E. BLOS.

AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED DEC. 21, 1909.

1,046,952.

Patented Dec. 10, 1912.

7 SHEETS—SHEET 1.

Fig. 1

Fig. 2.

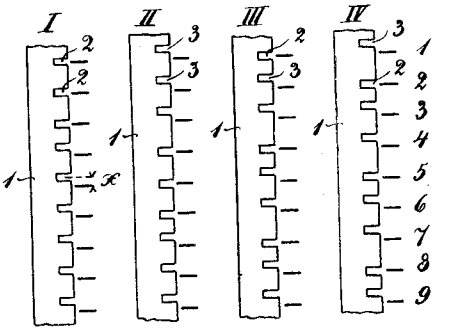


Fig. 3.

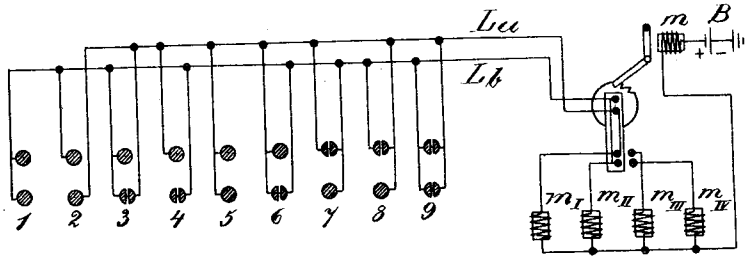


Fig. 4

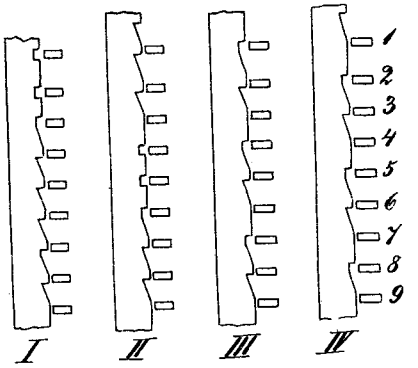
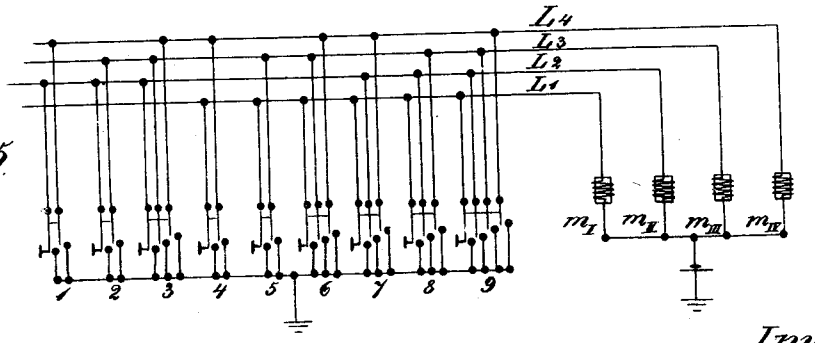


Fig. 5.



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7 SHEETS—SHEET 2.

Fig. 6.

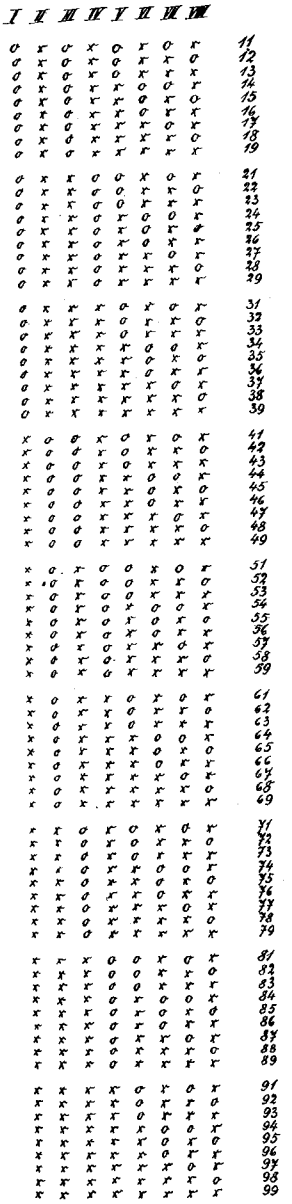
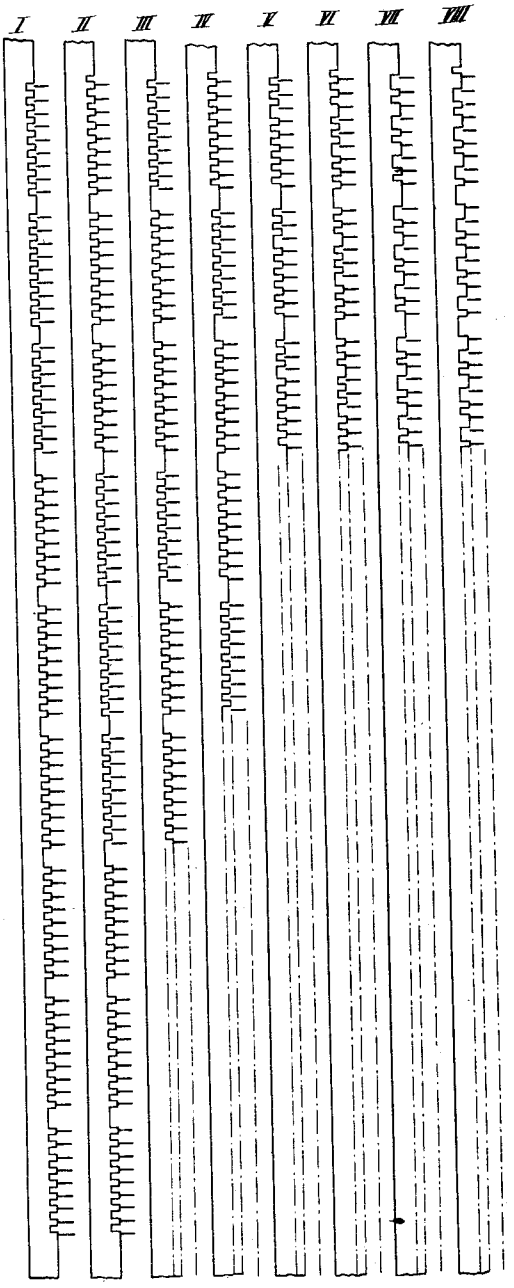


Fig. 7.



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7 SHEETS—SHEET 3.

Fig. 8.

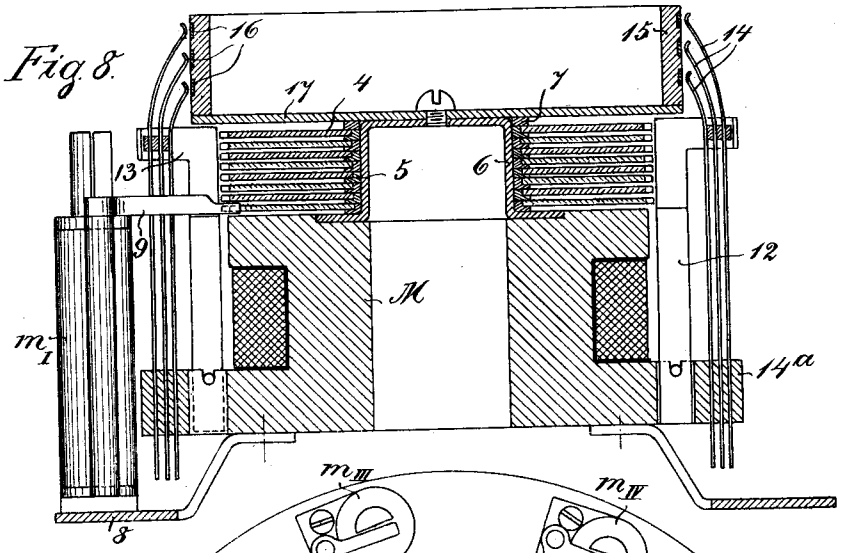

Fig. 9.

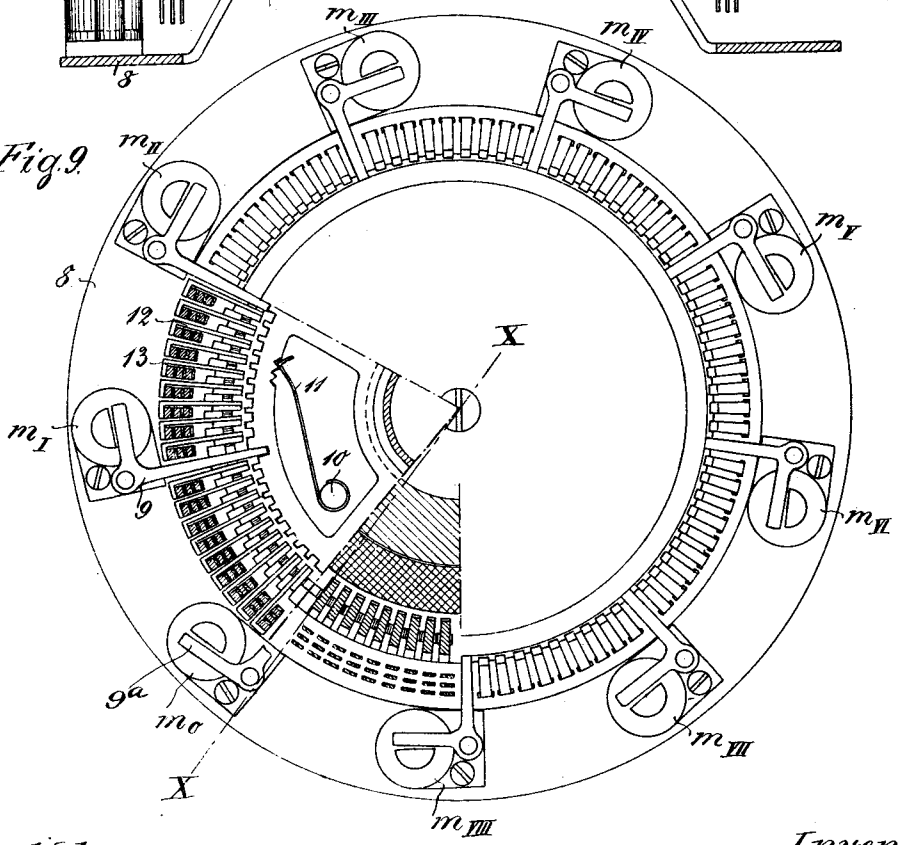

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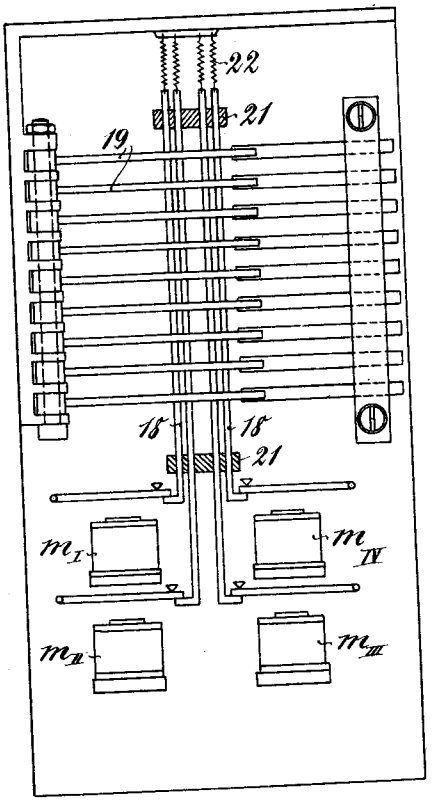
Fig. 10.



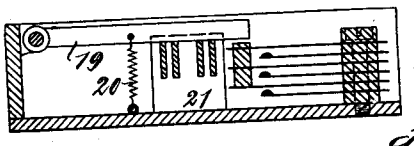
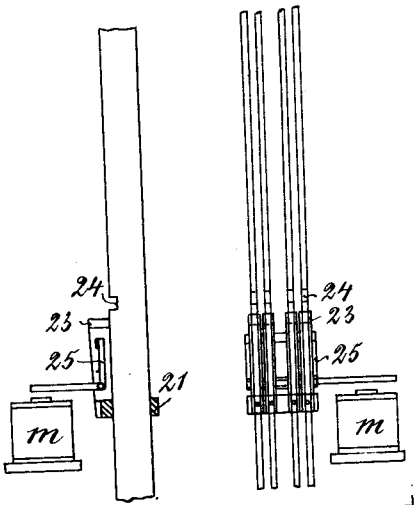


Fig. 11.

Fig. 12. Fig. 13.



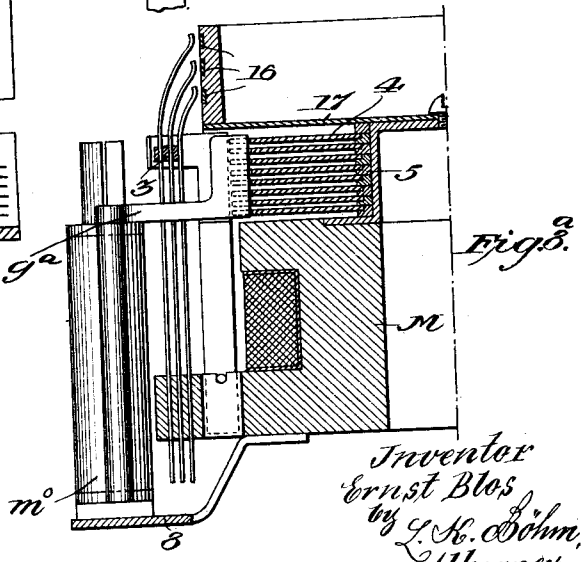


Fig. 3.

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7 SHEETS—SHEET 5.

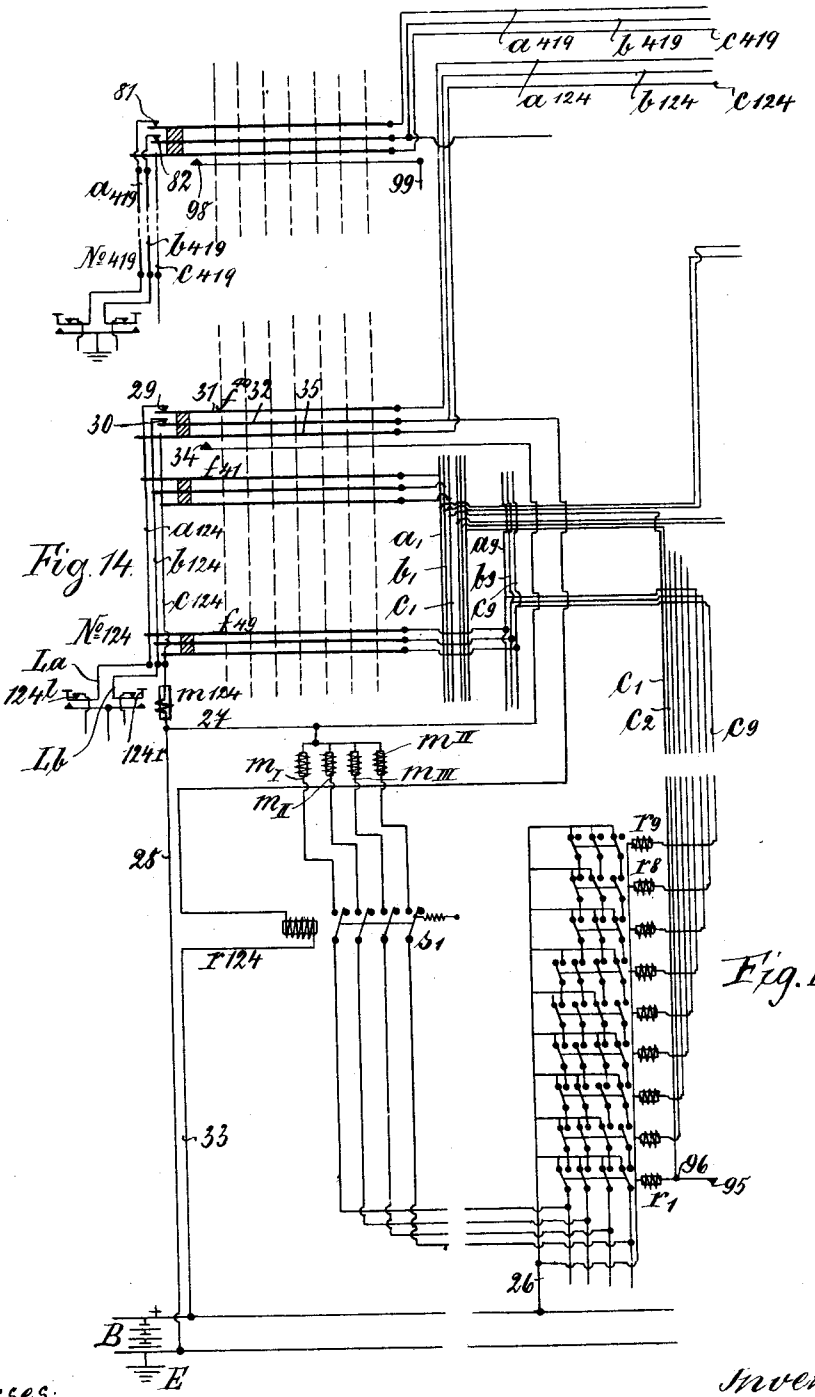

Fig. 14.

Fig. 15.

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7 SHEETS—SHEET 6.

Fig. 16

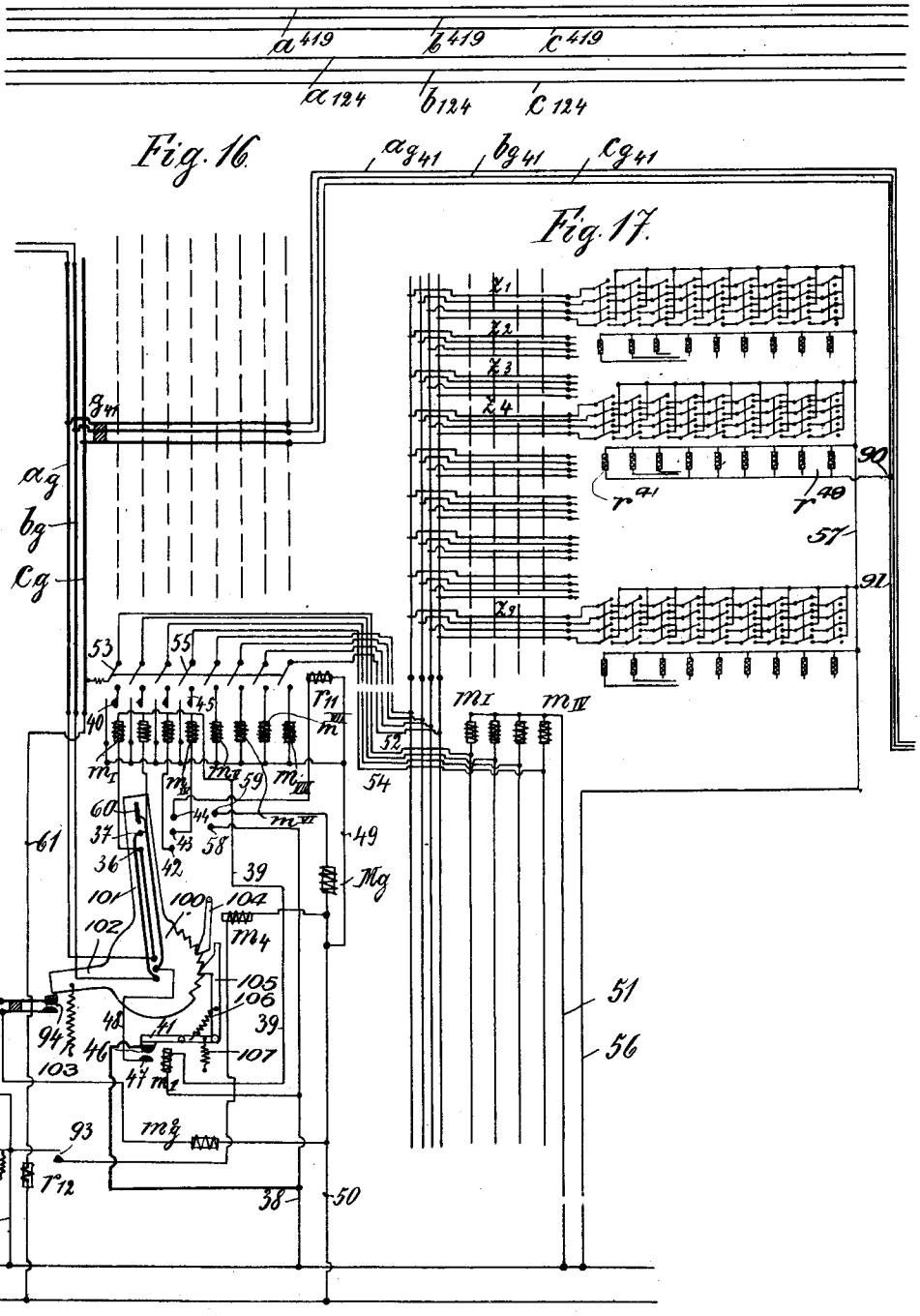

Fig. 17.

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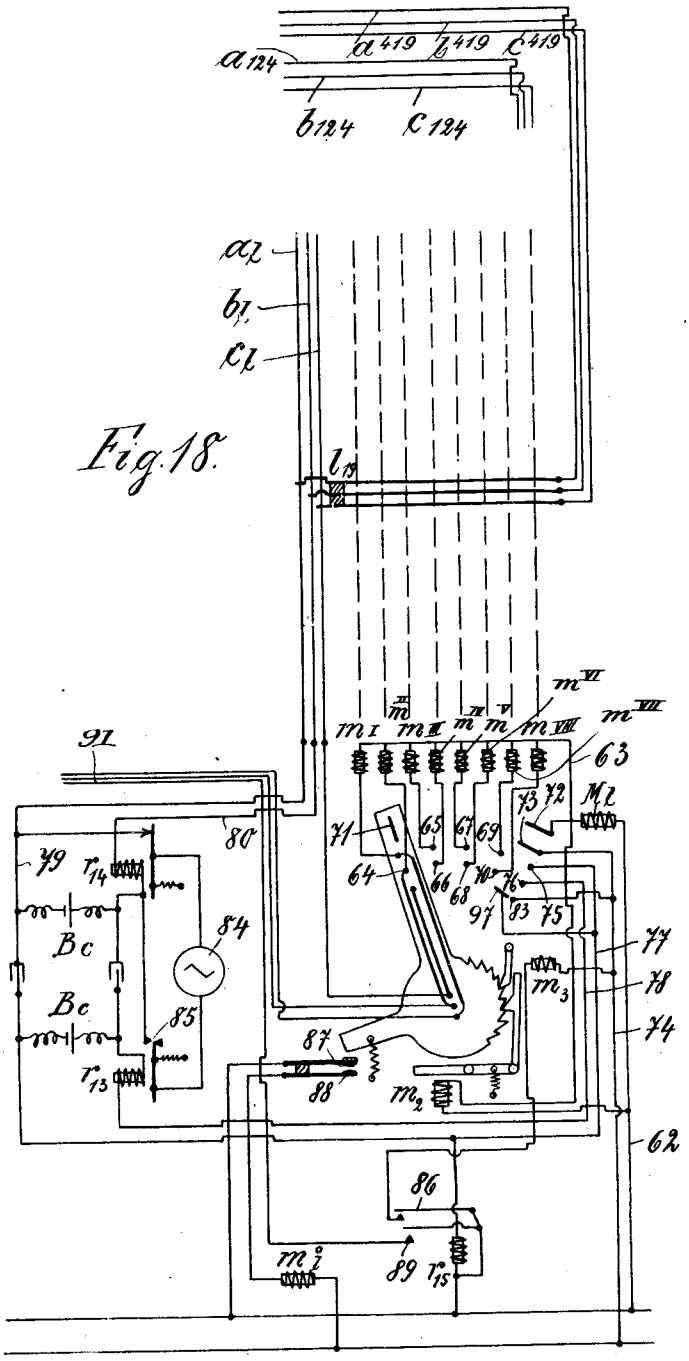
7 SHEETS—SHEET 7.

Fig. 18.



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UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE SYSTEM.

1,046,952. Specification of Letters Patent. Patented Dec. 10, 1912.

Application filed December 21, 1909. Serial No. 534,267.

To all whom it may concern:

Be it known that I, ERNST BLOS, a citizen of the German Empire, and resident of 10 Königsweg, Schöneberg, near Berlin, Germany, have invented certain new and useful Improvements in Automatic Telephone Systems, of which the following is a specification.

The main advantages, as compared with existing systems, of the new system of automatic telephony herinafter described, are first, that the number of current impulses necessary for making the connection desired is reduced to two per digit of the subscriber's number; secondly, that only such of the contacts which are used to make the one individual connection, are subjected to wear, and thirdly that the only movement of the selectors is a linear one over a maximum distance of one or two millimeters. None of the rotary or stepping movements which characterize the selectors of former systems are employed. In the well known Strowger system, the number of current impulses per digit reaches ten; the movement of the contact arms of the selectors is a stepping one over intermediate contacts which latter are not only useless for making the desired connection but are also subjected to useless wear at each of the connections made. A further advantage of the selectors of the new system is that they can be actuated directly by the line current, and that the adjustment of the preliminary selector which connects the calling subscriber to one of the first selectors which is not engaged is effected at one single stroke, and in the same manner the adjustment of each of the following selectors is effected. Therefore all connections are made within a very short time and in a very simple manner. Each of these advantages is obtained by the fact that the principle of selecting is not a quantitative one, as in the Strowger system, but a qualitative one, *i. e.* the digits are not transmitted by means of a chosen number of current impulses of the same kind, but by a combination of impulses of different kinds, the number of impulses being the same in each case. The different character of the current impulses which are applicable to my system can be attained by varying their direction, or their intensity, or their frequency (in the case of currents of alternating or intermittent currents), or by sending impulses of the same character over different lines. A series of three different kinds of current impulses can be obtained for example by earthing a double line consisting of two line wires L_a and L_b: (1) earthing the line L_a and not earthing L_b, or (2) earthing the line L_b and not earthing L_a, or (3) earthing the lines L_a and L_b simultaneously. This is the method of producing three different current impulses which will be used in the following description of my improved automatic exchange system. The number of different current impulses available being three, it is necessary to use two impulses of such kind so as to transmit each digit. In this way I obtain a total number of nine different combinations of impulses. This is sufficient for transmitting nine of the ten digits of the decimal scale; when numbering the subscribers therefore, one of the ten digits must be dispensed with, for instance, the zero, and all of the numbers containing the cipher 0 must also be omitted.

The improved automatic selectors consist substantially of a series of toothed disks which, by means of small electromagnets, are moved through a very small angle, and around which disks a series of flat tongues, parallel to the axis of the disks, are arranged. If pressed against the disks, only one of these tongues, corresponding to the relative position of the disks, can fall into the grooves of the disks and close the desired circuit.

I shall first generally describe the principle of selecting which I employ and then proceed to describe the arrangement of an exchange for 9^3 subscribers. The selectors of this exchange are divided, as usual, into the three general classes viz. (1) preliminary selectors, (2) first selectors, and (3) second or final selectors. The preliminary selectors connect the calling subscriber to a first selector which is not engaged; the first selectors select the hundreds; and the second selectors select the tens and units of the called subscriber. The arrangement of the preliminary selectors is novel in that they are connected to the subscribers by means of single wires, the number of the selectors nevertheless being not greater than in the improved Strowger system. Beside the selectors mentioned there is a further single selector interconnected between the first and second selectors. This single selector which is called a central selector, transmits the combination of current impulses correspond-

ing to the nearest free second selector within the calling hundreds to the calling first selector.

The principle of selecting employed will be understood from Figures 1 to 5, Figs. 1 to 3 whereof relate to the manner of transmitting digits and Figs. 4 and 5 to the manner of selecting a disengaged first or second selector. Figs. 6 and 7 show the arrangement of the combinations and the teeth on the selector disks. Figs. 8 and 9 show the construction of one of the first and second selectors, Fig. 8[a] is a section on the line X—X of Fig. 9, Figs. 10 and 11 that of the central selector, and Figs. 12 and 13 some details of the preliminary selectors.

Figs. 14 to 18 are diagrams of the connections for an exchange having $9^3=729$ subscribers.

The principle of selecting.—If a number (say z) of different signs is available, and each variation is composed of n terms, the whole possible number of variations is z^n. For instance, we can form, by means of the signs o and x, if each variation is to be composed of two terms, the following four variations:

(1)	o	o
(2)	o	x
(3)	x	o
(4)	x	x

Now let us imagine two line wires, L_a and L_b, in each of which may exist one of the current conditions. (1) o=no current flowing through the line wire. (2) x=a current of any kind flowing through the line wire. Then—

Variation 1=no-current in both line wires.
" 2=current in line L_b only.
" 3=current in line L_a only.
" 4=current in both line wires.

On the supposition that both terms of each variation are to be transmitted simultaneously over the lines L_a and L_b, variation 1 is not practically transmittable. Therefore in what follows the variations 2, 3 and 4 only are used. By combining these variations twofold the following nine variations are obtained:—

1.	o	x	o	x
2.	o	x	x	o
3.	o	x	x	x
4.	x	o	o	x
5.	x	o	x	o
6.	x	o	x	x
7.	x	x	o	x
8.	x	x	x	o
9.	x	x	x	x
	L_a	L_b	L_a	L_b

Each of these 9 variations consists of 4 terms, and is also to be transmitted over the two lines L_a and L_b. This is done, for example, in the case of the variation 1 by sending two successive current impulses through the line L_b; in the case of variation 6 by first sending an impluse through L_a and then an impulse simultaneously through both L_a and L_b. In the case of variation 9 it would be effected by first sending an impulse simultaneously through both L_a and L_b and then repeating this operation. An example showing diagrammatically the practical application of this principle is shown in Figs. 2 and 3. Fig. 2 illustrates four bars (1) each of which is provided with 9 grooves (2 and 3) and corresponds to one of the four vertical columns of Fig. 1. Across the bars nine tongues (No. 1–9), are arranged. The grooves of the bars may take up two possible positions relatively to the tongues 1–9. The grooves 2 are arranged precisely below the tongues, but the grooves 3 are displaced upward by a distance x from the center of the tongues. The arrangement of these grooves is arrived at by substituting for o in Fig. 1 a groove which lies below the tongue, and for x a groove which lies at a distance x from the tongue. Considering now the tongue 1, it may be caused to fall into the grooves on the parallel bars by displacing the bars II and IV downward through a distance x from the position illustrated. By this displacement of the bars all the other 8 tongues are prevented from falling in: the tongues 2 and 3 by the bar III and the tongues 4 to 9 by bar I. In this way each tongue corresponds to a certain combination of the bars displaced, and in all cases only that tongue, and none of the others, can fall in, whose predetermined combination is produced. From this it is clear that by displacing one or more of the bars, a proper and accurate selection of any of the tongues may be effected. Fig. 3 is a diagram of connections of the electrical circuit for selecting the tongues over the two lines L_a and L_b. The "current flow" state of the wires L_a and L_b is in this example effected by earthing the line of the battery B. Magnets m_I, m_{II}, m_{III}, and m_{IV} are arranged in the battery line behind the arm of a switch in such a manner that the magnets m_I and m_{II} are connected to the lines L_a and L_b and after the first current impulse has been passed over the line, the magnets m_{III} and m_{IV} are connected to the lines L_a and L_b. The progressive movement of the ratchet mechanism is effected by the magnet m which is energized each time either or both of the lines L_a and L_b is or are earthed. The magnets m_I to m_{IV} operate the slotted bars I to IV respectively. For selecting the tongue 1 for instance, a movable earthed contact is moved over the row 1 in Fig. 3. When the contacts of this row are earthed by the movable earthed contact the magnet m_{II} is ener-

gized over the line L_5 and thereby the bar II is moved through the distance x. In addition the magnet m is energized and the arm of the ratchet is moved right over the terminals of the magnets III and IV. When now the lower contact of the row 1 in Fig. 3 is earthed through the moving contact, the magnet m_{IV} is energized and the bar 4 of Fig. 2 moved downward through the distance a so that the tongue 1 now falls into the grooves of the parallel bars. Simultaneously the magnet m is energized and the arm of the step-by-step switch is moved through another step. It will be understood from the foregoing description that only the tongue 1 falls into the grooves of the bars. It is of course necessary that the bars be retained in the positions to which they have been moved by the magnets. The means proposed for effecting this will be described later as also shall the means used for returning the step-by-step switch arm into its initial position.

In Fig. 4 the arrangement of the grooves or teeth on the bars is substantially the same as in Fig. 2—the edges of the bars pressed against the tongues being inclined in order to obtain automatic return of the bars. This arrangement is applied at the central selector and will be specially described when describing the central station arrangement.

The variations according to Fig. 1 may be transmitted simultaneously instead of in two parts over two wires if 4 wires L_1, L_2, L_3, L_4 as shown in Fig. 5 are provided. Each wire is then connected to one of the four magnets m_1 to m_4 and the step-by-step mechanism is entirely dispensed with. For example to select tongue No. 6, the threefold switch No. 6 is pressed downward whereby the lines L_1, L_2, L_4 are earthed, the magnets m_I, m_{III}, and m_{IV} energized and the rods I, III and IV moved. As can be seen from Fig. 2, only the tongue 6 can fall into the grooves of the bars. This momentary transmission of the 9 variations of current is employed on the preliminary, first and auxiliary selectors. In the case of the preliminary selector however the variations *o o*, *o o* must be provided and therefore the four bars must be provided with holes or grooves arranged directly under or opposite a tenth tongue. This tenth tongue will of course be normally in the grooves and as soon as one or other of the bars is moved the tenth tongue will be raised out of the grooves and suitable contacts are thereby operated.

The table of combinations or variations given in Fig. 6 is derived from that given in Fig. 1, by writing each of the variations in that figure nine times to form 9 groups—thereby forming the rows I to IV, in Fig. 6. The rows V to VIII are formed by using the 9 variations of Fig. 1 successively in each group in Fig. 6. The toothed or grooved bars, see Fig. 7, and the corresponding tongues are disposed relatively to one another in the manner corresponding to the table in Fig. 6 and as explained with reference to Fig. 2. In the position of each *o* there is a groove under the tongue and in place of each *x* the groove is at a distance *a* from the tongue. In order to simplify the arrangement of the grooves the distance *x* is made equal, in Fig. 7, to half the pitch of the tongues. Further, for reasons hereinafter explained, the space between each group of nine is greater than the pitch of the tongues in each group. To test the correctness of this arrangement let us follow the selection of the tongue 99. According to the table in Fig. 6, all the bars have to be moved in order to allow the tongue to fall into the grooves—see Fig. 7—at the foot. On the other hand all the other tongues must remain out of their grooves. The tongues 11–39 are held out by the bar I, 41–69 by bar II, 71–79 by the bar III, 81–89 by the bar IV, 91–93 by the bar V, 94–96 by the bar VI, 97 by the bar VII and 98 by the bar VIII.

I shall now proceed to describe a selector which may be taken as representative of all the selectors which are required, with the exception of the central and preliminary selectors. In Figs. 8 and 9 a second selector is illustrated by way of example, Fig. 8 being an elevation and Fig. 9 a plan. In the first place, imagine the teeth and grooves of Fig. 7 as arranged on the peripheries of disks, which may be rotated through a small angle equal to half the pitch of the tongues. In Fig. 8 there are eight disks 4 which are loosely rotatable on disks 5 and these latter disks are arranged side by side, on a member 6 and pressed together by a closing disk 7. The disks 4 are controlled by magnets m_I, m_{II}, m_{III} *to* m_{VIII} which are all fixed to a plate 8. The magnet m_I, for example, controls the bottom disk 4 in Fig. 8 by means of its right angled armature 9 which engages in a groove on the disk. In order to retain the disk in its position of rest or working position, as the case may be, a flat spring 11 is arranged for each disk and is mounted on a pin 10. The flat springs 11 are adapted to engage in one or other of two notches on the disks, corresponding respectively to the position of rest and the working position. The magnet m^o serves to return the disks into their position of rest, its bell-crank armature 9^a engaging in a notch in every one of the disks 4, as seen in Fig. 8^a. The tongues 12, supported opposite the grooves on the peripheries of the disks are held with their ends working in grooves on the bed plate of a magnet M, and are all pressed against the disks 4 when the magnet M is energized. Each tongue is provided at its upper end with a part 13, which

carries the contacts 14 and presses them, when the tongue drops into the grooves on the disks, against the contact ring 16 which is cast in the insulating ring 15. The insulating ring 15 is itself fixed to a plate 17 which is fastened to the supporting body 6 for the disks. The contacts 14 are also cast into an insulating ring 14^a which is fastened to the bed plate of the magnet M.

As mentioned above, the second selector just described is also typical for first selectors. The central selector is constructed somewhat differently and will be understood from the following description of Figs. 10 and 11. The preliminary selector is constructed somewhat similarly to the central selector but has some modifications which are, illustrated in Figs. 12 and 13. In the central selector it is necessary that the tongue to be selected falls simultaneously with the motion of the bar 18 and that it has closed its electric circuit at the time when the bar completes its motion. To this end the tongues 19 are, under the action of springs 20 (Fig. 11) continually pressed against the bars 18. The bars 18 are longitudinally slidable in guides 21. The sliding motion of the bars is produced by magnets m_I—m_{IV} and when these become deënergized the bars 18 are returned to their positions of rest by springs 22. In order to facilitate as much as possible, the return movement of the bars, the teeth on which the tongues bear in the position of rest are inclined with a slow inclination as described above with reference to Fig. 4. In the case of a preliminary selector, it is not necessary that the bars be immediately returned but the bars must remain in the position to which they have been moved, until the subscriber returns the preliminary selector back to the disengaged position at the end of the conversation. Each bar is therefore held in its drawn out position by means of a pawl 23 (Figs. 12 and 13) which engages in a special groove 24 on the bar. This pawl remains in engagement until all the pawls in engagement are withdrawn by means of a right angled armature 25 on the magnet M (Figs. 12 and 13).

The principle of selection employed has now been described with reference to Figs. 1 to 7 and suitable selectors for the various purposes have also been briefly described. I shall now proceed to describe the arrangement of a station having 9^3 (*i. e.* 729) subscribers.

Exchange for 9^3 subscribers.—At this station only the digits 1 to 9 are employed for numbering the subscribers—the cipher 0 must be omitted for the reasons given at the beginning of this specification. Further only numbers each comprising 3 digits are employed. The numeration therefore commences with 111 so that it is unnecessary to precede units or tens with a corresponding number of naughts as is necessary in other systems.

The subscribers are numbered—111–119, 121–129 and so on to 191–199; 211–219, 221–229, and so on to 291–299; 311–319, 321–329 and so on to 391–399, and so on until 911–919, to 991–999 all numbers between 111 and 999 and containing the cipher 0 being omitted. As in other systems, the subscribers are divided into groups but whereas each group in other systems embraces 100 I divide them into groups of 81, so that in the present instance there are 9 groups. The first group embraces the numbers 111–199; the second group the numbers 211–299 and so on till the ninth group embraces the numbers 911–999. For each group of subscribers there must be provided as many first and second selectors as the maximum estimated number of simultaneous conversations. In the present instance 9 simultaneous conversations are estimated and provided for in each group which is about 11 per cent. and usually suffices. Each group of subscribers are given nine first selectors which are made available to each subscriber by a ninefold contact on the preliminary selector. In addition to the nine-fold contact a tenth is provided for each subscriber, as above mentioned, to act as a switch. Each subscriber is permanently connected to this switch and is automatically connected by lifting his receiver to one of the nine first selectors over the nine-fold contact. As usual a preliminary selector is provided for each subscriber, which preliminary selector is provided with the nine-fold contact and the return contact.

In Fig. 14 there is illustrated a preliminary selector to which it shall be assumed that subscriber No. 124 is connected. The multiple or manifold contacts f_{41} to f_{49} are connected to the trunk lines a_1 b_1 c_1 to a_9 b_9 c_9. These trunk lines have branch connections to all the nine-fold contacts of the 81 preliminary selectors for one group of subscribers, only the "zero" or "naught" contacts being omitted—for example f_{40} is omitted. From the trunk lines a_1–a_9 and b_1–b_9 lines branch off to nine first selectors, the first of which is illustrated diagrammatically in Fig. 16. The lines c_1 to c_9 are connected to the relays r_1–r_9 of Fig. 15 which are all connected to the positive pole of the battery B. These relays close a set of contacts arranged in series and from which four lines lead over the switch s_1 to the four magnets m_I to m_{IV}. In the position of rest the contacts from r_1 connect up all four magnets m_I to m_{IV} to the negative battery pole over the lines 26, 27 and 28. In the working positions these contacts connect the magnets m_I–m_{IV} to the contacts from r_2. These last mentioned contacts when in their

position of rest connect the magnets m_I m_{II} and m_{III} to the negative pole B, and when in their working position they connect the lines leading to all four magnets to the contacts of r_3 and so on in the same way throughout the group, the contacts of each relay in turn close the magnet circuits, when in their position of rest, in the same order as the letters x in the table of variations given in Fig. 1. In the working position the contacts of any one relay always connect up the contacts of the next following relay to the lines leading to the magnets. The lines leading to the switch s_1 also branch off to the switches of the other 80 preliminary selectors of the same group of subscribers so that the magnets m_I to m_{IV} of the subscriber in question are connected to the contacts of the relay r_1, the switch s_1 of which will be just closed by the relay r_{124} of the calling subscriber. As this closure of the circuits is only a momentary one, it is practically impossible that the switch s_1 be closed simultaneously by two selectors and that thereby two subscribers are connected to the same first selector. Care must now be taken that r_1 is immediately switched over on to the contacts of r_2 after magnets m_I to m_{IV} are energized. This takes place, as described later, as soon as that tongue at the preliminary selector which corresponds to the first selector selected, falls into the grooves in the bars. The double line leads from the subscriber's station to two current rails a_{124} and b_{124}. A third rail is connected over the magnet winding of m_{124} and the line 28 to the negative pole of B. The lines a_{124} and b_{124} form the speaking circuit and the line c_{124} forms the blocking circuit. The lines a_{124} and b_{124} are also connected to the contacts 29 and 30 against which springs 31 and 32 rest. From these the lines a_{124} and b_{124} lead to the second selector which has the connections Nos. 111–199. A branch from the line b_{124} leads past the spring 32 to the relay r_{124} which is also connected over the line 33 to the positive pole +B. The negative pole of B is earthed. When therefore the subscriber presses down the key 124^r on the right the following current impulse is transmitted: positive pole of B, 33, r_{124}, spring 32, contact 30, b_{124}, righthand 124^r key of the station, earthed to negative pole of battery. The relay r_{124} closes switch s_1. If now all the first selectors of the calling subscriber's group are disengaged, that is to say the relays r_1 to r_9 are not excited, then current passes from the positive pole of B and line 26 only over the contacts which are at rest, the springs of the relay r_1, magnets m_I–m_{IV} and lines 27 and 28 to the negative pole of B. The four magnets move their corresponding bars so that, according to Fig. 4, the tongue No. 9 can fall into its grooves. In this way both lines of subscriber No. 124 are connected to the lines of the first selector (Fig. 16) over the lines a_{124} and b_{124} the two upper springs f_{41} and the trunks a_1 and b_1. Since the under spring f_{41} bears on the line c_{124} the following circuit will be closed:—+B, 26, r_1, c_1, under spring f_{41}, c_{124}, m_{124}, 28 and — B. The relay r_1 is thereby energized and its springs switch over the lines for s_1 to the contact springs r_3. In this way the "first selector" of the subscriber's group is in the engaged position and the next calling subscriber from the same group will be connected up through the contacts of r_2 to the second "first selector." In the circuit of the relay r_1 there is also arranged the magnet m_{124} which has to be cut out by the contacts of the preliminary selector at the end of the conversation. It must therefore be so dimensioned that it remains inoperative when in series with r_1. It is rendered operative as described later by short circuiting r_1.

The purpose of the contacts 29, 30 and 34 remains yet to be explained. While the contacts 29 and 30 break circuit when the bars are moved, the contact 34 makes circuit. The former, 29 and 30, prevent the calling subscriber from being called up and and the current impulses now about to be transmitted have no more influence on the preliminary selector. The latter, 34, closes the blocking line c_{124} over 35, 34, 27, 28 to the negative battery pole and the subscriber 124 is engaged for all other calling subscribers. The action of this connection will be explained more fully later. The calling subscriber is therefore connected momentarily to the first selector Fig. 16 by once earthing his b line and may now get on to the desired number by 6 further current impulses. Assume now that No. 124 wishes to call up No. 419. He must first pass his earthed contact over the row 4 in Fig. 3 whereby two current impulses are transmitted to the first selector. The first impulse is over line L_a and energizes M, the second over line L_b and energizes M. IV of the first selector. The switching over is effected by ratchet mechanism, the arm of which rests on the contacts 36 and 37 in the position of rest of the selector. This ratchet mechanism consists of a disk 100, partially toothed, having two projecting parts 101 and 102 and being held under pressure by a spring 103. The disk is held in position by a ratchet 104 which fits into the teeth of the disk and which can be attracted by the magnet m_4, being its armature. The hook 105, which is linked to the armature 41 of the forwarding magnet m_1, is also pressed against the toothed circumference of the disk by means of the spring 106. When the armature 41 is attracted by the magnet m_1, its linked hook 105 gets into the next higher

tooth, pawl 104 meanwhile securing the position of the disk. If, now, m_I is demagnetized, its armature 41 is returned by the spring 107, whereby the disk is turned and the contact pieces of the arm 101 reach the contacts 42, 43 and 44. The same action is repeated on occurring of the next current impulse energizing m_I, after which the arm 101 covers the contacts 58 and 59. The arm is restored into its rest position by energizing the magnet m_4, the latter attracting its pawl-armature 104 and thereby simultaneously retracting both pawl 104 and hook 105 from the teeth of the disk, whereby the disk is allowed to follow the traction of the spring 103.

The full circuits are as follows: (1) L_a earthed; — B, line 38, m_I, 39, m_I, a_g, upper spring f_{41}, a_{124}, left hand key 124 l, earth to negative pole of B. The rotation of one of the disks through a small angle is effected by m_I as also is the closing of contact 40. The magnet m_I attracts its armature 41 and thereby moves the switch arm 36 to the contacts 42, 43, 44. (2) L_b is earthed, +B, 38, m_I, 39, m_{IV}, 43 switch arm 37, bg, b_1, center spring f_{41}, b_{124} right hand key 124^r of the station, then earthed to negative pole of B. The magnet m_{IV} rotates its disk and closes its contact 45 which remains closed like contact 40, because the armatures of the operating magnets remain in their attracted position during the entire duration of the conversation. The attraction of the armature 41 by m_I also closes the following circuit: +B, 38, 46, 47, 48, 44, r_{11}, 49, 50, and the negative pole of B. r_{11}, consequently closes an 8 pole switch to the left of r_{11} in Fig. 16. In this way the magnet m_I and the magnet m_{IV} of the central selector (Fig. 17) are energized by the closure of the following circuit:—+B, 51, on the one hand m_I (Fig. 17) 52, 53 and 40 on the other hand m_{IV} (Fig. 17) 54, 55, 45 and then together over 49, 50 to the negative pole of the battery B. Both current impulses of the digit 4 are therefore transmitted to the central selector. The magnets m_I and m_{IV} of this selector move their bars whereby the multiple contacts Z_4 descend and if none of the second selectors of the fourth hundred are engaged, the combination of the first "second selector" will be transmitted over the contacts r_{41} at the left hand side of Fig. 17 to the magnets m_{VI} and m_{VIII} of the first selector (Fig. 16). In detail the principle and working of the groups of relays r_{41} to r_{49} is precisely the same as in the group of relays r_1 to r_9 of Fig. 15. The circuit for this is as follows:—+B, 56, 57, contact springs of r_{41}, multiple contacts z_4, m_{VI} and m_{VIII}, 49, 59 to — B. It is assumed here that the impulse which energizes r_{11} lasts somewhat longer than the time required for shifting the bars of the central selector. This may be effected at the sending station by a suitable arrangement. When the earthing of the line Lb (Fig. 14) ceases the armature 41 (Fig. 16) moves the switch arm farther on to the contacts 58 and 59. In this position the exciting circuit of the main magnet M_g of the first selector by means of the metal piece 60 of the switch arm is closed over 38, 58, 59 and 50 and thereby all of the tongues of the selector are attracted but only the tongue 41 is drawn into the grooves of the bars and the multiple contact g_{41} at the top lefthand of Fig. 16 pressed against the contact rails a_g, b_g and c_g. In this way the subscriber is connected to the switching mechanism of the second selector (Fig. 18) over the upper springs g_{41}, lines ag_{41} and bg_{41}. As the third spring g_{41} rests on the rails cg, the relay r_{41} is also energized over lines 56, cg_{41}, bottom spring g_{41}, cg, 61 and through the winding of r_{12}. The relay r_{12} when in series with r_{41} remains inoperative. The relay r_{41}, by switching its spring, will cause the next caller for a number in the fourth hundred to be switched on at the calling first selector to the No. 2 second selector of the four hundred group.

The transmission of the digits 1 and 9 is effected by passing the earthed contact over the rows 1 and 9 (Fig. 3) successively whereby L_b is twice earthed and then L_a and L_b together are earthed. In the first earthing of L_b current passes from +B over 62, m_2, 63, m_{II}, 64, bg_{41}, center contact arm g_{41}, bg, center contact arm f_{41}, b_{124}, L_b, right hand key 124^r, then earthed to —B and causes the movement of the disk corresponding to m_{II} and also the movement of the switch arm in Fig. 18 to the contacts 65 and 66. This is repeated for the magnet m_{IV}, whereupon the arm covers the contacts 67 and 68. The earthing of the lines L_a and L_b now follows for the selection of the digit 9. The earthing of the latter follows the circuit path just described but passes over the magnet m_{VI} and contact 68. The earthing of L_a takes place over m_V 67, ag_{41}, upper contact arm g_{41}, ag, upper spring f_{41}, a_{124}, left hand key 1241 to the earth and —B. The earthing of these two lines therefore effects the movement of the disks corresponding to magnets m_V and m_{VI}, and the switch arm is moved forward to cover the contacts 69 and 70. The same is repeated for the magnets m_{VII} and m_{VIII}. After completion of this latter earthing the switch arm of Fig. 18 has moved into its end position and closes in the first place the circuit for M_1 by means of the contact piece 71 over 62, 72, 73, 74. Further in this end position the lines ag_{41} and bg_{41} are connected up to the central battery B_c, over 75, 76, 77, 78. From the central battery B_c there lead lines 79 and 80 to the rails a_1 and b_1 so that the speaking circuit to the subscriber is completed

through a_1 and b_1, the two upper springs l_{19}, lines a_{419} and b_{419}, contacts 81 and 82, and rails a_{419} and b_{419}. The blocking line c_{419} of the subscriber is arranged over the lower contact arm l_{19} of the second selector rail c_1, switch, contact 83, line 74 to the negative pole B.

The relays r_{13} and r_{14} (see below and above the central battery Fig. 18) operate the sounding device 84. As long as the receiver of the calling subscriber remains on its hook and the alarm is in the line circuit, the calling relay r_{13} does not operate. Only when the receiver is lifted and the microphone is switched in circuit in place of the alarm does the relay r_{13} attract its armature. This relay then closes its contact 85 whereby a calling current is transmitted over this closed contact and the stationary contact of r_{14} to the line of the called subscriber. In this way the called subscriber's alarm is operated. At the same time the calling subscriber hears a humming sound in his receiver which stops as soon as the called subscriber takes his receiver from the hook as the relay r_{14} then attracts its armature and cuts out the sounder. This method of switching in the calling current is however not new.

When the conversation is ended, the operated selectors must be returned into their positions of rest. This is effected by the calling subscriber earthing his line L_a. Since this line is still connected to 77 over contact 75, the relay r_{15} is energized when the line L_a is earthed. By closing the contact 86 of the relay r_{15}, the magnet m_3 is also energized and this magnet releases the switch arm so that it returns into its initial position and thereby M_1 is cut out. In consequence of the energy stored in the arm due to its motion the arm passes over its position of rest and causes contact for a brief period between the spring arms 87 and 88 whereby the magnet m°, returns the disks of the second selector to their starting position. The relay r_{15} also closes the contact 89 and thereby short circuits the relay r_{41} (Fig. 17) of the central selector, as this relay is on one hand connected through 56 to the positive pole of B and on the other hand to the branching point 90, which is further connected directly to +B through line 91 and contact 89. This short circuit does not only deënergize the relay r_{41} and thereby cause its contacts to resume their positions of rest and bring the second selector into disengaged position but also energizes the relay r_{12} of the first selector (see the lowest part of Fig. 16) direct over contact 89 from r_{15} of the second selector, line 91 Cg_{41} and Cg and thereby closes both the contacts of this relay. The result of this is in the first place the energization of m_4 over line 92, contact 93 and line 50 whereby the switch of the first selector is released and consequently Mg deënergized. The switch arm of the first selector closes the contact 94 in the same way as described with reference to the second selector, and thereby energizes the return magnet m_g° which brings the disks back into their position of rest. As in the case of the second selector, the contact 94 is only closed momentarily, owing to the kinetic energy of the switch arm on returning carrying it past its position of rest and after this closure of the contact 94 the switch arm sets back into its proper position of rest over the contacts 36 and 37. The contact 95 is also closed by the relay r_{12} whereby r_1 (Fig. 15) is short circuited. r_1 is connected by means of line 26 between the positive pole of the battery and the branching point 96 which is now connected directly to +B over contact 95 and line 92. By this short circuit the relay r_1 is deënergized, its contacts return to their positions of rest and the first selector is thereby brought into the disengaged position. The short circuit further causes m_{124} of the preliminary selector to attract its armature and the multiple contacts f_{40} and f_{41} to break circuit. The path of the current is as follows: +B, line 92, contact 95, 96, c_1, bottom arm of f_{41}, c_{124}, m_{124}, line 28 —B. With this return of the multiple springs f_{40} and f_{41}, the selectors required for the conversation are all returned to their disengaged positions and are ready to be used for a new call.

We have still to consider the case in which the called subscriber is engaged, having been called up, let us assume, by another party. In this case the multiple contacts No. 1_{19} (Fig. 18) on another second selector for the numbers 411–499 already rest on the contact rails a_1, b_1, and c_1 of this other selector and its ratchet mechanism is in its end position corresponding to the contacts 75, 76 and 83 of Fig. 18. Its rail c_1 is therefore connected through the switch arm to —B (in Fig. 18 through contact 83 and line 74). Of course all the multiple contacts bearing similar numbers are connected in multiple. When now, the switch arm of the selector operated by our call, passes into the end position on the occurrence of the four current impulses which correspond to the digit 9, it touches, in passing, the contact 97. By means of this contact, should the called subscriber be engaged, the following circuit is closed: +B, r_{15}, line 77, contact 97, contact arm, rail c_1 bottom arm of l_{19}, the same arm on the second selector over which the subscriber is already called, the rail c_1 of this selector switch arm, contact 83, line 74 to —B. This current impulse energizes r_{15} whereby all the selectors called into action by our calling up the engaged subscriber are returned to rest in exactly the same way as when the line was earthed by

the calling subscriber at the end of the conversation. If the called subscriber 419 is himself calling up some other subscriber the contacts 81 and 82 at his preliminary selector are broken and contact 98 is closed, so that his blocking line c_{419} is connected to —B over 98 and 99 (exactly as described with c_{124} over arm 35, contact 34 and lines 27 and 28). When therefore the switch arm of one selector contacts with 97 the following circuit is completed: +B, r_{15}, contact 97, switch arm, bottom arm of l_{19}, c_{419} contact 98 line 99 to —B. In this way r_{15} is again energized and all the selectors called into action by No. 124's call are returned into their positions of rest as described above. If now the called subscriber is already engaged no connection is made. The calling subscriber must however be notified of this, which is effected by the particular nature of the connection of the calling current. It is mentioned above that when the calling subscriber lifts his receiver from the hook, the calling or alarm circuit is bridged into the speaking circuit. This sounds the alarm of the called subscriber and causes a humming noise in the caller's receiver. When no connection is made, no humming noise is heard and this serves as a signal to the caller that the line called is engaged.

It is evident that the system described is also applicable to stations with 9^4, 9^5 and more subscribers. The number of selectors employed has merely to be increased by a corresponding amount. Thus for an exchange with 9^4 subscribers additional or secondary first selectors have to be employed. The first selectors (*i. e.* the additional first selectors) would in this case select the thousands, the second set of first selectors would select the hundreds and the second selectors would as described above select the tens and units. The number of first selectors must of course be in this case increased to $9^2 \times 9 = 729$, if each group including 9^3 subscribers is to be allowed 9 simultaneous conversations. The number of preliminary selectors in an exchange with 9^4 subscribers would be 9^4. In addition so many central selectors must be inserted between the first and second set of first selectors and between these and the second selectors that it is practically impossible for the central selectors to be simultaneously engaged by two callers.

I claim:

1. An automatic telephone selecting system employing different combinations of "no current" flows and current impulses for distinguishing the various subscribers comprising rows of contacts at the subscriber's station, the contacts of said rows corresponding to the combination of impulses required for each digit of the subscriber's numbers and the number of said rows corresponding to the number of different ciphers used to distinguish the subscribers, means for sending current through the contacts of said rows as desired, selectors located at a central station, magnets on said selectors, different magnets or combination of magnets, being energized when current is sent through the contacts of different rows, movable grooved members corresponding to said magnets and operable by the same, tongues placed variously over the grooved and non-grooved parts of said member, said tongues being arranged to correspond each to a fixed combination of impulses so that on the occurrence of said combination and the consequent movement of one or more of the grooved members only the tongue corresponding to said combination is enabled to fall into the grooves on the grooved members while the remaining tongues remain out of the grooves.

2. A selector for an automatic telephone selecting system of the type described comprising a plurality of disks mounted parallel to one another and rotatable through a small angle, notches on the peripheries of said disks, said notches being axially in line and axially displaced to the notches of adjacent disks in a predetermined manner, electro-magnets, means operated by said magnets for moving said disks in desired combinations, each combination being arranged to bring only one set of the grooves on all the disks axially in line, contact carrying arms opposite the grooves when brought axially in line and adapted to fall into said grooves in line to effect selection and means for returning said disks to their initial positions as required.

3. A selector for an automatic telephone selecting system of the type described comprising a plurality of disks mounted parallel to one another and rotatable through a small angle, notches on the peripheries of said disks, said notches being axially in line and axially displaced to the notches of adjacent disks in a predetermined manner, electro-magnets, means operated by said magnets for moving said disks in desired combinations, each combination being arranged to bring only one set of the grooves on all the disks axially in line, contact carrying arms opposite the grooves when brought axially in line and adapted to fall into said grooves in line to effect selection, a magnet adapted to draw said arms against the peripheries of the grooved disks.

4. A selector for an automatic telephone selecting system of the type described comprising a plurality of disks mounted parallel to one another and rotatable through a small angle, notches on the peripheries of said disks, said notches being axially in line and axially displaced to the notches of adjacent disks in a predetermined manner, electro-

magnets, means operated by said magnets for moving said disks in desired combinations, each combination being arranged to bring only one set of the grooves on all the disks axially in line, means for retaining the disks in the positions to which they are moved by the magnets.

5. In an automatic telephone exchange of the type described, preliminary selectors, first selectors, means for automatically connecting the preliminary selectors to a disengaged first selector, comprising a group of relays operable from the preliminary selector, multiple contact arms operated by said relays so that when the first relay is operated by the preliminary selector it automatically cuts out the first selector of the set of first selectors and connects the next caller to the second relay of the set and second selector of the set of first selectors and so on through the set.

6. In an automatic telephone system of the type described, a selector, means for sending combinations of current impulses to said selector, magnets in said selector adapted to be energized in combinations corresponding to the combinations of current impulses sent, means operated by the different combinations of energized magnets for effecting selection, a switch arm at said selector, means for moving said switch arm stepwise once after each combination of impulses, and means for returning said switch arm when desired.

7. In an automatic telephone system of the type described, a selector, means for sending combinations of current impulses to said selector, magnets in said selector adapted to be energized in combinations corresponding to the combinations of current impulses sent, means operated by the different combinations of energized magnets for effecting selection, a switch arm at said selector, means for moving said switch arm stepwise once after each combination of impulses, means for returning said switch arm when desired and means rendered operative by said switch arm when returned for effecting the return of the selecting means to their initial positions.

8. In an automatic telephone system of the type described, sets of first selectors, preliminary selectors for selecting a disengaged first selector of the desired set, means for sending combinations of current impulses to the first selector selected by the preliminary selector, sets of second selectors for said first selectors a relay (r_{11}) rendered operative by sending a combination of current impulses to the first selector, for establishing communication between the second selector and the first selector, and means interposed between the first and second selector for connecting said first selector to a disengaged member of the set of second selectors.

9. An automatic telephone selecting system comprising a sending device located at the subscriber's station for sending combinations of current impulses, different combinations being arranged to correspond to different digits used for numbering the subscribers, magnets located at the central station and arranged to be energized in different combinations corresponding to the combinations of impulses transmitted from the calling station, controlling members moved by said magnets when energized, and means rendered operative only by the movement of a particular combination of said controlling members for connecting one subscriber to another.

10. An automatic telephone exchange system comprising a sender, located at the subscriber's station, for sending nine different combinations of current impulses and comprising 9 rows of contacts corresponding one to each combination, magnets located at a central station and equal in number to the number of terms in the combinations required for selection of any given subscriber, a number of movable members controlled one by each of said magnets and a plurality of contacts to be selected said contacts cooperating with the movable members in such a manner that when a particular combination of the movable members is moved only that one of said contacts is operated which corresponds to the combinations of current impulses which operated the movable members.

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

ERNST BLOS.

Witnesses:
WOLDEMAR HAUPT,
HENRY HASPER.