No. 712,613. Patented Nov. 4, 1902.

W. STANLEY & J. F. KELLY.

ALTERNATING CURRENT DYNAMO ELECTRIC MACHINE AND SYSTEM OF DISTRIBUTION.

(Application filed Apr. 5, 1902.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 2.

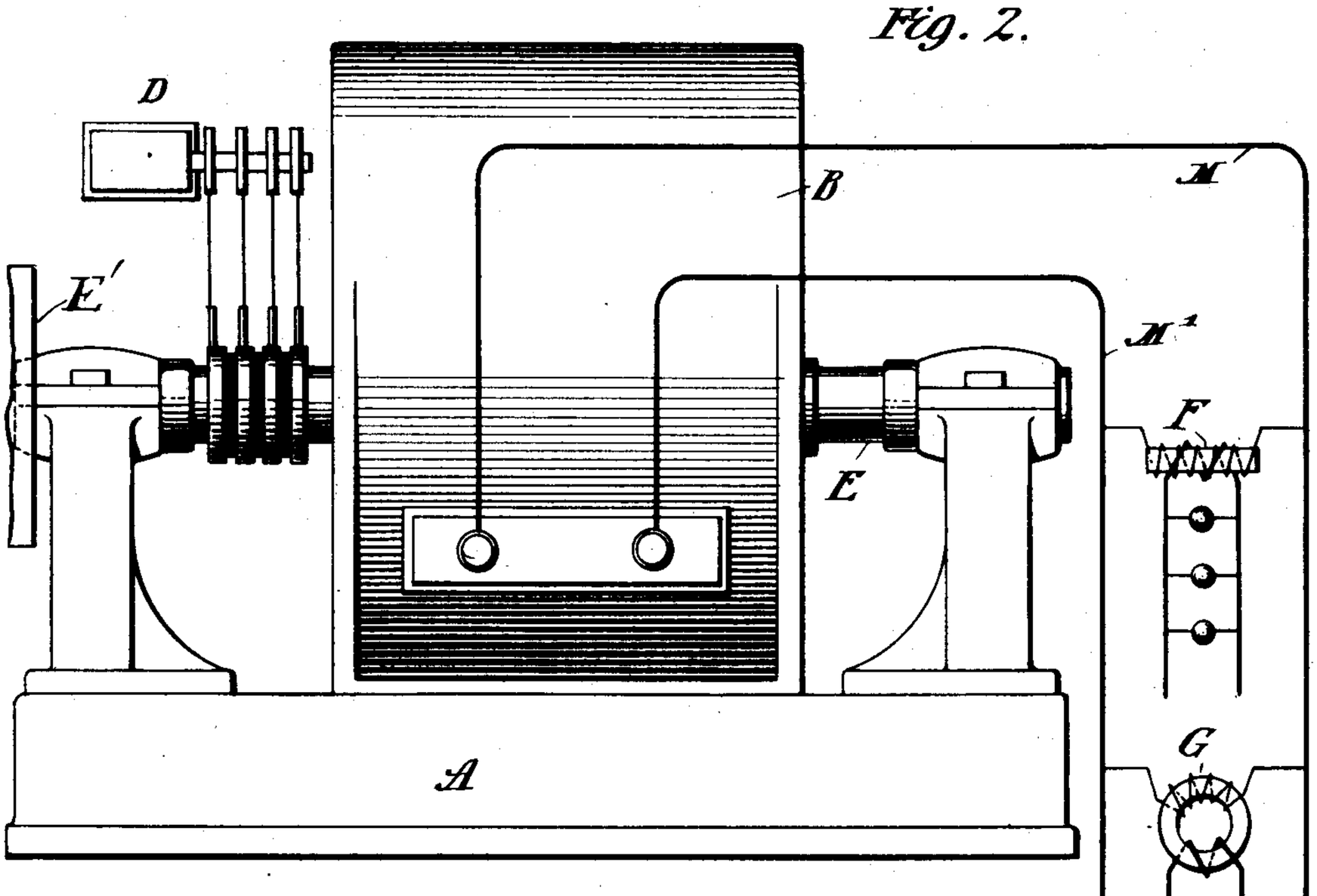
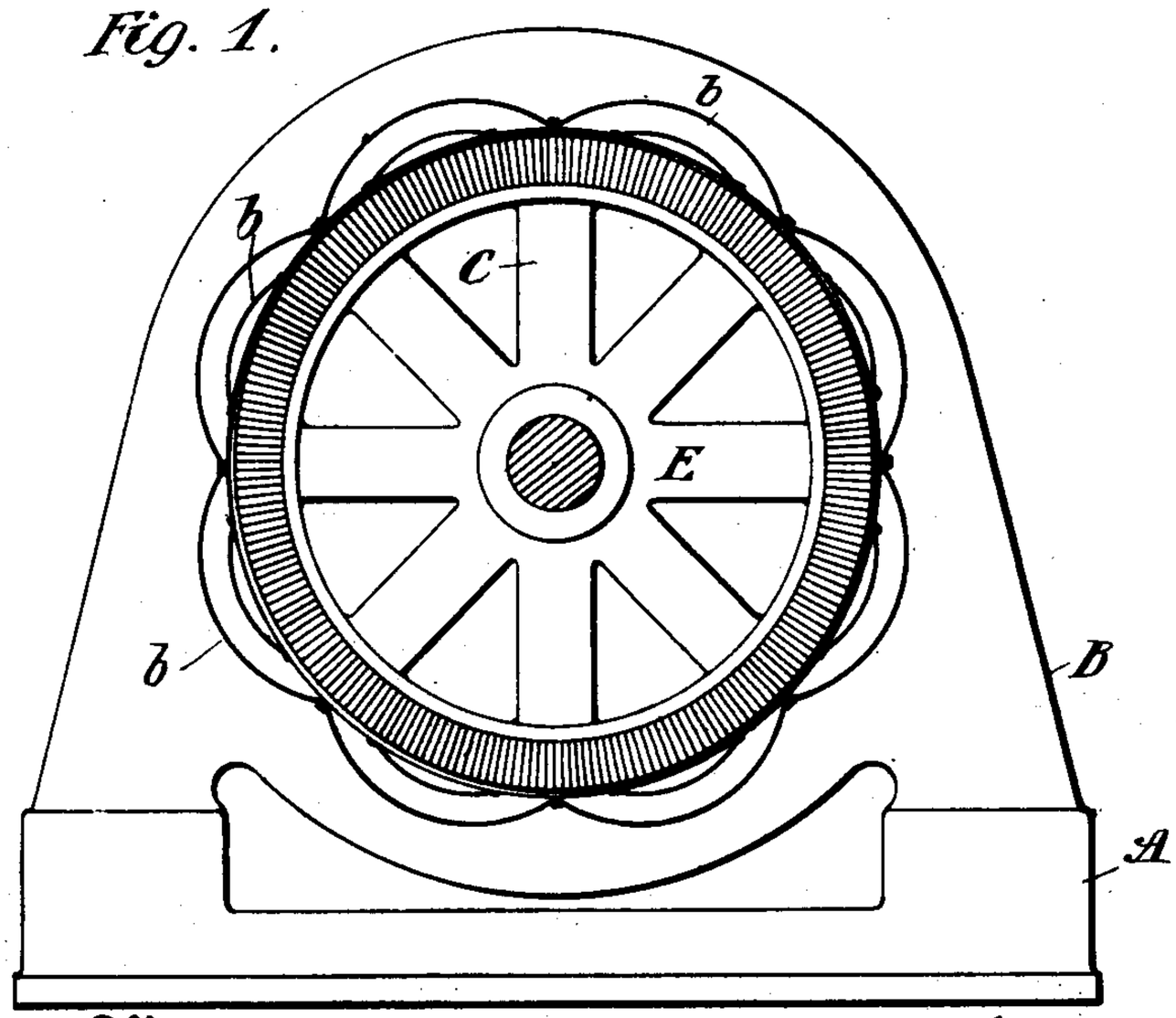


Fig. 1.



Witnesses
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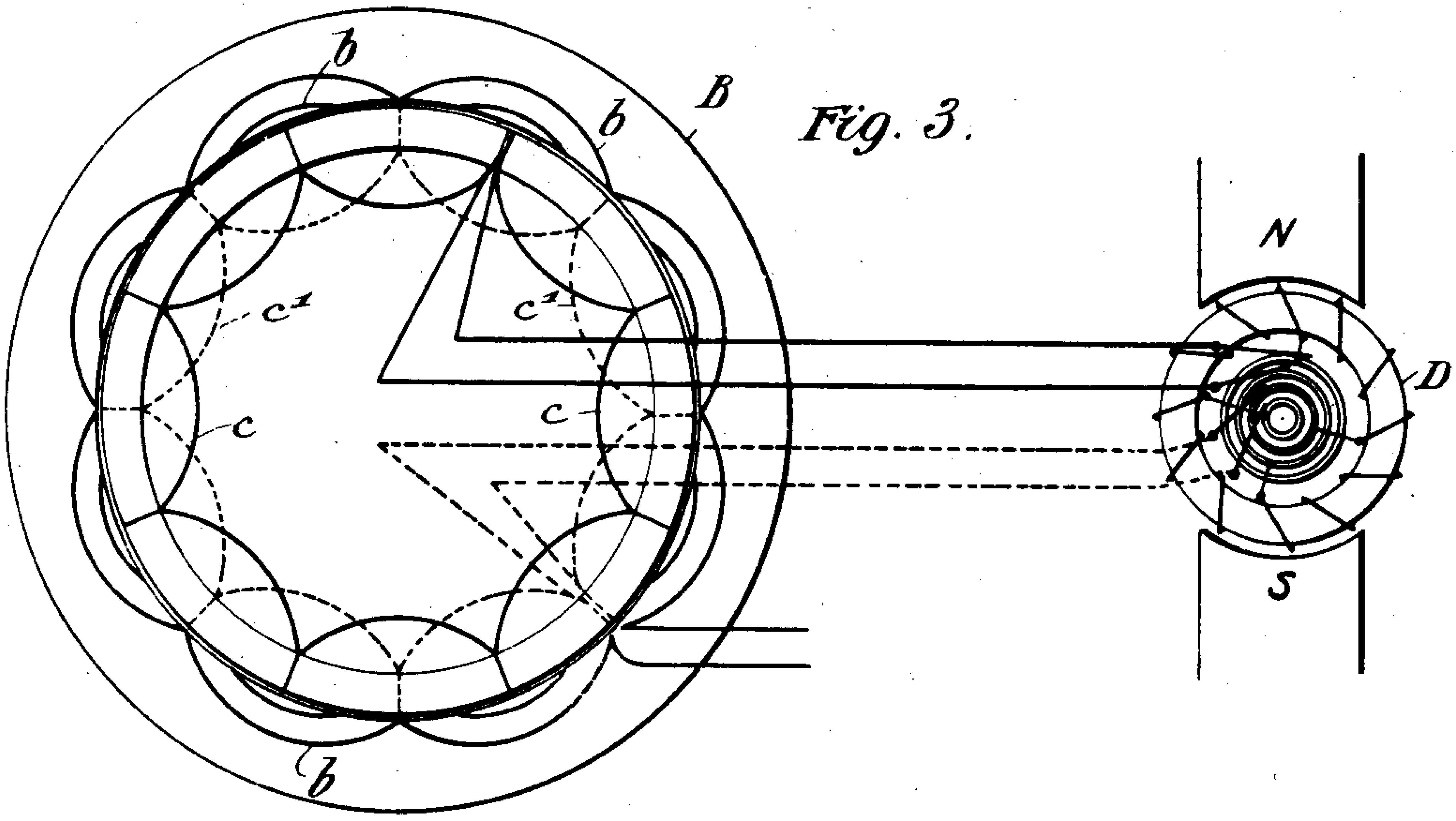

Fig. 3.

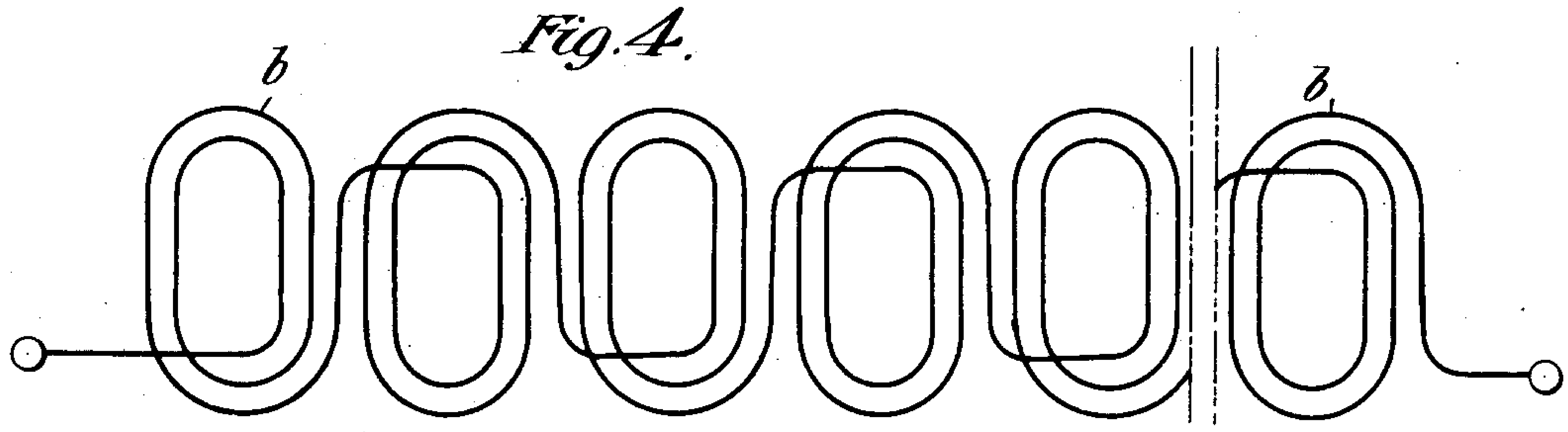

Fig. 4.

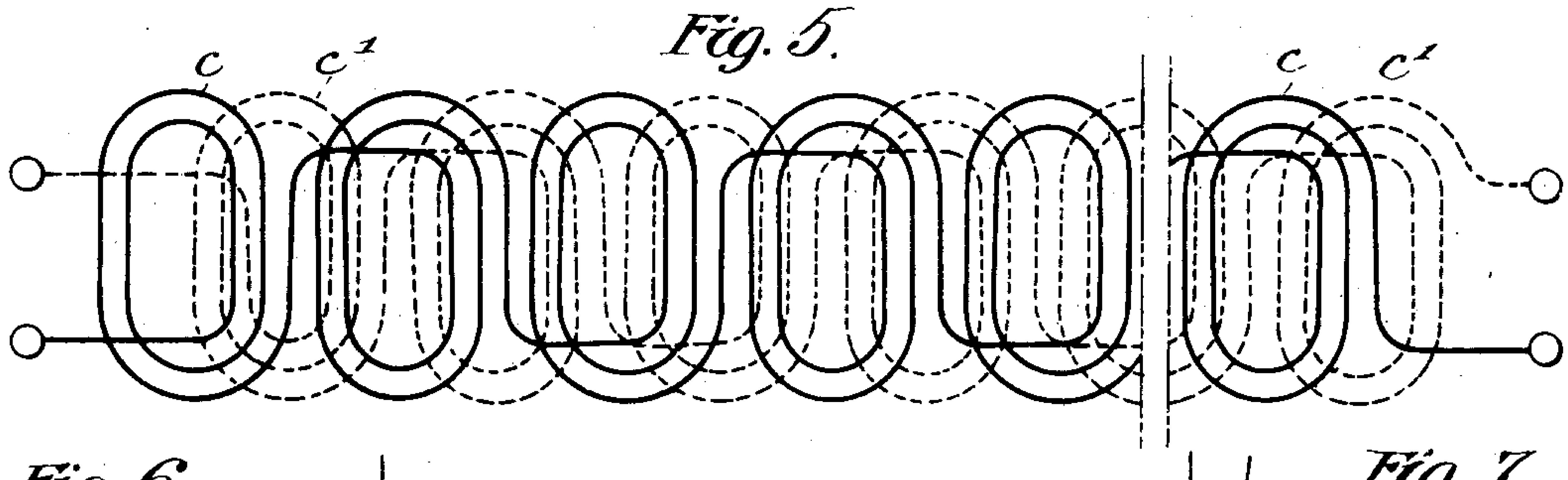

Fig. 5.

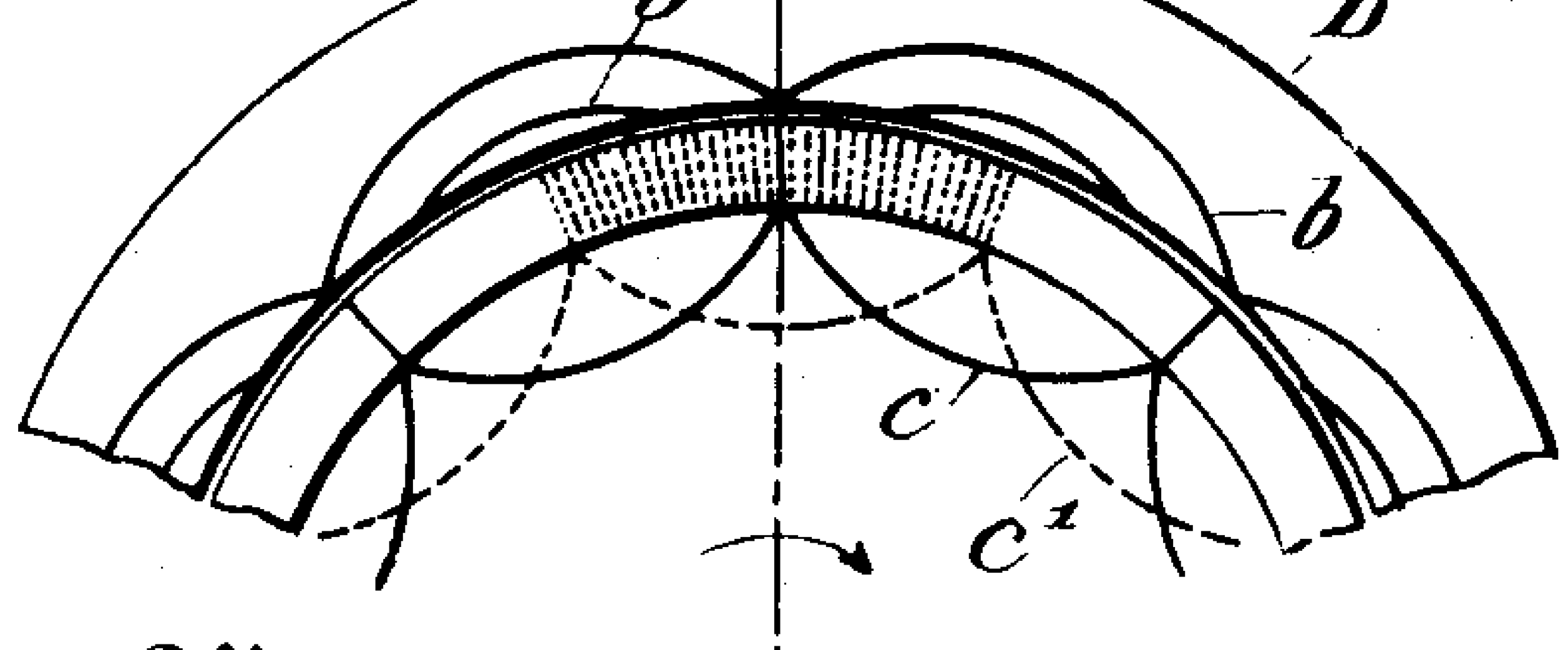

Fig. 6.

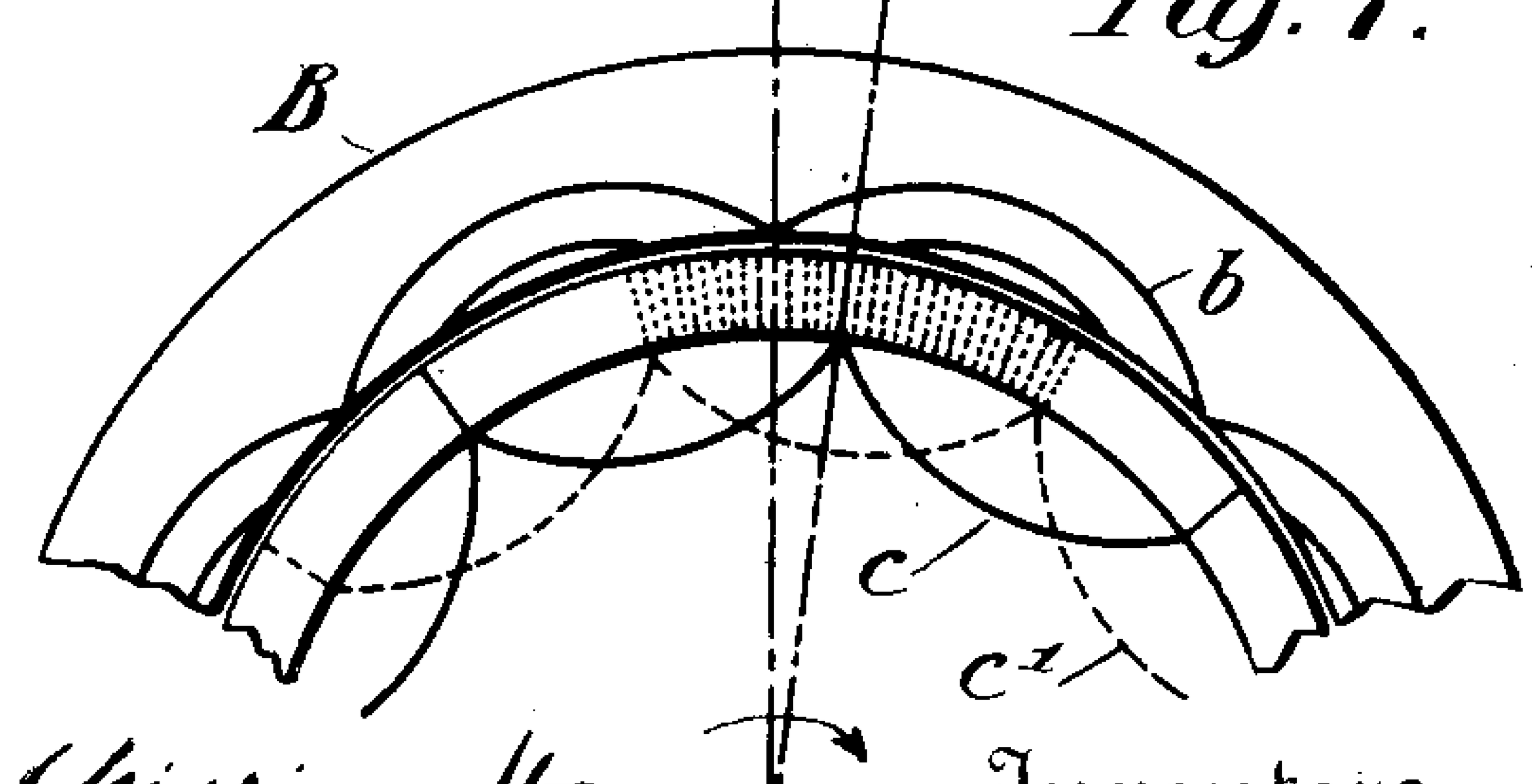

Fig. 7.

Witnesses

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UNITED STATES PATENT OFFICE.

WILLIAM STANLEY, OF GREAT BARRINGTON, AND JOHN F. KELLY, OF PITTSFIELD, MASSACHUSETTS.

ALTERNATING-CURRENT DYNAMO-ELECTRIC MACHINE AND SYSTEM OF DISTRIBUTION.

SPECIFICATION forming part of Letters Patent No. 712,613, dated November 4, 1902.

Application filed April 5, 1902. Serial No. 101,465. (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 Alternating-Current Dynamo-Electric Machines and Systems of Distribution, of which the following is a full, clear, and exact description.

Our invention relates to improvements in means for 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 system 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 familar with the art as now practiced, since it does away with 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 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 maguetic 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 and armature, as shown, with their windings distributed upon the surface of their 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 lag 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—*i. e.*, lags negatively instead of 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 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-trans-

former 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 lagging currents, which are produced because of the phase-displacing properties of open magnetic transformers and similar apparatus and the circuit of which they form a part. With our improvement, however, lagging or leading currents do not produce such evil effects, and therefore no adaptation such as has heretofore been necessary need exist; but the devices can be used indiscriminately 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.

We have shown the armature stationary and the field revolving, but do not intend to limit our invention to this physical arrangement, since it may obviously be embodied in a great many forms and arrangements of apparatus.

What we claim is—

1. In combination, an alternating-current generator having an armature and a field structure adapted to have a relative movement of rotation, and multiphase circuits for magnetizing said generator, together with a source of multiphase alternating excitation-currents of low periodicity as compared with the normal frequency of the generator.

2. In combination, an alternating-current generator having an armature and a field structure adapted to have a relative movement of rotation, multiphase circuits for magnetizing said generator, said multiphase circuits being of high inductance relatively to their resistance.

3. In combination, an alternating-current generator having an armature and a field structure adapted to have a relative movement of rotation, multiphase circuits for magnetizing said generator, said multiphase circuits being of high inductance relatively to their resistance, and means for supplying alternating currents of low periodicity to said multiphase circuits.

4. In combination, an alternating-current generator having an armature and a field structure adapted to have a relative movement of rotation, magnetizing-circuits for said generator having a high inductance relatively to their resistance, the magnetizing and armature circuits having high mutual induction.

5. In combination, an alternating-current generator having an armature and a field structure adapted to have a relative movement of rotation, multiphase circuits for magnetizing said generator, the armature-circuits and said multiphase circuits having high mutual induction, and means for supplying to said magnetizing-circuits alternating currents of low periodicity as compared with that of the currents produced by the generator.

6. In combination, an alternating-current generator having an armature and a field structure adapted to have a relative movement of rotation, magnetizing-circuits of high inductance for said generator, the magnetizing and armature circuits having high mutual inductance, and means for supplying said magnetizing-circuits with alternating currents of low periodicity.

7. The combination of a distribution-circuit possessing phase-displacing properties, an alternating-current generator supplying the same with electric energy, said generator having an armature and a field structure adapted to have a relative movement of rotation, and multiphase circuits for magnetizing said generator, together with a source of multiphase alternating excitation-currents of low periodicity as compared with the normal frequency of the generator.

8. The combination of a distribution-circuit possessing phase-displacing properties, and an alternating-current generator supplying the same with electric energy, said generator having an armature and a field structure adapted to have a relative movement of rotation, and multiphase circuits magnetizing said generator, the coils of said armature and field structure being arranged to have high mutual induction.

9. The combination of a distribution-circuit possessing phase-displacing properties, and an alternating-current generator supplying the same with electric energy, said generator having an armature and field structure adapted to have a relative movement of rotation,

multiphase circuits for magnetizing said generator, said multiphase circuits being of high inductance relatively to their resistance.

10. The combination of a distribution-circuit possessing phase-displacing properties, an alternating-current generator supplying the same with electric energy, said generator having an armature and a field structure adapted to have a relative movement of rotation, multiphase circuits for magnetizing said generator, said multiphase circuits being of high inductance relatively to their resistance, and means for supplying alternating currents of low periodicity to said multiphase circuits.

11. The combination of a distribution-circuit possessing phase-displacing properties, and an alternating-current generator supplying the same with electric energy, said generator having an armature and a field structure adapted to have a relative movement, magnetizing-circuits for said generator of high inductance relatively to their resistance, the magnetizing and armature circuits having high mutual induction.

12. The combination of a distribution-circuit possessing phase-displacing properties, an alternating-current generator supplying the same with electric energy, said generator having an armature and a field structure adapted to have a relative movement of rotation, multiphase circuits for magnetizing said generator, the armature-circuits and said multiphase circuits having high mutual induction, and means for supplying to said magnetizing-circuits alternating currents of low periodicity as compared with that of the currents produced by the generator.

13. The combination of a distribution-circuit possessing phase-displacing properties, an alternating-current generator supplying the same with electric energy, said generator having an armature and a field structure adapted to have a relative movement of rotation, magnetizing-circuits of high inductance for said generator, the magnetizing and armature circuits having high mutual induction, and means for supplying said magnetizing-circuits with alternating currents of low periodicity.

14. The combination of an alternating-current generator having an armature and a field structure adapted to have a relative movement of rotation, magnetizing-circuits of high inductance for said generator, the magnetizing and armature circuits having high mutual induction and a constant-potential alternating-current exciter for supplying said magnetizing-circuits with constant electromotive forces of low periodicity.

Signed at New York city this 14th day of February, 1902.

WILLIAM STANLEY.
JOHN F. KELLY.

Witnesses:
J. S. McDONALD,
H. C. TUXBURY.

Correction in Letters Patent No. 712,613.

It is hereby certified that in Letters Patent No. 712,613, granted November 4, 1902, upon the application of William Stanley, of Great Barrington, and John F. Kelly, of Pittsfield, Massachusetts, for an improvement in "Alternating-Current Dynamo-Electric Machines and Systems of Distribution," an error appears in the printed specification requiring correction, as follows: In line 105, page 3, the word "inductance" should read *induction;* and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 9th day of December, A. D., 1902.

[SEAL.]

F. I. ALLEN,
Commissioner of Patents.