E. E. CLEMENT.

TELEPHONE EXCHANGE SYSTEM AND APPARATUS.

APPLICATION FILED JULY 11, 1905.

1,107,135.

Patented Aug. 11, 1914.

9 SHEETS—SHEET 1.

Fig. 1.

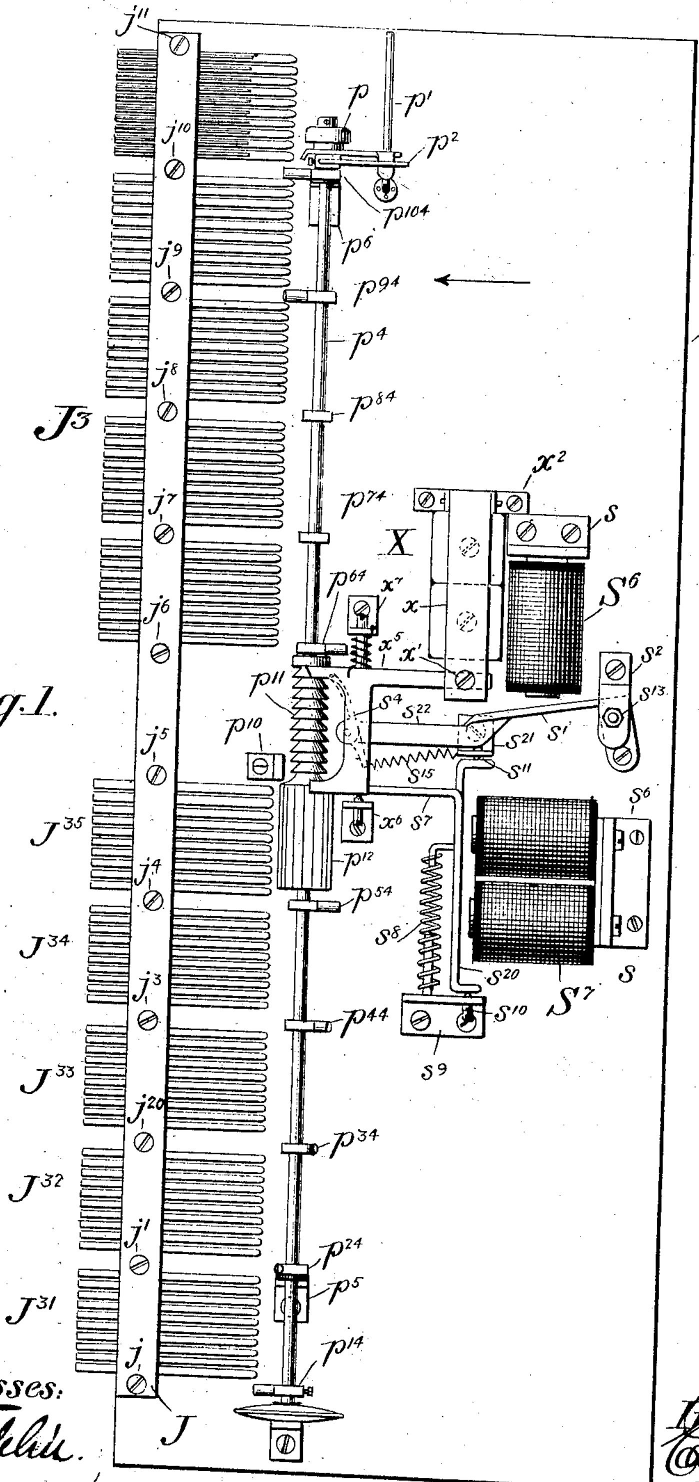

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Fig. 2.

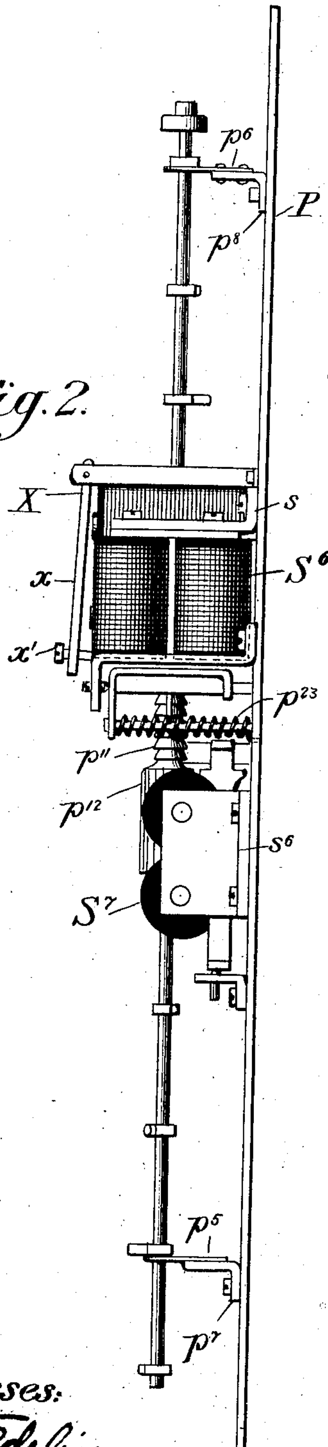

Fig. 3.

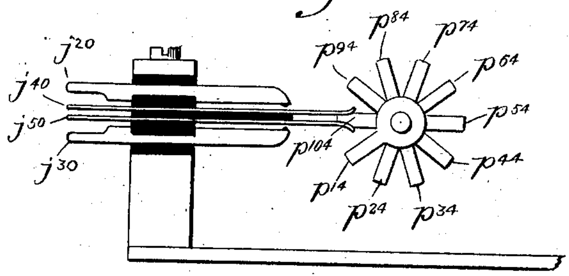

Fig. 4.

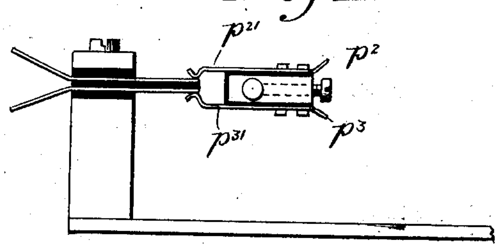

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Fig. 5.

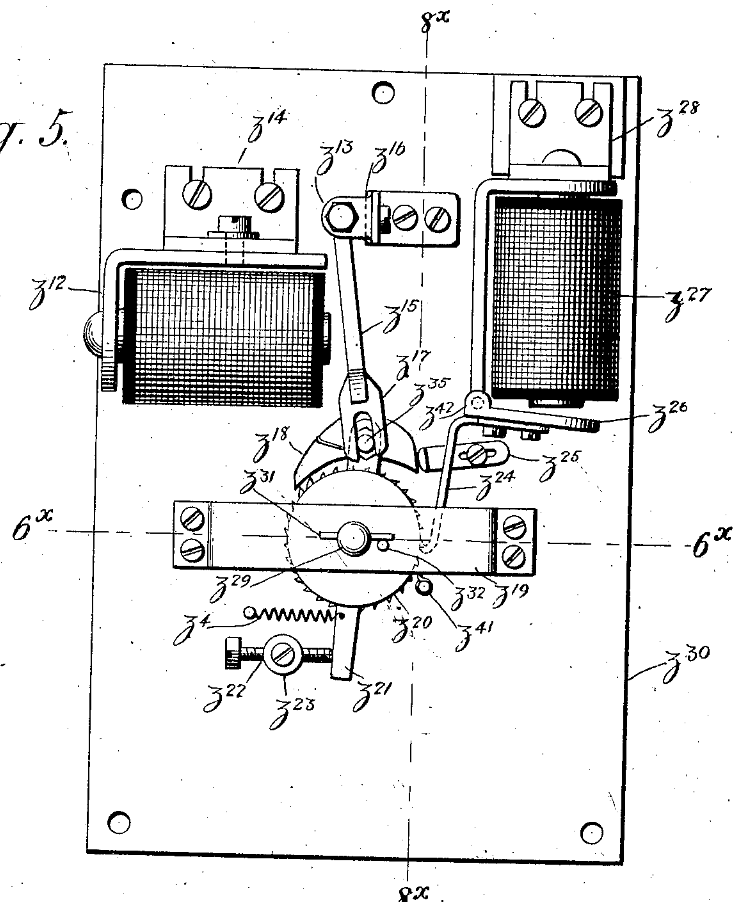
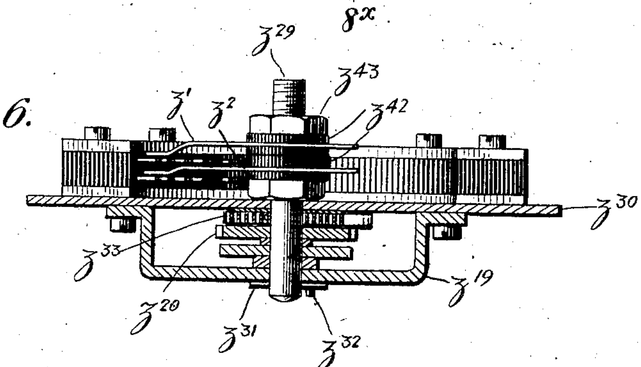


Fig. 6.



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9 SHEETS—SHEET 4.

Fig. 7.

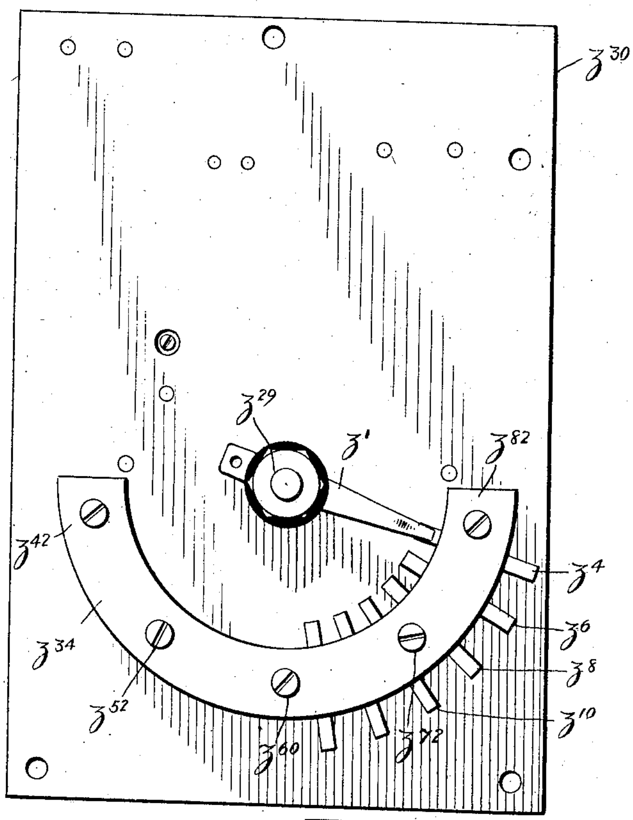


Fig. 8.

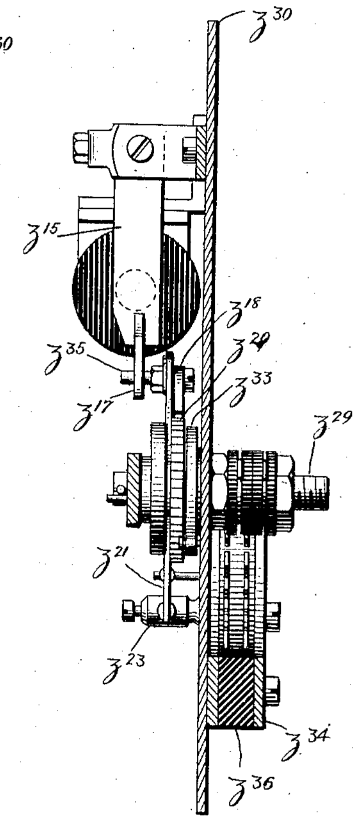
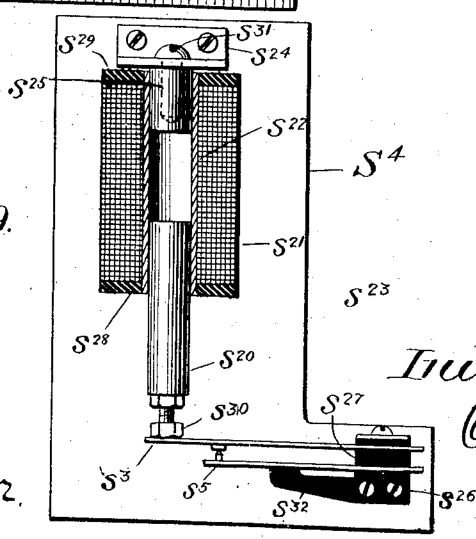


Fig. 9.



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9 SHEETS—SHEET 5.

Fig. 10.

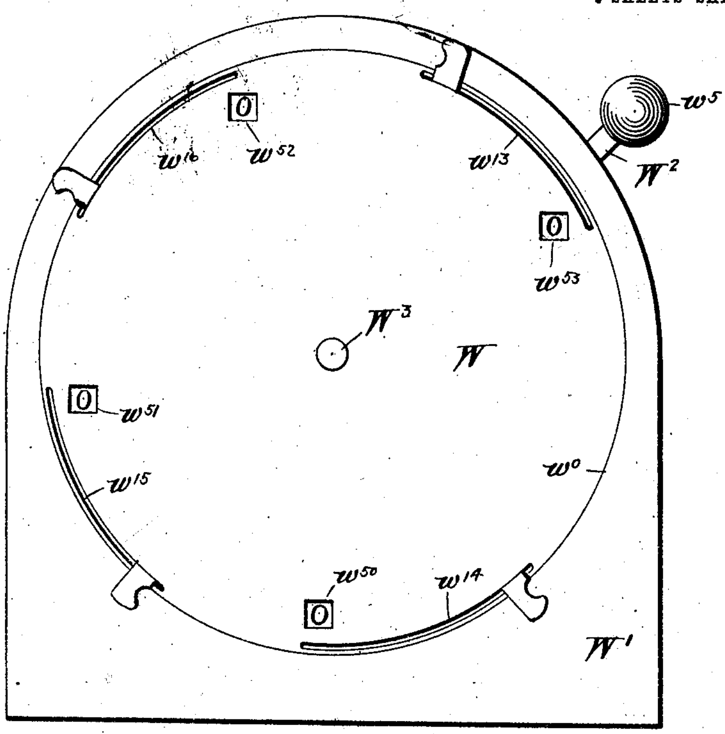

Fig. 11.

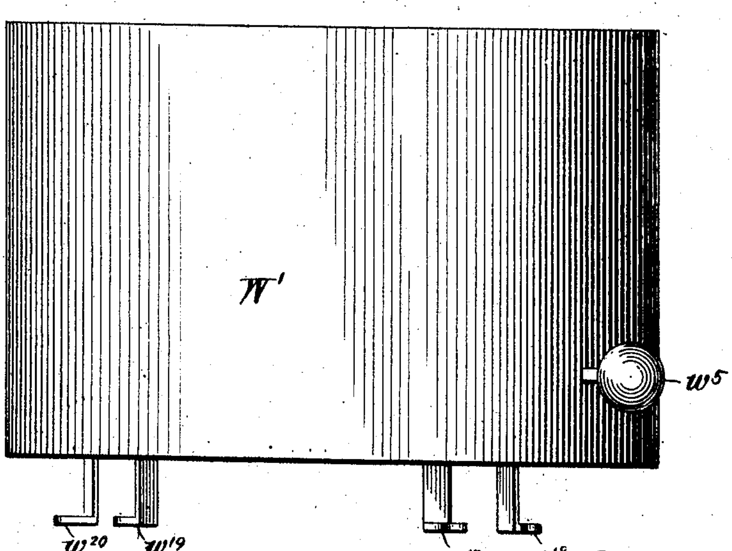

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Fig. 12.

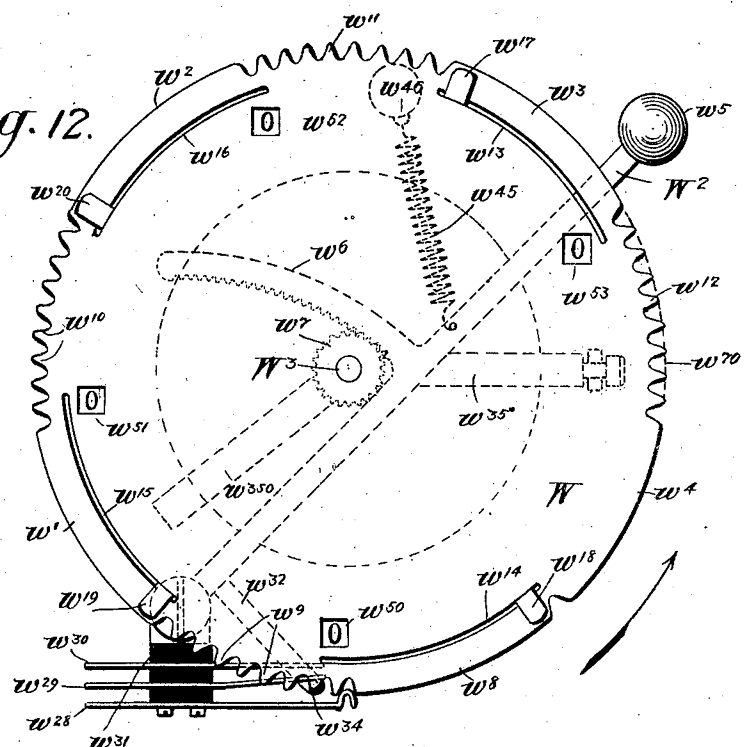
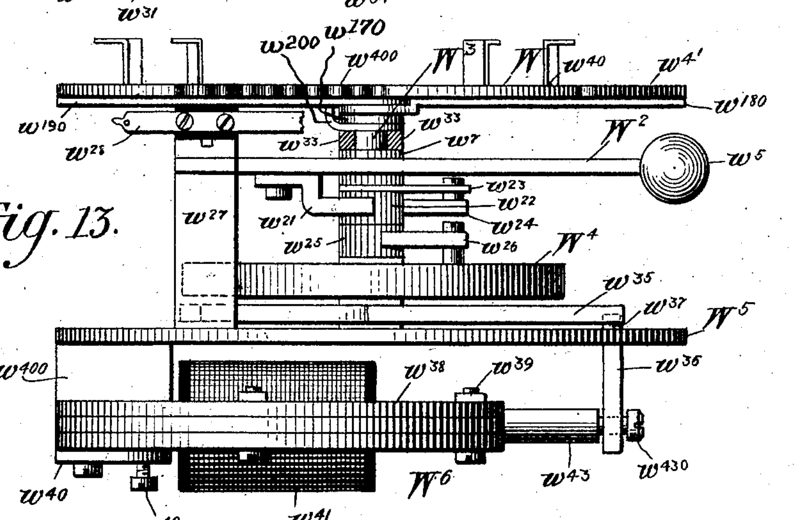


Fig. 13.



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9 SHEETS—SHEET 7.

Fig. 14.

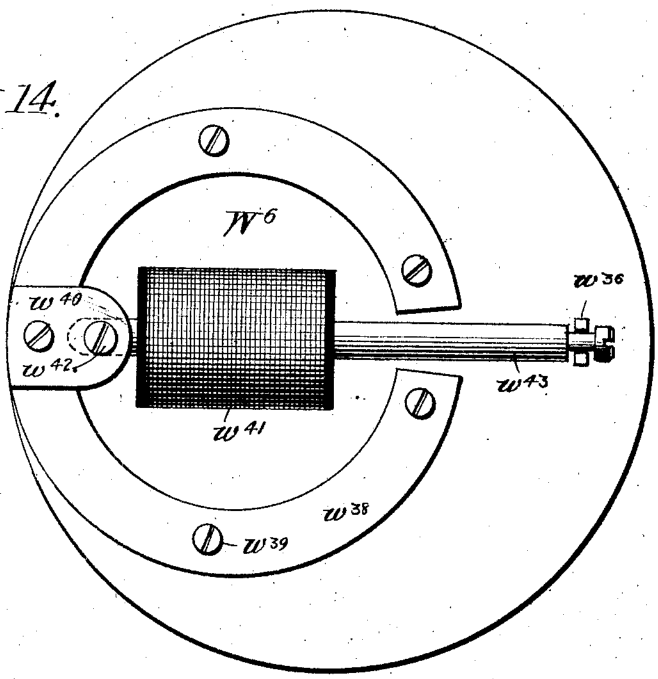
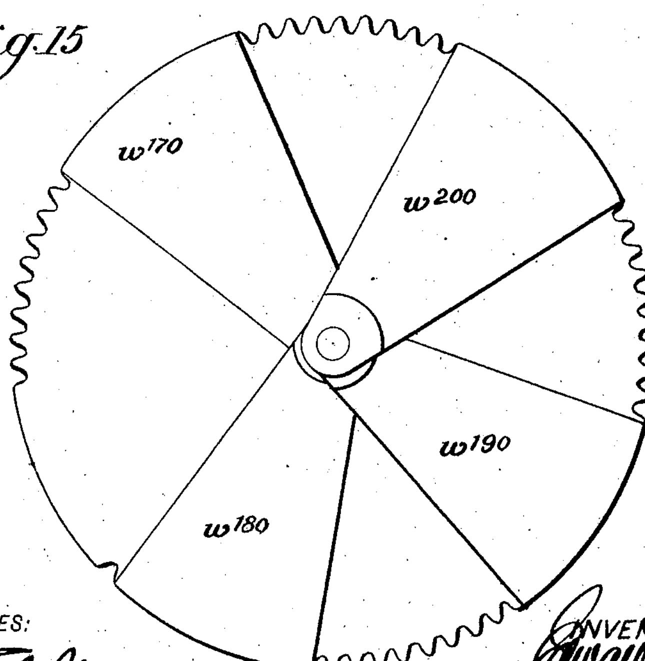


Fig. 15



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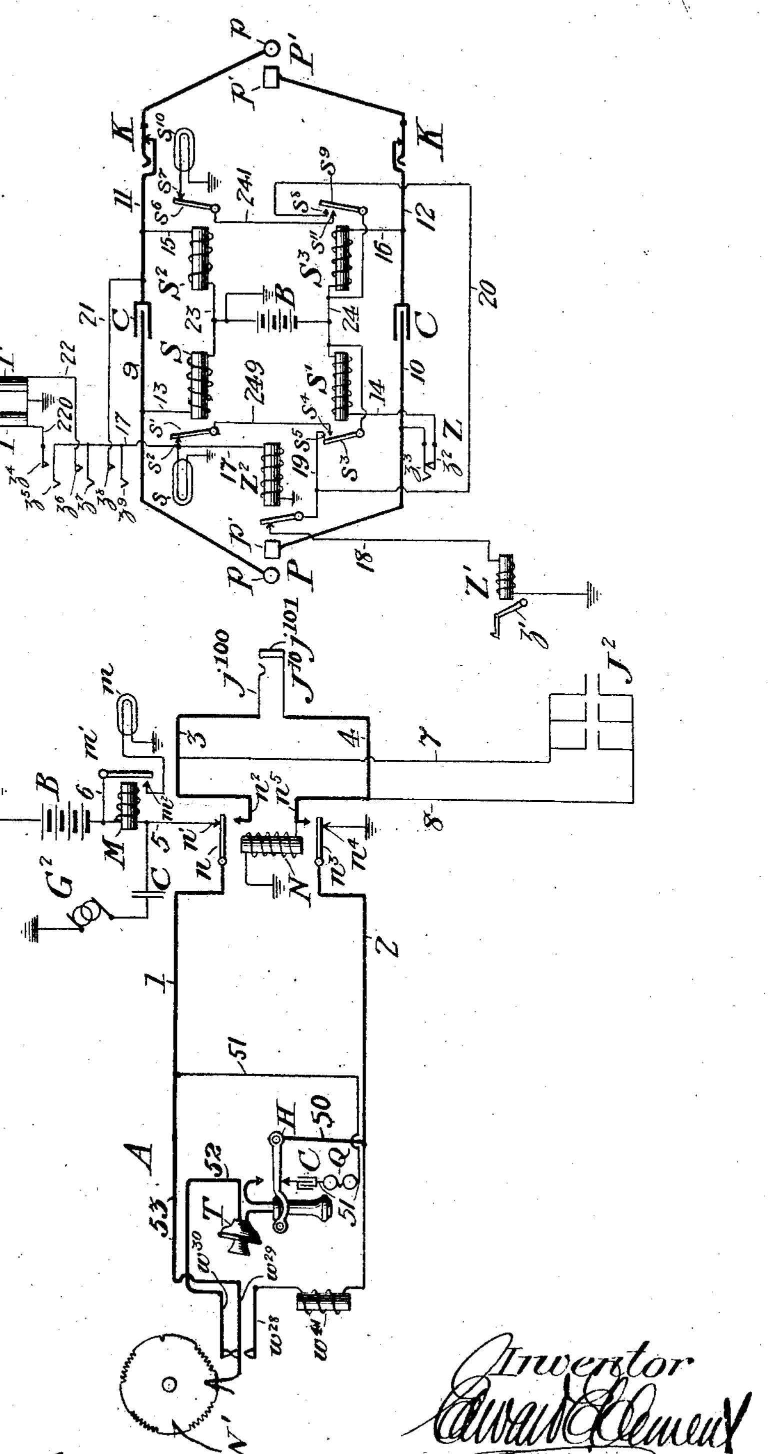
9 SHEETS—SHEET 8.

Fig. 16.



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9 SHEETS—SHEET 9.

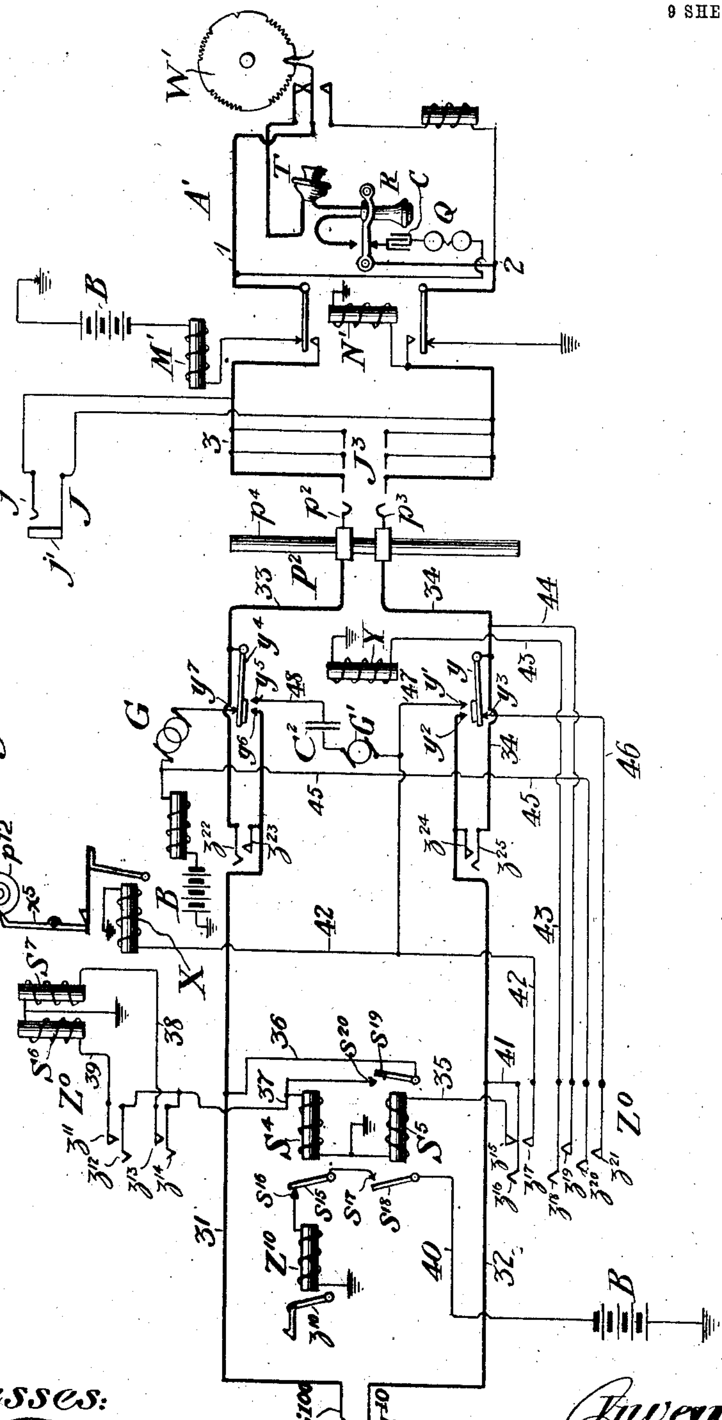

Fig. 17.

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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 AND APPARATUS.

1,107,135. Specification of Letters Patent. Patented Aug. 11, 1914.

Application filed July 11, 1905. Serial No. 269,157.

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 a certain new and useful Improvement in Telephone-Exchange Systems and Apparatus, of which the following is a specification, reference being had therein to the accompanying drawing.

My invention relates to telephone exchange systems and apparatus, and has for its object the improvement of what are known as semi-automatic circuits and apparatus. By semi-automatic, I mean those systems and that apparatus in and by means of which the subscribers are interconnected through the conjoint action of operators and automatic apparatus, the latter being controlled either by the subscribers or by the operators. It will be apparent after reading the following description that my apparatus and much of the circuit arrangement will be equally useful in full automatic or semi-automatic systems. I shall describe specifically a semi-automatic arrangement but I do not wish to limit myself thereto.

My invention herein set forth makes use of the circuit described in my prior application filed June 5, 1905, S. Number 263,784, but is not confined thereto, as will sufficiently appear from the following detailed description.

Briefly stated, the circuit scheme in the present case is for a two wire metallic circuit, with quick working magnets and very slow control magnets, preferably solenoids with movable cores. I shall call this for convenience a two-wire circuit with time element control.

The apparatus described herein comprises: 1. An automatic switch suitable for any circuit. 2. A controller or "side switch" for the same. 3. A sluggish relay by which the "time element" is made available. 4. An improved subscriber's sender, or variable signal transmitter.

The switch consists of a frame or base plate having 100 contacts in separated groups of ten, mounted on a straight strip along one edge, with a parallel spindle carrying an arm or stud for each group of ten, these arms being at different angles in a helical line around the spindle. The latter has a reciprocating motion through a space equal to the length of one group of contacts, also a rotary motion whereby one stud after another may be brought around in line with the strip of contacts. A vertical and a rotary magnet controlling the spindle, and a release magnet sending it back to zero at the end of a conversation, are mounted upon the frame.

The controller or side switch comprises a frame or base plate, a step-by-step-switch thereon, and a pair of magnets, one to step it around and the other to restore it.

The sluggish relay comprises a solenoid preferably arranged vertically, with a solid core sliding up and down within its spool, which is preferably lined with copper. When down the core rests upon the end of a contact spring, to close it upon another contact. The core is intended to pull up rapidly, but sink down slowly, and to this end I may form a check valve at the upper end of the spool, so that the core will move in a dash-pot. I find however that this is not necessary in ordinary practice, as the application of current energy brings the core up very sharply, whereas its own weight has to carry it down, and it moves comparatively slowly.

The subscriber's sender comprises a disk or wheel having five sets of teeth, four sets having ten teeth each and the last one an indeterminate number, depending upon the character of the system in which it is to be used. Each set of teeth has a segment underlying it, all pivoted on the same center, each segment movable by hand to cover one or more of the teeth, one tooth in each set being preferably exposed normally. An opening in the disk over each segment exposes a number which changes as the segment is moved, to indicate the number of teeth exposed or covered as the case may be. When set, the entire disk may be revolved by pulling a handle which winds a spring train that is then detained by a trigger until a magnet lying beneath the movement is energized from central to pull the trigger.

My invention is illustrated in the accompanying drawings, wherein the same reference letters and figures point out the same parts throughout.

In the drawings, Figure 1 is a side view of my switch. Fig. 2 is an edge view thereof, looking in the direction of the arrow in Fig. 1. Figs. 3 and 4 are detail figures showing two different types of contact studs and wipers for the switch. Fig. 5 is a face view of the controller or side switch. Fig. 6

is a section thereof on the line 6^x of Fig. 5. Fig. 7 is a back view of the switch. Fig. 8 is a vertical section thereof on the line 8^x of Fig. 5. Fig. 9 is a side view of the sluggish relay, with the spool and winding in section. Fig. 10 is a face view of my subscriber's sender, and Fig. 11 a top view of the same inclosed in its case. Fig. 12 is a face view of the mechanism with the case removed, and Fig. 13 is a side view of what is shown in Fig. 12, the contact springs being broken away to show the manner of pivoting the segments. Fig. 14 is a bottom view of the sender, showing the polarized release magnet. Fig. 15 is a rear view of the dial or disk of the sender, removed. Fig. 16 is a diagram of a subscriber's line, with sub-station and central station terminal apparatus and an operator's cord-circuit. Fig. 17 is a similar diagram of a switch trunk and automatic switch, with coöperating parts.

Referring first to Fig. 16, A is a subscriber's station equipped with the usual transmitter T, receiver R, switch-hook H, condenser C and ringer Q. This station is connected to the central office where line-wires 1—2 terminate in relay contacts n, n^3, of the cut-off relay N. These contacts are normally in engagement with other contacts n', n^4, the first connected by wire 5 through relay M to the main battery B, and the second to ground. The contacts, n, n^3, are taken away from their normal resting contacts when the relay N is excited, and brought into engagement with other contacts n^2, n^5, connected to the line jack J, in the spring and sleeve sides of the same, through the wires 3—4, and also through wires 7—8 to the multiple-contacts J^2, which are disposed in automatic switches.

The cord-circuit shown terminates in an answering-plug P and a calling-plug P′, each with tip and sleeve contacts p, p', connected through cord-conductors 9—11, 10—12, broken by condensers C, C. The main battery B is bridged across each end of the cord through a pair of relays. On the answering end the control relay S′ is between the battery and the sleeve side, and the supervisory relay S between the battery and the tip side, the former being a front contact relay and the latter a back contact relay. These two relays jointly control the local circuit of the supervisory lamp s. On the calling end of the cord the arrangement is the same, the control relay S^3 and the supervisory relay S^2 jointly governing the circuit of the supervisory lamp s^{10}. In the calling end of the cord is also included the ringing key K, which may be provided with listening contacts, if desired, but in the present system is not so shown.

So far, the circuits and apparatus are all of a well-known type of two-wire multiple, and as I describe my additions thereto it will appear that this much, which is the essential and distinguishing part of the manual system, remains unchanged. I add to but do not alter the cord or line-circuit. In a multiple-switchboard the wires 3—4 are connected to the multiple-jacks through the branches 7—8; and here the first difference occurs, for I discard the multiple-jacks, and substitute the terminals J^2 in the banks of the switches.

At the subscriber's station it is necessary to provide some means for sending impulses in predetermined order. These all go over the No. 1 side of line, hence it is possible to make and break the circuit manually, or to use an automatic sender such as that shown in Figs. 10 to 15. It is entirely possible to use the ordinary switch-hook without any change whatever. This is manipulated to send successive short breaks in groups, leaving the line closed for an appreciable time between the groups, the number of breaks in each group corresponding to a digit of the number wanted. Thus in sending the number 4436, the subscriber would remove his receiver from the hook, and listen. In Fig. 16, I have shown the special variable tone generator G^2, connected through a condenser C to the wire 5, so that as long as the line is connected to the line-relay M a characteristic sound will be produced in the subscriber's receiver. Even without this, however, the subscriber can tell when the plug is inserted, because (if the circuits are traced it will be found) the battery is reversely connected to line when the plug P is inserted. Having waited until he hears the plug inserted, knowing this either by the cessation of sound from generator G^2, or by hearing the loud click due to the battery reversal, the subscriber taps his hook sharply and rapidly four times, then after a short interval during which it remains up he taps it four times more. As soon as he has done this he will hear the battery cut off by the opening of contacts z^2, z^3, in the side switch, and he will then wait until battery comes on again, if the generator G^2 is employed the tone signal becoming audible in the meantime, inasmuch as the cut off-relay N has lost its current. When the plug P′ is inserted in the trunk jack J^{10} the relay S^3 pulls up, the side switch Z moves forward a step, and the contacts z^2, z^3 are again closed, whereby magnet N again takes current, relay M and the generator G^2 or reversed battery B are cut off, and the subscriber knows he can go ahead. He then taps the hook three times, and after an interval six times. The description of this operation sounds somewhat involved, but really it is simple in the extreme. The subscriber has only to remember that when he hears the musical note of generator G^2 he must wait until it ceases before he can signal. It almost goes without saying that a phonograph might be substituted for generator G^2, giving oral instructions.

My sender is illustrated in Figs. 10 to 15, inclusive. The function of this sender is to transmit makes and breaks, or more properly speaking to send over the metallic circuit long and short current impulses in predetermined order. The sender herewith presented is a device having five groups of teeth, four of which are adapted to be varied as to number from two to ten by covering segments, the fifth being invariable and consisting of one or more teeth or notches, which control the testing, the ringing, etc. The four segments are set by hand to uncover the desired teeth or notches, and then a train is wound up which turns the whole disk, bringing the successive teeth successively into position to engage the line-contact springs.

Fig. 10 is a face view of the device in its case. The central spindle W^3 carries a dial W, around which the edges w° of the case are rounded so as to conceal the edges of the disk and the teeth thereon. In this dial are cut four slots w^{13}, w^{14}, w^{15}, w^{16}. In the first named works the handle w^{17}, in the second the handle w^{18}, in the third the handle w^{19}, and in the fourth the handle w^{20}. These handles protrude from the face of the instrument a sufficient distance to enable them to be grasped conveniently, as best shown in Fig. 11. In Figs. 12 and 13 I have shown the mechanism without the case, and in Fig. 13, particularly, there appear below the disk W the four segments w^{170}, w^{180}, w^{190} and w^{200}. These are all pivoted on the central spindle W^3 and have the same radius as the disk, the result being that when a handle, as for instance w^{17}, is moved over to the extremity of its slot w^{13}, all the teeth, w^{12}, in its set except one are covered up as indicated in the dotted line in Fig. 12. In order to be able to set these segments accurately, I provide four openings in the face of the disk W, as shown at w^{50}, w^{51}, w^{52}, w^{53}. On each segment I mark in a curved line concentric with its edge the numerals from 0 to 9. If a segment is left with its numeral 0 showing, only one tooth of its set will be uncovered; if the number 1 is showing, then two teeth will be uncovered, and so on. The reason I add this is that in order to make the successive selections in an automatic exchange system it is necessary to send four sets of impulses, each of which may consist of any number from 1 up. Obviously, therefore, it is necessary to regard the 0 as the one impulse figure, otherwise no number containing a naught could be transmitted. By moving the handles and thereby the segments on the disk W, they may be set so that any combination of teeth appear uncovered.

Referring particularly to Figs. 12 and 13, the central spindle W^3 below the disk W passes through a bridge w^{33}, which extends from side to side of the device and has its ends secured to the back plate W^5. The spindle is journaled in this bridge and in the back plate, and has fixed rigidly upon it the two oppositely cut ratchet wheels w^{22} and w^{25}. It also carries loosely upon it the companion gear w^7 and the heavy fly-wheel W^4. Below the fly-wheel is fixed the angle arm w^{35}, by which the rotation of the spindle and the disk W is stopped. Attached rigidly to the companion w^7 is an arm w^{23}, carrying a pawl w^{24} taking into the ratchet w^{22}. Uprising from the fly-wheel W^4 is a post upon which is carried a pawl w^{26}, which engages the ratchet w^{25}. To one side of the movement thus described is a post w^{27} carrying at its upper end the contact springs w^{28}, w^{29}, and w^{30}, separated and secured by the insulation w^{31}. Pivoted upon the post below the springs is a winding arm W^2, carrying a handle w^5 and a stop-pawl w^{21}, the latter, however, not being essential, but provided to take into the latch w^{22} when the arm is up or idle, so as to positively prevent any back movement of the disk. This arm W^2 carries a toothed segment or arc w^6, engaging the pinion w^7 and adapted to turn the same when the arm is moved. The arm is pulled down by hand, and is moved back to the position shown in Fig. 12 by a suitable spring w^{45} attached to a post w^{46} indicated in dotted lines. As the arm is pulled down the pinion w^7 is turned, the arm w^{23} and pawl w^{24} turn with it and the latter moves back over the teeth of ratchet w^{22}, which it finally engages with a tendency to turn as the spring exerts an upward tension on the arm. This turning is prevented, however, by the stop-arm w^{35} which normally engages the detent w^{37} on the end of the horizontal arm of the bell-crank or trigger w^{36}, which is pivoted at its angle in a slot in the plate W^5, and is controlled by the armature w^{43} of the polarized controlling magnet W^6. This magnet is supported on the back plate as indicated at w^{400}, and carries a yoke w^{40}, in which the armature w^{43} is pivoted by means of screws w^{42}. This soft iron armature lever w^{43} carries the magnet winding w^{41}, the field being a laminated permanent magnet w^{38}, whose component parts are secured together in any desired manner, as by bolts w^{39}. The advantage of having the winding carried on an armature is that the permanent magnetism is never reversed but is always strengthened. After the box is wound up, when the magnet is energized by current of proper polarity, the armature lever w^{43} is thrown over to trip the trigger and release the spindle. It will be observed that no retracting spring is required for this trigger, by reason of the fact that it is moved positively in both directions by the armature. The lower end of the trigger is slotted to take a pin or screw w^{430} tapped into the end of the armature. The train being thus released, the spring w^{45} draws up the arm W^2, and with it the companion w^7, the pawl w^{24} and ratchet w^{22}, the twin ratchet w^{25}, which is fast to w^{22}, the pawl w^{26} and finally the heavy wheel W^4. This balance wheel prevents the too rapid movement of the train, which as it turns the spindle, turns also the disk W. The turning of this disk, which is in the direction of the arrow in Fig. 12, makes and breaks contact between the springs w^{28}, w^{29}, as the groups of teeth pass them. It should be stated that when the arm W^2 is first moved down, supplementary arm w^{32} moves down with it, carrying a pin w^{34} away from the spring w^{29}, permitting the latter to leave the spring w^{30} with which it is normally in contact and come into position to be engaged by the spring w^{28}. When the arm W^2 again reaches its uppermost position, the pin w^{34} returns the spring w^{29} to the position shown in Fig. 12. Owing to the double arm w^{35}, the train is only permitted to run a little more than one-third of an entire revolution, when owing to a reversal of current in the line after the second group of teeth has passed the springs, the trigger w^{37} again engages the arm at the end w^{350}, whereupon the spindle W^3 is instantly stopped, but the wheel W^4 turns idly on, its pawl w^{26} riding over the ratchet teeth w^{25}. Upon a second reversal of current in the line the trigger is again pulled and the arm is again released, when the disk W and the spindle are turned through the balance of their entire revolution, until the parts again resume the positions shown in Figs. 12 and 13.

Associated with the cord-circuit is an indicator shown as comprising two step-by-step disks, each adapted to be set around by a magnet I or I′, a retaining pawl being provided for each disk, and a restoring device, I^3. The indicator magnets, I, I′ are each grounded on one side, and are connected back through wires 22 and 220 to the contacts z^4 and z^6 of the control or pilot switch, Z. This indicator may be of any well known or desired form. This shifting or pilot switch Z consists of a spindle with a ratchet wheel and a magnet to turn the same, the latter being shown at Z′, and the movement as shown in Figs. 5 to 8, which will now be described. Referring first to Fig. 5, it will be seen that the stepping and release magnets and the working parts of the side switch are mounted on a base plate z^{30}. The stepping magnet z^{12} is fastened to the plate z^{30} by means of the angle support z^{14}. This magnet when energized attracts the armature z^{15}, one end of which is pivoted at z^{13}. The other end terminates in the fork z^{17}, which engages the pin z^{35}. The manner in which this fork engages the pin is well shown in Fig. 8. The pin z^{35} is fastened to the arm z^{21} which rides freely on the shaft z^{29} and carries the pawl z^{18}, which engages the ratchet wheel z^{20} when the magnet z^{12} is energized. In Fig. 5, the apparatus is shown in its normal position, and it will be noticed that one end of the pawl when in this position rests against the stop z^{25}, which throws it out of engagement with the teeth of the ratchet wheel. This is to allow the ratchet wheel to resume its normal position when the release magnet is energized. The ratchet wheel is fastened firmly to the shaft z^{29}, as are also the wipers z', z^2, shown in Figs. 7 and 6. This shaft extends through the plate and is supported by the bridge z^{19}, and the plate itself. In this form of construction I am enabled to mount the magnets and operating parts on one side of the plate, while the other side is used exclusively for the wipers and their banks of contacts. These wipers are insulated from one another by the bushings z^{42}, and are held on the shaft by the nut, z^{43}. The contacts z^4, z^6, z^8, etc., Fig. 7, are separated from one another by the insulation z^{36}, as shown in Fig. 8, and are held in place by the screws z^{42}, z^{52}, etc., passing through the brass clamping piece z^{34} and threaded into the base plate, z^{30}. These contacts are shown in Fig. 16 in pairs, supposed to be opened and closed successively as the arms or cam drum are turned. At the first step the pair z^4, z^5 is closed, to cut in the thousands indicator magnet, I; at the next step this pair is opened and the next pair, z^6, z^7 is closed to cut in the hundreds indicator magnet, I′; at the next step this pair is broken, and the next pair, z^8, z^9 is closed to connect the battery wire 240 by way of wires 17 and 21 to the conductor 11 and so through the tip of the plug to the tip side of the switch trunk, so as to repeat the impulses that follow, around the condenser C, into the trunk circuit; this same step opens the battery circuit through wire 14 by opening the contact pair z^2, z^3, which is normally closed. There is then another step by which the pair z^2, z^3 are again closed and the pair z^8, z^9 left closed. The final step or restoration then cuts off the wire 21, leaving the pair z^2, z^3, closed and all the other pairs open, so as to have a clean cord-circuit. The wipers are restored to their normal position by the watch-spring z^{33}, shown in Figs. 6 and 8, one end of the spring being fastened to the shaft, while the other end is fastened to the plate z^{30} by the pin z^{41}. The release magnet z^{27} is fastened to the plate z^{30} by the angle support z^{28}. This magnet has the armature z^{26} pivoted at z^{42}. To this armature there is fastened an arm z^{24}, which normally engages the teeth of the ratchet wheel, z^{20}, and when deënergized the magnet attracts the armature z^{26} and the arm z^{24} releases the wheel z^{20}, which allows the shaft carrying the wipers to return to its normal position. The movement of the pawl z^{18} controlled by the armature z^{15}, is regulated by the set-screw z^{22}, which is mounted to the plate z^{30} by the post z^{23}. This screw engages the lower end of the arm z^{21} which carries the pawl, and by adjusting this screw the movement of the pawl as well as the movement of the wipers is readily adjusted. Through the end of the shaft z^{29}, projecting above the bridge z^{19} a pin z^{31} is driven, which engages a similar pin z^{32} projecting from the bridge itself. These pins on coming into engagement serve as a stop for the ratchet and wipers when released by the magnet z^{37}, always causing them to come to rest in their normal or starting position. The operation of this switch is as follows: When the stepping magnet z^{12} becomes energized, the armature z^{15} is attracted and causes the pawl z^{18} to engage the ratchet wheel z^{20}, causing it to move the space of one tooth. The wipers z', z^2 being attached firmly to the shaft, but separated from one another by the insulating material z^{42} are caused to make a movement corresponding to the movement of the ratchet. The contacts z^4, z^6, z^8, etc., are spaced corresponding to the movement of one tooth. When the stepping magnet z^{12} is energized the first time the wipers z' and z^2 engage the first pair of contacts, and when energized the second time engage the second pair of contacts and so on. After the stepping magnet has operated, the pawl z^{18} by means of the tension spring z^4 is forced against the stop z^{25} and disengages itself from the ratchet wheel z^{20}. This wheel is kept from going back to its normal position by the arm z^{24} of the release magnet z^{27}, which engages the teeth while the stepping magnet is operated. When the release magnet z^{27} is energized, the armature z^{26} is attracted and the arm z^{24} releases the wheel z^{20}, the shaft z^{29} carrying the wipers starts back to its normal position under the tension of the spring z^{33}. When the pins z^{31} and z^{32} come into contact the shaft is brought to rest and the wipers are now in their normal or starting position.

In Fig. 9 I have shown a sectional plan of the solenoid which controls the foregoing pilot or side switch. The solenoid consists of the winding s^{21} wound on the copper sleeve s^{22} having insulated ends s^{28}, s^{29}. A soft iron core s^{20} moves freely in this sleeve, and in its normal position the lower end having the insulating block s^{30} rests on the contact spring s^3, causing it to make connection with the spring s^5. The solenoid is fastened to a base plate s^{23} by the angle support s^{24}, this angle support being fastened to the solenoid by means of a screw s^{31} threaded into the soft iron pole piece s^{25}. This pole piece becomes magnetized when the circuit of the winding s^{21} is closed and serves to reinforce the pull on the sliding core s^{20}. The contact springs s^3 and s^5 are mounted on a support s^{26} and separated from one another by the insulating material s^{27}. The frame of this support has a projection s^{32} which serves as a stop or rest for the contact springs s^3 and s^5, when the core s^{20} of the solenoid is in its normal position.

Referring now to Fig. 17, J^{10} is one of a group of trunk jacks located in front of each operator, each trunk line, 31 and 32, preferably appearing on a jack J^{10} in multiple at every section of the switch-board. The trunk comprises two wires 31 and 32, the former normally open everywhere, the latter connected only through the relay S^5 to ground. When a plug is insertea in a trunk jack the magnet S^5 gets current through the sleeve side of cord and magnet S^3, and pulling up closes the tip side 31 of the trunk to relay S^4 and ground. Impulses coming over the tip side thereafter affect this relay, which corresponds to the supervisory relay S of the cord-circuit. Each trunk is provided with a side or pilot switch by manipulation of which the different pieces of apparatus are successively brought into proper relation with the relay S^4 and other parts of the circuits and apparatus, as will be fully explained in a moment. This switch is here designated for convenience Z°, and is in every respect similar to the switch Z in the cord-circuit. Each of these switches has an operating magnet for stepping its arm around a step at a time, this marked Z' in the cord-circuit, Fig. 16, and Z^{10} in the trunk circuit, Fig. 17. Each switch is controlled by a solenoid or other slow relay S^4, which is quick to be energized and pull up its armature or core, but very slow to fall back and close the circuit of the stepping magnet. This solenoid or slow magnet is marked Z^2 in Fig. 1, and S^4 in Fig. 17. Each switch has a spindle and an arm or arms and contacts, as already set forth.

The trunk line 31—32 has for its terminal a selective switch P^2, through which the connection initiated by the operator with plugs P and P' may be completed. This switch is of the type designed by myself and shown in Figs. 1 to 4. Fig. 1 shows a face view of the switch containing the straight row of contacts, the spindle carrying the wipers or studs, the rotary, vertical and release magnets with their necessary operating parts. Fig. 2 is a side view of the switch showing the magnets and their operating parts, the row of contacts being omitted for clearness. Fig. 3 shows a form of contacts used where the studs in place of the ordinary wipers are mounted on the spindle. The contacts in this figure are arranged so platinum points can be used. Fig. 4 shows a form of contacts used where the ordinary wipers are mounted on the spindle. Referring now to Fig. 1, a base plate P is shown, on which are mounted the contacts and mechanism. The contacts used in this figure are of the type shown in Fig. 3. They are mounted in a straight row divided into ten groups, there being ten groups to each switch. The spacing between the various groups, J^{31}, J^{32}, J^{33}, etc., is made to allow the studs p^{14}, p^{24}, p^{34}, etc., to turn and each come opposite its own group. These contacts are mounted as shown in Fig. 3. j^{20}, j^{30}, represent a pair of line-contacts there being a pair of these contacts for every line connected to the switch. In this case there would be a hundred pairs of these contacts. j^{40} and j^{50} are busses common to all the contacts of the switch, so that when these busses are spread by one of the studs on the spindle they will come into contact with any pair of line contacts picked out. The busses in this switch are made of a continuous piece of metal preferably German silver made in the form of combs, each having a hundred teeth, one tooth opposite each line-contact. The line-contacts and the busses are separated from one another by insulating material as shown in Fig. 3. The whole strip thus made is fastened rigidly to the plate by means of the screws j, j', j^2, etc., passing through the heavy brass strip J. These screws enter the spacings between the various groups and thereby avoid short-circuiting any of the contacts. The spindle p^4, preferably made of steel, is mounted on the plate P by means of the supports p^5 and p^6. Fig. 2 shows the form of these supports, p^6 being a steel bearing-piece mounted on the brass angle support p^8 for rigidity. The spindle moves freely through the openings in the steel bearings p^6, p^5. The studs p^{14}, p^{24}, etc., are mounted on the spindle by means of a locking device, such as a set-screw; each stud is nothing more than a pin with an insulating sleeve. Commencing with one end these arms or studs are set so that each will correspond to one of the groups of contacts and will lie opposite the spacing at the beginning of that group. They are arranged helically, that is the arms are set around by successive steps so that only one of them can ever be brought into line with the strip of contacts to engage the same at any one time. p^{12} is a broad face pinion with ten teeth, which is engaged by the pawl of the rotary magnet to cause the spindle to rotate. p^{11} is a circular ratchet or a ratchet with circular teeth, which upon being engaged by the pawl of the vertical magnet causes the spindle to step up in a vertical position. A fixed detent p^{10} is secured to the frame, which as soon as the spindle steps up in a vertical position engages whichever tooth of the pinion, p^{12}, is in line, so that after the spindle starts up it cannot turn until it is slid back to its normal or starting position. At the upper end of the spindle a coil spring is provided housed in a cap, p, having one end connected to the spindle and its other end connected to an arm, p^2, which slides on the post, p', which is fastened to the plate P. The pair of rotary magnets S^7 are fastened to the frame by the angle support s^6, their armature s^{20} being pivoted at the points s^{10} and s^{11} on the supports s^9, s^{21}, which are screwed to the base-plate. This armature has a projecting arm s^7 carrying a pawl, which engages the teeth of the pinion p^{12}. The tension spring s^8 with one end fastened to the armature and the other end fastened to the support s^9 tends to keep the armature away from the pole-pieces of the magnets S^7. The pair of vertical magnets S^6, better shown in Fig. 2, are fastened to the plate by the angle support s, their armature s' is pivoted at s^{13} to the support s^2, which is fastened to the base-plate P. The armature s' is bent so as to form the arm s^{22}, which carries the pawl s^4, which engages the circular ratchet p^{11}. The tension spring p^{23}, Fig. 2, one end of which is fastened to the armature s', the other end being fastened to the base-plate P, tends to keep the armature away from the pole pieces of the vertical magnet. The pair of release magnets X are fastened directly to the base-plate by means of screws passing through the plate and entering the cores of the magnets themselves. The armature x is pivoted to the support x^2 which is fastened to the base-plate. A screw x' passes through one end of the armature x and rests upon the detent piece x^5, which normally engages both the pinion, p^{12}, and the circular ratchet, p^{11}. This detent piece is pivoted to the angular supports, x^6 and x^7, which are fastened to the base-plate. When the release magnets are energized the armature x is attracted and the screw x' pushes on the detent piece x^5 which then disengages the ratchet and the pinion and allows the spindle to resume its normal position. The operation of this switch is as follows: The first impulses coming in actuate the rotary magnet S^7, which upon attracting its armature according to the number of impulses, actuates the pawl which engages the pinion p^{12} and moves it accordingly. Suppose the first number of impulses had been three, then the third stud p^{34} would come opposite its group J^{33} in the spacing and in line with the busses j^{40} and j^{50}, as shown in Fig. 3. The next set of impulses coming in would affect the vertical magnet S^6, which attracting its armature according to the number of impulses sent in makes the pawl s^4 engage the ratchet p^{11} and step up the spindle correspondingly. Suppose the second number of impulses had been six, then the spindle would have stepped up six spaces and the stud p^{34} would push a pair of teeth of the combs j^{40}, j^{50} against the sixth pair of contacts of the group J^{33}, thereby connecting the busses to pair 36 in the bank of contacts. It will be noticed by referring to Fig. 3 that only one stud can enter the contacts at any one time. If the type of wipers shown in Fig. 4 had been used, in which the arms or studs are provided with conducting wipers, the wipers themselves would have come into contact with the springs leading to the desired line, but by using the type shown in Fig. 3 I am enabled to use platinum contacts which in itself is a desirable feature. The method of operations, no matter which type were used would be the same. At the end of the conversation when the release magnet is operated, the armature x is attracted and the screw x' presses down the detent piece x^5, releasing both the pinion and the ratchet. The spindle drops by its own weight and then turns under tension of the spring in the case p. The spindle is kept from turning when first released by means of the detent p^{10}, which enters one of the long teeth on the pinion p^{12}, and prevents it making a rotary movement until it has reached its resting position and the detent p^{10} is disengaged.

Referring now again to Fig. 17, I have shown the terminal contacts of the switch at p^2, p^3, and have indicated the spindle at p^4. The multiple line-contacts are shown at J^3, and this illustration, taken with the foregoing description will enable any one skilled in the art to practice my present invention. The trunk wires 31 and 32 pass to contacts y^2 and y^6, being also connected to contacts z^{23}, z^{24}. These contacts are normally open, the former pair being controlled by the test relay Y and the latter by the pilot switch Z°. The wipers p^2, p^3, are connected back by wires 33 and 34 to the contacts y, y^4 of the test relay, normally touching the generator contacts y^3, y^7; and wires 33 and 34 are also connected to the contacts z^{22} and z^{25} of the pilot switch. At a point between the generator G and the sleeve side of wiper p^3, the wire 45 is connected through a choke coil to the main battery B, this being for the purpose of holding up the cut-off relay N′ while ringing. A busy-back generator G′ preferably working through a condenser, C^2, is connected across the contacts y' y^5 of the test relay, these contacts being crossed together with the contacts y^2 and y^6 when the relay Y is energized, but insulated from the contacts y and y^4. X is the release magnet for the switch, and is connected from ground by wire 42 to the contact z^{17} of the pilot switch. The generator circuit 45—46 also passes through a pair of contacts z^{20}, z^{21}, and the test relay circuit 43—44 passes through a similar pair z^{18}, z^{19}, of the pilot switch. At the right-hand end of Fig. 17 is shown a subscriber's line-circuit and its connected apparatus, for a sub-station A′, similar to that of A.

The operation of my system will now be stated:

Assume that subscriber A desires to be connected to subscriber A′. He first sets his sender to the desired number, which we will assume to be 3364. He then removes the receiver from the switch-hook and we find the following circuit conditions: The subscriber's talking circuit is broken at the contacts w^{29} and w^{30} by the operation of setting up the desired number. It will be noticed that while the talking circuit remains open the line is closed by the contacts w^{28} and w^{29}, through the polarized magnet w^{41}, in series. The closing of the line by this circuit energizes the line-relay M, which attracting its armature lights the line lamp m. The current furnished through the line-relay M does not affect the polarized magnet w^{41} as it is of the wrong polarity. The operator perceiving the line-signal inserts the plug P, thereby putting battery on the line of an opposite polarity to that furnished by the line-relay M. The polarized magnet w^{41} is now energized and releases the sender at the subscriber's station, to send in the impulses in their proper order. When the plug P was first inserted the cut-off relay pulled up, disconnected the line-relay M and extinguished the line lamp m. The train w' runs down, sending the first number in a series of short breaks, the relay S is caused to vibrate its armature, opening and closing a circuit which may be traced as follows: B, 24, s^3, s^4, 249, s', s^2, 17, z^5, z^4, I, ground back to battery. Each short break puts battery onto this circuit, that is each short break in the line-circuit producing a corresponding make in the local circuit just traced, and causes the magnet I to advance its indicator one step. The number of impulses in the first set determines the number to which the first indicator is stepped around.

At the same time that magnet I gets its first pulsation of current, the relay Z^2, which is connected in parallel therewith through the wire 17, also takes current, and instantly pulls up its armature, which is made very sluggish in returning, so that on the succession of short breaks in the local circuit due to the short makes in the line, the armature will not fall back far enough to close the circuit of magnet Z′. At the end of the first set of impulses, however, the wheel W at the subscriber's station produces a long make (or if the subscriber is manipulating the switch-hook he lets it stay up for a moment). The effect of this is to cause relay S to hold up its armature and thereby cut off current from the relay Z^2 long enough to permit the armature of the latter to fall all the way back and close the circuit 18 of the magnet Z′ as follows: B, 24, s^3, s^5, 19, 18, Z′, ground. Magnet Z′ then pulls up and steps the side switch around, opening the springs z^4, z^5 and closing the pair z^6, z^7. The first break in the line of the second set, as the subscriber's wheel W continues to run, produces a corresponding make in the circuit of magnet I′, and of relay Z^2, the second indicator disk thus being started and the circuit 18 being again broken. When this second set of breaks has been completed, a long make in the line again holds up the armature s' and lets the armature of Z^2 close the circuit 18 and step around the side switch, opening the contacts z^6, z^7, and z^2, z^3. The indicator magnets I, I′, are thus cut off entirely and the battery supplied through the wire 14 is also cut off from line-wire 2 and the cut-off relay N, the latter permits its armature to fall back. At the same time current reversal in the line throws over the armature of magnet w^{41}, and stops the substation sender. The line-lamp m may now glow, and if the subscriber is using his switch-hook for a sender he will hear the tone of generator G^2, and the operator, perceiving the number which has been set up on the indicator by the magnets I, I′, takes up the plug P′ and inserts it in the trunk jack J^{10} of a group bearing that number. There may be anywhere from 2 to 15 trunk-jacks in a group, depending upon the percentage of lines which will be in use at once. In order to determine which of these are idle the operator may test them in the ordinary way, hence my reference to listening contacts in the key K. The test circuit is simple. It will be observed that the sleeve side of the trunk, 32, is normally to ground, but when a plug is inserted in any one of the trunk jacks the potential of the sleeve side is raised by the connection of the battery through the sleeve side of the cord. I may also use lamps or other busy signals instead of a test. The ordinary test is considered preferable, however.

As soon as the plug P′ is in the trunk jack the following circuit is established: B (in the cord), 24, S^3, 16, 12, p', j', 32, 41, z^{14}, z^{15}, 35, S^5 and ground. The two relays S^3, S^5, thereupon pull up. The former closes the following circuit: B, 24, s^9, s^8, 20 19, 18, Z′, ground. Magnet Z′ thereupon steps the cord side switch around one more step, closes the contacts z^2, z^3, and also closes the contacts z^8 and z^9. The former closure puts battery back on the sleeve side of subscriber's line, 2, again energizes magnet w^{41}, and lets the second set of impulses start. If the subscriber is manipulating his switch-hook he hears the generator G^2 go off and the battery B come on. The relay S^5, on the other hand, pulls up its two armatures and closes the following two circuits: From battery B (in Fig. 17), wire 40, s^{18}, s^{17}, s^{15}, and if the relay S^4 be deënergized, to s^{16}, magnet Z^{10} to ground; also from wire 34, 36, s^{19}, s^{20}, 37, z^{12}, z^{11}, 39, S^6 and ground. Now, since the wire 21 in Fig. 16 has connected the point s^2 to the tip conductor 11 of the cord, it is obvious that the breaks coming in over the line 1 and causing the armature s' of relay S to fall back, will produce a corresponding series of current pulsations over the following path: B (in Fig. 16), 24, s^3, s^4, 249, s', s^2, 17, z^9, z^8, 21, 11. At the point of connection with wire 11 the current divides, a portion going by each of the following paths: first, wire 15, relay S^2 and wire 23 to ground and back to battery; second, through conductor 11, to p, j^{10}, 34, 36, s^{19}, s^{20}, 37, relay S^4, and to ground; also 37, z^{12}, z^{11}, 39 and S^6 to ground. None of these parallel paths will affect the others because they are fed directly from battery through wire 21 without any intervening resistance, but care should be taken that all the contacts and wire connections have a sufficient current carrying capacity to supply the three paths without burning out or undue heating. Thus as the impulses come from the subscriber's station they are repeated by the relay S around the condenser C into the tip side of the trunk. These impulses coming over the wire 31 affect the magnet S^6, which is one of the two stepping magnets of the automatic switch P^2. As it takes the impulses the wipers p^2, p^3, are moved, vertically if it is a Strowger switch, but in a rotary direction if my own type of switch, in either case the tens group of line-contacts J^3 being selected in which the terminals of the wanted line are to be found. At the end of this set of impulses there comes a long make, as before, whereupon the armature s^{16} remains back long enough to make contact with the point s^{16}, and by energizing the magnet Z^{10} to step the side switch Z° around one step, thereby opening the springs z^{11}, z^{12} and closing z^{13}, z^{14}, thereby putting wire 37 through wire 38 to the second magnet S^7 of the switch P^2, this being the magnet which in the Strowger switch moves the wipers around the row, and in my switch moves the selector up the row, in both cases to select the unit contacts wanted.

When the side switch in the trunk worked the last time, the switch Z of the cord also moved a step; but no effect was produced thereby, the contacts z^8, z^9 being maintained closed during both steps. As the last or unit impulses now come in as breaks over the line, they are repeated as before over wire 31, to energize magnet S^7, as stated. At the end of a set of impulses the long make comes, armature s' in the cord stays up and the relays z^2 and S^4 of the side switches of the cord and trunk, fall all the way back, and both side switches are advanced a step.

The switch Z opens the contacts z^8, z^9 and remains in idle position. The switch Z° opens the contacts z^{13}, z^{14}, thereby disconnecting the magnets S^6 and S^7, and closes the springs z^{18}, z^{19}, thereby connecting the test relay Y to the wiper p^3 by the following path: Y, 43, z^{18}, z^{19}, 44, 34. As this wiper rests on the sleeve contact of the wanted line, if the sleeve side of that line has its potential raised because of another connection existing, the magnet Y will instantly take current and will pull in its armature y, y^4, thereby disconnecting the generator contacts y^7 and y^3, and bridging the busy-back G' across the wires 31, 32 through the insulated contacts y', y^2, y^5 and y^6. The calling subscriber then hears the buzz of the busy-back, or if desired the voice of a phonograph saying "Line is busy". The subscriber thereupon hangs up. A wire 47, it will be noted, connects as a branch of the wire 42 to the front contact y' of the relay Y. When the relay Y pulls up therefore, as an ordinary automatic switch is used, this puts the release magnet X on the wire 32 through the contact y^2, and the magnet immediately takes current and pulls up. As commonly used in Strowger automatic switches this would be what is called a "two-step" release, that is the magnet when it pulls up would simply hook its lever onto the release end of the detent pawls of the switch, and when it lets go the retractile spring of its armature would pull off the pawls and so let the switch return to normal or inoperative position. Hence in such case the switch remains set after the subscriber hangs up. When he hangs up, however, the operator perceives by the lighting of the supervisory lamp s that he has done so, and thereupon pulls the plug P' out of the jack J^{10}. This cuts off the current supply from the magnets S^5 and X, and as the latter then lets go its armature, the switch is forthwith released. By winding the magnet Y high and making it of considerable impedance, the amount of current abstracted from a busy circuit and the consequent annoyance to busy subscribers is no more than in any testing operation in systems now in use. Where this switch shown in Fig. 1 is used as a connective switch, the release magnet must be arranged to operate when a release circuit is closed under the control of the relay X. If the line wanted is not busy, the magnet Y gets no current when the switch wipers come to rest on the line terminals J^3, and the procedure is somewhat different. It should be stated here that after the last teeth of the set for number transmitting on the subscriber's wheel, W^1, there are two or more teeth which are always operative for the purpose of setting the side switch Z°. The side switch Z is unaffected after it makes the final movements stated, either because its arms have reached a stop which prevents further movement, or because the last steps go over tied contacts or solid contacts so as to maintain conditions unchanged. The side switch Z° has five movements, however, and if we cause the insertion of the plug P' to give the first movement and cut in the magnet S^6 simply by putting battery on at J^{10} and at the same time through the closure at s^{18}, s^{17} putting battery current on magnet Z^{10} before relay S^4 is energized, which is the proper and economical course,) still the subscriber only gives two long closures after that, by which means we are brought to testing, but the wanted line must still be rung and the circuit then put through. So two more invariable breaks of short duration are provided just before the wheels W^2 run down. If the line wanted is not busy, the next break comes in, in due course, and the side switch Z° makes another step, closing the generator contacts z^{20} and z^{21}, which may be on one side as shown, or double-pole if desired. This puts generator to the wanted line. After any desired and predetermined interval the last break comes, followed by the final make as the arm w^{32} closes the talking circuit 50—52—53, at the sub-station, and the switch Z° makes its final step, opening the generator contacts, leaving the test contacts open, and taking spring z^{16} off spring z^{15} and putting it on z^{17}, thereby cutting off the relay S^5 and cutting on the release wire 42, which remains on the sleeve side of line during the conversation. Everything else is disconnected, however, including magnets S^4 and S^5, and wire 36. The same step of the side switch closes the contacts z^{22}—z^{23}, and z^{24}, z^{25}, whereby the trunk is prolonged to the wipers, with the same clear talking circuit as in a manual system, and with no more contacts than any, but less than most, to talk through.

After the trunk is completed, the two supervisory relays S and S^2 in the cord-circuit are responsive to the two subscribers, as usual, and if the wanted subscriber does not answer within a reasonable time, the operator can ring him again by means of the key K, also as usual. This will not occur except in a small percentage of cases, and in fact automatic repeat of the ring can be arranged by merely giving the subscriber's sender more ringing teeth and the switch Z° more steps or a set-back, that is to say a means for setting the wheel back so that the last impulses will be repeated. If he finally fails to answer the operator will withdraw the plug P' and insert it in a busy back jack of usual pattern and connection, or can put the caller onto a manual or chief's desk to be talked with and soothed if necessary. The subscriber's operator under no circumstances attempts to talk, and in fact she cannot, having no equipment for the purpose, unless speed of service is to be sacrificed. She does not need to talk in the ordinary course of business, for if the steps in operation are followed carefully it will be observed that she gets signals for all, that are perfectly plain. The line-lamp lights when the man calls, and may also light after the first two numbers have come in, denoting that attention is required to insert the plug P′. The supervisory lamps flash as the signals go through, and respond to all the movements of the subscribers afterward. When the connection has been completed and the subscribers finish conversation, they hang up, and the supervisory lamps announce that they desire disconnection. The operator then pulls the plugs and the mechanism restores itself. In case the calling subscriber desires a recall he flashes his lamp, or if the wanted subscriber's lamp continues to glow while the calling supervisory remains dark, it may denote the same thing, although it is difficult to distinguish this from the condition when the subscriber has not answered and the operator then pulls the plug P′, leaving the plug P in the jack. The indicator I, I′ and the side switch Z being at the same time restored to normal or zero position, the subscriber can get another number at once. He must set up his sender, of course, or manipulate his hook as before.

In the manner of showing the circuits in Fig. 16, it is to be observed that the generator and busy-back circuits are both tied onto one side of the trunk during conversation. It will be understood, of course, that double-pole cut-offs or switches are to be used throughout so these connections will not exist in practice, but are herein shown because of a desire to simplify the drawing as much as possible. Such connections would make the lines noisy.

The sender W′ can be entirely omitted, with all its special circuit connections, leaving an ordinary common battery telephone only at the substation.

In practice, the magnets Z^2, and S^4 are solenoids with plunger armatures, which when at their lowest point rest by their own weight on springs to close them together. The first impulse of a somewhat rapid series pulls up such a plunger core or armature and relieves the springs of its weight, so that they open, and the inertia of the core, combined with the dash-pot effect of its fitting in the spool, vibrate it but do not permit it to fall far except on a long break.

In all mechanism of the above type hereinbefore described it has been found that considerable wear and deterioration is due to the successive shocks caused by the dropping of the switch spindles and the violent return of other parts to their zero or normal positions. In the case of my switch, shown in Fig. 1, the spindle and its connected parts are light, but in order to obviate any possible damage due to shock I have designed a simple take-up or check, consisting as shown, of a single element bellows supported on the frame and receiving the thrust of the lower end of the switch spindle in dropping. This comprises a pair of flexible disks clamped together around their edges by a metal ring crimped over upon them. Between these disks is a spring tending to force them apart, and the upper disk has a small hole in the center. A bracket fastened to the frame extends out and carries the device. The lower end of the spindle has a little leather washer secured to it, large enough to cover the hole in the upper disk, or this washer may be attached to the disk. As the spindle rises the disks spread apart, but when the spindle falls its end comes down upon the upper disk and closes the hole, the contained air thereupon taking up the shock and as it escapes slowly letting down the spindle quite gently upon its bearing brackets. The same check may be applied to the rotary stop lever, p^2, and to other parts, as the side switch.

I do not claim herein broadly a combination between the magnet S^4, which is of the slow relay type, the side switch, and the automatic selector switch, but wish it understood that I relinquish none of my rights to this subject matter, since I have made claims thereto in my copending application Serial No. 291,097, filed December 9, 1905.

I do not herein claim automatic switches controlled by relays having different time constants or through impulses of varying electrical characteristics transmitted over the subscriber's metallic line circuit (including the two sides of the line in series or other circuit normally free from ground connections) inasmuch as the same is claimed in my application Serial No. 291,097, filed December 9th, 1905.

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

1. In a telephone exchange system, a plurality of lines, central office link circuits for interconnecting them, automatic line switches for said link circuits, and controlling means therefor, each switch comprising line-contacts arranged in a straight row, a common contact, a spindle mounted to turn upon an axis parallel to said row and capable of a longitudinal movement, and a plurality of arms or studs on said spindle arranged helically around the same, and adapted to successively connect said line-contacts with said common contact at each longitudinal movement of said spindle, substantially as described.

2. In a telephone exchange system, a plurality of lines, central office link circuits for interconnecting them, automatic line switches for said link circuits, and controlling means

therefor, each switch comprising a straight row of line contacts and a spindle carrying a plurality of angularly placed arms or studs, means to rotate the spindle so as to bring any desired arm into alinement with a contact in the row and means to move the spindle longitudinally and thereby bring the stud into operative connection with successive contacts, substantially as described.

3. In a telephone exchange system, a plurality of lines, central office link circuits for interconnecting them, automatic line switches for said link circuits, and controlling means therefor, each switch comprising a plurality of line contacts composed of subordinate groups or divisions, a spindle in juxtaposition to said contacts, a plurality of selective arms or studs on said spindle arranged in a helical line around the same, one stud for each division of contacts, means to rotate the spindle so as to bring any desired stud into alinement with its division or group of contacts, and means to move the spindle longitudinally to bring the studs into operative connection with the successive contacts, substantially as described.

4. In a telephone exchange system, a plurality of lines, central office link circuits for interconnecting them, automatic line switches for said link circuits, and controlling means therefor, each switch comprising a plurality of line contacts composed of subordinate groups or divisions, a spindle in juxtaposition to said contacts, a plurality of selective arms or studs on said spindle arranged in a helical line around the same, one stud for each division of contacts and means to rotate the spindle so as to bring any desired stud into alinement with its division or group of contacts, together with means to move the spindle endwise so as to bring the selected stud into operative connection with any desired contact in its subdivision or group, substantially as described.

5. In a telephone exchange system, a plurality of lines, central office link circuits for interconnecting them, automatic line switches for said link circuits, and controlling means therefor, each switch comprising a row of line contacts and a member common thereto having individual contacts corresponding to and in juxtaposition with the several line contacts, a spindle capable of longitudinal movement and carrying a selective arm or stud, and means to move said spindle longitudinally so as to cross or interconnect any desired unit line contact with the common member through its corresponding contact, substantially as described.

6. In a telephone exchange system, a plurality of lines, central office link circuits for interconnecting them, automatic line switches for said link circuits, and controlling means therefor, each switch comprising a frame or support, a straight row of contacts divided into a plurality of groups, mounted upon but insulated from said frame, a spindle also mounted on the frame and carrying a plurality of selecting arms or studs, one for each group of contacts arranged helically around the spindle, means to rotate said spindle so as to bring any desired arm or stud into alinement with its group of contacts and means to move the spindle longitudinally so that the selected arm or stud will engage any desired contact in its group, substantially as described.

7. In a telephone exchange system, a line circuit, an automatic selective switch adapted to be associated with said line when calling and containing terminals of other lines, controlling electromagnets and local branch circuit connections for said switch, a step by step electromagnetically actuated side switch controlling said local branch circuits, and controlling means for the side switch responsive to distinctive current changes in the line of more than a determinate length only, substantially as described.

8. In an automatic telephone exchange system, an automatic switch and a controlling or side switch therefor comprising the following instrumentalities: a frame or base plate, a series of contacts thereon, a switch arm adapted to sweep over said contacts, a ratchet connected with the switch arm, a magnet controlling the ratchet, connections from the contacts to the respective parts to be controlled, and actuating means for said magnet and switch responsive to distinctive circuit changes above a predeterminate magnitude or duration only, substantially as described.

9. In a telephone exchange system, a plurality of lines, central office link circuits for interconnecting them, automatic line switches for said link circuits, and controlling means therefor, each switch comprising a plurality of line contacts divided into groups or divisions, a common spindle in juxtaposition to said contacts having a plurality of contact arms corresponding to the line contact groups, means for moving the spindle to bring any arm individually into operative position relatively to its particular group of contacts, and other means for further moving said arm thereafter into operative corelation with the contacts of said group successively, substantially as described.

10. In a telephone exchange system, a plurality of lines, central office link circuits for interconnecting them, automatic line switches for said link circuits, and controlling means therefor, each switch comprising a plurality of line-contacts arranged in groups, a spindle bearing a plurality of arms arranged in a helical line around the same, means to rotate the spindle so as to

bring any desired arm into operative relation with its particular group of line-contacts and additional means to thereafter bring said arm into operative relation with the line-contacts of the group successively.

11. In a telephone exchange system, a plurality of lines, central office link circuits for interconnecting them, automatic line switches for said link circuits, and controlling means therefor, each switch comprising line-contacts arranged in a single row and divided into groups, a spindle having a plurality of arms corresponding with said groups arranged in a helical line thereon, means to rotate said spindle to bring any particular arm in operative relation with its group of line-contacts and means for moving said arm thereafter along the row of contacts to bring the same into operative relation with the line-contacts of the group successively.

12. In an automatic telephone exchange system, an automatic switch, and a controlling switch therefor comprising a base, a switch arm and coöperative contacts carried on one side of said base, a spindle therefor extending through said base, a ratchet wheel mounted upon said spindle, a pawl and detent, controlling magnets therefor, all mounted upon the opposite side of said base, connections between said switch contacts and the working parts of said automatic switch and means to actuate the controlling magnets of said controlling switch by circuit changes of predetermined magnitude or duration only.

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

EDWARD E. CLEMENT.

Witnesses:

JAMES H. MARR,
CHARLES A. STANCLIFF.