No. 712,614. Patented Nov. 4, 1902.

W. STANLEY & J. F. KELLY.

ELECTRICAL GENERATION AND DISTRIBUTION.

(Application filed June 25, 1902.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 2.

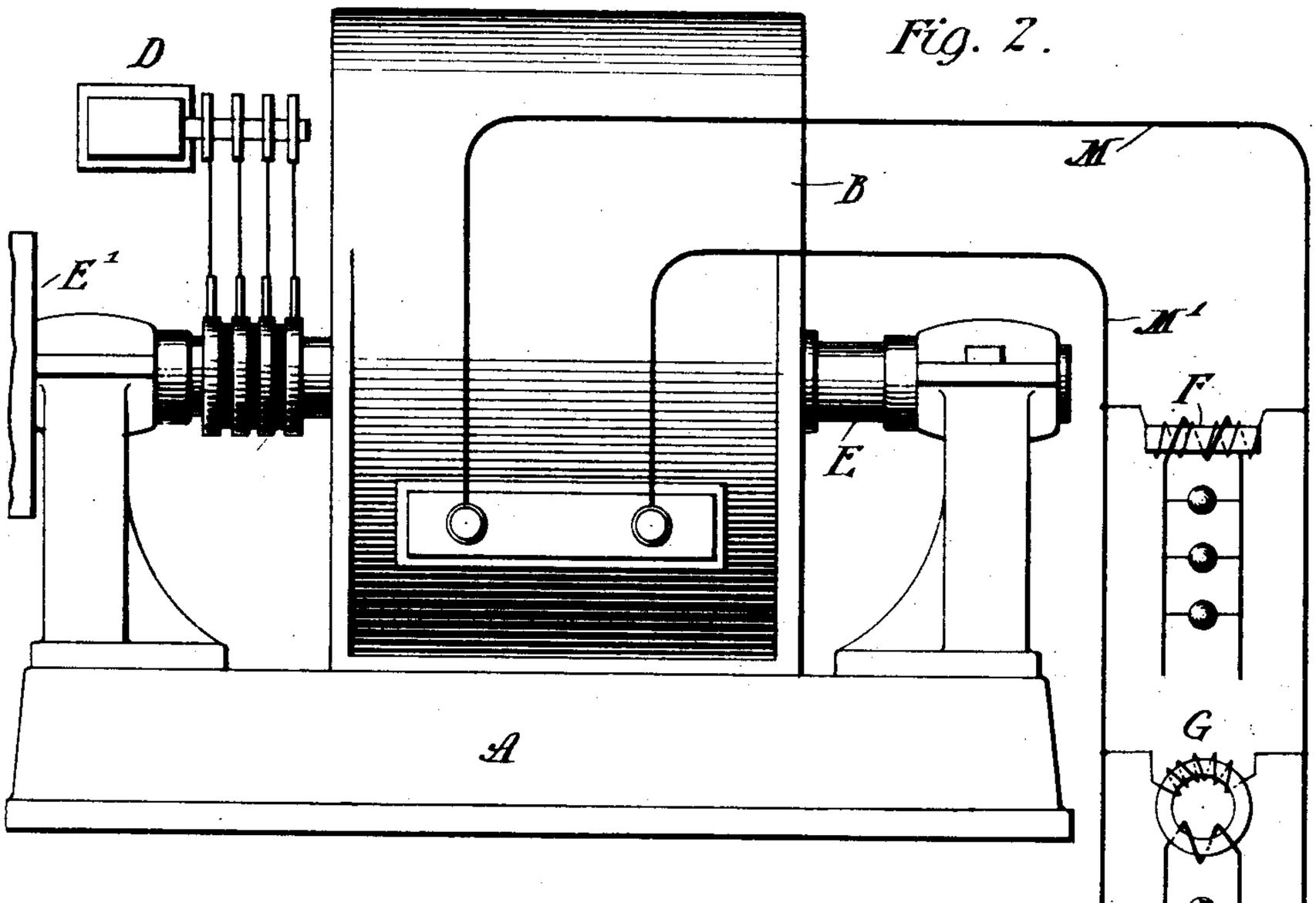

Fig. 1.

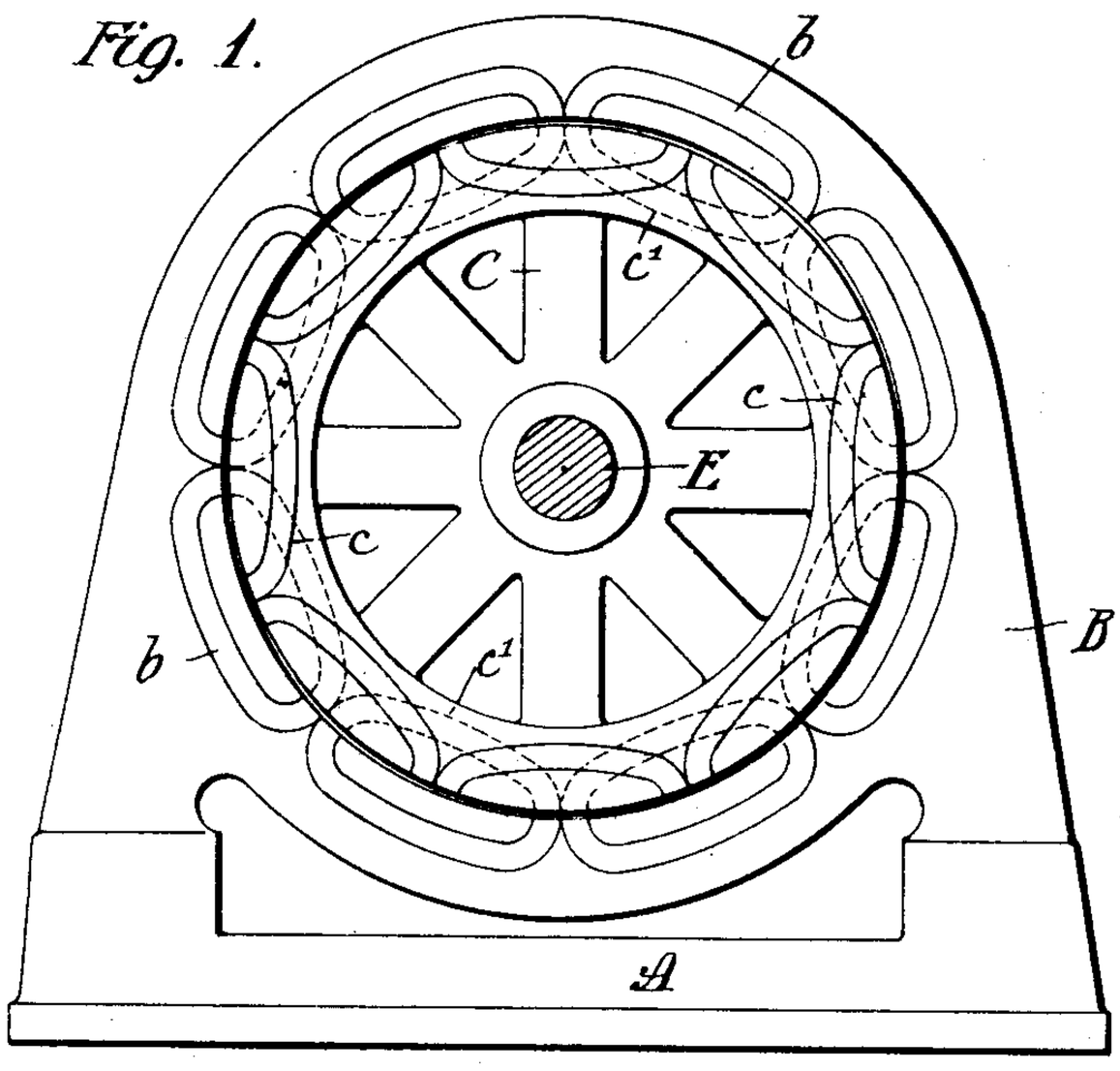

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Fig. 3.

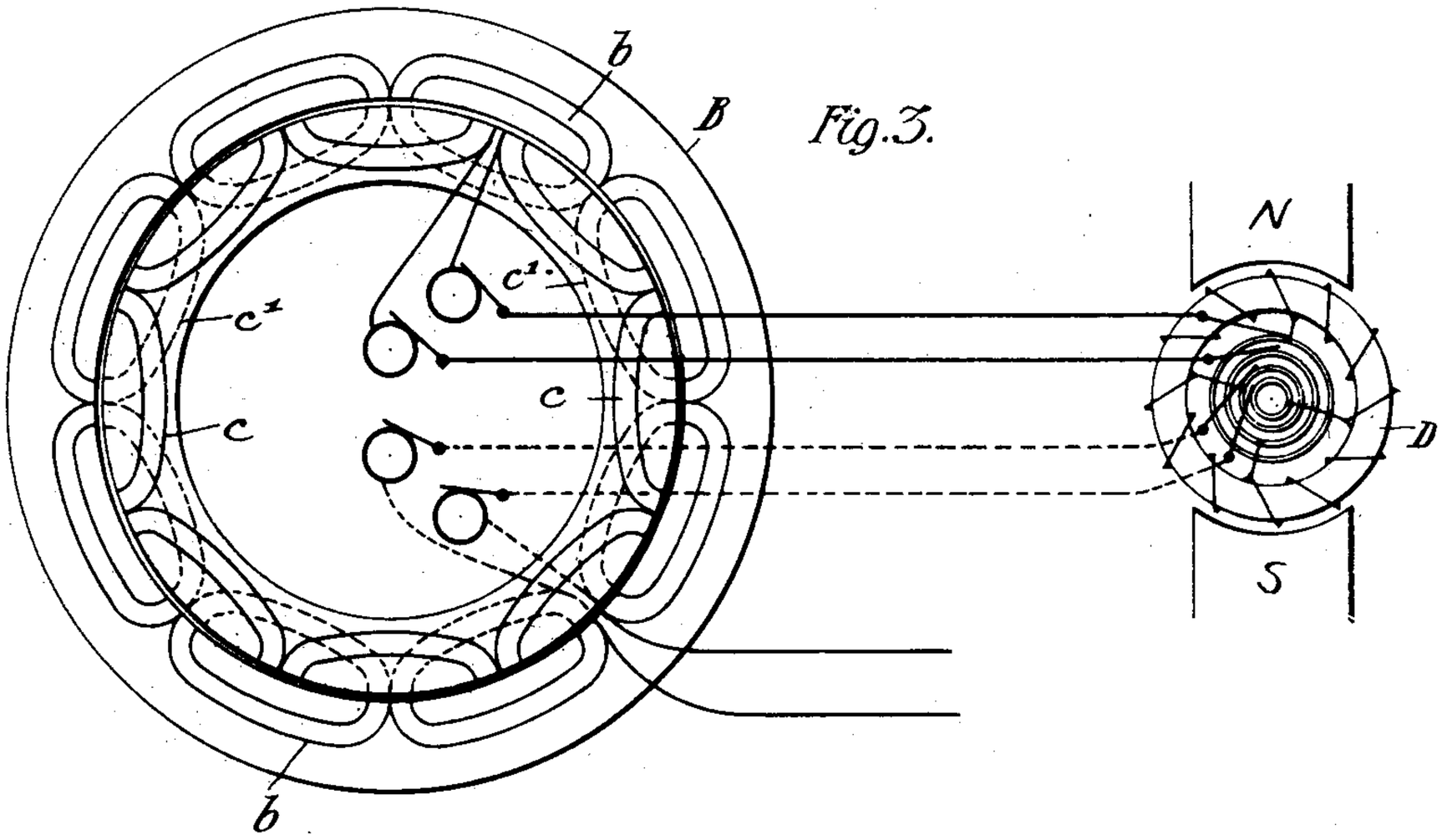

Fig. 4.

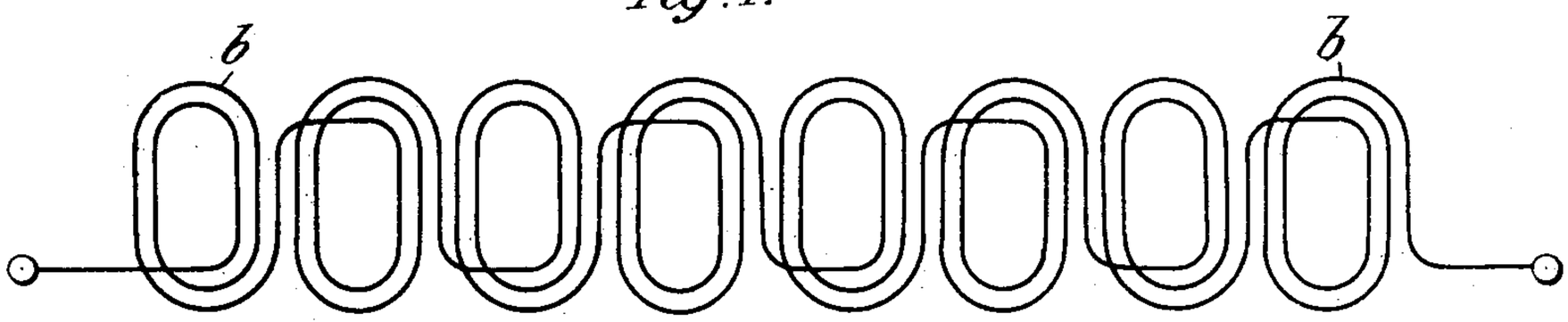

Fig. 5.

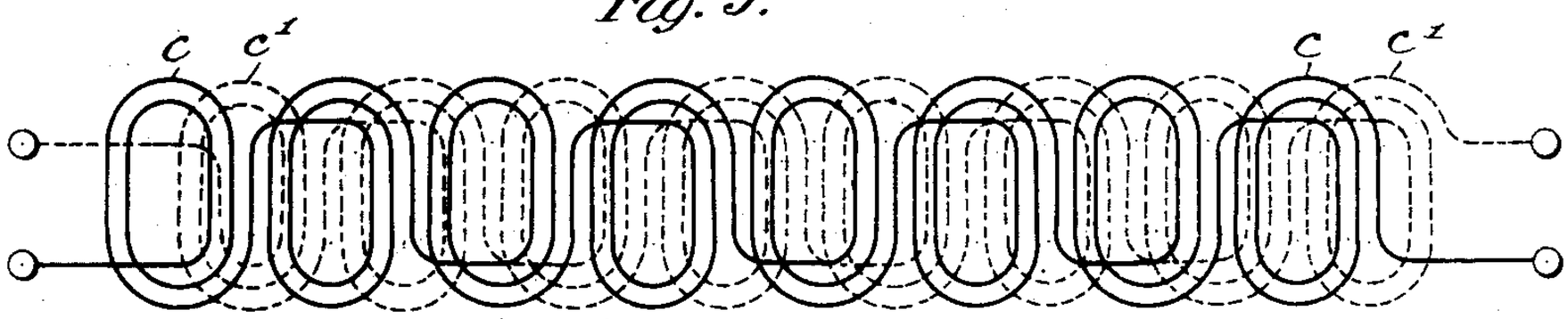

Fig. 6.

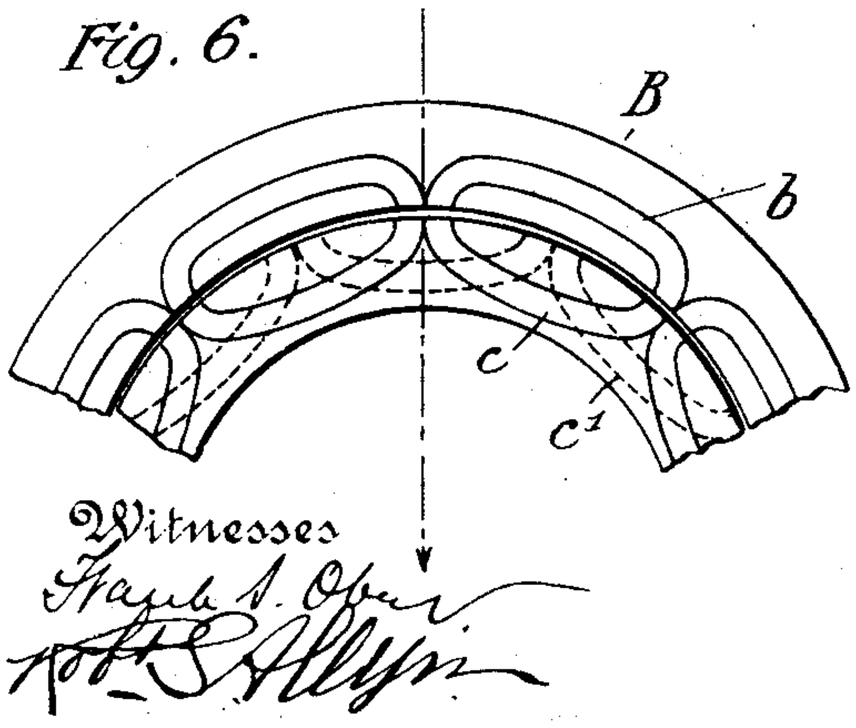

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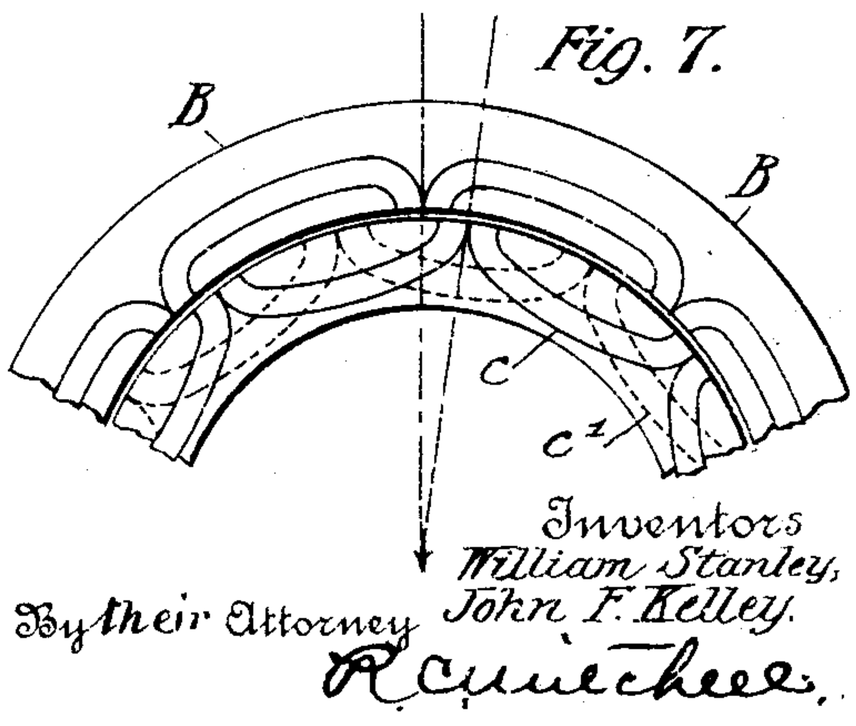
Fig. 7.



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ELECTRICAL GENERATION AND DISTRIBUTION.

SPECIFICATION forming part of Letters Patent No. 712,614, dated November 4, 1902.

Application filed June 25, 1902. Serial No. 113,061. (No model.)

To all whom it may concern:

Be it known that we, WILLIAM STANLEY, residing at Great Barrington, and JOHN F. KELLY, residing at Pittsfield, Massachusetts, citizens of the United States, have invented certain new and useful Improvements in Electrical Generation and Distribution, of which the following is a full, clear, and exact description.

Our invention relates to improvements in the generation of and distribution of electrical energy by alternating currents, and has for its object the production and distribution of currents of that class in such a manner that the pressure is automatically regulated without regard to the nature of the load upon the mains. This is a great advance, since in the present transformer system, in which a constant-potential generator is used for supplying transformers in multiple arc with lamps in multiple on their secondaries, it is necessary that the transformers should not only be made to be used with the potential upon the mains, but they must be adapted to the generator so as to have an insignificant leakage or magnetizing current at no load. It is well known that any closed magnetic-circuit transformer which will not burn up on account of core loss when connected to constant-potential mains will be adapted to the generator, so as to have such insignificant leakage-current, and that if the primary and secondary coils are sandwiched or intermingled, so that the turns are all in the same homogeneous magnetic atmosphere, approximate constancy of potential at the secondary terminals within limits is inherent and that the limit at which the drop in secondary potential exceeds any given amount, or, in other words, the capacity of the transformer depends only upon the resistances of the primary and secondary coils, so that if the cross-section of the wire is increased the capacity will be increased and the approximation to constancy of potential at the secondary terminals for any given load will also be increased. In open magnetic-circuit transformers or other similar phase-displacing devices, however, there is always a large magnetizing-current which lags behind its electromotive force, disturbing the ordinary generator and reducing its output by demagnetizing its field-magnet. These transformers, therefore, although they may be made to withstand the potential of the mains, are not adapted to the ordinary alternating-current generator and cannot be satisfactorily used in the systems at present in use.

The purpose of our invention is to generate and distribute alternating currents, so that when the currents supplied lag or lead because of the nature of the load such lagging or leading currents instead of disturbing the generator shall automatically act to maintain constant the potential on the mains. The advantages of such generation and distribution will be manifest to those who are familiar with the art as now practiced, since it does away with the disturbing effects of translating devices, such as motors and open-circuit transformers, which are very troublesome in ordinary systems.

The principle upon which our improvement depends is that of the inductive action of one alternating current upon another, the two being related as primary and secondary—viz., that if the two circuits be properly disposed if the secondary current lags positively it will react upon the primary circuit, increasing the primary current to the extent necessary to maintain the magnetic flux, and if the secondary has a negative lag then it will react upon the primary circuit, reducing the primary current to the amount necessary to maintain the flux.

In carrying out our invention the lagging or leading currents are the armature-currents, which are made to act upon field-energizing circuits carrying alternating currents. The resistance of the field-energizing coils is made very low, so that the electromotive forces applied to the terminals of the energizing-coils and the counter-electromotive forces set up therein will always be substantially equal, and the variation of current in the energizing-circuits will be controlled practically only by the reaction of the armature-currents.

The following is a description of a system for carrying out our improvements, reference being had to the accompanying drawings, in which—

Figure 1 is a side elevation of the generator. Fig. 2 is a diagrammatic view of the system employing the generator and various translating devices supplied thereby. Figs. 3, 4, 5, 6, and 7 are diagrammatic.

Referring more particularly to the drawings, A is a generator having an armature B with its induced windings *b* of such low resistance as to make the full-load resistance drop always practically negligible under normal working conditions.

C is a field structure having windings *c* *c'* supplied with multiphase alternating currents from the small substantially-constant-potential multiphase exciter D, the windings *c* *c'* being so disposed that the multiphase exciter-currents produce in the field C revolving magnetic poles or fields of force cutting the armature-conductors *b*. These windings *c* *c'* are of such low resistance that in normal operation their applied and counter electromotive forces are always practically equal. If the desired frequency of the generator is, say, sixty alternations per second, the frequency of the exciter D is made much less—say about four alternations per second—producing magnetic fields revolving four times per second. Power is then applied to the generator-shaft E, so as to revolve the field structure C at a constant speed of sixty minus four, or fifty-six times a second, thus producing a rotating field revolving sixty times a second, due partly to the mechanical rotation of the field structure C relatively to the armature and partly to the rotation of the magnetic poles or fields relative to the field structure.

The resistance of the field and the exciter circuits, being made low, as above described, does not interfere materially with the flow of the alternating currents therein, but leaves them to be controlled by the inductance of the field as modified by the reaction of the armature-currents. The inductances of the field-circuits must at all times be so high relatively to the resistances that they may determine the exciter-currents. The mutual induction between the armature-coils and the field-coils should also be high, so that the armature-currents shall modify the inductances of the field-circuits properly, which we accomplish by placing the armature-coils as close to the field-coils as possible, constructing the field, as shown, with its windings distributed upon the surface of its peripheries and making the magnetic circuit of very low reluctance. Now with such an arrangement if the potential delivered by the exciter D is constant the potential delivered by the generator is constant so long as the applied and counter electromotive forces of the energizing-circuits are substantially equal independently of any lagging or leading of the current in the armature-coils, being determined solely by the electromotive force of the multiphase exciter. Within the limits of operation no manipulation or variation of the electromotive force of the exciter is necessary, as the exciter and generator, reacted upon by the currents in the mains, will automatically adjust the value of the exciting-currents to produce a constant electromotive force at the main generator-terminals. The changes in the exciting-currents are instantaneous, and consequently the electromotive force of the main generator never varies because of changes in the power factor of the circuits which it supplies. The actions which produce this result may be explained as follows: Suppose the currents in the armature do not lag—viz., are in phase with the electromotive force. Then the pole or field of the revolving field structure will lie as shown in Fig. 6, and four-sixtieths of the electromotive force and four-sixtieths of the current will be due to the movement relative to the field structure of the field or pole produced by the multiphase exciting-currents, and fifty-six sixtieths will be due to the rotation of the field structure. If now the current in the armature-coils lags through some angle—say thirty degrees—it tends to demagnetize the field-magnet. The revolving field structure will, however, have been advanced thirty degrees of the armature-electromotive-force period before the current in the armature-coils attains its maximum value, and the armature and field circuits will be more nearly opposite each other—viz., in better mutual induction—as shown in Fig. 7. The field-circuits will then be more powerfully reacted upon by the armature-current, allowing more primary current to flow, and so keeping up the value of the field cutting the armature-circuit. In other words, the armature-circuit is so related to the field-circuits that it is acted upon as a secondary by the alternating currents in the field, and when the current in the mains lags reduces the inductance of the field-circuits, thereby permitting more energizing-current to flow and maintaining the field magnetism. This is in marked contrast with the ordinary system in which the lagging current simply demagnetizes the field of the generator, the energizing-current not being affected by any reduction of inductance, and therefore not increasing, so as to counteract the demagnetizing effect. In our improvement if the current leads instead of lagging positively such lead places the armature-coil in a position to assist or increase the magnetizing effect of the field-windings by reacting upon them as a primary, and consequently increases the inductance of the exciter-circuit and reduces the exciter-currents correspondingly, thus again maintaining the field constant and preventing a change in the electromotive force at the main generator-terminals.

In the system shown in Fig. 2, A is the generator, having the substantially-constant-potential multiphase exciter D and the circuits M M' leading therefrom, with various translating devices in multiple arc—to wit, an open-circuit transformer F, with lamps in parallel on its secondary, a closed magnetic

circuit-transformer G, with lamps in parallel on its secondary, a transformer H, with lamps in series on its secondary, and an alternating-current induction-motor I—which devices it has never before been possible to use on the same generator without expensive and unsatisfactory local devices for preventing the evil effects due to the lagging currents which are produced because of the phase-displacing properties of open magnetic-circuit transformers and similar apparatus and the circuits of which they form a part. With our improvement, however, lagging or leading currents do not produce any such evil effects, and therefore no adaptation, such as has heretofore been necessary, need exist; but the devices can be used indiscrimately so long as they are made to be used with the voltage and frequency employed.

The low frequency of the exciter permits the use of a small exciter, and thus makes a practicable system. The frequency should be as low as is compatible with the desired regulation. The self-induction of the field-exciting coils must be high relatively to their resistance, though not necessarily high in an absolute sense, so that, as in an ordinary transformer, the flow of current will be made to vary inversely with the inductance and be substantially independent of the resistance. The desired results are attained by energizing the generator by impressing alternating electromotive forces of low frequency on the field-coil terminals and maintaining at these terminals counter electromotive forces always substantially equal to the impressed, and from the currents thus produced and by motion due to external mechanical power inducing currents of normal frequency in the armature, which, if they lag or lead, react so as to control the flow of the low-frequency energizing-currents, so as to maintain a substantially constant inducing-field and consequent constant potential at the generator-terminals.

Such generation and distribution as above described is of peculiar value in connection with systems of high-tension long-distance transmission, in which the power factor varies very greatly with the load.

What we claim is—

1. The method of producing alternating currents of normal frequency and constant potential, which consists in producing alternating currents of very low frequency and inducing from them by the aid of mechanical motion currents of normal frequency, and controlling the flow of the low-frequency currents by the reaction of the induced currents so as to maintain a substantially constant inducing-field.

2. The method of generating and distributing electrical energy by alternating currents which consists in applying to the terminals of a plurality of field-circuits alternating currents of differing phase, maintaining in said circuits counter electromotive forces substantially equal to the applied under all normal conditions, and causing said field to act upon a revolving-armature circuit to induce alternating currents therein.

3. The method of producing alternating currents of normal frequency and constant electromotive force which consists in applying to the terminals of field-circuits alternating electromotive forces of very low frequency, maintaining in said circuits a counter electromotive force substantially equal to the applied electromotive force under all normal conditions, and inducing from the currents thus produced by the aid of mechanical motion currents of the normal frequency and controlling the flow of the current due to the low-frequency electromotive forces by the reaction of the induced currents so as to maintain a substantially constant inducing-field.

4. The method of maintaining constant magnetization in an alternating-current generator which consists in exciting the field of the generator by very-low-frequency polyphase alternating currents inducing by the field thus produced and by mechanical rotation alternating currents of normal frequency and causing the high-frequency currents in case they lag or lead to react so as to vary the exciting-currents to the proper amount to maintain the field constant.

5. The method of maintaining constant magnetization in an alternating-current generator which consists in exciting the field of the generator by very-low-frequency polyphase alternating currents inducing by the field thus produced and by mechanical rotation alternating currents of normal frequency and causing said normal-frequency currents to react upon the exciting-currents, the applied and counter electromotive forces in the field-circuits being maintained substantially equal under all normal conditions.

6. The method of producing alternating currents of normal frequency and constant potential, which consists in producing substantially-constant-potential alternating currents of very low frequency and inducing from them by the aid of mechanical motion currents of normal frequency, and controlling the flow of the low-frequency currents by the reaction of the induced currents so as to maintain a substantially-constant inducing-field.

7. The method of generating and distributing electrical energy by alternating currents which consists in applying to the terminals of a plurality of field-circuits substantially-constant-potential alternating currents of differing phase, maintaining in said circuits counter electromotive forces substantially equal to the applied under all normal conditions, and causing said field to act upon a relatively-revolving-armature circuit to induce alternating currents therein.

8. The method of producing alternating currents of normal frequency and constant electromotive force which consists in applying to the terminals of field-circuits substantially-

constant-potential alternating electromotive forces of very low frequency, maintaining in said circuits a counter electromotive force substantially equal to the applied electromotive force under all normal conditions, and inducing from the currents thus produced by the aid of mechanical motion currents of the normal frequency and controlling the flow of the current due to the low-frequency electromotive forces by the reaction of the induced currents so as to maintain a substantially-constant inducing-field.

9. The method of maintaining constant magnetization in an alternating-current generator which consists in exciting the field of the generator by very-low-frequency, substantially-constant-potential polyphase alternating currents, inducing by the field thus produced and by mechanical rotation alternating currents of normal frequency and causing the high-frequency currents in case they lag or lead to react so as to vary the exciting-currents to the proper amount to maintain the field constant.

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