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AUTOMATIC TELEPHONE SYSTEM.

No. 587,435. Patented Aug. 3, 1897.

Fig. 2.

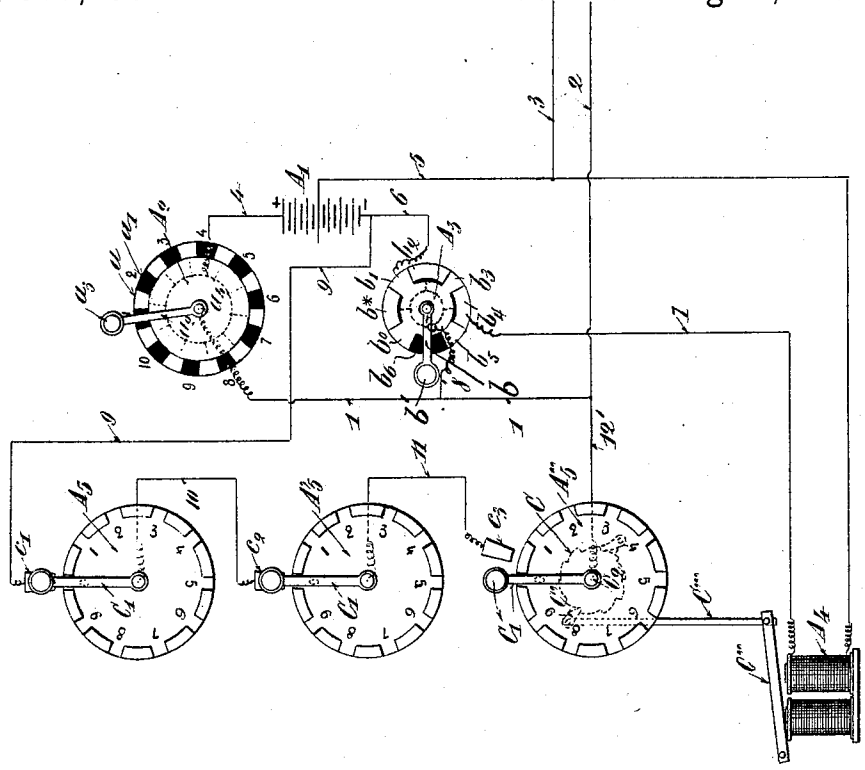
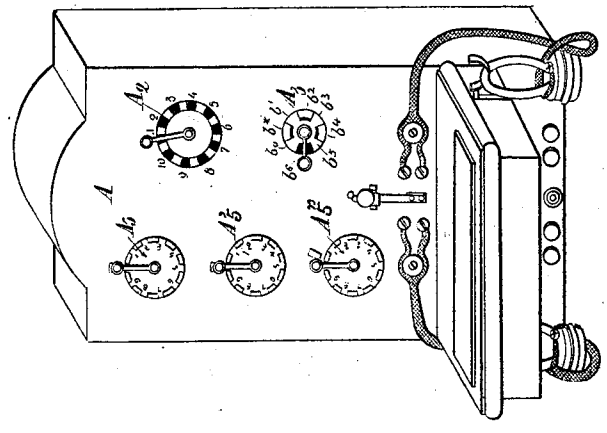


Fig. 1.



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No. 587,435. Patented Aug. 3, 1897.

FIG. 3.

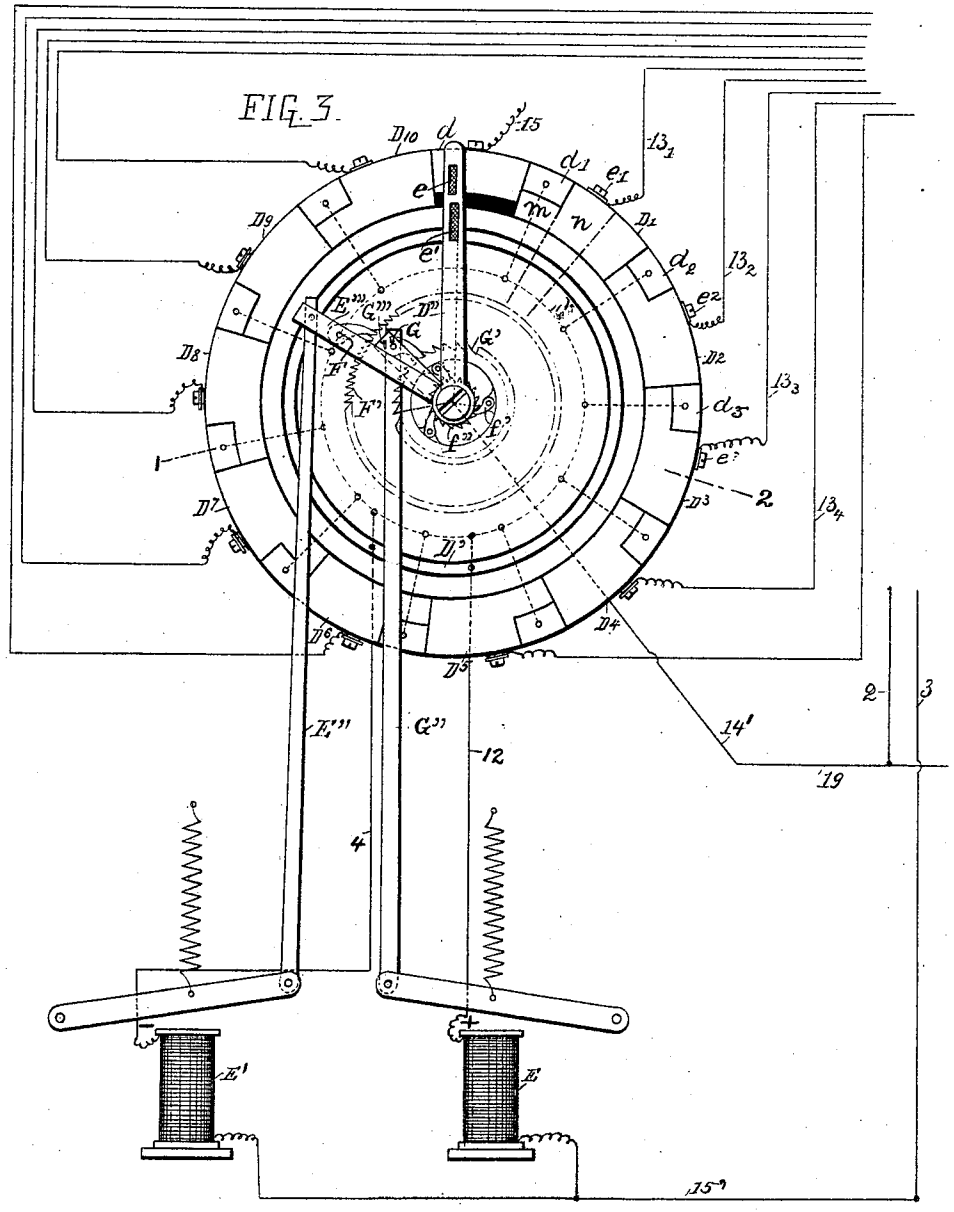
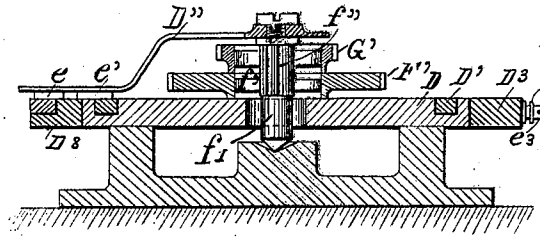


FIG. 4.



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AUTOMATIC TELEPHONE SYSTEM.

No. 587,435. Patented Aug. 3, 1897.

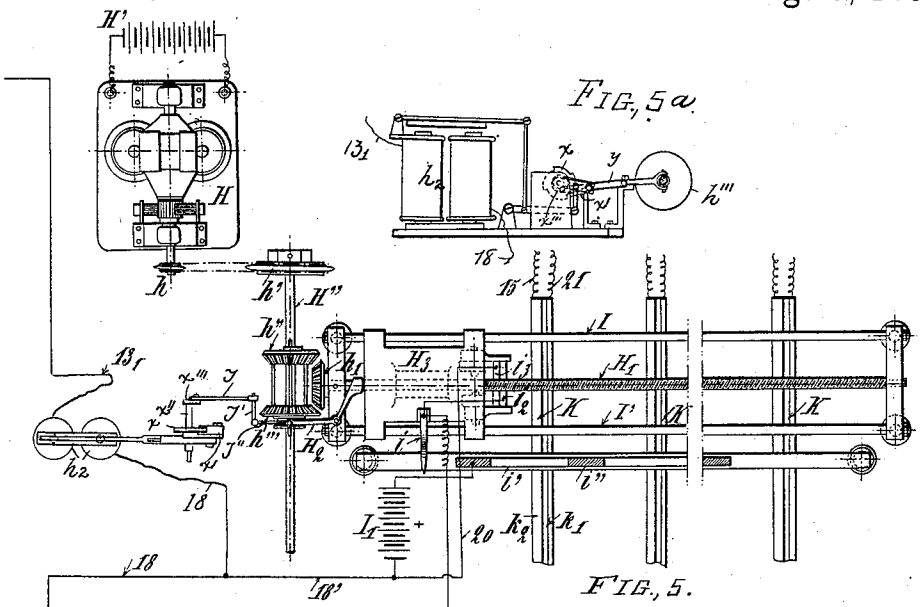

FIG. 5a.

FIG. 5.

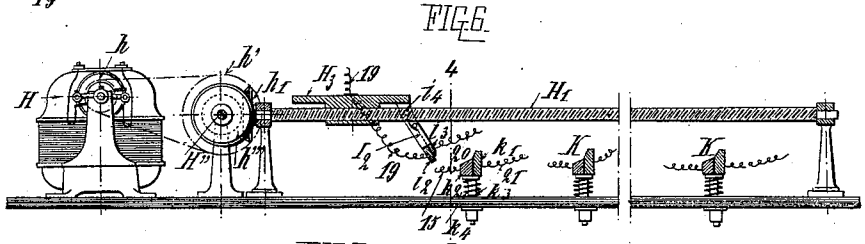

FIG. 6.

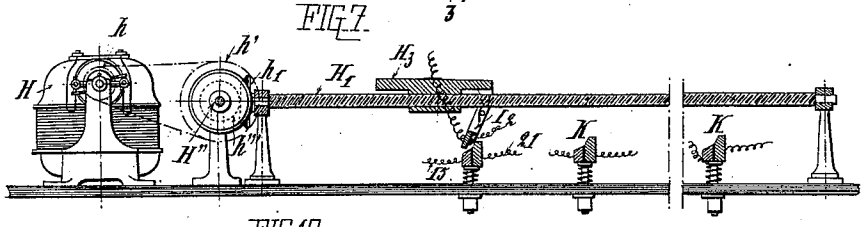

FIG. 7.

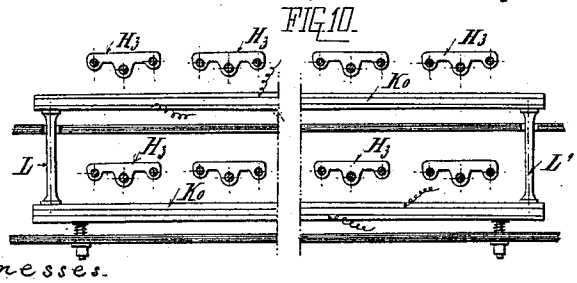

FIG. 10.

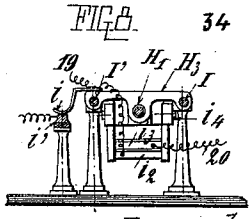

FIG. 8.

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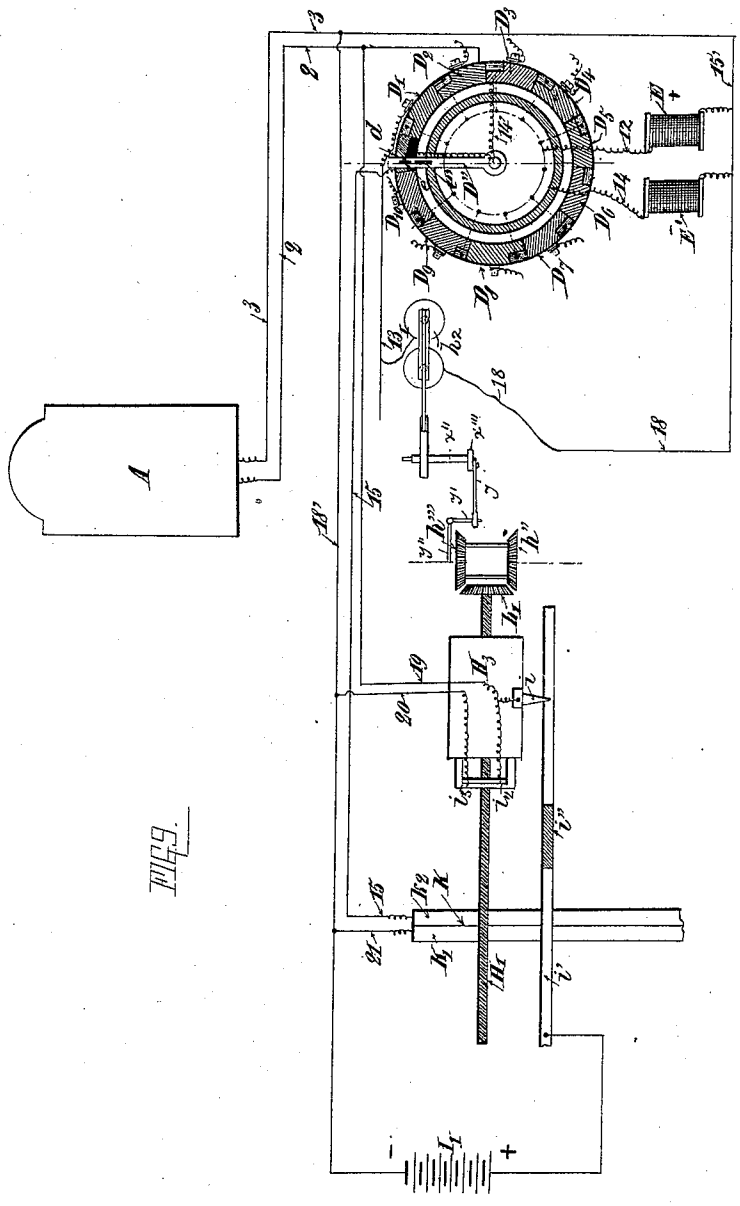

Fig. 4.

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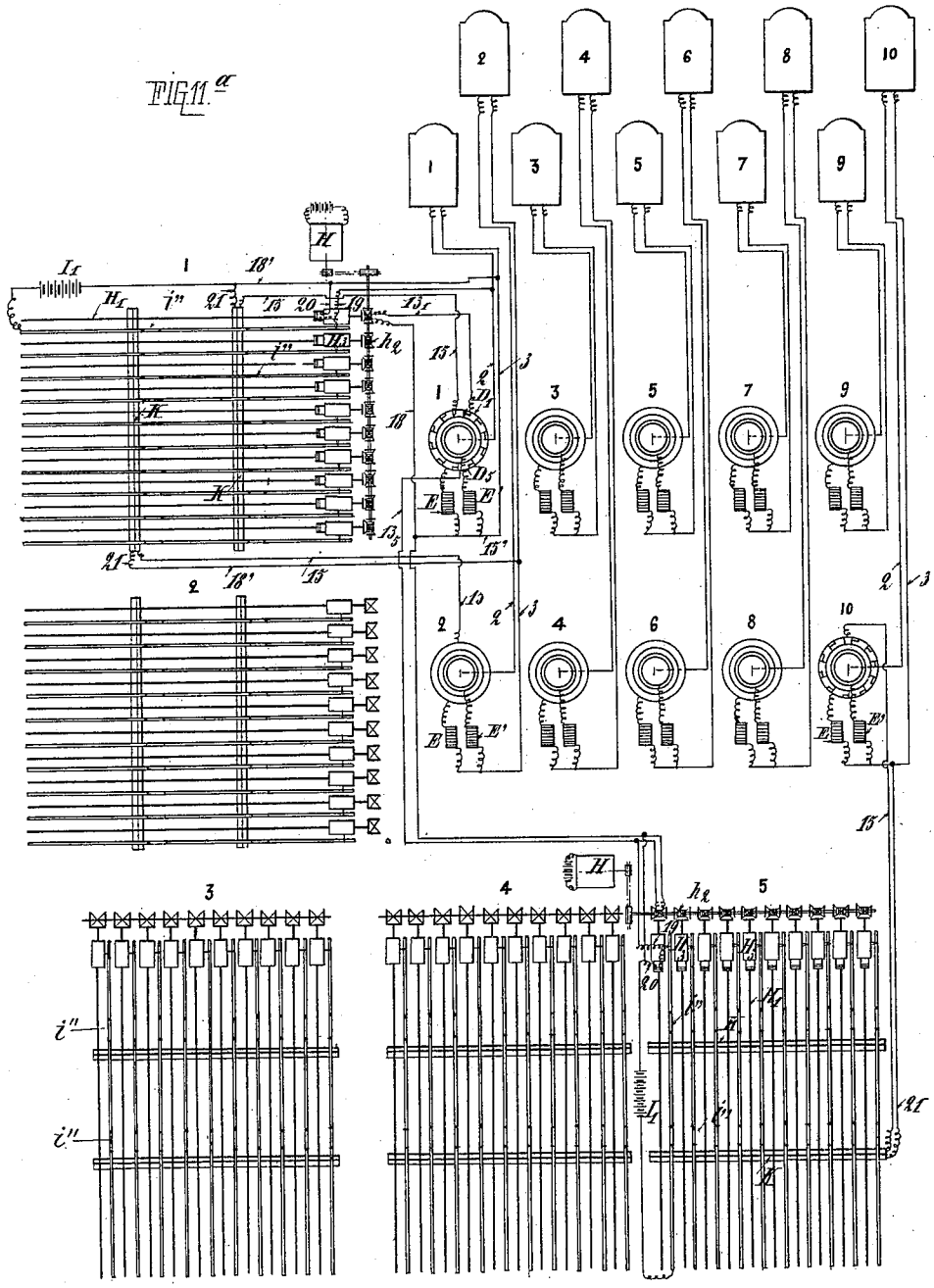
FIG. 11.



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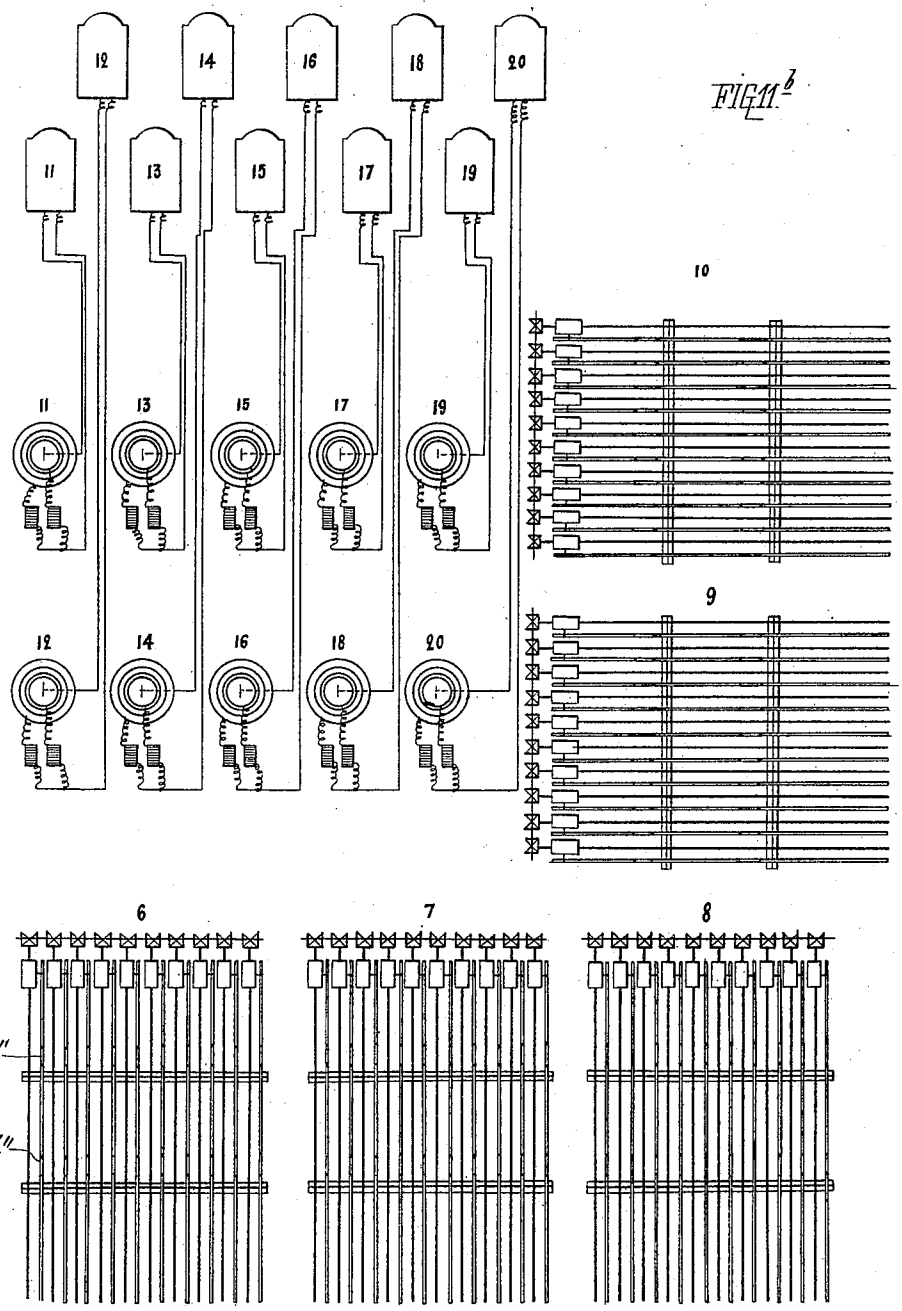
AUTOMATIC TELEPHONE SYSTEM.

No. 587,435. Patented Aug. 3, 1897.

FIG. 11.b



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W. R. Edelen.

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UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 587,435, dated August 3, 1897.

Application filed October 22, 1896. Serial No. 609,721. (No model.)

To all whom it may concern:

Be it known that I, MOISE FREUDENBERG, a citizen of the Empire of Russia, and a resident of Paris, (Seine,) in the Republic of France, have invented certain new and useful improvements in telephonic self-commutators permitting the suppression of employees in the office connecting the subscribers together, of which the following is a full, clear, and exact description.

This invention relates to a new or improved system of automatic apparatus for enabling a subscriber to a telephone-exchange to obtain communication with another subscriber to the same exchange directly without having to ask a central-office operator to make the desired connection.

Before explaining in detail the different elements employed in the new or improved system of automatic telephone-switching a general indication will be given of the system as a whole and the mode of connecting the elements which compose it.

At each subscriber's is a telephonic apparatus connected with a switch at the central office, the connection being effected between the subscriber's apparatus and the central-office switch by means of two wires, for it will be supposed that the telephone-exchange is established for working by means of two wires, the return not being effected by the earth.

The switch at the central office corresponding with each subscriber's apparatus is divided into a certain number of sectors—ten, for example—and each of these sectors is connected (as will be explained below) with a carriage forming part of a particular group of carriages at the central office. The central office has then, besides the switches, ten groups of carriages, and each subscriber has a carriage in each of these groups, which carriage is connected with one of the sectors of the subscriber's switch.

Under the action of currents sent from the subscriber's station to the desired sector of the switch appertaining to the said subscriber the carriage connected with this sector can be put in motion, can pass successively over strips underlying the path which the carriage follows, and can stop itself in contact with one of these strips, thereby putting the subscriber to whom the carriage belongs into communication with him whose line is connected with the designated strip.

At the central office there are as many strips as subscribers, and the wires of each subscriber's line are connected with the corresponding strip in one of the carriage groups at the central office.

If it be supposed for a moment that the exchange has ten thousand subscribers, these may be divided into groups of one thousand, which give ten groups of subscribers, and in each of the groups of carriages before referred to are placed one thousand strips, each of which corresponds with one of the subscribers of the group and is connected with his station, as before mentioned.

It will seem then that if any subscriber wishes to talk with another subscriber having a number belonging to the third group—say, for example, subscriber 2,846—he will so act as by proper currents to place his switch on the third sector in order to connect himself through said switch with the carriage of the third group which belongs to him. This carriage, being put in motion by currents of the proper direction, passes at a given point over the strip corresponding with the eight hundred and forty-sixth subscriber of the third group. At this moment communication is established between the two subscribers, and they can then converse.

As may be seen from the preceding explanation, the principle upon which is based the present new or improved system of automatic telephone-switching consists in the division of subscribers into distinct groups, each subscriber having at the central office a special switch, as many carriages as there are groups in the system, and a special device, which has hereinabove been called a "strip," placed in a determined group—that is, in the group to which the subscriber belongs.

In order to make the following explanation as clear as possible, an automatic telephone-switch apparatus in accordance with the invention is illustrated by way of example in the accompanying drawings.

As thus illustrated, various device-shifting electromagnets at the subscriber's station and at the central office are shown placed in

derivations of the main-line circuit, when in practice they would be placed in local circuits and be controlled by relays placed in the main-line branches in which the electromagnets are located, as shown. This arrangement permits the production of very considerable mechanical effects with feeble currents. Should the available main-line currents suffice (by reason of their own strength or the easy operation of the mechanism) to effect the shifting of the devices without the aid of local currents, these might of course be dispensed with.

Figure 1 is a perspective view of the telephone apparatus at a subscriber's station. Fig. 2 is a diagram showing the details of the different parts of the apparatus which is shown in perspective in Fig. 1. Fig. 3 is a plan view of one of the switches at the central office, each subscriber's station being connected with a switch which may be identical with that shown in this figure. Fig. 4 is a section on line 1 2 of Fig. 3. Fig. 5 is a plan view in detail of one of the central-office carriages, which may belong to any group and any subscriber. Fig. 5^a is a detail side elevation of mechanism for controlling the movements of the carriage. Figs. 6 and 7 are vertical sections showing the different positions occupied by one of these carriages. Fig. 8 is a section on line 3 4 of Fig. 6. Fig. 9 is a diagram illustrating the electrical connections between a subscriber's station, the corresponding switch, and the carriage corresponding with sector No. 1 of the switch. Fig. 10 is a vertical section showing the interconnection of the strip-segments belonging to the same subscriber when the carriages of a single group, instead of being disposed in one horizontal plane, are placed on several parallel horizontal planes. Figs. 11^a and 11^b are diagrams showing the whole of an installation in accordance with the present invention for twenty subscribers.

The automatic telephone switch apparatus of the present invention may be considered under four distinct heads:

First. The substation or home apparatus at a subscriber's, (all the subscribers' stations being identical with one another.)

Second. One of the switches placed at the central office and connected directly with one of the substations, (all the switches being identical with one another.)

Third. One of the carriages which is connected with one of the switch-sectors, (all the carriages being identical with one another.)

Fourth. The general arrangement with examples referring to communication (*a*) between two subscribers of the same group and (*b*) between two subscribers of different groups.

1. *The substation apparatus.*—In considering the apparatus at the subscriber's station no account will be taken of the telephone itself, which may be of any suitable description, although in the drawings the telephones are supposed to be of the Ader system, generally used in Exchanges in France. The additional devices employed for applying the new or improved automatic switching in conjunction with this system of telephones will now be described in order.

The various parts of the substation apparatus are placed in a box A above and behind the subscriber's telephones, the box A being shown in perspective in Fig. 1. They comprise a battery A_1, a switch A_2, a second switch A_3, a polarized electromagnet A_4, and a counting system of three wheels A_5 A_5' A_5'', Fig. 2.

The switch A_2 is formed of a flat disk which carries ten metallic contacts a, between which insulated blocks a_1 are interposed. At the center of the disk is mounted on a pivot an arm a_2, provided at its end with a button a_3, by which the arm can be turned from left to right about its center a_4 in such manner as to perform a complete rotation about this center.

The arm a_2 is connected by a wire 1 with the line-wire 2, going from the substation to the central office, and all the metallic sectors a of the switch are connected by the wire 4 with the positive pole of the battery A_1, whose central element is connected by the wire 5 with the return-wire 3 from the central office to the subscriber's. By this mode of connection it will be seen that if the arm a_2 is turned about its center it will come successively in contact with each of the sectors a and that every time a contact of this kind takes place a positive current from the battery A_1 will pass by the wire 4 to the switch-point opposite the arm a_2 and thence through the said arm and the wires 1 and 2 to the central office, returning from said office by the wires 3 and 5 to the battery A. Every time therefore the subscriber turns the arm a_2 through an arc equal to a sector of the switch he will send to line a positive current. The arm a_2 is of course insulated from the body of the switch.

The switch A_3 (the second switch before mentioned) is composed of a disk divided into eight sectors b_0 b^* b_1 b_2 b_3 b_4 b_5 b_6. At the center of this disk is pivoted an arm b, provided with a button b' for turning the arm from left to right completely around the switch-disk.

Of the eight sectors which compose the switch just spoken of the first, b_6, is made of insulating material, and it is on this sector that the arm b rests when the apparatus is in repose. The word "Repose" may be inscribed above the sector b_6 and also above the first sector of the switch A_2, so that the subscriber can see at a glance whether the parts of his apparatus are in the positions which they should normally occupy.

The four sectors b_0, b_1 b_3, and b_5 are connected by the wire 6 with the negative pole of the battery A_1. The sectors b^* and b_2 are insulated. The sector b_4 is connected by the wire 7 with the polarized electromagnet A_4. The arm b is connected by the wire 8 with the

wire 1 and by it with the line-wire 2, which goes from the subscriber's station to the central office.

So long as the arm b is on the insulating-point b_6 the apparatus is in repose. By carrying the arm b from the point b_6 to the point b^* it is made to pass over the point b_0, on which the arm should not stop but only pass over it. The passage of the arm b over the point b_0 has the effect of sending a negative current to line, the conducting-point b_0 being connected with the negative pole of the battery A_1 by the wire 6. The current from this negative pole on reaching the point b_0 passes by the arm b and wires 8 and 1 to the line-wire 2. It returns from the central office by the wire 3 and finally reaches the battery A_1 by the wire 5. The same phenomena are produced when the subscriber passes the arm b from b^* to the point b_2 and from the point b_2 to the point b_4, in consequence of the arm rubbing over the points b_1 and b_3, which are connected with the negative pole of the battery.

When the arm b is in contact with the point b_4, the line is put in communication with the polarized electromagnet A_4, since the point b_4 is connected with the electromagnet by the wire 7 and the arm b is connected to line by the wire 1. By bringing the arm b from the point b_4 onto its point of repose b_6 it will be made to rub over the point b_5, which will send a negative current, as in the case of the points b_0, b_1, and b_3. It will be seen then that a complete revolution of the arm b of the switch A_3 will have the effect of sending four negative currents and of putting the positive electromagnet A_4 to line at a given moment, (intermediate the third and fourth negative currents.) The function and effect of each of these currents will be seen later when consideration is given to the communications.

The three-wheel counter (represented in Fig. 2) is of the kind employed to register the number of turns. It consists, essentially, of a primary disk A_5'', on the axis of which is fixed a ratchet-wheel C, that can be operated by the polarized electromagnet A_4 through the pawl C', this latter being connected by the arm C''' with the armature C'' of the electromagnet. A stop-pawl controls the movement of the ratchet-wheel C, which should only turn through an arc equal to one tooth at each retraction of the armature C'' after each attraction of the latter by the polarized electromagnet A.

The disk A_5'', or it may be the box outside the disk A_5'', carries the figures "0" to "9," and opposite each of these figures at the margin of the disk is formed a notch that may engage the arm C_1, which can be maneuvered by hand and which is pivoted at its center C_2. This arm is analogous, as also are the arms b and a_2 of the switches A_3 and A_2, to those in use in switches of the "Breguet" kind—that is to say, they can engage notches in the margins of the disks over which they are placed.

The second disk A_5' of the turn-counter is identical with the disk A_5'', but it is not operated (as the latter is) by the polarized electromagnet A_4. The disk A_5' turns one division every time the disk A_5'' makes a complete revolution.

The mode of shifting the disk A_5' by the disk A_5'' is not shown, for there is nothing peculiar in this point, and use may be made of any known or suitable arrangement whereby in turn-counters the tens-wheel is shifted by the units-wheel.

What has just been said about the wheel A_5' applies fully to the wheel A_5, which corresponds with the hundreds-wheel of a turn-counter. Every time the tens-wheel A_5' makes a complete revolution the hundreds-wheel A_5 moves one division. It follows from this that the system of three wheels A_5 A_5' A_5'' apart from the arms C_1 and the notches at the margins of the wheels constitutes a veritable turn-counter. The three-wheel system is completed by certain electrical arrangements which will now be considered.

When the hundreds-wheel is at zero in the position shown in Fig. 2, the arm C_1 being in the zero-notch, it bears on a conducting-point c_1, which is connected by the wire 9 with the negative pole of the battery A_1. The arm C_1 itself, which is of course insulated from the body of the apparatus, is connected by the wire 10 with the point c_2, on which the arm C_1 of the disk A_5' bears when this disk is in repose and its arm is in the notch corresponding with zero. The arm C_1 of the disk A_5' is itself connected by the wire 11 with a point c_3, which is situated like the preceding outside the disk to which it appertains, but in this case between the zero and one of such disk—to wit, of the disk A_5''—when the said disk is in repose. In this position, as shown in Fig. 2, the arm C_1 of the disk A_5'' does not touch the point c_3. To finish the description of the electrical communications of the counter, it is added that the arm c_1 of the disk A_5'' is connected with the line-wire by the wire 12'.

Such is the nature and arrangement of all the devices at the subscriber's station. They serve, as will be explained below, to operate automatically the devices at the central office.

2. *A subscriber's switch at the central office.*—All the subscribers' stations have apparatus indentical with that described, and each of them is connected by the two line-wires 3 and 2 with a switch at the central office. Since all of these central-office switches are alike, it will suffice to explain one of them. It is shown in detail in Figs. 3 and 4. It is composed mainly of a horizontal disk D, of insulating material, Fig. 4, which carries near its outer edge a ring divided into ten sectors D_1 D_2 D_3, &c., equal to one another, and a smaller sector d, called the "repose-sector," which is two-thirds of any one of the other sectors.

The division of the switch into ten equal

sectors results from the grouping adopted (by way of example) for the subscribers. In general, the number of the switch-sectors should be equal to the number of the subscribers' groups. In the case then of ten groups of subscribers the switches D would have ten sectors.

Each of the large sectors D_1 D_2 D_3, &c., is divided into two parts insulated from each other, and of these parts that marked d_1 d_2 d_3, &c., is connected by the wire 12 with an electromagnet E, responding to positive currents, while the other, m n p, is connected by a wire 13_1 13_2 13_3, &c., with one of the groups of carriages, which will be considered later.

To make the drawings simpler, it is supposed, in Fig. 3, that all the parts d_1 d_2 d_3, &c., of the sectors D_1 D_2 D_3, &c., are connected electrically with a central wire d', which is itself connected by the wire 12 with the electromagnet E. In practice in constructing the apparatus any suitable mode of establishing the electrical connections could be adopted.

If attention be given to sector D_1, it will be seen (in confirmation with what has been said above) that the part d_1 of this sector which is insulated from the rest is connected with the positive electromagnet E and that the other part of the sector is connected by a binding-post e_1 with a wire 13_1. In like manner the part of sector D_2 which is not connected with the positive electromagnet is connected by a binding-post e_2 with the wire 13_2, and so on with the others. It should be said in addition that the different sectors D_1 D_2 D_3, &c., are insulated from one another and from the body of the disk D. On this disk, concentric with the ring of sectors D_1 D_2, &c., is fixed a continuous ring D', which is connected by a wire 14, Fig. 3, with a polarized electromagnet E', responding to negative currents.

The sector of repose d, which is insulated from the sectors D_1 and D_{10}, which inclose it, and is two-thirds of one of these sectors, is connected by its outer portion with a wire 15, that, like the wires 13_1 13_2, &c., leads away from the switch.

Above the disk D is a movable arm D'', carrying two brushes e e'. The first of these—to wit, the brush e—rubs during the rotation of the arm D'' over the sectors D_1 D_2 D_3, &c., in such manner that when the arm D'' is over the part d_1 of sector D_1, for example, the brush e rubs at the same time on this part d_1 and on the part m of the sector connected with the wire 13_1.

The second brush e', which is placed below the preceding, is intended simply to connect the wire 14' with the ring D'. A single wide brush could replace the two brushes, and, in fact, the ring D and brush e' could be dispensed with, the wire 14 being otherwise connected with the line-wire 2 in any suitable way.

Suppose for a moment that each of the sectors is divided by radii of the disk D into three equal parts m n p. It will be seen that, Fig. 3, the parts d_1 d_2 d_3, &c., each cover exactly a third part of the length of the sector in which it is intercalated—that is to say, the length of one of said equal parts; but it should be noticed that it only has half the width of the ring of sectors.

The electromagnet E', which operates, as above mentioned, by means of negative currents, acts through its armature upon an arm E'', jointed at its opposite end to a second arm E''', which carries a pawl F for action upon a ratchet-wheel F', having ninety-six teeth. The retraction of the armature upon the cessation of the current raises the pawl and advances the wheel. The play of the armature of the electromagnet is so adjusted that every time the electromagnet E' is traversed by a negative current the pawl advances idly an amount equal to the arc formed by three teeth, and when the current ceases the wheel F' is advanced through an equal arc. This ratchet-wheel has at its center, which is hollow, small pawls f', which act on teeth f'', formed on the shaft f_1, which supports the arm D'', but it could be fast on the shaft f_1, if preferred. This shaft f_1 terminates at its lower part in a point resting in a step, Fig. 4. By this arrangement it will be seen then that the rotation of the wheel F' under the action of the pawl F produces the rotation of the shaft f_1, and consequently of the arm D''.

The electromagnet E is actuated by positive currents, and when its armature is attracted it depresses the bar G'', which is jointed to the arm G''', which carries a pawl G. This pawl G on the retraction of the armature ascends and then acts upon a ratchet-wheel G', which has thirty-two teeth, and the play of the armature of the electromagnet E is so calculated as that the pawl G at each elevation turns the corresponding ratchet-wheel G' through an arc equal to three teeth. The ratchet-wheel G' also, like the ratchet-wheel F', might be fast on the shaft f_1, but, as shown, it is hollow at its center and carries pawls f', which engage teeth f'' on the shaft f_1 of the arm D''. Either of the wheels F' or G' may therefore turn the arm D'' without carrying the other along. In other words, the two wheels, while independent of each other, can, when required, each turn the shaft f_1 on which the arm D'' is fast.

From what has been said it follows that when the electromagnet E' is traversed by a negative current the arm D'' will on cessation of said current turn through an arc equal to three ninety-sixths of the complete circumference—that is to say, through one thirty-second of a circle—and will make a complete revolution under the influence of thirty-two successive negative currents. With three such currents it will run over a complete sector D_1 or D_2, or as the case may be. When the electromagnet E is traversed by a positive current, on the contrary, the arm D'' on cessation of the current turns three thirty-seconds of a circle—that is to say, every displacement

of the arm under the influence of the electromagnet E is three times as great as a displacement under the influence of the electromagnet E'.

The line-wires from the substation corresponding with the switch are connected as follows: one of them (the wire 2) with the arm D'' by the wire 14' and the other (the wire 3) with the electromagnets E and E' by the wire 15'. Such is the complete arrangement of all the devices which constitute any one of the switches placed at the central office and connected with a subscriber's station.

3. *A carriage for a sector of one of the subscriber's switches at the central office.*—In the preceding description of the subscriber's switch it is explained that the wires 13_1 13_2 13_3, &c., lead away from the different sectors of a switch. Each of these wires leads to certain devices which are now to be described and which so control the carriage which in the selected group corresponds with the subscriber as to put it in motion or to stop it, according to the circumstances. It may be recalled that the division of the automatic switch is so made as that each subscriber has a carriage in each group. In the example chosen each subscriber would therefore have ten carriages at the central office.

In Figs. 5, 6, 7, 8, 9, and 10 the carriage arrangements and electrical connections of the different parts with one another and with the switch are shown in detail.

For each group of carriages at the central office is a rotating motor H, which is driven by a battery of accumulators H' or any suitable source. The motor transmits its motion through pulleys h h' to a shaft H'', Fig. 5. On this shaft is mounted for each carriage a set of bevel-toothed wheels h'' h'''. These turn with the shaft H'', but can be shifted lengthwise thereof in such manner that sometimes the wheel h'' engages with a third wheel h_1, and sometimes the wheel h''' engages with the same wheel h_1. Electromagnet h_2, Figs. 5 and 5^a, is connected with the wire 13_1, and on the other side by the wire 18 with the subscriber's return-wire 3. Suitably connected to be operated by the armature of the electromagnet is a ratchet x', engaging a four-toothed ratchet-wheel x on the shaft x'', to which is attached the crank or eccentric x'''. This crank x''' is connected by link y to one arm y' of a pivoted bell-crank lever, whose other arm y'' acts at one end of the system of bevel-wheels h'' h'''.

Normally—that is to say, when no current traverses the electromagnet h_2—the two bevel-wheels h'' and h''' are in their middle position and neither of them engages the wheel h_1. When the electromagnet h_2 is traversed by a negative current, it shifts the system of bevel-wheels h'' and h''' in a direction parallel with the shaft H''. The shifting might be made to take place on the cessation of the current. At the first change of the wheels the bevel-wheel h'', for example, comes in contact with the middle wheel h_1 and puts in motion both said wheel h_1 and the screw H_1 on which the same is mounted. The electromagnet h_2 is so arranged that if it is traversed by a second current the bevel-wheel system h'' and h''' is shifted in the opposite direction and thereby brought back to the middle position—that is to say, to the position in which the wheel h_1 is in contact with neither of the two others. A third current sent through the electromagnet effects a shifting in the same direction as the second, but so as that the wheel h''' now comes in contact with the wheel h_1. The screw H_1 is rotated thereupon in the opposite direction, and in order to bring the system of wheels afterward to their middle position use is made, not of a fourth negative current, but of the mechanical device H_2, Fig. 5, which is formed by a bent lever acting at one end of the said system and having its outer end under the screw H_1, and so placed in the path of the carriage which moves lengthwise of said screw as that when the carriage returns to the starting-point it strikes the end of the bent lever H_2 and brings the system of wheels h'' h''' to the middle position, thereby arresting the rotation of the screw.

In the drawings the details of the electromagnet h_2 for producing the movements above explained are shown; but use may of course be made of any known or suitable arrangement for accomplishing the three movements mentioned.

From what precedes it is seen then that the screw H_1, which is fast in the wheel h_1, may either be stationary or turn in one direction or turn in the opposite direction, and that its condition can be controlled by the passage of currents through the electromagnet h_2. The object of the movements will be explained below.

On the screw H_1 is mounted a carriage H_3, which forms the nut for the screw and which consequently is moved horizontally lengthwise of this screw from right to left or from left to right, according to the direction of rotation of the screw. To prevent the carriage from turning with the screw, two supports I I', Fig. 5, are provided for retaining it. The carriage proper, H_3, is composed of a platform carrying an index or brush i, which during the travel of the carriage rubs along a band i', provided at given distances with metallic switch-points i''. The brush i is connected by the wire 19 with the subscriber's line-wire 2, and the metallic contacts i'' on the band i' are connected with a battery I_1, Fig. 5, which itself is connected by the wires 18' and 18 with the subscriber's return-wire 3. On Fig. 9 and in the general views, Figs. 11^a and 11^b, to simplify the illustration the wire 18' is shown as connected directly with the wire 3. The front part of the carriage carries an inclined arm I_2, which is jointed to the carriage and provided at the end with two metal portions i_2 and i_3, insulated from each other. This inclined arm I_2, Fig. 6, can turn on its joint i_4, and a spring holds it normally slightly in-

clined forward, as indicated in Fig. 6. The metallic portion i_2 of the arm is connected with the wire 19, and consequently with the subscriber's line-wire 2, while the metallic portion i_3 is connected by the wire 20, Fig. 9, with the subscriber's return-wire 3. Under the carriages of each group, which are arranged parallel with each other, as indicated in Figs. 11ª and 11ᵇ, are placed in a position at right angles to the paths of the carriages the strips K_1, which are divided into two metallic portions $k_1 k_2$, insulated from each other. These strips are mounted on vertical bars k_3 and subjected at given distances to the action of springs k_4, which tend constantly to maintain the strips at a certain height. Stops (not represented on the drawings) may be used to arrest the strips at the desired height, the springs forcing the strips against the stops. If any carriage H_3 passes above one of these strips, the arm I_2 of the carriage will bear upon the strip and depress it. If at this moment the carriage is stopped, the arm will remain in contact with the strip K; but if, on the contrary, the carriage continues its movement the arm I_2 will escape from the strip, as indicated in Fig. 7, and this latter under the action of the spring k_4, Fig. 4, will ascend to its original position. It hence follows that any carriage advancing from its starting-point at the end of the screw H_1, on which it is mounted, will in succession depress all the underlying strips and that these will return to their positions at once on the passage of the carriage under the action of the springs k_4.

In Fig. 9 the scheme of communication between a subscriber's station, the corresponding central-office switch, and the carriage corresponding with one of the switch-sectors is shown on a larger scale.

As explained above, each subscriber of the exchange belongs to a particular group at the central office and has, in this group only, a strip K. It remains then to explain the mode of connection which exists between the subscriber's station and the strip belonging to him at the central office. To aid in this explanation, the strip K in Fig. 9 is shown as belonging to the subscriber whose station apparatus is indicated at A. The two portions of this strip K are connected one by the wire 21 with the subscriber's return-wire 3 and the other by the wire 15 with the repose-point in the subscriber's switch D. The object of this arrangement will be given below in explaining the connections.

If the automatic switching system should be applied to an exchange having a very large number of subscribers, ten thousand subscribers, for example, divided into groups of one thousand, it would be necessary to have ten thousand carriages in line in each group; and although the dimensions of the carriages might be very small the shaft H″ would have to be very long. To avoid this difficulty, instead of arranging in one horizontal plane all the carriages of the same group they are divided into secondary groups placed in parallel horizontal planes, Fig. 10. In this case the strip of a subscriber instead of being continuous is divided into segments K_0 placed vertically under one another, the different segments being connected by bars L L′, so that under the action of a carriage the system composed of all the segments is depressed as if it were a continuous strip. This connection of the segments with one another has for its object to avoid the simultaneous connection of several subscribers with another subscriber.

If the case be taken of a continuous strip not divided into segments, it will be seen that when a strip is depressed by a carriage it is impossible for another subscriber to put his line in contact with it; and it is the same with a strip divided into several segments joined together, as explained above, since they move together as one piece.

In the preceding description it is said that a motor is used for each group, the motor rotating continuously; but of course at the central office instead of providing a motor for each group there may be one motor for the exchange which drives the different shafts H″ of the groups by means of mechanical gearing, or any number of motors, according to the working of the central office.

Having thus described in detail all the elements of the new or improved system of automatic switching for telephone-exchanges, the communications between these different parts will now be explained.

4. *General explanation, with examples, of the system of communication.*—It should be said at once in the explanation which follows, an exchange is supposed with twenty subscribers divided into groups of two, and, further, it is assumed that the carriages in each group are placed, as indicated in Fig. 10, in two parallel horizontal planes, each containing only ten carriages.

To facilitate the description, reference will be made to Figs. 11ª and 11ᵇ, which show the system as a whole, reference being also made to the detail views for the different movements of the various parts of the system.

As shown in Figs. 11ª and 11ᵇ the subscribers No. 1 and No. 2 have their respective strips in group No. 1, the subscribers No. 3 and No. 4 in group No. 2, the subscribers No. 5 and No. 6 in group No. 3, the subscribers No. 7 and No. 8 in group No. 4, the subscribers No. 9 and No. 10 in group No. 5, the subscribers No. 11 and No. 12 in group No. 6, the subscribers No. 13 and No. 14 in group No. 7, the subscribers No. 15 and No. 16 in group No. 8, the subscribers No. 17 and No. 18 in group No. 9, and the subscribers No. 19 and No. 20 in group No. 10. The subscribers No. 1 and No. 2 may then be respectively designated by the fractions 1—1 and 1—2, the subscribers No. 3 and No. 4 by the fractions 2—1 and 2—2, and so on, meaning that subscriber No. 4 is the second member of

the second group. The second strip of the second group, therefore, belongs to him, just as subscriber No. 1 is the first member of the first group, and the first strip of the first group belongs to him, and so on for the others. In the fraction designating a subscriber the numerator designates the group and the denominator the number in order of the subscriber in the group.

In the scheme of connections the connections are shown completely only for subscribers No. 1, No. 2, and No. 10.

First. In explaining the working of the apparatus when the telephonic communication is to be established between two subscribers of the same group reference will be made to stations 1—1 and 1—2.

Second. In explaining the connection of two subscribers of different groups reference will be made to stations 1—1 and 5—2.

The subscriber 1—1 wishing to enter into communication with any subscriber of the exchange should first of all remove the arm D″ of the central-office switch from its position of repose. To do this, he should send two negative impulses, which he can do by turning the arm *b* of his substation-switch A_3 until it reaches the point b_2. The arm *b* during the movement rubs over the points b_0, *b**, and b_1 interposed between the two points mentioned. In rubbing over the points b_0 and b_1 the arm *b* closes the circuit of the electromagnet E′ through the battery A_1. A negative current leaving the battery A passes by the wire 6, the point b_0 or b_1, the arm *b*, the wire 8, the wire 1, and the wire 2 to the central office, where it goes by wire 14′ to the arm D″ of the subscriber's central-office switch, and passing thence by brushes *e* and *e′* to the ring D′ and wire 14 it enters the electromagnet E′. After traversing the coils of this magnet the current goes by wire 15′ to line-wire 3 back to the subscriber's and returns to the battery A_1 by the wire 5. The circuit of the electromagnet E′ is thereby closed and this electromagnet is traversed by a negative current, to which it responds, since it is polarized to respond to negative currents. Its armature is attracted and then released, and on its return the bar E″ is depressed, causing the pawl F to turn the ratchet-wheel F′ through an arc equal to three teeth. Each current turns the switch-wheel through one thirty-second of a circle, and the arm D″ comes (as a result of the two currents) over the first part *m* d_1 of the sector D_1, so that the brush *e* makes contact with both the point d_1 and part *m*, while the brush *e′* makes contact with both part *m* and with the ring D′. It will be noted that after the arm D″ has left its position of repose it is impossible for any subscriber to the exchange whatsoever to put himself in communication with the subscriber to whom the switch in question belongs, for the strip corresponding with this subscriber is connected by the wire 15 with the repose-point *d*, and this, by the movement of the arm D″, is no longer in electrical connection with the line. After the arm D″ has left the position of repose the subscriber 1—1 who wishes to talk should connect with the group of the subscribers with whom he wishes to put himself in communication. In the example selected it is a subscriber of the first group who is indicated by the fraction 1—2. In such case the subscriber 1—1 does not have to move the arm D″ to another sector of the switch, since the arm is already on the sector desired—the first. It would not be the same if the subscriber to whom the subscriber 1—1 might wish to talk were in a group other than the first. In the latter case, as will be seen when explanation is given of communication between the subscribers 1—1 and 5—2, the subscriber 1—1 would have to manipulate the arm a_2 of his home switch A_2 in such manner as to bring the arm D″ of his central-office switch D on the fifth sector. To repeat, the transfer of the arm D″ from one sector to another is produced by manipulating the home switch A_2, and in the example chosen the subscriber does not have to trouble himself to shift the arm D″ to another sector, since it is already on the desired sector. The subscriber 1—1 then does not have to select the group in which the subscriber 1—2 is located, because the arm D″ of the switch of subscriber 1—1 has already come, under the influence of the first negative current, in contact with the sector No. 1, which is connected with the group to which the subscriber 1—2 belongs. The arm D″ of the calling subscriber's switch being then in contact with the sector corresponding with the group in which is located the strip of the subscriber to be called, it suffices for the subscriber 1—1 to advance his carriage in group 1 until it makes contact with the second strip of the group, which strip corresponds with the subscriber 1—2. In order to move the carriage forward, the subscriber 1—1 manipulates the arm C_1 of the first disk A_5″ of the turn-counter by turning it in the direction of the arrow and placing it in the notch corresponding with the unit-number of the subscriber—that is, in the example selected, in the notch No. 2. The manipulation of the arm C_1 of the counter is now ended, for the subscriber's number neither contains tens nor hundreds.

It would have been otherwise if instead of considering a system of self-switching for twenty subscribers divided into ten groups of two a system had been taken of ten thousand subscribers divided into ten groups of one thousand. In that case, apart from the indication of the group, certain subscribers would have had three or two figures in the numbers by which they would be desinated. So it would be if the subscriber 2—846 or 3—846 were taken as an example. He would be in the third group and possess strip No. 846. In case the subscriber 1—1 wishes to talk with subscriber 2—846, he would have to manipulate first his home switch A_2 to se-

lect the group, as explained below, and then his turn-counter so as to place the arm C_1 of the disk A_5'' in the notch No. 6, the arm C_1 of the disk A_5' in the notch No. 4, and the arm C_1 of the disk A_5 in notch No. 8. Apart from the positions of the arms C_1 of the turn-counter the following explanation of what is to be done with reference to the subscriber 1—2 is as applicable to the case of subscriber 3—846 in an exchange having ten thousand subscribers as to said subscriber 1—2 in an exchange of twenty subscribers. The subscriber 1—1, after placing the arm C_1 of the disk A_5'' in notch No. 2, manipulates anew the arm b of the home-switch A_3, so as to shift it from the point b_2 onto the point b_4. In this transfer the arm b rubs over the point b_3, which has the effect, as mentioned before, of closing the circuit of the electromagnet E' through the battery A_1. A negative current traverses then this electromagnet E', and the armature acts as before upon the arm D'', but now in such manner as to bring it to the middle part n of the first sector D', for it takes three movements of the arm D'' for it to complete its passage over a sector—namely, a first movement to bring it over the portions d_1 m, a second to bring it over the portion n, and, lastly, a third to bring it over a portion p. The arm D'' being on the middle portion of the sector, is only in contact with the portion thereof which is connected by the wire 13_1 with the electromagnet h_2, Fig. 5. It has wholly left the part d_1 of the sector, which is connected with the electromagnet E, Fig. 3. The negative current last mentioned, which when sent by the subscriber 1—1 shifts the arm D'', goes also by way of the sector D' and wire 13_1 to the electromagnet h_2, returning by wire 18, subscriber's return-wire 3, and wire 5 (at the subscriber's) to the battery. Consequently the circuit of this electromagnet h_2 is closed. It responds and brings together, as before explained, the wheel h'' and the wheel h_1. These wheels intermesh and the screw H_1 rotates. The corresponding carriage H_3 is advanced, and the brush i of this carriage bears upon the first metallic point i'' of the band i'. Through this contact the brush i closes the circuit of the electromagnet A_4 of the subscriber's station through the battery I_1. The current from this battery goes from the point i'', brush i, and wire 19 to the line-wire 2, and after arriving over this wire at the subscriber's station it passes by the wire 1, arm b of the home switch A_3, point b_4, (on which the arm is at this time,) and wire 7 to the electromagnet A_4. After traversing this magnet it returns by the wire 3 and wires 18 and 18', Figs. 3 and 5, to the battery I_1. The circuit of the polarized electromagnet A_4 is then traversed by a positive current, for the battery I_1 can only send positive currents.

The electromagnet A_4, being traversed by a positive current, attracts and then releases its armature and turns the disk A_5'' through an arc equal to one division, carrying along the arm C_1, which has been placed in the second notch of the disk.

The carriage when it touches the switch-point i'' with its brush i is preferably just about to bear with its front arm i_2 on the strip K, No. 1, so the positive current from battery I_1 does not go to the said strip. Under the action of the dynamo the carriage continues to advance; but it only depresses the strip without stopping, and the arm I_2 leaves the first strip K in the manner shown very clearly in Fig. 7. The subscriber's carriage continuing to move on causes the brush i to touch the second metallic contact i''', and in the same way as before a second positive current goes to the subscriber's station and operates his home magnet A_4. The disk A_5'' is turned then again through an arc equal to one division, but in this second rotation the arm C_1 of the disk A_5'' makes contact with the point c_3, Fig. 2, and closes the circuit of the electromagnet E' of the switch D through the battery A. A negative current now goes from the battery A_1 by the wire 9, point c_1, arm C_1 of disk A_5 and wire 10 to the point c_2, and from this point it passes through the arm C_1 of disk A_5', wire 11, and point c_3, thence through the arm C_1 of the disk A_5'', (which at this time is over the last-mentioned point,) and at length by the wire 12' to the subscriber's line-wire 2, Fig. 2. This conducts it to the wire 14' and arm D'' at the central office. From the arm D'' it passes by the brush e to the sector D_1, thence by the brush e' to the ring D', and so to the electromagnet E'. After traversing this magnet the current returns by wire 15', return line-wire 3, and wire 5 to the battery A_1. The electromagnet E', being traversed by a negative current, responds, and the arm D'', which was on the middle part n of sector D_1, comes over the last part p of this sector; but, further, the negative current sent by the battery A_1 to the sector D_1 divides into two, of which one goes to the electromagnet E' and operates as just explained, while the other passes by the wire 13_1 to the electromagnet h_2 and returns by the wire 18 and the return line-wire 3. The circuit of the electromagnet is therefore also closed and it is traversed by a current which produces, as explained above, a shifting of the system of two wheels h'' h''' in such manner as to place them in the middle position. The wheel h_1 no longer meshes with either of the wheels h'' h'''. It no longer rotates and the carriage H_3 stops. On stopping it is over the strip No. 2 and in contact therewith, for the brush i and the arm I_2 are preferably so arranged with reference to one another that at the moment when there is contact between any one of the points i'' and the brush i the arm I_2 is just about to depress the strip K, above which it at that moment may be, and, further, that the arm I_2 makes contact with the strip K during the time which elapses after the contact is broken between the brush i and the point i'' before the carriage is arrested. The negative cur-

rent which is sent by the electromagnet A_4 would go by strip K, No. 2, to the switch D of subscriber 1—2 and shift the arm D″ thereof, but not so as to clear the repose-point, since for this two negative currents are required. In the position thus attained the carriage H_3 of group No. 1 which belongs to subscriber 1—1 is in contact with strip No. 2 of the same group belonging to subscriber 1—2, with whom the subscriber 1—1 wishes to put himself in communication. Now the strip No. 2 which is thus depressed by the arm I_2 of the carriage is divided, as said above, into two portions k_1 k_2, of which one is connected with the repose-point d of the switch of the subscriber 1—2, to whom the strip belongs, and the other is connected by the return line-wire 3 with this subscriber's station. Telephonic communication is therefore established between the two subscribers 1—1 and 1—2, and the subscriber 1—1 can call up the subscriber 1—2 by means of positive currents which do not change the positions of the devices of the exchange. These currents cannot reach the electromagnet E, because the arm D″ is not in contact with the point d_1 of the switch-sector D_1, and all the other polarized electromagnets of the exchange act upon their armatures only when influenced by negative currents, except the electromagnet A_4. The electromagnet A_4 belonging to the calling subscriber 1—1 may be operated by the positive currents used in calling or conversation, for at this time the lever b of the switch A_3 is on the point b_4; but the action of the positive currents on the electromagnet A_4 can only produce rotation of the counting-wheels, an inconvenience of secondary consideration, and one, moreover, which can be avoided by taking the trouble of holding these wheels by any appropriate means before calling or speaking with the subscriber with whom communication has been established.

The positive calling-currents, or those employed in the operation of the telephone proper, neither of them produce any operation of the parts of the switch D belonging to the subscriber 1—2, with whom the subscriber 1—1 talks. These currents reach the repose-points d of the switch D of the subscriber 1—2 by the wire 15, pass to the brush e, and thence to the line of subscriber 1—2, over which they reach his station, there to produce the call desired, they returning by the return line-wire 3, portion k_1 of the strip, and part i_3 of the subscriber 1—1. At this time no other subscriber can put himself in communication with the subscriber 1—2, because the strip which corresponds with the latter subscriber is depressed by the carriage corresponding with the subscriber 1—1 in the group 1. Conversation ended, it is necessary to bring back the parts displaced to their original positions. The subscriber 1—1, who was the calling subscriber, operates the arm b of his home switch in such a manner as to make it pass from the point b_4 to the point b_6 and in passing to rub upon the point b_5. The contact of the arm b with the point b_5 sends, as above explained, a negative current to line. This negative current goes by the wire 2, the wire 14′, to the arm D″ of the switch of subscriber 1—1, passes thence by the brush e to sector D_1, and then divides into two currents, of which one, going by way of the brush e' and ring D′, traverses the electromagnet E′, to return by the wire 15′ and wire 3 to the station of subscriber 1—1, and the other, going by way of the binding-post e_1 of sector D_1 and wire 13_1, traverses the electromagnet h_2, to return to the station of subscriber 1—1 by the wires 18 and 3. The two electromagnets E′ and h_2, which are each traversed by a negative current, are thereby operated, the former to shift the arm D″ from the part p of the first sector D_1 to the part m of the second sector D_2 and the latter to shift the system of the two wheels h'' and h''' and bring the wheel h''' in contact with the wheel h_1. This latter then turns in the opposite direction to that in which it revolved in advancing the carriage H_3. This then runs back, and in reaching its starting-point it strikes against the end of the bent lever H_2, and thereby brings the system of wheels h'' h''' back to the middle position, so that carriage H_3 stops and remains at rest. The negative current last referred to, which is produced by the passage of the arm b of switch A_3 over the point b_5 of the home apparatus of subscriber 1—1, is divided, as has been seen, into two, of which one traverses the electromagnet E′ and the other the electromagnet h_2; but, further than this, the current goes by the wire 14′ and the wire 19 to the portion i_2 of the arm I_2, and from there it passes to the strip before its separation from the arm I_2, and by said strip and connections to the central-office switch of the subscriber 1—2. The negative current on traversing the electromagnet E′ of this switch forces the arm D″ to place itself on the part m of the first sector D_1. At this moment, that is to say, after the sending of the last negative current by the manipulation of the switch A_3 of the substation 1—1, the parts occupy the following positions:

First. At the station of subscriber 1—1 the arm a_2 of switch A_2 is in notch No. 1. It has not budged. The arm b of the switch A_3 is at its starting-point, and the wheels A_3 A_5' A_5'' are in the position of repose.

Second. At the central-office switch of subscriber 1—1 the arm D″ is on the part m of the sector D_2.

Third. In the first carriage group the carriage belonging to subscriber 1—1 is in the position of repose, ready for a new connection.

Fourth. At the central-office switch of the subscriber 1—2, with whom the subscriber 1—1 has been talking, the arm D″ is on the part m of sector D_1.

Fifth. At substation 1—2 none of the devices have changed place. All are in the repose positions.

It suffices then for all the parts to be brought to zero that the arms D″ of the two switches be returned to their repose-points. This is easily effected, and it suffices for each subscriber to turn the arm a_2 of his home switch A_2 from left to right until this arm reaches its repose position. This operation has for its object to send to each switch as many positive currents as there are contacts with metallic points a of the switches A_2. When the arm a_2 of one of the switches A_2 comes into contact with one of the switch-points thereof, a positive current from the battery A_1 reaches the respective point by the wire 4, and after traversing the arm a_2 goes thence by the wires 1, 2, and 14′ to the switch D. If now consideration is given first to the arm D″ of the switch D of subscriber 1—1 which is on the part m d_2 of the sector D_2 it will be seen that the first positive current will reach the point d_2 through the brush e and will thence pass to the electromagnet E, to return by the wires 15′, 3, and 5 to the battery A_1. The electromagnet E being traversed by a positive current attracts its armature, and the bar G″, through the intermediary of the pawl G, turns the ratchet-wheel G′ through an arc equal to three teeth, so that the arm D″ will come from the point d_2 onto the point d_3 of sector D_3, for the displacements of the arm D″ produced by the electromagnet E are three times as large as those produced by the electromagnet E′. If the subscriber 1—1 continues to operate the arm a_2 of his switch A_2, the arm D″ will continue to step progressively from point d_3 to point d_4, from point d_4 to point d_5, and so on until it passes from point d_{10} to the repose-point d. It will then budge no farther, for this point is not connected with the electromagnet E. All the parts of substation 1—1 will thus have been brought to zero when this subscriber shall have effected a complete rotation of the arm a_2 of his switch A_2. What has just been said of the subscriber 1—1 applies also to the subscriber 1—2, and the manipulation of the arm a_2 of his switch A_2 will in like manner bring the arm D″ of his switch onto the repose-point. All the operations are now ended.

In the example just given the subscriber 1—1 is supposed to talk with the subscriber 1—2, who belonged to the same group as himself.

A case will now be taken in which the subscriber 1—1 wishes to talk with a subscriber 5—2, for example, belonging to group No. 5. The same functions and effects are produced in the same manner as in the preceding example, and to follow them it is sufficient to refer to Figs. 11[a] and 11[b], on which the scheme of communication between these two subscribers is represented. The only difference in the manipulation in this case is in the operation of the arm a_2 of his switch A_2 by the subscriber 1—1, an operation which he did not have to make in the first case because the two subscribers belonged to the same group. As mentioned above, after the sending of the negative currents for shifting the arm D″ from its repose position the subscriber 1—1 should operate his switch A_2 so as to place the arm D″ of the switch D on the sector corresponding with the group in which the subscriber is with whom he wishes to talk. In the example selected this subscriber belongs to the fifth group. He will have then to shift the arm a_2 in such manner as to bring it between the metallic contacts 5 and 6. By this means he sends five positive currents, and thereby shifts the arm D″ of his switch onto the part d_5 of the sector D_5, thus making a connection between the switch and the carriage of the subscriber 1—1 in group No. 5. From now on the same operations as in the first case are performed in the same way and in the same order.

The following is a résumé of what a subscriber has to do in order to put himself in communication with another subscriber of the exchange:

First. The negative currents are sent by the switch A_3 in order to shift the arm D″ of the central-office switch from its repose position to the point d_1 of the first sector D_1.

Second. A series of positive currents is sent by the switch A_2 in order to place the arm D″ of the switch on the first part of the sector corresponding with the group to which belongs the subscriber with whom it is wished to talk.

Third. The arms C_1 of the counting-wheels are arranged according to the number in order of the last-mentioned subscriber in the group selected.

Fourth. A negative current is sent by the switch A_3 to start the subscriber's carriage in the selected group. After this current is sent the carriage in advancing sends to the calling-subscriber's station positive currents, which traverse the electromagnet A_4 and move the counting-wheels A_5 A_5' A_5''.

Fifth. The arms C_1 of the counting-wheels in reaching their positions of repose send to the central office a negative current, which stops the carriage. It is at this time that conversation can be carried on between the subscribers.

Sixth. A negative current is sent by the switch A_3 from the station of the calling subscriber. This current has the effect of bringing back the carriage to its original position.

Seventh. The arms a_2 of the two substation-switches A_2 are rotated completely, so as to bring all the parts back to the repose positions.

In claiming the new or improved system of automatic switching for telephones whereby the services of employees at the central office for connecting the different subscribers with one another may be dispensed with, as also the various new or improved parts, arrange-

ments, or combinations forming part thereof, it will of course be understood that it is intended to secure the invention and each of the improvements constituting the same for all the applications of which they may severally or together be susceptible.

I claim as my invention or discovery—

1. An automatic system of telephone-switching in which the station of each subscriber is connected with a central-office switch divided into as many sectors as there are groups of subscribers and in which each sector of said central-office switch is connected with a carriage that passes over strips connected respectively with the subscribers' lines and is arranged to put itself in electrical connection with any given strip according to its position, the exchange being thus divided into groups in each of which there are as many carriages as there are subscribers to the exchange and as many strips as there are subscribers in that group, substantially as described.

2. An apparatus for a subscriber's station comprising (in addition to the telephone instruments proper) a switch arranged to send to line positive currents, a second switch arranged to send negative currents to line, a counter composed of a number of wheels, and an electromagnet arranged in a branch which is closed by said second switch and having its armature connected with said counter, in combination with a central-office switch responding to negative and to positive currents, and arranged to connect the subscriber's line with wires which lead from different divisions of said office-switch substantially as described.

3. An apparatus for a subscriber's station comprising (in addition to the telephone instruments proper) a switch arranged to send to line positive currents, a second switch arranged to send negative currents to line, a counter composed of a number of wheels, and an electromagnet arranged in a branch which is closed by said second switch and having its armature connected with said counter, in combination with a central-office switch responding to negative and to positive currents and arranged to connect the subscriber's line with the wires that lead from the different sectors, and electrical devices responding to negative currents, and arranged to put said wires in electrical connections with other subscribers' lines, substantially as described.

4. In combination with the other parts of an automatic system of telephone-switching in which the station of each subscriber is connected with a central-office switch divided into as many sectors as there are groups of subscribers and in which each sector of said office-switch is connected with a carriage that passes over strips connected respectively with the subscribers' lines and is arranged to put itself in electrical connection with any given strip according to its position, a counter at a subscriber's station arranged to control the carriage belonging to such station so that it stops over the strip corresponding with the subscriber to be called, said counter being composed of a series of wheels with adjustable arms which can be set in a position to represent the number of the subscriber to be called and which being carried along with the wheels conjoin in sending to line a current to arrest the carriage at the central office substantially as described.

5. A counter composed of a series of wheels provided with adjustable arms, switch-points and connection for completing a circuit through the arms in series, and an electromagnet operating means for turning the wheels, substantially as described.

6. A counter composed of a series of wheels provided with adjustable arms, switch-points and connection for completing a circuit through the arms in series, and an electromagnetic operating means for turning the wheels, in combination with an automatic switching apparatus at the central office arranged to send currents to the subscriber's station for turning said wheels and to be arrested by a current sent out by the conjoint action of said series of arms, substantially as described.

7. A switch having two electromagnets for turning its switch-arm, and two sets of switch-points, one set of points being arranged for establishing the circuit through one of said electromagnets and the other for establishing connections with devices outside the switch, and movable circuit-closing means contacting with a member of each set of switch-points in one position and with a member of but one set of switch-points in another position, whereby the circuit is simultaneously closed through one of said magnets and said outside devices in one position of the circuit-closing means, and through said outside devices solely in the other position, substantially as described.

8. A switch having two electromagnets for turning its switch-arm, and two sets of switch-points, one set of points being arranged for establishing the circuit through one of said electromagnets and the other for establishing connections with devices outside the switch, in combination with electromagnetically-controlled switching devices responding to currents of opposite polarity to those which actuate the last-mentioned electromagnet and arranged in the branches which are connected with the last-mentioned set of switch-points, substantially as described.

9. In combination with the other parts of an automatic system of telephone-switching in which the station of each subscriber is connected with a central-office switch divided into as many sectors as there are groups of subscribers and in which each sector of said office-switch is connected with a carriage that passes over strips connected respectively with the subscribers' lines and is arranged to put itself in electrical connection with any given strip according to its position, a cen-

tral-office switch having a switch-arm connected with the subscribers' line and two polarized electromagnets responding to positive and negative currents respectively for turning said arm and the said switch being provided with a sector of repose and two additional sets of switch-points, of which one set is connected with the positive electromagnet aforesaid and the others with the respective electromagnets which control the carriages belonging to the subscriber in the several groups, substantially as described.

10. In the herein-described automatic system of telephone-switching, wherein each subscriber is provided at the central office with a movable carriage for effecting the desired connections, the central-office switch for each subscriber connected with the subscribers' station by wires leading respectively through the arm of said switch and through two electromagnets of opposite polarity whose armatures operate ratchet-wheels that turn the said arm, the plate of said switch carrying two concentric metallic rings of which one is connected with the said negative electromagnet while the other divided into ten insulated two-part sectors and a sector of one-third the width has one insulated part of each of the ten sectors connected with the said positive electromagnet and the other insulated part with one or other of the electromagnets which control the movements of the corresponding carriages, and the said switch-arm being provided with two brushes one of which is connected with the line and rubs over the sectors and the other of which is insulated and rubs over the ring and a part of the sectors, substantially as described.

11. A carriage system comprising an electromagnet arranged to control a system of bevel-wheels on a continuously-rotating shaft so that they are both out of contact with a third wheel or separately intermesh therewith according to their position, a screw connected with said third wheel and provided with a nut which constitutes or forms part of the carriage, an arm of said carriage, and strips which are depressed by said arm in passing and rise when it has passed, the said carriage not being arrested by the contact of said arms with the strips but continuing to advance and carrying a brush which during the depressions of the strips makes contact with a series of metallic points equal in number to the strips so as to close each time the circuit of a battery and send a positive current, substantially as described.

12. In combination with the other parts of an automatic system for telephone-switching in which the station of each subscriber is connected with a central-office switch divided into as many sectors as there are groups of subscribers and in which there is a counter at each subscriber's station, a carriage system corresponding with each sector of the respective switches and comprising an electromagnet arranged to control a system of bevel-wheels on a continuously-rotating shaft so that they are both out of contact with a third wheel or separately intermesh therewith according to their position, a screw connected with said third wheel and provided with a nut which constitutes or forms part of the carriage, an arm of said carriage, and strips which are depressed by said arm in passing and rise when it has passed, the said carriage not being arrested by the contact of said arms with the strips but continuing to advance and carrying a brush which during the depressions of the strips makes contact with a series of metallic points equal in number to the strips so as to close each time the circuit of a battery and send a positive current to the subscriber's station for operating the counter there, substantially as described.

13. An automatic system for telephone-switch in which the apparatus at each subscriber's station is composed of a series of wheels with adjustable switch-arms, means whereby a current may be sent to line by the conjoint action of the series of arms, a polarized electromagnet for operating said wheels, and means whereby at one time positive and at another negative currents may be sent to the central office independently of said adjustable arms, and whereby said polarized electromagnet may be connected in circuit at a particular time, and the apparatus at the central office is composed of groups of strips connected with different subscribers' lines, carriages for all the subscribers, one for each, arranged to pass over the strips of each group for establishing electrical connection with any desired strip in such group, means whereby the said carriage may be controlled by currents from the subscriber's station and may send currents to said station for operating the aforesaid series of wheels and switch-arms, and an electromagnet-switch for putting the subscriber's line in connection with a carriage in one or other of said groups according to the position of said switch, substantially as described.

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

MOISE FREUDENBERG.

Witnesses:
H. T. SMITH,
EDOUARD BARBARY.