No. 606,761. Patented July 5, 1898.

M. HUTIN & M. LEBLANC.

METHOD OF AND APPARATUS FOR GENERATING ALTERNATING CURRENTS.

(Application filed Mar. 13, 1894.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1.

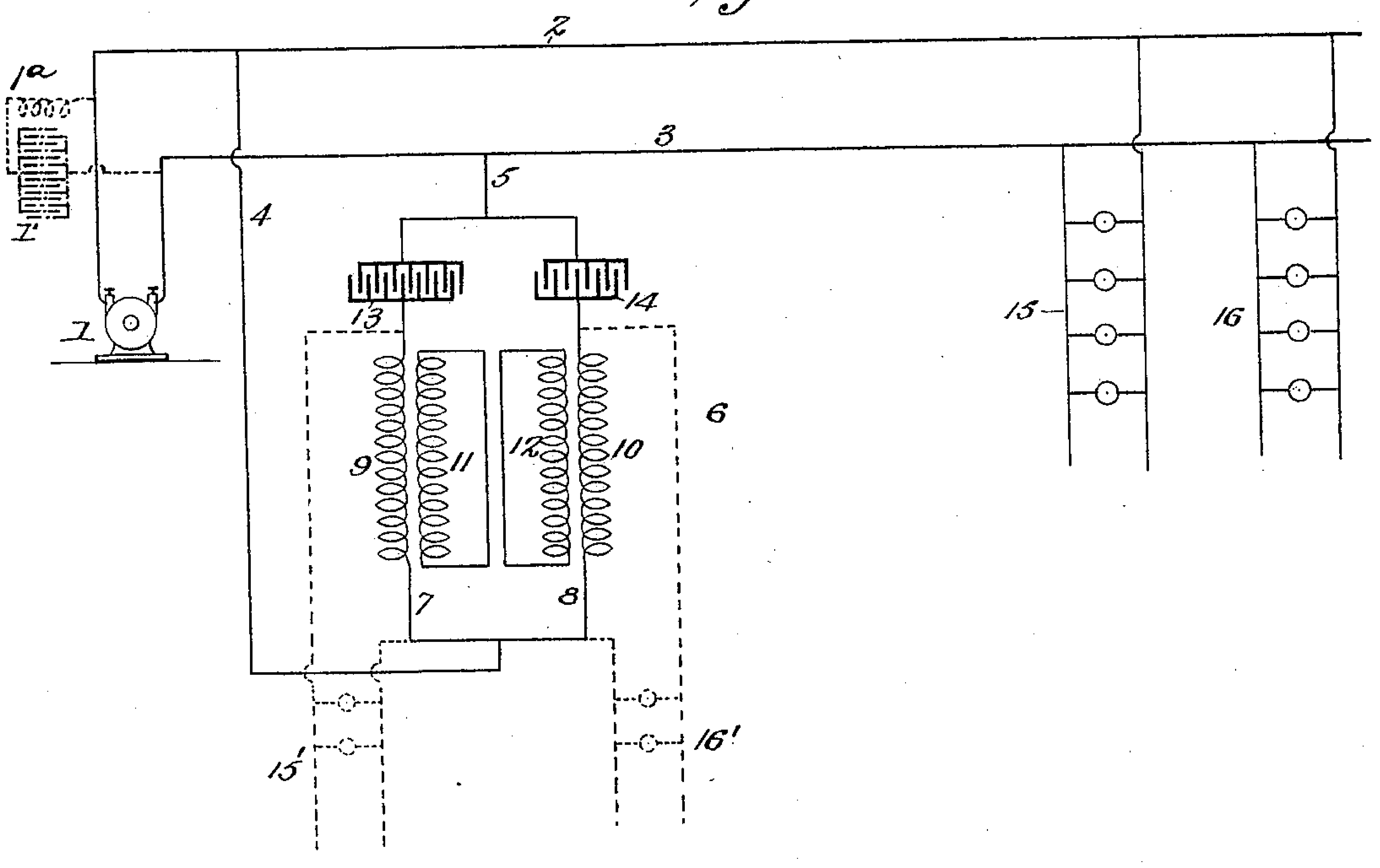


Fig. 3.

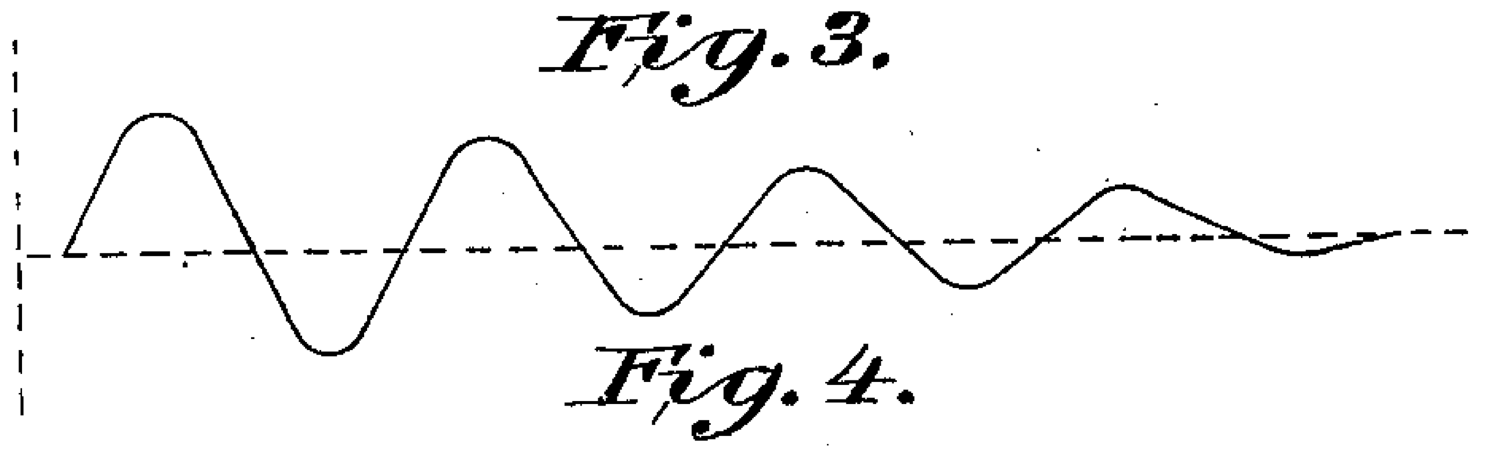


Fig. 4.

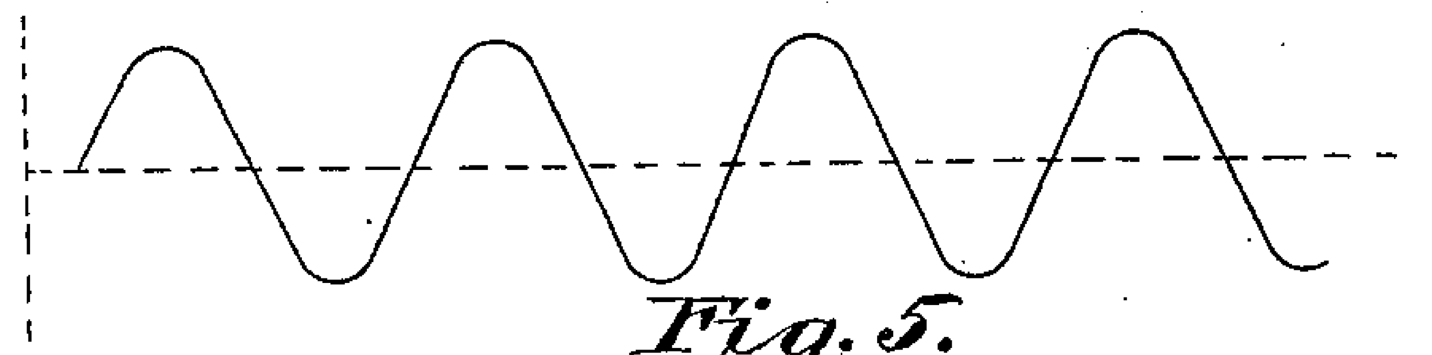
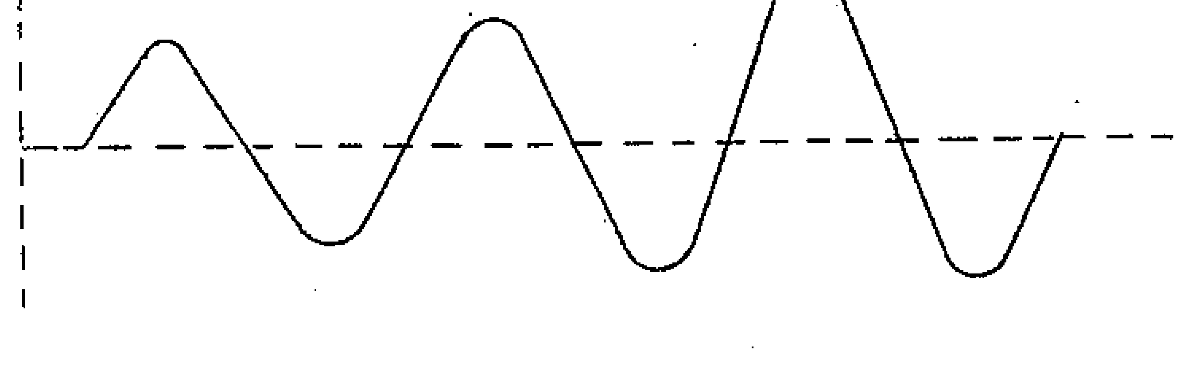


Fig. 5.



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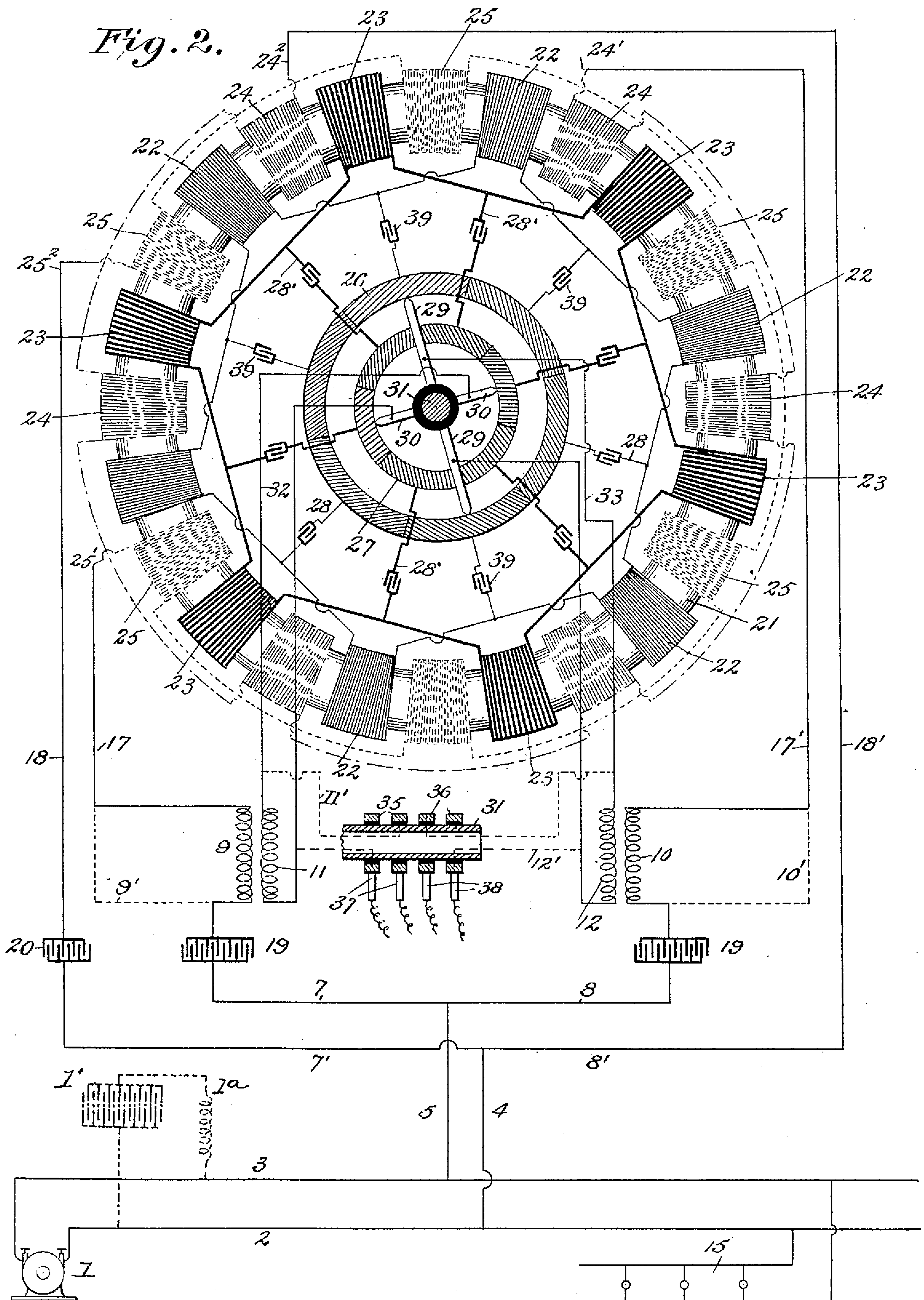
(No Model.) 3 Sheets—Sheet 2.

Fig. 2.



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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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Fig. 6.

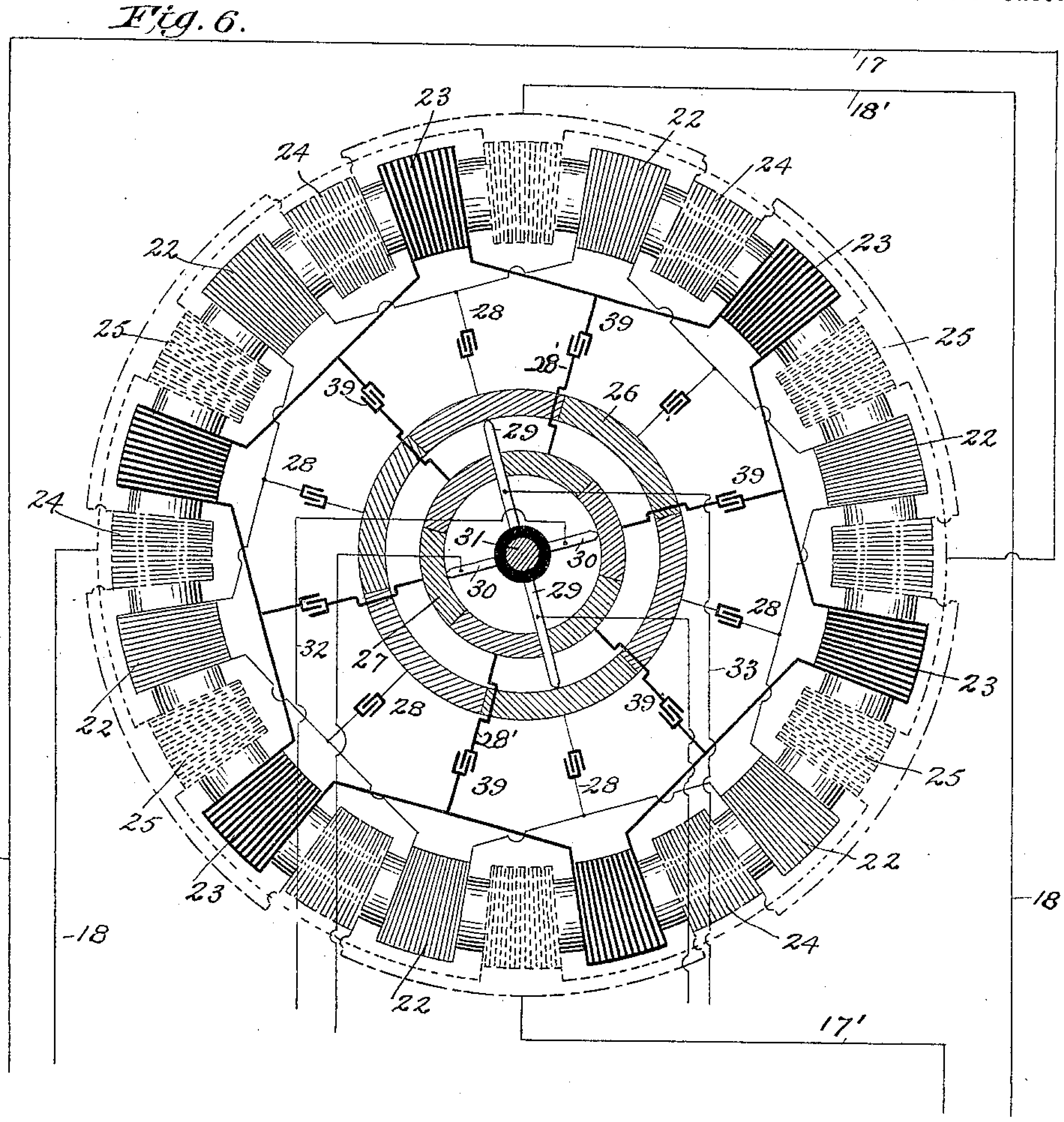
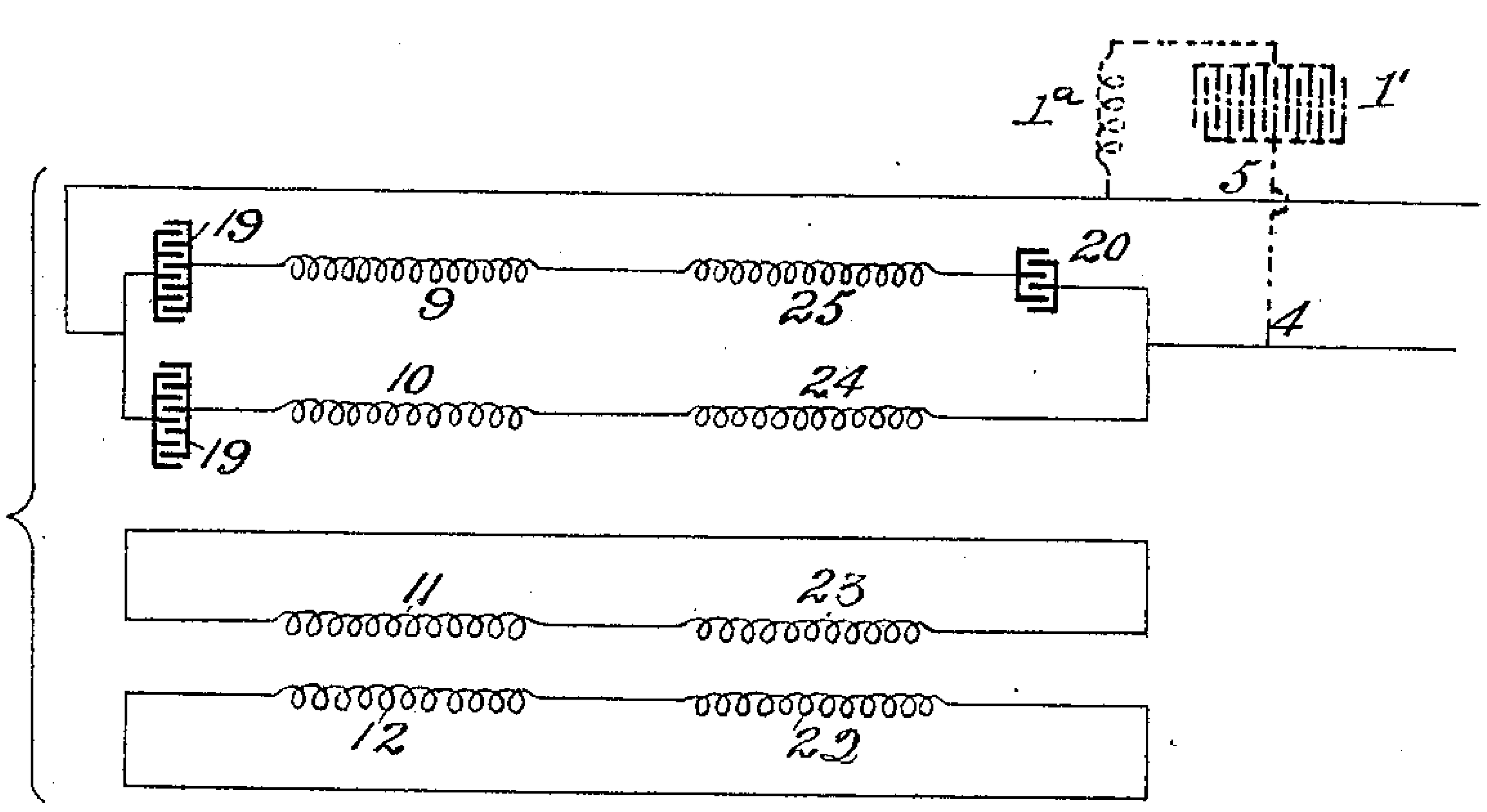


Fig. 7.



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UNITED STATES PATENT OFFICE.

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

METHOD OF AND APPARATUS FOR GENERATING ALTERNATING CURRENTS.

SPECIFICATION forming part of Letters Patent No. 606,761, dated July 5, 1898.

Application filed March 13, 1894. Serial No. 503,524. (No model.) Patented in France October 8, 1891, No. 216,620; in Germany October 30, 1891, No. 72,461, and in Austria October 23, 1892, No. 20,131 and No. 42,071.

To all whom it may concern:

Be it known that we, MAURICE HUTIN and MAURICE LEBLANC, citizens of the Republic of France, residing in Paris, France, have invented certain new and useful Improvements in the Production of Alternating Currents of High Frequency, of which the following is a specification.

This invention is the subject of Letters Patent in France, dated October 8, 1891, No. 216,620; in Austria, dated October 23, 1892, No. 20,131 and No. 42,071, and in Germany, dated October 30, 1891, No. 72,461.

Our invention has reference to improvements in the methods of and apparatus for generating alternating currents, and specifically of alternating currents of high frequency; and the invention comprises also as a part of the system a converter of frequency or of frequency and tension.

It is well known that currents of very high frequency can be generated by means of an apparatus comprising a large number of field-magnet poles and an armature, which is driven with great speed past the field-magnets. With such machines currents of any desired frequency may be generated; but if the frequency is to be very high the intensity of the same will be necessarily very low, since in that case there must be a very great number of field-magnets, so that the size of them must be very small in order that the machine may come within practicable limits and may be driven with the requisite high speed without injury to the structure. It will also be seen that if the number of poles is reduced in order to increase their dimensions the speed of the armature must be correspondingly increased, and when it is required to generate currents of very high frequency the speed required would be too great for the strength of the material that must be used.

It is the object of our invention to generate alternating currents, and specifically alternating currents of high frequency and great volume, by machines driven at speeds that do not exceed the safety limits of their structure and that may fall far below that limit, in consequence whereof our generators may be made of any desired capacity.

Our invention is based upon the utilization of certain properties of alternating-current machines which we have discovered and which will be explained farther on with reference to the accompanying drawings, in which—

Figure 1 is a diagram illustrating the simplest form which our invention may assume; Fig. 2, a diagram illustrating our invention, in connection with a converter of frequency, which may also be a converter of tension and which constitutes a part of our invention; Figs. 3, 4, and 5, diagrams explanatory of the action of a condenser when used as an exciter in our system. Fig. 6 illustrates the transformer of frequency and tension with some of its coils differently connected than those shown in Fig. 2, and Fig. 7 is a diagram illustrating the general disposition of circuits in the apparatus illustrated in Fig. 2.

Like numerals of reference indicate like parts.

We have heretofore constructed alternating-current machines with two or more sets of field-coils, each set energized by currents of the same period, but with shifted phases, so as to produce a rotary field and with an armature having a like number of sets of coils, each set of armature-coils being closed upon itself. Now we have found that when the armature of such machine is rotated in the direction of the rotation of the field, but with a speed exceeding that of the field, it reacts upon the field-coils to produce in the same currents of the same period and with the same difference of phase as has primarily been sent through these coils and whereby the exciting-currents are reinforced. They are reinforced in volume and they are reinforced in proportion as the speed of the armature above that of the field increases. Under these circumstances, therefore, the armature reacts upon the field-magnet coils to greatly reduce the effective resistance of the same. In fact, these field-coils behave as if their effective resistance had become negative, while of course the ohmic resistance is unchanged.

This property of alternating-current machines we utilize in the generation of alternating currents of moderately high frequency and great volume by the arrangement illustrated in Fig. 1. In this figure of drawings, 1 represents a small generator of alternating currents of the desired frequency, but of small volume. Such currents can be easily generated in a small magneto-machine having the requisite number of small field and generating coils, the armature being driven at the required speed without danger to the structure. Other means for generating the alternating currents of the desired frequency and small volume may be employed and some of them will be referred to later on. The currents thus obtained may for the purposes of our invention be faint, since they are only used to determine the frequency of the currents to be obtained from the system. The generator 1, therefore, has the function of an exciter only. This generator 1 is connected with the line 2 3, and from this line are derived the branch conductors 4 5, connected with the generator proper, 6. This latter contains in the multiple-arc branches 7 8 the series of field-coils 9 and 10, respectively, and it has two independent armature-circuits 11 12. In the branch 7 is a condenser 13 and in the branch 8 a condenser 14 of less capacity, so that the two sets of field-coils will be charged with currents having a difference of phase of one-quarter of a wave.

It will be understood from what has been said that the currents passing through the field-coils from the generator 1 will be weak. They may be as weak as desired, since the object of the generator 1 is not to charge the line with current that may be used for consumption, but merely to give an initial charge to the two sets of field-coils of the generator 6 which is to produce the working current for the line. The two independent armature-circuits of this generator are closed upon themselves in this particular instance. In a system thus constituted when the armature is rotated with a speed exceeding that of synchronism it reacts upon the field-magnets to augment or reinforce the current in the same, and it reinforces these currents in proportion as the speed of the armature surpasses that of the field produced by the two dephased currents, as hereinbefore stated. Neither the periods nor the difference of potentials of the currents in the fields is thereby affected, but the volume of the current is very greatly increased, and the line 2 3 is thus charged with current of any desired strength. This line may now be tapped and the current from it utilized by the multiple-arc branches 15 16 for the operation of electric motors, electric lights, or any other translating devices. In addition thereto it is also practicable to tap each of the field branches 7 8 separately, as is indicated by dottted lines at 15′ 16′. The currents in these working circuits 15′ 16′ will be dephased with reference to each other, but will have the same period as the exciting-currents coming from the small generator or exciter 1, while the currents in the working circuits 15 16 are single-phase currents corresponding to those from the exciter.

In order to obtain the augmentation of the exciting-current on the line, it is necessary to rotate the armature at a speed that is higher than that of the field, and this is practicable only when the frequency of the exciting-current is not too great, and the practical limit is found at a frequency of about one thousand per second. When higher frequency is required, the arrangement shown in Fig. 1 becomes impracticable, mainly because the armature cannot be driven with the required higher speed without straining the armature beyond the limits of safety, also because the hysteresis of the iron cores in a machine of the kind designated by the reference-numeral 6 would involve great loss of energy. For this reason when currents of higher frequency than one thousand are required we modify our ordinary machine by substituting for the iron field and armature cores cores or supports of non-magnetic and preferably insulating material. With this modification, therefore, there is no needless absorption of energy due to hysteresis, which absorption, as is well known, increases with the frequency of the current. It is, however, impracticable to rotate the armature of the machine with that high speed which would be required if the exciter furnished currents of a frequency anywhere above one thousand and up to two thousand, three thousand, or more, and we therefore, when currents of such high frequency and of great volume are required, modify the process described with reference to Fig. 1, as will presently appear. The general plan of the procedure is based upon the following considerations: Currents of any desired frequency can be obtained from a small magneto-electric machine and by other means, to which we will hereinafter refer, if these currents are to be very faint, so faint, indeed, as to represent practically no energy. Now when these currents are used in a machine of the kind represented at 6 in Fig. 1 or in such a machine containing no iron cores to excite the field-coils, and thus produce a rotary field, and if then the armature is supposed to be held fixed, then the currents generated in the two sets of armature-coils will have the same frequency as those of the exciter and the same shift of phase as in the field-coils. If now the armature is rotated in a direction opposite to that of the rotating field with a speed Ω, then if by $\frac{1}{T}$ we designate the frequency of the current furnished by the exciter, which is the same as the speed of rotation of the field, then the frequency of the currents induced in the armature-coils will be $\frac{1}{T}+\Omega$. In this case, however, the armature does not react upon the field-coils to augment the currents in the same, and our mode of operation is therefore modified in the following particular: The currents of higher frequency obtained in the armature-coils we convert into currents of the same frequency as those furnished by the exciter by means of an apparatus which we have called "transformer of frequency," and these transformed currents are returned to the field-coils and thus augment the original currents in the same and on the line. This process we will now describe with reference to Fig. 2. In this figure of drawings the exciter 1 is represented as charging the line 2 3, from which the branches 4 5 are carried to the generator proper. This generator consists of two sets of field-coils 9 10 and two sets of armature-coils 11 12, the same as represented in Fig. 1. The branch conductor 5 connects on one side with the conductor 7, which leads to the field-coils 9, the other terminal of which is connected by conductors 17 with one set of windings of the converter of frequency, which will be presently described, and from said converter of frequency the circuit is completed by the return-conductors 18 7′ to the branch conductor 4. On the other side the branch conductor 5 connects with the conductor 8, which leads to the field-coils 10, the other terminal of which is connected by conductors 17′ with another set of windings of the converter of frequency, which circuit is completed by the return-conductors 18′ 8′ to the branch conductor 4.

In each of the field-coil circuits is inserted a condenser 19, both having the same capacity, and in addition thereto in one of the field-coil circuits—in this case in the circuit of the field-coils 9—there is a condenser 20 of such capacity as to dephase the currents in the two branches by one-quarter of a wave. As thus far described, the generator represented in Fig. 2 is identical with the generator 6 delineated in Fig. 1, except that the field and armature cores are understood to be of insulating material, whereby the frequency of the currents to be furnished by the machine may be as high as desired.

The converter of frequency is represented in Fig. 2 as follows: There is a ring-core 21 of insulating material, and upon the same are placed four series of coils, which in the drawings are distinguished from each other by different shadings and by different thicknesses of the lines; but it must be understood that this mode of distinguishing the sets of coils from each other is not intended to convey an idea of the relative thicknesses of the wires used for these coils. The four sets of coils are marked 22 23 24 25, respectively. The set of coils 22 is wound and connected upon the core like the coils of a Gramme ring—that is to say, the successive coils of this set are connected in a closed series. The set of coils 23 is arranged in precisely the same manner. The set of coils 24 has also its successive coils connected in series; but the series is not closed upon itself, but terminates at $24'$ 24^2, and these terminals are connected with the conductors 17′ 18′, respectively, of the branch 8 8′, which includes the set of field-coils 10 of the generator. The fourth set of coils 25 is wound in the same manner as the set of coils 24, and its terminals $25'$ 25^2 are connected with the conductors 17 18 of the branch 7 7′, which includes the field-coils 9 of the generator.

It will now be seen that the faint exciting-currents of high frequency derived from the line by the branch conductors 5 4 will divide in two branches, one branch passing by conductor 7, condenser 19, field-coils 9, conductors 17 to and through the series of converter-coils 25, and from the same by conductor 18, condenser 20, and conductor 7′ to the branch conductor 4, while the other branch will pass by conductor 8, condenser 19, field-coils 10, conductor 17′ to and through the series of converter-coils 24, and by conductors 18′ 8′ to the branch conductor 4. It will also be seen that since the currents in the two branches will be dephased with reference to each other a quarter of a wave they will in their passage through the coils 9 10 cause a rotation of the polar line or lines of the field. If there is only a single polar line, the speed of the rotation of the field will be equal to the frequency of the exciter-currents. This frequency we designate by $\frac{1}{T}$. If under these conditions the armature 11 12 stands still, the currents generated in its two coils will have the same phases and the same frequency as those in the field-coils; but if the armature 11 12 is rotated with the speed Ω in a direction opposite to that of the field the frequency of the currents induced in its coils will be $\frac{1}{T}+\Omega$.

The two closed series of coils 22 23 in the converter of frequency are connected each with a commutator 26 27, respectively, precisely in the manner of a Gramme ring, by the radial conductors 28 28′, and upon these commutators bear the rotating pairs of brushes 29 29 and 30 30, all fixed upon a common shaft 31 and insulated from the same and from each other. In the drawings the commutators are shown, for the sake of simplicity of illustration, as two concentric segmental rings, one larger than the other. In practice a different arrangement may be and is ordinarily used. The terminals of the armature-circuit 11 are connected to the pair of brushes 30 30 by conductors 32, and the terminals of the armature-circuit 12 are connected to the pair of brushes 29 29 by conductors 33. The pairs of brushes are disposed at right angles to each other, and the coils of the two sets 22 23 are alternated by the coils of the two sets 24 25, as shown, and there is an even number of coils in each set. Supposing now that while the armature is rotating with the speed Ω in opposition to the direction of the rotation of the field of the generator, so that the frequency of the currents in the armature-coils will be $\frac{1}{T}+\Omega$, as hereinbefore assumed, and that under these circumstances the brushes 29 30 are held in a fixed position—say in the position shown in the drawings—it is clear that currents of frequency $\frac{1}{T}+\Omega$, having in the coils 22 23 a difference of phase of one-quarter of a wave, will produce on the converter-ring a rotation of the polar lines with the same speed $\frac{1}{T}+\Omega$, and that, therefore, in the circuits 24 25 there will be induced two sets of currents of the same frequency, but dephased with reference to each other. If, however, the brushes 29 30 are rotated in opposition to the direction of rotation of the polar lines on the converter-ring the original speed of rotation of these lines will be reduced by the speed of the brushes, and if the speed of the brushes is Ω—that is to say, equal to that of the armature 11 12—then the frequency of rotation of the polar lines and the frequency of the currents in the coils 24 25 will be $\frac{1}{T}+\Omega-\Omega=\frac{1}{T}$—that is to say, the currents in the coils 24 25 will have the same frequency as those furnished by the small exciter 1 to the line 2 3 and to the field-coils 9 10, and they will be dephased precisely as in these latter. They will therefore reinforce the original currents in the field-coils and finally in the line, which may be tapped by working circuits in any suitable manner and for any suitable translating devices. One such working circuit 15 is indicated in the drawings. In order to secure this result, it is necessary to rotate the brushes 29 30 of the converter with the speed Ω—that is to say, with the speed of the armature 11 12—and this is done by fixing the brushes on the shaft of the armature. The shaft 31, therefore, is understood to be the armature-shaft, and the conductors 32 33 may be passed through this shaft, if it is made hollow, or along the surface of the shaft, if it is made solid.

The generator here described, whether of the simple form illustrated in Fig. 1 or combined with the converter of frequency described with reference to Fig. 2, is a true dynamo-electric machine, which, starting with a faint initial charge, will build up its own field of force.

When used in connection with our method of generation, the coils of the converter of frequency will either all have the same number of turns, in which case the currents which reinforce the original currents in the field-coils and in the line will have the same tension as those furnished by the exciter, which, therefore, will not short-circuit the line, or the coils 24 25 will be made with a smaller number of turns of preferably heavier wire, in which case the line-currents will have lower tension than those furnished by the exciter. Our converter of frequency may, therefore, also be a converter of tension.

The converter of frequency or of frequency and tension, while it constitutes an essential element of our system of generation of working currents of very high frequency, may be used independently of said system for converting currents of any period and tension into currents of any other period and tension. Thus, for instance, if from the system shown in Fig. 2 the exciter 1 and the generator proper be removed and the circuits to the brushes 29 30 and to the coils 24 25 completed by the wires 11′ 12′ and 9′ 10′, respectively, as indicated in dotted lines, then two alternating currents of the same period, but with the required difference of phase, may be conveyed to the brushes 29 30 and to the coils 22 23 from any source or sources and the line will receive a monophase current of the same period and of any desired tension. The two alternating currents to be converted would then conveniently arrive at two pairs of stationary brushes 37 38, bearing upon collector-rings 35 36, mounted upon the shaft 31, to which the brushes 29 30 are fixed, (which shaft is here shown hollow,) and these collector-rings will then be connected with the brushes 29 30, as indicated.

The shaft 31 may be rotated by any suitable means at the desired speed and in the required direction. If this shaft is rotated in a direction opposite to that of the rotation of the polar lines of the converter, the converted currents will be of lesser frequency, and if it is rotated in the same direction the converted currents will have a higher frequency.

Instead of uniting the converted currents upon the line to produce monophase currents the conductors 17 18 and 17′ 18′ may be tapped separately, in which case the result will be two currents of any desired period with shifted phase.

If only a single pair of brushes 37 or 38 be used to convey a monophase alternating-current to the converter, the result will be a monophase current of changed period, which may be derived either from the conductors 17 18 or 17′ 18′. For such work the converter will have only a single set of coils 22 or 23, a single set of coils 24 or 25, and a single pair of brushes 29 or 30.

The converter may also be used in a reversed manner—that is to say, the currents to be converted may be on the line—in which case the generator 1 would be not a mere exciter, but furnish currents of useful volume. The result would then be two dephased currents derived from the brushes 37 38, or a monophase current from either pair of them.

In the operation of this converter of frequency at the moments when either of the brushes 29 30 bridge two consecutive segments of a commutator one of the coils of the series 22 or 23 would be short-circuited and a considerable amount of energy needlessly consumed thereby if the circuits of these coils were continuous. To obviate this difficulty, the metallic continuity of these circuits must be interrupted by means which permit the passage of alternating currents—namely, by condensers of suitable capacity—and we insert such condensers at the proper places—as, for instance, in the connections 28 28′ between the coils and commutators. These condensers are marked 39.

The converter of frequency is evidently adapted for the simultaneous conversion of any number of alternating currents which are dephased with reference to each other. The number of sets of primary and secondary circuits will be adapted to the number of dephased currents, and the commutator will have as many rings with corresponding sets of brushes as there are circuits of each kind. When the converter is used in connection with the generator of high frequency, the coils 22 23 are the primary or inducing circuits and the coils 24 25 the secondary or induced circuits; but when the converter of frequency is used independently of our generator either of these circuits may be used as the primary or as the secondary member, as will now be readily understood.

While the system represented in Fig. 2 is particularly useful for the generation and conversion of currents of very high frequency, it may with equal advantage be used for alternating currents of moderate frequency. If so used, both the generator and the converter may have magnetic cores, and, in fact, such cores will then be of advantage.

The system described in detail with reference to Fig. 2 is delineated in Fig. 7 by a diagram which shows the principal circuit connections developed in a skeleton fashion and which facilitates the tracing of these circuits. This figure of drawing requires no particular description, since its parts corresponding to the parts described with reference to Fig. 2, are marked with the same numerals.

In place of a small magneto-electric machine 1 there may be used as an exciter an induction-coil the charged primary circuit of which is interrupted as many times as required by a circuit-breaking wheel (Masson's wheel) or in any other well-known manner. We prefer, however, to use a condenser 1′ as an exciter, as indicated in dotted lines in Figs. 1, 2, and 7.

If a charged condenser is allowed to discharge into a circuit having self-induction supplied in any manner—as, for instance, by coil 1^a—the discharge is generally alternating. Its frequency is always high and may be made as high as desired, since it depends only on the relations of resistance, self-induction, and static capacity of the circuit. The amplitude of the successive oscillations, however, rapidly decreases by reason of the consumption of energy due to the resistance of the system. This is graphically represented in Fig. 3, which requires no further explanation. If the resistance of the circuit were null, the amplitude of oscillation of discharge of the condenser would continue constant, as indicated in Fig. 4, and if a circuit having a negative resistance could be obtained the amplitude of the oscillations would constantly increase, as indicated in Fig. 5.

Now it has hereinbefore been pointed out that if the armature of our generator is rotated in the direction of rotation of the field, but with greater speed than the latter, the field-circuit behaves as if it had a negative resistance, and it would therefore seem that the combination of such machine with a condenser serving as an exciter would tend to continuously increase the current beyond all limits. There is, in fact, such tendency; but it is or may be neutralized in a variety of ways. In the machine which is used when currents of moderately high frequency are required there are iron cores, and these act automatically to limit the tendency of continued increase of currents. The reason for this is that the magnetic permeability of iron diminishes as the intensity of the inducing-current increases, and this operates to decrease the negative resistance of the field-circuits as the current increases, and thus establishes a permanent equilibrium.

In the case of the machine for currents of very high frequency which contains no iron we employ electrolytic condensers, the capacity of these becoming greater in proportion as the intensity of the currents traversing them is augmented. If it is preferred to use an ordinary condenser, the same must be provided with lightning-arresters, which will partially discharge the condensers whenever the difference of potential between their armatures exceeds a certain limit.

The converter of frequency or of frequency and tension may be constructed in a variety of ways, and more particularly is it practicable to close each series of its coils upon itself, as shown in Fig. 6. In this case the inducing-coils 22 23 are arranged and connected with commutators, the same as shown in Fig. 2; but the sets of induced coils are each closed upon themselves and are each tapped at diametrically opposite sides. Since all parts corresponding to those in Fig. 2 are here marked with the same numerals, no further description is deemed necessary.

It is evident that instead of using the machines here described as generators they may be used as motors. In that case, however, the machine marked with the numeral 1 will be of suitable size and construction to furnish working currents and not merely exciting-currents. Preferably our generators herein described will be used. The monophase currents thus thrown upon the line will be decomposed in the field-circuits into two currents with a difference of phase. The greater part of electrical energy conveyed to the field-circuits will be transferred by induction to the armature-circuits and then given back to the field-circuits. These motors may be worked in parallel or in series and may receive current from the line either directly or by the invervention of transformers.

It will be understood that we are not limited to any particular details of apparatus herein described nor to any particular forms that may be given to the apparatus as a whole or to its parts. The windings of the armature and field circuits, the cores or frames upon which the windings are placed, and numerous other details may be made in a great variety of ways without departing from our invention.

Having now fully described our invention, we claim—

1. The method of generating alternating electric currents, by causing electrical alternations of the desired frequency, and reinforcing the same to the desired volume, substantially as described.

2. The method of generating alternating electric currents, which consists in producing a rotating field of force, by dephased alternating currents coming from an exterior source, and rotating an armature, having circuits closed upon themselves, in either direction, independently of and with reference to the said field of force, substantially as described.

3. The method of generating alternating currents of high frequency and any desired volume by first causing electrical alternations of the desired frequency and then reinforcing the same to the desired volume, substantially as described.

4. The method of generating alternating currents of high frequency and any desired volume, which consists in producing by initial alternating currents or discharges an initial magnetic field rotating with the desired frequency, and reinforcing the initial charges by and in accordance with the speed of rotation of an armature in said magnetic field, substantially as described.

5. The method of generating currents of high frequency and of any desired volume, which consists in first producing by initial alternating currents or discharges a magnetic field rotating with the desired frequency; inducing thereby currents of higher frequency and greater volume by and in accordance with the rotation of circuits in said magnetic field; reducing the frequency of these currents to that of the initial charges, and superimposing them upon the latter, substantially as described.

6. The method of generating alternating electric currents, which consists in producing a magnetic field or fields by initial alternating currents from an exterior source, and reinforcing said initial currents by the rotation, by external power, of an armature having circuits closed upon themselves, within said magnetic field or fields, substantially as described.

7. A system of generation of alternating currents of any desired frequency and of any desired volume, comprising an exciter defining the frequency of the currents to be obtained and a reinforcing-generator operating in conjunction therewith substantially as described.

8. A system of generation of alternating currents of any desired frequency and of any desired volume, consisting of an exciter furnishing faint currents or charges of the desired frequency and a generator having stationary circuits receiving the exciting-currents and moving circuits in inductive relation to the former and reinforcing the currents in the same, substantially as described.

9. An apparatus for generating alternating electric currents of high frequency and any desired volume which consists of sets of field-coils connected with the line and receiving an initial charge of the desired frequency, an armature in inductive relation to the field-coils rotating to have currents of increased frequency and volume induced therein, and a converter of frequency reducing the frequency of these currents to that of the field-currents and superimposing them upon the latter, substantially as described.

10. A system of generation of alternating currents of any desired volume, comprising an exciter consisting of a condenser for defining the frequency of the currents to be obtained, and a reinforcing-generator operating in conjunction therewith, substantially as described.

11. A generator of alternating electric currents comprising a field magnet or magnets, a condenser for exciting the same, and an armature, substantially as described.

12. A generator of alternating electric currents comprising an armature, rotatable within a rotary magnetic field of force, and a condenser or condensers for exciting such rotary field, substantially as described.

13. The method of exciting a magnetic field of force for an alternating-current dynamo, which consists in passing oscillatory discharges of a condenser through the field-coils of such dynamo, substantially as described.

14. The method of generating alternating electric currents, by causing oscillatory discharges from a condenser and reinforcing the same to the desired volume, substantially as described.

15. The method of generating alternating electric currents by causing oscillatory electrical discharges in an exciting circuit or circuits, and reinforcing the same by the rotation, by external power, of circuits closed up on themselves, within inductive proximity of

the exciting circuit or circuits, substantially as described.

16. A generator of alternating currents provided with an exciting circuit or circuits, and means for maintaining oscillatory electrical discharges in the same, substantially as described.

In witness whereof we have hereunto signed our names in the presence of two subscribing witnesses.

MAURICE HUTIN.
MAURICE LEBLANC.

Witnesses:
JULES ARMENGAUD, Jeune,
CLYDE SHROPSHIRE.