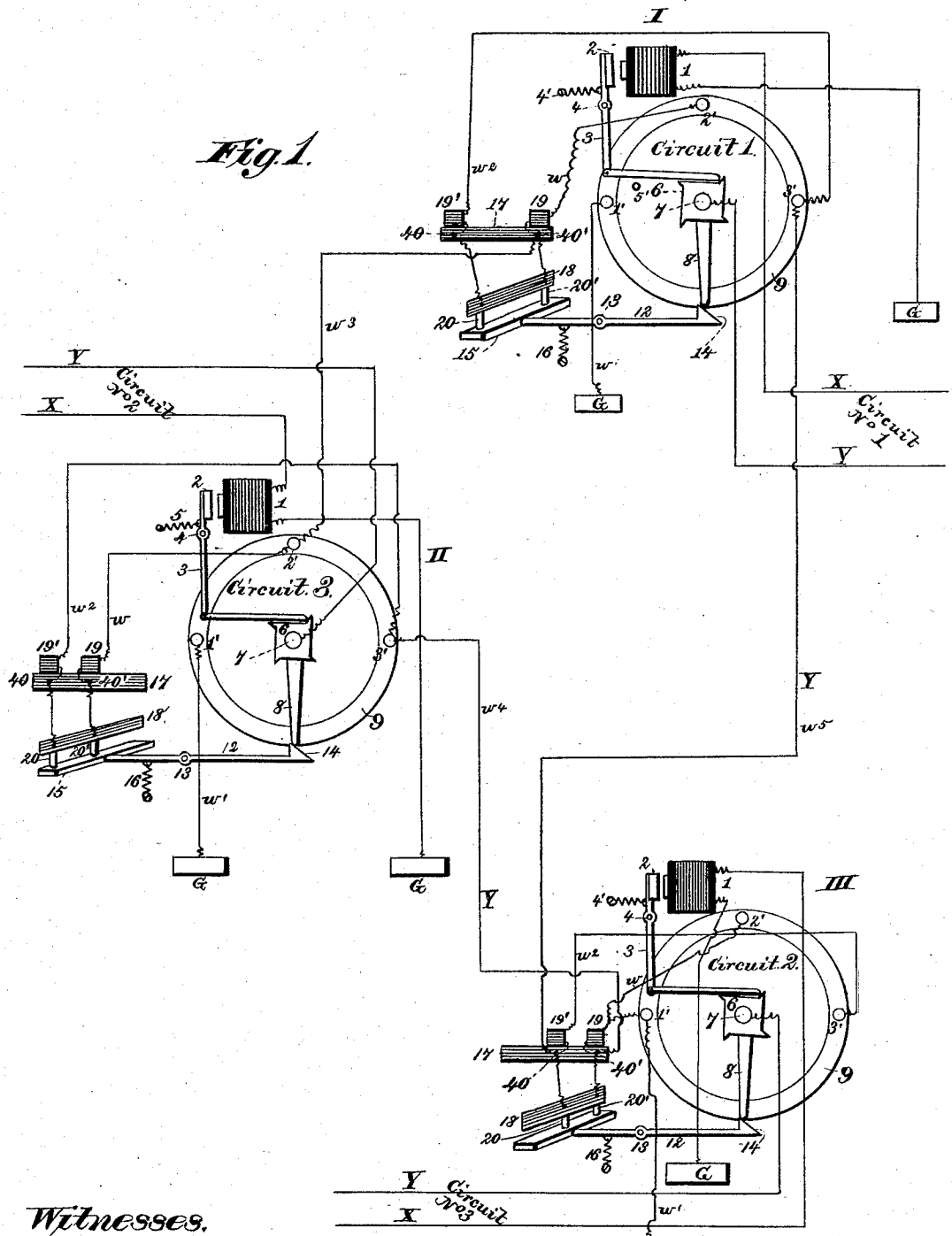
(No Model.) 3 Sheets—Sheet 1.

F. H. SNELL.

AUTOMATIC TELEPHONE EXCHANGE.

No. 269,130. Patented Dec. 12, 1882.

Fig. 1.



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(No Model.) 3 Sheets—Sheet 2.

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Fig. 2.

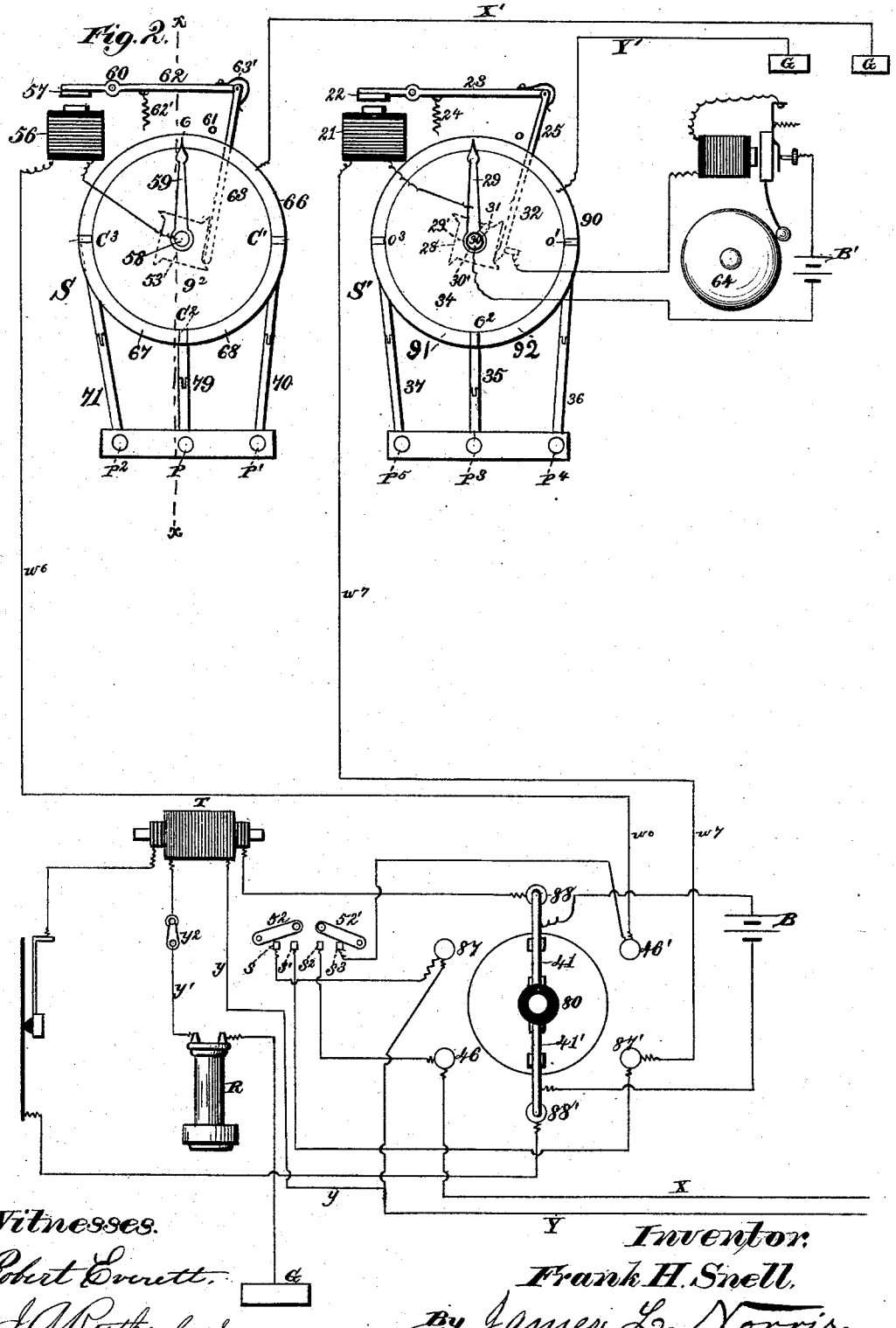

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Fig. 4.

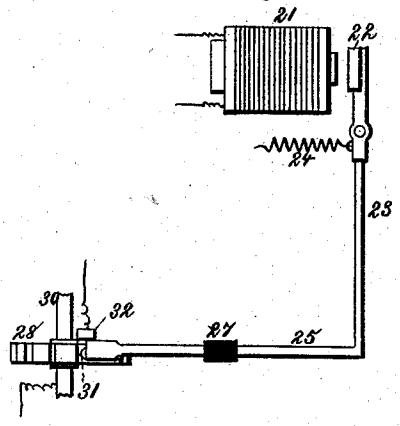


Fig. 5.

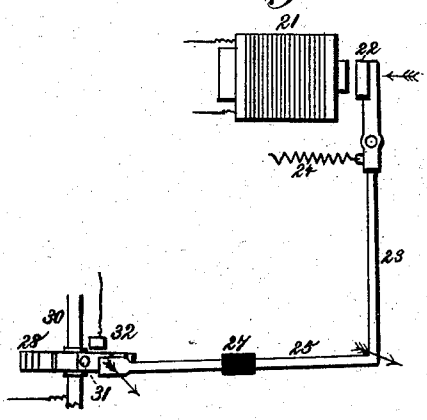


Fig. 3.

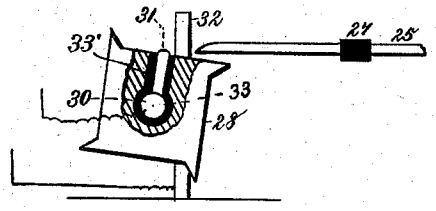


Fig. 6.

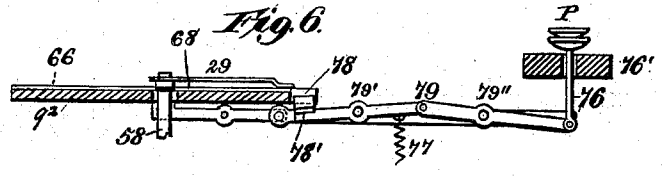
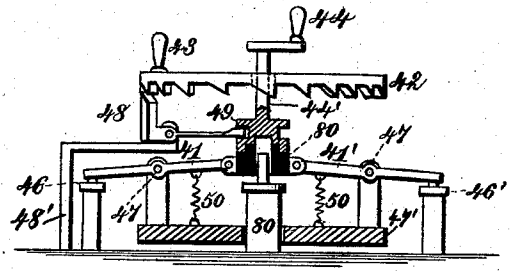


Fig. 7.



Witnesses.

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UNITED STATES PATENT OFFICE.

FRANK H. SNELL, OF WASHINGTON, DISTRICT OF COLUMBIA.

AUTOMATIC TELEPHONE-EXCHANGE.

SPECIFICATION forming part of Letters Patent No. 269,130, dated December 12, 1882.

Application filed September 6, 1882. (No model.)

To all whom it may concern:

Be it known that I, FRANK H. SNELL, a citizen of the United States, residing at Washington, in the District of Columbia, have invented new and useful Improvements in Automatic Telephonic Exchanges, of which the following is a specification.

My invention relates to a telephone system in which the subscribers' circuits are all connected with a common central office, where connection is made between any two circuits over which telephonic communication is desired to be had by subscribers thereon.

The main object of my invention is to provide for the automatic connection and disconnection of the subscribers' lines at the central office, and the dispensing with the usual complicated cumbersome systems of switching and the services of the operators and attendants which have been required at the central offices of all telephone systems heretofore in actual use, thus reducing the expense of a telephone-exchange to a nominal sum after it has been once established. My invention has also the further object of preventing other subscribers from interrupting or overhearing a conversation going on between two subscribers whose lines have been properly connected at the central office.

With these objects in view the invention consists in certain novel constructions and combinations of devices, which will be hereinafter fully described with reference to the accompanying drawings, in which—

Figure 1 is a diagram illustrating the arrangement of the apparatus at the central office, the connecting mechanisms having their essential parts shown in elevation. Fig. 2 is a diagram illustrating the arrangement and construction of the apparatus at a subscriber's station. Fig. 3 is a detail view, partly in section, of certain parts of the station signaling and indicating instrument. Figs. 4 and 5 are illustrations of modifications of the operating devices of the indicating-instruments at the subscribers' stations. Fig. 6 is a section on the line *x x* of Fig. 2. Fig. 7 is a view, partly in section and partly in elevation, of a calling and switching instrument used at each subscriber's station.

In my system each subscriber is connected with the central office by two line-wires, and these two line-wires are at the central office connected with special automatic connecting mechanism which is connected with every other similar connecting mechanism in the central office by suitable conductors. Each subscriber's station is provided with a battery or electric generator, which may be connected with the two line-wires alternately. One of the line-wires I call the "connecting-wire," and the other the "communicating-wire." The connecting-wire has a current passed over it from the station-generator for operating its connected automatic connecting mechanism at the central office, for the purpose of connecting the communicating-wire with the communicating-wire of another subscriber, which is connected with a separate connecting mechanism. This being accomplished, the calling-subscriber's battery is placed on the circuit formed by the two connected communicating-wires, and signal apparatus in said circuit at the called subscriber's station notifies him that he is called. Communication having been thus established, the telephone apparatus at the two stations may be connected in circuit in any convenient manner, but preferably by means of devices of my invention, which will be hereinafter described.

The central office represented by Fig. 1 is supposed to be that of a telephone-exchange having three subscribers' circuits, that number being used simply for the purpose of illustration, as it will be understood that the number of circuits entering the central office may be greater or less. There may be any desired number of subscribers' stations on a circuit, and they may signal and communicate telephonically with each other as well as with subscribers upon other circuits. The circuits and stations are designated by numbers for convenience—as, for instance, stations Nos. 1, 2, and 3 on circuit No. 1; stations Nos. 1, 2, and 3 on circuit No. 2, and so on. The stations are not indicated in Fig. 1; but from the description hereinafter given and the illustration in Fig. 2 of the apparatus at a single station, the manner of connecting the stations in circuit will be readily understood.

I will now describe the apparatus of the central office with reference to Fig. 1.

The pairs of subscribers' lines are marked "Circuit No. 1," "Circuit No. 2," and "Circuit No. 3," and the connecting mechanisms are designated respectively by the Roman numerals I, II, and III, the parts of these mechanisms being shown in their proper relative positions, but without supporting-frames, as the latter may be constructed in any convenient manner, and would obscure some of the operative parts if shown in the drawings.

Referring particularly to line-connecting mechanism I, with which the wires X Y of circuit No. 1 are connected, the number 1 indicates an ordinary electro-magnet, and 2 is an armature therefor. This armature is fixed to the short arm of a lever, 3, pivoted at 4, and having its long arm pivoted to an impelling-pawl, 5, arranged to rotate a toothed wheel, 6, which is fixed upon a metallic axle, 7. A retractile spring, 4′, withdraws the armature 2 from the magnet when it is not attracted thereby. The wheel 6 has a tooth for each subscriber's circuit entering the central office, and one additional tooth, and there projects from the metallic axle 7 a conducting-arm, 8.

Concentrically with the wheel 6 is arranged a non-conducting ring, 9, which supports (in the present instance) three electrical contact-points, numbered 1′, 2′, and 3′, respectively, and correspondingly in radial position with three of the positions to which the conducting-arm 8 may be brought by the step-by-step motion of the wheel 6 and its axle. These contact-points are so arranged that they will be touched successively by the tip of the conducting-arm when said arm describes a circle. One terminal of the coil of magnet 1 is connected with the connecting-wire X, which belongs to circuit No. 1, and the other terminal of said coil is connected with the ground. The metallic axle of wheel 6 is connected with the communicating-wire Y of the same circuit.

The number 12 indicates a conducting-lever pivoted at 13, and having at one end a beveled head, 14, the beveled face of which is arranged to be struck by the tip of arm 8, which will thus force that end of the lever downward. At its opposite end the lever 12 carries a transverse metallic plate, 15, which, as the lever turns on its pivot, may be brought into or out of contact with metallic contact-points 20 and 20′, which are supported by a plate, 18, of non-conducting material, and are respectively in electric connection with the binding-posts 40 40′, supported by a non-conducting plate, 17. Upon this non-conducting plate 17 are mounted resistance-coils 19 and 19′, the former having one terminal connected by wire w with contact-point 2′ of the ring 9, while the latter has one terminal connected with the binding-post 40, and the other by a wire, w^2, with contact-point 3′ of said ring.

The other connecting mechanisms, II and III, are constructed precisely as mechanism I, and similarly connected with their respective circuit-wires, X and Y, and the several connecting mechanisms are connected together as follows: From the binding-post 40′ of mechanism I a wire, w^3, leads to contact-point 2′ of mechanism II, from the contact-point 3′ of mechanism II a wire, w^4, leads to binding-post 40′ of mechanism III, and from binding-post 40 of mechanism III a wire, w^5, leads to contact-point 3′ of mechanism I. These three connecting-wires w^3, w^4, and w^5 have each one end connected directly with a contact-point and the other with a binding-post, the purpose of which arrangement will presently appear. The coils 19 and 19′ have each a resistance greater than any one communicating-wire, Y, and all its connected conductors. In the normal condition of the connecting mechanisms the arms 8 stand with their tips in contact with the beveled faces of the heads 14 of levers 12, thus depressing the heads and raising the transverse plates 15 against the stress of springs 16, and bringing said plates in contact with the metallic contact-points 20 and 20′.

The operation of the central-office apparatus is as follows: Supposing that a subscriber on circuit No. 1 wishes to communicate with a subscriber on circuit No. 2, he first connects his battery or other generator with his connecting-wire X, and sends two impulses over said wire and through the coil of magnet 1 of connecting mechanism I. At each impulse the magnet attracts its armature against the stress of spring 4′, and the pawl 5 is withdrawn from wheel 6, against one tooth of which it normally rests, and drops upon a stud, 5′, and when the magnet releases its armature, the spring 4′ causes the lever 3 to drive the pawl forward to engage a fresh tooth and impel the wheel and its axle one step, the two steps bringing the arm 8, which is carried by the axle, into contact with contact-point 2′. As the arm 8 releases the head 14 of lever 12 the metallic plate 15 falls and breaks contact with the metallic contact-points 20 and 20′. When said arm 8 comes in contact with contact-point 2′, connection is established between the communicating-wires Y of circuits No. 1 and No. 2, as follows: first, through mechanism I, from the communicating-wire Y of circuit No. 1, over the connected axle 7, arm 8, contact-point 2′, wire u, resistance-coil 19, and binding-post 40′; thence over wire w^3 to contact-point 2′ of mechanism II, and then through said mechanism by way of wire w, resistance-coil 19, binding-post 40′, over the connection to contact-point 20′, over plate 15, lever 12, arm 8, and axle 7, to the wire Y of circuit No. 2, which is connected therewith. Connection of the two lines having thus been established, the subscriber on circuit No. 1 connects his generator with his communicating-wire, and may call up any particular subscriber on circuit No. 2 by means of signaling devices, to be hereinafter described. When the subscriber on circuit No. 1 sends a current to signal subscriber on circuit No. 2, said current would divide nearly equally at the plate 15 of mechanism II, and about half would flow

over the connecting-wires to mechanism III, were it not for the resistance-coil 19′; but, owing to the resistance offered by said coil, the main portion of the current flows over the lever 12 of mechanism II, and the conductors leading from the same to line Y of circuit No. 2, and only a very small and practically insignificant portion flows over wire w^2 and connected conductors to and through the mechanism III and its communicating-wire. Over whichever set of connections a current may be sent the resistance-coil of the other set will, in a similar manner, cause the main portion to flow over the lever 12 of the mechanism at which it first arrives. In order to prevent interruptions, as soon as the subscriber on circuit No. 2 learns what line is connected with his, he sends a proper number of impulses to bring arm 8 of mechanism II into contact with contact-point 2′ of said mechanism, and thus cuts out the lever 12, resistance-coil 19, and all other conductors of mechanism II, except contact-point 2′, arm 8, and axle 7, so that while securing privacy and freedom from interruption he also reduces the resistance of the connected lines to an extent better adapted for telephonic communication than if the coil 19 were included therein, as said coil would increase the resistance one-half. It will now be understood why one end of each of the connecting-wires w^3 w^4 w^5 is connected directly with a contact-point of a ring, 9, instead of to a binding-post connected with a resistance-coil as the other end is connected, for if both ends were connected to binding-posts of the bars 17, two coils would be included in circuit when the lines are connected for privacy. If communication were desired with a subscriber on circuit No. 3, the subscriber on circuit No. 1 would in the first place send three impulses, so as to connect arm 8 of mechanism I with contact-point 3′, and with connecting-wire Y of circuit No. 3, through a set of conductors, which will readily be traced in view of the explanation already given.

It will be obvious that any number of circuits within the limits of practical convenience might enter the central office, each being provided with a connecting mechanism connected with all others, and each connecting mechanism provided with the proper number of contact-points, and the ratchet-wheels having a corresponding number of teeth.

It will be understood that the contact-point 1′ of each connecting mechanism is connected with the ground. This is for the purpose of enabling any subscriber to ground his communicating-wire at the central office, so that a complete circuit may be established over said wire and telephonic communications be had between subscribers' stations of the same circuit.

The construction and operation of the central-office apparatus being now explained, I will proceed to describe the apparatus of a subscriber's station, referring to Figs. 2 and 7. The latter figure shows the switching and signaling instrument partly in elevation and partly in section, and the lower portion of Fig. 2 is a diagram illustrating the action of the switch. This switch, as shown in Fig. 7, has two metallic radial levers, 41 41′, pivoted to and projecting in opposite directions from a non-conducting hub, 80, which is pivoted to turn horizontally upon the top of the post 80′. The said levers are also pivoted intermediately at the top of posts 47 47, which stand upon a platform, 47′, arranged to rotate about the post 80′, and springs 50 50 draw the inner ends of the levers and the hub, to which they are pivoted, downward toward the platform, said hub having vertical play upon its pivot. The numbers 46 and 46′ are stationary conducting-posts, arranged on opposite sides of the platform 47′, and for simultaneous contact with the outer ends of the levers 41 41′, respectively. Four other conducting-posts are arranged in a similar manner in two pairs on lines at angles with each other and with the posts 46 46′, but are not shown in Fig. 7. They are, however, indicated in the diagram Fig. 2, from which it will be seen that there are three pairs of conducting-posts—viz., 46 and 46′, 87 and 87′, and 88 and 88′—the two posts of each pair being arranged in line, so that they may make simultaneous contact with the switch-levers 41 and 41′. From the top of the hub 80 extends a post, 44′, provided with a crank, 44, by which it, the hub-levers, platform, and connected parts may be turned to bring the outer ends of the switch-levers into coincidence with any pair of the conducting-posts, as desired. A bent lever, 48, is pivoted to an arm projecting from a post, 48′, and has the end of its long arm inserted in a circumferential groove in the hub 80, while the tip of its upwardly-projecting arm is arranged to be struck and forced downward by the downwardly-projecting teeth of a reversed crown ratchet-wheel, 42, arranged to revolve concentrically with but independently of the post 44′. A station-battery, B, Fig. 2, has one of its poles connected with the switch-lever 41 and the other connected with the lever 41′. The connecting-wire X, entering the station, terminates at post 46, and from the post 46′ a wire, w^6, connects with one terminal of the coil of the operating electro-magnet 56 of an indicating-instrument, S, which will presently be described, and the other terminal of said magnet-coil is grounded through certain parts of said instrument. The communicating-wire Y entering the station terminates at the post 87, and from the post 87′ a wire, w^7, connects with one terminal of the coil of the operating electro-magnet 21 of a signaling and indicating instrument, S′, the other terminal of said coil being grounded through the instrument, as will be hereinafter explained. The posts 88 and 88′ are respectively connected with the opposite terminals of the primary helix of a transmitter induction-coil, T. The communicating-wire Y is also con-

nected by a branch, *y*, with one terminal of the secondary helix of the induction-coil T, and wire *y'* connects the other terminal of said coil with one binding-post of the receiver R, the other binding-post of which is connected with the ground. In the wire *y'* is a switch, y^2, which should be left open to cut out the receiver when not in use; or the receiver may, when not in use, be disconnected from the ground by any of the ordinary means.

It will be observed that the indicating-instrument S and the signaling and indicating instrument S' are grounded through lines X' and Y', respectively; but it must be understood that these instruments would only be grounded at the terminal station of a circuit. At intermediate stations these wires X' and Y' would connect with continuations of the circuit-wires X and Y, which would pass on to the next station and be there connected with the posts of a switching-instrument, as already described.

The posts 87 and 87', besides their other connections, are connected respectively with contact-points *s s'*, and the posts 46 and 46' are connected with contact-points s^2 and s^3. A switch-lever, 52, is arranged to metallically connect the points *s* and *s'*, and a similar lever, 52', is arranged to connect points s^2 and s^3. Normally these points should be connected by their respective switch-levers so that the connecting and communicating lines will be completed through the station, as it will be understood that the switch-levers 41 and 41' do not make contact with the conducting-posts except when depressed temporarily for the purpose of connecting the station-battery with one of the line-wires or the transmitter.

Before explaining the operation of the switching apparatus in making its several connections, I will describe the indicating-instrument S and the signaling and indicating instrument S'.

The indicating-instrument S is normally in connection with the connecting-wire X through wire w^6, post 46', contact-point s^3, and the wire which connects it to said post, switch-lever 52', contact-point s^2, and the connecting-wire to post 46.

The number 92 indicates a non-conducting disk, carrying at the upper portion of its periphery a nearly semicircular metallic segment, 66, and below it two metallic segments, 67 and 68, each forming nearly a quarter of a circle. The segments are separated from each other by intervening spaces, and into each of these spaces fits a metallic lug formed on the end of a metallic lever, as shown at 78 in Fig. 6, said lug having on each side shoulders, as at 78', which rest against the backs of two adjacent segments, thus forming metallic connection between them, while the outer end or tip of the lug will be flush with the front faces of the segments. The lug 78 is carried by a compound lever, 79, the two parts of which are pivoted at 79' and 79'', respectively, and the end of said lever opposite that which carries the lug is connected to a rod, 76, playing through a guide-passage in a bar, 76', and carrying at its outer end a push-button, P. The lug 78 is held normally in the space between the segments 67 and 68 by means of a spring, 77, acting on the lever. Similar levers, 70 and 71, (see Fig. 2,) carry lugs, which are held normally between the ends of segments 66 and the adjacent ends of segments 67 and 68. The lever 70 is connected with a push-button, P', and the lever 71 with a push-button, P^2. The space on the right between the segments is marked C', that at the bottom C^2, and that on the left C^3, while the middle point of the upper segment is marked 0, (zero.)

At the center of the disk 92 is mounted a metallic axle, 58, which, in front of the disk, carries a metallic index-finger, 59, the tip of which extends in front of the plane of the metallic segments and bears against whichever one of the same it may be at any time immediately in front of. The tip of the finger is of less width than the spaces between the segments, and therefore when it stands directly in front of one of said spaces it will rest entirely upon the tip of the lug which fills such space; or, if the lug be withdrawn, the tip of the finger will have no metallic contact.

Behind the disk 92 the axle 58 carries a four-toothed ratchet-wheel, 53, and 63 is a pawl arranged to turn said wheel step by step by engaging successively with its teeth, said pawl being pivoted to the end of the long arm of a lever, 62, pivoted at 60, and carrying the armature 57 of magnet 56. The armature is normally held away from the magnet by a spring, 62'. The coil of the magnet 56 has one terminal connected with the metallic axle 58, its other terminal being connected with the wire w^6, heretofore referred to. The pawl 63 is forced against the wheel 53 by a spring, 63', and is prevented by a stop, 61, from moving too far laterally when it withdraws from one tooth to engage a fresh one. In the normal condition of the instrument the finger 59 points to its zero-point at the middle of segment 66, and is in contact with said segment. From this segment the wire X' leads to the ground or connects with a continuation of the connecting-wire leading to the next outward station.

The office of the instrument now described is to indicate to the subscriber when by the impulses sent over his connecting-wire X the desired connection has been made at the central office. For instance, if the subscriber is on circuit No. 1, and desires to connect with circuit No. 2, he would first depress the push-button P, so as to remove the lug 78 from between segments 67 and 68, and then after connecting his battery with his connecting-wire X he would begin to send impulses without taking the trouble to count them, but would observe the finger 59. Two impulses would bring this finger, by the operation of the devices already described, opposite the space C^2,

and the lug being removed from said space the tip of the finger would have no metallic contact. The continuity of the line being thus broken, the magnet ceases to act, and the finger halts opposite space C^2, which indicates to the subscriber that the connection with circuit No. 2 has been made by his connecting mechanism at the central office, for it will be remembered that two impulses over the line X cause the arm 8 of the connecting mechanism to make two steps, which brings it in contact with contact-point 2′, and connects the line Y of the calling subscriber on circuit No. 1 with the line Y of the called subscriber on circuit No. 2, as has been heretofore fully explained. If the lug had been withdrawn from space C′, the finger would have halted there, showing that the line Y had been grounded at the central office, and the subscriber might then signal another subscriber on his own circuit and be free from interruption from any other circuit.

The instrument might be provided with any number of segments, spaces, and lug-carrying levers, each space being designated by a letter, number, or other sign corresponding to a contact-point of the connecting mechanism at the central office, and the operation for indicating the forming of the desired connection would be similar to that described—that is, removing the lug from the space corresponding to the desired connection, and sending impulses over line X until the indicating-finger halts opposite said space. At all the other stations on the same circuit the indicating-instrument is also operated, and any subscriber may thus know whether his line is in use or not. Connection having been made with the proper circuit, it is then desired to signal or "call up" the particular subscriber on said circuit with whom communication is wished without sounding or operating the signals of other subscribers on the same circuit.

The signaling apparatus S′ of each subscriber is connected in his communicating-line Y, as heretofore stated, and comprises an instrument similar to the indicating-instrument S, with some additions, which will be described and explained. In the instrument S′ the non-conducting disk is numbered 34, the long metallic segment 90, the short metallic segments 91 and 92, respectively. The spaces between segments are marked o', o^2, and o^3. The compound levers carrying the lugs to fill said spaces are numbered 35, 36, and 37, the push-buttons P^3 P^4 P^5, the metallic axle 30, the armature-lever 23, its retracting-spring 24, the armature 22, and the magnet 21. Some of the minor parts are not numbered, as their functions will be readily understood to be the same as in instrument S. The magnet 21 has one of its coil-terminals connected with the finger 29 and the other with wire w^7, as before stated. The finger 29, instead of being attached directly to the axle 30, is insulated therefrom by means of an insulating-ring, 30′, interposed between the axle and the collar 29′ of the finger. The finger and the segments and lugs, however, form the metallic connection between the magnet-coil and wire Y′ the same as connection is formed between the finger and wire X′ of instrument S, and as thus far described the two instruments would act precisely alike.

The ratchet-wheel 28 in the instrument S is insulated from the axle 30 by means of an interposed insulating-ring, 33, as shown in the detail, Fig. 3, and from the axle a metallic pin, 31, projects through the ring and radially through the wheel 28, its tip extending slightly beyond the periphery of the wheel or the long face of one of its teeth, and the pin being insulated from the wheel by an insulating-bushing, 33′, which lines the aperture through which said pin extends.

Alongside the wheel, but insulated therefrom, stands a metallic post, 32, in such position that the tip of metallic pawl 25 will come in contact therewith and slide against the adjacent side thereof each time said pawl impels a tooth of the wheel forward, and will be drawn out of contact therewith each time it is retracted to engage a fresh tooth, its contact with said post occurring only at the latter part of the impelling movement, and being very brief when the pawl is kept in operation by successive electrical impulses through the magnet, for the reason that the long arm of the armature-lever 23 is so much longer than its short arm, which carries the armature, that only a slight movement of the armature is necessary to cause the extended movement required in the pawl, and this extended movement must of course be correspondingly rapid.

To the post 32 is connected one terminal of a local circuit, including a vibratory electrical bell, 64, and having its other end connected with the metallic axle 30.

It will now be observed that when the pawl 25, in impelling the wheel 28, comes in contact with the pin 31 it also comes in contact with post 32 and closes the local-battery circuit, the two terminals of which are connected with said post and the axle 30, and if the contact of the pawl and post is of sufficient duration to permit the battery-current to overcome the inertia of the bell said bell will be rung and continue to ring as long as the circuit is closed.

The instruments S′ at all the stations on the circuit are alike, except as to the position of the pin 31, and, as shown, the said instrument is for use on a circuit comprising three subscribers' stations. At station No. 1 the pin 31 will project from the long side of the ratchet-tooth next to the left from that upon which the pawl rests when the finger 29 points to zero. At station No. 2 the pin will project from the second tooth to the left, and at station No. 3 from the third tooth to the left. Now, when two communicating-wires have been connected through the connecting mechanism at the central station—as, for instance, the communicating-wires of circuit No. 1 and No. 2, as heretofore explained—and subscriber No. 1,

say, on circuit No. 1, wishes to call up subscriber No. 3 on circuit No. 2, he connects his battery with his communicating-wire, depresses push-button P^5 to remove the lug from space o^3 between segments 90 and 92 at instrument S′, and then commences to send electrical impulses over the two connected lines, causing the finger 29 to move, step by step, until it comes opposite space o^3, and there it halts, as the line-circuit of which it forms a part will then be broken. The fingers and ratchet-wheels of all the stations on the two connected lines will have made three steps, and at station No. 3 the pin 31 of instrument S′ will come under the pawl 25, and the pawl will pause in contact therewith and with the post 32, and the signal-bells at this station will be rung, and continue to ring as long as the instruments are allowed to stand in that condition. When the calling subscriber has allowed the bell to ring long enough as he supposes to attract the attention of the subscriber called, he releases the push-button P^5 and allows the lug to resume its place in space o^3, and sends another impulse to restore all the instruments S′ to normal position—that is, with the indicating-fingers pointing to zero. It will be understood that while the ratchet-wheels were all making their three steps to bring the fingers to space o^3, the fingers 31 at the intermediate stations No. 1 and No. 2 will have come under their pawls 29, said pawls at the same time making contact with the posts 32, and closing the local-battery circuits; but the closing, as before explained, is of such brief duration that the inertia of the bells at these intermediate stations will not have been overcome, and the said bells therefore not rung.

I will now explain the manner of using the switching devices, as shown in Fig. 7, and the diagram at the lower portion of Fig. 2.

When a subscriber wishes to communicate with another on another circuit, he first breaks his connecting-line X by turning the switch-lever 52 off the contact-points s and s', and then turns the crank 44 (see Fig. 7) to bring the switch-levers 41 41′ over the posts 46 and 46′. He next depresses a push-button at instrument S to remove the lug from the space corresponding to the circuit with which he desires to connect, and holds said button depressed. He then turns the crown-ratchet 42, the teeth of which operate the lever 48 to raise the hub 80, and depress the ends of the switch-levers into contact with the posts 46 46′, thus throwing the current of battery B on the line intermittently. He continues to turn said wheel until the finger 59 halts opposite the space from which the lug is removed, and then he knows that the desired connection has been made at the central office. He leaves the instrument S in this condition for the present, because all the similar instruments on his circuit are in the same condition and indicate to the other subscribers on his circuit that it is in use. He then opens the switch 52′, depresses a button at instrument S′ to remove the lug from the space corresponding to the number of the station of the particular subscriber whom he wishes to call, turns the crank 44 to bring the switch-levers 41 and 41′ over posts 87 and 87′, and then turns wheel 42, sending battery-impulses over the connected communicating-lines Y until the finger 29 halts opposite the space from which the lug has been removed. He then knows that the signal-bell is being rung at the station of the subscriber with whom he wishes to converse, and after allowing it to ring for a sufficient length of time he replaces the lug in its space, thus restoring the continuity of the line, and turns wheel 42 until finger 29 points to zero, thus restoring all similar instruments on the two connected lines to their normal condition. He then immediately turns crank 44 to bring the switch-levers 41 and 41′ over the posts 88 and 88′, which are connected with the transmitter primary helix, and turns wheel 42 so that one tooth thereof will ride upon the upturned arm of lever 48 and depress it, and leaves the wheel thus to hold the switch-levers in contact with the posts 88 and 88′, thus placing the battery in connection with the transmitter T. He then closes the switch y^2 and places his receiver R to his ear and awaits the response of the called subscriber, who, as soon as he learns on what circuit the calling subscriber is located, sends a sufficient number of impulses over his connecting-wire to the proper contact-point at the central station, thus securing privacy and freedom from interruption, as heretofore explained. When a subscriber receives a call, he first simply opens switch 52, closes switch y^2, connects his battery with the transmitter, and through the latter asks who it is wants him, making the connection for privacy after learning who it is. After the conversation is finished the battery should be connected with line X of both circuits, and the wheel 42 turned until the finger 59 points to zero, the switches 52 and 52′ should be closed and switches y^2 opened.

It is true that when a subscriber on one line signals a subscriber at a station on another line he will cause the bell to ring at a correspondingly-numbered station on his own line; but the subscriber on the calling-line who is not wanted may know the fact by observing his indicator S, which, as explained, will show that the circuit has been connected with another, while if the call were intended for him the indicator S would show that the communicating-line had been grounded at the central office—that is, its finger 59 would stand opposite the space C′. The manner of restoring the connecting mechanism at the central office to normal condition after use will be obvious.

In Figs. 4 and 5 is illustrated a modification of the impelling devices of the signaling apparatus S′. In these figures the magnet 21 is shown arranged off to one side of the ratchet-

wheel and its axis parallel with the horizontal diameter of the said wheel. In this modification the pawl 25′ is attached rigidly to the armature-lever 23′, and its top at each impelling and retracting movement plays in the arc of a circle across the toothed edge of the wheel, and therefore the instant that the magnet begins to attract its armature the end of the pawl will be moved laterally out of contact with the post 32, and has not even that very brief sliding contact which occurs in the form shown in Fig. 2, but merely an instantaneous impact when impulses follow each other rapidly through the coil of the operating-magnet.

Having now fully described the construction and operation of my invention, I wish it to be understood that I do not limit myself to the precise details of construction and arrangement shown and described, but reserve to myself the right to vary therefrom by using the known equivalents for any or all of the described devices, and generally to avail myself of the existing state of electrical science and practice in carrying out my invention within the true spirit and scope thereof.

What I claim is—

1. In a telephone-exchange system, the combination, with a series of automatic line-connecting mechanisms at a central office and intermediate conductors connecting said mechanisms with each other, of a series of subscribers' circuits, each provided with two line-wires, one wire of each circuit being a connecting-wire and connected with a single connecting mechanism for operating the same, and the other wire of each circuit including the telephonic and signaling instruments, and being connected with the same connecting mechanism, and arranged to be connected thereby, through one of said intermediate conductors, with any other line of similar character connected to another of said connecting mechanisms, substantially as described.

2. In a telephone-exchange system, the combination, with two subscribers' circuits, each including two or more subscribers' stations, and automatic mechanism for connecting the said circuits at a central office, of signaling devices at the respective stations in each circuit, arranged to separately operate and be separately operated by a similar signaling device at any particular station on either of the two circuits, substantially as described.

3. In a telephone-exchange system, the combination, with a series of automatic line-connecting mechanisms at a central office, and a series of subscribers' circuits connected with said connecting mechanisms, respectively, and each provided with two line-wires, one of which is a connecting-line, and connected with a single connecting mechanism only for operating the same to form connections, and the other including the telephone-instruments, and adapted to be connected by said mechanism with another line of similar character connected to one of the other connecting mechanisms of an indicating-instrument at a subscriber's station on each circuit, and included in the connecting-line itself, and arranged to indicate to the subscriber the condition of the connecting mechanism with which his circuit is connected at the central office, substantially as described.

4. In a telephone-exchange system, the combination, with a series of subscribers' circuits, each provided with two line-wires, of a series of automatic line-connecting mechanisms at a central station, each of said connecting mechanisms being connected with a separate subscriber's circuit and comprising the following elements, namely: an electro-magnet having one of its terminals connected with one of the line-wires and the other to ground, an armature arranged for operation by said magnet and mounted upon one arm of a lever, the other arm of which carries a pawl, a ratchet-wheel arranged for operation by said pawl and fixed upon a metal axle which is connected with the other line-wire, a revolving conducting-arm projecting from said axle, and a series of conducting contact-points arranged to be struck successively by said arm as the axle is turned, certain of said contact-points of each mechanism being electrically connected respectively with the revolving conducting-arms of other similar mechanisms, substantially as described.

5. The combination, with the revolving conducting-arms of the several mechanisms and means, as described, for revolving the same, the line-wires electrically connected with said arms and the contact-points arranged to be struck by said arms, of the intermediate conductors connecting the contact-points of each mechanism with a common conductor arranged to connect them with the revolving arms of similar mechanisms, and the resistance-coils interposed in said intermediate conductors, substantially as described, and for the purpose set forth.

6. The indicating-instrument composed of the electro-magnet, its armature-lever and pawl, the ratchet-wheel arranged to be turned by said pawl, the axle carrying said wheel, the conducting-finger carried by said axle and electrically connected with one coil-terminal of the magnet, the metallic segments separated by intervening spaces and arranged to make contact with said finger, the metallic lugs arranged to fill said spaces and electrically connect the segments, and means for removing and replacing said lugs, substantially as described.

7. The combination, with the axle 30 and impelling devices, of the signal-indicating instrument S′ of the ratchet-wheel, insulated from said axle, the conducting-pin projecting from the axle in the path of the pawl, the conducting-post arranged to make contact with said pawl, and the local circuit having its op-

posite terminals connected with said axle and post, respectively, substantially as and for the purpose set forth.

8. In a switching mechanism, the combination, with the revolving switch-levers 41 and 41′, insulated from each other and arranged for connection with the opposite poles of an electrical generator, of two or more pairs of contact-points arranged to make contact with said levers, means for bringing said levers in line with either pair of said posts, and devices for forcing levers into contact with and withdrawing them from said posts, substantially as described.

9. The combination, with the posts 46 and 46′ and 87 and 87′, and the contact-posts s s' and s^2 s^3, connected therewith respectively, of the switch levers arranged to connect said contact-points, as described, and for the purpose set forth.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

FRANK H. SNELL.

Witnesses:
JAMES L. NORRIS,
J. A. RUTHERFORD.