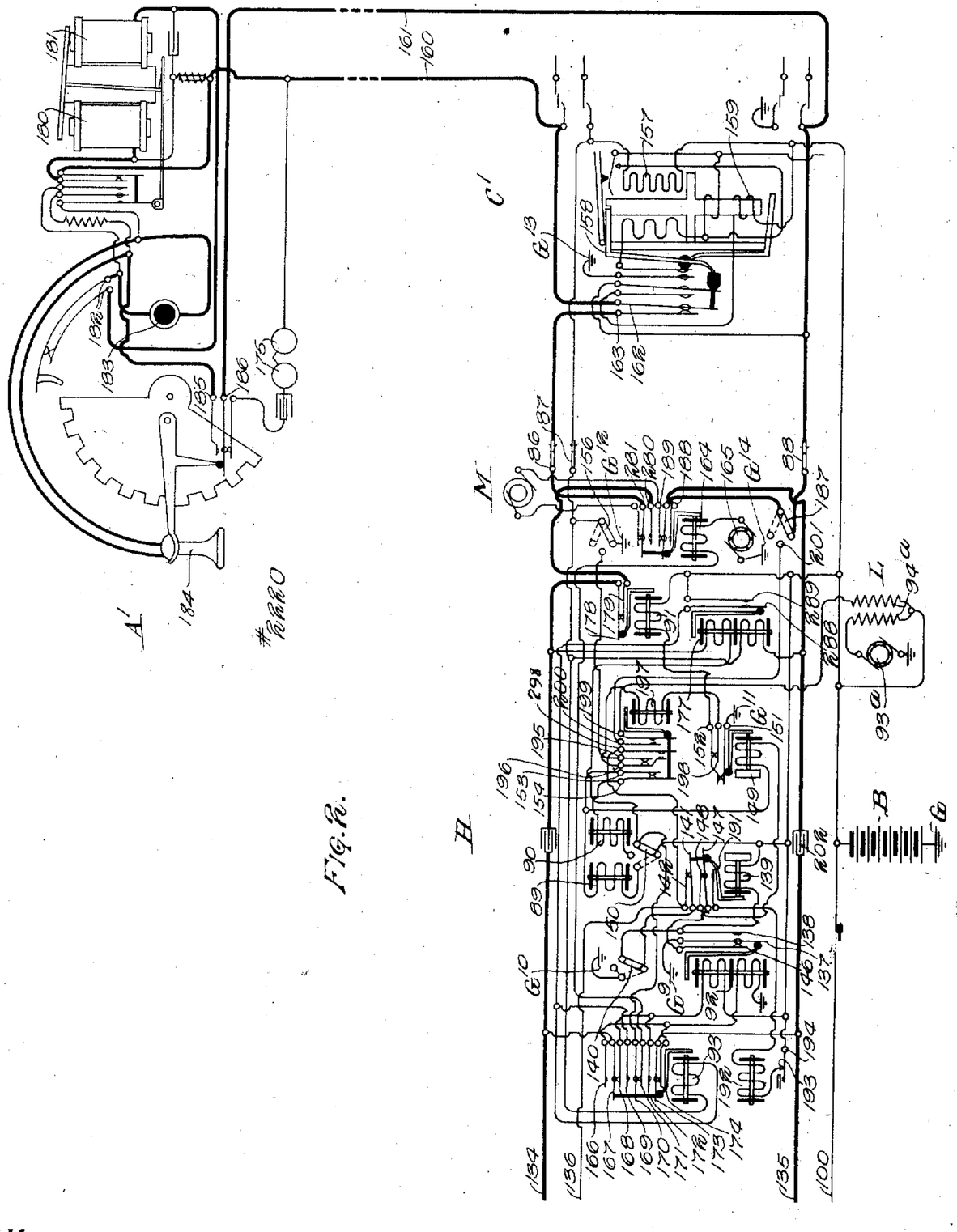

FIG. 2.

WITNESSES

A. Anderson

A. J. Roy

INVENTOR:

John Erickson

By Bulkley & Durand

ATTORNEYS.

J. ERICKSON.

MEASURED SERVICE TELEPHONE SYSTEM.

APPLICATION FILED MAY 5, 1911.

1,257,828.

Patented Feb. 26, 1918.

4 SHEETS—SHEET 3.

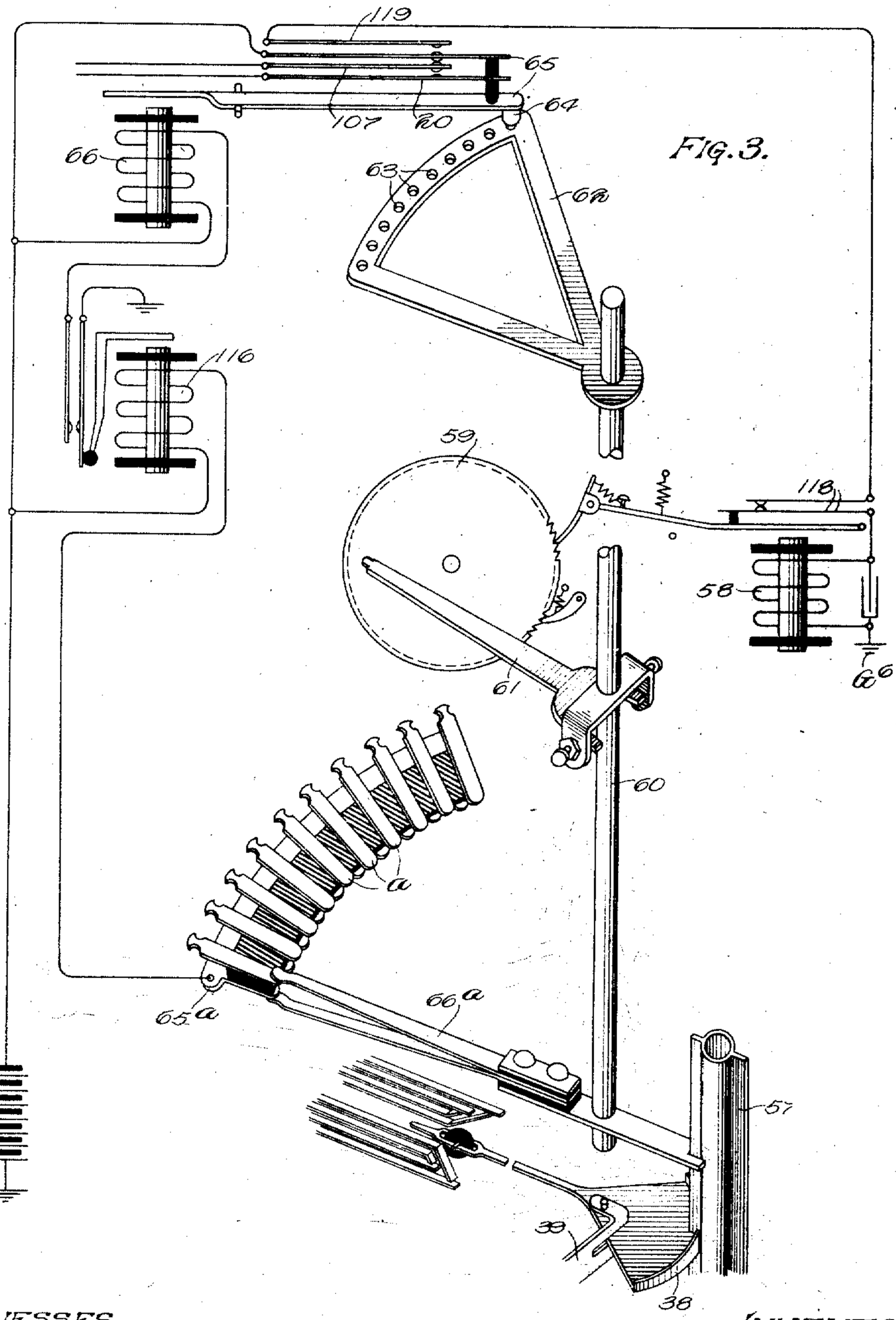

FIG. 3.

WITNESSES

A. Andersen.

A. J. Ray.

INVENTOR.

John Erickson

By Buckley & Durand

ATTORNEYS.

J. ERICKSON.

MEASURED SERVICE TELEPHONE SYSTEM.

APPLICATION FILED MAY 5, 1911.

1,257,828.

Patented Feb. 26, 1918.

4 SHEETS—SHEET 4.

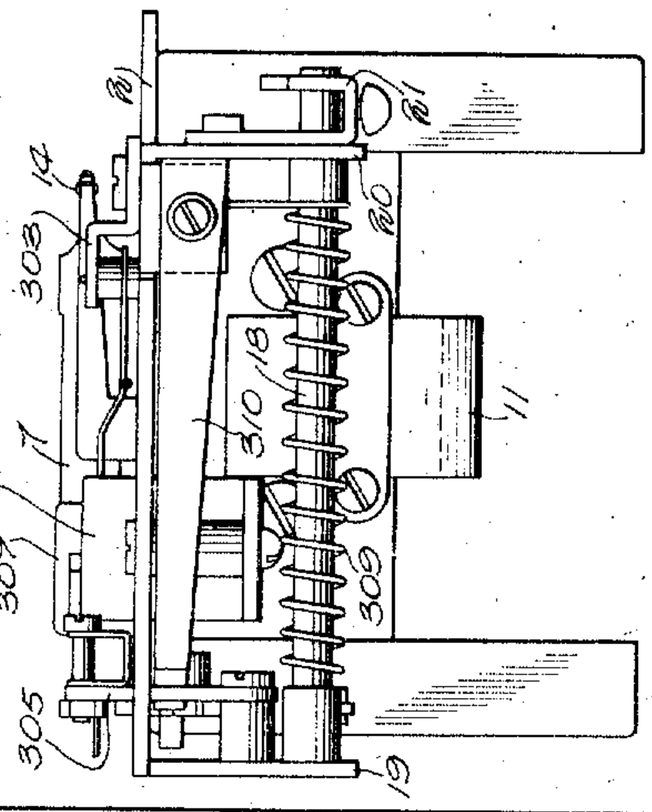

FIG. 6.

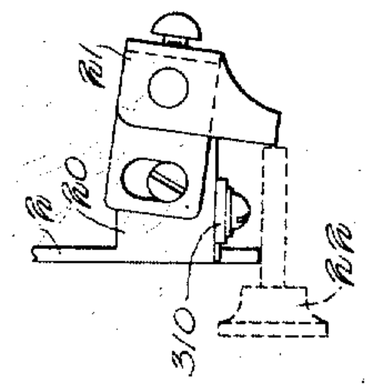

FIG. 7.

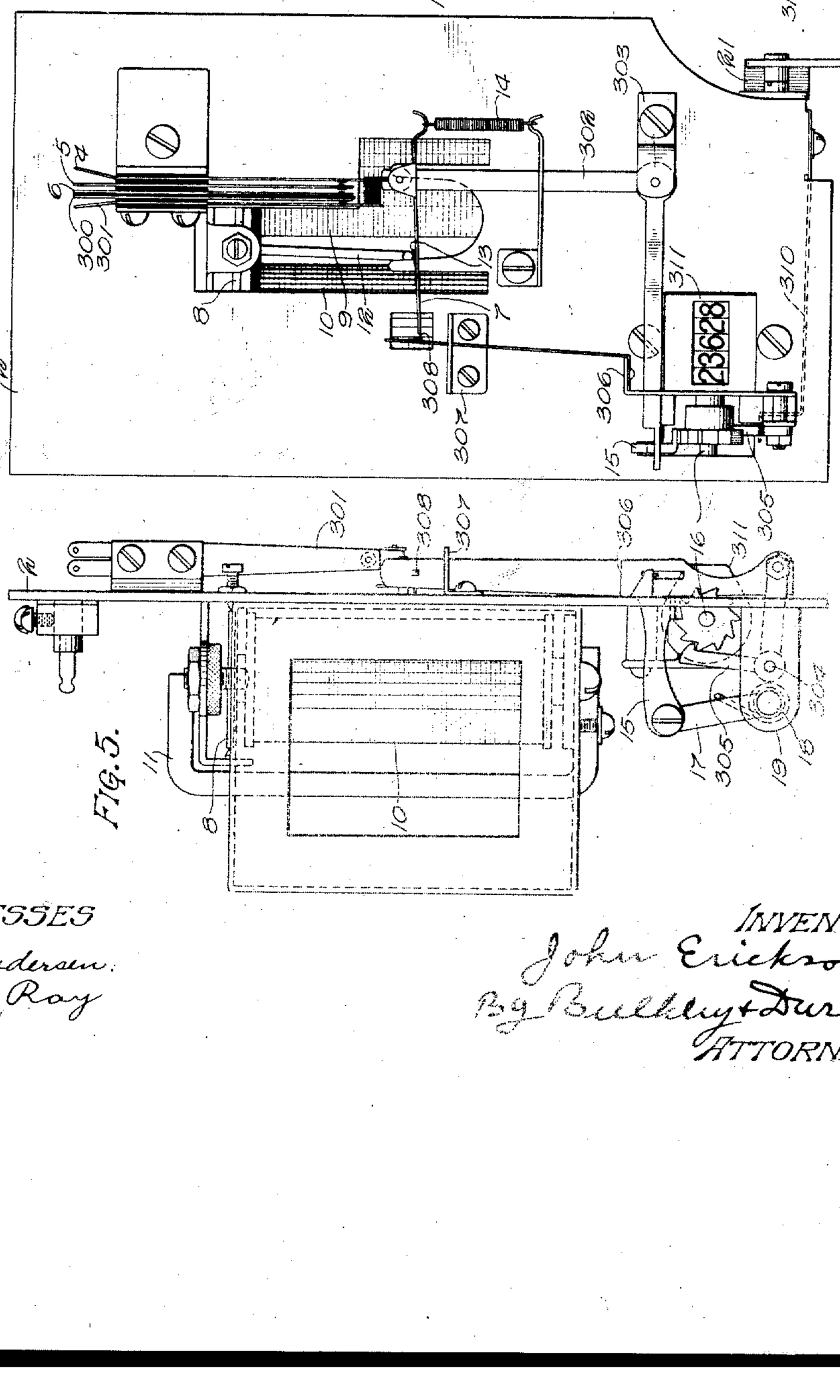

FIG. 4.

FIG. 5.

WITNESSES

A. Andersan.

A. J. Roy

INVENTOR:

John Erickson

By Buckley & Durand

ATTORNEYS,

UNITED STATES PATENT OFFICE.

JOHN ERICKSON, OF CHICAGO, ILLINOIS, ASSIGNOR TO AUTOMATIC ELECTRIC COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

MEASURED-SERVICE TELEPHONE SYSTEM.

1,257,828. Specification of Letters Patent. **Patented Feb. 26, 1918.**

Application filed May 5, 1911. Serial No. 625,179.

To all whom it may concern:

Be it known that I, JOHN ERICKSON, a citizen of the United States of America, and resident of Chicago, Cook county, Illinois, have invented a certain new and useful Improvement in Measured-Service Telephone Systems, of which the following is a specification.

My invention relates to measured service telephone systems in general, but more particularly to automatic or semi-automatic telephone exchange systems, and especially to systems in which a common or central source of talking current is employed.

Generally stated, the object of my invention is to provide an improved and highly efficient measured service telephone exchange system.

To these and other useful ends my invention contemplates a substation service meter of such character that it cannot be operated by the calling subscriber to register the call until after the called subscriber has answered.

It further contemplates a substation service meter in an automatic or semi-automatic system in which means are provided at the substations for controlling the two sides of a calling line in series to operate one or more automatic switches in extending the call.

It further contemplates a substation service meter having means for rendering the calling subscriber's transmitter inoperative when the called subscriber answers, and in which means are provided for restoring the said transmitter to operative condition when the meter is manually operated by the calling subscriber, whereby such operation serves both to register the call and place the calling subscriber in a position to converse with the called subscriber.

It further contemplates a substation service meter of this kind in which provision is made for preventing more than one operation thereof for each call.

The nature and advantages of my invention will, however, hereinafter more fully appear.

In the accompanying drawings, Figures 1 and 2 represent a complete connection between a calling substation A (Fig. 1) and a called substation A′ (Fig. 2) in a system embodying the principles of my invention.

In Fig. 1 there is represented an automatic substation A to the line conductors of which there is allotted at the central office 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 selector switches E. A number of first selectors have common access to a number of second selectors F, which in turn have access to connector switches H (Fig. 2) by means of which connection may be completed with subscribers' lines, said selectors and connectors respond to the numerical operations of the calling subscriber and for that reason are sometimes spoken of as numerical switches.

Fig. 3 is a diagrammatic view of a portion of the central office apparatus, showing the essential features of the master switch D (Fig. 1).

Fig. 4 is a front elevation of my improved call register device.

Figs. 5 and 6 are a side and end view, respectively, of the same.

Fig. 7 is a partial side view taken on the side opposite that shown in Fig. 5.

As illustrated in the above drawings, the construction and method of operation of the call register is as follows: In Figs. 4, 5 and 6 a face plate 2 is shown, to the back of which there is attached a polarized electromagnet comprising the coils 9 and 10, a permanent magnet 11 and a pivoted armature 8. Attached to the armature there is a downwardly projecting arm 12, the lower end of which is bent at right-angles and projects forward through an opening in the plate 2. On the front of the plate 2 there is mounted a group of contact springs 4, 5, 6, 300 and 301. On the lower end of the spring 4 there is pivotally mounted a flat strip 7, upon the upper side of which there is a small projection or lug 13. By means of the coiled spring 14 the upper side of the strip 7 is caused to bear against the under side of the forward projection on the arm 12. On the back of the plate 2, and near the lower end thereof, there is mounted a counting mechanism 311 which may be operated by the pawl 15 through the medium of the ratchet wheel 16. The pawl 15 is pivotally attached to the arm 17, which is firmly secured to the shaft

18, which latter is journaled in the lugs 19 and 20. On the other end of the shaft 18 there is secured a lever 21 with which the push button 22 registers. The pawl 15 is normally held out of engagement with the teeth of the wheel 15 by the end of an L-shaped lever 302 which is pivoted upon the stationary bracket 303. The upper end of the vertical arm of the lever 302 is attached to the lower end of the spring 4. Journaled at the point 304 on the lug 19 there is a bell crank lever 305. The upper end of the vertical arm of the lever 305 is provided with a hook which registers with the teeth of the wheel 16. To the end of the horizontal arm of the lever 305 there is attached a vertical arm 306 which passes through an opening in the bracket 307. The upper end of the arm 306 carries a small projection 308 which normally rests slightly below the plane of the strip 7.

With the apparatus in the position shown in Figs 4, 5, 6 and 7, it will be seen that if the button 22 is pressed it will cause the pawl 15 to be pushed forward, and it will be pulled back again by the spring 309 when the button is released; but this operation of the pawl has no effect on the wheel 16, because it is held above the wheel by the lever 302. If, however, the magnet coils 9 and 10 are energized in the proper direction to attract the armature 8 in a counter-clockwise direction, the lower end of the arm 12 will be carried behind the projection 13 on the strip 7. If the magnet then be energized in the opposite direction, the arm 12 engages the projection 13, moving the strip 7 to the left and bringing the end of said strip against the arm 306. When the strip 7 is pulled over it forces the springs 4, 5 and 6 into contact, separates the springs 300 and 301 and tips the lever 302 in a counter-clockwise direction so as to allow the pawl 15 to drop down into engagement with the teeth of the wheel 16. If, now, the button 22 is pressed, the pawl 15 will be advanced one tooth around the wheel 16, and when the button is released the return movement of the pawl advances the wheel 16 and counter disks of the register one step. As the wheel 16 rotates it rotates the lever 305 (Fig. 5) in a counter-clockwise direction, causing the end of its horizontal arm to raise the arm 306 against the tension of the spring 310 (Figs. 4 and 6). As the arm 306 is lifted the projection 308 is carried above the strip 7. After the wheel 16 has completed its advance movement the hook on the upper end of the lever 305 drops into the next notch and the spring 310 pulls the arm 306 downward. As the arm 306 descends the projection 308 engages the strip 7 and trips it off from the arm 12. The spring 4 then returns to normal position and rotates the lever 302 so as to raise the pawl 15 out of engagement with the wheel 16. Thus the counting mechanism can be operated again only after the current in the magnet coils has been reversed twice, first to bring the arm 12 behind the lug 13, and, second, to swing the strip 7 to the left and to tip the lever 302 downward. The whole mechanism, with the exception of the push button, may be inclosed in a suitable box provided with two openings in its face, one through which the push button may project, and another through which the numbers on the counting mechanism may be seen.

The general operation of the calling device in the system shown herein is as follows: When the calling subscriber initiates a call, the magnet of his register device receives current in such a direction as to attract the armature toward the coil 10. When the called subscriber answers, after the connection is completed, the current in the calling line is reversed, which attracts the armature of the register device in the opposite direction, operating the contact springs and placing the counting mechanism in operative relation to the push button. When the contact springs are in their operated position, the circuits of the calling substation are placed in such a condition that the calling subscriber can hear the called subscriber, but cannot talk to him. In order to place the calling substation in operative condition for talking, the calling subscriber must press his button. The pressure of the button will not only restore the calling telephone to operative condition, but will also register the call on the counting device.

The automatic substations may be of any suitable or approved type. Those in connection with which I have elected to illustrate my invention, as shown in Fig. 1 at A, comprise the usual receiver 25, switch hook 26, transmitter 27, ringer 29 and condenser 30. In addition, the substation A is provided with the impulse springs 31 and 32 and an impulse wheel 33. The impulse wheel 33 carries upon its periphery the impulse teeth 34 and is secured to a shaft 35 to which there is also attached a dial (not shown) provided with finger holes, through the medium of which the impulse wheel may be rotated. As the impulse wheel is returned to normal position by a spring (not shown) after it has been rotated for any digit, each of the teeth 34 which pass the end of the spring 31 forces said spring out of engagement with the spring 32. The number of times these springs are separated depends upon the digit called. Connected to the line of the substation A there is also shown one of my improved call-register devices. The call-register device is represented only diagrammatically in Fig. 1, and the parts are designated by the same reference numerals as in Figs. 4 and 5.

The line switch C, which is individual to the line of 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, and in the *American Telephone Journal* of New York, N. Y., of June 6, 1908. As herein represented, the line switch C comprises, among other details, a plunger 38 (Fig. 3) attached to the end of a so-called plunger arm 39 which is controlled by the magnet 40. The magnet 40 also controls the relay armatures 41 and 42 and is composed of four windings, namely, a pull-in winding 43, a holding or cut-off winding 44, a line winding 46 and an auxiliary winding 45. The core of the magnet is provided near the center of its length with a lateral projection 47, by means of which the magnet is mounted upon the bracket 48, upon which latter the armatures 39, 41 and 42 are pivoted. With this method of mounting the magnet the magnetic circuit of the windings 43 and 44 is maintained separate from that of the windings 45 and 46, so that the armatures at one end of the magnet are not affected by the energization of the windings upon the other end. Of the two windings upon the upper end of the magnet, only the winding 43 is strong enough to attract the plunger arm 39 from its normal position. The winding 44 is not strong enough to thus operate the plunger arm, but will hold it in an operated position after it has been drawn down by the winding 43. When the plunger arm 39 is attracted by the magnet 40, the plunger of the switch is forced into a bank of contact springs, forcing springs 49, 51, 53 and 55 into engagement with springs 50, 52, 54 and 56, respectively. Although only one set of springs 49—56 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 through the corresponding springs of all the line switches of the group which is controlled by the master switch D. The plungers of the line switches of this group normally engage the plunger shaft 57 (Fig. 3) and, through the medium of the master switch D, are normally maintained opposite the terminal of an idle trunk line. The master switch consists essentially of a motor magnet 58 for rotating the ratchet wheel 59. The ratchet wheel 59 is connected with the shaft 60 by means of a link 61 in such a manner that a rotary motion of the ratchet wheel is transmitted to the plunger shaft 57, imparting to it an oscillating motion about the shaft 60, so as to move the idle plungers back and forth in front of their trunk terminals. To the shaft 60 there is secured a locking plate 62 provided near its outer edge with a number of openings 63 which are adapted to be engaged by the pin 64 upon the end of the armature 65 of the relay 66. The openings in the plate 62 are so spaced that the pin 64 can engage one of them only when the plungers that are in locking engagement with the plunger shaft are directly in front of the corresponding trunk terminal. The master switch is also provided with a bank of contacts comprising a common segment 65^a and one individual segment *a* for each trunk to which the line switches have access. The wiper 66^a always keeps the common segment in electrical connection with the individual segment corresponding to the trunk line before which the idle plungers are being held by the master switch.

The selector E is of the general type of selector disclosed in United States Letters Patent #815,321, granted to Keith, Erickson and Erickson, March 13, 1906, being somewhat modified, however, so as to operate in a two-wire system, *i. e.*, a system in which the central office apparatus is controlled from the calling substation over the two sides of the line in series. As herein represented, the selector E comprises the usual wipers 67, 68 and 69 carried upon a vertically and rotatably movable shaft (not shown) which is controlled by the vertical magnet 70 and rotary magnet 71. The usual side switch, comprising the wipers 72, 73, 74 and 75, is controlled by the private magnet 76 in a well known manner. The operation of the selector is controlled by the calling subscriber through the medium of the double-wound line relay 77. Means for restoring the mechanism of the selector to normal position is provided in the release magnet 78, which is connected with the battery only when the switch shaft is raised one or more steps, whereby the arm 79, which is carried by said shaft, permits the spring 81 to engage the spring 80. The mechanism of the selector E is released immediately upon the energization of the release magnet, rather than by its deënergization as shown in the said selector patent. The relays 82, 83 and 84 are slow acting relays, *i. e.*, they are slow to deënergize after their energizing circuits have been broken. This slow action is usually accomplished by securing a heavy ring of copper around one end of the core of the relay. The selector F is similar to the selector E, with the addition of the side switch wiper 85.

The connector H is of the general type of connector switch disclosed in United States Letters Patent #815,176, granted March 13, 1906, to Keith, Erickson and Erickson, but, like the selectors, is modified in order to operate in a two-wire system. Like the selectors, the connector is provided with a shaft (not shown) carrying the wipers 86, 87 and 88, and is controlled by the vertical magnet 89 and rotary magnet 90. The usual side

switch is controlled by the private magnet 91 in the usual manner. The line relay 92 is connected with the line conductors through the springs of a reversing relay 93. The connector is provided with a so-called back bridge relay 177, through which the called substation is provided with talking battery current, and with a ringer relay through the medium of which ringing current may be applied to the called line after connection is completed therewith.

The substation A′ and line switch C′ are similar to the substation A and line switch C, respectively. At M there is shown a ringing current generator and at L is shown a busy signaling machine comprising a current interrupter 93^a and an induction coil 94^a. For operating the central office apparatus and for furnishing talking current there is provided a battery B having one pole (preferably the positive) grounded at G.

Having given a general description of the apparatus, I will now explain in detail the operations by which one subscriber establishes connection with another in a system embodying the principles of my invention. It will be explained how substation A may obtain connection with substation A′, the number of which is assumed to be 2220. When the calling subscriber removes his receiver preparatory to making a call, the switch hook rises, permitting the spring 95 to pass out of engagement with spring 97 and into contact with spring 96, whereby the circuit of the ringer 29 and condenser 30 is broken, and a bridge consisting of the substation transmitter and the windings of the call-register device is closed across the line conductors 98 and 99. The closure of this bridge across the line completes an energizing circuit through the line winding 46 of the switch C. This circuit extends from ground G′ through the springs 101 and 102, line 99, springs 95 and 96, receiver 25, transmitter 27, impulse springs 31 and 32, coils 10 and 9 of the call-register device, springs 300 and 301, line 98, springs 104 and 103 and winding 46 to the battery lead 100. The current through the coils of the call-register device at this time flows in such a direction as to attract the armature toward the coil 10, as shown in Fig. 1, thereby bringing the end of the arm 12 into engagement with the lug 13 on the arm 7. The energization of the winding 46 serves to attract the armature 42, which operates to force the spring 105 into engagement with the spring 101, whereby a circuit is closed through the pull-in winding 43. This circuit extends from ground G′ through the springs 101 and 105, windings 43 and 45, contact point 107 and armature 65 to the battery lead 100. The winding 43, upon energization, attracts the armature 41 and plunger arm 39. The armature 41, upon being attracted, operates to disconnect the line winding 46 and ground G′ from the calling line. The armature 42 does not fall back immediately upon the deënergization of the winding 46, but remains held up by current flowing in the winding 45 until the plunger arm 39 forces spring 108 into contact with spring 109, whereby the winding 45 is short-circuited and consequently deënergizes slowly to hold the armature 42 in its operated position for an instant longer. Before the armature 42 is restored sufficiently to break the circuit of winding 43, a circuit is closed through the winding 44 in the following manner: When the springs 49 and 55 are forced into contact with springs 50 and 56, respectively, by the plunger of the line switch C, a circuit is closed through the line relay 77 of the selector E. This circuit extends from ground G^2 through lower winding of relay 77, side switch wiper 73, springs 56 and 55, thence over the heavy conductors to and through substation A and back over the other side of the line through upper winding of relay 77 to the battery lead 100. The relay 77, upon energizing, operates to close a circuit through the relay 82, said circuit extending from ground G^3 through the springs 110 and 111 and relay 82 to battery lead 100. The relay 82, upon energizing, operates to close the circuit of the holding winding 44 of the line switch C, said circuit extending from ground G^4 through springs 113 and 114, 52 and 51 and winding 44 to the battery lead 100. The current in this winding serves to hold the plunger arm 39 and armature 41 in their operated positions after the winding 43 has been deënergized. The energization of the relay 82 at the selector E also extends a guarding potential from ground G^4 over conductor 115 to the connector private bank contacts of the calling line.

When the springs 53 and 54 are forced into contact by the plunger of the line switch, a circuit is closed through the master switch relay 116. This circuit extends from ground G^5 through springs 53 and 54, contact point 117, wiper 66^a, segment 65^a and relay 116 to battery lead 100. The relay 116, upon energizing, operates to close a circuit through the relay 66. The relay 66, upon energizing, operates to withdraw the pin 64 from the plate 62 and to close the circuit of the motor magnet 58. This circuit extends from ground G^6 through magnet 58, interrupter springs 118, contact point 119 and armature 65 to the battery lead 100. As long as the armature 65 engages the contact point 119, the magnet 58 operates in a manner similar to that of a buzzer to rotate the ratchet wheel 59 step by step to advance the idle line switch plungers away from the trunk just seized. After the plun-

gers have been advanced a short distance, the wiper 66ª passes off the contact point 117 and allows the relays 116 and 66 to de-energize. The armature 65 does not fall back immediately upon the deënergization of relay 66, but remains in contact with contact point 119 until the next opening in the plate 62 passes under the pin 64. When the next opening does pass under the pin 64 the armature 65 falls back, forcing the pin into this opening to lock the plunger shaft, and breaking the circuit of the motor magnet 58. The foregoing is the operation of the master switch in case the next trunk line after the one seized by the switch C is idle. If, however, this next trunk is busy, the wiper 66 finds the corresponding contact in the master switch bank grounded, and consequently the relays 116 and 66 remain energized while the next opening is passing under the pin 64 and the plungers are carried past the busy trunk to an idle one. As long as the master switch is operating, the armature 65 is disengaged from the spring 107 and spring 107 engages the spring 120, whereby the pull-in windings of all the idle line switches are disconnected from the battery and connected to the busy signaling machine L'. With this arrangement no line switch can be operated while its plunger is being moved from one trunk to another, and any subscriber who attempts to make a call at that time will receive the busy signal, due to the inductive relation between the line winding 46 and the winding 45, which is then connected to the busy signaling machine L'.

The foregoing are the operations which take place immediately upon the removal of the receiver at the calling substation. The calling subscriber now operates his calling dial in the usual manner for the first digit 2 of the desired number. As the impulse wheel 33 returns to normal position after being rotated for this digit, the impulse springs 31 and 32 are separated twice momentarily. Each time the springs 31 and 32 are separated, the energizing circuit of the line relay 77 of the selector E is broken, allowing said relay to be momentarily deenergized. Since the relay 82 of the selector is slow acting, it does not have time to deenergize during the momentary interruption of its circuit at the springs 111 and 110. Consequently, the engagement of springs 110 and 112 closes an energizing circuit through the vertical magnet 70. This circuit extends from ground G^3 through springs 110 and 112, springs 121 and 122, private magnet relay 83, vertical magnet 70 and the side switch wiper 74 to the battery lead 100. 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 83, 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 deënergize until the last impulse for the digit is transmitted. In its energized condition the relay 83 operates to close a circuit extending from ground G^3 through springs 124 and 125 and private magnet 76 to battery lead 100. When the relay 83 deënergizes, after the last impulse is transmitted to the vertical magnet, this circuit through the private magnet is broken. The private magnet thereupon deënergizes and allows the side switch to pass to second position. The movement of the side switch wiper 74 from first to second position disconnects the battery from the vertical magnet 70 and completes an energizing circuit through the rotary magnet 71. This circuit extends from ground G^2 through the interrupter springs 120ª, rotary magnet 71, relay 84 and side switch 74 to battery lead 100. 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 private magnet 76 and to open the circuit of its own magnet at the interrupter springs 120ª. 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 68 finds the first contact which it engages provided with a guarding ground potential. When the wiper 68 thus engages the grounded contact, the locking circuit is completed through the side switch wiper 75 (in second position) and the private magnet 76 to battery lead 100. 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 68 engages the non-grounded contact of an idle trunk, the private magnet 76 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 72 and 73 from second to third position disconnects the line relay 77 from the line and extends the line connection through the shaft wipers 67 and 69 to the second selector F. The line relay 127 in the selector F then becomes energized in the same manner in which the relay 77 of the selector E was energized

when the connection was first extended through that selector. The energization of the relay 127 serves to close an energizing circuit through the slow acting relay 128 in the same manner in which the circuit of relay 82 was closed by the relay 77. The relay 128, upon energizing, extends the guarding potential from ground G^7 to side switch wiper 85 and springs 129 and 130 and 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^7 through the said selector private bank contacts, private wiper 68, side switch wiper 75, springs 131 and 132 and relay 82 to battery lead 100. This circuit prevents the relay 82 from deënergizing after its former circuit is broken by the deënergization of the relay 77 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 128 energizes to extend a guarding potential back to the first selector private bank contacts from the ground G^7. During this interval the trunk line leading to the selector F is guarded by a ground potential extending from ground G^8 through the springs 133 and 131, side switch wiper 75 and private wiper 68 to the private bank contacts. It will be remembered that the relay 84 is included in the operating circuit of the rotary magnet 71 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 84 is already energized when the side switch reaches third position, and a guarding potential is extended from ground G^8 in the manner described. The relay 84 is quicker than the relay 82 and thus deënergizes in time to close the new energizing circuit for the relay 82 before it has time to deënergize.

The calling subscriber now operates his calling device for the second diget 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 134 and 135. When the connection is thus extended to the connector H its line relay 92 becomes energized in the same manner that the selector line relays are energized. The relay 92, upon energizing, operates to complete a circuit extending from ground G^9 through springs 137 and 138 and the slow acting relay 139 to battery lead 100. The relay 139, upon energizing, extends the guarding potential from ground G^{10} through side switch wiper 140, springs 141 and 142 and conductor 136 to all of the selector private bank contacts which belong to the trunk line leading to the connector H. The energization of the relay 139 of the connector also provides a new holding circuit for the release relays 128 and 82 of the selectors F and E, respectively. This circuit extends from ground G^{10} through side switch wiper 140, springs 141 and 142, conductor 136, private wiper 143 of the selector F, side switch wiper 144 and springs 145 and 145^a to point 147^a. From point 147^a one branch of this circuit extends through the relay 128 to battery, while another branch extends through the side switch wiper 85 (in third position) to and through the relay 82 of selector E over a circuit which has already been traced.

The calling subscriber now operates his dial for the third digit 2, momentarily separating the impulse springs 31 and 32 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 92 is broken momentarily. Since the relay 139 of the connector is slow acting it does not have time to deënergize during the momentary deënergization of the relay 92; consequently the engagement of springs 137 and 146 completes an energizing circuit through the vertical magnet 89. This circuit extends from ground G^9 through the springs 137 and 146, springs 147 and 148, private magnet relay 149, vertical magnet 89 and side switch wiper 150 to battery lead 100. The vertical magnet receives two impulses over this circuit and operates to raise the shaft wipers 86, 87 and 88 two steps. The private magnet relay 149 operates in the same manner as the private magnet relay 83 of the selector E to close the circuit of the private magnet while the vertical magnet is operating. The circuit through the private magnet extends from ground G^{11} through springs 151 and 152 and private magnet 91 to battery lead 100. This circuit is broken shortly after the last impulse is delivered to the vertical magnet, whereupon the private magnet deënergizes and permits the side switch to pass to third position. The movement of the side switch wiper 150 from first to second position transfers the battery connection from the vertical magnet 89 to the rotary magnet 90. 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 92 ten times. Each time the relay 92 deënergizes it completes a circuit extending from ground G^9 through springs 137, 146, 147 and 148, relay 149, springs 153 and 154, rotary magnet 90 and side switch wiper 150 (in second position) to the battery lead 100. The rotary magnet 90 receives ten impulses over this circuit and operates to rotate the wipers ten steps onto the contacts of line No. 9990. The private magnet relay 149 is

energized by the first impulse to the rotary magnet and again closes the circuit of the private magnet 91. The circuit of the relay 149 is not opened long enough to permit it to deënergize until after the last impulse has been delivered to the rotary magnet. The relay 149 then deënergizes and breaks the circuit of the private magnet 91 which, if the called line is not already busy, in turn deënergizes and permits the side switch to pass to third position, whereby connection is completed between the calling and called lines. The side switch wiper 156 (in third position) extends the guarding potential from ground G^{12} through the private wiper 87 to the connector private bank contacts of the called line, and also provides an energizing circuit for the cutoff winding 157 of the line switch C'. The winding 157, upon energizing, attracts the armature 158, which operates to disconnect the line winding 159 and ground G^{13} from the called line, and to extend the line conductor 160 through the springs 162 and 163 to the connector bank contact which is engaged by wiper 86. When the side switch wiper 150 of the connector reaches third position, the energizing circuit is established for the ringer relay 164. This circuit extends from ground G^{14} through the interrupter 165, relay 164, springs 171 and 170 and side switch wiper 150 to the battery lead 100. Since this circuit includes the interrupter 165, the relay 164 is energized only intermittently. Each time the relay 164 is energized it operates to disconnect the calling line from the called line, and to bridge the generator M across the called line to ring the bell 175. When the called subscriber removes his receiver, or as soon thereafter as the relay 164 deënergizes, 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^{12} to the side switch wiper 156, lower winding of the relay 177, ringer relay springs 188 and 189, side switch wiper 187, shaft wiper 88, line 161, hook switch springs 186 and 185, receiver 184, transmitter 183, impulse springs 182, coils 181 and 180 of the call-register device, line 160, springs 162 and 163, shaft wiper 86, ringer relay springs 281 and 280, private magnet springs 179 and 178, upper winding of the back-bridge relay 177 and side switch wiper 150 to the battery lead 100. The current through the coils 181 and 180 and the call-register device of the substation A' is in such direction at this time as to attract the armature toward the coil 181. When the connector back-bridge relay 177 is energized by the talking current, it operates to close the circuit through the relay 93. This circuit extends from ground G^{12} through the side switch wiper 156, relay 93 and springs 288 and 289 to the battery lead 100. The relay 93, upon energizing, operates to break the circuit of the ringer relay 164 at the springs 171 and 170, and to complete a locking circuit for itself through the springs 170 and 169 and side switch wiper 150. This locking circuit is independent of the springs 288 and 289 of the back-bridge relay 177. Consequently, the relay 93 will not deënergize and close the circuit of the ringer relay 164 again in case the called subscriber should hang up his receiver and break the circuit of the back-bridge relay 177 before the calling subscriber has hung up his receiver. When the relay 93 is energized it also operates to shift the springs 167 and 173 out of engagement with the springs 168 and 174 and into contact with the springs 166 and 172, respectively. By this operation the connections between the windings of the relay 92 and the trunk conductors 134 and 135 are interchanged. By this shifting of the connections of the relay 92 the current in the calling line is reversed. This reversal of the current causes the polarized relay of the call-register device at substation A to attract its armature in the opposite direction—that is, toward the coil 9. When the armature is attracted in this direction it carries the arm 7 to the left, forcing the springs 4, 5 and 6 into engagement, as was explained in connection with Figs. 4 and 5. The engagement of these springs 4, 5 and 6 short-circuits the transmitter 27 and shunts the receiver 25 with the resistance 190. The short-circuiting of the transmitter 27 makes it impossible for the calling subscriber to talk to the called subscriber through the medium thereof. The shunting of the receiver does not prevent the calling subscriber from hearing the called subscriber answer, but does not allow him to converse through his receiver. When the calling subscriber hears the called subscriber answer, he presses the button 22. This operates the counter-mechanism and permits the springs 4, 5 and 6 to separate in the manner previously explained. The separation of these springs restores the talking circuit of the calling substation to operative condition, and the two subscribers may converse over the circuits outlined by heavy conductors in the drawings.

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 25 is restored to the switch hook 26, the springs 95 and 96 are separated, thereby breaking the energizing circuit through the connector line relay 92. The relay 92, upon deënergizing, breaks the holding circuits of the release relays 139, 128 and 82 of the switches H, F and E, respectively. Although it has not been previously mentioned,

it will be seen that when the side switch wiper 140 of the connector passes from second to third position, the holding ground of the release relays 128 and 82 of the selector switches is transferred from ground G^{10} to ground G^{9} through the springs 138 and 137, so that the circuits of all of the release relays are controlled by the connector line relay. When the relay 139 of the connector deënergizes it completes a circuit from ground G^{9} through springs 137 and 146, springs 147 and 191, release magnet 192 and off-normal springs 193 and 194 to battery lead 100. The energization of the magnet 192 immediately restores the mechanism of the connector to normal position, thereby breaking the connection at the called line and allowing the winding 157 of the switch C' to deënergize. The deënergization of the release relays 128 and 82 of the selectors E and F closes the circuits of their respective release magnets. The energizing circuit for the release magnet 78 of the selector E extends from ground G^{8} through springs 110 and 112, springs 121 and 123, magnet 78 and off-normal springs 80 and 81 to battery lead 100. The circuit of the release magnet 193 of the selector F is similar to that just traced for the magnet 78. The energization of the magnets 78 and 193 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 deënergization of the release relay 82 of the selector E also opens the holding circuit of the winding 44 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 the manner in which connection is obtained with an idle line. It will now be explained how the calling subscriber is given the busy signal in case the called line is already in use when called by the subscriber at substation A. In the foregoing description it has been explained how, whenever a line is busy, either by having made a call or by having been called, there is a guarding ground potential on the connector private bank contacts of the said busy line. Thus if the wipers of the connector H are rotated onto the contacts of the busy line, a ground potential is extended from the private bank contact in that line through the private wiper 87, side switch wiper 156 (which is then in second position), springs 195 and 196, relay 197 and to the spring 198 of the private magnet relay 149. As the relay 149 deënergizes after the last impulse has been delivered to the rotary magnet of the connector, the spring 152 engages the spring 198 before it breaks contact with the spring 151. The circuit of the private magnet 91 is therefore maintained by the current extending from the private bank contact of the busy line through the relay 197, causing the side switch to be locked in second position and the relay 197 to be energized. The energization of the relay 197 disconnects the rotary magnet 90 from the impulse spring 146, and shifts the holding ground of the relay 197 and the private magnet 153 from the guarded private bank contact to ground G^{10}, through the springs 196 and 298, springs 142 and 141, and the side switch wiper 140. In its energized position the relay 197 also completes a circuit over which busy signaling current flows from the busy signaling machine L to the calling substation. This circuit extends from the battery lead 100 through the secondary winding of the induction coil 94^{a}, springs 199 and 200, contact point 201, side switch wiper 187, ringer relay springs 188 and 189, condenser 202, thence over the heavy conductors shown in Figs. 2 and 1 to and through the substation A and back over the other side of the line to the upper winding of the connector line relay 92 to battery lead 100. Although the wipers of the connector H are standing on the contacts of the called line while a calling subscriber is thus receiving the busy signal, there is no connection between the two lines. The connection is opened on one side of the line at the private magnet springs 178 and 179 and on the other side at the side switch wiper 187, which is locked in second position. The switches are released in this position by the hanging up of the receiver at the calling substation in practically the same manner as when an idle line is called. It will be noted that when a busy line is called the current in the calling line is not reversed. Therefore, the armature of the coin-collecting device at substation A is not attracted toward the coil 9 to close the springs 4, 5 and 6, but remains in the position shown in Fig. 1 until at some subsequent time an idle line is called from substation A and the call is answered.

It will be seen that when the magnet of the call register is operated by the reversal of current in the calling line upon the response of the called subscriber, the separation of the springs 300 and 301 removes a short-circuit from around the impedance 315. This is for the purpose of inserting a resistance in the bridge at the telephone to replace the resistance of the transmitter, which is short-circuited. The insertion of this resistance is useful only when the device is used in party-lines, and is useful then in case a second subscriber on a calling line should remove his receiver while a conver-

sation is in progress. The magnet at this second telephone would energize in the direction to short-circuit the transmitter, and at the same time the insertion of the impedance 315 prevents sufficient talking current from being shunted from the first telephone to interfere with the conversation.

From the foregoing it will be seen that the calling subscriber's telephone set is inoperative for talking after the called subscriber answers. The calling subscriber can listen and hear the response of the called subscriber, but cannot use his transmitter until the call has been registered at the calling substation. This is the only way in which the calling subscriber can talk to the called subscriber.

A further advantage of my improved system is as follows: In telephone systems giving so-called measured service it is very often desired that no charge shall be levied for calling certain lines, such as lines which terminate at the central office over which operators or exchange attendants are called, etc. In the system shown herein it is very easy to provide for free service when certain lines are called. This may be done by making the lines which are to be called free of charge accessible from special connector switches. These special connectors may be similar in all respects to the connector H, with the exception that the line relay 92 should be connected with the trunk conductors 134 and 135 direct instead of through the springs of the relay 93. In these special connectors the relay corresponding to the relay 93 would have no springs corresponding to the springs 166, 167, 168, 172, 173 and 174. Since the line relay of these connectors is connected directly to the line conductors, the current is not reversed in the calling line upon the removal of the receiver at a substation which has been called through one of the special connectors. Since the current in the calling line is not reversed, the calling telephone is not made inoperative for talking, and consequently the calling subscriber does not need to operate his meter before he can talk.

My improved substation service meter is especially adapted for use in two-wire systems. By a "two-wire system" I mean one in which means are provided at the substation for controlling the two sides of a calling line in series to operate one or more automatic switches in extending the call. This meter, as explained, is operable by the calling subscriber after, but not before, the called subscriber answers. It cannot be operated more than once for each call, and the calling subscriber must operate the meter and thereby register the call in order to restore the transmitter to operative condition. For the broader purposes of my invention I do not, however, limit myself to the exact construction and circuit arrangement shown and described.

What I claim as my invention is:—

1. In a telephone system, a calling and a called line, switching apparatus for establishing a connection between said lines, a meter and an operating magnet at the substation of the calling line, and means controlled by said magnet for rendering the calling telephone inoperative only as to its transmitter upon the response of the called subscriber.

2. In a telephone system, a calling and a called subscriber's line, a meter and an operating magnet on the calling line, and means controlled by said magnet upon the response of the called subscriber for rendering the calling telephone inoperative for transmitting but not for receiving voice currents.

3. In a telephone system, a calling and a called line, switching apparatus for establishing a connection between said lines, a meter and an operating magnet at the substation of the calling line, means controlled by said magnet for rendering only the transmitter of the calling telephone inoperative for talking purposes upon the response of the called subscriber, and means for preventing said meter from being operated until after the response of the called subscriber.

4. In a telephone system, a calling and a called subscriber's line, a meter and an operating magnet on the calling line, means controlled by said magnet upon the response of the called subscriber for rendering the calling telephone inoperative for transmitting but not for receiving voice-currents, and means for preventing said meter from being operated until after the response of the called subscriber.

5. In a telephone system, a calling and a called line, means including automatic progressively moved switching apparatus for establishing a connection between said lines, a switch hook for controlling the operation of said apparatus, a meter associated with the calling line, manual means for operating said meter to register a call, and means for preventing said meter from being operated until after the response of the called subscriber.

6. In a telephone system, a calling and a called line, switching apparatus for establishing a connection between said lines, a meter associated with the calling line, an operating magnet therefor, means controlled by said magnet for rendering only the transmitter of the calling telephone inoperative for talking purposes upon the response of the called subscriber, and manual means to

again render said telephone operative for talking purposes and for operating said meter.

7. In a telephone system, a calling and a called line, switching apparatus for establishing a connection between said lines, a meter for the calling line, a magnet associated therewith, means for closing an energizing circuit for said operating magnet upon the response of the called subscriber, contact springs controlled by said magnet adapted to be brought into contact upon the operation of the same, a short-circuit about the transmitter of the calling telephone, and a shunt circuit about the receiver controlled by said contact springs, whereby the calling telephone is rendered inoperative for transmitting but not for receiving voice-currents.

8. In a telephone system, a calling and a called line, switching apparatus for establishing a connection between said lines, a meter for the calling line, a magnet associated therewith means for closing an energizing circuit for said operating magnet upon the response of the called subscriber, contact springs controlled by said magnet adapted to be brought into contact upon the operation of the same, a short-circuit about the transmitter of the calling telephone, a shunt circuit about the receiver controlled by said contact springs, whereby the calling telephone is rendered inoperative for transmitting but not for receiving voice-currents, and means for preventing said meter from being operated to register a call until after the response of the called subscriber.

9. In a telephone system, a calling and a called line, switching apparatus for establishing a connection between said lines, a meter for the calling line, a polarized operating magnet associated therewith, a circuit for transmitting current in one direction through said operating magnet when the calling subscriber initiates a call, means for reversing the current through said magnet upon the response of the called subscriber, and means controlled by said reversal of current for rendering only the transmitter of the calling telephone inoperative for talking purposes.

10. In a telephone system, a calling and a called line, means including automatic switching apparatus for establishing a connection between said lines, a meter for the calling line, a polarized operating magnet associated therewith, means for transmitting current in one direction through said magnet when a subscriber initiates a call, means for reversing the current through said magnet upon the response of the called subscriber, and a short-circuit about the calling transmitter adapted to be closed upon the operation of said magnet upon the response of the called subscriber to render said transmitter inoperative for talking purposes.

11. In a telephone system, a calling and a called line, switching apparatus for establishing a connection between said lines, a meter at the substation of the calling line, a polarized electromagnet associated with said meter, an arm controlled by the armature of said electromagnet, means for closing the circuit in one direction through said electromagnet when the subscriber initiates a call, means for reversing the current through said electromagnet upon the response of the called subscriber, means for moving said arm in response to said reversal of current, and contact springs controlled by said arm for rendering only the transmitter at the calling substation inoperative for talking purposes.

12. In a telephone system, a calling and a called line, switching apparatus for establishing a connection between said lines, means for controlling the two sides of the calling line in series for controlling the operation of said switching apparatus, a meter associated with the calling line for registering successful calls, and a magnet operated over the line circuit, for controlling said meter.

13. In a telephone system, a calling and a called line, switching apparatus for establishing a connection between said lines, means for controlling the two sides of the calling line in series for controlling the operation of said switching apparatus, a magnet on the calling line, a meter associated with the calling line, means controlled by said magnet for rendering the calling telephone inoperative for talking purposes upon the response of the called subscriber, and manual means for then operating said meter to register the call and to render the telephone again operative for talking.

14. In a telephone system, a calling and a called subscriber's line, means including automatic switches 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 for establishing a connection between said lines, a switch hook for controlling the operation of said apparatus, a meter at the substation of the calling line, means included in the line circuit for operating other means for placing said meter in condition to register successful calls, and manual means for operating said meter.

15. In a telephone system, a calling and a called subscriber's line, means including automatic switches 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 for establishing a connection between said lines, a meter at the substation of the calling line, means controlled by said meter for rendering the calling telephone

inoperative for talking purposes upon the response of the called subscriber, and means for then operating said meter to register the call and to render the telephone again operative for talking.

16. In a telephone system, a calling and a called line, means including automatic progressively movable switching apparatus for establishing a connection between said lines, a meter associated with the calling line, an operating magnet associated with said meter, means controlled by said magnet for rendering the calling telephone inoperative for talking purposes upon the response of the called subscriber, and manual means for operating said meter to again render said telephone operative for talking purposes.

17. In a telephone system, a calling and a called line, means including automatic switching apparatus for establishing a connection between said lines, a meter associated with the calling line, a polarized operating magnet associated with said meter, a circuit for transmitting current in one direction through said operating magnet when the calling subscriber initiates a call, means for reversing the current through said magnet upon the response of the called subscriber, and means controlled by said reversal of current for rendering the calling telephone inoperative for talking purposes.

18. In a telephone system, a calling and a called line, means including automatic switching apparatus for establishing a connection between said lines, means for controlling the two sides of the calling line in series for controlling the operation of said switching apparatus, and a manually operated meter associated with the calling line for registering only successful calls, said meter being controlled by means operated over the established connection.

19. In a telephone system, a calling and a called line, progressively movable switching apparatus for establishing a connection between said lines, a switch hook for controlling the operation of said apparatus, a meter associated with an electromagnet winding in the line circuit of the calling line, manual means for operating said meter to register a call, and means controlled by said winding for preventing said meter from being operated until after the response of the called subscriber.

20. In a telephone system, a calling and a called line, progressively movable switching apparatus for establishing a connection between said lines, a normally inoperative meter associated with a polarized operating magnet in the line circuit of the calling line, means for transmitting current in one direction through said magnet when a subscriber initiates a call, means for reversing the current through said magnet upon the response of the called subscriber to render said meter operative, and a short-circuit about the calling transmitter adapted to be closed upon the operation of said magnet upon the response of the called subscriber to render said transmitter inoperative for talking purposes.

21. In a telephone system, a calling and a called subscriber's line, means including progressively movable switching mechanism for establishing a connection between said lines, a switch hook for controlling the operation of said switch mechanism, a meter associated with the calling line, mechanical means for operating said meter, said meter normally inoperable by said mechanical means, and an operating magnet for rendering said meter operable.

22. In a telephone system, a calling and a called subscriber's line, means including progressively movable switching mechanism for establishing a connection between said lines, a switch hook for controlling the operation of said switch mechanism, a meter associated with the calling line, mechanical means for operating said meter, said meter normally inoperable by said mechanical means, and an operating magnet for controlling means for rendering said meter operable.

23. In a telephone system, a calling and a called subscriber's line, means including progressively movable switching mechanism for establishing a connection between said lines, a switch hook for controlling the operation of said switch mechanism, a meter associated with the calling line, mechanical means for operating said meter, said meter normally inoperable by said mechanical means, an operating magnet for rendering said meter operable, and means under the control of the calling subscriber for operating said meter.

24. In a telephone system, a calling and a called subscriber's line, means including progressively movable switching mechanism for establishing a connection between said lines, a switch hook for controlling the operation of said mechanism, a meter associated with the calling line, a pawl for operating said meter, said pawl normally disassociated from the operating parts of said meter, a magnet for associating the pawl with said operating parts, and manual means for operating said pawl.

25. In a telephone system, a calling and a called subscriber's line, means including progressively movable switching mechanism for establishing a connection between said lines, a switch hook for controlling the operation of said mechanism, a meter associated with the calling line, a pawl for operating said meter, said pawl normally disassociated from the operating parts of said me-

ter, a magnet for associating the pawl with said operating parts, and means controlled by the calling subscriber for controlling said pawl to operate said meter.

26. In a telephone system, a calling and a called subscriber's line, means including progressively movable switching mechanism for establishing a connection between said lines, a switch hook for controlling the operation of said mechanism, a meter associated with the calling line, a pawl for operating said meter, said pawl normally disassociated from the operating parts of said meter, a magnet for associating the pawl with said operating parts, manual means for controlling said pawl to operate said meter, and means for again disassociating said pawl.

27. In a telephone system, a calling and a called subscriber's line, means including progressively movable switching mechanism for establishing a connection between said lines, a switch hook for controlling the operation of said mechanism, a meter associated with the calling line, a latch for normally rendering the meter inoperable, release means for rendering said meter operable, a central battery for supplying current for operating and talking purposes, a magnet responsive to the operating current for setting said release means, said magnet responsive to the talking current for operating said release means for rendering said meter operable, and manual means for operating said meter.

28. In a telephone system, a calling and a called subscriber's line, means including progressively movable switching mechanism for establishing a connection between said lines, a switch hook for controlling the operation of said mechanism, a meter associated with the calling line, a latch for normally preventing the meter from operating, release means for rendering said meter operable, a central battery for applying current for operating and talking purposes, a magnet responsive to the operating current for setting said release means, said magnet responsive to the talking current for operating said release means for rendering said meter operable, and means under the control of the calling subscriber for operating said meter.

Signed by me at Chicago, Cook county, Illinois, this 27th day of April, 1911.

JOHN ERICKSON.

Witnesses:
ARTHUR J. RAY,
E. D. FALES.