(No Model.)

5 Sheets—Sheet 1.

C. J. VAN DEPOELE.

PULSATORY CURRENT MOTOR.

No. 422,856. Patented Mar. 4, 1890.

Fig. 1.

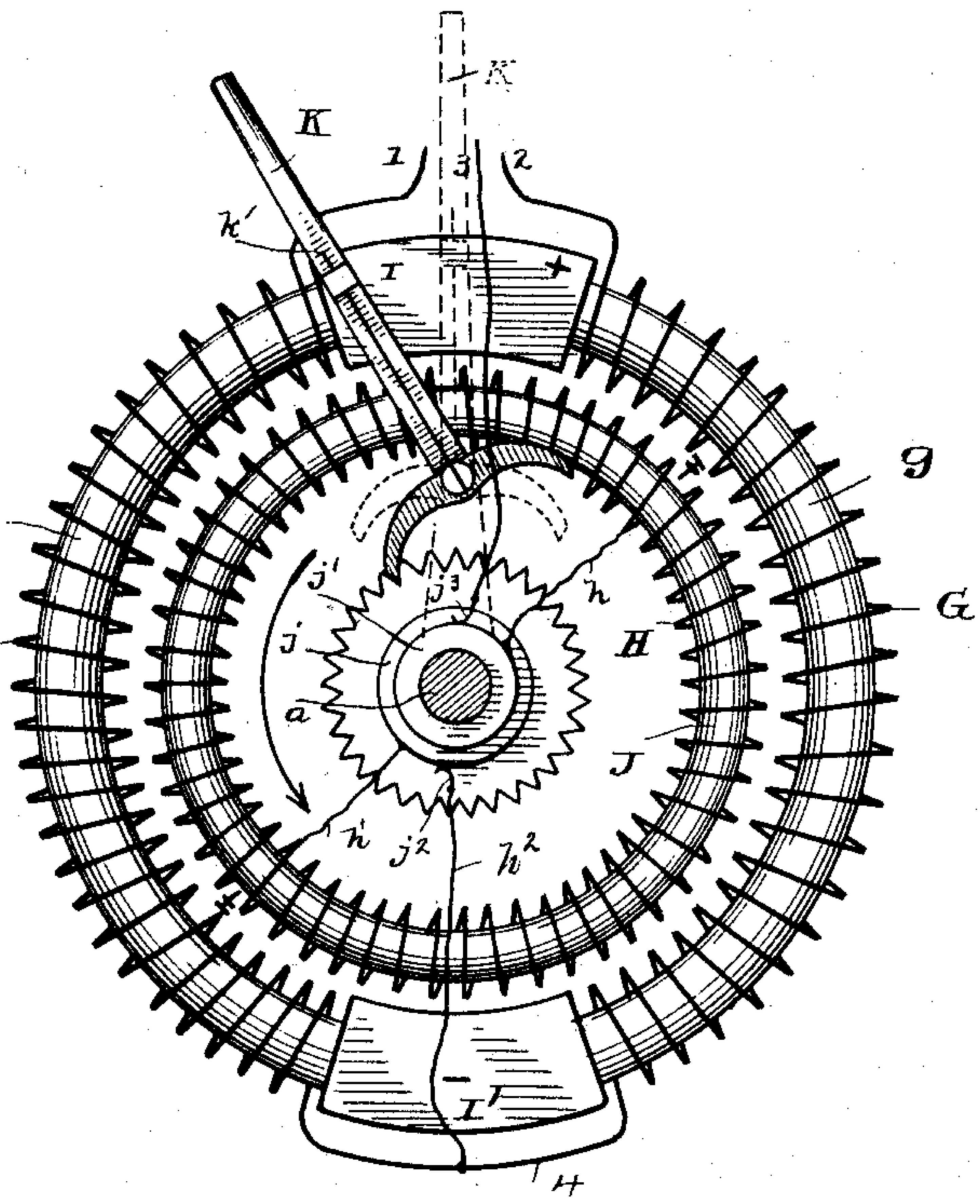
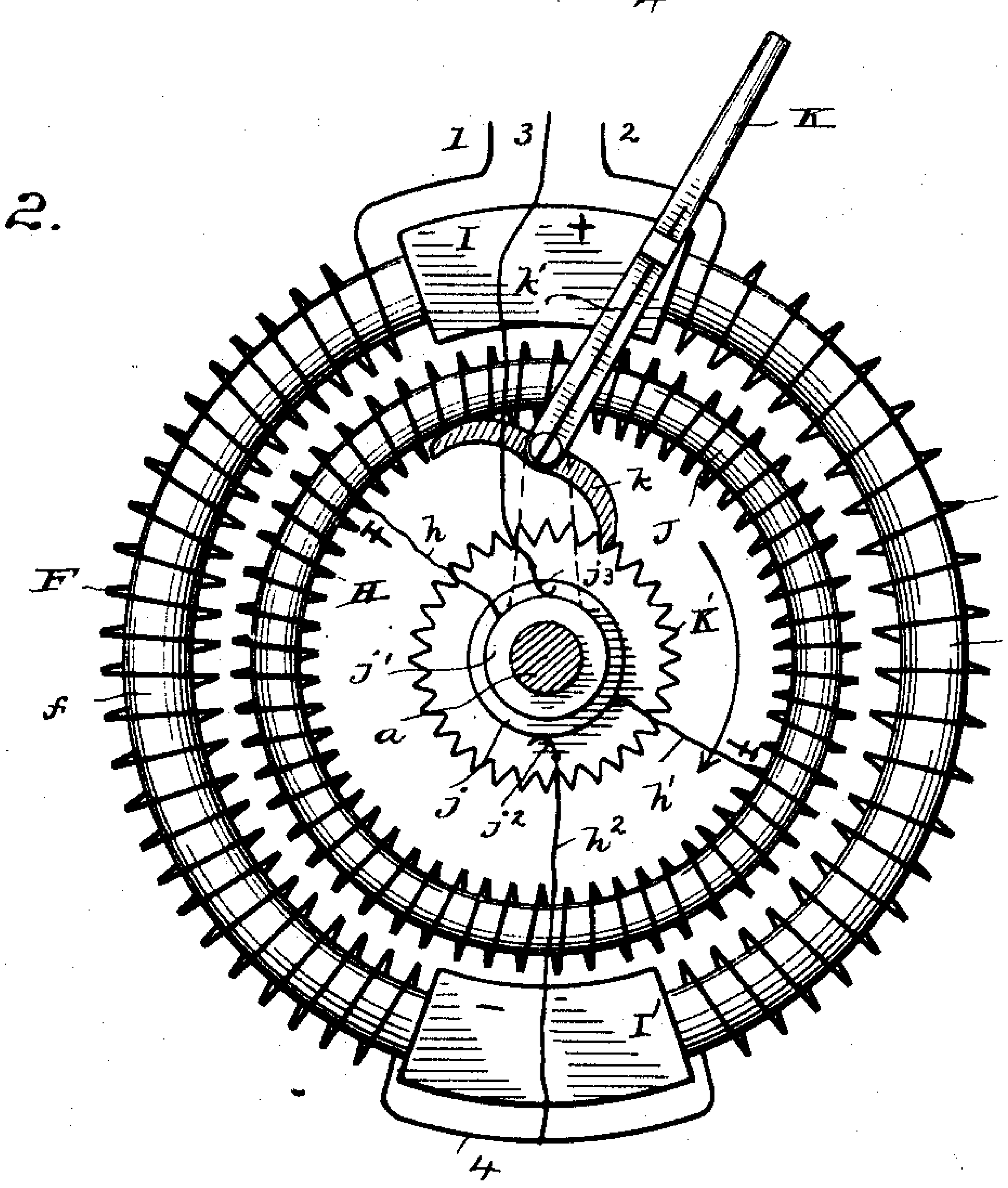


Fig. 2.



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(No Model.) 5 Sheets—Sheet 2.

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Fig. 3.

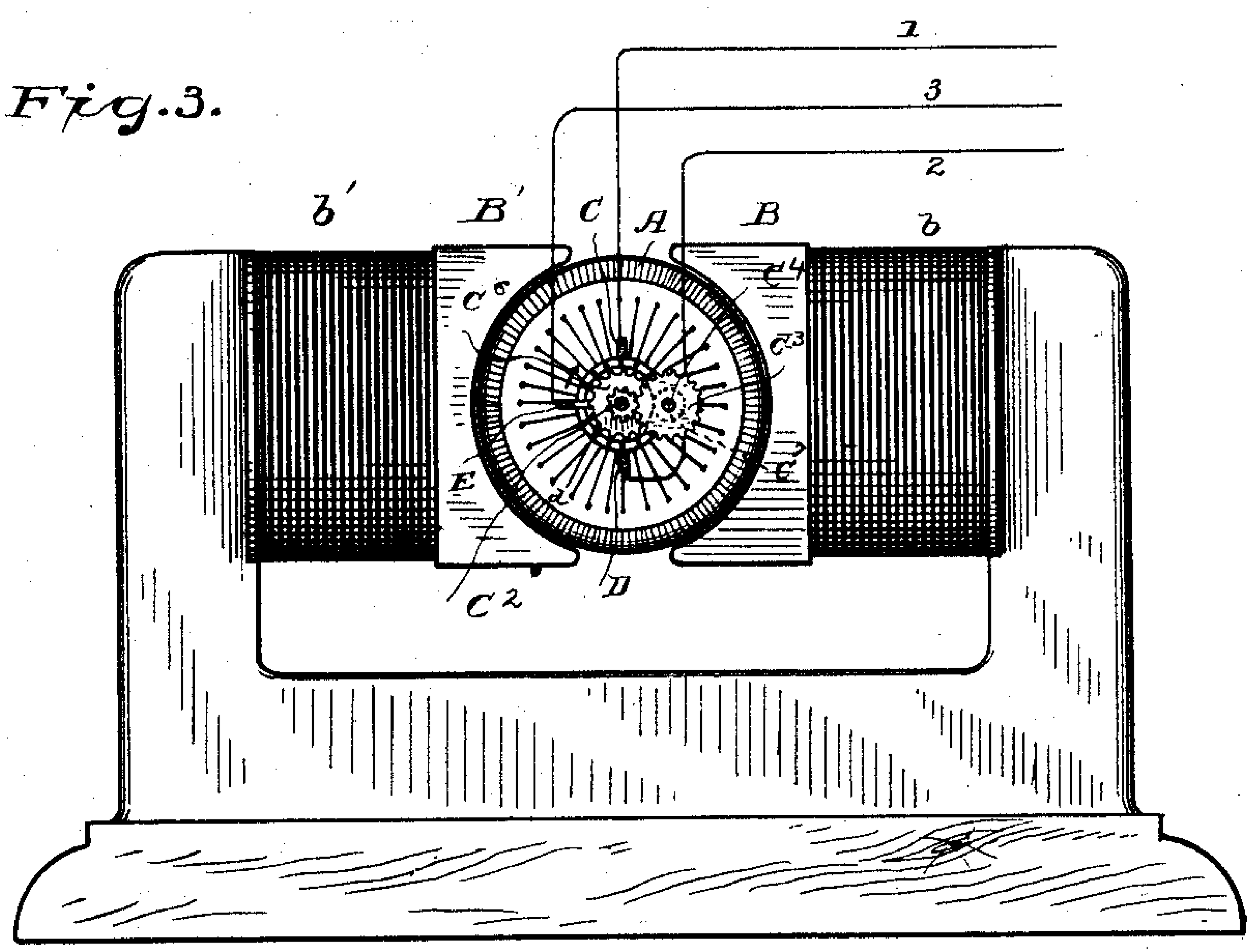

Fig. 3a.

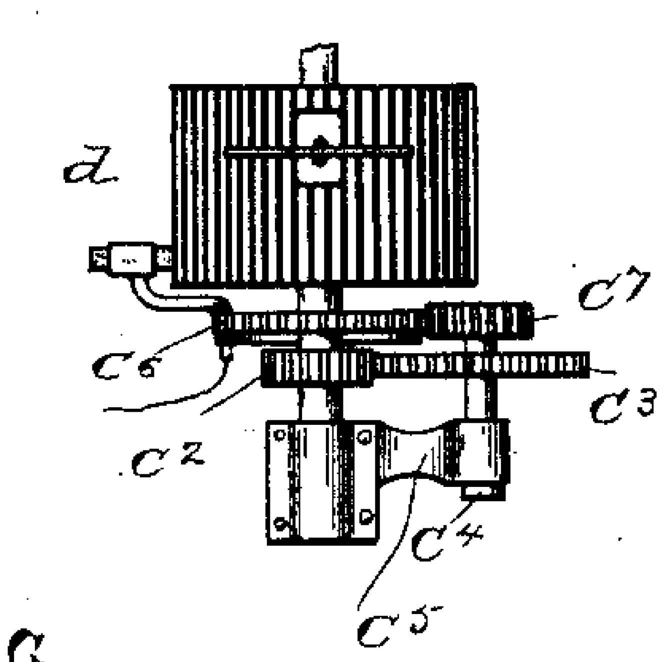

Fig. 4.

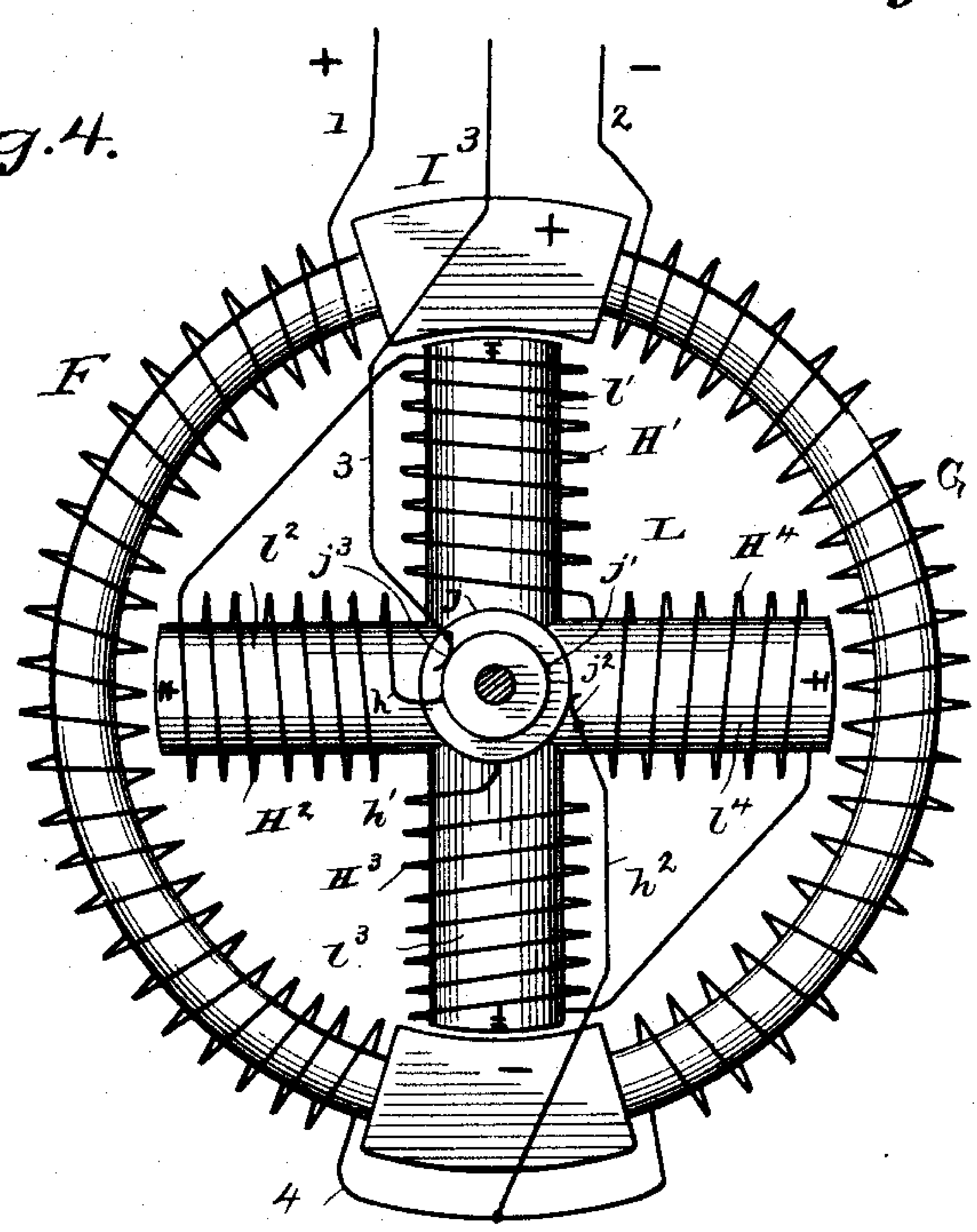

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Fig. 5.

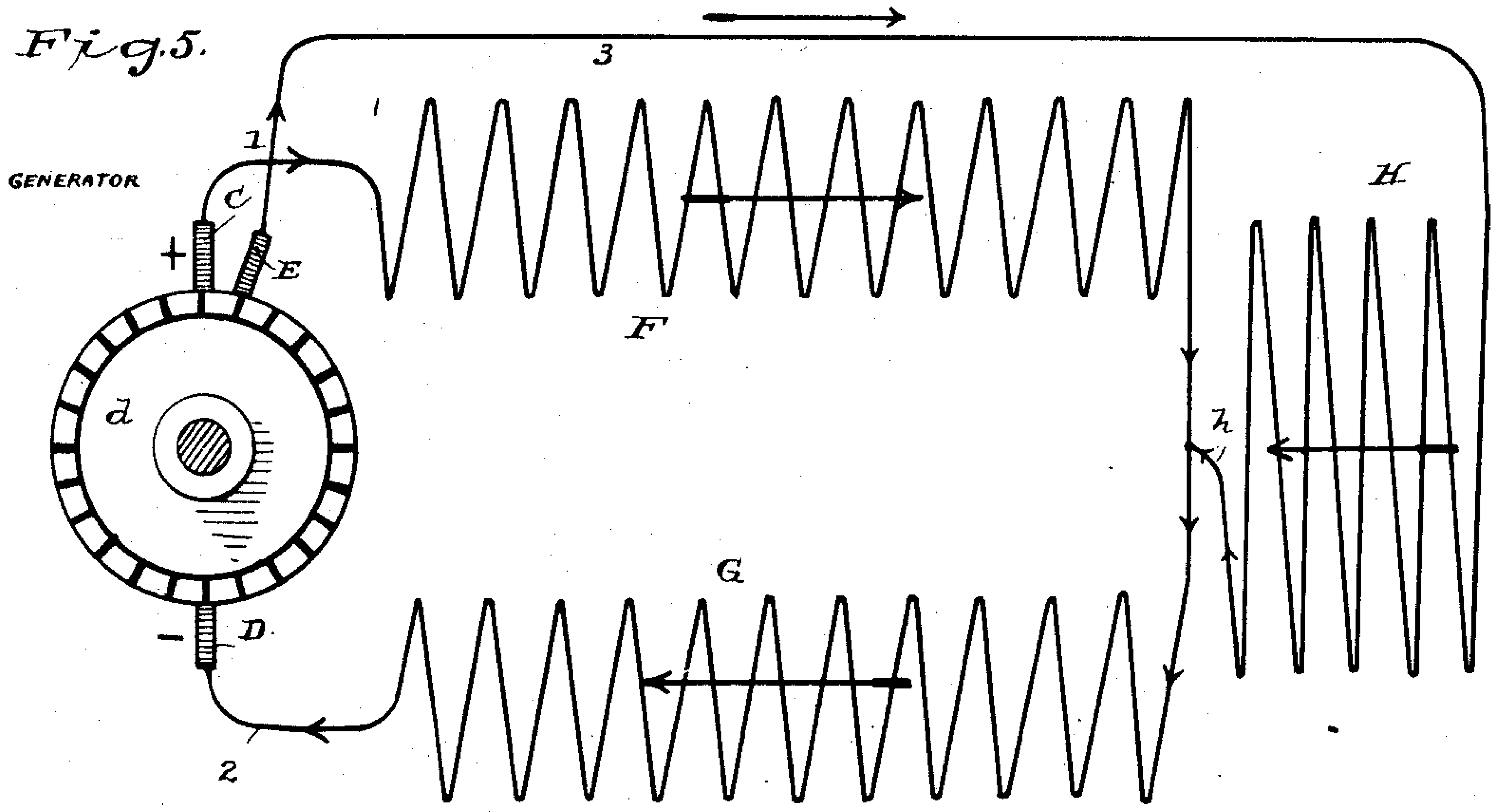
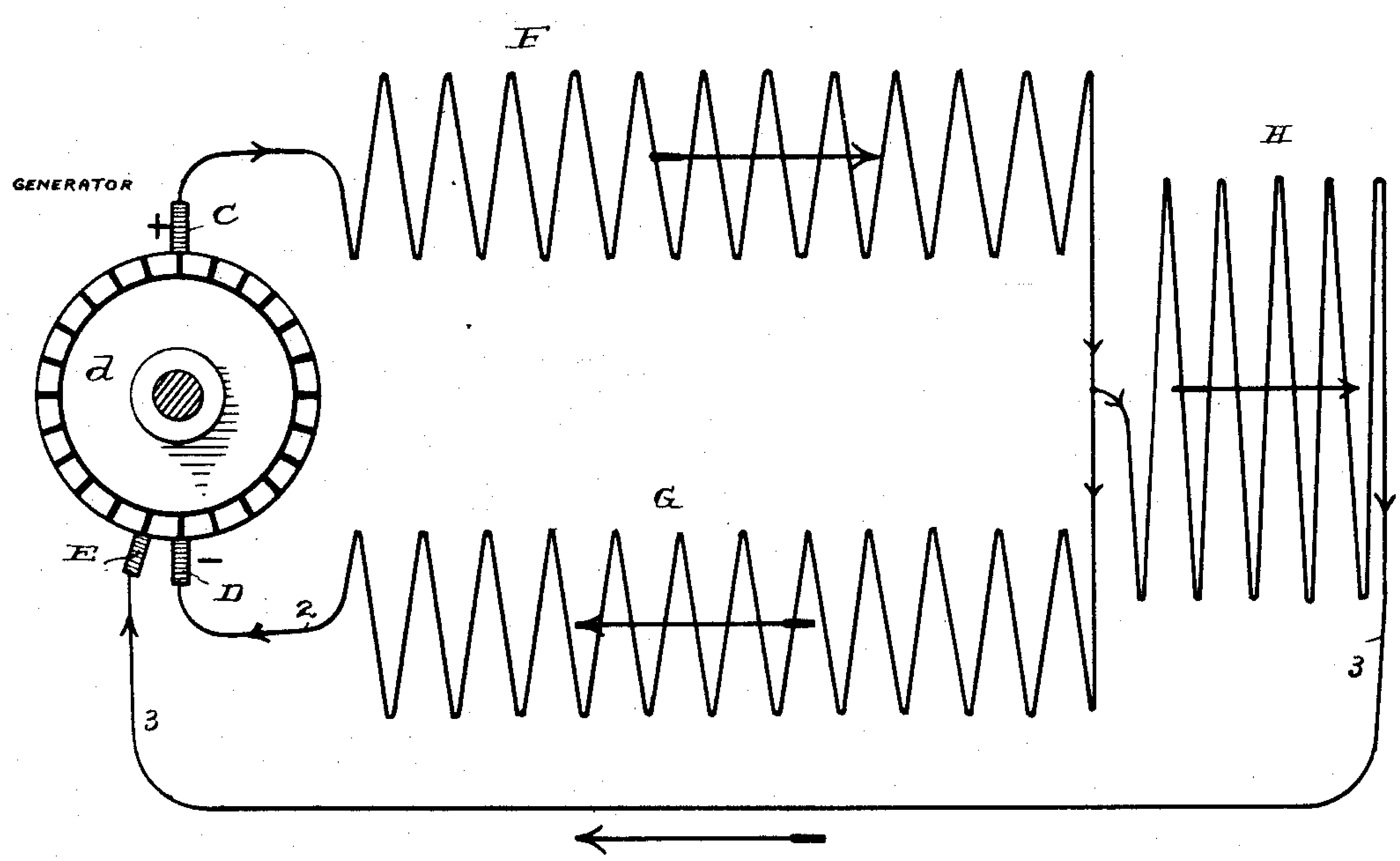


Fig. 6.



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(No Model.) 5 Sheets—Sheet 4

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PULSATORY CURRENT MOTOR.

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Fig. 9.

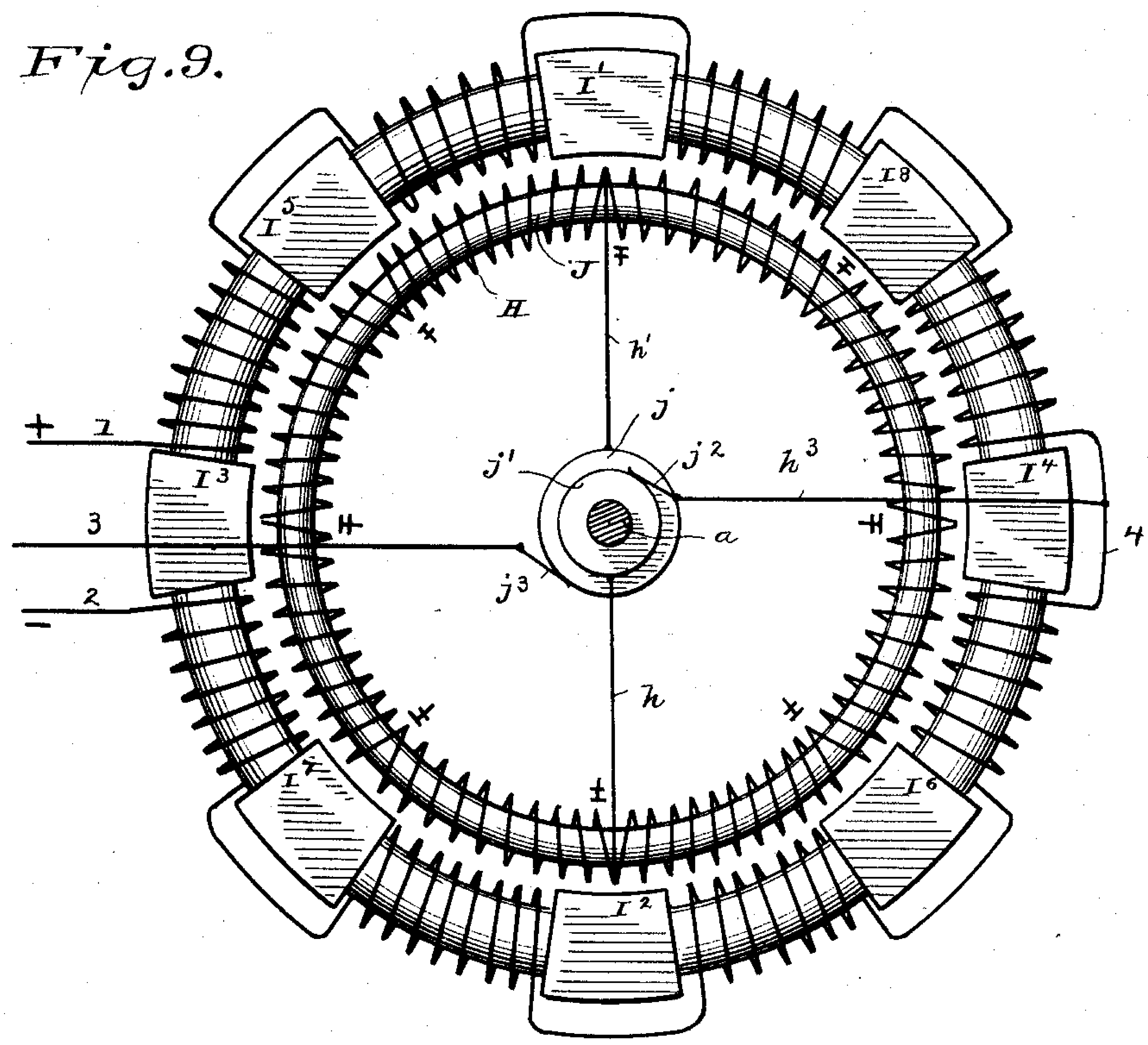

Fig. 7.

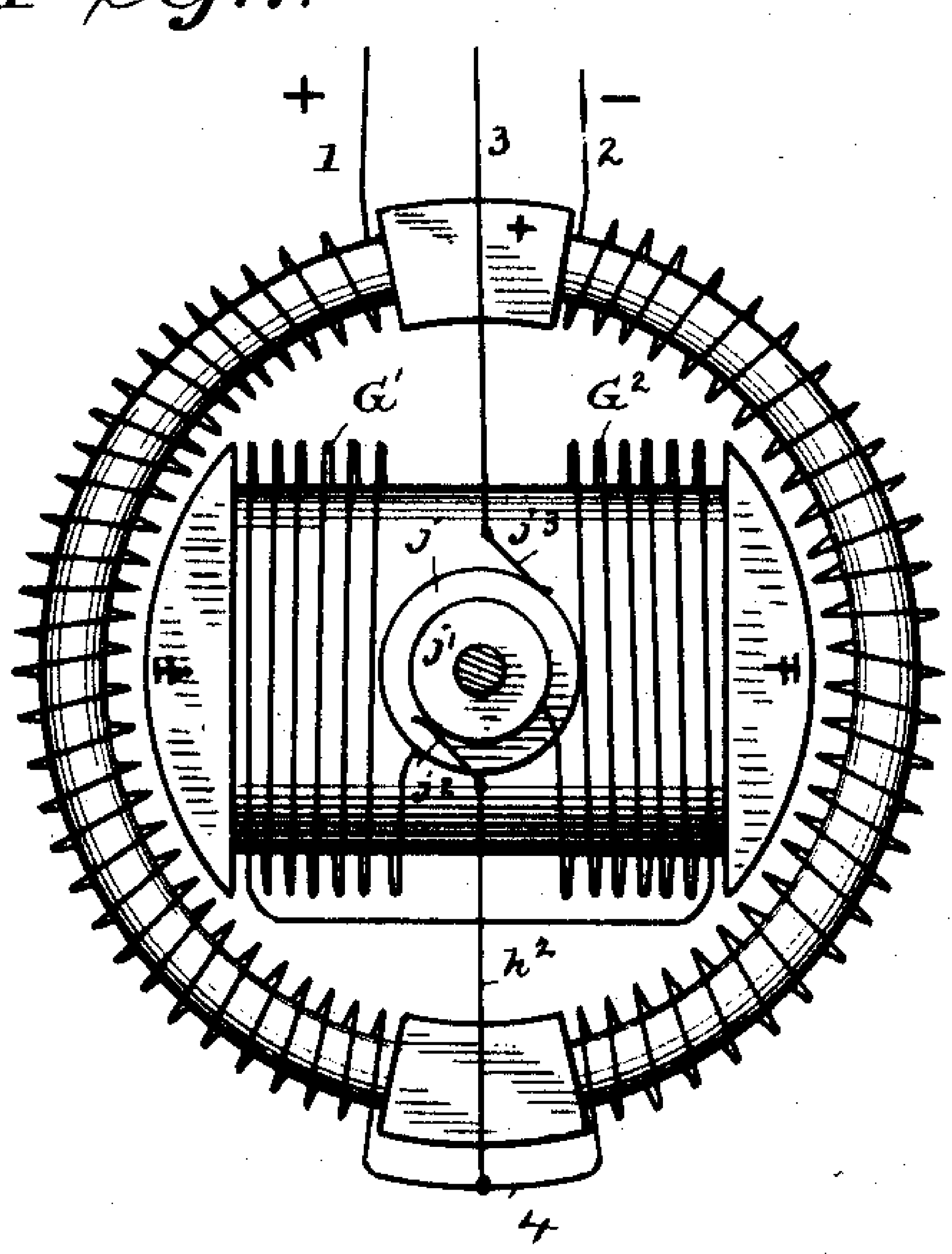

Fig. 8.

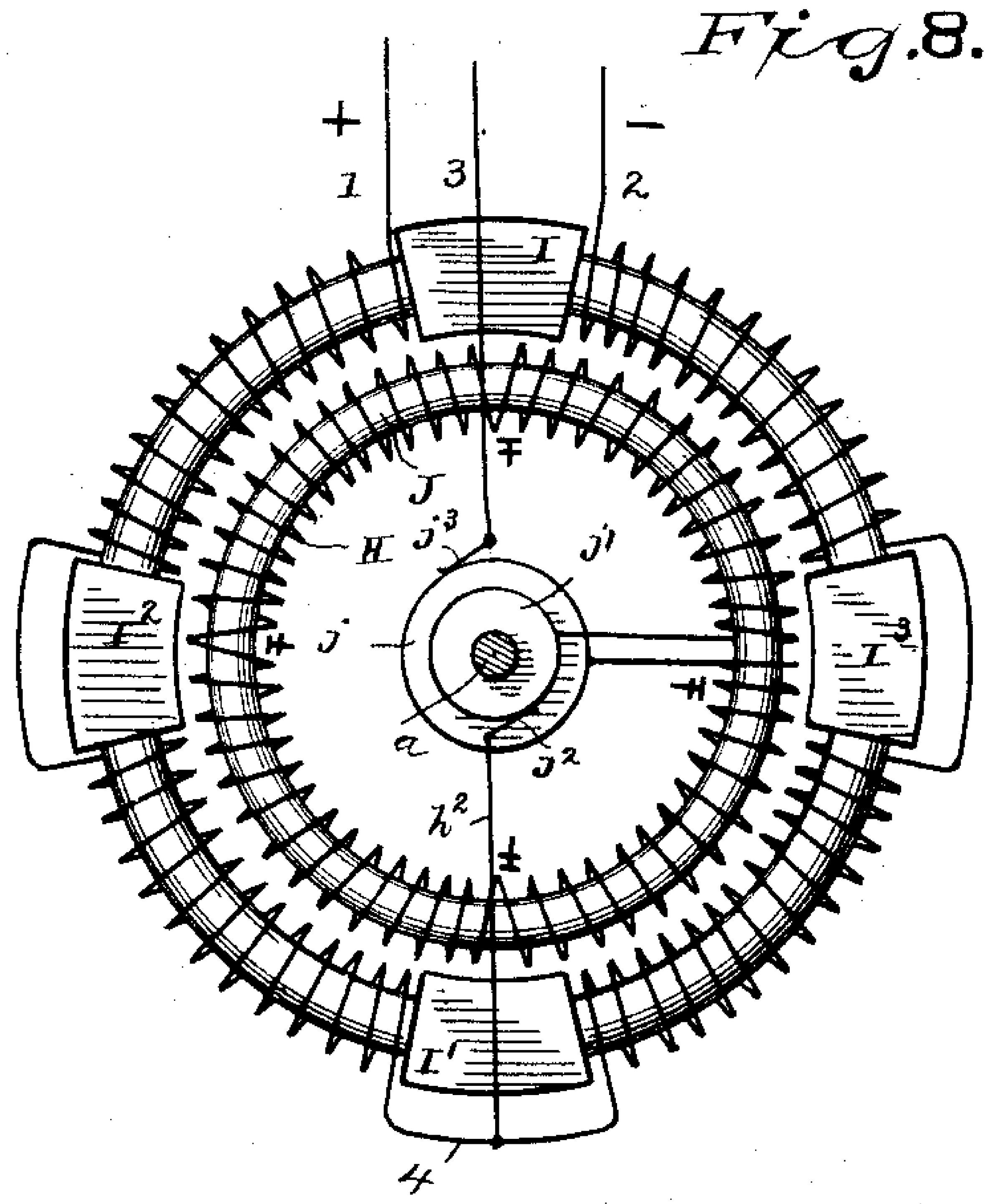

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Fig. 10.

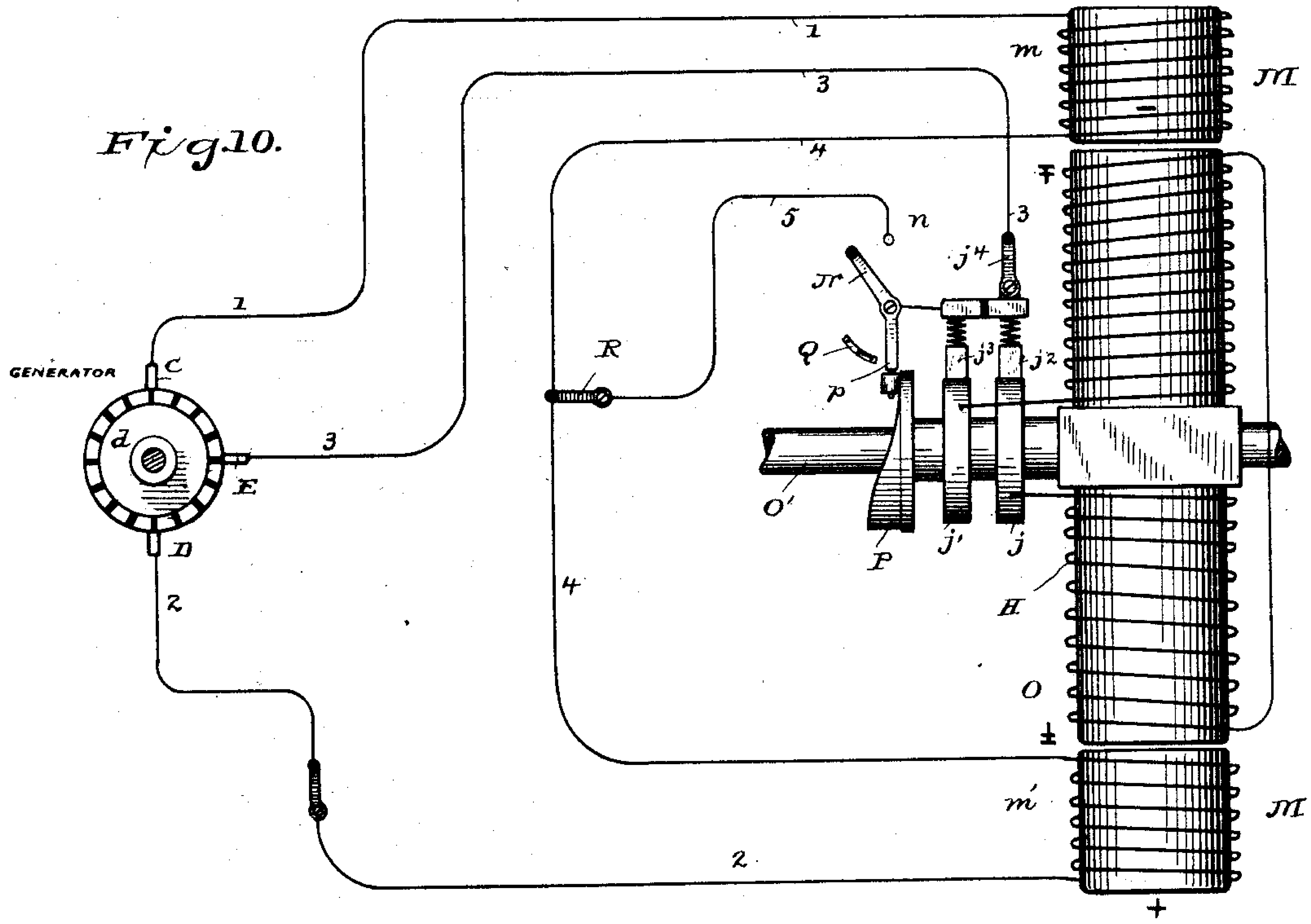


Fig. 11.

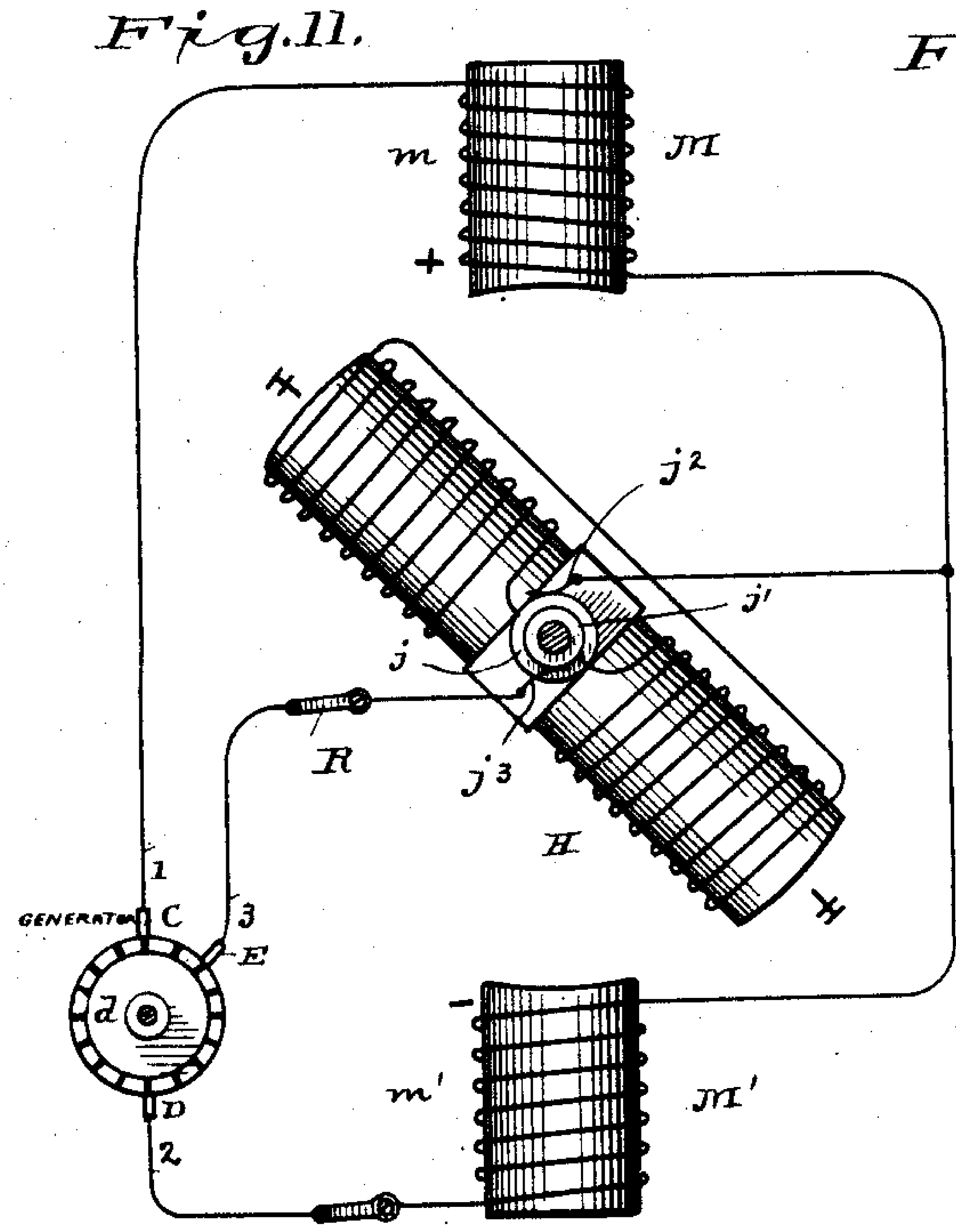
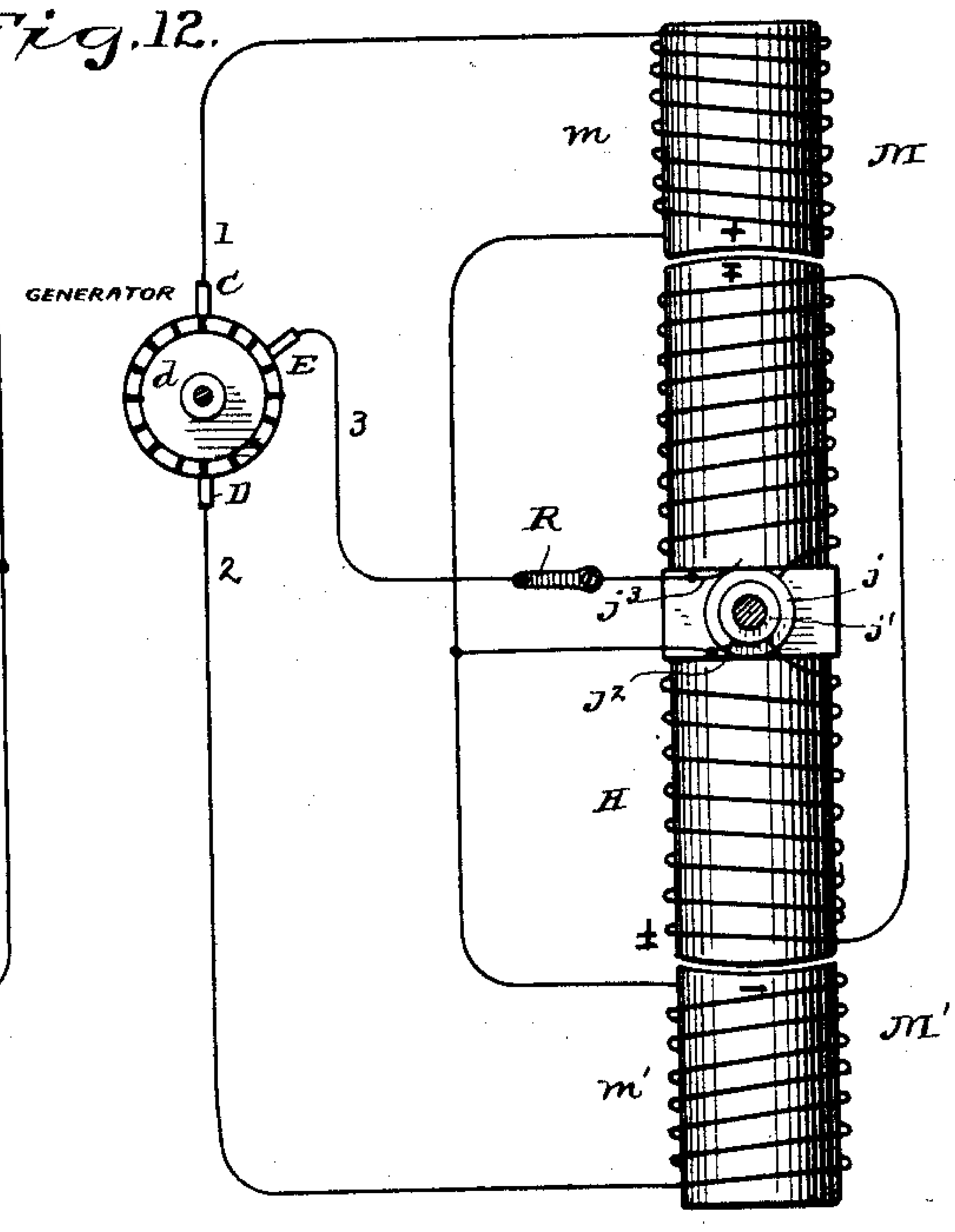


Fig. 12.



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UNITED STATES PATENT OFFICE.

CHARLES J. VAN DEPOELE, OF LYNN, MASSACHUSETTS.

PULSATORY-CURRENT MOTOR.

SPECIFICATION forming part of Letters Patent No. 422,856, dated March 4, 1890.

Application filed May 22, 1889. Serial No. 311,717. (No model.)

To all whom it may concern:

Be it known that I, CHARLES J. VAN DEPOELE, a citizen of the United States, residing at Lynn, in the county of Essex and State of Massachusetts, have invented certain new and useful Improvements in Pulsating-Current Motors, of which the following is a description, reference being had to the accompanying drawings, and to the letters and figures of reference marked thereon.

My invention relates to improvements in electro-dynamic motors.

A motor constructed according to the present invention is operated without the use of a sectional commutator, and is especially designed to be operated by currents supplied from a generator of the type shown, described, and claimed in my application, Serial No. 304,544, March 23, 1889.

My improved motor is neither a continuous-current machine *per se* nor an alterating-current machine, but is, so to speak, a combination of both, in that the supply-current is always of the same polarity in the field-magnets and continually changing or reversing in the armature-circuit, or vice versa. This apparently paradoxical arrangement results in continually shifting one set of poles with respect to the other, whereby I am enabled to secure continuous rotary motion without the use of the very objectionable sectional commutator, and, moreover, while the machine constructed according to the present invention must be moved in synchronism with the pulsations of the supply-current, it will develop a powerful torque at starting and fulfill all the requirements of a continuous-current machine. The peculiar nature of the supply-current would ordinarily result in an oscillatory motion of the armature at starting. I find, however, that by providing a simple mechanical or electrical contrivance this tendency is entirely overcome and the armature readily started in either direction, when it will continue to move in the desired direction so long as current is supplied. Broadly considered, the system comprises a three-wire supply-circuit. Two of the three conductors are connected to stationary positive and negative commutator-brushes upon the commutator of the generator, and the field-magnet coils of the motor are in circuit therewith and receive current of continuous polarity therefrom. One terminal of the armature-circuit is connected with the field-magnet circuit, the other terminal thereof being connected to the third-circuit conductor, itself connected to a moving commutator-brush mechanically rotated about the commutator-cylinder and alternately approaching and receding from the main stationary positive and negative commutator-brushes. From this it will be understood that the current flows continuously in the same direction through the field-magnet coils of the motor, but that the armature-circuit is controlled by the moving brush, and that as said brush is carried around the commutator the current flowing in said armature-circuit will first be in one direction—that is, when the moving brush is in the vicinity of the fixed positive commutator-brush—and then in the other direction when said moving brush is nearest the main stationary negative commutator-brush.

The simplest form of the invention comprises a motor having two field-magnet poles and an armature having two poles, with which arrangement the highest possible speed will be developed with a stated number of impulses per minute. A stronger torque at starting but a slower speed is, however, produced by the use of a larger number of poles both in the field-magnet and armature. The armature may have four poles to the field-magnet two, or the number of poles in the field-magnet and armature may be equal. It will be apparent, therefore, that the invention may be considerably modified so long as the principle of operation which comprises a reversal of the polarities is only one element of the motor, whether armature or field-magnets be retained.

Several forms of motor embodying the invention are shown in the accompanying drawings and will be referred to in the following detailed description and appended claims.

Figures 1 and 2 are diagrammatic views of a motor embodying the invention and provided with mechanical means for determining the direction of rotation of the armature thereof, said means being shown in different positions in the figures. Fig. 3 is a view in elevation showing a generator arranged with a revolving brush to produce currents for operating the motor. Fig. 3^a is a plan view of the commutator-brush-rotating mechanism. Fig. 4 is a side elevation of a motor differing from the motor seen in Figs. 1 and 2 principally in having a four-pole instead of a two-pole armature. Figs. 5 and 6 are diagrams showing the circuits of the motor and the directions of the flow of current in the armature during two successive phases. Fig. 7 is a diagrammatic view of a motor, showing a different construction of a two-pole machine. Fig. 8 is a diagrammatic view of a motor, the armature and field-magnets of which are each provided with four poles. Fig. 9 is a diagrammatic view of a motor differing from those previously referred to principally in being arranged to develop eight poles in the armature and a similar number in the field. Fig. 10 is a digrammatic view of a two-pole motor, together with circuits and connections whereby the direction of rotation thereof can be controlled electrically. Figs. 11 and 12 are diagrammatic views of a two-pole motor, together with circuits and connections therefor.

The species of current for which the present motor is adapted may be furnished by a generator, which, as stated in my said prior application, may consist of any type of continuous-current machine. One form is, however, shown in Fig. 3 for completeness of illustration. As there seen, the armature A rotates between polar extensions B B′ of the field-magnets *b b′*, which said field-magnets may be separately excited in any convenient manner, or may be placed in shunt relation to the fixed positive and negative commutator-brushes C D. Main circuit-conductors 1 2 extend from the positive and negative commutator-brushes, respectively, and a third conductor 3 is connected to a commutator-brush E, which is arranged to be rotated about the commutator-cylinder *d* by appropriate mechanical means—for example, as described in my said prior application. The brush E, as seen in Fig. 3, is in position equidistant between the stationary brushes, and therefore the minimum current will be passing in conductor 3 and the maximum in conductors 1 2. As the brush E approaches the brush C, moving in the direction of the arrow, positive current will be collected thereby and flow into the third wire, and the positive impulse will increase until the traveling brush E is nearest to the fixed brush C, decreasing as the said brush moves away therefrom in its travel about the commutator. When past the opposite equidistant point, as the brush E approaches the negative main brush D negative current will flow therethrough until it has passed the said negative brush and again reaches the position shown in Fig. 3. The current flowing in conductor 3, or the third wire, will therefore be first in one direction and then in the other, or positive and negative—that is, the armature-circuit will be alternately in shunt with each half of the field-magnet circuit. While the rotating brush will detract from the sum of the current flowing in the main conductors from the stationary brushes, it will never entirely deprive them of current, and, therefore, while the potential may rise and fall in said conductors, any body of iron wound with conductors in circuit with said main conductors will be continuously magnetized with a constant polarity, which, although it may rise and fall to some extent, will never be interrupted, and which can be rendered practically constant by increasing the mass of the cores of the said field-magnets.

The foregoing is illustrated in Figs. 5 and 6, in which F G represent the coils of the field-magnet of a motor and H the coils of the armature thereof. The arrows upon said coils F G indicate the constant flow of current from the fixed brushes of the generator. One terminal *h* of the armature-circuit is connected to the field-magnet circuit, the other terminal being attached to the conductor 3, connected with the rotating brush E.

When, as seen in Fig. 5, the brush E is receiving current from the positive portion of the commutator-cylinder, the said current will flow through conductor 3 and armature-coils E in the direction indicated by the arrow, returning to the generator through field-magnet coil G and the negative commutator-brush.

As seen in Fig. 6, the succeeding phase is flowing through the motor and the conditions in the armature-circuit are reversed. In this instance the brush E is nearest to the negative commutator-brush and current is returning into the generating-armature therethrough, instead of flowing out, as in Fig. 5. Under these conditions the armature-coils H receive current from the field-magnet coils F, the current so diverted from the field-magnet circuit passing out through the armature to conductor 3 and thence to the generator through brush E.

As seen in Figs. 1 and 2, F G are the field-magnet coils wound upon suitable cores *f g*. The cores *f g* are magnetically united to positive and negative polar extensions I I′. The armature-conductor H is wound upon a suitable laminated or subdivided armature-core J, mounted in rotative relation to the field-magnet poles I I′. The armature-terminals *h h′* are connected to a pair of annular metallic contact-surfaces *j j′*, upon which bear contact-brushes j^2 j^3. The brush j^2 is connected by wire h^2 with the field-magnet conductor, and the brush j^3 is connected to the conductor 3, extending to or in circuit with the traveling commutator-brush E of the generator.

It will be apparent that, the field-magnet poles being of constant polarity and the poles in the armature of alternating polarity, if the armature of the motor when at rest is energized by an alternating current it would be magnetized in one direction by one phase of the supply-current and then attracted toward the fixed field-magnet poles. Being energized in an opposite sense by the succeeding phase, said armature would be repelled thereby, and instead of moving forward with a continuous motion would oscillate between the poles of the field-magnet. I find, however, that at starting by simply preventing the effect of the second phase the similar attraction of the poles produced by the succeeding phases will start the armature in the desired direction and impart sufficient momentum thereto to secure continuous rotation, for just as soon as rotation is established one set of armature-poles will be attracted toward the field-magnet poles, and the opposite poles set up in the armature by the succeeding phase will, if they have passed the field-magnet poles, be first repelled thereby and then attracted by the poles in advance, which are then of opposite sign, and so on, be first attracted and then repelled.

Any form or species of clutch may be employed to prevent backward rotation of the armature (or the effect of the reverse phase) at starting, the form here illustrated comprising a pivoted lever K, provided at its lower extremity with a centrally-pivoted double-contact pawl k, pivotally connected to the lever K and normally held at right angles thereto by a spring k'. The lever K is suitably mounted upon an extension of the motor-frame, (indicated in dotted lines,) and the pawls k may either of them engage the ratchet K′, mounted upon the armature-shaft a. With the lever K in the position shown in Fig. 1 the armature will rotate in the direction of the arrow.

Fig. 2 shows the lever K in the opposite position when the armature will rotate in the contrary direction. The starting-lever K is only used for a short period, or until the armature has obtained synchronism, when it is moved into the position indicated in dotted lines in Fig. 1, when both pawls are out of engagement with the ratchet.

Although not shown in the remaining figures of the drawings, it will be understood that some kind of contrivance is needed to restrain the undesired movement of the armature at starting.

The motor seen in Fig. 7 differs from the form shown in Figs. 1 and 2 chiefly in the construction of the armature, which, instead of being of the Gramme type, arranged for two poles, is in the form of an elongated magnet rotatably mounted within the field-magnet and oppositely magnetized at its extremities by coils G′ G^2, wound thereon, the circuits and connections being similar to those already described.

Fig. 4 shows a form of motor comprising a two-pole field-magnet, as seen in Figs. 1 and 2; but the armature L is of the four-pole type, and may be constructed with four arms l' l^2 l^3 l^4 of suitably subdivided iron. Said arms are provided with windings H′ H^2 H^3 H^4, all in circuit with the main conductor 3 and arranged and connected to produce diametrically-opposite poles at the extremities of the said four arms, which extremities are arranged to rotate in close proximity to the poles I I′ of the field-magnet. The armature-conductors are connected to form a single circuit, one terminal of which is connected to the ring j, the other to the ring j'. A contact-brush j^2 bears upon the ring j and is connected by suitable conductor h^2 with the field-magnet circuit. The ring j', representing the other armature-terminal, is in connection with the main third conductor through brush j^3 and suitable connection.

My improved motor being synchronous in operation, when the field-magnet and armature poles are equal in number, the speed of the armature will correspond with the pulsations of the supply-current. Where, however, as in Fig. 4, the armature has twice as many poles as the field-magnet, the speed of the armature will be exactly half that of the number of pulsations of the supply-current.

Various different motive effects may be secured and machines constructed with reference to particular service in view of the principles here stated. By increasing the number of poles in the armature and in the field-magnet the speed of the armature will not be affected, but its torque may be greatly increased. For constant speed-motors, therefore, the simplest and cheapest form comprising the fewest number of pole-pieces, both in field and armature, may be adopted; but where the motor is constantly required to start a heavy load—as, for example, in electric railways—it will be found desirable to provide the motor with an increased number of poles, both in the armature and field-magnets, in order to have the desired torque at starting.

In Fig. 8 is seen a motor provided with four polar extensions I I′ I^2 I^3 united by suitable cores and wound with conductors included in circuit between the main conductors 1 and 2. The armature of this motor is similar to that seen in Fig. 1, except that the conductor H thereon is arranged and connected to produce four instead of two poles in the core J, as indicated by the signs.

A duplication of the motor seen in Fig. 8 is found in Fig. 9, where is seen a machine provided with eight polar extensions I′ I^2 I^3 I^4 I^5 I^6 I^7 I^8, connected by suitable cores and energized by conductors wound thereon and connected between the main supply-conductors 1 and 2, substantially as hereinbefore described and as indicated in diagrams, Figs. 5 and 6. The armature seen in said figure is similar to that shown and described with reference to Fig. 1, except that the conductor H upon the core J thereof is so disposed as to produce eight poles therein, as indicated by the signs. The usual signs are used throughout to indicate the positions of the poles both in field-magnets and armatures, the poles established by one phase being indicated in full lines and those of the succeeding phase in dotted lines.

A form of automatic electric switch for use in starting the motor, and which may be substituted for the mechanical device hereinbefore referred to, is shown in Fig. 10 in connection with the simplest form of my improved motor. As there seen, M M′ are the field-magnets, which are provided with coils *m m′* in circuit with the main conductors 1 and 2, extending from the stationary brushes of the generator. 4 represents the bridge-conductor, by which the coils of the field-magnets are connected and the main circuit closed.

O represents a two-pole armature wound with magnetizing-coils H. The said coils are connected to form a single circuit the terminals of which are brought to two annular metallic contact-surfaces j j'. Contacts j^2 j^3 are held in contact with the rings j j', and one of said brushes—for example, j^2—is connected by switch j^4 and conductor 3 with the rotating brush E. The brush j^3 is connected to a movable switch N, adapted to engage a contact *n*, connected by conductor 5 with the bridge-conductor 4. When the switch N is upon the contact *n*, the armature-circuit is closed, and currents will flow therethrough in alternation, precisely as hereinbefore described. It is obvious, however, that if said circuit is opened during the period of every alternate phase current of only one polarity will flow therethrough, and if the armature has received motion through one phase of current if the next one is prevented from exerting a neutralizing effect the said armature will be free to move forward by its momentum, which, if sufficient, will carry it into position to be again attracted by the field-magnets. A single impulse in the right direction is, however, sufficient to start the motor. A simple means for accomplishing the desired result consists in providing mechanism for throwing the switch N after one phase of current has passed and before the next is received and then closing the switch for the succeeding phase, after which it can remain closed—as, for instance, by engaging the catch Q. The contact-rings j j' are mounted upon the armature-shaft O′ and suitably insulated therefrom. A cam P is also mounted upon said armature-shaft and arranged to engage an extension *p* of the switch N, so that during one half-revolution of said armature-shaft the cam will move the switch N into engagement with its contact *n* and close the armature-circuit. If, therefore, at starting the armature O is in the position indicated in Fig. 11—that is, at an angle with respect to its field-magnets—and if at that moment the switch N is open, the iron cores of the armature will be powerfully attracted to the field-magnets, when by the partial rotation the cam will close the switch N, and current flowing in the armature will then be repelled from the field-magnets, the circuit closed, and rotation established. The magnetism in the armature set up by the attraction of the field-magnets will of course diminish as it moves away therefrom; but being free from the restraining influence of current of opposite polarity it will be carried forward by its momentum, and upon the closing of the switch N it will receive another impulse and be again attracted or repelled.

It will be obvious that the results just described may be accomplished magnetically, as by the closing of a switch in the armature-circuit, and thus depriving it of current. Such an arrangement is indicated in Figs. 11 and 12, a switch R being provided in the armature-circuit, by opening which at starting the armature will move forward as a bar of iron. When once started, the switch R is closed and the machine will continue to operate on the principles hereinbefore set forth.

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

1. An electro-dynamic motor having two circuits separately connected to the source of current, one circuit being connected at an intermediate point to the other, and separate means for directing current of constant polarity through one circuit and of alternating polarity through the other.

2. An electro-dynamic motor having two circuits, one including the field-magnet coils and the other including the coils of the armature, and means for placing one of the said circuits in shunt relation alternately with either half of the other circuit.

3. The combination, with an electric motor having two circuits, one arranged to receive continuous currents and the other currents of alternating polarity, of a generator supplying both pulsatory and continuous currents and circuit-connections between the generator and motor, whereby currents of one polarity are supplied to one of the motor-circuits and currents of alternating polarity to the other of said circuits, substantially as described.

4. The combination, with an electro-dynamic motor having armature and field-magnet circuits, of a generator of the continuous-current type having stationary commutator-brushes and circuit-connections therefrom to one of the circuits of the motor, a movable commutator-brush rotated about the commutator, and circuit-connections from the movable brush to the other of the motor-circuits, whereby continuous currents are supplied to one motor-circuit and alternating currents to the other, substantially as described.

5. The combination, with an electro-dynamic motor having two circuits thereon, one supplied with currents of continuous polarity and the other with currents of alternating polarity, of means for preventing oscillation of the armature or rotating member of the motor at starting, substantially as described.

6. The combination, with an electro-dy-

namic motor having two circuits, one supplied with continuous current and the other with currents of alternating polarity, of means for preventing the backward movement of the armature at starting, substantially as described.

7. The combination, with an electro-dynamic motor having two circuits, one supplied with current of continuous polarity and the other with currents of alternating polarity, whereby said motor is adapted to rotate in either direction, of a clutch mechanism adapted to engage the armature-shaft to prevent rotation in one direction, whereby action of the reverse phase is prevented and the armature free to move in the desired direction only, substantially as described.

8. An electro-dynamic motor system comprising a combined source of continuous and pulsating currents, two circuits upon the motor, one including the field-magnets and the other the armature, and connections whereby the current is divided and caused to flow always in the same direction in one circuit and alternately in opposite directions in the other circuit, substantially as described.

9. An electro-dynamic motor having two circuits arranged to be operated by the flow of currents of continuous direction in one circuit and of alternating direction in the other, and means for connecting the second circuit in shunt relation first with one side and then with the other side of the said continuous-current circuit.

10. An electro-dynamic motor having two circuits arranged to be operated by the flow of currents of continuous direction in one and of currents of alternating direction in the other, closed connections between the continuous-current circuit and the positive and negative supply-conductors, connections to one terminal of the second circuit located midway of the continuous-current circuit, and means for placing the other terminal of said second circuit in circuit with first one and then the other half of the continuous-current circuit.

In testimony whereof I affix my signature in presence of two witnesses.

CHARLES J. VAN DEPOELE.

Witnesses:

FRANKLAND JANNUS,

CHAS. L. STURTEVANT.