E. E. CLEMENT.

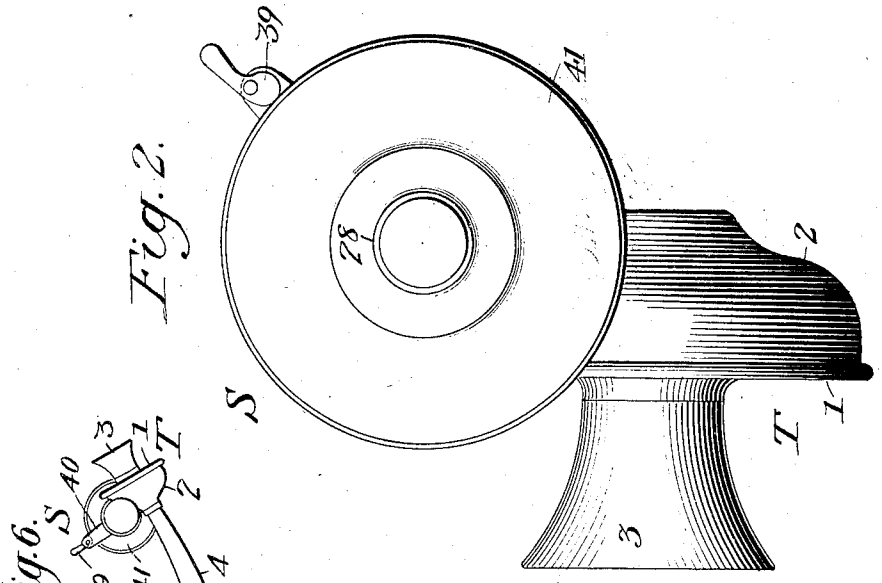
TELEPHONE EXCHANGE SYSTEM.

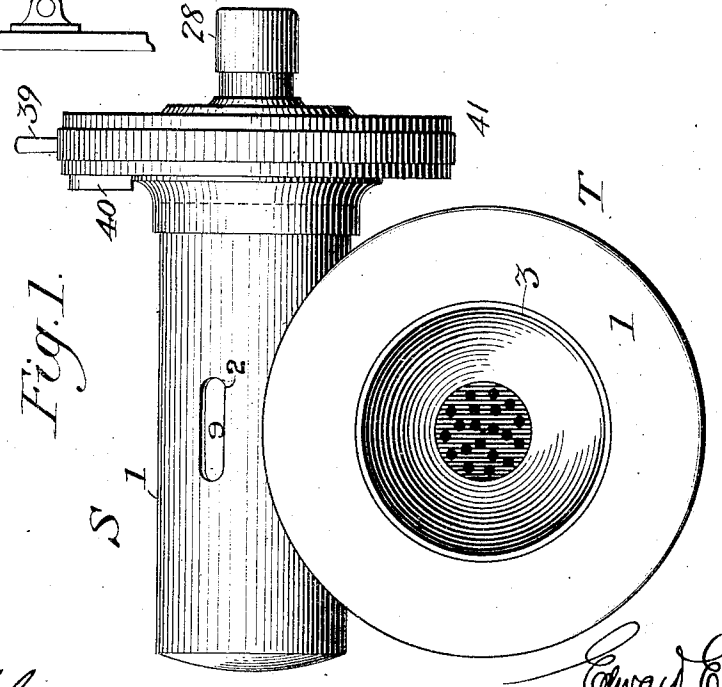
APPLICATION FILED NOV. 21, 1905.

1,107,140.

Patented Aug. 11, 1914.

7 SHEETS—SHEET 1.





Witnesses

D. W. Edelin.

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TELEPHONE EXCHANGE SYSTEM.

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7 SHEETS—SHEET 2.

Fig. 4.

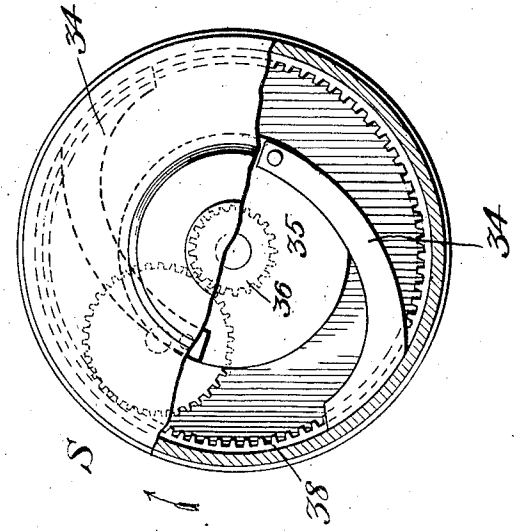


Fig. 3.

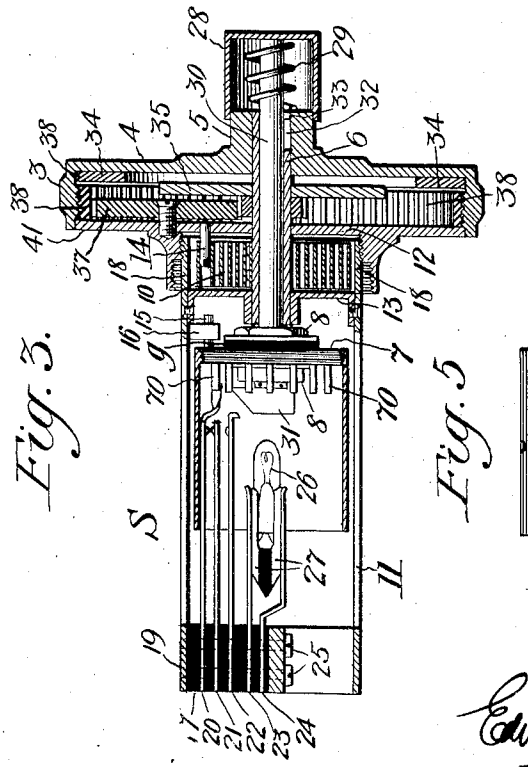
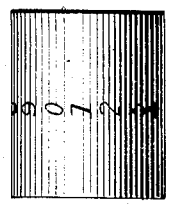


Fig. 5



Witnesses

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7 SHEETS—SHEET 3.

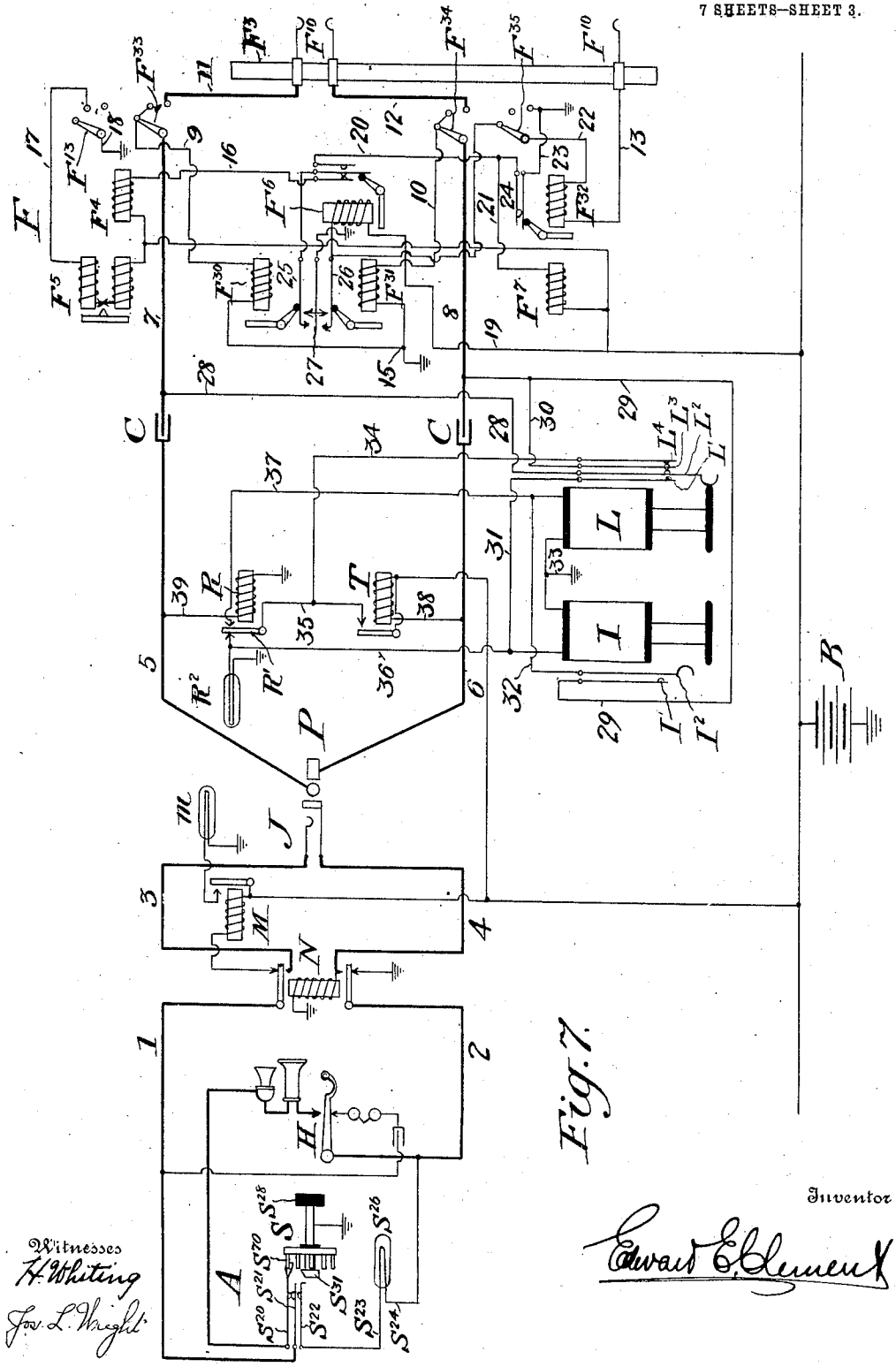


Fig. 7.

Witnesses
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7 SHEETS—SHEET 4.

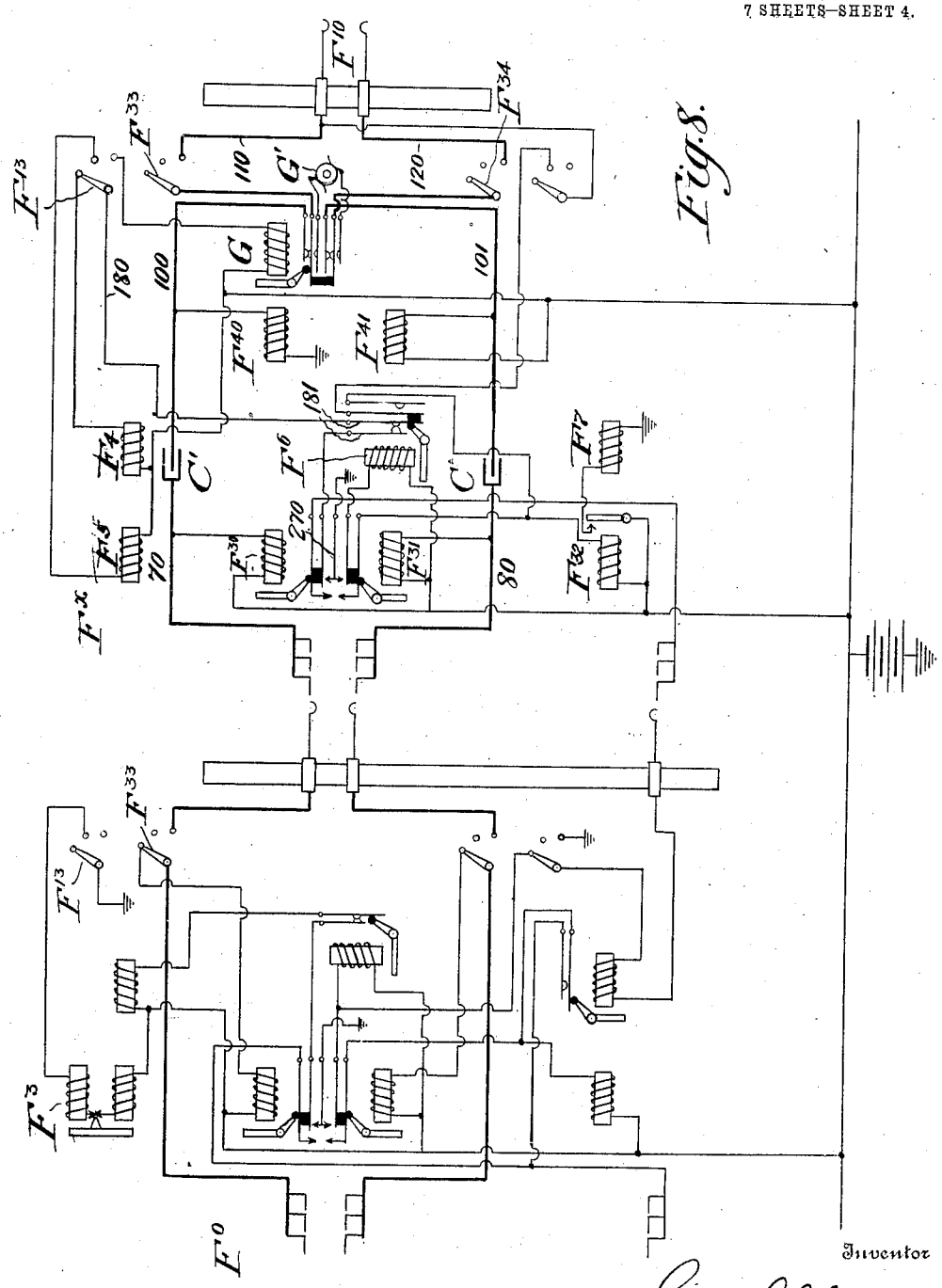


Fig. 8.

Witnesses

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APPLICATION FILED NOV. 21, 1905.

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7 SHEETS—SHEET 5.

Fig. 10.

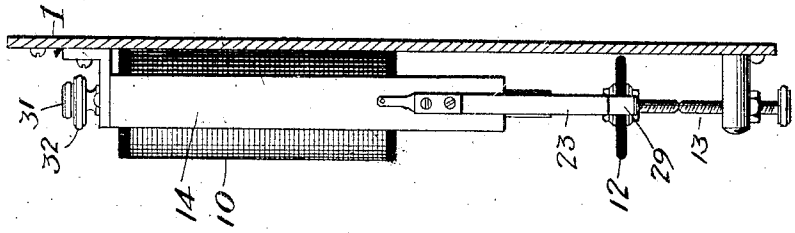
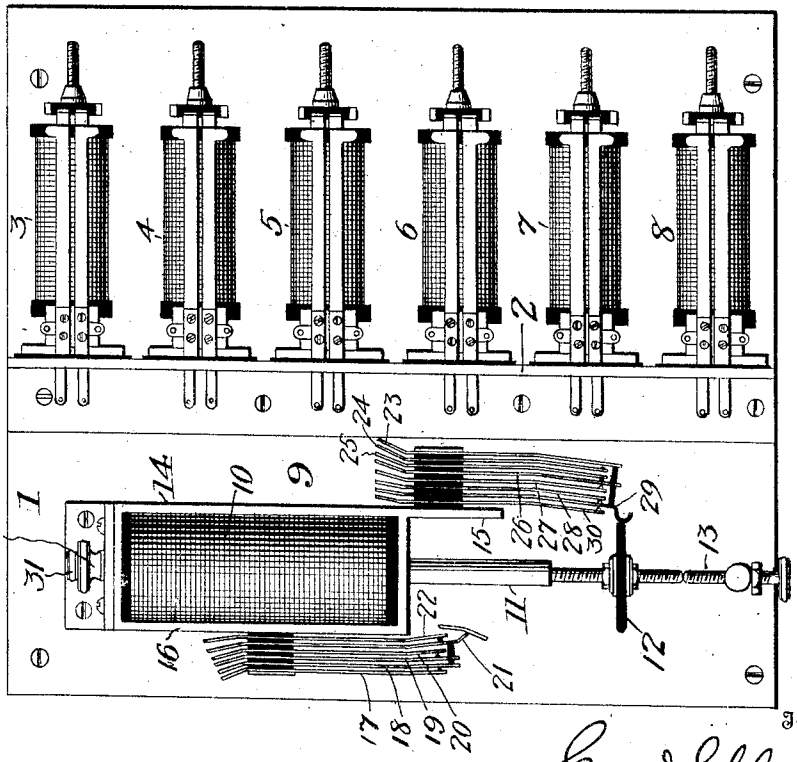


Fig. 9.



Witnesses

D. W. Edelin.

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APPLICATION FILED NOV. 21, 1905.

1,107,140. Patented Aug. 11, 1914.

7 SHEETS—SHEET 6.

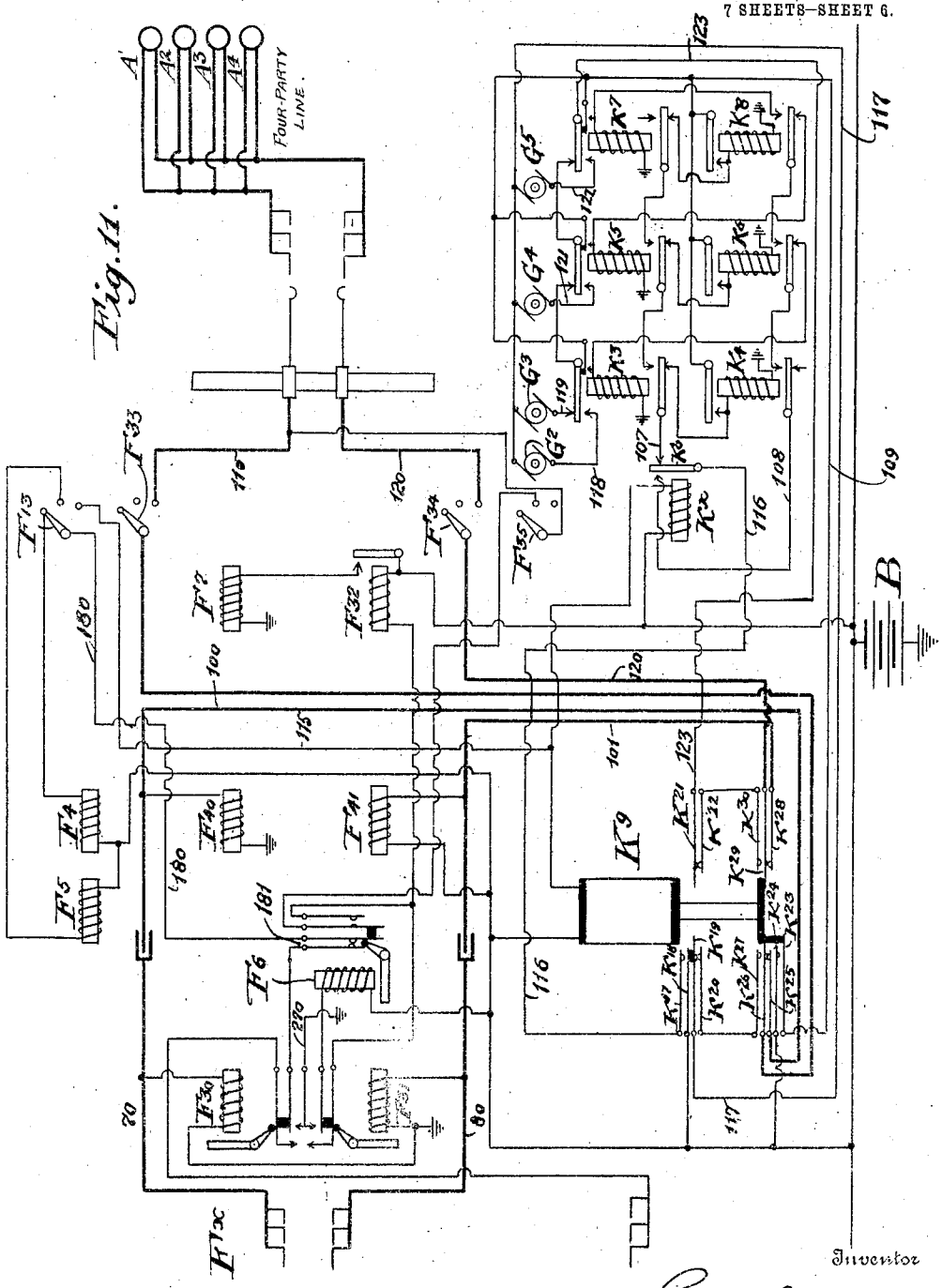


Fig. 1.

Witnesses

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TELEPHONE EXCHANGE SYSTEM

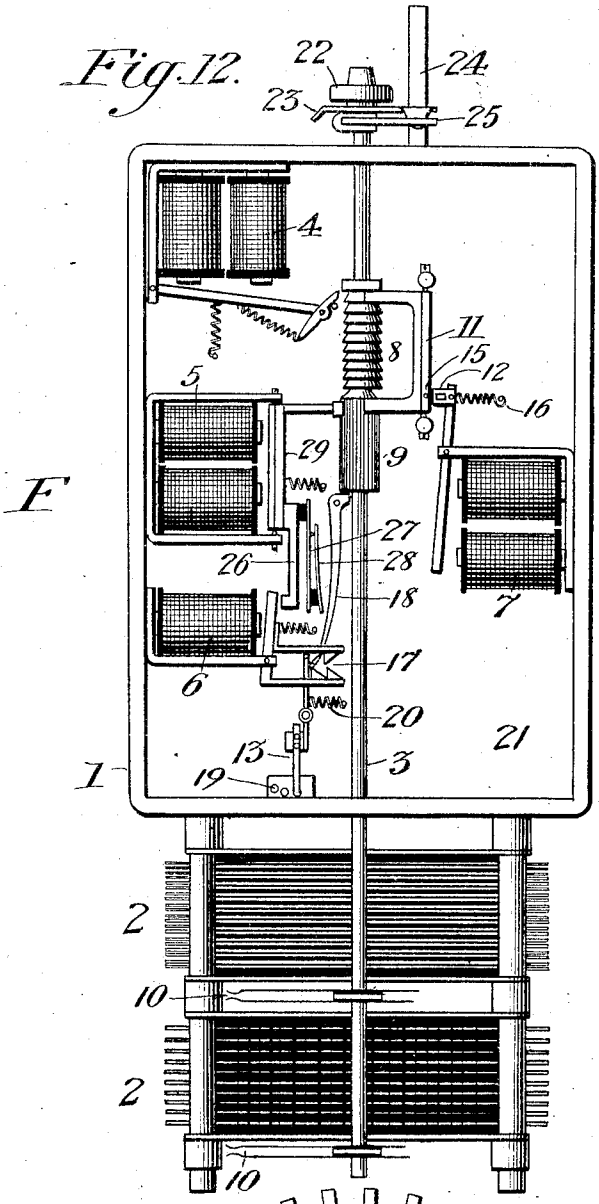
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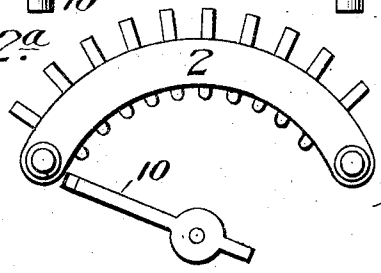
7 SHEETS—SHEET 7.

Fig. 12.



F

Fig. 12a.



Witnesses

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UNITED STATES PATENT OFFICE.

EDWARD E. CLEMENT, OF WASHINGTON, DISTRICT OF COLUMBIA, ASSIGNOR, BY MESNE ASSIGNMENTS, TO FREDERICK C. STEVENS, OF ATTICA, NEW YORK.

TELEPHONE-EXCHANGE SYSTEM.

1,107,140. Specification of Letters Patent. **Patented Aug. 11, 1914.**

Application filed November 21, 1905. Serial No. 288,368.

To all whom it may concern:

Be it known that I, EDWARD E. CLEMENT, a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Telephone-Exchange Systems, of which the following is a specification, reference being had therein to the accompanying drawing.

My invention relates to telephone exchange systems, and has for its object the improvement of such systems in the particulars which will be hereafter enumerated.

My invention is designed to permit a calling subscriber, by the proper and very simple manipulation of a piece of apparatus called a sender at his substation, to connect his line with the line of any other subscriber in the exchange, whether the exchange is large or small.

The invention is directed first to the provision of a simple and reliable sender at the substation, which may be used at night as well as in the day; second, to the reduction of apparatus required at the central office, by providing a number of automatic switching devices less than the number of lines, a calling line being connected manually by an operator to the switching apparatus which it will thereafter control; third, the invention is directed to a selective device composed entirely of relays, no particular type of relay being required and no moving mechanical parts other than the ordinary relay armatures being employed. In the system I shall describe these relays are used for selective party-line work, but they are available for any purpose of selection, and may be used to replace the automatic selective switches which are also described for the purpose of connecting lines.

The specific system herein presented is what is commonly called semi-automatic.

Subsidiary points and features of invention will appear from the following detailed description as I proceed.

It will be understood that while all of the portions of the present system which are presented herein mutually contribute to the unitary result of effecting connection between subscribers in the exchange, some of the pieces of apparatus may be used in any system, such as the subscriber's sender, and the selective party-line apparatus.

While I have spoken of the invention as an improvement in semi-automatic systems it will be apparent that the improvements may be equally applicable to full automatic systems with slight modifications in the central office connective links.

My improved subscriber's sender is a self-contained unit, which in its simplest form merely makes and breaks the metallic circuit, consequently can be attached to any common battery telephone without change in the wiring. In order to make it useful at night I add, as I shall hereinafter show, a small incandescent lamp which is contained within the device, and serves to illuminate the numbers while sending. The working parts of this sender are contained within a cylindrical shell and an end cap constituting the handle or wheel by which the numbers are sent. The shell is intended to be attached to the transmitter shell of the telephone with which it is to be used, the numbers appearing behind a small window as the wheel is turned. When the lamp is used to illuminate these numbers, a ground wire is required.

To reduce the apparatus at the central office, I provide each line with the ordinary and well-known answering-jack and line-signal. When a calling subscriber removes his receiver from its hook preparatory to sending a number, his operator at the central office inserts an answering-plug into his jack. This plug forms the terminal of a cord-circuit which passes to a first selector-switch. When the operator has connected the subscriber to the switch, battery is supplied to the line in such manner as to light up the lamp in his sender, thereby notifying him so that he may proceed to send the number he wants. The operation of the first and subsequent selector and connector switches in response to the subscriber's sender, is substantially the same as in full automatic systems. The switches of themselves constitute no essential part of the present invention, except as elements in the combinations I shall set forth. Certain features of the cord-circuit, and certain relays employed therein, are in themselves novel, and constitute matters of invention, but these will be subsequently pointed out and claimed.

The selective relay scheme which will be described herein as applied to party-line selecting, and which I have said may be used

for other purposes, involves the use of a double set of interlocking relays controlled through the front and back contacts of a moving arm, which is conveniently an armature of a relay. Suppose the relays in one set are called for the moment 1, 3, 5, 7, etc., and those of the other set are called 2, 4, 6, 8, etc. Then the operation is that when the control relay pulls up, current is put on a locking circuit common to all the selective relays. Then upon falling back the control relay closes through No. 1, which pulls up, locks itself, and connects No. 2 to the front contact of the control relay. If the single motion of the control relay is all that is made, that is, if but a single make or break has been received, then nothing further happens. If, however, a second impulse is received, the control relay again pulls up, thereby closing the circuit of No. 2, which pulls up and locks itself, at the same time connecting No. 3 to the back contact of the control relay. When the latter again lets go, No. 3 pulls up, locks itself, and connects No. 4 to the front contact of the control relay. At this stage, there have been two impulses received, two complete movements of the control armature, and one change in the selective relays, together with a preparation for a second change. To speak more specifically, suppose there are four generators of selected ringing current, one of which is normally connected to the ringing key or relay. Any one of these may be selected and put on the ringing key by sending 1, 2, 3, 4 impulses. The first impulse sets the guard relay No. 1, which prepares No. 2 or the active relay, but does nothing further, hence a single impulse will leave the No. 1 generator still connected to line. A second impulse will work No. 2 relay, cut off No. 1 generator, connect No. 2 generator, and prepare relays 3 and 4 for the next step, and so on. I consider this arrangement of selective relays a very important feature of my invention, and as I believe I am the first so to arrange relays, I shall claim the same broadly. I am aware that various combinations of relays have been used heretofore for purposes of selection, but always, so far as I know with a plurality of transmitting wires. I have here produced an arrangement which can be controlled from a distance over a single wire, whose action is practically instantaneous and whose results are much more certain and dependable than those of any form of switch mechanically moved. In order to select any one of ten numbers or connections, or what not, a maximum number of twenty-one relays is required. In order to select any one of the same number with a mechanically actuated switch, two relays and two magnets as well as all the moving mechanical parts and contacts are required.

A very marked point of superiority in my arrangement of relays over anything of the kind heretofore produced, is its adaptability to perfect protection from dust and moisture. My relays are preferably mounted on the regulation racks, in standard dust-proof shells, or covers, and the expense of maintenance of a system employing them should be so low as to be almost negligible, since there are no parts to wear, all contacts can be made of platinum, and all joints can be soldered solidly.

While I shall not present specific claims herein, for my relay selective scheme as a selector or connector switch, I shall claim the scheme broadly, as I have already indicated.

My invention is illustrated in the accompanying drawings, in which—

Figures 1 and 2 are respectively a front and a side view of my improved subscriber's sender. Fig. 3 is a longitudinal sectional view thereof, and Fig. 4 is an end view similar to Fig. 2, but with parts broken away to show the retarding or governing mechanism. Fig. 5 is a detail view of the number drum or cylinder removed from the case. Fig. 6 is a side view of the sender attached to a transmitter, and taken from the opposite side to Fig. 2. Fig. 7 is a diagram of a subscriber's line-circuit, an operator's cord-circuit and a first selector switch. Fig. 8 is a diagram complementary to that of Fig. 7, showing the contact banks of the first selector switch, a second selector, and a connector switch, the latter containing only individual-subscriber lines. Figs. 9 and 10 are respectively a front and a sectional view of my relay selector set, in a form designed for use with automatic connector switches for four-party selective ringing. Fig. 11 is a diagram similar to Fig. 8, and also complementary to that of Fig. 7, showing a connector switch equipped with the four-party selective relay set of Fig. 9. Figs. 12 and 12^a show a type of automatic switch which may be employed in the system, these figures being added in order to complete the illustration. Fig. 12^a is a detail of the switch banks.

In describing this system, with reference to the drawings, a great many reference characters will be required, and I shall therefore adopt the following system throughout: I shall designate each piece of apparatus by a letter, and shall number each part of such piece. It is to be understood that the letter and each of its subsidiary numbers are to be read together. Thus I shall call the subscriber's sender, shown in Figs. 1 to 6, S, and in these six figures, instead of writing S', S^2, S^3, S^4, etc., I shall write simply 1, 2, 3, 4, etc., throughout the specific description of the part S. In the diagram, however, where the various parts appear together, and confusion might be caused by having

the same numerals repeated, these numerals will always appear with the letters to which they belong.

Referring then to Figs. 1 to 6, inclusive, these all show the sender S. Figs. 1, 2 and 6 also show the telephone transmitter T. This transmitter has the usual front plate 1, shell 2, and mouthpiece 3. It is supposed to be fastened to an arm 4 through which the circuit wires are led to the transmitter. If the lamp is to be used in the sender, a ground wire is also led through this arm, and connection with all the wires is effected in the shell 2. The sender itself, S, is best shown in Fig. 3, all the working parts here being in section, and removed from the shell 1, which is permanently secured to the transmitter shell 2, as clearly shown in Figs. 1, 2 and 6. The sender shell 1 has a window 2, through which the numbers upon the indicating cylinder are visible as the handle 3 is turned. This handle 3 is a milled flange formed on the disk 4, whose hub 5 is rigidly secured to a tube 6, which serves to connect the handle and the operating disk 7, which is also mounted rigidly on the tube by means of nuts 8, but insulated therefrom by bushings 9. The handle and disk are normally maintained in a fixed zero position by the spring 10, housed in a chamber formed in one end of the frame 11, between an outer disk or cap 12 and an inner disk or bearing partition 13. The spring is secured at its inner end to the tube 6 and at its outer end to a stud 14, fixed in the cap 12. The normal or zero position of the disk is accurately determined by the stop 16 fixed to the frame 11, and a pin, 15, on the disk, 7.

The frame 11 comprises two rings, 18 and 19, one at each end, joined by straight parallel members. The one end, as I have said forms a housing for the actuating spring 10, and the other end supports the contact springs and the lamp. For this purpose the springs 20, 21, 22, 23 and 24 are piled up between insulating slips 17, and secured to the ring 19 by means of the screws 25. Springs 20 and 21 are the line-signal springs, normally closed; spring 22 is the lamp spring, normally open; and springs 23 and 24 constitute together a socket or jack for the reception of the lamp 26, which has the usual coöperating contacts, 27.

The disk 7 carries a number of steel pins, 70, arranged in a circle, and they are all rather small in diameter or flattened and each inclined edgewise to a spring 20, for a purpose which will presently appear. As the handle is turned these pins pass over the end of the spring 20, which is likewise inclined, so as to form cam surfaces with its two faces. When the spring 10 turns the tube 6 the handle and the disk back, the pins 70 pass successively under the end of the spring 20.

In calling the central office, the subscriber presses in the button 28, which is normally kept out from the hub 5 by the coiled spring 29, and which is secured to the spindle 30, which passes through the tube 6 and the disk 7 to a point near the end of the spring 22, where it is fitted with a contact latch 31. This latch has an inclined face, forming an edge, which when the button 28 is pressed in engages the hooked end of the spring 22, and completes the lamp circuit therethrough, being mechanically held thereby against the tension of the spring 29. Afterward, when the subscriber starts to send the number, the first movement of the handle 3 and the tube 6 turns the latch block 31, so that its point or edge disengages the spring 22, breaking the lamp circuit and permitting the spring 29 to draw the block back. In order that the block 31 will turn with the tube 6, I provide the spindle 30 with a pin 33, working in a slot 32 milled in the end of the tube 6.

The retarding mechanism which prevents the tube 6 from being turned back too rapidly by the spring 10, is housed within the hand-wheel, in order to save space. This consists of a pair of friction members 34 pivoted to a freely rotating disk 35 journaled on the tube 6. This disk is rigidly secured to a pinion 36 meshing with an idler wheel 37 which takes into the internal gear 38 cut on the inside of the milled flange 3 of the hand-wheel 4. When the wheel is turned forwardly or in the direction of the arrow, Fig. 4, to set a number, the idler wheel turns with it, and turns the pinion 36 and the disk 35 oppositely, so that the friction members 34 are drawn loosely around the smooth inside surface 38′ of the flange 3. When the wheel is released, however, and starts to return, it rotates the idler wheel and the pinion 36 in the reverse direction, whereby the friction members 34 are thrown out against the inner surface 38′, and by reason of their shape and the eccentric manner of their pivoting, they develop considerable friction against the inside of the flange 3, thus retarding the return of the wheel so as to prevent the pins 70 from passing too rapidly over the contacts.

As it would ordinarily be difficult to turn the wheel 3 completely around to the higher numbers, such as 9, with a single motion of the wrist, I provide a locking cam 39, carried in a bracket 40 secured to the plate 41. This cam bears on the milled edge of the wheel and prevents its retraction, so that the wheel may be turned by several motions or steps to a desired number, and may be released by throwing the cam 39 out of engagement with it.

Before proceeding to any description of the circuits in the present case, I will briefly describe the typical switch and the selective

ringing set shown in Figs. 12, 9 and 10, respectively. The switch F, Figs. 12 and 12ª, has a frame 1, carrying the contact banks 2, a spindle 3, a vertical magnet 4, a rotary magnet 5, a private or test magnet 6, and a release magnet 7. The spindle carries wipers 10 to coöperate with the contacts in the banks 2, and is fitted with a rotary ratchet 9 and a vertical ratchet 8, the former engaged by a pawl actuated by the magnet 5, and the latter by a pawl under the control of the magnet 4. A detent pawl 11 has two arms which engage both the rotary and vertical ratchets, being lifted therefrom when it is desired to release the switch, by means of a link 12 on the armature lever 14′ of the release magnet 7. The latter being energized, pushes forward the link 12 until it engages a pin 15 on the upper or bell-crank arm of the double detent 11, and when the magnet is deënergized the retracting spring 16 throws over the pawl to disengage it from the ratchets. The circuits of the controlling magnets of this switch are completed and broken in proper sequence by what I shall call a side-switch 13. This comprises a set of arms mounted together and sweeping over contacts 19 forming the terminals of the different magnet circuits, as will presently appear in the description of the diagrammatic figures. The pivoted lever carrying these springs has a finger on its upper end engaging the escapement 17 controlled by magnet 6. A spring 20 tends to throw the lever over, but is only permitted to do so one full step for each complete double motion of attraction and repulsion of the armature of magnet 6. When the switch is finally restored by the release magnet 7, and the spindle 3 drops into the position shown in Fig. 12, the lower edge of the rotary ratchet wheel 9 engages the short arm of a bell-crank 18, the long arm of which pushes back the side switch lever to its normal position shown. The frame 1 in the figure is supposed to have a back 21, upon which the various parts may be mounted.

Fig. 12ª is a bottom plan view showing the switch banks 2, and the wiper arm 10. The contacts are arranged in curved rows forming a portion of a cylindrical surface, whose axis is in the middle.

The upper end of the spindle is provided with a cap 22, in which is a coiled spring having one end secured to the spindle, and the other to a rod 23, journaled on the spindle at one end, and on a post 24 at the other. Attached to the spindle is a stop-arm 25, and these parts operate as follows: Sliding on the post 24, the parts 23 and 25 permit vertical movement of the switch, and the spring in the cap 22 turns the spindle around from any position in which it may be, to the zero position with the stop-arm against the lip on the arm 23, when the detent 11 is lifted.

The selective ringing device, shown in Figs. 9 and 10, will be designated by the letter K. It has a base plate 1, with an upstanding flange 2, on which are secured relays 3, 4, 5, 6, 7 and 8. Upon the opposite side of the flange from these relays is a master relay 9, which is made sluggish, for a purpose which will presently appear. This relay consists of a solenoid 10, with a vertically sliding core 11, carrying a head 12, of insulating material, and having its lower end supported on an adjustable stop 13, when the solenoid is deënergized. The solenoid winding is formed on a hollow spool, preferably having its tube of brass, and its heads of rubber or hard fiber. Around this is the magnet frame 14—15—16, of soft iron, the core 11 being also of soft iron, but bushed with copper or brass at the point where it passes through the frame, in order to prevent sticking. Upon the member 15 are mounted contact springs 23 to 30, inclusive, with their lower ends adjusted to be moved by the head 12 when in its lowest position. The springs 23, 26 and 29 are secured together by insulating connections, so that they all move as one. On the member 16 of the iron frame are secured the contact springs 17 to 22, inclusive, on which 18, 19 and 21 are secured and moved together. I have shown all these contact springs mounted on the solenoid frame and operated directly by the core for the sake of simplicity in tracing the circuits, which are sufficiently complicated in a system of this kind, without adding extra features. In practice, however, I wish it understood that the solenoid relay 9 has not as many contacts as are shown in this figure, being fitted, preferably, with only one pair of up contacts and one pair of down contacts, all the rest being mounted on relays of the same type as the relays 3 to 8, and carried on the same support. The purpose of employing this solenoid is to produce certain circuit changes of appreciable duration, in order that the selective relays, 3 to 8, may be operated to select without connecting, during the said circuit changes. To put this more specifically, the solenoid is the master relay, which, on being energized, cuts off the generator circuit entirely, and maintains it cut off as long as the core 11 is drawn up. The top of the tube of the solenoid is provided with a valve 31, which rests upon the cap 32, by gravity, with its stem sticking down into an opening through the cap. By regulating the weight of this check valve, and the closeness of the joint it makes with the top of the cap, I can regulate the relative speeds of the up and down movement of the core 11, to a nicety. The core is moved up very quickly, the check valve then lifting and permitting the air in the tube to rush out; but the downward

movement of the core is much slower, so slow in fact that the head 12 does not move far enough during the makes and breaks, which operate the relays 3, 4, 5, 6, 7 and 8, for it to pass off of the extended end of the spring 21, the operative or changed position of the upper set of springs being thus maintained until a break in the circuit occurs, of sufficient duration to permit the slowly dropping core to pass off the spring 21, when the upper set of springs connects the ringing circuit to line, together with the particular generator of current that has been selected, and this connection is maintained until the head 12 reaches its lowest position, as determined by the stop 13, when the lower set of springs will be operated to again cut off the generator. The further operation of this device will more fully appear from the description of the circuits, to which I will now pass.

Figs. 7 and 8 are to be read together in the first part of the description, which will be limited to the case where the lines to be called are single-party-lines.

Figs. 7 and 11 are to be read together in the second part of the description, referring to party lines and selective signaling.

Referring now to Figs. 7 and 8, and particularly to Fig. 7, A is a subscriber's station, having line-wires 1 and 2 extending to the central office, where they terminate in contacts of a cut-off relay N, normally connecting them to a line-relay M, on one side, thence to the main battery B, and to ground on the other side. At the subscriber's station I provide the usual transmitter, receiver, ringer, condenser, and switch-hooks, which need no special description. In addition to these I provide the sender *s*, which is shown in Figs. 1 to 6. Their operation will appear later. The springs S^{20} and S^{21} are normally closed together, and are included in the talking circuit. The spring S^{22} and the lamp S^{26}, normally disconnected, are in a ground tap.

At the central office the line has a terminal jack J, with which the answering plug P coöperates. This plug forms the terminal of a cord-circuit, 5—6, connected through condensers, C, with the trunk circuit 7—8 of an automatic selector switch F. This selector switch is of the type shown in Figs. 12 and 12^a, and the description already given thereof makes it unnecessary to do more than point out the one difference between a selector and a connector switch. The description already given of the switch F is for a connector, that is to say, a switch containing the terminals of one hundred subscribers' lines, and adapted to have its spindle stepped up to the desired contact in the row by a definite number of impulses. In a selector switch, on the other hand, the spindle is stepped up to the desired row of contacts, (the contact banks being the same as the connector) and then is stepped around the row by a continued and automatic action of the rotary magnet, until an idle trunk is reached, when the switch stops. This continued action of the rotary magnet is produced by a pair of contacts 27—28, included in a circuit of the magnet, so as to make it a vibrator or "buzzer". At the same time, the armature 29 of the magnet 5 (Fig. 12), has a projecting stud 26, which comes into the path of the armature of the private magnet 6, when the magnet 5 is energized. The purpose of this is to maintain the armature of magnet 6 attracted, and, therefore, the side switch unmoved, during the continued vibration of the armature 29, of magnet 5, or, in other words, until an idle trunk has been reached.

In Fig. 7 the various parts are marked so that further description is unnecessary. The relays are as follows: F^{30} is called the vertical relay, and F^{31} the rotary relay, these being arbitrary designations, the former controlling successively the vertical and rotary magnets, and the latter controlling the private magnet F^6. They jointly control the circuit of the release relay F^{32}, which controls the release magnet F^7. The relay F^{30} is connected by wire 9 to the first and second contacts of the side switch arm F^{33}, while the relay F^{31} is connected by wire 10 with the first and second contacts of the side switch F^{34}. Intermediate of these relays they are both grounded through wire 15. The other circuit connections will sufficiently appear from the description of the operation hereinafter. The cord-circuit 5—6 has a pair of bridge relays R and T, and also a pair of solenoid relays I and L. The relay I is connected in parallel with the lamp R^2 from the back contact of the armature R', by wires 36 and 33 to ground; while relay L is connected from the front contact of the relay R by wires 37 and 33 to ground. Each of these relays, in its mechanical construction and mode of operation, is the same as that illustrated in Fig. 9, the only difference being in the number and arrangement of the contact springs. The relay I closes together its springs I' and I^2 when it pulls up in passing, making a momentary closure, while relay L closes the three springs L^2, L^3 and L^4, and opens the pair L'—L^2, when it is down, maintaining this condition continuously. The operation of this will also sufficiently appear hereinafter.

Referring now to Fig. 8, I show therein another selector switch, known as the second selector, which I designate at F^o, and a connector switch designated as F^x. The individual mechanical parts and the circuit connections of these switches are the same as already described for

the switch F, with the exception of the ringing portion of the connector circuits which I will now describe. When the side switch arms F^{33} and F^{34}, of the connector switch, pass onto their third contacts they connect the wires 100 and 101 to the terminal wires 110 and 120, corresponding to 11 and 12 of the first and second selectors. The ringing relay G then becomes connected through the wiper arm F^{13} to the wire 180, which runs back to a pair of contacts 181 of the private magnet F^6. When the last rotary impulse comes in through the relay F^{31} of this switch, the magnet, F^6, opens this ringing circuit and closes the test, and when the next vertical impulse comes in through relay F^{30} the circuit 180 is closed to ground at 270, and relay G becomes energized, connecting the ringing generator G′ to the wipers F^{10}. The trunk circuit through the connector is broken by the condensers C′, and in order to supply battery current to the called subscriber I provide the bridging magnets F^{40} and F^{41}, through which the main battery is connected to the conductors 100 and 101.

The foregoing is sufficient to enable the operation of an individual line to be understood.

I will now take up Figs. 7 and 11 together, and explain the operation of party-lines with selective ringing. In Fig. 7, the first selector is shown, and need not be described again. In Fig. 11 the circuits of a connector switch only are given. The first selector and connector, taken together, are sufficient for an exchange having more than one thousand subscribers, but if the exchange is to be larger, say about ten thousand, then a second selector, like F^0, in Fig. 8, must be interpolated between the first selector, (Fig. 7) and the connector, (Fig. 11). The only description necessary for understanding the party line work is that of the connector, since there is no change whatever in the second selector, if that be employed. The connector apparatus and circuits are also the same as in Fig. 8, except as to the connections and operation of the ringing relay. In Fig. 8 this is a plain relay, G, with spring contacts normally closed connecting the wires 100 and 101 to the switch arms F^{33} and F^{34}.

Fig. 11 differs from Fig. 8 in its showing of the circuits of the connector switch in one respect only, that is, instead of the ringing relay G being a simple form of relay, as shown in Fig. 8, it comprises a master relay K^9, and subsidiary selective relays K^3, K^4, K^5, K^6, K^7 and K^8. The relay K^x I shall call the controlling relay. It will be observed that it is connected in parallel with the master relay K^9 on one side to the main battery B, and on the other side to the wire 115, leading to the third contact of the side switch arm F^{13}. Thus, in the third position of that arm, when the relay F^{30} is energized, current will flow from the ground contact 270 back through the contacts 181 and the wire 180 to wire 115, and the relays K^x K^9, in parallel, and so to battery, and from battery through the ground to 270 again. The relay K^x is quick, and the master relay K^9 is very slow, being, in fact, a solenoid with a plunger core, as already described, in connection with Figs. 9 and 10. The function of the master relay, stated very briefly, is to disconnect the generator and connect the wires 100 and 110 on the one side, and 101 and 120 on the other, when it is down; to disconnect these wires when it is up or at any intermediate point, to disconnect the generator also when it is in its uppermost position, at the same time closing the battery through contacts K^{18} and K^{17} onto the armature K^0 of the relay K^x, through the wire 116, which I shall hereafter call the working wire, since it furnishes current, during selection, for the various relays, K^4, K^5, etc. In this figure there are shown four generators,—G^2, G^3, G^4 and G^5,—all connected on one side to a common return wire 117, and on the other side by individual wires 118, 121 and 122, to front contacts on the relays K^3, K^5, K^7, the generator G^3, however, being connected by wire 119 to a back contact on the relay K^3, this particular generator being therefore normally connected in circuit, with the wires 117 and 123. These two wires pass to the springs K^{21} and K^{19}, respectively, of the master relay K^9, through whose action, as already explained, they are connected to and disconnected from the wires 110 and 120, in a manner that will more fully appear from the description of the operation, which will now be taken up.

The operation of an individual line circuit is substantially the same as that of a four-party circuit, except in the final selection. I will therefore commence with Figs. 7 and 8, and then read the operation upon both Figs. 8 and 11.

We will assume that subscriber "A" is calling: He presses in the button S^{28}, whereupon the latch S^{31} engages the spring S^{22}, and is detained thereby. He then removes his receiver from the hook H, closing the circuit of the line relay M, by way of B, M, 1, S^{20}, S^{21}, transmitter and receiver, H, 2 and ground, which lights the lamp *m* by means of current flowing from the battery B through the local lamp circuit to ground. Although the lamp S^{26} at the sub-station is connected through the frame of the device and springs S^{20}, S^{21}, to ground from the line wires, it gets no current, for the reason that there is a dead ground between it and the

battery, at the back contact of the cut-off relay N. When the plug P is inserted battery is reversed, the ground battery then going on the sleeve side 6, and the ground on the tip side, B, T, 38, 6, P, J, 4, N and ground, also through 2, S^{24}, S^{26}, S^{28}, S^{22}, S^{31} and through the frame to ground, whereupon lamp S^{26} at the sub-station gets current and lights, illuminating the opaque cylinder carried by the disk S^7, in Fig. 3, and showing up the word "Number", which, when the parts of the sender are in their normal position, rests opposite the window, but is not normally visible, because it is printed on the inside of the paper cylinder. In the drawings this cylinder is shown threaded, but in practice I have found it best to make it of paper or similar material. The word "Number", thus exhibited, is the same as if the operator has said "Number" ?, to the subscriber, and he then proceeds to send in his number by manipulating the hand-wheel S^3, in the manner described, in connection with Figs. 1 to 6.

Each time the wheel is turned around until a certain number on the paper cylinder appears opposite the window S^2, the lamp blinks and flashes, so that even if the numbers are not watched carefully, the recurring flashes can be counted. As long as the subscriber's receiver is off the hook, and the plug P in the jack J, the relays T and R are energized. Breaks in the metallic circuit, due to the pins S^{70} lifting the spring S^{20}, work the armature R′ back and forth, flashing the lamp R^2, pulling up the solenoid I, over the path B, through contacts of T, wire 35, R′, 36, I, 33 to ground, as well as the solenoid L, over the path B, contacts of T, R′, 37, L, 33 to ground, keeping both of them energized effectively, as long as the armature R′ is oscillating, and sending impulses over the path B, contacts of T, 35, R′, 36—31, L′, L^2, 28 to the vertical side 7 of the trunk circuit of the first selector switch F and through its vertical relay by way of F^{33}, 9, F^{30}, 15 to ground. This works the relay F^{30}, which works the vertical magnet F^4, over the circuit B, F^4, 16, 25, 27 to ground, which steps up the switch spindle F^3 as many steps as there are breaks. The final make of the first set pulls up the armature R′, lets go the solenoid I, and a single impulse is sent over the path B, contacts of T, 35, R′, 37—32, I^2—I′, 29, to wire 8, F^{34}, 10, the rotary relay F^{31} and 15 to ground. This relay works the private magnet F^6, over the circuit B, 19, F^6, 26, 27 to ground, which advances the side switch arms one step and starts the rotary magnet F^5, over the circuit B, F^5, 17, F^{12}, 18 to ground, which steps around the spindle F^3 continuously, until the test wiper F^{10} of the wire 13 finds a contact that is not grounded or busy. Thereupon the private magnet F^6 lets go, and the side switch goes around another step, the first selector stops, and wires 7 and 11, 8 and 12, are completed, and the circuit is put through to the second selector, shown in Fig. 8, and ground is put on the test wiper F^{10} through 13, F^{32}, 22, F^{35} through its last contact to ground, thus occupying and putting a busy test on the bank terminals selected as far as other selector switches may be concerned. The operation here for the second group of breaks produced by the sender S is precisely the same as that already described, the first selection having been for the thousands, and the second selection for the hundred, leaving the tens and units to follow. In either Fig. 8 or 11 this much of the selection is the same. The third group of breaks brings impulses through wires 7, in Fig. 7, and the vertical wires of the second selectors and the connectors to the vertical relay F^{30}, which works the vertical magnet and steps up the spindle of the connector switch F^x to the desired row of tens. The next impulse from the rotary side 8 and the same side of the trunks to wire 80 and relay F^{31} works the private magnet F^6, steps ahead the side switch, cuts on the rotary magnet F^5, opens the wire 16 of the vertical magnet until F^6 releases, and the next group of impulses on the vertical side 7—70 through the relay F^{30} turns the spindle until the desired unit in the row is reached. This much of the operation is identical for both Figs. 8 and 11, and the test is also the same, which consists in the next rotary impulse coming from the side 8—80 to the relay F^{31}, which causes the magnet F^6 to pull up once more, and closes the circuit of the test or release relay F^{32}, since the side switch is on the second point. If there is a ground on the tip side of the line tested, the relay relay F^{32} will pull up and release the switch. If, however, the line is not busy, and hence there is no ground on its tip side, (this being due to the connection of a magnet F^{40}, or a cord circuit magnet R, if the line is busy), the relay does not pull up, the magnet F^6 lets go, the side switch goes the last step, and the wires 100—110, and 101—120, are connected, while at the same time the switch arm F^{13} connects the wire 180 with the ringing relay G, in Fig. 8, or the two relays K^9—K^x, in Fig. 11.

If it is the switch shown in Fig. 8 the subscriber now has control of the ringing relay G, and may, by sending a series of short breaks in indeterminate groups, cause the ringing relay G to pull up and put the generator G′ onto the called line. On the other hand, with the switch of Fig. 11, the called subscriber may go farther, and since he has selected the line wanted, he may now, by means of the selective relays, pick out the particular party wanted on the line. In

order to do so he sends a further group of one, two, three or four breaks. One break brings a single impulse to work the relay F^{30} of the connector switch, and this now works through the wire 115, causing the master relay K^9 to pull up to the limit, and then start slowly back, while the controlling relay K^x pulls up and falls back quickly. The master relay breaks apart the springs K^{26} and K^{25} of one pair, and K^{29} and K^{28} of the other, putting the generator through springs K^{27} and K^{30} to the springs K^{20}—K^{22}, but taking it off the wires 123 and 117, by lifting the springs K^{19} and K^{21} at the upper extremity of its movement. At the same time it closes battery onto the operating wire 116, and onto the locking wire 109. If battery were normally on the wire 116 the relays K^4 would get current, prematurely, and, of course, the locking wire must be broken to clear out all the relays when the solenoid K^9 is down. For one impulse the relay K^x pulls up and falls back, doing nothing on the up-stroke, but on the back-stroke energizes relay K^4, which pulls up, locks itself through the wire 109, and connects the front contact wire 108 of relay K^x to the relay K^3. If the party wanted is number one, the subscriber does nothing further, and the solenoid K^9 permits its core to sink gradually down, ringing current being fed out to line from the generator G^3, through the wires 117 and 123, and the springs K^{20}, K^{22}, and K^{30} K^{27}, through wires 110 and 120. This action continues as long as the head K^{12} of the solenoid is between the upper springs K^{19}—K^{21}, and the lower springs K^{26}—K^{25}, ceasing when it reaches the latter, and the contact spring being then restored.

If a second impulse comes from the calling subscriber quickly following the first, the relay K^3 will pull up on the up-stroke of relay K^x, locking itself on a wire 109, cut off the generator G^3, cutting on the generator G^2, and connecting the back contact of K^x through the wire 107 to the relay K^6. When armature K^6 falls back, relay K^6 will pull up, locking itself, in turn, on wire 109, and connecting K^5 to the wire 108. Thus the first generator has been cut off, the second generator cut on, and the next selection prepared by connecting the relay K^5. If no further impulse comes, current from generator G^2 will flow to line, as already described; but if another impulse comes, the relay K^5 will pull up, cutting off generator G^2, and cutting on generator G^4, and so on, as the armature K^6 moves back and forth.

It is apparent that while I have shown this set of selective relays applied thus to selective ringing, they may be similarly applied to almost any kind of a circuit or mechanism requiring selective action controlled over a single circuit or a single wire from a distance. I shall therefore claim the same broadly, considering myself to be the originator thereof.

Having thus described my invention what I claim and desire to secure by Letters Patent is:

1. In a telephone system, a substation containing a telephone having the usual substation ringer and an electric lamp, a line circuit extending from the substation, and a central station receiving the same, a connective link normally disconnected from the line circuit and a source of current supply at the central station, and means to bring the connective circuit into association with the line circuit in response to a call therefrom, and thereupon to supply current from the central station source to both the telephone and the electric lamp at the substation, whereby the subscriber is apprised of the establishment of the central station connection.

2. In a telephone system, a subscriber's station, a line circuit, a telephone including the usual substation ringer and additionally an electric illuminating device connected to the line circuit at the substation, central office connective means, normally disconnected from the line but adapted to be brought into connection therewith in response to a call therefrom, and means at the central office to simultaneously supply working current for both the substation telephone and the illuminating device when said connection has been established, whereby the subscriber is apprised of the establishment of the connection.

3. In a telephone system, a plurality of substations each containing a telephone equipment including the usual substation ringer and additionally an associated illuminating device, a plurality of line circuits extending from the substations, a central office receiving the same and containing a common source of current supply and normally disconnected connective means for the lines, and means to associate the connective means with the line circuits when calling, and to simultaneously supply current from the central office source through a calling line to the telephone and illuminating device at the substation thereof.

4. In a telephone system, a plurality of substations each containing a telephone, a sending device and an electric illuminating device for the latter, line circuits extending from the substations, a central office receiving said line circuits, a common source of current supply at the central office, means at the central office for interconnecting the lines, normally dissociated therefrom, and means to associate the connective means with any of the lines when calling, and thereby supply current over the line circuit to the telephone, the sending device, and the illuminating device, whereby the calling subscriber is enabled to work his

sender with certainty both as to the impulses transmitted and the connective apparatus to be affected thereby.

5. In a telephone system a central office having connective means, a plurality of subscribers' lines extending therefrom, a telephone set including a substation ringer and an electric light simultaneously connected therewith at each subscriber's station, a common source of current at the central office, and means whereby said source may furnish current to both telephone set and to the electric light at each substation over the telephone talking circuit, when a calling line is connected with the central office connective means, whereby the subscriber is apprised of the connection.

6. In a telephone system, a main office and a substation, a line circuit interconnecting the two, a telephone talking set and a variable impulse telegraphic signaling apparatus connected to the circuit at the substation, a normally disconnected signal receiving apparatus and a source of current at the main office, an electric light at the substation associated with the signal apparatus to illuminate the latter when operated, and adapted to work upon the signaling current, and means to bring the signal receiving apparatus into association with the line in response to a call thereover, whereby current may be supplied from said source to the substation telephonic, signaling, and illuminating devices respectively, and whereby the subscriber is apprised of the connection and may thereupon operate his signaling apparatus to actuate the signal receiving apparatus.

7. In a telephone exchange system, a central office and a plurality of subscribers' lines leading therefrom, normally disconnected signal receiving and connective apparatus with a source of current at the central office, a telephone set including a substation ringer and a signal transmitting device at a substation, an electric light associated with the signal device and adapted to be illuminated by current over the talking circuit from the central office, and means for connecting the signal receiving and connective apparatus and the source of current to the substation line in response to a call thereover, whereby the substation telephone will be supplied with actuating current and simultaneously illuminated only when a desired connection is initiated at the central office, thereby apprising the subscriber of the completion of the connection.

8. In a telephone exchange system, a central office and a plurality of subscribers' lines with automatic switching devices at the central office arranged to form successive link connections and sending devices at the subscriber's station to control the same for effecting connection between the subscribers' lines, a common source of current supply at the central office, and illuminating devices associated with the subscribers' senders, said illuminating devices deriving current from a common source over the telephone lines, when the first central station connective link is brought into connection with the calling line, whereby the subscriber is apprised of the connection with the automatic switching devices and may operate his sender to effect the desired connection.

9. In a telephone exchange system, a central office and subscribers' lines leading therefrom, normally disconnected automatic switching devices at the central office with senders at the subscribers' stations adapted to control the same, electric lights associated with and adapted to illuminate said senders when operated, a common source of current at the central office, and means to connect the central office source so as to supply current to any line in response to a call for operating the electric light, whereby the subscriber is apprised of the connection with the automatic switch and may thereupon operate the sender to effect the desired connection.

10. In a telephone exchange system, a plurality of stations and a central station, with line circuits interconnecting them, a sending device, an illuminating device therefore, and a telephone, at each substation, a plurality of electrical switches less in number than the number of lines located in the central station and normally disconnected from the lines, a central source of current, and means to associate an idle switch with a line in response to a call thereover, whereby the subscriber may have access to other switches or subscribers' lines, and to supply current over the line from the central office source to the substation sender, lamp and telephone, whereby the lamp is illuminated and the subscriber thereby apprised of his connection with an automatic switch.

11. In a telephone exchange system a central office, and a subscriber's line, a calling device and a return signal receiving device at the subscriber's station, a source of current at the central office normally connected to line with ground on one side thereof, means actuated in calling into connect the subscriber's return signal to the dry or grounded side of line and battery, and means for reversing the battery ground at the central office when the call is received, whereby the return signal at the subscriber's station may derive current over the live side of line from the source of current at central, and whereby the calling subscriber receives a positive signal of completion of connection with his line.

12. In a telephone exchange system a subscriber's calling device and means for setting the same, together with a return signal thereby connected to ground from the dry side of line, a central office battery grounded on one side and normally connected to line, means at the central office to effect connection with the line in response to a call, and means for thereupon reversing the battery connection to line, whereby the return signal at the subscriber's station will be energized, and whereby the calling subscriber is apprised of the central office connection with his line.

13. In a telephone exchange system, a central office and substation, a line circuit connecting them, means at the substation to close the line circuit to the central office, a source of current at said central office available for talking purposes, a signal energized thereby when the circuit is closed, connective means normally disconnected from the line, but adapted to be brought into connection therewith in response to a call, and an electric lamp at the substation with means to connect the same to the telephone circuit when the call is answered, so as to derive current through the line from the central office source and indicate to the calling subscriber the connection of his line with the central station connective apparatus.

14. In a telephone exchange system, automatic switching devices, metallic line circuits, devices at the subscribers' stations capable of making and breaking the metallic line circuits a definite number of times to control said switches, ringing devices at the central office associated with the automatic switching devices, and means whereby said ringing devices may be controlled by the same subscribers' controlling devices and in the same manner as the switches.

15. In a telephone exchange system, subscribers' lines and substations normally disconnected, connective links for said lines, a telephone set, a signal receiving device and an illuminating device at each substation and means for causing the operation of the illuminating device as a result of the connection of a calling line with the first connective link, whereby the subscriber is apprised of the connection with a connective link.

16. In a telephone exchange system, subscribers' lines and substations, normally disconnected connective links for said lines containing signal receiving devices, a signal sending and a signal receiving device at each station, an illuminating device associated therewith and means for causing the operation of the illuminating device as a result of the connection of a calling line with the first connective link, whereby the subscriber may operate his signal sending device to actuate the signal receiving devices of the connective links at the proper time.

17. In a telephone exchange system, subscribers' lines and substations, connective links therefor, certain of said connective links being provided with automatic switches, impulse sending apparatus at said substations for operating the automatic switches, an electric lamp associated with said impulse sending apparatus for illuminating the latter when operated, and means acting on the completion of the connection with the first connective link for causing the lighting of the lamp, whereby the subscriber may commence operation of his impulse sending apparatus at the proper time to effect connection through said automatic switches.

In testimony whereof I affix my signature in presence of two witnesses.

EDWARD E. CLEMENT.

Witnesses:

JAMES H. MARR,

E. EDMONDSTON, JR.