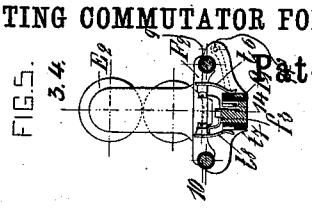
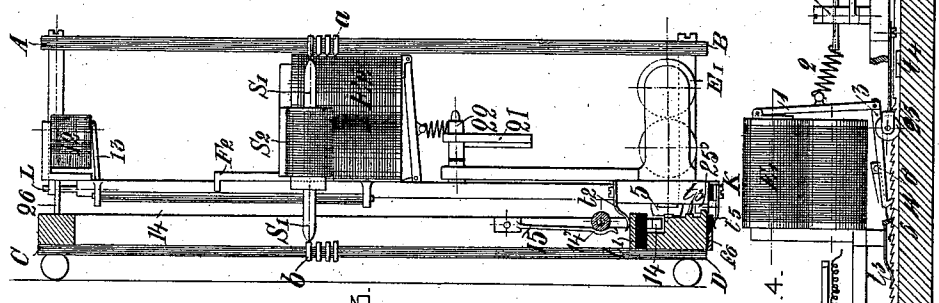
(No Model.) 8 Sheets—Sheet 1.

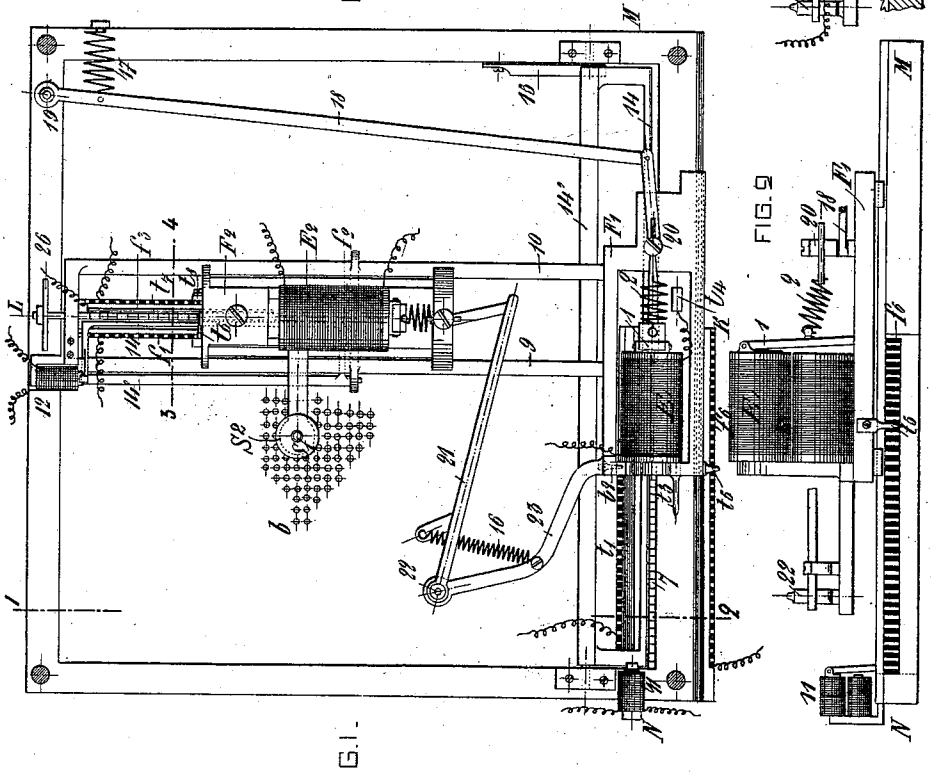
S. BERDITSCHEWSKY DIT APOSTOLOFF & M. FREUDENBERG.

SELF ACTING COMMUTATOR FOR TELEPHONES.

No. 546,725. Patented Sept. 24, 1895.







Witnesses
Rees Lewis
H. P. Edelen.

Inventors
S. Berditschewsky dit Apostoloff,
and Moise Freudenberg
by Tolson & Mauro.
their attorneys

(No Model.) 8 Sheets—Sheet 2.

S. BERDITSCHEWSKY DIT APOSTOLOFF & M. FREUDENBERG.

SELF ACTING COMMUTATOR FOR TELEPHONES.

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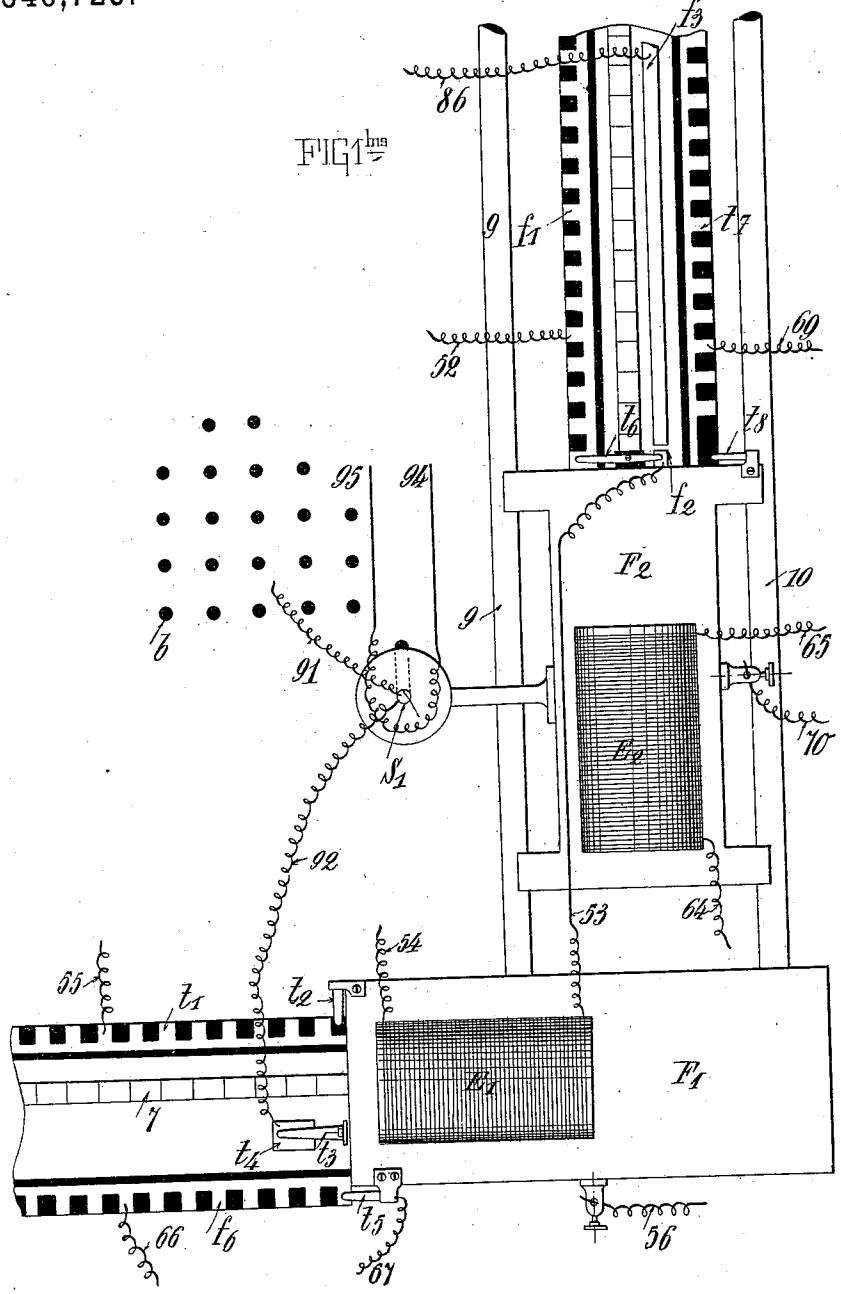
FIG 1ns



Witnesses
W. R. Edelin.

Inventors
S. Berditschewsky dit Apostoloff,
and Moise Freudenberg,
by Foster & Freeman
their attorneys

(No Model.) 8 Sheets—Sheet 3.

S. BERDITSCHEWSKY DIT APOSTOLOFF & M. FREUDENBERG.

SELF ACTING COMMUTATOR FOR TELEPHONES.

No. 546,725. Patented Sept. 24, 1895.

FIG. 6bis.

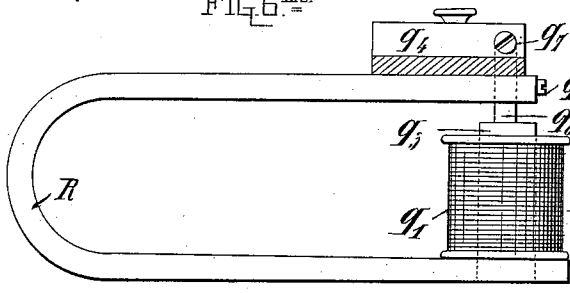


Fig. 6.

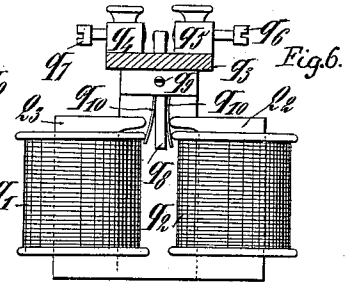


FIG. 7.

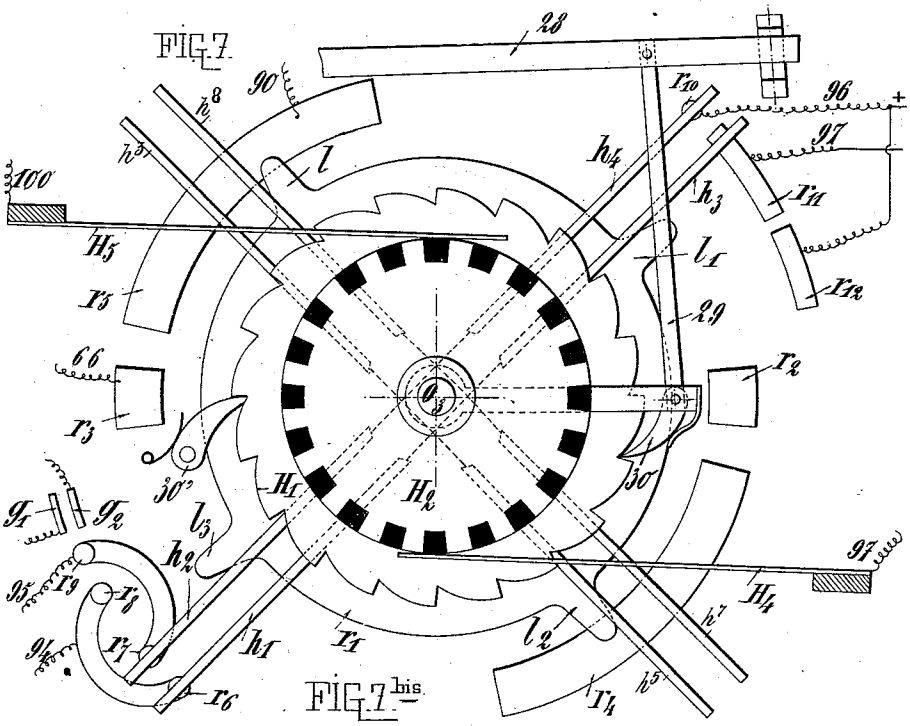
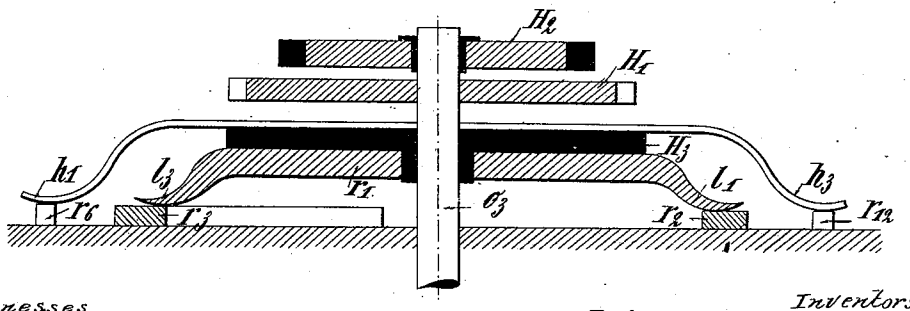


FIG. 7bis.



Witnesses
Geo. Lewis
W. R. Edelin

Inventors
S. Berditschewsky dit Apostoloff
and Moïse Freudenberg
by Foster Freeman
their attorneys

(No Model.) 8 Sheets—Sheet 4.

S. BERDITSCHEWSKY DIT APOSTOLOFF & M. FREUDENBERG.

SELF ACTING COMMUTATOR FOR TELEPHONES.

No. 546,725. Patented Sept. 24, 1895.

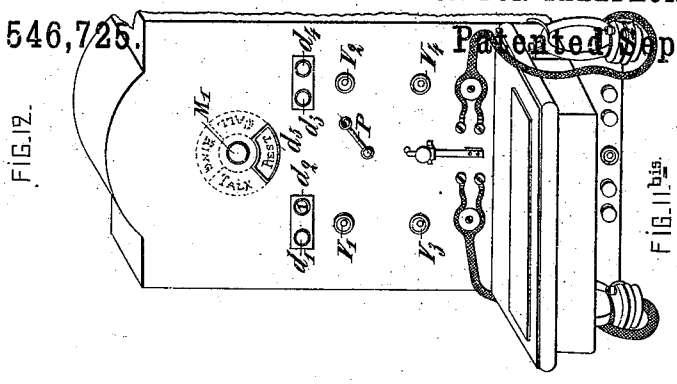


FIG. 12.

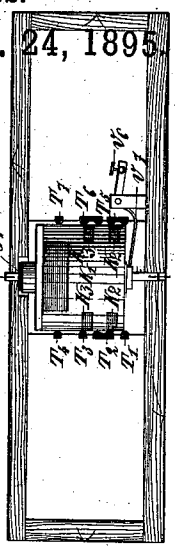


FIG. 11 bis.

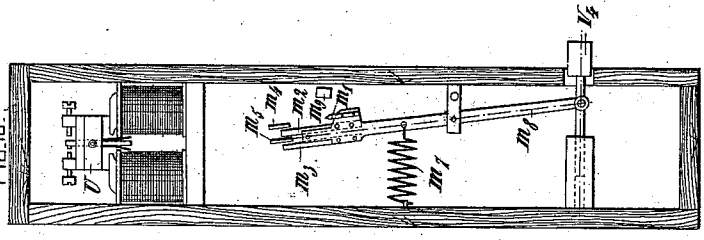


FIG. 10.

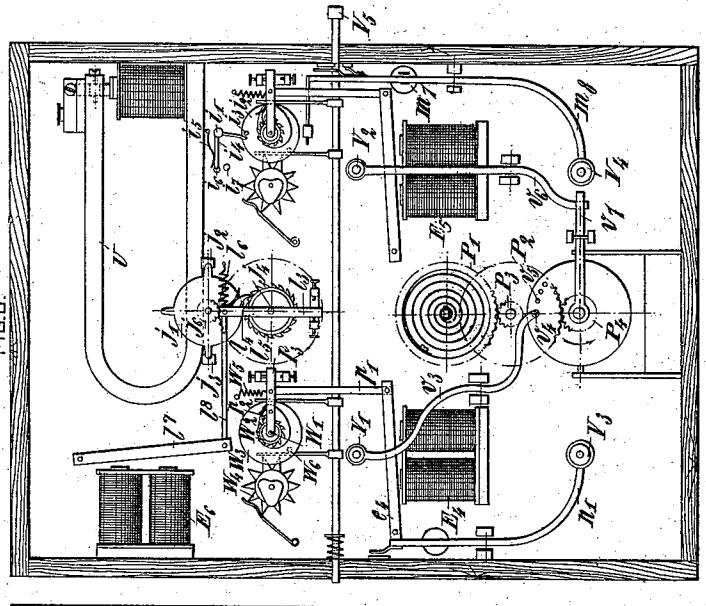


FIG. 8.

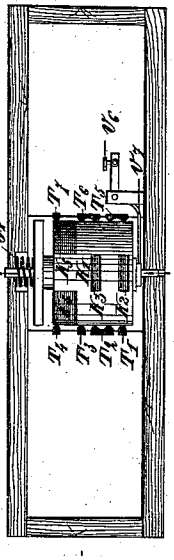


FIG. 11.

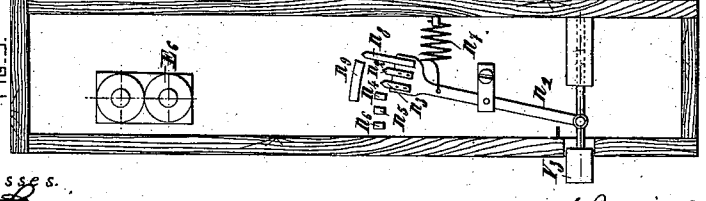


FIG. 9.

Witnesses.
Geo. Lowe
W. P. Edson.

Inventors,
S. Berditschewsky dit Apostoloff
& Marie Freudenberg
by Foster Brown,
their attorneys.

(No Model.) 8 Sheets—Sheet 5.

S. BERDITSCHEWSKY DIT APOSTOLOFF & M. FREUDENBERG.

SELF ACTING COMMUTATOR FOR TELEPHONES.

No. 546,725. Patented Sept. 24, 1895.

FIG. 14.

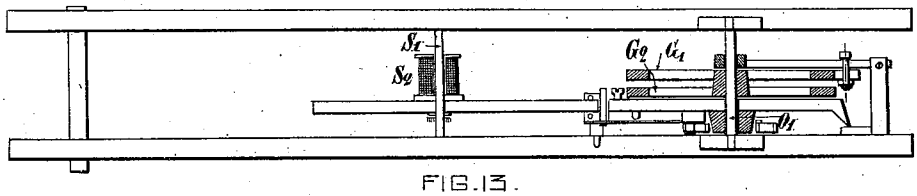
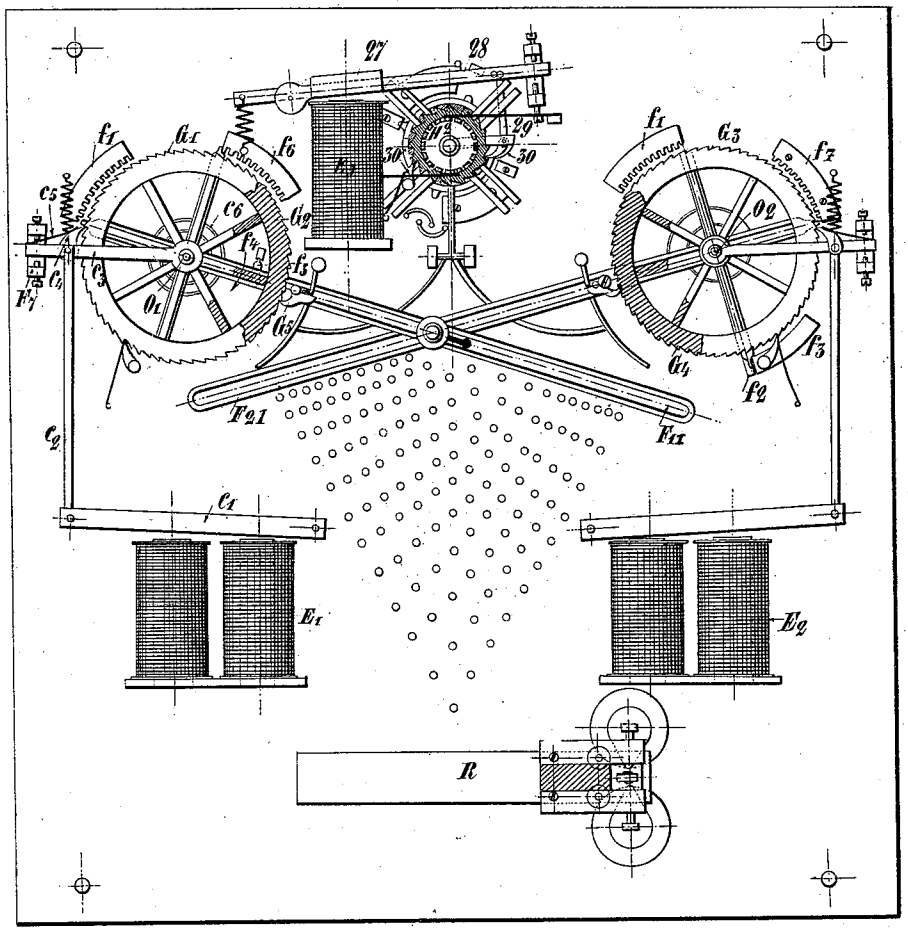


FIG. 13.



Witnesses
Chas. Lowie
W. R. Edelen.

Inventors.
S. Berditschewsky dit Apostoloff.
and Moïse Freudenberg
by Foster & Freeman
their attorneys.

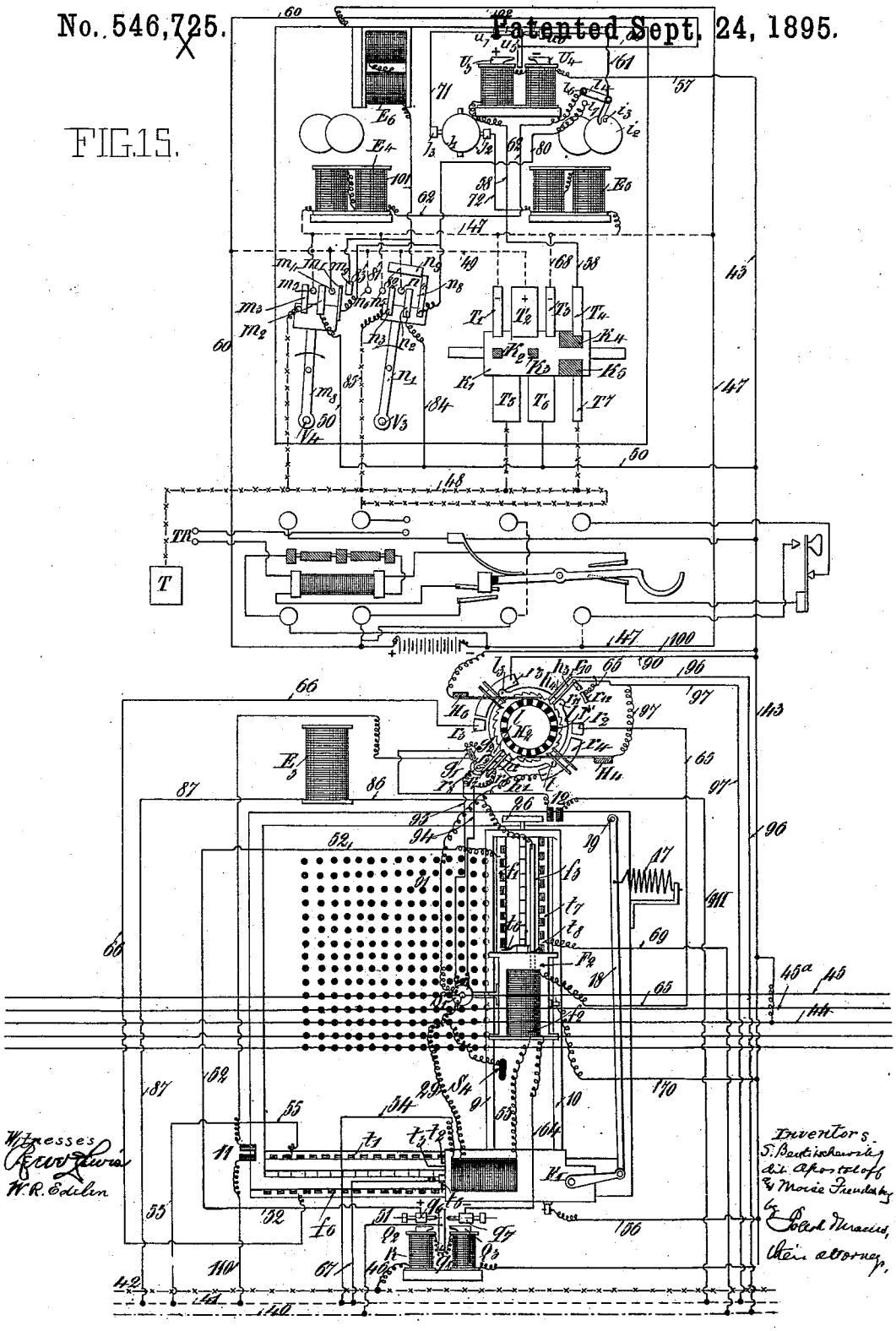
(No Model.) 8 Sheets—Sheet 6.

S. BERDITSCHEWSKY DIT APOSTOLOFF & M. FREUDENBERG.

SELF ACTING COMMUTATOR FOR TELEPHONES.

No. 546,725. Patented Sept. 24, 1895.

FIG. 15.



Witnesses
Chas. Lewis
W. R. Edelin

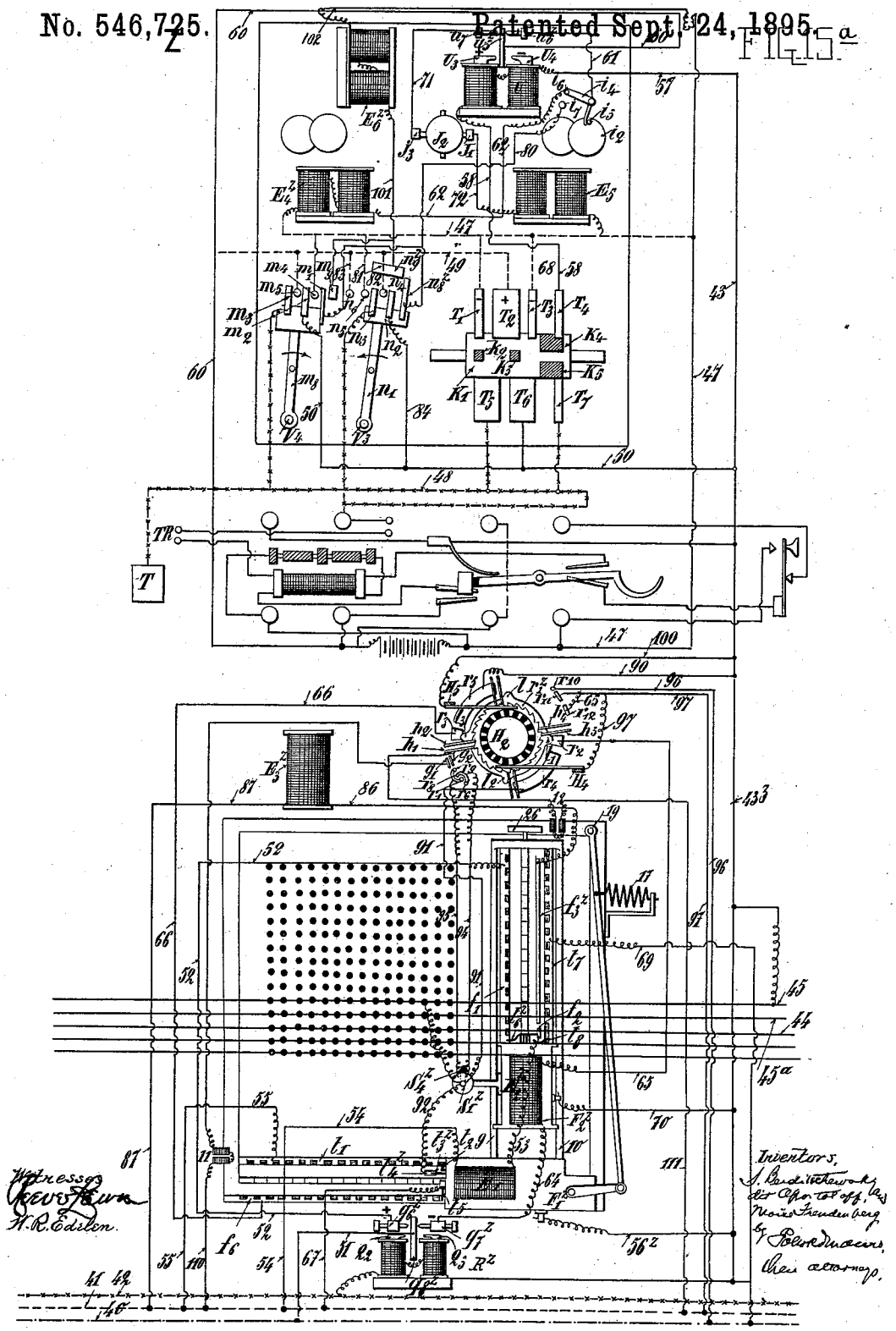
Inventors
S. Berditschewsky dit Apostoloff
By Marie Freudenberg
& Edward Meacci,
their attorneys.

(No Model.) 8 Sheets—Sheet 7.

S. BERDITSCHEWSKY DIT APOSTOLOFF & M. FREUDENBERG.

SELF ACTING COMMUTATOR FOR TELEPHONES.

No. 546,725. Patented Sept. 24, 1895.



Witnesses:
H. R. Edilen.

Inventors:
S. Berditschewsky dit Apostoloff and Moïse Freudenberg
by Poland Duncan
their attorneys.

(No Model.) 8 Sheets—Sheet 8.

S. BERDITSCHEWSKY DIT APOSTOLOFF & M. FREUDENBERG.

SELF ACTING COMMUTATOR FOR TELEPHONES.

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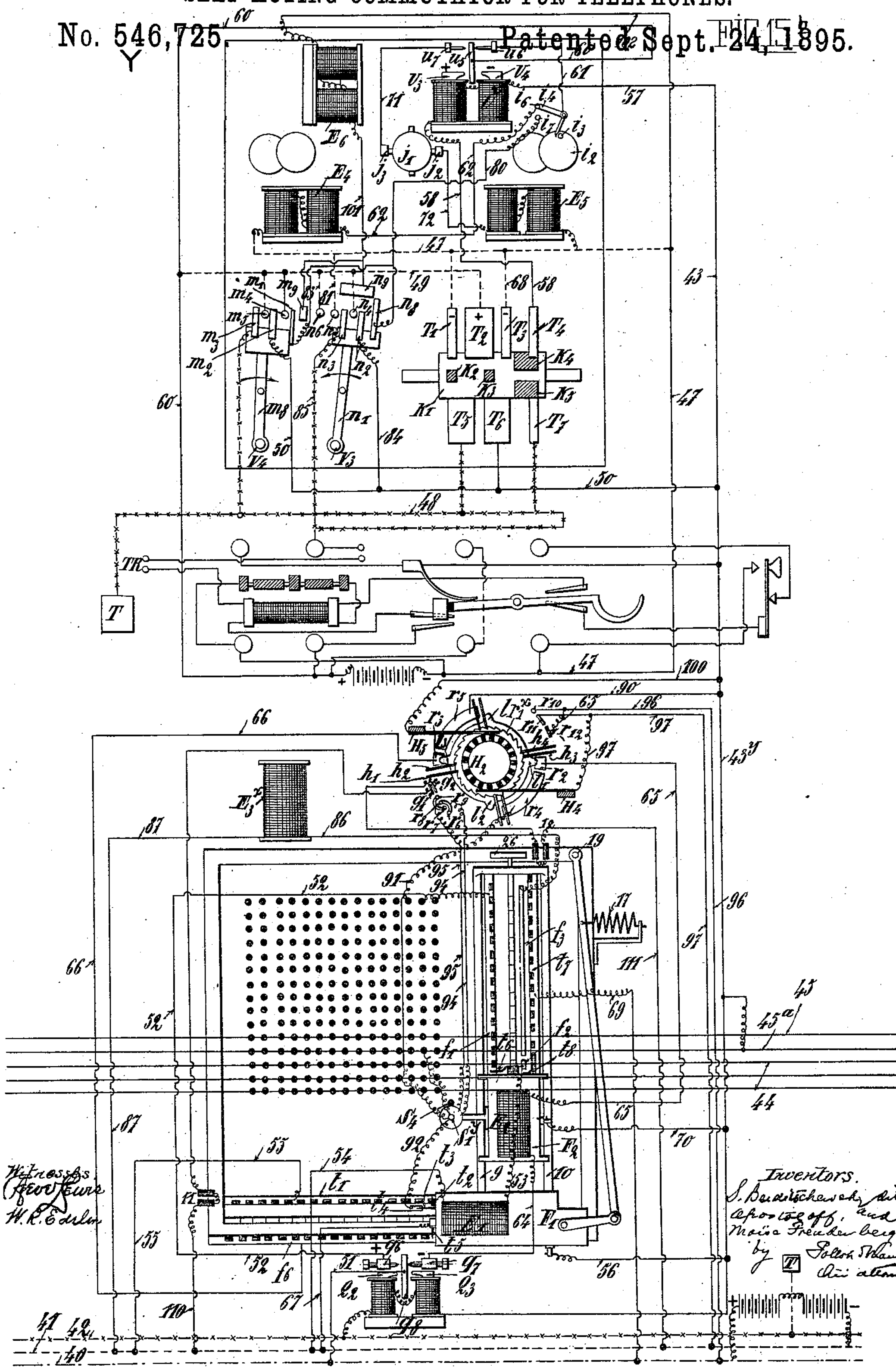

Witnesses

Inventors.
S. Berditschewsky dit Apostoloff, and Moïse Freudenberg
by Pollok & Mauro
their attorneys

ANDREW B. GRAHAM, PHOTO-LITHO. WASHINGTON, D.C.

UNITED STATES PATENT OFFICE.

SALOMON BERDITSCHEWSKY DIT APOSTOLOFF AND MOISE FREUDENBERG, OF PARIS, FRANCE.

SELF-ACTING COMMUTATOR FOR TELEPHONES.

SPECIFICATION forming part of Letters Patent No. 546,725, dated September 24, 1895.

Application filed March 27, 1895. Serial No. 543,412. (No model.)

To all whom it may concern:

Be it known that we, SALOMON BERDITSCHEWSKY DIT APOSTOLOFF and MOISE FREUDENBERG, citizens of the Russian Empire, residing at Paris, France, have invented certain new and useful Improvements in Self-Acting Commutators for Telephones, which improvements are fully described in the following specification.

The central office, which puts the subscribers of a telephonic exchange in communication with one another in conformity with their directions, requires (as ordinarily conducted) a considerable number of employés, whose services are a cause of very large expense, generally, in the working of a telephone-exchange. It is with a view of remedying this inconvenience, and also of increasing the rapidity of telephonic communications, that we have invented the present system of automatic switching apparatus, which permits any subscriber to put himself in communication with any other without requiring the intervention of employés at a central office, whatever may be the number of the subscribers of the exchange.

An automatic switching apparatus for telephones for serving an indefinite number of subscribers should satisfy the following conditions: first, it should require only one wire to a subscriber; second, it should occupy little space, not more in any case than the apparatus which actually exist in central offices; third, the management should be easy, as also repair, in case of derangement; fourth, it should operate with rapidity and with absolute precision, while requiring only a minimum expenditure of electric energy. These are the essential conditions which we have sought to realize in the automatic switching apparatus for telephones which constitutes the present invention.

Before entering into the full study of our apparatus we will first explain the principal means on which it is based. Suppose that in a given room of a telephone-exchange corresponding to the existing central office there is a surface of ebonite or other appropriate material on which, at equal distances apart, are disposed contacts that are connected exclusively each with the wire of a single subscriber's line, and assume for a moment that on this ebonite surface a metallic point connected with a subscriber's wire to whose use the surface and contacts mentioned are appropriated is movable. By providing each subscriber a contact-plate composed of a similar surface and contact at the central office, if any one of the subscribers can at will at his own house shift the corresponding point on the contact-plate he can evidently connect himself with any other subscriber of the exchange without the intervention of an employé, the role of the latter being taken by the devices in question. The point need not be shifted in a straight line, for with a considerable number of subscribers the path which the point would have to traverse would be overlong. To obviate this inconvenience, we have conceived of utilizing a system of co-ordinates, rectilinear or not—that is to say, of giving to the subscriber the ability to shift the point not only in one direction but in two nonparallel directions—say, two lines oblique to each other, or a circle and a radius, or, further, two series of concentric circles. The advantage of shifting the point, not merely in one direction, but in two non-parallel directions, will be at once perceived, if we take perpendiculars as an example. In the first case (one direction only) if the point in being shifted passes over X contacts, it will pass over X^2 in the second case (two non-parallel directions) within substantially the same distance from the starting-point. The displacement of the point in each direction may therefore be small, although there are a large number of contacts on the plate. It only remains, therefore, to find a means whereby the subscriber is able, at his house and with few manipulations, to shift the point above the corresponding plate at the central office to receive signals as required, to establish telephonic communication, and then to return all the parts of the mechanism to their original positions.

Having thus briefly explained the principles of our system of automatic switching apparatus for telephones, we will study in detail those arrangements which we have devised for practically carrying it into effect, reference being made to the accompanying drawings, in which an automatic switching

apparatus in accordance with our invention is illustrated by way of example.

Figure 1 is a plan view of a subscriber's switchboard at the central office. Fig. 1^{bis} is a detail view showing some of the principal parts on a larger scale. Fig. 2. is a front elevation of the switchboard. Fig. 3 is a section on line 1 2 of Fig. 1. Fig. 4 is a detail view, partially in section, of the mechanism for shifting one of the electromagnets above the contact-plate. Fig. 5 is a section on line 3 4 of Fig. 1, showing the carriage of the other electromagnet. Figs. 6 and 6^{bis} are front and side elevations, respectively, of our special electromagnetic relay, whose function will be explained hereinafter. Figs. 7 and 7^{bis} are plan and section, respectively, of a special switch placed at the side of each subscriber's switchboard at the central office. Fig. 8 is a front view of the mechanism at the subscriber's station, the telephonic apparatus of Ader's system, in common use in France, being represented. Figs. 9 and 10 are views, in planes at right angles to that of Fig. 8, of devices at opposite sides of the said mechanism. Figs. 11 and 11^{bis} are plan views showing the commutator belonging to said mechanism in the two positions which it can occupy. Fig. 12 is a perspective view of a sub-station apparatus of Ader's system provided with mechanism in accordance with the present invention. Figs. 13 and 14 are views in plan and section, respectively, of a switchboard at the central office, in which the point, instead of moving in two perpendicular directions, can be shifted about two points taken as centers; and Figs. 15, 15^{a}, and 15^{d} represent, respectively, in diagram, the apparatus at three subscribers' stations X, Y, and Z, with the apparatus corresponding to each at the central office.

In our new or improved automatic switching apparatus there are two parts: first, the apparatus with movable point, which is installed at the central office, and, second, the mechanism or manipulator combined with the telephonic apparatus and placed at the domicile of each subscriber. We will consider successively each of these, and then describe in detail their operation, availing ourselves (for this latter study) of the diagrams Figs. 15, 15^{a}, and 15^{b}.

The movable-point apparatus is composed of two ebonite plates A B and C D, Fig. 3, disposed horizontally one over the other. On these two plates are fixed contacts, (contacts *a* on the upper plate and contacts *b* on the lower plates.)

In the central office there are for each subscriber two metallic bands, one of which passes under all the lower plates at the central office and the other passes over all the upper plates, there being at the central office as many switchboards composed of an upper and a lower plate as there are subscribers' lines. In each switchboard the metallic bands corresponding to each subscriber's line-wire are connected with two contacts, respectively, one contact being in the upper and the other in the lower plate, and so placed as to be in the same vertical line. Between each pair of parallel plates A B and C D moves a point S', which is a permanent magnet loosely placed in the interior of a solenoid S^{2}. According to the direction of the current through the solenoid, the point can move up or down within said solenoid. Normally—that is to say, when the solenoid is without current—the point S', acted upon by a spring, tends constantly to make contact with the lower plate. The point S' forms part of a double carriage system, of which one carriage F', Fig. 1, is movable in the direction M N, while the other carriage F^{2} is movable in the direction K L or in directions parallel thereto. The carriage F^{2} is forced to go with the carriage F', but it is movable in the direction K L (or a parallel direction) independently of the carriage F'. On the carriage F' is mounted the electromagnet E', (see Fig. 4,) provided with an armature 1, held by a spring 2 constantly away from the magnet-poles and against a stop. To the lower end of the armature a pawl 3 is jointed, said pawl having a hook 4 for engaging the underlying ratchet 7. A second hooked pawl 5 is jointed to the carriage at 6 and engages the same ratchet, which extends widthwise of the switchboard. When the electromagnet E' is traversed by a current, it attracts the armature 1 and advances the hook 4 of pawl 3 over the next tooth of the ratchet, which it then engages, so that on the interruption of the current the spring 2 advances the carriage the length of one tooth to the left and at the same time shifts the pawl 5 to a new tooth. At each new passage and cessation of the current the same phenomena are repeated and the carriage F' is advanced step by step, the length of one tooth at each step. By a series of currents, therefore, traversing the electromagnet E', the carriage F' is made to move toward the left an equal number of tooth-lengths.

To the carriage F' are fastened the two horizontal bars 9 and 10, which form the ways for said carriage F^{2} and which support the ratchet therefor. When, therefore, the carriage F' is moved in the direction MN, the carriage F^{2} on the bars 9 and 10 goes with it, and the whole system thus moves to the left across the contact-plate. When the carriage F' has been brought to the position which it should have selectively to the contact-plate, the carriage F^{2} can be moved relatively to the carriage F' by sending a series of currents through the electromagnet E^{2}, which advances the carriage F^{2} step by step along the bars 9 and 10 in a direction parallel to KL in the same manner as the carriage F' is moved in the direction MN. Of course if the carriage F' occupies the position shown in Fig. 1 the carriage F^{2} would move in the same direction of the line KL and not in a line parallel thereto.

In order to make the working clearer by an

example, suppose that a subscriber whose line is served by the switchboard under consideration wishes to bring the point of his board into contact with the wire of another subscriber whose line is connected with that contact which is in the third line from the right of the switchboard and occupies the fifth place from the point in that line. The carriage F′ being at the extreme right and the carriage F^2 at the front of the board, the subscriber will, by the means to be described below, send the currents which shall advance the carriages F′ F^2 three steps to the left and the carriage F^2 four steps back. At this moment the point of his board will make the desired contact, and through it and the electrical connection which it has with the line of the desired subscriber the two subscribers will be put in communication with each other.

At the end of the travel of the carriage F′ is an electromagnet 11, Fig. 1, and an electromagnet 12 is similarly arranged at the end of the travel of the carriage F^2. The object of these magnets is to cause the quick return of the carriages to their respective starting-points. To this end each of these return magnets is provided with an armature 13, which normally holds down the bar 14 against the pressure of a spring 15 that tends to raise it, the bar 14 being fastened to arms of the rock-shaft 14′, which turns in its bearings when the bar 14 is raised or lowered. The spring 15 for the bar 14 of electromagnet E′ is clearly shown in Figs. 1 and 3. So long as the bars 14 are depressed below the level of the ratchet 7 by the armatures of the electro magnets 11 and 12, the pawls of the carriages engage the ratchet-teeth; but as soon as either of these electromagnets receives a current its armature is attracted and releases the corresponding bar 14, which is thereupon raised by its spring 15 and lifts the pawls out of engagement with their respective ratchet, so that the carriage being no longer held by its pawls can be drawn back to its starting-point by a spring. A very powerful spring is used for this purpose, that for returning the carriage F^2 being marked 16 and that for the carriage F′ being marked 17. The spring 16 returns the carriage F^2 when a current passes through the electromagnet 12, and the spring 17 returns the carriage F′ when the electromagnet 11 is energized by a current. The spring 17 is placed near the end of a lever 18, fulcrumed at 19 on the frame of the ebonite plate and connected at 20 by a link with the carriage F′. The spring 17, being placed very near the fulcrum 19, is compressed or expanded through a very small distance for large movement of the carriage F′. For a like reason the spring 16 for returning the carriage F^2 is placed very near the fulcrum 22 of the lever 21, whose free end is connected with the carriage F^2 by a link. The arm 23 on which the lever 21 is fulcrumed is fast on the carriage F′. A small contraction of the spring 16 thus produces a very large movement of the carriage F^2. The point S′ is, of course, supported by the carriage F^2, and to maintain the equilibrium of the whole system, so that the two carriages move always in a perfectly horizontal plane, a wheel 25, Fig. 4, and a slide 25′ are arranged to run on the side MN of the frame of the ebonite plate, and a wheel 26, Figs. 1 and 3, on the opposite parallel side of said frame.

Parallel with the ratchet of carriage F′ are arranged—

First. A metallic plate t', insulated from all the other parts of the mechanism and presenting a series of metallic contacts, Figs. 1^{bis} and 15, between which ebonite or other insulating material is interposed. The metallic parts have the same length as the ebonite parts, and a tooth of the ratchet corresponds to two parts of metallic plate t'—that is to say, to a metallic and an ebonite part. A spring or brush t^2, Figs. 1^{bis} and 15, fastened in the carriage F′, rubs (during the movements of the carriage F′) lengthwise of the piece t', passing thus successively at each shift of the carriage over a non-metallic and a metallic part. When the carriage is at rest, the spring t^2 bears upon an insulating part, and if the carriage F′ advances one tooth of the ratchet the spring t^2 comes again over an insulating part of the piece t', after having crossed over the metallic part comprised between the two insulating parts just referred to. A second spring or brush t^3 is fastened on the carriage F′, in electrical contact therewith. When said carriage is at the beginning of its course—that is to say, before it has been shifted—the metallic spring t^3 is in contact with the the metallic plate t^4, Figs. 1^{bis} and 15; but as soon as the carriage F′ is shifted, even the length of one tooth, the spring t^3 leaves the plate t^4.

Second. A second plate f^6, like the plate t', has a succession of metallic parts with insulating parts of equal length between them, Figs. 1^{bis} and 15. The metallic and insulating parts of the plate f^6 alternate with those of the plate t'—that is to say, (contrary to what has been explained with reference to the plate t',) a metallic instead of an insulating part is placed at the right-hand end of the plate f^6. A metallic spring t^5 (fixed to but insulated from the carriage F′) rubs over this plate during the movements of the carriage F′.

To recapitulate what has been said: At the start—*i. e.*, before any shifting of the carriage F′—the spring t^2 (which is in electrical connection with the carriage F′) bears on an insulating part of the plate t', the spring t^5 (which is insulated from the carriage F′) bears on a metallic part of the plate f^6, and, lastly, the spring t^3 (which is in electrical connection with the carriage F′) is in contact with the plate t^4. When the carriage F′ has advanced the length of a ratchet-tooth, the springs t^2 and t^5 occupy like positions, but the spring t^3 is no longer in contact with the plate

l^4. During this advance of the carriage F′, the spring l^2 passes over a metallic part of the plate l' and the spring l^5 passes in like manner over an insulating part of the plate f^6.

Referring now to the carriage F^2, the following devices are arranged parallel with the ratchet corresponding with this carriage and lengthwise of which said carriage moves, namely:

First. A plate f', similar to the plate f^6 and commencing, like it, with a metallic part. Over this plate rubs a brush composed of one end of the spring l^6, which is fastened to the carriage F^2, with insulating material interposed, and whose other end rubs over a metallic band f^3, Figs. 1bis and 15. This band, however, commences with the second tooth of the ratchet, and at the start, when the carriage F^2 has not moved, the brushes composing the spring l^6 are in contact one with a metallic part of the plate f' and the other with a plate f^2. When the carriage F^2 has been shifted the length of one tooth, one end of the spring l^6 breaks contact with the plate f^3 just above mentioned.

Second. A plate l^7, Figs. 1 and 1bis, similar to the plate l', and like it commencing with an insulating part; but the first metallic part corresponds with the second tooth of the ratchet. Commencing with the second movement of the carriage F^2 a spring-brush l^8 moves lengthwise of this plate l^7.

The object of these different plates will be explained below, when we come to consider the electrical connections.

Outside of the ebonite plate over which the carriages are shifted, and very near said plate, is a third electromagnet E^3, Fig. 15, which on the passage through it of an electric current attracts the armature 27, Fig. 13. This armature is provided with an extension 28, Figs. 7 and 13, which carries a link 29, at the extremity of which is a pawl 30 for acting upon the ratchet-wheel H′, Fig. 7, keyed on the vertical axle O^3. On the attraction of the armature 27 the link 29 descends and forces the pawl 30 to turn the wheel H′ in the direction of the hands of a watch. A stop-pawl 30′ acts as a brake and regulates the rotation of the ratchet-wheel H′, so that it turns one tooth at each attraction of the armature 27. On the axle O^3 (which is put into motion by the ratchet-wheel H′) are fastened, first, a metallic wheel r', Figs. 7 and 7bis, insulated from the axle O^3 and provided with four projecting parts $l\ l'\ l^2\ l^3$, placed at the ends of two diameters at right angles to each other. Second, an ebonite wheel H^3, which carries four metallic strips forming two groups of two parallel strips each, the two groups being perpendicular to each other. The ends of these strips $h'\ h^3$, $h^2\ h^4$, $h^3\ h^5$, and $h^6\ h^7$ are curved downward, Fig. 7bis, and are adapted to rub over a number of electrical contacts, as explained below. So also are the projections $l\ l'\ l^2\ l^3$ of the ring r', it being understood that the ends of the metallic strips of the wheel H^3 cannot touch the contacts over which the projections $l\ l'\ l^2\ l^3$ move, and, reciprocally, that these projections cannot touch the contacts over which move the ends of the metallic strips. Third, the ratchet-wheel H′, before mentioned. This wheel is fastened directly on the axle O^3, without interposition of insulating material. It has twenty teeth. Fourth, in the last place, wholly above the ratchet-wheel H′ and out of contact with it, is a disk H^2, whose circumference is divided into forty parts, of which twenty are metallic and twenty of insulating material. Two brushes H^4 and H^5, Fig. 7, rub on the circumference of this wheel. The object of all of these wheels will be explained below in considering the electrical communications.

At the side of each ebonite plate is the special electromagnet-relay R, Figs. 6, 6bis, and 15, which is arranged as follows: It is in the form of a horseshoe, and one of its poles is divided into two branches $Q^2\ Q^3$, on which are the bobbins $q'\ q^2$. Above the horseshoe is an ebonite plate q^3, over which are fastened two metallic bars $q^4\ q^5$, provided with adjustable contact-screws q^6 and q^7. Between the branches Q^2 and Q^3 is a small armature q^8, movable about a pivot q^9 and passing through a hole in the upper pole of said magnet R. The wires of bobbins $q'\ q^2$ are so wound that when they are traversed by a current in a given direction one of them (say the bobbin q') tends to strengthen the magnetism of the core Q^3, while the other q^2 tends to weaken the magnetism of the core Q^2. If the current be in the opposite direction, the magnetism increases in the core Q^2 and diminishes in the core Q^3. It follows from this that in the first case the armature q^8 is attracted toward the core Q^3 and in the second case toward the core Q^2. To prevent the armature sticking to the cores it is provided with small springs q^{10}. If the subscriber whose line enters this electromagnetic relay sends positive or negative currents through the bobbins q' and q^2, the armature q^8 is attracted toward one or the other of the cores and touches at its upper part the contact-piece q^6 or q^7, according to the direction of the current. The armature q^8 being connected, as indicated in Fig. 15, with the positive pole of the central-office battery, the battery-current therefor will be directed, according to the position of the armature, either to the screw q^6 or the screw q^7. The object and operation of this relay will be considered below in explaining in detail the electrical connections of the central office.

The apparatus at the subscriber's house may, in a telephonic point of view, be of any system. In the description it will be supposed that the telephone employed is of the Ader system, (generally adopted in France;) but it should be observed that our invention has nothing to do with the telephonic apparatus proper, but only with certain accessory arrangements, and that these may be used in conjunction with no matter what telephonic

apparatus, as well as with that of the Ader system.

All the mechanism which we add to the telephonic apparatus is arranged above the telephones in a box, on the face of which are placed diverse buttons and indicators for the manipulation of our system. This mechanism is composed, essentially, of an electromagnetic relay U, Fig. 8, identical with the electromagnet R at the central office, of three ordinary electromagnets E^4 E^5 E^6, and of a commutator K′. (Shown in detail in Figs. 11 and 11^{bis}.) This commutator consists, essentially, of a drum of insulating material, with two metallic bars K^2 K^3 of rectangular cross-section extending through it. These are insulated from each other and form at the surface of the cylinder four metallic contacts. Two other metallic contacts K^4 and K^5 are, moreover, fastened to this ebonite cylinder and are connected electrically with each other by a wire which goes through the commutator-drum. The two plates K^4 and K^5 extend, as shown in Fig. 11, around the drum, except for two spaces corresponding with the ends of the bars K^2 and K^3. About the cylinder of the commutator are arranged the springs T′ T^2 T^3 T^4 T^5 T^6 T^7. These press against the cylinder, are insulated from one another, and are connected in circuit, as explained below. On one end of the commutator-shaft is fastened the toothed wheel P^4, which meshes with the toothed wheel P^2, keyed on an auxiliary shaft, Fig. 8. The toothed wheel P^3 is keyed on the same shaft and engages the toothed wheel P′, which is subjected to the action of a spiral or other spring tending to turn the wheel P′, and consequently the commutator K′. The spiral spring is rewound when necessary by means of a crank P, Fig. 12, on the front face of the box which holds the mechanism.

As shown in Fig. 11, commutator K′ is so mounted as to be movable in the direction of its axis. Normally it is constantly pressed against the front face of the box by the action of the spring 34, and it is prevented from turning by the pin v^4, which is inserted into one of the holes v^5 in one of the faces of the commutator, Fig. 8. So long as the operator fails to press the button V′ the pin v^4 remains in its hole v^5 and holds the commutator from turning; but on the operator pressing in the button V′ the lever v^3 is turned on its fulcrum, the pin v^4 is withdrawn from the hole v^5, and the commutator begins to turn under the action of the spiral spring. If instead of pressing in the button V′ the operator presses upon the button V^2, he will turn the lever v^6 on its fulcrum, as shown in Figs. 11 and 11^{bis}, and this will act upon the lever v^7, which will shift the commutator in the direction of its axis, at the same time compressing the spring 34. By this lateral shifting of the commutator the pin v^4 is freed from the hole v^5 in which it has been, so that the commutator is again free and can turn under the action of the spiral spring. In this latter case, the commutator being shifted lengthwise of its axis, the position of the bars K^2 K^3 and plates K^4 K^5 will be altered selectively to the contact-springs T′ T^2 T^3, &c. The purpose of this will be explained below. Three other buttons V^3 V^4 V^5 are arranged on the apparatus, the button V^3 connected with the end of lever n', which carries three fingers or metallic contacts n^2 n^3 n^8. Normally—that is to say, when no pressure is exerted on the button V^3—the lever n' is maintained by spring n^7 in the position shown in Fig. 9; but if the operator presses upon the button V^3 the lever n' will turn on its fulcrum and will bring the finger n^8 in contact with the plate n^9 and will cause the fingers n^3 n^2 to make contact, successively, with the plates n^4 n^5 n^6. On removing the pressure on the button V^3 the spring n^7 will bring the lever n' back to its primitive position. The button V^4 is connected with the end of a lever m^8, Figs. 8 and 10, which has three fingers or contacts m', m^2, and m^3 at its other end. By exerting a pressure on the button V^4 the finger m^2 is brought into contact with the plate m^5. By continuing the pressure the finger m' is brought into contact with the plate m^9, finger m^2 into contact with plate m^4, and finger m^3 into contact with plate m^5. On removal of the pressure the lower lever m^8 will return to its primitive position under the influence of the spring m^7, and during such return the finger m' will abandon the plate m^9, while the fingers m^2 m^3 will pass again over the plates m^4 and m^5.

It has been said above that the essential organs of the mechanism of the subscriber's house apparatus were an electromagnetic relay U, identical in construction with the electromagnet R, and three ordinary electromagnets E^4 E^5 E^6. The electromagnet U, like that before described, has for its object to distribute the currents. The electromagnet E^4 controls an armature e^4, to which is jointed a link p', connected at its upper end with a bar p^3, that carries a pawl p^2 and is pivoted on the shaft W′. A spring constantly holds the pawl against the teeth of the ratchet-wheel W^2. On sending a current into the electromagnet E^4 the armature e^4 is attracted and the link p' and pawl p^2 are drawn down, the pawl riding idly over a tooth of the ratchet-wheel. As soon as the attraction of the electromagnet E^4 ceases, through the interruption of the current, the spring W^5 returns the armature e^4 and pawl p^2 and turns the wheel W^2 one tooth. The shaft W′ of the ratchet-wheel W^2 has mounted thereon a circular plate W^3, provided near its circumference with a pin W^6. When the wheel W^3 makes a complete revolution, the tenon, meeting the teeth of the wheel W^4 at its side, will turn this latter one tooth. It will be readily understood, without its being necessary to dwell overlong upon it, that if the shafts of wheels W^4 W^2 carry disks on which are inscribed the figures "1," "2," "3," "4,"

"5," "6," "7," "8," "9," "0," these two disks can indicate the number of currents which traverse the electromagnet E^4, one of them exhibiting units and the other tens, provided the ratchet-wheel W^2 has ten teeth, and also the wheel W^4. The counting-wheels W^2 W^4 can evidently be supplemented by a third wheel for hundreds, and so on. They constitute, in fact, the mechanism of the ordinary register for indicating the number of rotations. In the front face of the box which holds the sub-station apparatus are two openings d' and d^2, through which the operator can observe the numbers of the just-mentioned disks as they pass in succession.

The electromagnet E^5 controls a system of toothed wheels identical in construction with that just described, so that the operator can, in like manner, by observation of the number appearing at the openings d^3 d^4, note the number of currents which have passed through the coils of electromagnet E^5. It is well to mention, however, a peculiarity in the system of toothed wheels belonging to the electromagnet E^5. When the two disks are at zero—that is to say, when no current has traversed the electromagnet E^5—a pin i^3, fixed on the wheel i^2, holds the bent lever i^4 in the position shown, notwithstanding the pressure of spring i^5; but so soon as the wheel i^2 has been turned one division by the excitation of the electromagnet E^5 said lever i^4, being no longer held by the pin i^3, turns on its fulcrum i' under the force of spring i^5, Fig. 8. The upper arm of the bent lever rests upon the contact i^6 in the position shown; but it leaves the contact i^6 and moves over to the contact i^7 when the lever i^4 is released by the pin i^3. The object of this change of electrical connection will be explained below.

The electromagnet E^6 is arranged to attract an armature l^7, and thus, through the link l^8, to turn the lever l^9, which is pivoted on the shaft j^4 and carries the pawl l^4. This last is so arranged that when the armature l^7 is attracted it rides idly over the teeth of ratchet-wheel l^5. A spring l^6 brings the armature l^7 back to its first position on the cessation of the current in the coils of the electromagnet E^6, and in so doing it causes the pawl l^4 to turn the ratchet-wheel l^5 one tooth. This ratchet-wheel is mounted on the shaft j^4, which carries, moreover, a gear-wheel for engaging the wheel j^6. On the same shaft as the wheel j^6 a wheel j' is mounted, which is provided with four projections at the ends, respectively, of two diameters which cross each other at right angles. Two of these projections (at opposite ends of the same diameter) are in contact with the metallic plates j^3 j^2, Fig. 8, when the apparatus is not in operation. The wheel j' carries on its front face a disk divided into four sectors, which have, respectively, the inscriptions "Rest," "Call," "Ring," "Talk," or the like. The operator can see the inscriptions one at a time through the window d^5. At the start, before any current has passed through the electromagnet E^6, the word "Rest" is visible through the window d^5.

The button V^5 at the side of the apparatus is for bringing the wheels back to zero, which are controlled by the electromagnets E^4 E^5. It is not important to use this button in connection with the numbering-wheels, but any appropriate arrangement can be employed.

Having thus described the different organs which go to make our new system of automatic switching apparatus for telephones, their operation will next be described, together with the electrical connections of the different organs. To facilitate this explanation there is represented diagrammatically on Figs. 15, 15^a, and 15^b, first, a central office with three subscribers' switchboards; second, the three sub-station apparatuses at the subscribers' houses. It should be observed, however, that the central office, such as herein described for three sub-stations, can, without other modification, receive two hundred and twenty-two additional switchboards, each of the switchboards represented in this figure having two hundred and twenty-five available contacts and each subscriber being thereby able to put himself in connection, at his fancy, with any one of two hundred and twenty-four subscribers, and it being understood that what is said about the lower plates C D applies to the upper plates.

The central-office battery is divided into two parts, as shown in Figs. 15, 15^a, and 15^b. The wire 40 corresponds with the positive pole of the battery, the wire 41 with the negative pole, and the wire 42 being grounded.

Taking the switchboard X and the corresponding sub-station, the electrical connections will be explained with reference to them, and these connections, it will be understood, are similarly established on the switchboards Y and Z and the sub-station apparatus corresponding thereto, respectively.

The line-wire 43 enters the central office and terminates in the metallic band 44, extending below all the switchboards of the office and having a terminal contact in every one of them at a position assigned in them to the subscriber X. In the example chosen all the contacts whose abscissas are 4 and the ordinates 3 are connected with the band 44, constituting a prolongation of the line-wire of the subscriber X. The band 45^a, which corresponds with the line-wire of subscriber Y, is in like manner in communication with all the contacts which in the several switchboards have 2 for their abscissas and 4 for their ordinates. Similarly the band 45, which corresponds with the line-wire of subscriber Z, is connected with all the contacts which in the several switchboards of the office have 3 for their abscissas and 5 for their ordinates. The line-wire 43 of subscriber X is also connected with the coils of the relay R, and through such coils and the wires 46 and 42 is led to ground. Suppose the subscriber X wishes to put himself in communication with the subscriber Z,

the contacts of whose line-wire are represented by the fraction $\frac{3}{5}$—that is to say, 3 for the abscissas and 5 for the ordinates, for it should be understood that the subscriber of an exchange on the present system, in place of being designated by a number, would be designated by a fraction whose numerator would represent the abscissas and the denominator the ordinates of the appropriate contact on the switchboards. The subscriber X should then, to bring the movable point S′ of his switchboard over the contact corresponding with the line of subscriber Z, cause said point to move three steps in the direction of abscissas and six steps in that of ordinates, for the point S′, when at rest, touches the plate S^4, which has a length of two contacts in the direction of ordinates, so that to arrive at the first line of abscissas the point S′ must travel two steps in the direction of ordinates. By pressing on the button V′ at his sub-station the subscriber X frees the commutator K′ of the sub-station apparatus, (as before explained,) and this turns so long as the subscriber X continues to press in the button V′. As the commutator is put into motion the ends of the bar K^2 are brought into contact with the springs T′ and T^5, while the ends of bar K^3 come into contact with the springs T^2 and T^6. The spring T′ is connected by the wire 47 with the negative pole of the sub-station battery and the spring T^5 is grounded by the wire 48. Hence the contact of the ends of bar K^3 with the springs T^2 and T^6 serves to ground the negative pole of the sub-station battery. The spring T^2 is connected by the wire 49 and 60 with the positive pole of the battery and the spring T^6 is connected by the wire 50 with the line-wire 43. Hence the contact of the ends of the bar K^3 with the springs T^2 T^6 puts the positive pole of the battery to line. A positive current therefore travels over the line 43 and passes through the coils of relay R and wires 46 and 42 to the ground, which conducts it to the wire 48, and it then goes by the spring T′, bar K^2, spring T^5, and wire 47 to the negative pole of the battery. Under the influence of this current the armature q^8 of the relay is attracted by the core Q^3 and the upper end of said armature touches the screw q^6. The armature q^8 is permanently connected by the wire 51 with the positive pole of the central-office battery and the screw q^6 is connected by the wire 52 with the plate f'. A current therefore travels by way of the wire 51, armature q^8, screw q^6, and wire 52 to the plate f'. From the plate, Fig. 1^{bis}, the brush t^6, in contact with a metallic part of said plate, delivers the current to the plate f^2, (inasmuch as the carriage F^2 has not yet moved.) Thence the current passes by the wire 53 to the electromagnet E′, and after passing through its coils it returns by the wires 54 and 41 to the negative pole of the battery. The electromagnet E′ is thus energized and attracts the armature and pawl ready to shift the carriage F′ a tooth of the ratchet 7, Fig. 1, so soon as the current shall be interrupted.

In Fig. 15 the organs of the switchboard of subscriber X are shown in the position occupied after the carriage F′ has been advanced three steps and the carriage F^2 six steps, while the organs of the switchboards of subscribers Y and Z are in their initial positions.

As the positive current sent to line by the commutator K′ ceases (that is to say, as soon as the ends of the bar K^3 are no longer in contact with the springs T^2 and T^6) the armature q^8, being no longer attracted by the core Q^3, resumes its first position between the two cores and the circuit of the armature E′ is broken and the carriage F′ is advanced one step. This circuit will not be closed again until after a semirotation of the commutator, when contact is made again between the ends of the bar K^3 and the springs T^2 T^6 and a positive current sent, as before, through the relay R. Reverting now to the central office at the moment when the first positive current from the subscriber's station stops—that is to say, when the ends of the bar K^3 have left the springs T^2 T^6—the circuit of the electromagnet E′ is interrupted and the carriage F′ advances a tooth on the ratchet 7, as has been already stated; but during this advance the brush t^2 on the carriage F′ has rubbed over a metallic part of the plate t', and consequently has put the carriage F′ in electrical connection, by the wire 55, with the negative pole of the central-office battery. The carriage F′ is connected by the wire 56 with the line 43, and consequently on the passage of the brush t^2 over a metallic part of the plate t' the line 43 is put into connection with the negative pole of the central-office battery. A negative current therefore enters the relay U by the wire 57, passes through its coils, goes by the wire 58 to the spring T^4, passes between plates K^4 and K^5 of the commutator, and goes by spring T^7 and wire 48 to the ground, which returns it to the battery at the central office. It will be observed that the plates K^4 and K^5 only allow the circuit of the relay U to be closed when the bars K^3 K^2 of the commutator are not in position to send a current to line, or, in other words, when there is no current on the line, since the intervals between the plates K^4 and K^5 correspond, on the circumference of the commutator, with the ends of the bars K^2 and K^3. The before-mentioned negative current causes the relay U to attract its armature u^5 toward the core U^3 and to bring its upper end against the screw u^6, and, inasmuch as the said armature is connected by the wire 60 with the positive pole of the sub-station battery, a current is thereby sent over wire 60, screw u^6, and wire 61 to lever i^4, thence by contact i^6 and wire 62 to the electromagnet E^4, thence, after traversing its coils, by the wire 47 to the negative pole of said battery. This electromagnet is thereby energized and attracts its armature e^4, which on its release advances the wheel W^2, as be-

fore described, and thereby causes the figure "1" to appear at the window d^2. It should be observed that the negative current from the wire 56 divides, a part only passing through the relay U, the other part passing the relay R at the central office. The armature q^8 is then attracted toward the core Q^2 and touches with its upper end the screw q^7, which is connected by the wire 64 with the electromagnet E^2. This last is in its turn connected by the wire 65 with the contact r^2, Figs. 15, 7, and 7^{bis}, which at this moment is in electrical connection, by the projections $l' l^3$ of the wheel r', with the contact r^3, that is connected by the wire 66 with the plate f^6, Fig. 1^{bis}. To this point, therefore, the circuit of the electromagnet E^2 is closed from the central-office battery by wires 40 and 51, armature q^8, screw q^7, wire 64, electromagnet E^2, wire 65, contact r^2, wheel r', contact r^3, wire 66, and plate f^6; but at the moment when a current might otherwise pass—that is, when the negative current is sent from the central office to the subscriber's station—the spring l^5, which is connected by the wire 67 with the negative pole of the central-office battery, is in contact solely with an insulating part of the plate f^6, so that at this moment the circuit of the electromagnet E^2 is open at the plate f^6, and it hence follows that the negative current sent from the central office to the sub-station by the central-office battery has no effect on any organ at the central office, except to produce an idle movement of the relay R.

After the action of the negative current on the electromagnet E^4 has taken place a new positive current is sent from the sub-station to the central office through the continued rotation of the commutator-drum K', and this is followed by a negative current from the central office to the sub-station, and this succession of a positive followed by a negative current is continued so long as the subscriber pushes in the button V'. In the case supposed the subscriber would release the button as soon as the figure "3" should appear at the window d^2, since the abscissa of the subscriber Z, with whom the subscriber X is supposed to wish to communicate, is equal to three.

After releasing the button V' the subscriber will press in the button V^2. The pressure exerted on this button V^2 has the effect (indicated in Fig. 11^{bis} and hereinbefore referred to) of moving the commutator, so that the ends of the bar K^2 will (through the rotation of the commutator-drum K') make contact with the springs T^2 and T^3, while the ends of the bar K^3 will make contact with the springs T^3 and T^6. Pressure on the button V^2 also has the effect of freeing the commutator-drum (as before described) and allowing it to rotate.

The rotation of the commutator, when pressed back by means of button V^2, first brings the ends of the bar K^2 in contact with the springs T^2 T^5 (which will have no effect on the line, but simply ground the positive pole of the battery) and the ends of the bar K^3 in contact with the springs T^3 and T^6. As the spring T^3 is connected by the wires 68 and 47 with the negative pole of the sub-station battery and the spring T^6 with the line, a negative current will be sent from the sub-station battery over the line to the relay R at the central office and will return by the ground and the springs T^2 T^5. Such current causes the relay R to attract the armature q^8 toward the core Q^2 and to bring the upper end of said armature against the screw q^7. The making of this contact completes the circuit of the electromagnet E^2, which circuit includes the wire 64, (from the screw q^7,) the electromagnet E^2 itself, the wire 65, contact r^2, the projections l' and l^3 of wheel r', the contact r^3, the wire 66, the plate f^6, the spring l^5, and the wire 67. This circuit is now complete when the armature q^8 touches the screw q^7, because the spring l^5 is in contact with a metallic part of the plate f^6. The electromagnet E^2 is thus traversed by a current which retracts the armature of said magnet for feeding the carriage F^2 a tooth of its ratchet, as before explained. When, through the rotation of the commutator, the ends of the bar K^3 leave the springs T^3 and T^6, the negative current stops, the armature q^8 resumes its position, and the circuit of the electromagnet E^2 is opened. The commutator K' continuing to turn a second negative current is sent from the subscriber's station to the central office and the carriage F^2 advances a second tooth; but at this instant a return current, like that sent when the button V' was pushed in, although by another part of the apparatus and of the contrary polarity, (being positive now instead of negative, as before,) is sent automatically from the central office to the sub-station in the following manner: The plate l^7, over which the spring l^8 on the carriage F^2 slides, is connected by the wire 69 with the positive pole of the central-office battery, while the carriage F^2 is connected by the wire 70 with the line-wire 43. Therefore at the moment when the spring l^8 on the carriage F^2 passes over a metallic part of the plate l^7 a positive current from the central-office battery passes over the wire 69, plate l^7, spring l^8, carriage F^2, wire 70, and line 43 to the relay U at the subscriber's station. This current passes through the coils of the relay U, and goes thence by wire 58, spring T^4, metallic pieces K^4 K^5, spring T^7, and wire 48 to the ground, which conducts it back to the central office. This positive current passing through the relay U causes it to attract its armature u^5 toward the core U^4 and to bring its upper end against the screw u^7, whereupon, as has been before shown, the circuit of the electromagnet E^5 will be closed, the armature u^5 being connected (as said before) by the wire 60 with the positive pole of the sub-station battery. The current passes by wire 60, armature u^5, screw u^7, wire 71, plate j^3, wheel j', plate j^2, wire 72, electromagnet E^5, and,

finally, the wire 47, which terminates at the negative pole. The current in traversing the electromagnet E^5 attracts its armature ready for its release to cause the figure "1" to appear at the window d^4. So long as the operator's finger holds in the button V^2 the same phenomena are repeated in the same order—that is to say, a negative current will go from the sub-station and a positive current (which is a sort of controlling-current) will come back from the central office for indicating to the subscriber the number of steps taken by the carriage F^2. For reasons like those given above the positive current sent from the central office to the sub-station produces no effect on the organs at the central office beyond the contact of the armature q^8 with the screw q^6, for (the carriage F^2 being moved) the spring t^6 is no longer in contact with the plate f^2, (which is connected with the electromagnet E',) but with the plate f^3, and, moreover, at the moment of sending the positive current the other end of the spring t^6 is moving over an insulating part of the plate f'. The circuit of the electromagnet E is therefore interrupted at both points and no current can pass through it. The subscriber continues to press with his finger on the button V^2 until he sees through the windows d^3 d^4 a number equal to the denominator of the fraction of the subscriber with whom he wishes to be put in communication. In the case supposed of his wishing to be put in communication with the subscriber Z he would retain his finger on the button until the figure "5" appeared at the window d^4. At this instant the point S' of X's switchboard will be on the fifth line of abscissas, although the carriage F^2 has advanced six steps, for it should be observed that the first step of the carriage F^2 sent no controlled current to the sub-station, the point t^8 being out of contact with a metallic part of the plate t^7 during such first step. These primary operations having been effected, the point S' will be on that contact of the subscriber X's switchboard which is connected with the line-wire of the subscriber Z. When the subscriber X has placed his point S' on the proper contact, the present function of the electromagnets ceases, since they have no other purpose than to move the carriages F' F^2. Their circuits should therefore be broken, or, in other words, these electromagnets should be blocked. So far as the electromagnet E' is concerned this has been already effected, for from the time when the carriage F^2 has passed over the first tooth of its ratchet—that is to say, after it has abandoned its initial position—the spring t^6 has left the plate f^2, which is connected with the coils of the electromagnet E', and has been transferred to the plate f^3, which is connected with the coils of the magnet E^3. The spring t^6 rests in contact with this plate f^3 unto the end of the travel of the carriage F^2. It follows from this that positive currents acting on the electric relay R would no longer cause the excitation of the electromagnet E', but of the electromagnet E^3, provided such positive currents were sent at a time when the spring t^6 touched a metallic part of the plate f'.

In an analogous way the circuit of the electromagnet E^4, which is at the subscriber's station and which corresponds with the electromagnet E' at the central office, has had its connection with the screw u^6 interrupted, for as soon as the wheel i^2 has turned a tooth the lever i^4, being no longer held by the pin i^3, is turned by the spring i^5 and made to rest upon the contact i^7, so that the screw u^6, in place of connecting with the electromagnet E^4, connects by the wire 61, lever i^4, contact i^7, and wire 80 with the finger n^8, fastened to the end of the lever n', which is controlled by the button V^3. As explained below, this finger n^8 closes at the proper time the circuit of the electromagnet E^6. The electromagnet E^3 at the central office serves in its turn to break the circuit of the electromagnet E^2, the action being as follows: After the subscriber X has ceased to press in the button V^2 he presses in the button V^3 in order to send to the central office, first, a positive current; second, a negative current, and, third, a positive current again. When the lever n' turns on its fulcrum in the direction of the arrow, Fig. 15, the fingers n^2 n^3 slide over three metallic contacts n^4 n^5 n^6. The contact n^5 is connected with the negative pole of the sub-station battery by the wires 81 and 47 and the contacts n^4 and n^6 with the positive pole by the wires 82 and 83. The lever n', when turned by the pressure on the button V^3, brings the finger n^2 over the contact n^4 and the finger n^3 over the contact n^5. Since the finger n^2 is connected by the wires 84 and 50 with the line and the finger n^3 by the wires 85 and 48 with the ground, when they touch the contacts n^4 n^5, respectively, a positive current is sent over wire 82, contact n^4, finger n^2, wires 84 and 50, line 43, relay R, wire 46 to ground, from ground to wires 48 and 85, finger n^3, contact n^5, and wires 81 and 47. The fingers n^3 n^2 are of course insulated from the lever n'.

The positive current energizes the relay-electromagnet R and causes the armature to make contact with the screw q^6, thereby closing the circuit of the electromagnet E^3. This circuit includes the wire 51, the armature q^8, the screw q^6, the wire 52, the plate f', the spring t^6, the plate f^3, the wire 86, the electromagnet E^3, the wire 87, and, lastly, the wire 41, which terminates in the negative pole of the battery. The positive current in passing through the electromagnet E^3 produces the attraction of its armature 27, Fig. 13, moving it and the armature-lever 28, Figs. 7 and 13, and forcing down the link 29 and pawl 30, so as to turn the ratchet-wheel H' one tooth.

The ratchet-wheel in turning carries with it the shaft O^3, (on which it is fixed,) and consequently the wheel r' will be moved also an amount which corresponds with a tooth of the

ratchet-wheel. The projections l' l^3 leave the contacts r^2 r^3 and make connection with contacts r^4 r^5. The action of the positive current sent through the electromagnet E^3 is therefore to open the circuit of the electromagnet E^2, which is thus blocked and further movements of the carriage F^2 prevented. In addition to this the positive current causes the movement of the wheel r' and brings the projections l' l^2 over or into connection with the contacts r^4 r^5. The contact r^5 is connected by the wire 90 with the line-wire and the contact r^4 with the point S′ by the wire 91. Besides the connection between the point S and the contact r^4 this point S′ is connected by the wire 92 with a plate t^4, which makes contact with the point t^3, Figs. 1 and 15, fast on the carriage F′, that is itself connected to line by line-wire 56, so that when the carriage F′ is in its original position, Fig. 1^{bis}, the point S′ is in electrical connection with the line by the wire 92, the plate t^4, the point t^3, the carriage F′, and the wire 56; but as soon as the carriage F′ is shifted, as a result of the action of the subscriber's finger on the button V′, the point t^3 leaves the plate t^4, and the point S′ is thus, after the first step of carriage F′, without a line connection until such a connection is re-established by the electromagnet E^3, as just described. This temporary interruption is made between the point S′ and the line in order to eliminate the influence of the currents which serve to shift the point over the contacts of the ebonite plate, for otherwise these currents, entering the contact-line of some other subscriber, would pass to the point of this subscriber, and from there into the aerial conducting-wire, thus putting in motion apparatus foreign to the communication desired.

The movements of the distributing-wheel r' are governed automatically from the subscriber's station. The shaft O^3 has keyed thereon, as before explained, a wheel H^2, whose circumference is provided with alternate metallic and insulating parts. Two brushes H^4 and H^5 bear on this wheel. One of these brushes H^5 is connected by the wire 100 with the line-wire 43, whereas the other brush H^4 is connected by the wire 97 with the negative pole of the central-office battery. Before the wheel r' has moved—that is to say, while the projections l' and l^3 are over, respectively, the contacts r^2 and r^3—the brushes H^4 and H^5 bear on portions of insulating material, and consequently nothing happens. When the wheel r' turns one tooth, the wheel H^2 turns equally, and the brushes H^4 and H^5 rub during this movement over metallic portions to come to rest upon portions of insulating material. A circuit is thus established during said movement, which circuit includes the battery, the wire 97, the brush H^4, the wheel H^2, the brush H^5, the wire 100, the line-wire 43, the wire 57, the electromagnet U, the wire 58, the spring T^4, the plates K^4 K^5, the spring T^7, and wire 48 to ground. The circuit of the electromagnet U is therefore closed when the brushes H^4 and H^5 bear upon the metallic parts of the wheel H^2, and the electromagnet U is traversed at this moment by a negative current coming from the central office. The armature u^5 then comes into contact with the screw u^6, which closes the circuit of the electromagnet E^6, this circuit being composed of the wire 60, (leading from the positive pole of the sub-station battery,) the armature u^5, the screw u^6, the lever i^4, the contact i^7, the wire 80, the finger n^8, the plate n^9, the wire 101, the electromagnet E^6, and the wire 102, which leads to the negative pole of said battery. The circuit of the electromagnet E^6 being thus closed it attracts its armature, and when the current stops the ratchet-wheel l^5 is turned by the spring l^6 and pawl l^4. The wheel j^6 is mounted on the same shaft as the ratchet-wheel l^5, and a wheel j', divided into four sectors, is controlled by a toothed wheel keyed on the shaft of wheel j^6, so that when the ratchet-wheel has turned a tooth the wheel j' is shifted a quarter of a turn. The wheel j' is divided into four sectors, on which are the following inscriptions, respectively—namely, "Rest," "Call," "Ring," and "Talk." At each turn of the wheel j' these inscriptions (commencing with "Rest") appear, one after the other, at the opening d^5.

The object of these inscriptions is as follows: When the sub-station apparatus is in the state of rest, the inscription "Rest" is shown through the opening d^5, and so remains exposed while the subscriber is manipulating the buttons V′ V^2. When he presses on the button V^3, as we have seen, the first negative current sent from the central office to the sub-station closes the circuit of the electromagnet E^6, thereby turning the ratchet-wheel l^5 one tooth and the wheel j' a quarter-turn and bringing the inscription "Call" into view through the opening d^5. After having thus examined the effects of the positive current sent to the central office by the contact of finger n^2 and plate n^4 and of the controller-current sent from the central office to the sub-station consideration will next be given to the effect produced by the further movement of the lever n' under the pressure applied to the button V^3. The fingers n^3 and n^4 are thereby brought into contact with the plates n^6 and n^5, respectively. A negative current passes by the plate n^5, finger n^2, and wires 84 and 50 to line, the contact of the finger n^3 with the plate n^6 serving to ground the positive pole of the subscriber's battery. The negative current passes to ground through the relay R at the central office. The attraction of the relay R now brings the armature q^8 against the screw q^7; but inasmuch as the circuit of the electromagnet E^2 is open the action of the negative current in the relay R is without effect upon the subscriber X's devices at the central office. This negative current, however, goes by the wire 90, plate r^5, projections l^3 l', plate r^4, and wire 91 to point s', and from this it passes over the contact-wire 45 of subscriber Z to his contact S^{z4} and point $S^{z'}$. From the

point $S^{z\prime}$ there is a path for the current through the plate t^{z4}, spring t^{z3}, carriage $F^{z\prime}$, wire 56^z, line-wire 43^z, and relay R^z to ground. The effect on the relay R^2 is to bring the armature q^{z8} against screw q^{z7}, which thus closes the circuit of the electromagnet E^{z2}, so that this, being energized, draws in its armature for shifting the carriage F^{z2} one tooth in order to block the electromagnet $E^{z\prime}$ by opening its circuit at the spring t^{z6} and to connect the coils of electromagnet E^{z3}, by way of the plate f^{z3} and spring t^{z6}, with the screw q^{z6} of the relay. From all this it follows that the negative current sent by the subscriber X produces the before-recited effects on the subscriber Z's switchboard, the point $S^{z\prime}$ being shifted one contact in the direction of ordinates, without being brought, however, onto any of the subscriber's contacts, for the plate S^{z4} occupies two spaces in the direction of ordinates and is not connected with the subscriber's lines.

The negative current sent by the subscriber X to the switchboard of subscriber Z not only produces the effects just examined, but it also passes over the line to sub-station Z and through the relay U^z to ground, this relay being operated to close the circuit of electromagnet E^{z4} and cause the figure "1" to appear at the window d^2. The first step of the carriage F^{z2} produces no controller-current, as before seen.

To proceed now to the effect of the third current sent by the subscriber to the central office when the lever n' is returned to the initial position by the spring n^7, Fig. 9, on release of the button V^3, this current, as has been said, is positive, for it is produced by a new contact between the plate n^4 and the finger n^2. It passes through the electromagnet-relay R and closes the circuit of the electromagnet E^3, which acts again on the lever 28 and wheel r', turning said wheel through an arc equal to a tooth's length. Besides this first effect (which will be further considered below) the positive current also passes through the plate r^5, the projection l^3, the wheel r', the projection l', the plate r^4, the wire 91, the point S', the switchboard of subscriber Z, and the relay R^z, thus closing the circuit of the electromagnet E^{z3}. This electromagnet turns the distributing-wheel $r^{z\prime}$ one tooth, (the first from the initial position.) In this manner (precisely as the corresponding change was before made in the apparatus of subscriber X) the circuit of the electromagnet E^{z2} is opened and the connection through the wheel $r^{z\prime}$ of the point $S^{z\prime}$ with the line-wire to the sub-station Z is established. This positive current also goes to the sub-station Z and then closes the circuit of the electromagnet E^5, so that the figure "1" appears at the opening d^4 and the circuit of the electromagnet E^{z4} is opened. The wheel $r^{z\prime}$ in turning sends, as is evident from what has been said, a negative current over the line-wire of subscriber Z, (that is, the controller-current.) This current passes through the electromagnet U^z and armature u^{z5} is attracted and brought into contact with the screw u^6; but this has no action on the organs of sub-station Z, since this attraction can only close one of the breaks in the circuit of the electromagnet E^{z6}, this circuit being also broken between the finger n^{z8} and the plate n^{z9} when there is no pressure on the button V^3. The two negative controller-currents, one sent by the wheel r' and the other by the wheel $r^{z\prime}$, unite at the sub-station X, and passing through the relay U they close the circuit of the electromagnet E^6, which closure is possible because the finger n^8 is in contact with the plate n^9. The wheel j' is thus turned through a quadrant and the inscription "Ring" made to appear at the opening d^5. Then the subscriber X, by turning the button M', Fig. 12, of his apparatus, connected to wheel j', causes the inscription "Talk" to appear, such movement of the wheel j' simply causing the rotation of wheel j^6 and ratchet-wheel l^5 a distance of one tooth under the pawl l^4. By such operation the disk j' is brought into proper position for the next succeeding movement to the "Rest" position, which is effected by the magnet E^6, as hereinafter explained. Thus, after the button V^3 has been operated, the central-office apparatus belonging to the subscribers X and Z are in the following conditions: In the subscriber X's apparatus, the movements of the point S' are blocked, and consequently the points S' $S^{z\prime}$, in the two apparatus cannot be shifted farther. The distributing-wheel r' has advanced two steps from the initial position and the distributing-wheel $r^{z\prime}$ a single tooth. The points s' and $S^{z\prime}$ are in connection with the aerial conducting-wires of the subscribers X and Z.

Negative currents sent by either of the two subscribers will have no effect on their respective apparatus, but every positive current sent by either will advance the distributing-wheels r' and $r^{z\prime}$ of both apparatus simultaneously one tooth.

The subscriber X, profiting by the fact that a negative current produces no effect in either apparatus, sends a call-signal by means of a bell. To this end, he presses on the special button of the Ader apparatus provided for ringing up, which (as the diagram indicates) sends a negative current to line. The subscriber Z', after having heard the call-bell, manipulates the button V^3 of his apparatus, which (as explained above) produces three currents in succession—namely: a positive current, a negative current, a positive current. The first positive current closes the circuit of electromagnet E^{z8}, (which has the effect of turning the distributing-wheel r' one tooth,) and also closes the circuit of the electromagnet E^8, (which has the effect of similarly turning the distributing-wheel r',) so that after this positive current the distributing-wheel r' has been shifted three times and the distributing-wheel $r^{z\prime}$ twice only.

The wheel $r^{z\prime}$ in turning sends, as we know,

a negative controller-current, which passes through the electromagnetic relay U^z and closes the circuit of the electromagnet E^{z6}, (inasmuch as the finger n^{z8} touches the plate m^{z9},) thus causing the word "Call" to appear at the subscriber Z's, but which has no action at the subscriber X's (because, as already explained, the finger n^8 is no more in contact with the plate n^9). Moreover, the wheel r' in turning sends a negative controller-current, which has no effect on the apparatus of subscriber X, nor upon the switchboard of the subscriber Z, but which, passing through the sub-station Z, excites the relay U^z to draw over the armature u^{z5} and close the circuit of the electromagnet E^{z6}, which has the effect of making the word "Ring" appear at the opening d^{z5}. The wheel R', in turning the third time, produces certain additional effects, which will now be explained. When the wheel r' turns the third time the strip $h^2\ h^4$ touches the plate r^6 with one of its ends and the plate r^{11} with the other. The plate r^6 is connected by the wire 94 with the solenoid S^2 of the point S', and the plate r^7 is connected by the wire 95 with the other terminal of the same solenoid. The plate r^{10} is connected by the wire 96 with the positive pole of the central-office battery, and the plate r^{11} with its negative pole. When, therefore, the wheel r' has turned for the third time, the strips $h^2\ h^4$ and $h^3\ h'$ close the circuit of the solenoid. The winding of this solenoid is such that when it is traversed by this current the point S' (which is simply a permanent magnet) is withdrawn from the lower plate C D (which we term the "communication-plate") to the upper plate A B (which we term the "conversation-plate") and the said point S' (which, up to the present, has been in contact on the plate C D with the contact corresponding with the wire of subscriber Z) presses against the contact of the upper plate, which likewise corresponds with the line of subscriber Z. In passing, it may be noted that it is not the subscriber X who has put himself into position to speak to the subscriber Z; but that only after this latter has pressed upon the button V^3 of his apparatus is the point S' transferred to the conversation-plate. This has its importance, for, assuming for a moment that the two subscribers X and Z are conversing and that a third subscriber Y should wish to cut into their conversation, he would not be able to do so, since that would require the assistance of the two subscribers X or Z to bring point $S^{y'}$ to the conversation-plate. Thus, after the first positive current sent to the subscriber Z, the point S' is against the contact of the upper plate A B and at the sub-station of Z, the wheel $r^{z'}$ has turned twice, and the word "Ring" appears at the opening d^{z5}.

The second (or negative) current, which the subscriber Z sends by pressing the button V^{z3}, produces no effect either in this subscriber's apparatus or in that of the subscriber X.

The third current, (a positive current,) sent by the same subscriber by manipulating the button V^{z3}, will act solely on the relay R^z, because the subscriber X, whose point S' is now in the contact-line of the platform A B, has no communication with the subscriber Z, whose point $S^{z'}$ rests on the contact-line of the platform C D. The action of this positive current on the relay R^z is to cause the wheel $r^{z'}$ to turn for the third time, which movement effects (as explained above for the wheel r') the closure of the circuit of the solenoid S^{z2}, and consequently the transfer of the point $S^{z'}$ from the plate C D to the plate A B. It follows from this that after the manipulation of the button V^{z3} the subscribers X and Z are in communication, and that, too, in such manner that no third party can insert himself, because the two points S' and $S^{z'}$ are against contact of the plate A B and there remain until the signal, if given, which announces the end of the conversation—that is to say, as we shall see later, until one of the two subscribers has pressed the button V^4. The wheel $r^{z'}$, in turning the third time, sends a negative controller-current, which acts in the sub-station Z to close the circuit of the electromagnet E^{z6} and thereby to turn the wheel $r^{z'}$ through another quadrant and cause the inscription "Talk" to appear at the window d^{z5}.

It has been explained how the inscriptions "Call" and "Ring" present themselves in succession before the eyes of the subscriber X when he manipulates the button V^3, but it is well to observe that (owing to the rapidity of sending the currents by pressing the button V^3) the word "Call" does not remain exposed, but gives place immediately to the inscription "Ring." On the contrary, at the station of the subscriber Z who is called, the negative currents which enter his apparatus are so produced when he manipulates the button V^{z3} as that the inscriptions "Call" and "Ring" pass very rapidly, and the sole inscription "Talk" will remain exposed at the opening d^{z5}. It follows from this that the subscribers between whom the communication has been established cannot converse until the inscription "Talk" shall have appeared at the opening d^{z5} at the sub-station Z.

When the conversation is ended, the subscriber X (who has put himself in communication with the subscriber Z) presses the button V^4 and what the subscriber Z must do will be hereinafter explained. The pressing in of the button V^4 has the effect of sending two positive currents in succession. The first is produced by the passage of the finger m^2 across the contact m^4 and of the finger m^3 across the contact m^5. Then when the pressure on the button is relieved the fingers move back across the contacts m^4 and m^5, respectively, and a second positive current is sent. In the diagram, Fig. 15, the arrow shows the motion of the lever m^8 when the button is pressed in.

Before considering the effect produced in the apparatus by the pressure exerted on the

button V^4, it should be observed that the finger m' (which closes the circuit of the electromagnet E^6) comes into contact with the terminal m^9 only after the first contact of the fingers m^2 m^3 with the plates m^4 m^5, the advantage of this being explained later.

The pressure exerted on the button V^4 produces, first, a positive current from the substation X to the central office; second, a negative current from the central office to the sub-station, which current is able to act upon the electromagnet E^6, because at this time the finger m' is in contact with the plate m^9; third, a positive current from the sub-station X to the central station, and, fourth, a negative current from the central office to the sub-station X, which current has no action on the devices on account of finger m' having left the plate m^9, and the circuit of the electromagnet E^6 being broken, therefore, between the finger m' and the plate m^9.

The first positive current sent by the pressure exerted on his button V^4 by the subscriber X passes through the relay R', and this closes the circuit of the electromagnet E^3. A part of this current also passes over the switch-board-connecting wire and goes through the relay $R^{z'}$, so as to close also the circuit of the electromagnet E^{z3}. The wheels r' and $r^{z'}$ are thus each turned one tooth. As a result of this partial rotation, the strip h^2 h^4 touches the terminal r^9 with its end h^2 and the terminal r^{11} with its end h^4, while the strip h^8 h^3 touches the terminal r^8 with its end h^3 and the terminal r^{12} with its end h^3. The circuit of the solenoid S^{x2}, as also that of the solenoid S^{z2}, will thus be closed, so as to be traversed by a current in the opposite direction to that which first passed over it. The point S' (and also the point $S^{z'}$) is thus returned to the lower contact-plate C D. By the brushes H^4 and H^5 of the wheel H^2 a negative current is sent back over the line of subscriber X and also over the line of subscriber Z; and this current, in the case of subscriber X, passes through his relay U, which therefore closes the circuit of the electromagnet E^6, (for the finger m' is at this moment in contact with the plate m^9,) so that the wheel j' is moved a quarter-turn and the word "Rest" appears at the window d^5. In the case of subscriber Z the negative controller-current, caused by the last partial rotation of the wheel $r^{z'}$, also passes through the relay U, but results in no action on the rest of his apparatus, for the circuit of the electromagnet E^{z6} is open (the subscriber Z not pressing at this moment on his button V^3 nor on his button V^4).

The second positive current (produced by the contact of the fingers m^3 m^2 with the plates m^5 m^4 when these fingers are returned by the spring m^7) has the effect (to be explained) of bringing the apparatus X and Z at the central office back to the starting-point. This current passes through the relays R' and R', so that they close the circuits of the electromagnets E^3 and E^{z3}. The wheel r' is then turned anew one tooth, as is also the wheel $r^{z'}$. During this new movement the ends h^2 h' of strips h^2 h^4 and h' h^3 pass without stopping over the contacts g' and g^2, so as to close the circuit of the electromagnets 11 and 12, for during such passage the opposite ends h^4 and h^3 pass over the terminal r^{12}, which is in connection by the wire 96 with the positive pole of the battery. The electromagnet 11 is connected by the wire 110 with the negative pole of the battery and the electromagnet 12 is connected by the wire 111 with the same pole. It follows, therefore, that these two electromagnets (at the moment of passage of the strips over the contacts g' g^2) are traversed by a current, are energized and (as explained near the beginning of this specification with reference to Figs. 1 to 5) the bars 14, which are parallel to the ratchets 7 of the carriages F' F^2, are lifted to disengage the pawls 3 and 5 and allow the said carriages to be returned to their starting-points by the springs 16 and 17. The two apparatus at the central office are thus brought to rest, and the negative current (sent at the same time by the brushes H^4 H^5 and the wheel H^2 to the sub-stations) have no effect on the sub-station apparatus, since at each sub-station the circuit of the electromagnet E^6 is at this time open at the finger m'.

To bring the apparatus completely to the normal, it will suffice for each of the subscribers to press on button V^5, so as to bring to zero the figures at the windows d' d^2 d^3 d^4, only the subscriber who was called up, in this case the subscriber Z, should also turn the button M', on the end of the shaft of the wheel j', so as to bring the word "Rest" back into view at the window.

By the preceding operations not only the carriages F' F^2 are returned to their primitive positions, but the wheels $r^{x'}$ $r^{z'}$ are also brought not, indeed, to their first positions, but into corresponding positions, for they have made a quarter-revolution—namely, five teeth out of a circumference of twenty—and when the carriages F' F^2 have been brought back to their starting-points it is the projections l l^2 of the wheel r' which come in contact with the plates r^2 r^3, a matter, however, of no importance, since the four quadrants of the wheel r' are similarly disposed. During the next communication it is no longer the strips h^2 h^4 and h' h^3 which act, but the perpendicular pair of strips h^3 h^5 and h^6 h^7; neither is it the projections l^3 l' which are included in circuit, but the projections l^2 l.

Such is the apparatus which is considered the best embodiment of the present invention. Its operations may be recapitulated as follows: The subscriber who desires to enter into conversation with another subscriber presses in the button V' and maintains the pressure until the numerator of the fraction (assigned in the list of subscribers to such other subscriber) appears at the windows d' d^2. He then presses the button V^2 until the denominator of the same fraction appears at the win-

dows d^3 d^4. When the figures visible through the windows correspond exactly with the desired fraction, the subscriber presses his finger on the button V^3 and assures himself that the inscription then visible is "Ring." He complies with this direction, and after he has rung up the other subscriber the inscription "Talk" is made to appear at the window d^5, whereupon he understands that the subscriber who has been called up is ready to speak to him. The conversation finished, the "called" subscriber gives the signal which announces the end of the interview. With this object he presses on the button V^4. In practice all the buttons, except the button M', would be provided with inscriptions. Thus the button V' would carry the designation "Numerator;" the button V^2, "Denominator;" the button V^3, "Call;" the button V^4, "End of Interview;" the button V^5, "Figures." The subscriber "called," having heard the bell, approaches his telephonic apparatus and presses his button V^3. When the inscription "Talk" appears at the opening d'^5, he proceeds with the conversation. When this is finished, the "called" subscriber turns the button M', as before said. At the beginning of this specification it was said that the use of perpendicular co-ordinates would be taken by way of example. It will be readily understood that the operation of the apparatus would be the same if the carriages F' F^2, instead of being shifted in two perpendicular directions, were shifted in two oblique directions. Nothing more need be changed in the apparatus; but if instead of employing rectilinear co-ordinates it be desired to use polar co-ordinates, for example, the arrangement of the apparatus, while remaining unchanged so far as the electrical connections are concerned, is modified with reference to the operation of the carriages F' and F^2. In this case the carriages are replaced, as indicated in Figs. 13 and 14, by beams F^{11} and F^{21}. These beams are fulcrumed loosely in their respective shafts O' and O^2, on which ratchet-wheels are fast mounted—namely, the ratchet-wheels G' G^2 on the shaft O' and the ratchet-wheels G^3 G^4 on the shaft O^2. The wheels G' and G^3 have teeth inclined in the same direction, while the teeth of wheels G^2 and G^4 are inclined in the opposite direction. The beam F^{11} can be coupled to the wheel G^2 by the pawl G^5 in such a way that when the shaft O' is turned in the direction of the arrow the beam partakes of such movement.

The rotation of the shaft O' is effected by means of the second ratchet-wheel G' in the following manner: When the electromagnet E' is traversed by a current, it attracts the armature c', which is connected by the link c^2 with the lever c^3, which is fulcrumed loosely on the shaft O'. On this lever is the pawl c^4, which the spring c^5 presses against the teeth of wheel G'. When the armature c' is attracted by the electromagnet E', the pawl c^4 slips idly over one of the teeth of the wheel G'. To prevent it slipping over too many teeth a screw E^7 is arranged to act as a stop in limiting the movement of the lever c^3. As soon as the current is interrupted, the spiral spring c^6 retracts the armature c', and at the same time makes the wheel G' (and the beam F^{11} as well) advance one tooth. In this manner, at each current through the electromagnet E', the beam F' (advancing each time an amount corresponding with a ratchet-tooth) passes successively from one series of contacts to the next and carries with it the point S'. A similar movement of the beam F^{21} is produced in like manner by the electromagnet E^2, the beam F^{21} being shifted at each pulse of the current as explained for the beam F^{11}. It will be readily understood that the point S' can thereby be made to travel over all the contacts arranged on the plate C D. The electromagnets E' and E^2 in this arrangement are stationary and do not themselves move, as in the first-described arrangement. As to the electrical connections, all the parts before described are to be used in this arrangement, including the shaft O^3 and all the wheels supported thereon, the plates f^5 f^7 f^3, &c.

What we claim as our invention is—

1. A switchboard system for automatic intercommunication, having separate switchboards for the several subscribers' lines, each switch board composed of duplicate series of similarly arranged contacts with a switch point electrically movable relatively to both series and transferable (as by a solenoid) from one series to the other, the corresponding contacts of the different switchboards being interconnected so that a given subscriber's line may be connected with any other such line through their switchboards by either of the series of contacts, substantially as described.

2. The combination with duplicate series of contacts, of two carriages, a switch point movable with said carriages and transferable from one contact series to the other and an electromagnet with pawl and ratchet for advancing each carriage; said pawls being adapted to be disengaged from their ratchets to permit the return of said carriage by springs, substantially as described.

3. The combination with a series of contacts, a movable switch point and electrical means for shifting said point, of circuit-changers for breaking the line connection of said point during the shifting of said point, and electrical means for reestablishing such connection when the said point has reached the desired contact, substantially as described.

4. The combination with subscribers' lines and interconnected switchboards having each an electrically movable switch point normally connected to line, of means for breaking said line connection with the switch point during the shifting of said point and then reestablishing such connection, substantially as described.

5. The combination with duplicate series of

contacts, and a switch point electrically movable with reference to both series and transferable electrically from one series to the other, of an apparatus composed of an electro-magnet, a ratchet wheel arranged to be turned by the armature of said electro-magnet, a toothed circuit-breaking wheel mounted on the shaft of said ratchet wheel but insulated therefrom, brushes arranged to bear on said wheel for putting a central office battery to line to send a shunt current as often as the said wheel is advanced a step, a circuit changing wheel also movable with said ratchet wheel arranged to close the circuit through the point-shifting means in one position and to establish a line connection for said point in another position and additional circuit-changers also movable with said ratchet wheel to establish a circuit through the point transferring solenoid, substantially as described.

6. The combination with a polarized relay, of two electro-magnets in two local circuits connected with the same terminal of said relay one of said circuits being normally open while the other is normally closed, an electro-magnet in a local circuit connected with the other relay terminal, a circuit changer operated by the last mentioned electro-magnet to break the said normally closed local circuit and close the said normally open local circuit, and a circuit changer operated by the electro-magnet in the normally open circuit to break the circuit of the third-mentioned electro-magnet aforesaid, substantially as described.

7. The combination with a series of contacts at the central office, an electrically movable switch point, and circuit-breakers for sending controller currents at each movement of said point, of apparatus at the subscribers' substation arranged to be operated by such controller currents, and means whereby the subscriber sends the currents to shift said switch point, substantially as described.

8. A circuit breaking drum adapted to be shifted horizontally as well as to be rotated, in combination with contact springs or brushes arranged to bear on said drum so as to send positive currents when the drum rotates in one position and negative currents when it is in its other position, substantially as described.

9. The combination of the circuit breaking drum adapted to be shifted longitudinally as well as to be rotated, its contact spring or brushes, a mechanical power for turning said drum when released, a pin for retaining said drum when engaged, means for effecting its disengagement without shifting said drum longitudinally and means for effecting its disengagement by such shifting of said drum, substantially as described.

10. The combination with the point-shifting electro-magnets at the central office, one operated when a positive current is sent over the subscriber's line and the other when a negative current is so sent, of the circuit-breaking drum at the subscriber's substation adapted to be shifted longitudinally as well as to be rotated, contact springs or brushes for sending positive currents when said drum rotates in one position and negative currents when it is in its other position, substantially as described.

11. The combination with subscribers' lines, and current sending means at the subscribers' substations, of subscribers' switchboards at the central office composed each of a series of contacts with the similarly placed contacts in the several switchboards interconnected and the several sets of interconnected contacts in electrical connection with different subscribers' lines, movable switch points normally connected to line, electrical means for shifting said points and for connecting them with their subscribers' lines after having been shifted, means for breaking the line connections of the switch-points during the shifting of such points to the desired contacts, substantially as described.

12. The combination with subscribers' lines, and current sending means at the subscribers' substations, of subscribers' switchboards at the central office composed each of duplicate series of contacts with the similarly placed contacts in the several switchboards interconnected and the several sets of interconnected contacts in electrical connection with different subscribers' lines, movable switch points transferable from one series of contacts to the other and electrical means for shifting said points and for connecting them with their subscribers' lines after having been shifted, such line connections being broken during the shifting of said points to the desired contacts and for transferring the said switch-points from one series of contacts to the other, the aforesaid electrical connections between the subscribers' lines and the sets of interconnected contacts being through said switch-point, substantially as described.

13. The combination with subscribers' lines, and current sending means at the subscribers' substations, of subscribers' switchboards at the central office composed each of duplicate series of contacts with the similarly placed contacts in the several switchboards interconnected and the several sets of interconnected contacts being in electrical connection with different subscribers' lines, movable switch-points transferable from one series of contacts to the other polarized relays in the subscribers' lines, and electro-magnets arranged in the local circuits of said relay for shifting the said switch points, the aforesaid electrical connections between the subscribers' lines and the sets of interconnected contacts being through their corresponding switch points, substantially as described.

14. An automatic switch board system composed of switchboards with duplicate series of contacts and electrically movable switch points connected with the substation lines

and electrically transferable from one series of contacts to the other and also composed of means whereby the line connections with the respective switch-points are interrupted during the shifting of said switch-points, substantially as described.

In testimony whereof we have signed this specification in the presence of two subscribing witnesses.

SALOMON BERDITSCHEWSKY DIT APOSTOLOFF.
MOISE FREUDENBERG.

Witnesses:
CLYDE SHROPSHIRE,
JOSEPH LACOSTE.