No. 681,965. Patented Sept. 3, 1901.

M. HUTIN & M. LEBLANC.

APPARATUS FOR TRANSFORMING ALTERNATING INTO CONTINUOUS CURRENTS.

(Application filed Jan. 5, 1900.)

(No Model.) 5 Sheets—Sheet 1.

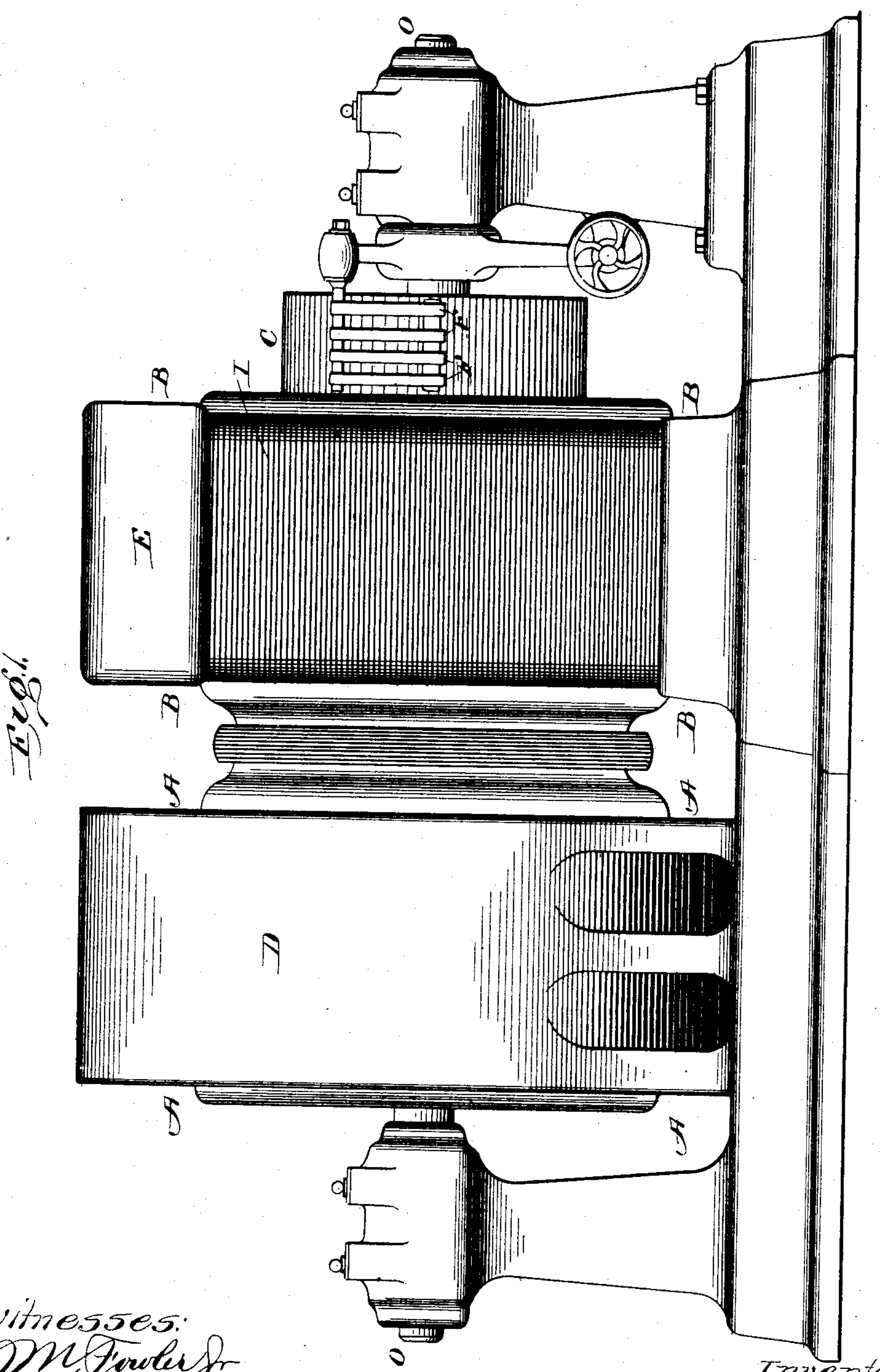

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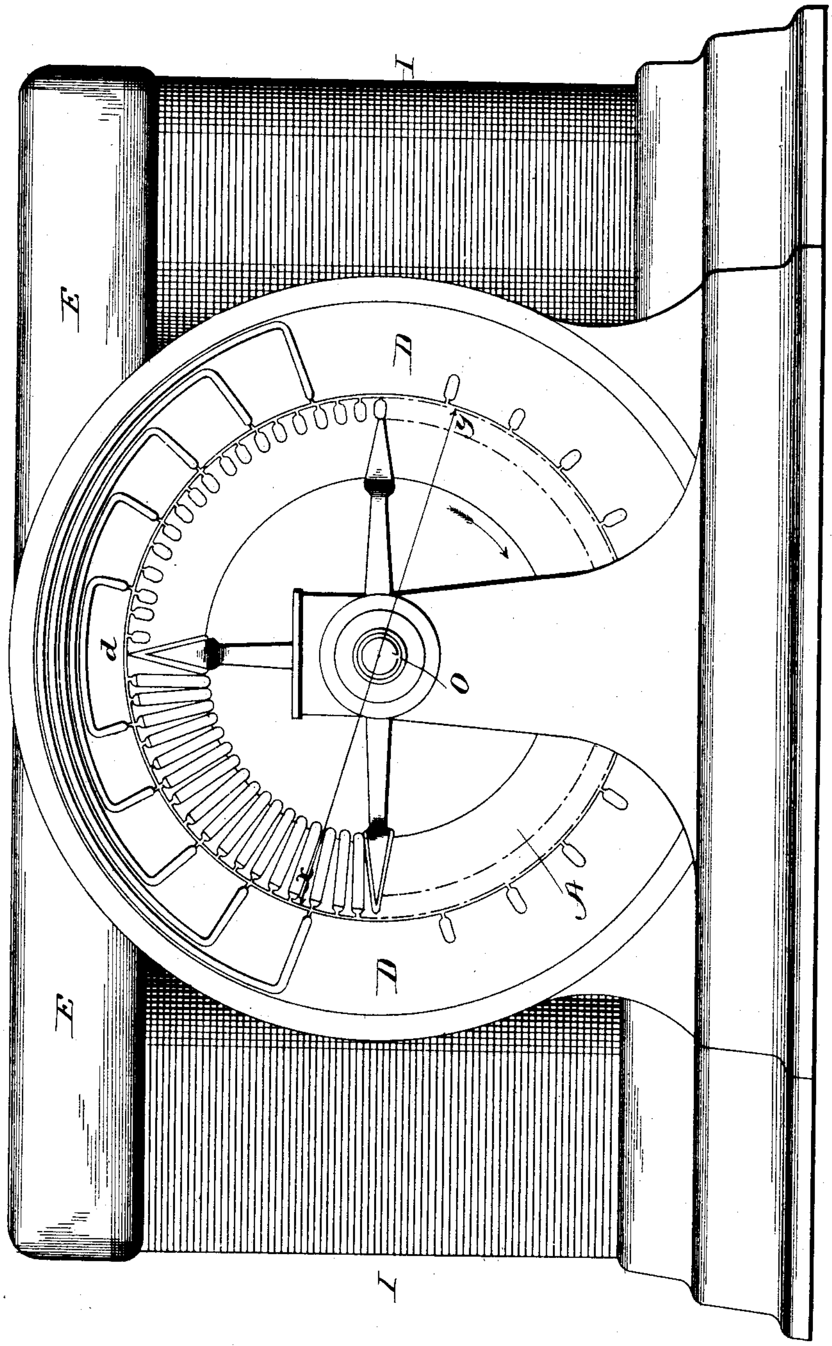
Fig. 2.



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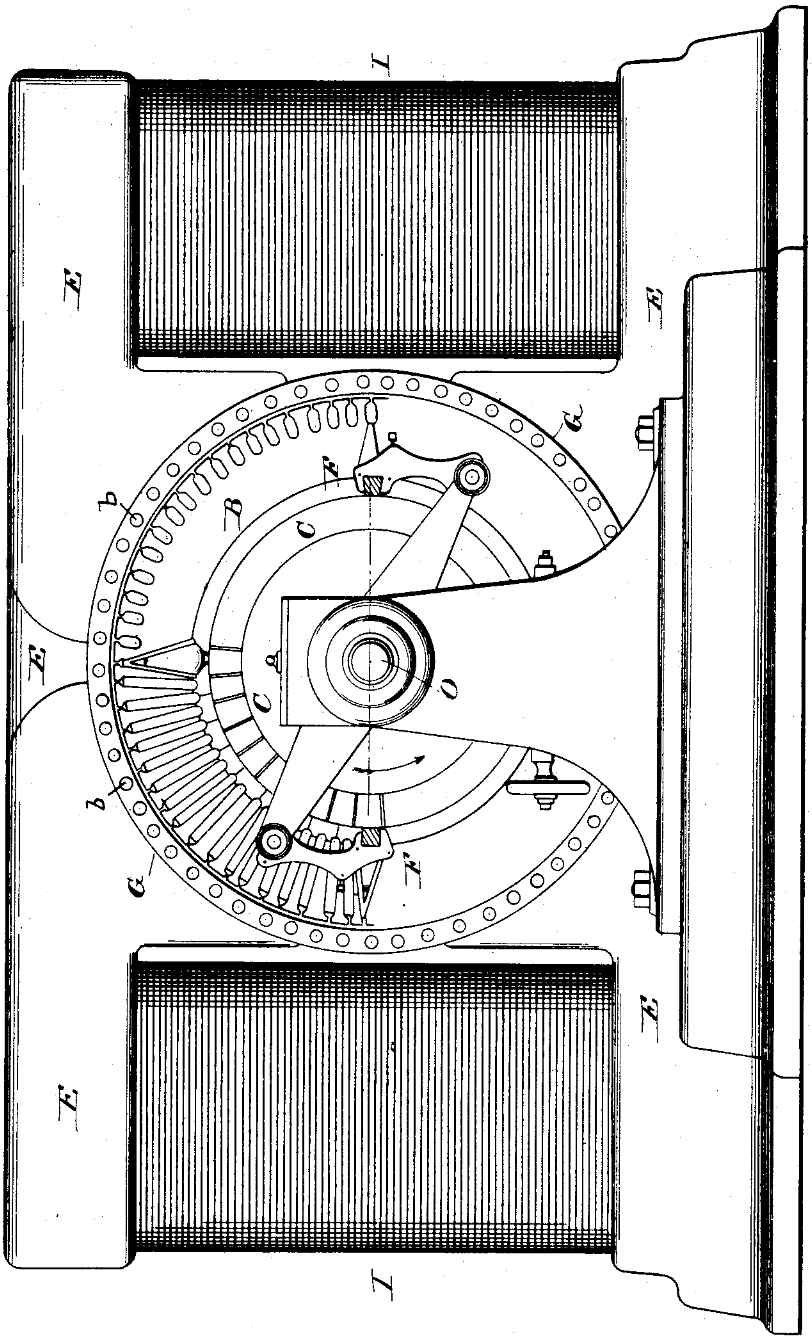

Fig. 3.

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(No Model.) 5 Sheets—Sheet 4.

Fig. 5

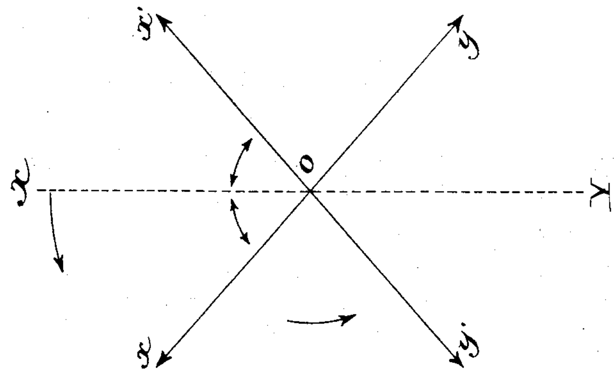

Fig. 4

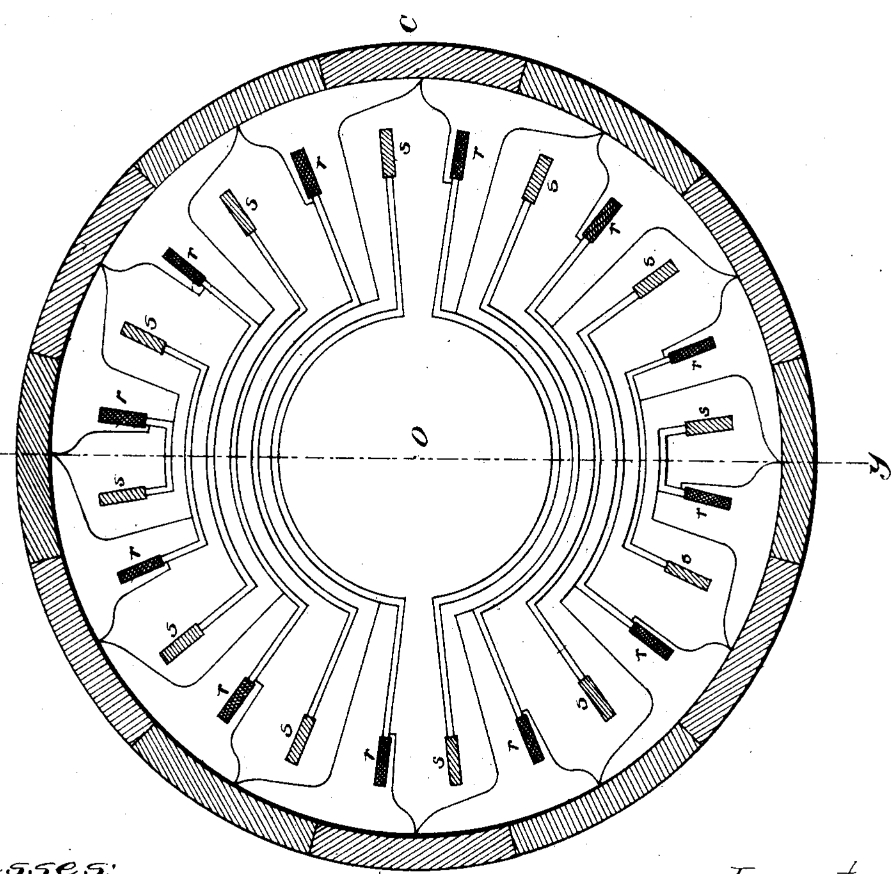

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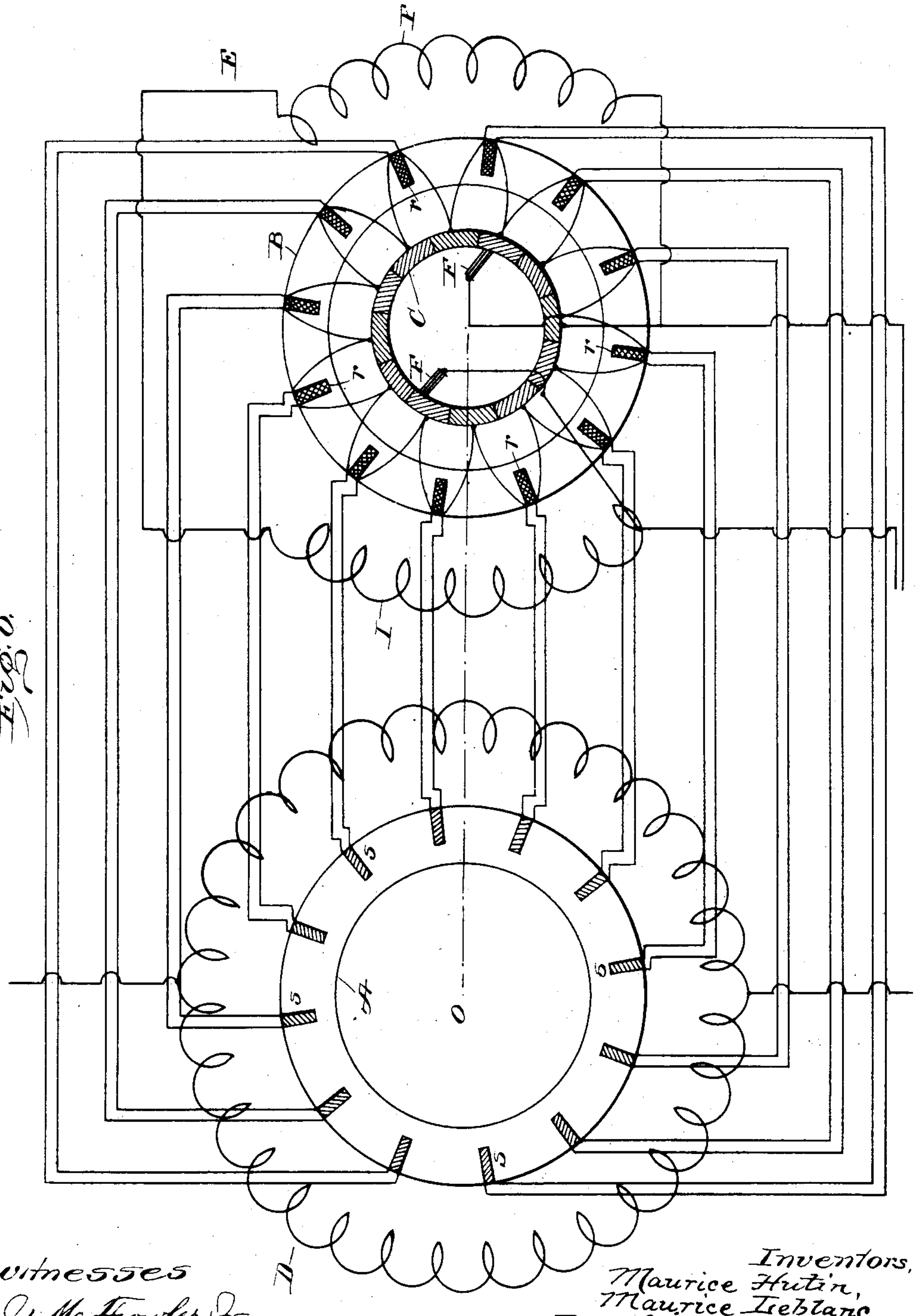
Fig. 6.



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UNITED STATES PATENT OFFICE.

MAURICE HUTIN AND MAURICE LEBLANC, OF PARIS, FRANCE, ASSIGNORS TO SOCIÉTÉ ANONYME POUR LA TRANSMISSION DE LA FORCE PAR L'ÉLÉCTRICITÉ, OF SAME PLACE.

APPARATUS FOR TRANSFORMING ALTERNATING INTO CONTINUOUS CURRENTS.

SPECIFICATION forming part of Letters Patent No. 681,965, dated September 3, 1901.

Application filed January 5, 1900. Serial No. 457. (No model.)

To all whom it may concern:

Be it known that we, MAURICE HUTIN and MAURICE LEBLANC, citizens of the Republic of France, and residents of Paris, in the Republic of France, have invented certain new and useful Improvements in Apparatus for Transforming Single-Phase or Polyphase Currents into Continuous Currents, of which the following is a specification.

The object of our invention is to devise an apparatus for transforming alternating currents, whether monophase or polyphase, into continuous currents and, conversely, for transforming continuous currents into alternating currents, whether monophase or polyphase. Since, however, the apparatus is completely reversible, it will only be necessary to describe it in one of its two forms, and for this purpose we shall select that form in which alternating currents are transformed into continuous currents, it being understood that our claims are broad enough to cover either alternative. In effecting such transformation we may transform the alternating currents into continuous currents of the same tension, or we may by properly winding the parts change the tension of the continuous currents with reference to that of the alternating currents. Thus, for instance, we can begin with alternating currents of high tension and transform them into continuous currents of low tension.

The means which we have devised to carry out our invention may in a general way be described as follows: We create by means of the alternating current, whether monophase or polyphase, a rotary field of force. Such field rotates in space with a velocity of synchronism—that is, the velocity determined by the frequency of the current. Let us assume that the rotation is clockwise—that is, like the hands of a clock. Let us also assume that the frequency is p—that is, let us assume that p cycles of the alternating current take place in a second of time. The angular velocity of the rotary magnetic field due to this alternating current, assuming the inductor to be bipolar, will then be $2\pi p$. If there are $2n$ poles, then this number, to represent the angular magnetic speed of synchronism, will have to be divided by n. In any case the angular speed of the magnetic field due to the alternating current, which we may call the "angular magnetic velocity of synchronism," may be denoted by a. There is an armature carrying two groups of conductors. Assuming a plane of symmetry fixed within and rotating with the armature, the members of what we may call the "first group" of the armature-conductors at one end of the armature, measured along the axis of rotation, are connected each to each to the members of what we may call the "second group" of conductors at the other end of the armature, so that each member of the first group is connected to that member of the second group which lies at an equal angle with it on the opposite side of the plane of symmetry. These conductors are connected in the usual fashion to the segments of a commutator mounted on the armature-axis. The armature is rotated clockwise with a velocity of $\frac{a}{2}$. Now the armature is so situated with reference to the rotary field of force, which we have before described, as to have this field act upon one group—say the first group—of armature-conductors only. It will be plain, therefore, that as the field is rotated clockwise in space with a velocity a it is rotating with reference to the plane of symmetry fixed in the armature with a velocity of $\frac{a}{2}$. This relative motion of the field of force with reference to the plane of symmetry in the armature is also clockwise. It is also plain that the effect of a field of force rotating clockwise with reference to the first group of conductors at a velocity of $\frac{a}{2}$ will be to create certain electromotive forces in these conductors, which in turn will create equal electromotive forces in the second group of armature-conductors connected therewith; but as the rotary field is moving clockwise with a velocity of $\frac{a}{2}$ with respect to the plane of symmetry in the armature it is clear that the electromotive forces in the second group of armature-conductors will correspond to a field of force traveling counter-clockwise with reference to the plane of symmetry with a velocity equal to $\frac{a}{2}$. This follows at once when we consider that the corresponding conductors of the two armature-groups are connected on opposite sides of the plane of symmetry to make equal angles therewith. Now since the armature and its plane of symmetry are rotating clockwise with a velocity of $\frac{a}{2}$ and the field of force in the second group of armature-conductors is rotating counter-clockwise with reference to the plane of symmetry with a velocity of $\frac{a}{2}$, it follows that the second field of force, though moving with relation to the armature-conductors, will be fixed in space. This means that there will be a constant difference of potential between such diametrically opposite sections of the second group of armature connections as lie at any given instant of time upon the opposite ends of a diameter passing through the axis and fixed in space. We can therefore take a continuous current therefrom by reason of stationary branches resting on a commutator connected to these sections. We can also utilize this stationary field by acting upon it by another stationary field making a given angle therewith, after the manner of an electrodynamic motor, to drive the armature at the proper speed—namely, half the speed of synchronism.

It will be evident at once that with our apparatus the commutator is required to rectify currents of a frequency of $\frac{a}{2}$—that is, a frequency of half that of synchronism. In other systems it is necessary to rectify currents having a frequency equal to that of synchronism. One great advantage of our system, therefore, is that it permits us to use double the number of coils in the armature, supposing the tangential velocity of the commutator and the size of the plates to be the same. This naturally facilitates commutation and permits of the easy production of continuous current of high tension. Other advantages will be referred to later on.

There is an important advantage which is gained by having each group of the two groups of the armature-windings divided into separate members or sections, which separate sections are connected together across the plane of symmetry and to the sections of the commutator in the manner indicated. With such separate sections or members the armature is fed by as many distinct alternating currents having regularly-displaced phases as there are plates on the commutator. During its rotation the distribution of current at the surface of the armature becomes the same each time that it turns through an angle defined by the distance between two consecutive commutator-plates. There can therefore be no variation of flux in the armature sufficient to injuriously affect the commutation.

In the drawings, Figure 1 shows a side elevation of an apparatus constructed in accordance with our invention and carrying out the process referred to. Fig. 2 shows an end elevation viewed from the left of Fig. 1. Fig. 3 shows an end elevation viewed from the right of Fig. 1. Fig. 4 shows a diagram of the mode of connecting the two groups of armature-conductors to each other and to the plates of a commutator. Fig. 5 shows a diagram, and Fig. 6 shows a diagram of the several circuits.

The alternating current to be transformed is fed to the windings of the inductor D, which is of the alternating current, a synchronous type. The end view of Fig. 2 shows how the winding d of this inductor may be arranged. It has not, however, been considered necessary to show the details of the windings or the manner of feeding current thereto, since all this is old and common in the art. It is to be understood, in a word, that substantially any old type of inductor-field may be used in place of that indicated by the ring D. The inductor E, on the other hand, is that of a continuous-current machine, and its coils I I are mounted in shunt between the brushes F F, which supply a continuous current. It will also be advantageous in general to add to the coils I I in shunt of the brushes F F coils mounted in series in the exterior circuit, and thus give the field a compound winding in the manner which is ordinary and well understood.

Rotating within the alternating-inductor D and the continuous-current inductor E is the armature of the machine, which rotates upon the axis O. This armature is in two rigidly-connected parts, one part turning within the inductor D, the other part turning within the inductor E. The part of the armature turning within the inductor D is composed of rings A, having slots in their periphery, as shown in Fig. 2. The part of the armature rotating within the inductor E is composed of rings B, having similar slots in their periphery, as shown in Fig. 3. There is also a commutator composed of a number of plates C, which is mounted on and turns with the axis O. On this commutator rest the stationary brushes F F.

In order to understand how the armature-windings on the ring A are connected to the armature-windings on the ring B and how these connected armature-windings are connected to the plates of the commutator C, we have to refer to Fig. 4, which shows what is in effect a projection of these windings and their connections to the commutator-plates on a plane perpendicular to the axis O. In reading this drawing it must be remembered that the armature-windings on the rings A are represented by rectangles s, covered with simple hachures and that the armature-windings on the rings B are represented by rectangles r covered with crossed hachures. It must also be remembered that in order to avoid confusion, which would be caused by showing a rectangle r superimposed on a rectangle s, we have supposed these rectangles slightly displaced with reference to each other. This being stated it will be seen at once that each section s wound on the ring A is connected in parallel with a corresponding section r wound on the ring B and that these connected sections are connected to the plates of the commutator C just as though we were winding an ordinary continuous-current machine. It will also be seen that instead of connecting a section r—that is, a coil on the ring B—with a section s—that is, a coil on the ring A, which is on the same side of the axis of symmetry X Y—we connect the coil of the ring A, which is one side of the axis of symmetry, with a coil on the opposite side of the axis of symmetry, which makes an equal angle therewith. Thus, for instance, if we take a section s in Fig. 4, which is on the right of the plane of symmetry X Y and which makes an angle of thirty degrees therewith, we see that it is connected with a rectangle r, which is on the left of the axis of symmetry X Y and which makes an angle of thirty degrees therewith. The diagram of Fig. 4 shows us how these connections may be made without having to cross the conductors, which serve to establish the connections at any point. Such connections may, therefore, be made as readily as those of an ordinary continuous-current machine. Let us now suppose that we throw an alternating current of frequency a into the circuit of the inductor D, so as to create a field of force within the inductor D, rotating clockwise at a velocity a. Let us furthermore suppose that the axis on which the armature is mounted is turned clockwise with a velocity of $\frac{a}{2}$. Let us for convenience designate the rotary field within the inductor D as Φ. The field Φ will develop electromotive forces of frequency $\frac{a}{2}$ and present successive differences of phase in different sections of the armature-windings of the ring A. At each instant there will be a constant difference of potential developed between the armature-sections of the ring A, situated at the extremities of a diameter $x\ y$, (see Fig. 5,) which turns clockwise around the axis O with a velocity a, (since the field turns with a velocity a,) and in consequence turns clockwise with a velocity $\frac{a}{2}$ with respect to the plane of symmetry X Y, which is fixed within the armature and turns with it clockwise with a velocity of $\frac{a}{2}$. Now as the sections of the armature-winding on the ring B are connected with the sections of the armature-winding on the ring A, but corresponding windings are symmetric on the opposite sides of the plane of symmetry, it follows that the sections between which the same constant difference of potential is developed in the armature-windings of the ring B will be situated, at each instant, upon the extremities of a diameter $x'\ y'$, which is displaced counter-clockwise within the ring B, and at a velocity of $\frac{a}{2}$ with respect to the plane of symmetry X Y. The plane of symmetry X Y is fixed within the armature and moves clockwise with it with a velocity of $\frac{a}{2}$ in space. It follows, therefore, that the diameter $x'\ y'$ will be fixed in space. This means that the armature-windings of the ring B, between which the same constant difference of potential is developed, will be situated at each instant upon the opposite extremities of a stationary diameter. Since the armature-windings of the ring B are connected to the commutator-sections C, it follows that two stationary brushes situated at the opposite extremities of a stationary diameter will act to take off a continuous current.

We have supposed in the above description that the armature is rotated clockwise with a velocity of $\frac{a}{2}$. Such rotation we may immediately obtain by reason of the presence of the inductor I, corresponding, as it does, to the inductor of a continuous-current machine and creating a field of force fixed in space. We have seen, in fact, if the armature is rotated with a velocity of $\frac{a}{2}$ that then the field of force created by the currents due to the electromotive forces in the armature-windings of the ring B will be fixed in space. If now we act upon this stationary field of force in the armature-windings of the ring B by another stationary field of force making a given angle therewith, generated, for instance, by the inductor I, it will be apparent that the armature will be rotated at the velocity desired.

We have assumed in the above description that the alternating current which is fed to the inductor D produces a rotary field of force within such inductor. In case the alternating current is polyphase and the windings of the inductor are arranged for polyphase currents this result will be immediately brought about, as is well understood; but if the alternating current with which we start and which is fed to the inductor D is monophase something more is needed in order to produce what is in effect a single rotating field of force. To this end we use a series of copper bolts $b\ b$, which traverse the polar extremities of the inductor E in a region very near the air-space. Their extremities are connected by two conducting-circles G, situated one on each side of the inductor E. If now we impose a monophase alternating current of frequency a onto the circuit of the inductor D, it will be understood from what we have described in our previous patent, No. 545,693, of September 3, 1895, and in our Patent No. 613,203, of October 25, 1898, that the alternating current may be considered as developing two constant rotary fields Φ' and Φ^2, which will turn about the axis O, each with a velocity a, but that the field Φ' will turn, say, clockwise and that the other field Φ^2 will turn counter-clockwise. The action of the field Φ' has already been described. It now remains to destroy the action of the field Φ^2; but as the field Φ^2 is assumed to move counter-clockwise with a velocity of a and as the ring A moves clockwise with a velocity of a it will be seen that the field Φ^2 moves counter-clockwise with reference to the plane of symmetry and with a velocity of $\frac{3a}{2}$. The electromotive forces which it will tend to generate within the armature-windings of the ring B will therefore move clockwise with a velocity of $\frac{3a}{2}$ with respect to the axis of symmetry X Y, and therefore with a velocity of $2a$ in space; but as the ring B turns within a magnetic screen composed of the copper bolts b and connecting circles G, as we have shown, it may not, as will be evident to one who has read the prior patents referred to, be the seat of a flux which is variable in space. The flux Φ^2 will therefore be practically suppressed and non-existing. In other words, by means of the magnetic screen b G we may use a monophase alternating current in the inductor D to create what is in effect a single rotary field of force, just as if such single rotary field of force were produced by the action of a polyphase current in the inductor D. By this it must not be understood that the magnetic screen or squirrel-cage is dispensed with when a polyphase current is employed. While its use is not so vital with polyphase as with monophase currents, it is yet of great value by insuring the stability of synchronism. So, too, we may reduce the flux Φ^2 by making it jump a large air-space instead of employing a magnetic screen. We much prefer, however, to employ the magnetic screen, especially as it assists in maintaining synchronism.

In case we use a monophase current in the inductor D it will be necessary to adopt some special means for starting the apparatus from rest. It is evident that one may start it as an asynchronous motor. In this case it would be necessary to provide the inductor D with an auxiliary circuit, as is a matter of common practice. So, too, one may initially feed the constant-current field I with continuous currents taken from a battery of accumulators.

While we have referred to the two associated motors as "bipolar" in the above description, it will be evident that they may be made of any polarity whatever. So, too, although the windings have been described as of the gramme type it is clear that they may be of any type whatever. Again, as before pointed out, the windings of the inductor D may be such as to make it suitable for high-tension currents. This inductor will then be in effect the primary circuit of a transformer for transforming high-tension alternating currents into low-tension continuous currents. We repeat, also, that the apparatus shown and described by us may also be used to transform continuous currents into alternating currents, whether monophase or polyphase. To this end continuous currents are fed into the brushes F F and alternating currents are taken from the inductor D. These ideas being exactly equivalent our claims are to be read as covering either the transformation from alternating to continuous and from continuous to alternating currents. Again, it will be seen that the members of the two groups of conductors on the armature are connected, so that a member of one group is electrically connected with that member of the other group which is symmetrical to it with respect to a plane of symmetry, but on the opposite side thereof. Such winding may be called an "image-winding." So, too, it appears that the rotating field in one portion of the armature rotates in one direction and the rotary field created thereby in the other portion of the armature rotates in the opposite direction, as an image of the first field, with respect to a rotary plane of symmetry.

What we claim is—

1. A rotary transformer comprising an armature having two groups of conductors each in sections, a commutator having a number of plates corresponding to the number of sections, the respective sections of the conductors being electrically connected to each other on the opposite sides of a plane of symmetry and to the corresponding plates of the commutator, an alternating-current inductor acting on one of the two groups of conductors, and means for driving the armature at half the speed of synchronism, whereby there are generated such electromotive forces in the sections of the other group of armature-conductors as present a constant difference of potential between sections at the extremities of a diameter fixed in space, substantially as described.

2. A rotary transformer comprising an armature carrying two groups of conductors, each divided into a number of sections corresponding to the number of commutator-plates, the respective sections of the conductors on the opposite sides of a plane of symmetry being connected to each other and to the corresponding segments of a commutator, an alternating-current inductor for acting on one of the two groups of armature-conductors, means for rotating the armature at half the speed of synchronism and stationary brushes

bearing on the commutator for taking a continuous current therefrom, substantially as described.

3. A rotary transformer comprising an armature carrying two groups of conductors each divided into a number of sections corresponding to the number of commutator-plates, the respective sections of the conductors being symmetrically connected to each other and to the corresponding segments of the commutator, an alternating-current inductor acting on one of the groups of armature-conductors, a continuous-current inductor acting on the other group of armature-conductors and thus rotating the armature at half the speed of synchronism and stationary brushes, bearing on the commutator, for taking a continuous current therefrom, substantially as described.

4. A rotary transformer comprising an armature carrying two groups of conductors each divided into a number of sections corresponding to the number of commutator-plates, the respective symmetrical sections of the conductors being connected to each other and to the corresponding segments of the commutator, an alternating-current inductor acting on one of the groups of armature-conductors, a continuous-current inductor acting on the other group of armature-conductors and thus rotating the armature at half the speed of synchronism, a magnetic screen between the continuous-current inductor and the armature for insuring the stability of synchronism and stationary brushes, bearing on the commutator, for taking a continuous current therefrom, substantially as described.

5. A rotary transformer comprising an armature carrying two groups of conductors, each divided into a number of sections corresponding to the number of commutator-plates, the respective symmetrical sections of the conductors being connected to each other and to the corresponding segments of a commutator, an alternating-current inductor of the monophase type acting on one of the groups of armature-conductors, a continuous-current inductor acting on the other group of armature-conductors, a magnetic screen between the continuous-current inductor and the armature for suppressing any magnetic field which moves in space and thus insuring the rotation of the armature at half the speed of synchronism, and stationary brushes bearing on the commutator for taking a continuous current therefrom, substantially as described.

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

MAURICE HUTIN.
MAURICE LEBLANC.

Witnesses:
EDWARD P. MACLEAN,
ALBERT DELOS.