No. 681,878. Patented Sept. 3, 1901.

L. M. ERICSSON.

TELEPHONE SWITCH APPARATUS.

(Application filed Mar. 29, 1899.)

(No Model.) 5 Sheets—Sheet 1.

Fig: 1.

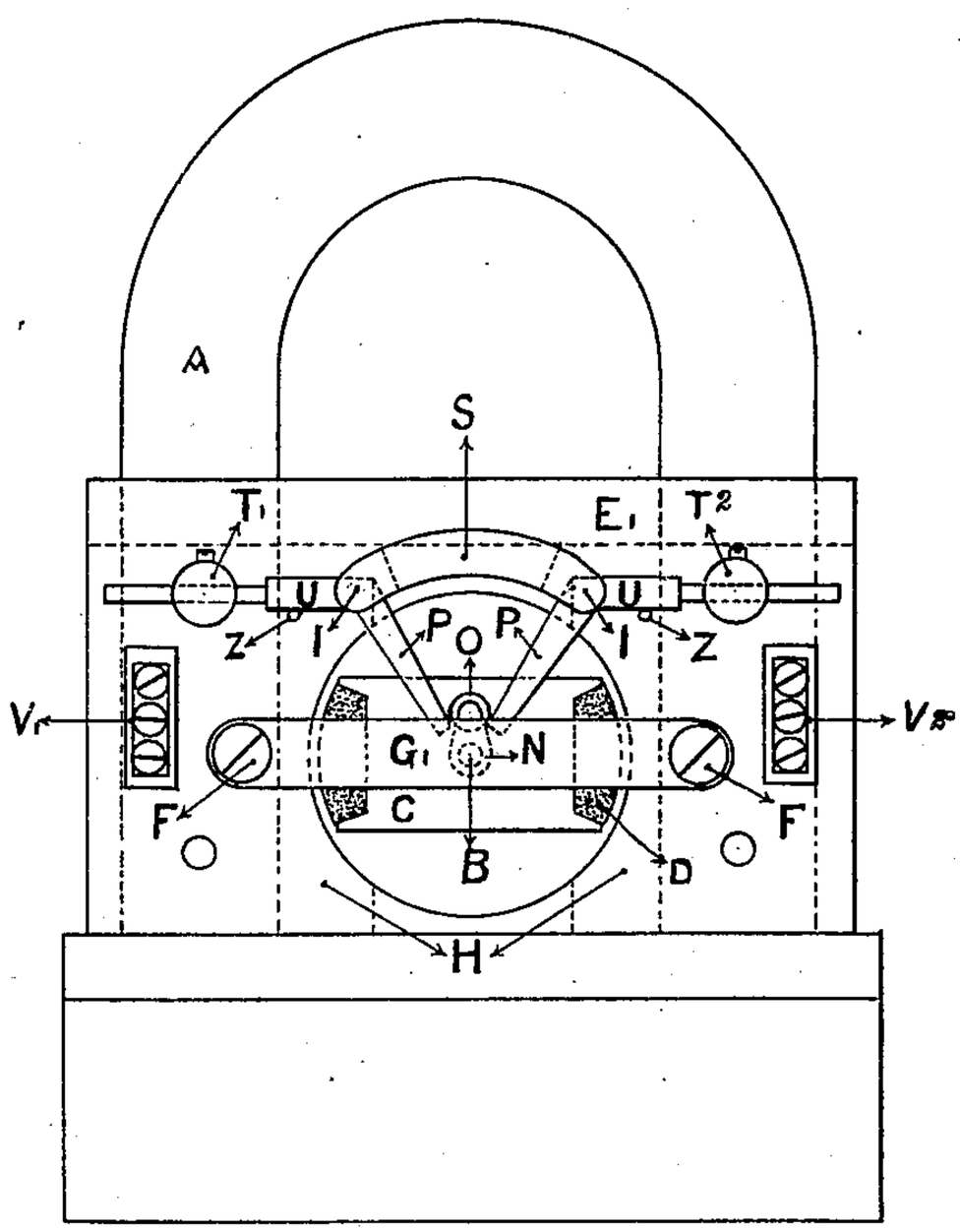

Fig: 2.

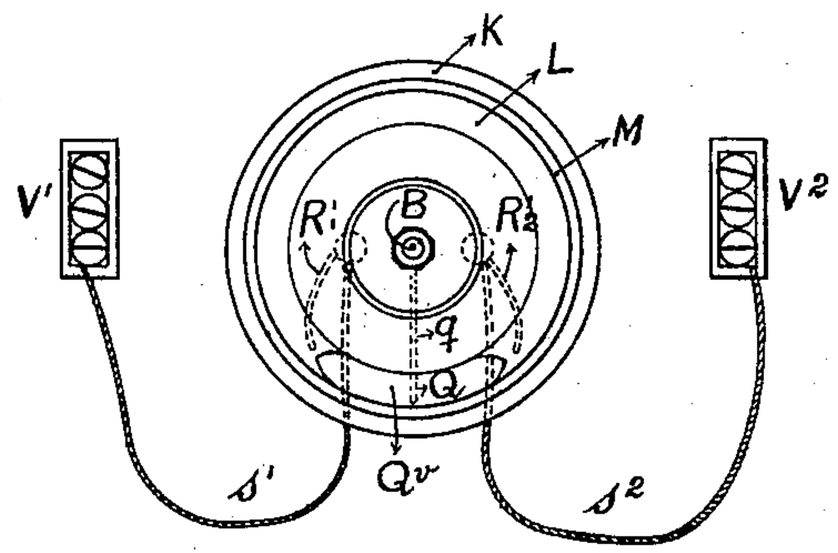

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Fig. 3.

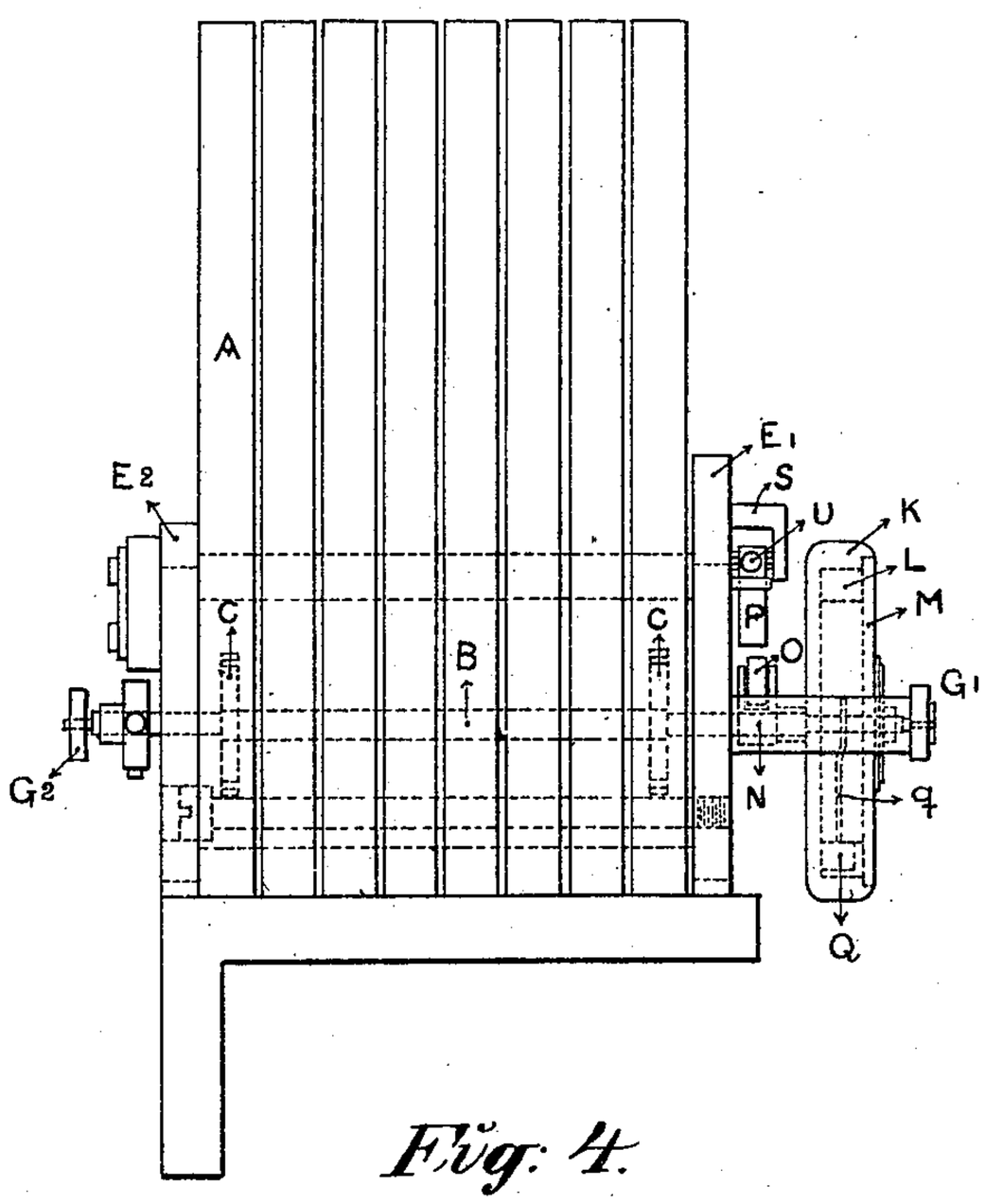

Fig. 4.

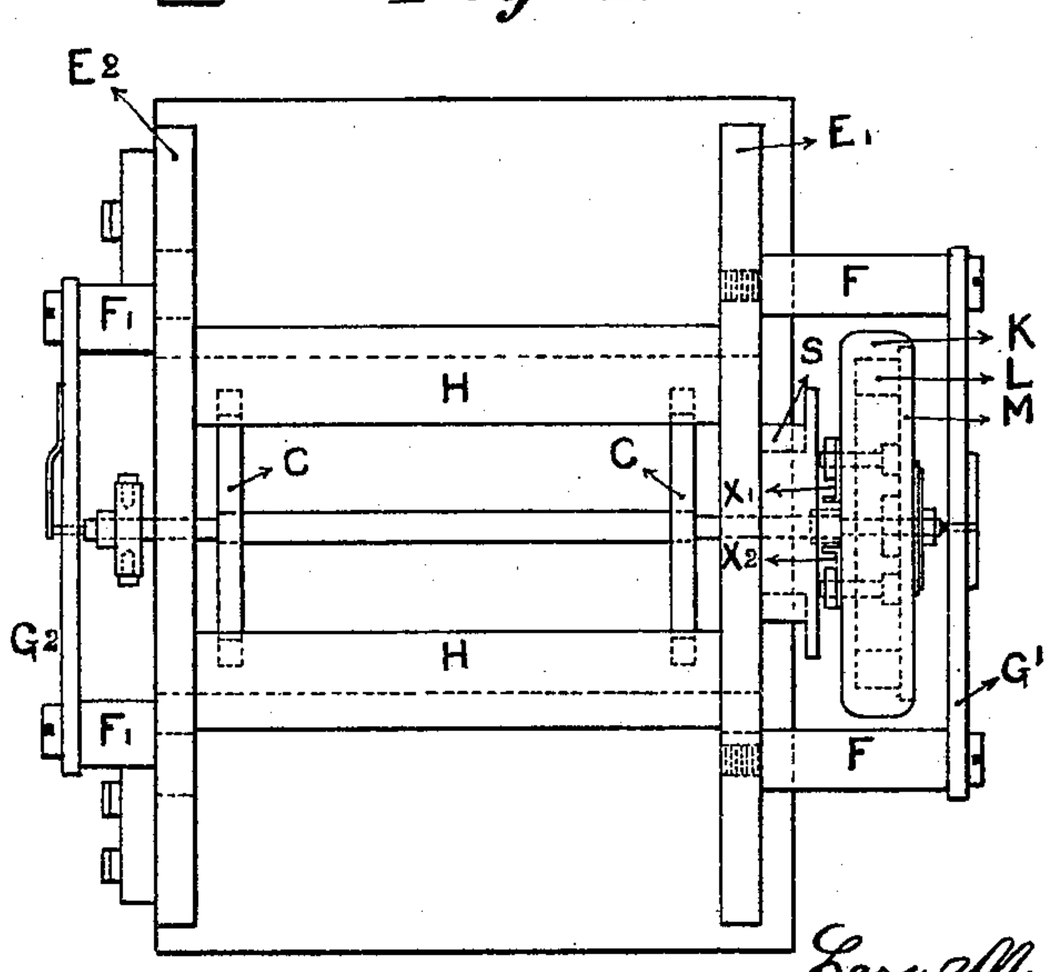

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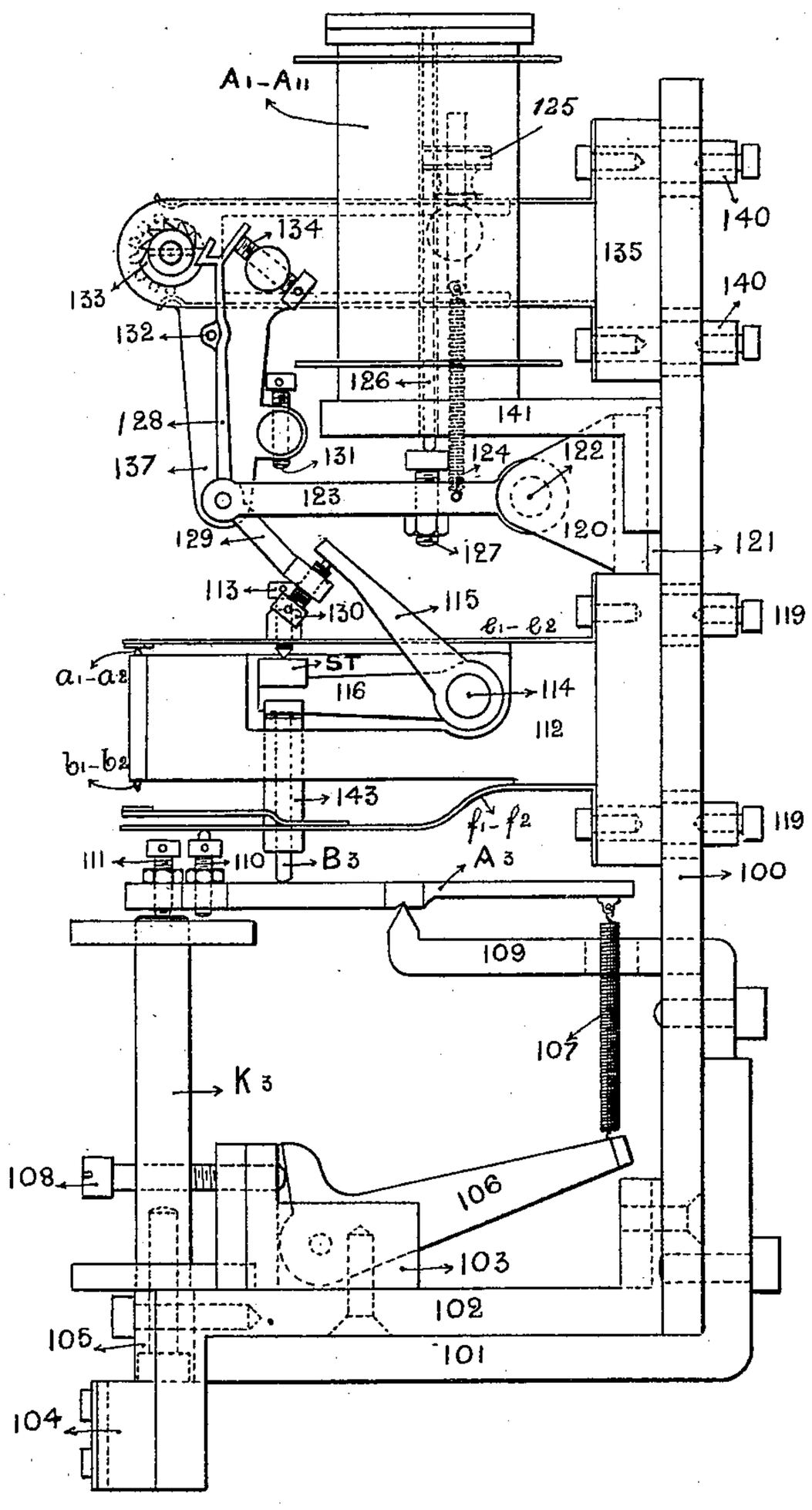
Fig: 5.



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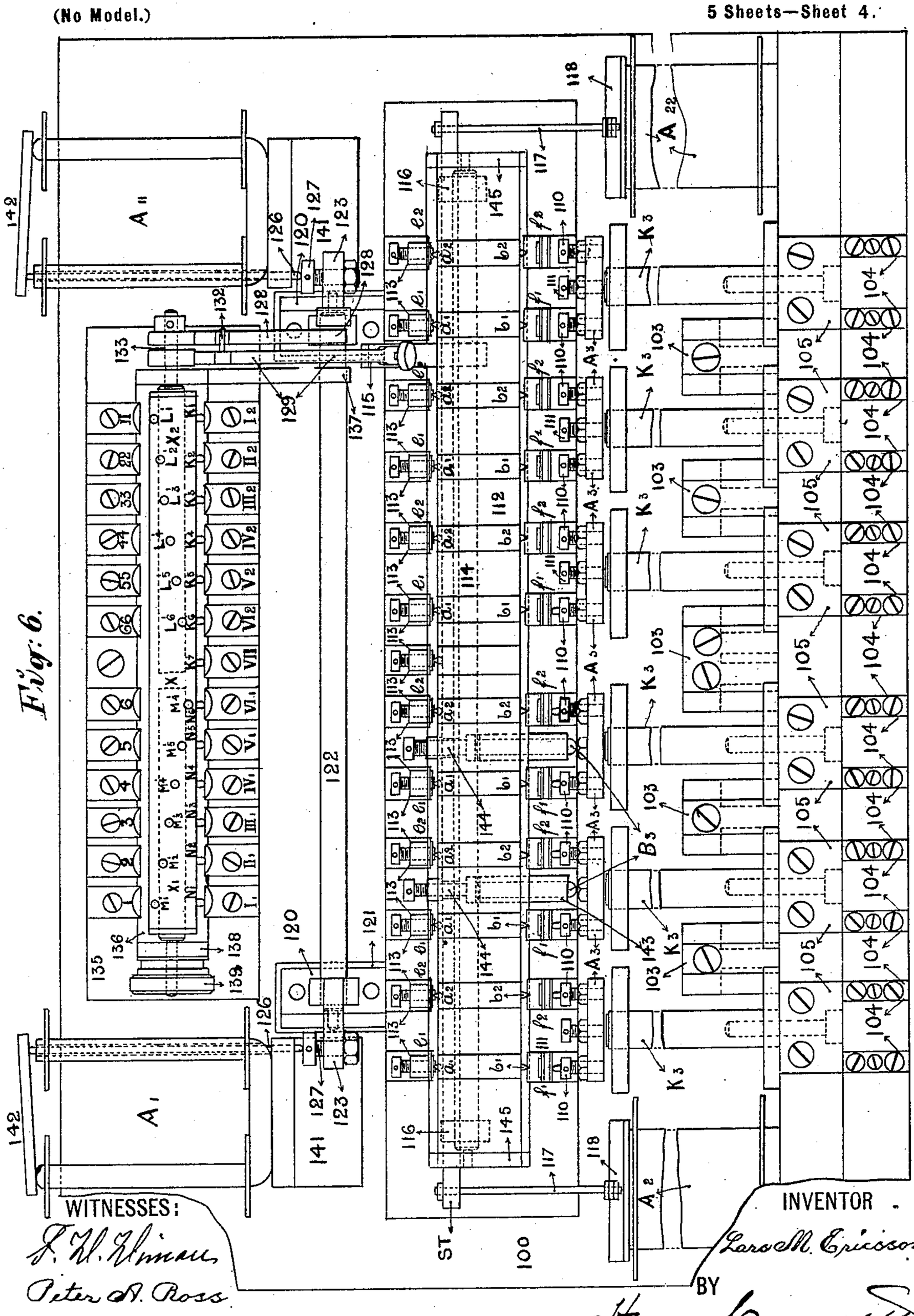
(No Model.) 5 Sheets—Sheet 4.

Fig. 6.



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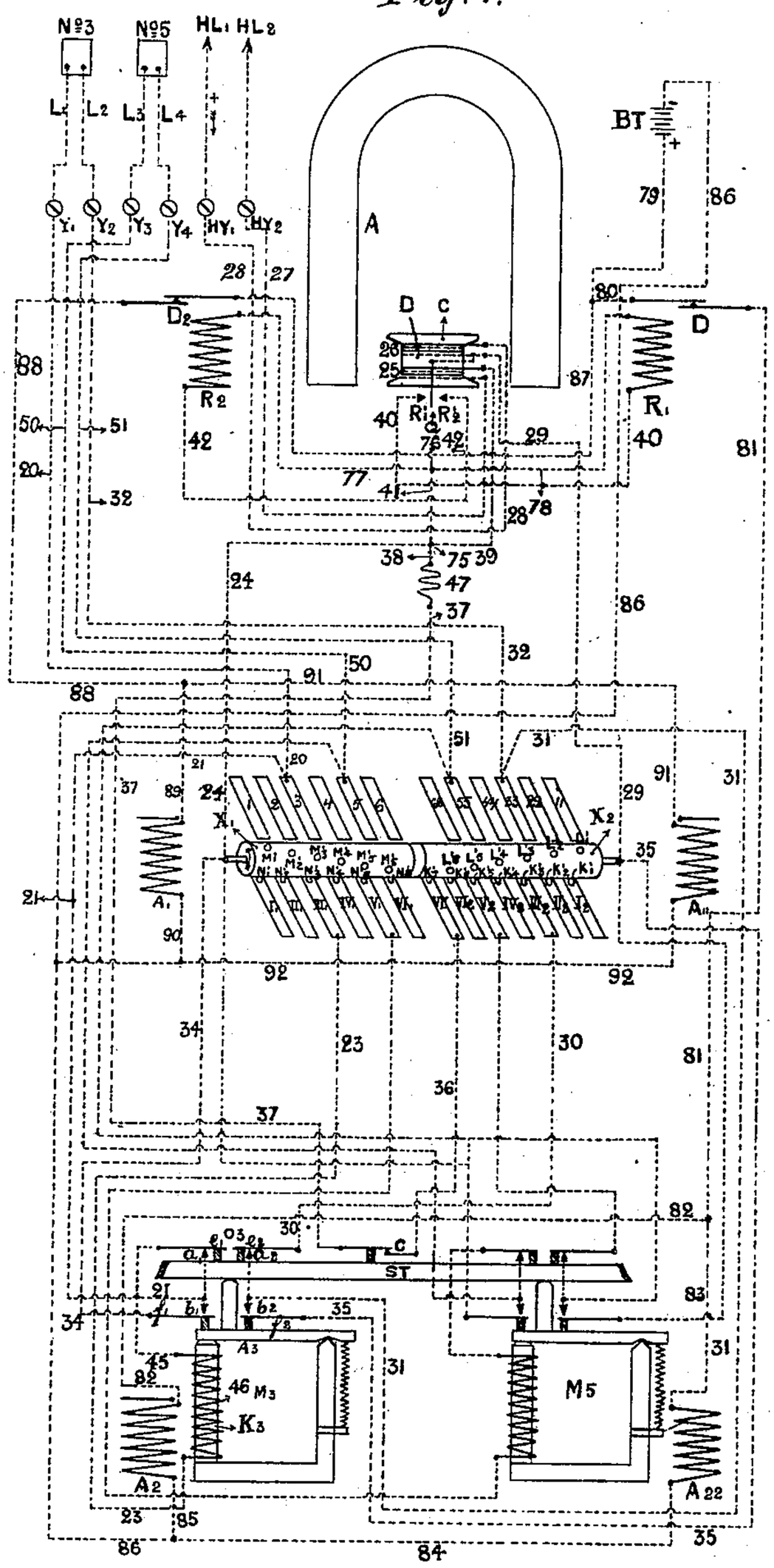
(Application filed Mar. 29, 1899.)

(No Model.) 5 Sheets—Sheet 5.

Fig: 7.



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UNITED STATES PATENT OFFICE.

LARS MAGNUS ERICSSON, OF STOCKHOLM, SWEDEN, ASSIGNOR TO THE AKTIEBOLAGET L. M. ERICSSON & CO., OF SAME PLACE.

TELEPHONE SWITCH APPARATUS.

SPECIFICATION forming part of Letters Patent No. 681,878, dated September 3, 1901.

Application filed March 29, 1899. Serial No. 710,973. (No model.)

To all whom it may concern:

Be it known that I, LARS MAGNUS ERICSSON, manufacturer, a subject of the King of Sweden and Norway, and a resident of Thulegatan 5, Stockholm, in the Kingdom of Sweden, have invented certain new and useful Improvements in Telephone Switch Apparatus, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to telephone switch apparatus.

The object of the present apparatus is to connect automatically metallic circuits of telephone subscribers with a likewise metallic circuit leading to a central-exchange station.

The apparatus is primarily intended to be installed in places having a small number of telephone subscribers connected by a main circuit with a central exchange of some size. It is evident, however, that it can be used in any other telephone system, even a single wire or earth system, if it is desired to save wire. Its greatest significance, however, lies in the fact that in very small systems with but slight chances of development it completely fills the place of a manually-operated switchboard, thus doing away with the operating cost, which is usually quite burdensome in plants of the kind. In order to fill its said main purpose, the apparatus must be so arranged that a complete metallic circuit is obtained. Consequently it works with no earth connection whatever. In its construction attention has, moreover, been paid to a strict adherence to the principle of maintaining an electric equilibrium of the two branches of the line, which principle is more especially of importance in long telephone-lines, as well as to avoiding a reduction in efficiency by the presence of a shunt between the branches or a resistance coupled into them.

There is no theoretical obstacle to constructing the apparatus for any number of subscribers' circuits. As only one main line can enter into it, however, it is a good plan to limit the number of subscribers to a few only. The apparatus described in the following is constructed for six subscribers' circuits. This number has been chosen for the reason that in systems with a greater number of subscribers a single main circuit, no doubt, must be regarded as insufficient. There is, however, no absolute hindrance to the apparatus being used also for systems having several main lines. It is only to be taken into account that one switch apparatus must be provided for each main line. The location of the apparatus in the system may of course be varied in many ways. The best plan, however, is undoubtedly to install it with the subscriber who is most centrally located, the main line being accordingly drawn to this point as well as the wires of all the other subscribers. It should be mentioned that the length of a subscriber's circuit has no effect on the working of the apparatus, which is perfectly sure even though the resistance of the subscriber's circuit amounts to ten thousand ohms. After all the apparatus and wires of the system have been connected the latter operates as follows: Any one of the subscribers connected can immediately obtain communication with the central-exchange station by signalling by means of the inductor belonging to his apparatus. The limitation must here be made, however, that if one subscriber is already in connection through the switch with the central exchange—said connection may have been brought about by the subscriber himself or by the said exchange—none of the other subscribers belonging to the switch apparatus in question can obtain connection with the main line. Should a subscriber make an attempt to obtain such connection, he immediately discovers that the main line is engaged by the fact that his own call-bell does not sound. The central exchange is enabled by sending off current impulses of a certain direction to obtain connection with any one of the subscribers' circuits attached to the switch apparatus, and thus to place outsiders in connection with the subscribers belonging to the said switch. A subscriber of the switch is likewise able to obtain connection with another subscriber of the same switch, but only by the assistance of the central exchange. The main line is thus engaged also in this case. This may be regarded as a disadvantage; but on the other hand it involves important advantages, for

only in this manner the central exchange can exercise complete control over the switch and the subscribers' circuits attached to it. The necessity of such control is readily perceived when it is borne in mind that the central exchange should not only be able to bring about connection with any one of the subscribers of the switch, but also when a conversation is ended, even if this be held between two subscribers of the small system, be able to immediately effect the return of the switch to its normal position. Besides, they should be able from there, if need be, to plunge into a conversation while going on for transmitting messages of importance, &c. Moreover, the central exchange should always have such control of the switch that it will be impossible for a subscriber to hold either the main line or the circuit of another subscriber engaged for an arbitrary period of time. In order to perform said duties, the central exchange must always, by means of the main line, have control over the switch and the conversations carried on through it.

The apparatus is composed of three principal parts, which may here be termed the "reversing" apparatus, the "connecting" device, and the "relay" apparatus. Between these three parts there is no mechanical (only an electric) connection.

Figure 1 is a front elevation of the reversing apparatus with one contact device removed, and Fig. 2 is a front elevation of said contact device. Fig. 3 is a side elevation of said apparatus, and Fig. 4 is a plan of the same. Fig. 5 is a side elevation of the connecting device, and Fig. 6 is a front elevation of the same as seen from the left in Fig. 5. Fig. 7 is a diagrammatical face view of the entire apparatus.

The function of the reversing apparatus is to conduct a constant current through its winding into the one or the other of two different paths or branches, according to the direction of the passing current. Each of these two current branches passes through a relay. One of said relays effects the connection of the main line with any one of the subscribers' circuits by means of electromagnets actuated by a local battery. The other relay in similar manner effects the return of the apparatus to its normal position.

In order to obtain a rotary movement the direction of which is determined by the direction of the current in a circuit, there have heretofore been employed sensitive and permanent magnetic needles, influenced by the current in said circuit, which is fixed. As experience, however, has shown that such a magnetic needle is easily liable to lose its magnetism under influence of the atmospheric currents which frequently appear, more especially in long circuits, the reversing apparatus here referred to has been constructed on quite a different principle.

Referring primarily to Figs. 1 to 4, the reversing apparatus will now be described.

In the different figures the same characters everywhere designate the same parts.

Between pole-shoes H, fixed to a system of permanent magnets A, there are secured on a shaft B pieces C, forming a framing, on which is carried a wire winding D. On a forward frame-piece E_1 and a rear piece E_2 cross-bars G_1 and G_2 are respectively fixed by means of studs or brackets F and F_1. The shaft B is journaled in said cross-bars. An electric current passed through the wire winding or coil D will, owing to the interaction taking place between it and the magnetism, produce a turning moment which, according to the direction of the current, will rotate the wire coil in one direction or the other. On the forward end of the shaft B is rigidly mounted a disk K of insulating material. In this disk is formed a concentric channel L. In said channel is placed a body Qv of mercury, which is prevented by a glass disk M from running out of the channel in which enter three contacts Q, R'_1, and R'_2 of platinum, one of which, Q, is, by means of a platinum wire q, in electric connection with the shaft B and the framing, while the contacts R'_1 and R'_2, by means of contact-pieces x_1 and x_2 and insulated cords s_1 and s_2, are respectively connected with terminals v_1 and v_2. The distances between the contacts Q, R'_1, and R'_2 are such that when the wire coil occupies its normal position the body of mercury is in contact only with the contact Q. When the wire coil is revolved, the mercury will connect the last-mentioned contact Q with the one or the other of the contacts R'_1 and R'_2, depending on the direction of rotation. To keep the wire coil in its normal position when no current is passing through—*i. e.*, in such a position that the contacts Q, R'_1, and R'_2 will not be in contact with one another—the following contrivance is provided: On a bracket S, fixed to the forward frame-piece E_1, there are mounted on shafts i bell-crank levers P U, the arms U of which carry adjustable weights T_1 and T_2, respectively. On the shaft B is fixed behind the contact-disk K a metal piece N, with a roller O. In the normal position of the wire coil said roller rests freely between the arms P, because the arms U then rest on pins Z. On the other hand, if the wire coil be revolved in one direction or the other, the roller O will press against either of the arms P, the corresponding arm being thereby lifted. By the weight T_1 or T_2 there is consequently produced a turning moment, counteracting the motion of the wire coil and forcing the latter back into its normal position as soon as the current ceases to flow in the wire.

For reasons to be given below it is of importance that the reversing apparatus should operate only for continuous currents. An alternating current should have no influence on it. For this reason the contact q is made in the shape of a plate filling the greater portion of the cross-section of the channel L, this

having for result that the movement of the body of mercury is impeded, so that only a current impulse of comparatively long duration, and thus not one forming an element of an alternating current, is able to produce a noticeable rotation of the wire coil. This choking of the channel L may of course be produced in some other manner and occur in more than one place.

In the connecting device there are three principal parts. By means of one of said parts the central exchange can obtain connection with any one of the subscribers' circuits entering the switch and at the same time shut out all the other subscribers from the possibility of disturbing the connection effected. By means of the second part any subscriber of the switch can place his circuit in connection with the main line while simultaneously shutting off all the other subscribers of the switch from the possibility of reaching said main line. The third part serves to return the switch to its normal position when a conversation is finished.

As before stated, Figs. 5 and 6 show the parts belonging to the connecting device. For the sake of clearness all connections needed for the electric action of the apparatus, and thus also all electromagnet-windings, have been omitted in these figures.

The parts brought into service when a subscriber belonging to the automatic switch is to be connected from the central exchange are the electromagnet contrivances A_1 and A_{11} and the connecting-drum X. The electromagnets are made of horseshoe shape, and each is provided with an armature 142. In a hole drilled in one branch of each magnet a pin 126 is movable vertically. The connecting-drum X is composed of two metallic portions X_1 and X_2, deposited in insulating material and insulated from each other, in which portions there are inserted in drilled holes pins or pegs N'_1 to N'_6, M'_1 to M'_6, K'_1 to K'_7, and L'_1 to L'_6. The pins N'_1 to N'_6 and M'_1 to M'_6 are in electric connection with the metallic portion X_1 and the pins K'_1 to K'_7 and L'_1 to L'_6, on the other hand, are in electric connection with the metallic portion X_2. On an insulating-piece 135, fixed to a metal plate 100, there are located brackets 137, one at each end of the drum. In these brackets the drum X is journaled. A ratchet-wheel 133 is secured to the drum. The pins 126 previously mentioned bear against adjustable screws 127, placed on arms 123. The arms 123 are secured to a shaft 122, journaled in the brackets 120. With one of the arms 123 is connected a feed-pawl 128, said connection, however, not being rigid, but such that the pawl can move in relation to the arm and engage with the teeth of the ratchet-wheel 133. By means of a screw 134 the feed-pawl can be adjusted to proper engagement with the ratchet 133.

139 is a spring-box containing a coil-spring connected with the drum, the tension of which is increased when the drum is turned from its normal position.

As will be explained in the description below of the electrical action of the apparatus, the windings of the magnets A_1 and A_{11} will be simultaneously traversed by currents of equal strength when the central exchange connects a subscriber belonging to the switch. They will then coöperate in their respective functions. The task to be performed by them is that during the passage of the current the armatures 142 shall depress the pins 126, thus causing the arms 123 to be depressed. The result will be that the feed-pawl 128 is drawn downward and caused to rotate the ratchet 133 and drum X. When the current ceases, the arms 123 will be raised by a spiral spring 124, actuated by a screw 125, thus bringing the feed-pawl in engagement with the next tooth of the ratchet. In order that in this action the drum may not under the influence of the coil-spring in the spring-box 139 return to its original position, there is provided another pawl 129, similar to the pawl 128, but independent of it, said pawl serving to retain the drum in the position given to it by the feed-pawl 128. The effect of this rotation is that the pins or pegs N'_1 to N'_6 and K'_1 to K'_7 are brought out of contact with contact-springs I_1 to VI_1 and I_2 to VI_2 and VII, fixed on the insulating-piece 135, and that of the springs 1 to 6 and 11 to 66, fixed on the same insulating-plate, the spring 1 is brought into contact with the pin M'_1, and the spring 11 in contact with the pin L'_1. The object hereof is stated in the description below of the electric action of the apparatus. A succeeding current impulse sent through the windings of the electromagnets A_1 and A_2 will advance the ratchet, and thus the drum, another step, &c. The springs 1 to 6 and 11 to 66 above the drum serve to connect any one of the six subscribers with the central exchange, while the springs I_1 to VI_1 and I_2 to VI_2 at the under side of the drum serve to make it impossible for the other subscribers to influence the apparatus as soon as such connection has been made.

To enable a subscriber of the switch to place himself in connection with the central exchange six electromagnets are provided—one for each subscriber. K_3 designates the cores of these electromagnets, which are constructed as follows: On each core K_3 is screwed a pole-piece 105, of soft iron. On this pole-piece bears one end of a permanent magnet 101, bent at an angle and bearing with its other end against a pole-piece 109, likewise of soft iron. The latter pole-piece has its end shaped as an edge, on which rests an armature A_3. By means of a screw 108, a bell-crank 106, and a spiral spring 107 the armature A_3 is given a certain tendency to release itself from the core K_3, by which it is held fast under influence of the magnet 101. The magnetism is so strong, however, that a release cannot take place until favored by an outer impulse. This impulse is furnished

when a subscriber by means of his inductor sends out an alternating current. In the inactive position of the switch each subscriber's circuit is connected with the winding or coil of the corresponding magnet. One of the current directions in the alternating current will counteract the magnetism of the magnet 101, and this to such an extent that the spiral spring 107 will have power enough to release the armature A_3 from the core K_3. Owing to the construction of the electromagnet the magnetism after such a release is unable to again attract the armature into contact with the magnet. Under the influence of the spiral spring 107 the armature A_3 will now perform the operations necessary for connecting the subscriber with the main line and shutting off the other subscribers from said line. This is accomplished in the following manner: In the sleeve 143, which is inserted in an insulating-piece 112, a pin B_3 is movable vertically. One such pin is provided for each of the six electromagnets. Springs e_1 e_2 normally bear on contacts a_1 a_2. By means of adjustable screws 113, insulated from the springs e_1 e_2, the said springs can be acted on by a bar S T, sustained by arms 116, which are rigidly connected with each other by means of a shaft 114, journaled in side pieces 145. When a call is made and one of the armatures A_3 consequently is released, its upward movement will be transmitted by means of the pin B_3 to the bar S T. The latter will then likewise move upward, causing all the springs e_1 and e_2 to be removed from the contacts a_1 and a_2. By this means the other subscribers are shut out from all possibility of influencing the apparatus. In the upward motion of the armature A_3, moreover, springs f_1 and f_2 are pressed by means of two screws 110 against contacts b_1 and b_2. This, however, takes place only at the electromagnet influenced by the current and has for result that the apparatus of the calling subscriber is placed in direct connection with the main line.

By the construction here given to the subscriber's electromagnet important advantages are gained. As the influence of the permanent magnetism on the armature when the latter is in direct contact with the core is very great, while it is greatly diminished as soon as the armature has become slightly removed from the core, a considerable amount of energy can be stored in the spiral spring 107. This is of importance as producing a very powerful and sure action in the release of the armature. If the electromagnet be provided with many windings, the apparatus will at the same time be very sensitive. As mentioned above, the apparatus in question, the electromagnet-coils of which have a resistance of three thousand ohms, is perfectly reliable in its action for subscribers' circuits reaching ten thousand ohms resistance.

The parts forming the replacing motion are the electromagnets A_2 and A_{22}, the arms 116 with the bar S T, and the arm 115. As will be explained below, the operator at the central exchange in replacing the apparatus sends out a current of opposite direction to that used in making the connection. By the aid of a relay a local current is thereby passed through the windings of the electromagnets A_2 and A_{22}, which coöperate in the same manner as the magnets A_1 and A_{11} in making the connection. The construction of the electromagnets A_2 and A_{22} is the same as that of the electromagnets A_1 and A_2. With the armatures 118 of the former ones are connected draw-rods 117, fixed to each end of the bar S T, which consequently is drawn down when a current traverses the windings of the magnets A_2 and A_{22}. The tension of the springs e_1 and e_2 will then bring said springs to bear against their respective contacts a_1 a_2. The bar S T simultaneously depresses, by means of the pin B_3, the armature A_3 of the magnet belonging to the calling subscriber. Owing to their tension the springs f_1 f_2 then resume their normal positions. On the other hand, if the replacement is to be done subsequent to a connection made by the central exchange, in which case nothing pertaining to the subscriber's magnets has been disturbed, but only what belongs to the connecting-drum X, the bar has no other function to perform than to rotate, by means of the arms 116, the shaft 114, on which the arm 115 is fixed. The latter arm presses on the lower end of the pawl 129, which is made in the shape of a bell-crank, this having for result that the pawl is brought out of engagement with the ratchet 133. The feed-pawl 128 is likewise compelled, by means of the pin 132, secured to the pawl 129, to disengage itself from said ratchet, and the drum X thus released resumes its normal position under influence of the coil-spring in the spring-box 139. When two subscribers connected by the aid of the automatic switch have had a conversation with each other, both one of the subscriber's electromagnets and the connecting-drum X have been actuated. The replacement is then effected, as described, two operations, however, being involved—viz., the replacing of the magnet and the replacing of the drum.

Fig. 7 shows diagrammatically the entire apparatus. To make its mode of operation clear, the latter is described for the three cases which can be assumed in practice, viz: First, that a subscriber having a circuit attached to the automatic switch wishes to obtain connection with the central exchange or a circuit entering the latter; second, that the central exchange or a subscriber having a circuit entering the latter wishes connection with a circuit attached to the automatic switch, and, third, that a subscriber having a circuit attached to the automatic switch wishes to obtain connection with another circuit attached to the same switch.

First. A subscriber having a circuit attached to the automatic switch wishes to ob-

tain connection with the central exchange or a circuit entering the latter. Let this subscriber be the one, for instance, who has apparatus No. 3. (See Fig. 7.) This subscriber accordingly makes a call by means of the inductor of his telephone. The circuit of the alternating current generated will be as follows: Apparatus No. 3, the line branch L_1, the wire 20, spring 3, (which will not be traversed because in the normal position of the switch it is not in contact with the connecting-drum X,) the wire 21, contact a_1, and spring e_1, the wire 45, winding 46 of the magnet M_3, the wire 23, spring III_1, the pin N'_3, the metal part X_1 in the connecting-drum X, wire 24, branch point 75, wire 39, one branch 25 of the coil D of the reversing apparatus, the wire 27, one of branches HL_2 of the main-line indicator-drop or other corresponding device of the central exchange, the other line branch HL_1 of the main line, the wire 28, the other branch 26 of the coil D of the reversing apparatus, the wire 29, the metal part X_2 in the connecting-drum X, the pin K'_3, spring III_2, wire 30, spring e_2 and contact a_2, wire 31, spring 33, (which is not traversed because in the normal position of the switch it is not in contact with the connecting-drum X,) the wire 32, line-terminal of the switch Y_2, the line branch L_2, and the subscriber's apparatus No. 3. As the springs $I_1\,II_1\,III_1\,IV_1\,V_1\,VI_1$ are in contact with the pins $N'_1\,N'_2\,N'_3\,N'_4\,N'_5\,N'_6$, respectively, and thus also with the metal part X_1, and the springs $I_2\,II_2\,III_2\,IV_2\,V_2\,VI_2$ are in contact with the pins $K'_1\,K'_2\,K'_3\,K'_4\,K'_5\,K'_6$, respectively, and thus also with the metal part X_2, there is between X_1 and X_2, besides the circuit just pointed out through 24, 75, 39, 25, 27, HL_2, the exchange apparatus HL_1 28 26 29, five additional branch circuits by which the call-current from the apparatus No. 3 can pass—viz., the circuits of the subscribers Nos. 1, 2, 4, 5, and 6, which circuits issue from the springs $I_1\,II_1\,IV_1\,V_1\,VI_1$, reach the springs $I_2\,II_2\,IV_2\,V_2\,VI_2$, and in every way correspond to the circuit 23, 46, 45, e_1, a_1, 21, 3, 20, Y_1, L_1, No. 3, L_2, Y_2, 32, 33, 31, a_2, e_2, 30. As, however, in each of said circuits among other resistances enters that of three thousand ohms of the winding of a magnet corresponding to the magnet M_3, which resistance is greatly self-inductive, the branch current arriving at each subscriber's apparatus will be so much reduced in strength that it will not have power enough to actuate the bell of the apparatus. There is, however, another circuit coupled in parallel to the main line for the current from the subscriber's apparatus. This branch circuit passes from the branch point 75 through the wire 38, the resistance 47, wire 37, contact c, wire 36, spring VII, pin K'_7 to the metal part X_2 in the connecting-drum X. As the resistance of 47 is made equal to but two hundred ohms, the greater portion of the call-current from the subscriber's apparatus will take this path, more especially if the main line is of any considerable length, and in this manner a sufficiently powerful action of the current in the winding of the electromagnet M_3 is produced. Without this branch circuit and if the resistance of the main line were considerable it might occur that the call-current suffered so great a loss of strength that in passing through the winding of the magnet M_3 it would be unable to perform the work required of it at this point. With the construction here used such failure cannot occur. The branch circuit through the resistance 47 might, however, produce such weakness in the current traversing the central exchange that the indicator of the latter cannot be brought into action. This is of no consequence, however, as will be shown in the following. The call-current sent out from the subscriber's apparatus No. 3 passes undivided through the winding of magnet M_3. This being an alternating current, however, which, as is well known, may be defined to consist of a series of impulses, every alternate one positive and every alternate one negative, one of the two first impulses must, owing to the construction of the magnet M_3, release the armature A_3 from the core K_3. The effect produced is as follows: The pin B_3 will raise the bar ST, thus breaking connection between the contacts a_1 and e_1 and between the contacts a_2 and e_2 not only for the subscriber's magnet in question, but simultaneously for all six of the magnets. Besides the contacts b_1 and f_1 and b_2 and f_2 are respectively brought to touch each other, this only for the magnet in question, however. Finally connection is broken at c. The circuits previously pointed out for the call-current from No. 3—viz., partly through the resistance 47, partly through the main line, and partly through the five remaining subscribers' circuits—thus exist only during the first, or, at the most, during the first and second of the current impulses. During the succeeding ones the circuit will be the following: Apparatus No. 3, the line branch L_1, the line-terminal of the switch Y_1, the wire 20, spring 3, wire 21, contact b_1, spring f_1, wire 34, metal part X_1 in the drum X, the wire 24, branch point 75, wire 39, one branch 25 of the coil D of the reversing apparatus, the wire 27, line-terminal HY_2, one branch HL_2 of the main line, the exchange, the other branch HL_1, wire 28, the other branch 26 of the coil D of the reversing apparatus, the wire 29, metal part X_2 in the connecting-drum X, the wire 35, spring f_2, contact b_2, wire 31, spring 33, wire 32, line-terminal of the switch Y_2, the line branch L_2, and the subscriber's apparatus No. 3. The springs 3 and 33, which are not in contact with the metal parts of the connecting-drum X, do not enter directly in the circuit. There are no branch circuits to the circuit last mentioned, partly because all the other subscribers' circuits have become broken by the breaking of the contacts between the respective parts e_1 and a_1 and e_2 and a_2, and partly because of the breaking at c of the branch cir-

cuit through the resistance 47. The result is that as soon as a subscriber has made a call none of the remaining subscribers can make one. It is evident that even if the first two current impulses should have proved too feeble to actuate the indicator-flap of the exchange the succeeding ones will surely do so, as no weakening branches or unnecessary resistances are present. In the circuit mentioned enter only the line resistance of the subscriber's line and the main line and the resistance of the coil D of the reversing apparatus. As already mentioned, the reversing apparatus is so constructed that it is not influenced by alternating currents. On having called the central exchange in the manner stated the subscriber No. 3 can freely converse with the latter and obtain connection with the subscriber desired. From the diagram it is evident that, on the one hand, no unnecessary resistances enter this connection, with the exception of that of the coil of the reversing apparatus, and, on the other hand, that there are no shunts nor earth-circuits. As regards the resistance of the reversing apparatus, this is so small (some sixty or seventy ohms, and besides, practically speaking, so free from self-induction) that it cannot interfere with the transmission of speech in any perceptible degree. In order to make the telephonic circuit completely symmetrical, the said resistance, moreover, has been divided in two equal parts between the two branches of the circuit. When the conversation carried on is concluded, a "ringing-off" signal is given from the subscriber's apparatus to the central exchange. The operator here has then to break the connection and return the automatic switch to its normal position. The description of the replacing operation is deferred, however, and will be given in connection with the second case, viz:

Second. The central exchange or a subscriber having a circuit entering the latter wishes connection with a circuit attached to the automatic switch. As the connection between a calling-subscriber's circuit and the main line to the automatic switch is brought about in usual manner by the operator at the central exchange, it will only be described how the latter obtains connection with some particular subscriber of the said switch. Assume that the central exchange desires to converse with, for instance, subscriber No. 3 of the automatic switch. The operator then sends through the main line a continuous current of a certain direction, which may be assumed to be that indicated by the arrow in the diagram—*i. e.*, positive in the line branch HL_1 in the direction of the switch. The circuit of this current will be as follows: The line branch HL_1, line-terminal of the switch HY_1, the wire 28, one branch 26 of the coil D of the reversing apparatus, the wire 29, metal part X_2 in the connecting-drum X, the pin K'_7, spring VII, wire 36, contact *c*, wire 37, resistance 47, wire 38, branch point 75, wire 39, second branch 25 of the coil D of the reversing apparatus, the wire 27, line-terminal of the switch HY_2, line branch HL_2 of the main line, and the central exchange. As all the springs I_2 to VI_2 are connected, respectively, by means of the pins K'_1 to K'_6, with the metallic part X_2, and all the springs I_1 to VI_1 are connected, respectively, by means of the pins N'_1 to N'_6, with the metallic part X_1, there will still be between the spring VII and the branch point 75 six current-paths running parallel through the windings of magnet M_3 and the remaining subscribers' magnets and subscribers' wires. As, however, the resistance of each of these current-paths is very great in comparison with the resistance of the branch circuit through the resistance 47, the current in each of them will be so weakened that it cannot actuate the bell of the subscriber's apparatus. As this is designed to be operated by alternating currents, the worst that can happen is that its armature makes one single stroke. The effect of the current in passing through the coil D of the reversing apparatus is to cause said coil to rotate in one direction or the other, the body of mercury being thereby made to connect electrically the middle contact with the one or the other of the side contacts. Assume that in the diagram Q designates the middle contact and R'_1 R'_2 the two side contacts. The result will then be, according to the diagram, that the contact Q is brought in electric connection with the contact R'_1 or R'_2, depending on the direction of the current passed through the coil of the reversing apparatus. Assume that a positive current in the branch HL_1 in direction of the switch effects connection between the contacts Q and R'_2 and that a positive current in the branch HL_2 in direction of the switch effects connection between the contacts Q and R'_1. If we further assume that the connecting of a subscriber's circuit is to be brought about by sending out from the central exchange a positive current through the branch HL_1, the contact Q will in this case be brought in connection with the contact R'_2. A circuit parallel to that through the resistance 47 will then be opened for the current sent out—viz., from the contact Q, which is connected with the branch 26 of the coil of the reversing apparatus, through the contact R'_2, the wire 42, magnet-winding of the relay R_2, wire 77, branch point 76, wire 41 to the branch point 75. The relay R_2, having a winding of two hundred ohms resistance and possessing a high degree of sensitivity, will when a current traverses its magnet-winding close the contact D_2, and the battery BT, located at the automatic switch, will then work in a circuit consisting of the battery BT, wire 79, wire 87, contact D_2, wire 88, the parallel branches—viz., the wire 89, winding of magnet A_1, wire 90, and wire 91, the winding of magnet A_{11}, wire 92, and the wire 86, which conducts the current back to the other pole of the battery. As already mentioned, A_1

and A_{11} (see Fig. 6) are two electromagnet devices coöperating with each other. When their windings are traversed by a current, the connecting-drum X will be revolved by means of their armatures. The rotation is assumed to take place in the direction indicated by the arrow on the drum. The first impulse emitted from the central exchange in the direction assumed will rotate the drum one step. The result produced is that the contact of the springs I_1 to VI_1 with the respective pins N'_1 to N'_6 and that of the springs I_2 to VI_2 with the respective pins K'_1 to K'_6 are broken. As a consequence all the subscribers' circuits but one will remain cut out and will be unable to actuate the switch. One single circuit—viz., No. 1—is connected with the main line by the spring 1 being in contact with the pin M'_1 and the spring 11 being in contact with the pin L'_1. In the rotation of the drum the contact is also broken between the spring VII and pin K'_7. As the shunt-circuit through the resistance 47 passes through this contact, the said circuit will be broken, and therefore cannot enter in the circuit of the succeeding impulses emitted from the central exchange. However, as the connection between Q and R'_2 will remain as long as the first impulse lasts and also owing to the above-mentioned inertia of the body of mercury, said circuit will be closed during the interval between the two impulses mentioned if said interval be made short. The circuit is then closed by means of the relay R_2. Should the connection cease between the contacts Q and R'_2—for instance, owing to carelessness in sending out the current impulses—there is nevertheless the possibility of producing a current through the coil of the reversing apparatus, since the subscriber's apparatus No. 1 enters in the circuit. The second impulse emitted from the central exchange, which impulse must pass in the same direction as the first, will revolve the drum, and thereby break the contacts 1 to M'_1 and 11 to L'_1, while the contacts 2 to M'_2 and 22 to L'_2 are, instead, produced. The third impulse finally breaks these two contacts and instead brings about the contacts 3 to M'_3 and 33 to L'_3. The object in view—viz., effecting the connection of apparatus No. 3 with the main line—has now been attained. Had the intention been to make connection with apparatus No. 6 the central exchange would have had to emit six impulses of the same direction. During the whole time the springs I_1 to VI_1 and I_2 to VI_2 remain out of contact with the metallic parts of the connecting-drum, and consequently all the subscribers' circuits but that temporarily connected will remain cut out. As soon as the operator at the exchange has sent out the three impulses mentioned he will be able to call and converse with subscriber No. 3 by means of a circuit composed of the parts HL_1, HY_1, 28, 26, 29, X_2, L'_3, 33, 32, Y_2, L_2, No. 3, L_1, Y_1, 20, 3, M'_3, X_1, 24, 75, 39, 25, 27, HY_2, HL_2. As the contact is broken both between the parts VII and K'_7 and between the parts Q and R'_2 when the reversing apparatus has resumed its normal position, there will be no branches to this circuit. Neither are there any extra resistances in it with the exception of the coil of the reversing apparatus; but as the latter, as mentioned, is small and practically free from induction it will not interfere with the transmission of speech. The rest of the subscribers, whose circuits are broken in two places—viz., at the respective springs I_1 II_1 IV_1 V_1 VI_1 and I_2 II_2 IV_2 V_2 VI_2—are deprived of every means of disturbing the conversation. When the conversation is ended and the conversing subscribers consequently have rung off, the operator at the central exchange must remove the connection. This must be preceded, however, by the return of the switch to its normal position. To effect this, the operator sends out a current of opposite direction to that used for making the connection. This current traverses, of course, the circuit which has just been used for the conversation. When passing through the coil D of the reversing apparatus, it brings about connection between the contacts Q and R'_1, thus creating a branch circuit through the contacts Q and R'_1, the wire 40, the winding of the relay R_1, the wire 78, branch point 76, wire 41, and branch point 75. The relay R_1 has exactly the same properties as the relay R_2, previously mentioned, and when a current traverses its winding it closes a circuit to the battery BT, which circuit consists of battery BT, the wire 79, wire 80, contact D_1, wire 81, the parallel branches, wire 82, the winding of magnet A_2, wire 85 and wire 83, the winding of magnet A_{22}, the wire 84, and the wire 86, and the other pole of the battery. The magnet devices A_2 and A_{22} cooperate, as already mentioned, and bring the switch back into its normal position by means of their armatures, no matter whether it has been disturbed from said position by switching from the central exchange or by a call made by a subscriber, which case has been treated under 1.

Third. A subscriber having a circuit attached to the automatic switch wishes to obtain connection with another circuit attached to the same switch. This case is a combination of the two cases previously mentioned. The calling subscriber first calls the central exchange, the course of events being then the same as mentioned under 1. The central exchange subsequently in the manner described under 2 places itself in connection with the desired subscriber of the switch. This being done, the two subscribers will be in connection with each other. Connecting the desired subscriber by the central exchange differs as regards the circuit from the course outlined under 2 in that the first impulse does not pass through the resistance 47, which is cut out at *c* by the subscriber's calling operation, but through this subscriber's appara-

tus. The circuit in a conversation between two subscribers—for instance, Nos. 3 and 5—by the aid of the automatic switch, when No. 3 is the calling and No. 5 the called subscriber, will be No. 3, L_1, Y_1, 20, 3, 21, b_1, f_1, 34, X_1, M'_5, 5, 50, Y_3, L_3, No. 5, L_4, Y_4, 51, 55, L'_5, X_2, 35, f_2, b_2, 31, 33, 32, Y_2, L_2, and No. 3. Between X_1 and X_2 the main line is coupled in the circuit as a branch circuit, and consequently it is able, as mentioned in the beginning, to exercise complete control over the connection. In replacing the switch the procedure consists of a combination of those in cases 1 and 2.

As stated in the beginning of this specification, the prime purpose of this switch apparatus is to replace the hand-operated switchboard in small country systems connected with a larger central exchange-station. As circuits of great length and consequently of great resistance may here frequently be involved, it is of importance that the apparatus should combine great sensitiven ess with sure working. As already pointed out, the subscribers' magnets possess a high degree of sensitiveness, while at the same time being capable of performing the work required of them with great power. By the construction given to the reversing apparatus this is also made very sensitive, which of course is of great importance, since by this means the required quantity of current in the lines for switching will be small even for a main line of quite a great length. The work to be performed in the switch, moreover, is executed, as is evident from the above description, by electromagnets supplied with current from a local battery, which electromagnets are set into action by extremely-sensitive relays. By this means great power and surety of action are obtained.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In an automatic telephone switch apparatus, a reversing apparatus comprising as its essentials one or more permanent magnets, a rotatable frame, a coil carried thereby and situated between the pole-shoes of said magnet, said coil being coupled in the main line from the central station, in combination with a subscriber's electromagnet, a permanent magnet connected therewith, an armature in contact with one pole of said permanent magnet, and means for maintaining said armature in contact with a yielding pressure, substantially as and for the purposes set forth.

2. The combination with a reversing apparatus, comprising the permanent magnet or magnets, the rotatable frame, and the coil carried thereby and situated between the pole-shoes of the magnet, of a disk of insulating material carried by said frame and having in it a circumferential channel containing mercury, an intermediate contact Q, always in the mercury, two lateral contacts, R'_1 and R'_2, adapted to be put into contact alternately with the mercury by the rocking of said disk, the terminals V′ and V^2, and conductors connecting said lateral contacts respectively with said terminals, substantially as set forth.

3. In the reversing apparatus, the combination with the rotatable frame, of the disk K, having in it an annular channel L, for mercury, contacts which enter said channel, and means for choking said channel, whereby the reversing apparatus is protected against the influence of alternating currents, substantially as set forth.

4. In the reversing apparatus, the combination with the rotatable frame of the latter, of the disk K, having in it an annular channel L, for mercury, contacts R'_1 and R'_2, which enter said channel, and the intermediate contact Q, which enters said channel and is of such size as to choke said channel and thus protect the reversing apparatus against the influence of alternating currents, substantially as set forth.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

LARS MAGNUS ERICSSON.

Witnesses:
HEMMING JOHANSSON,
HENRIK PETTERSON.