W. E. GOLDSBOROUGH.

ALTERNATING CURRENT MOTOR.

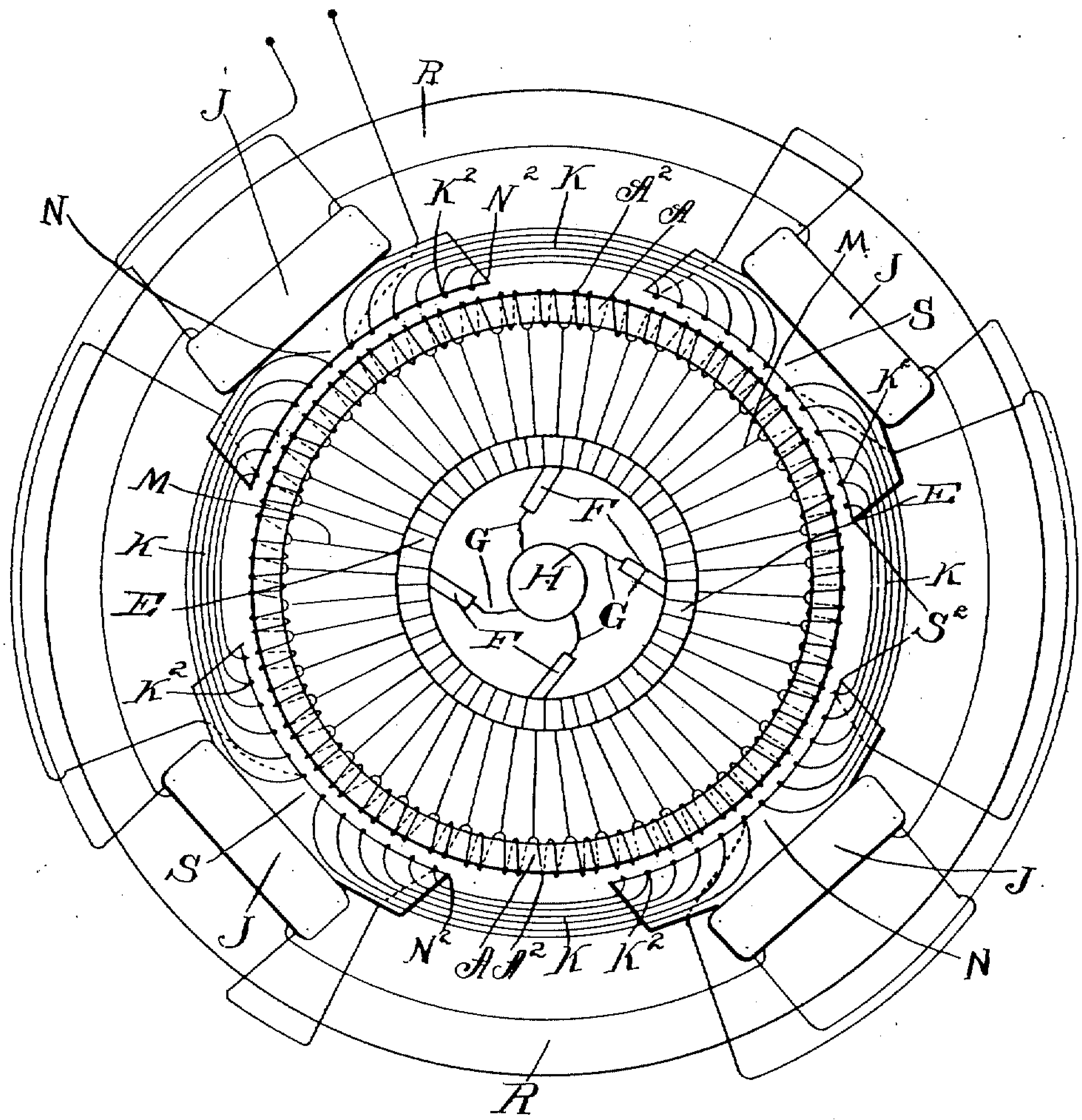
APPLICATION FILED MAY 1, 1903.

990,647.

Patented Apr. 25, 1911.

10 SHEETS—SHEET 1.

Fig. 1.



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10 SHEETS—SHEET 2.

FIG. 2.

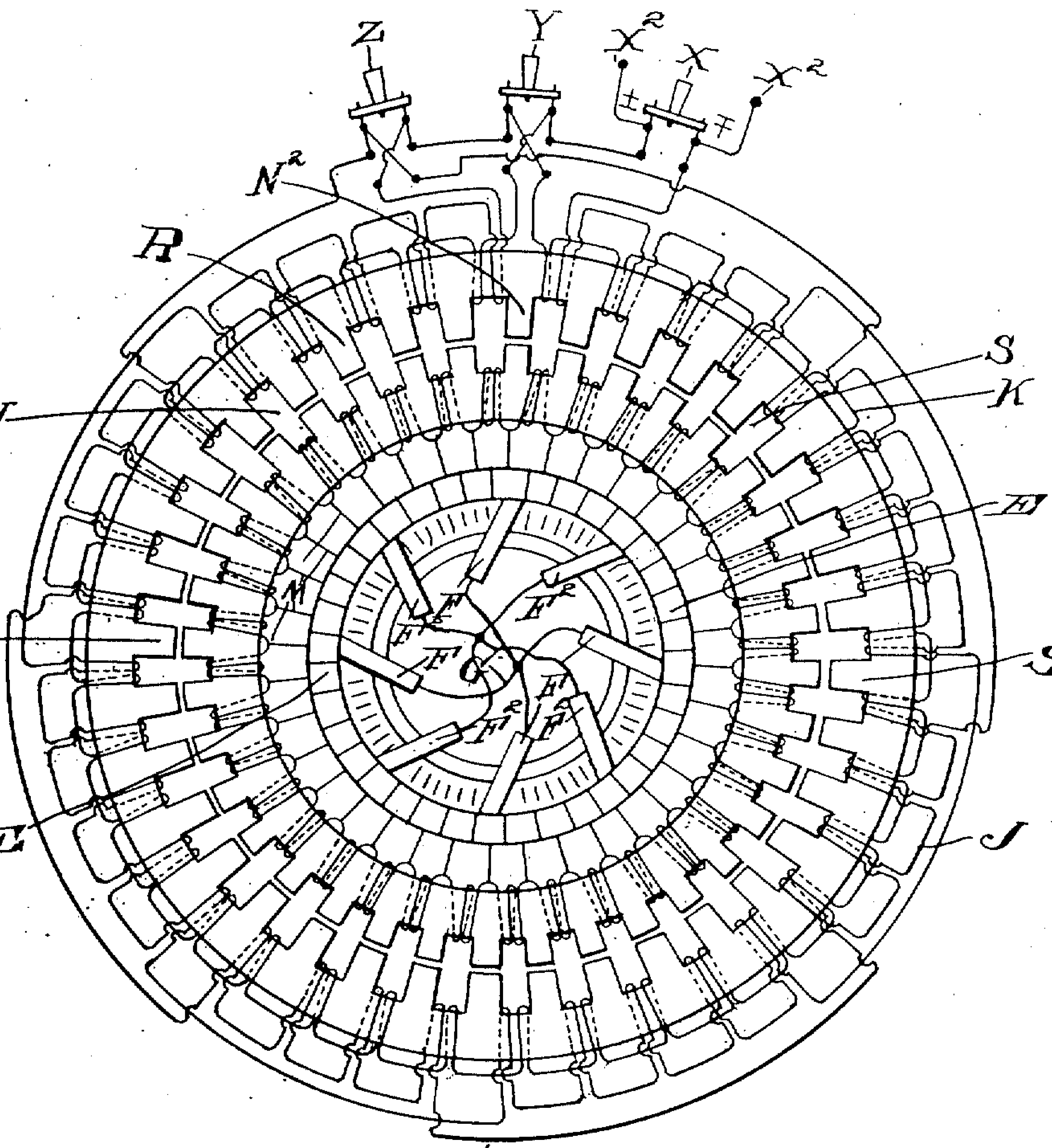

FIG. 3.

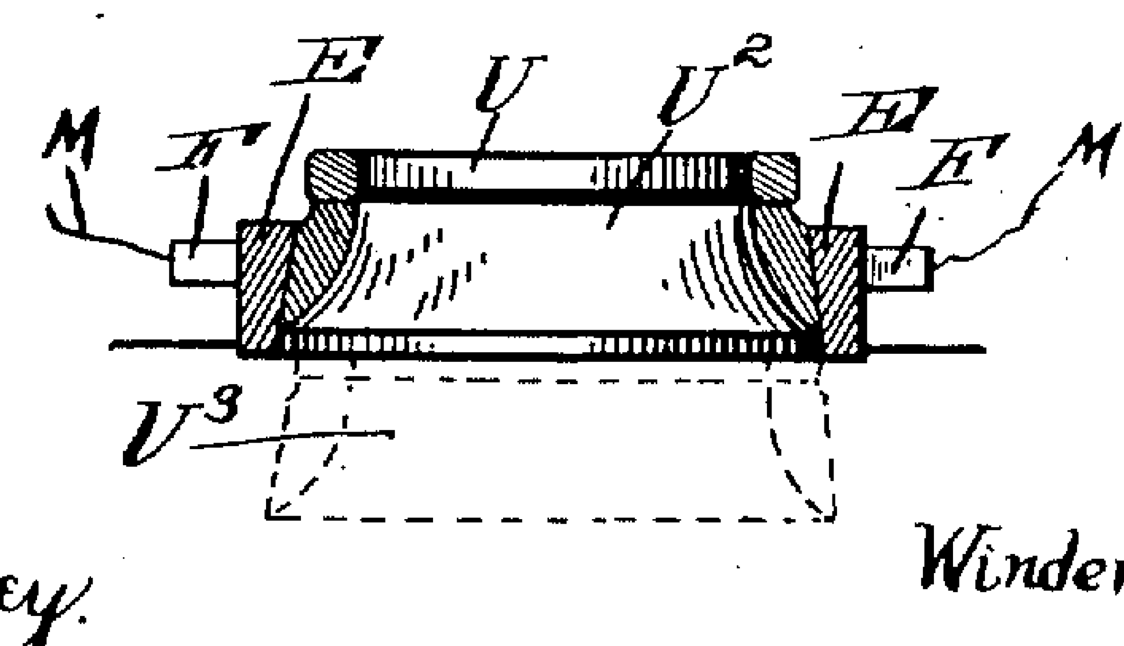

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Fig. 5.

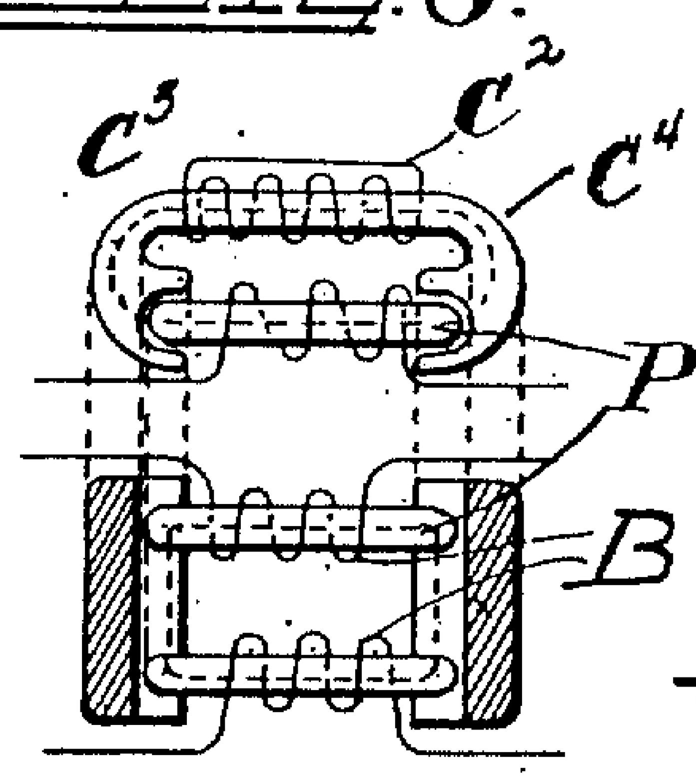


Fig. 6.

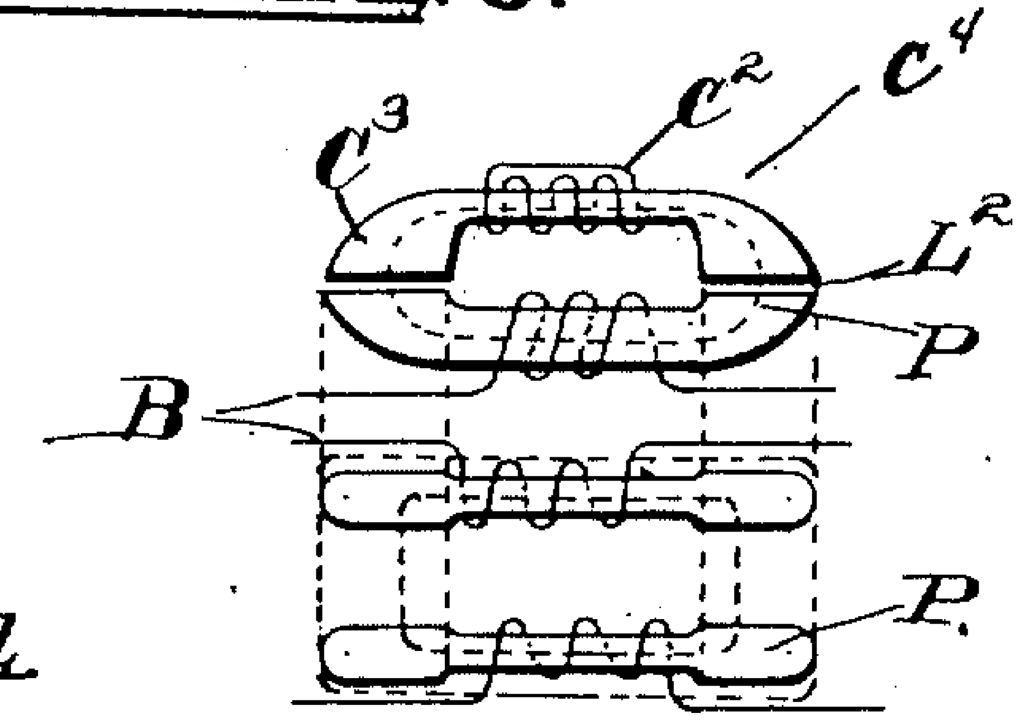
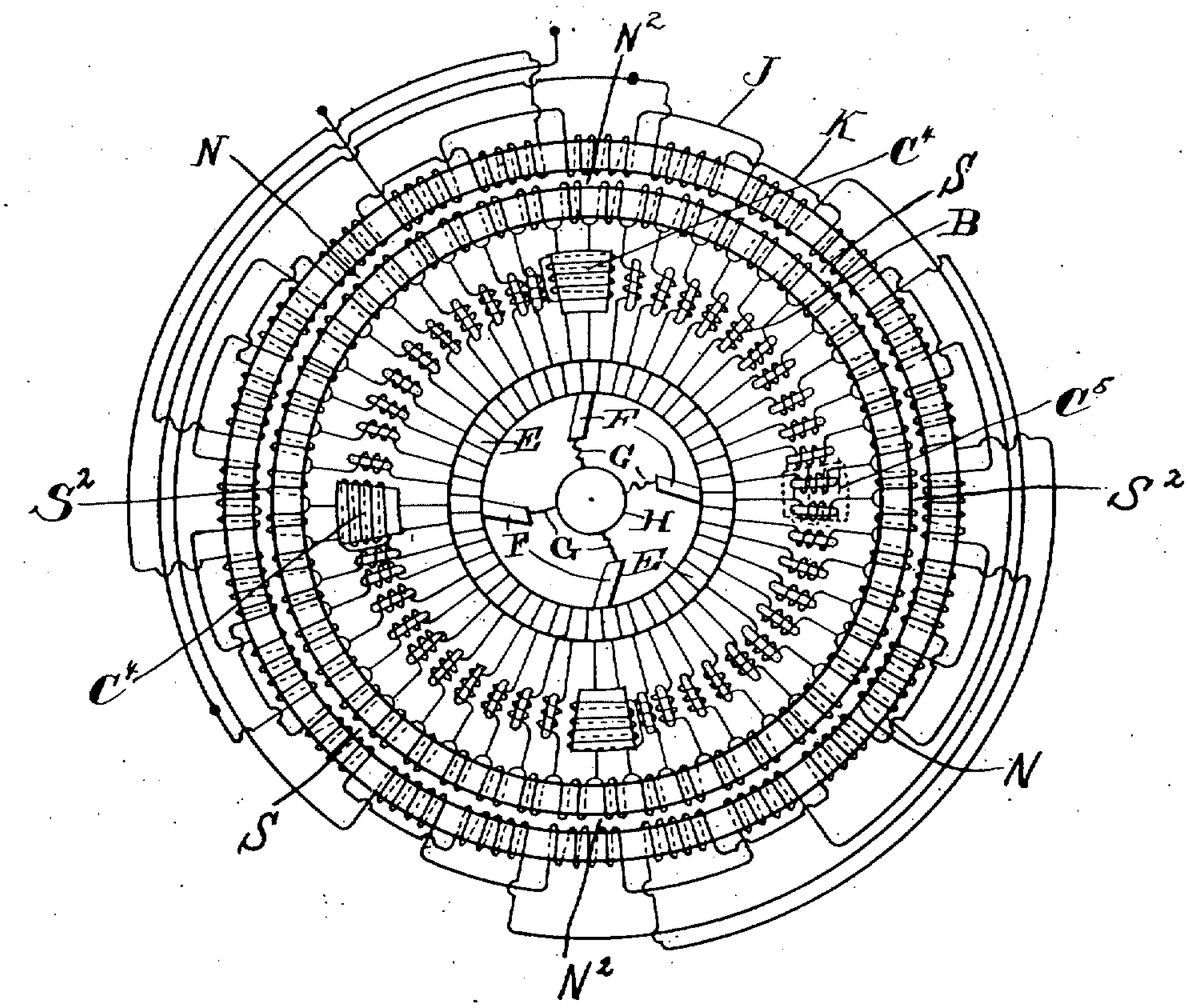


Fig. 4.



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10 SHEETS—SHEET 4.

Fig. 7.

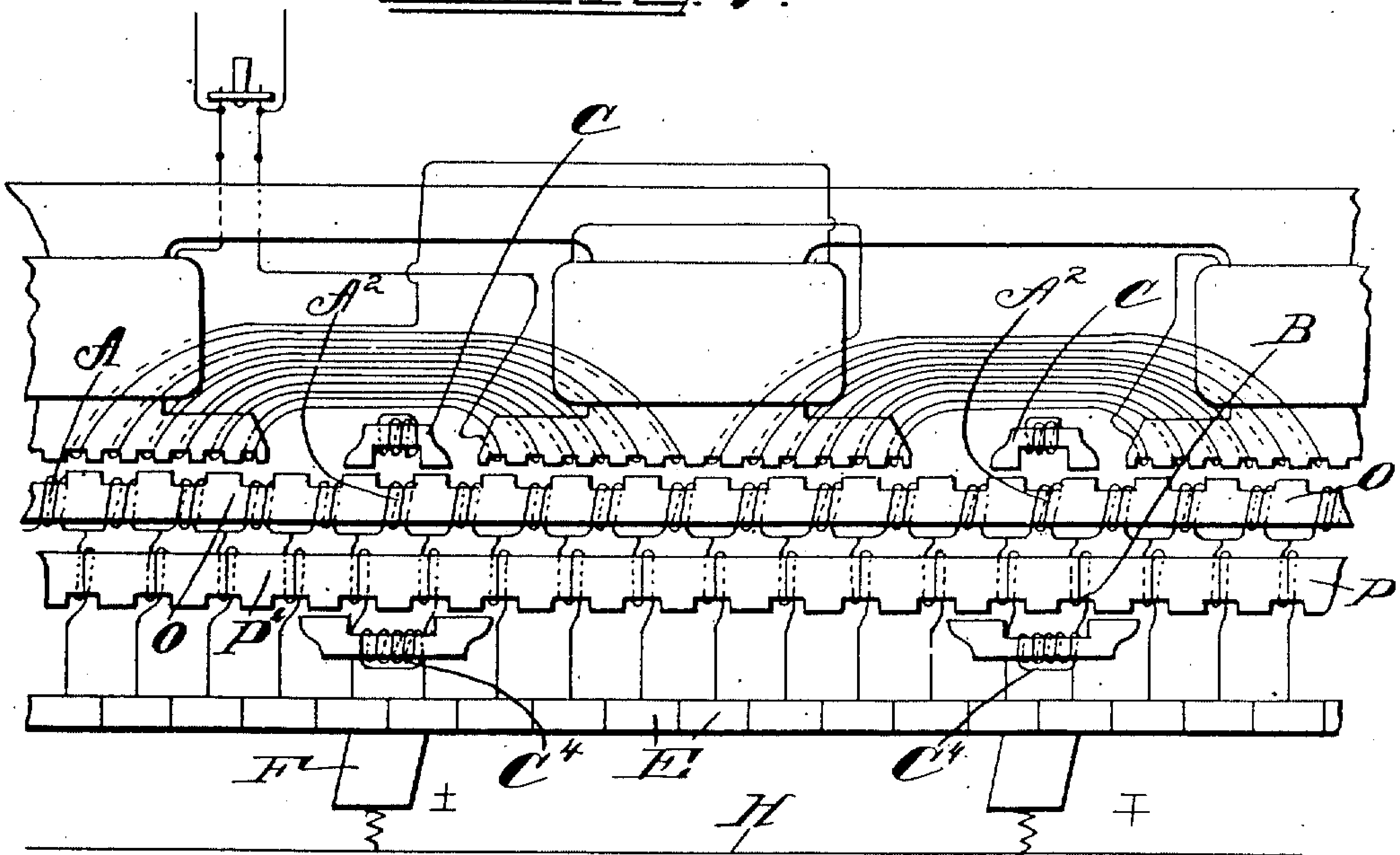
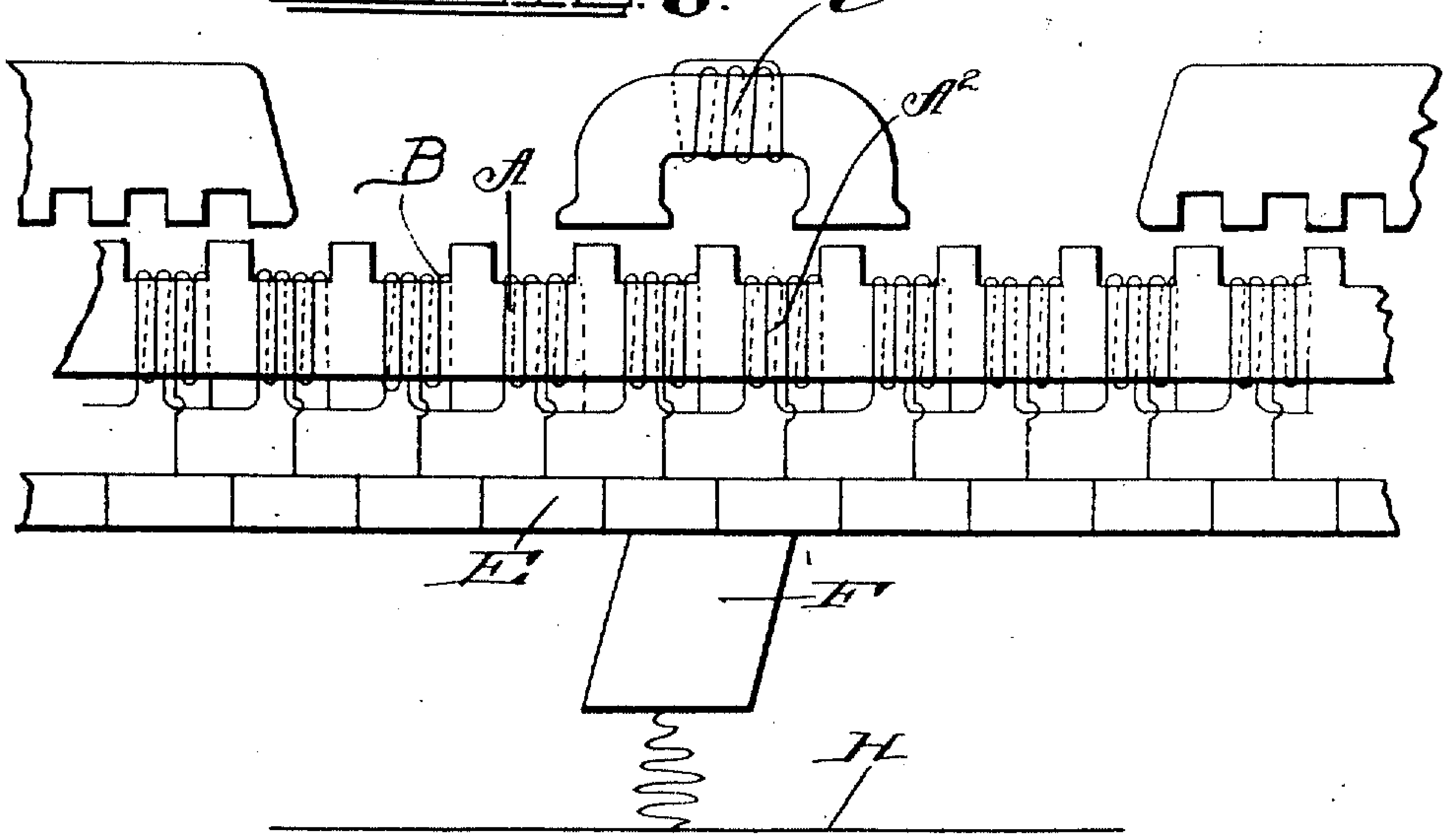


Fig. 8.



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10 SHEETS—SHEET 5.

Fig. 11.

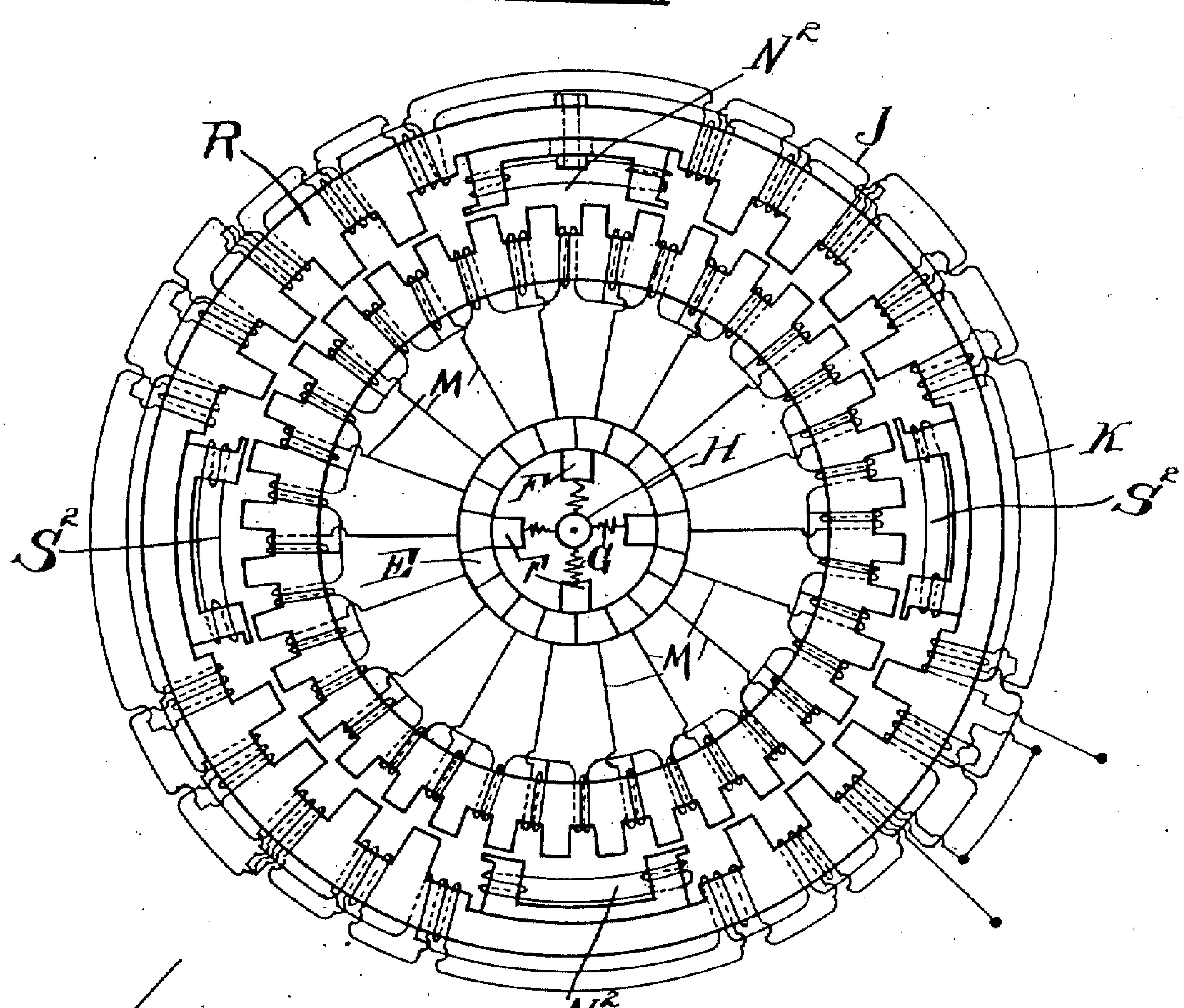
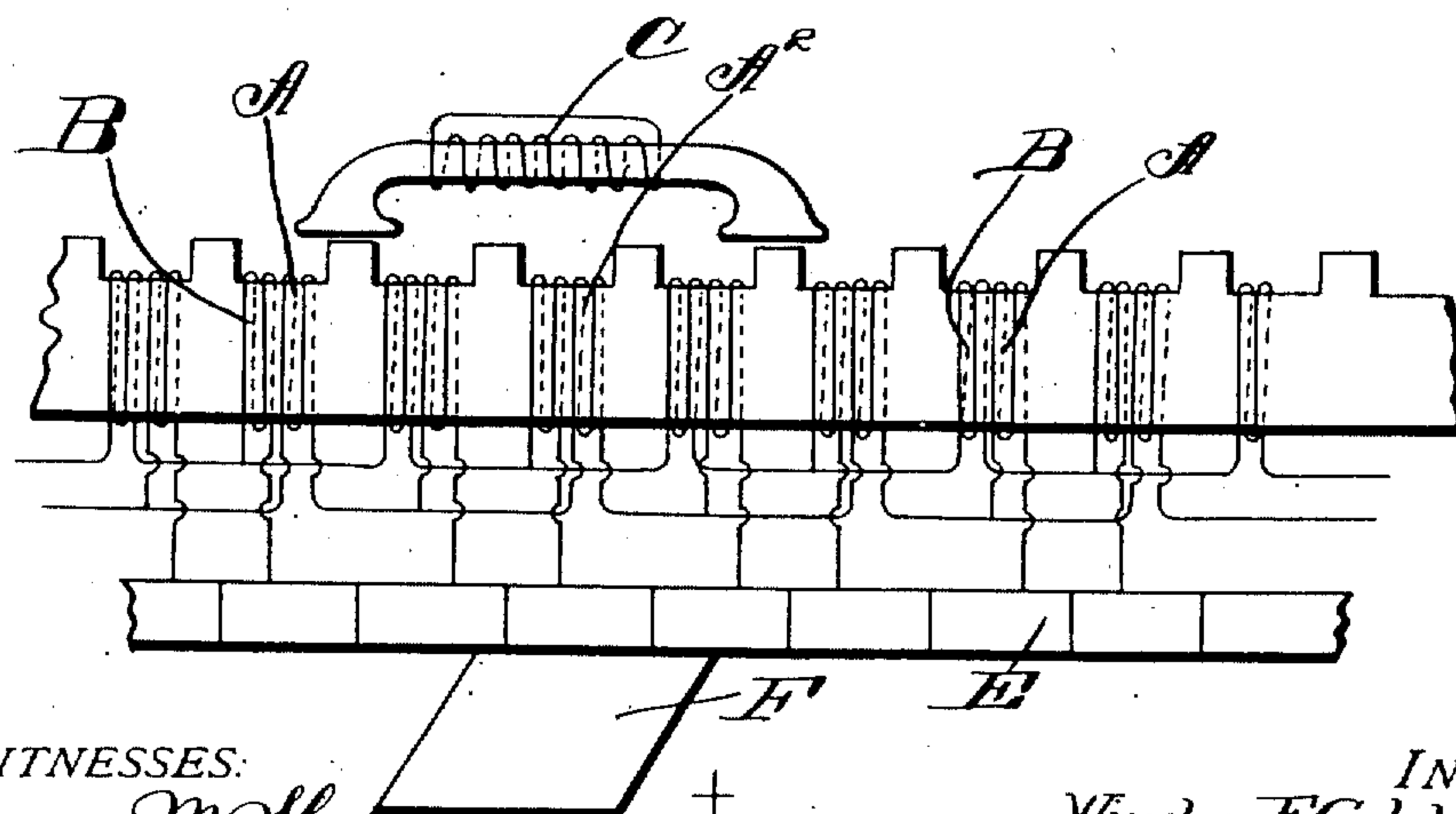


Fig. 9.



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10 SHEETS—SHEET 6.

Fig. 10.

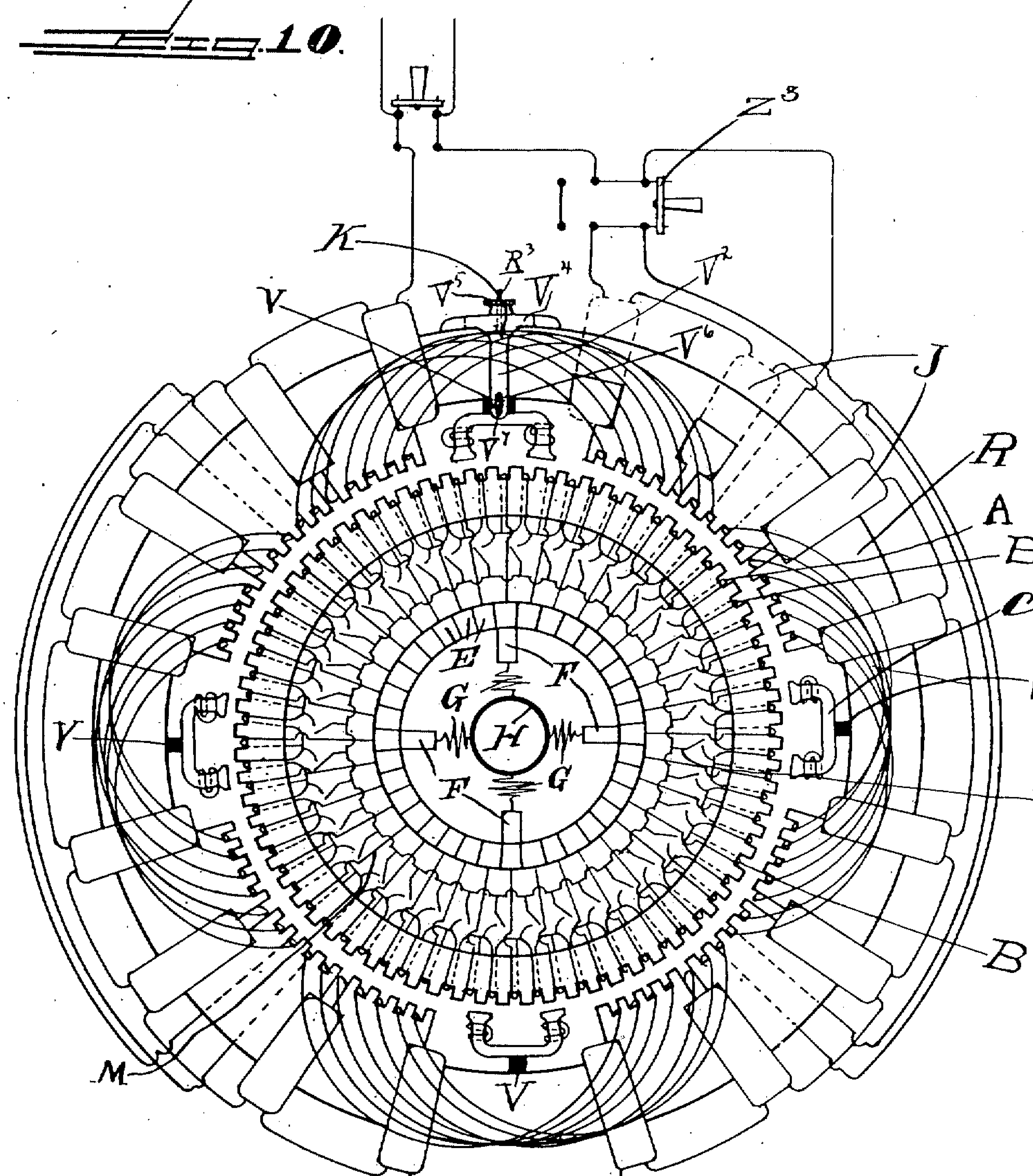
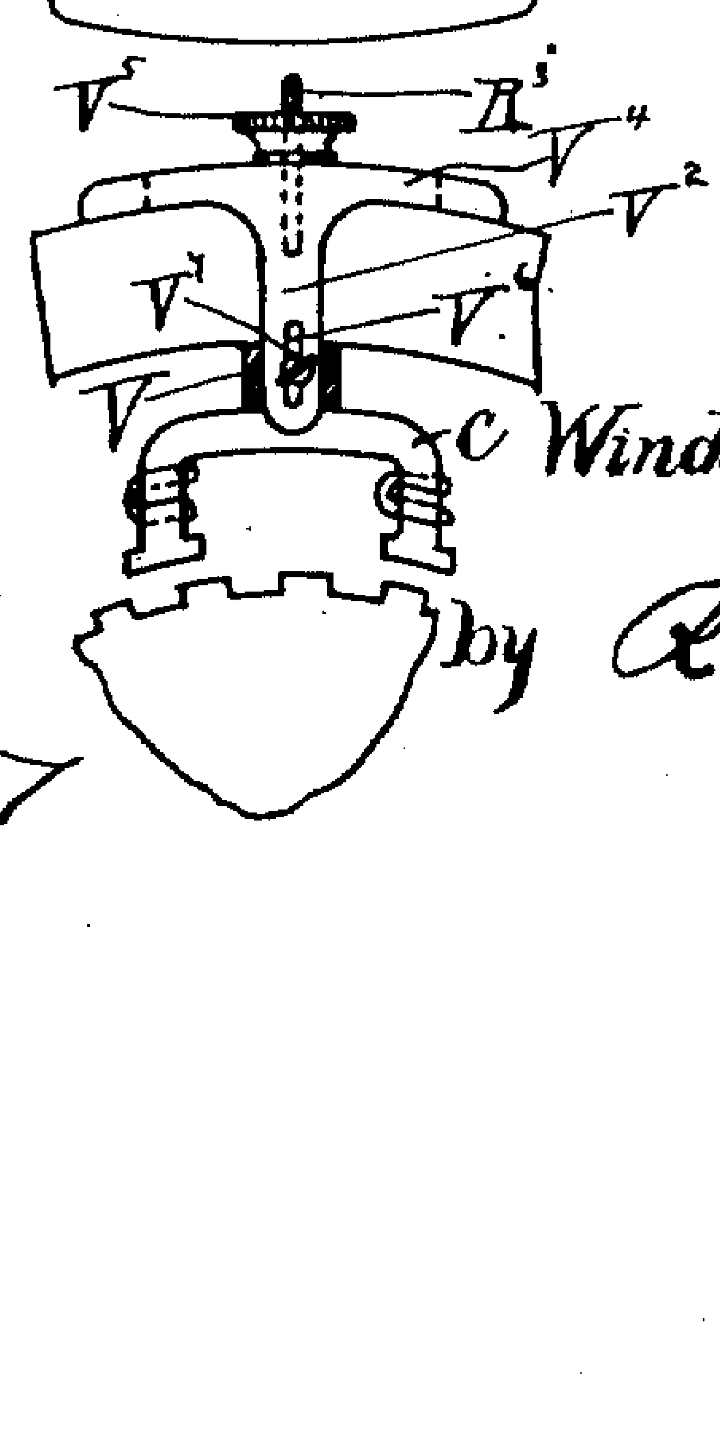


Fig. 10.b



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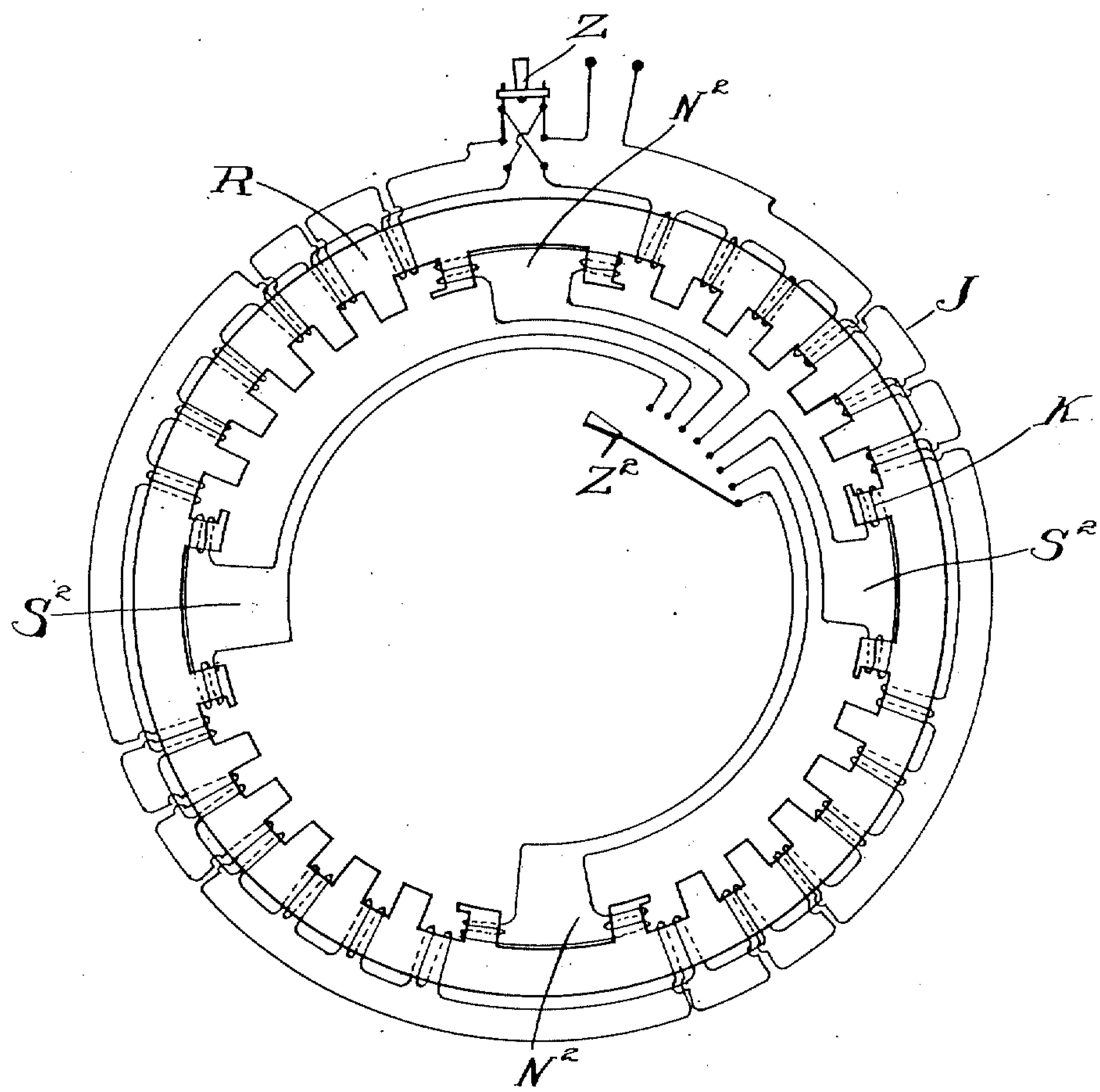
10 SHEETS—SHEET 7.

Fig. 12.



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10 SHEETS—SHEET 8.

Fig. 13.

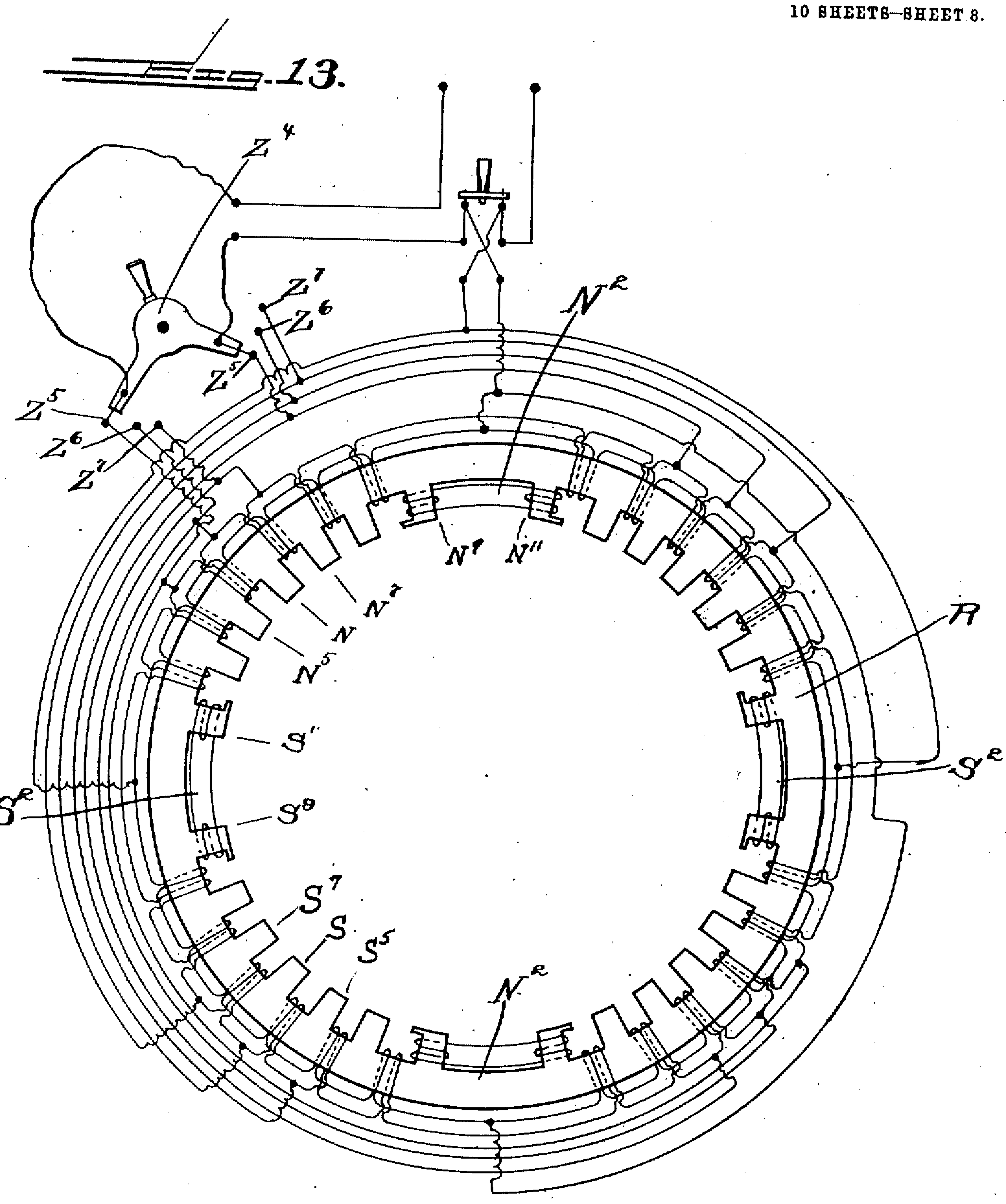

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Fig. 14.

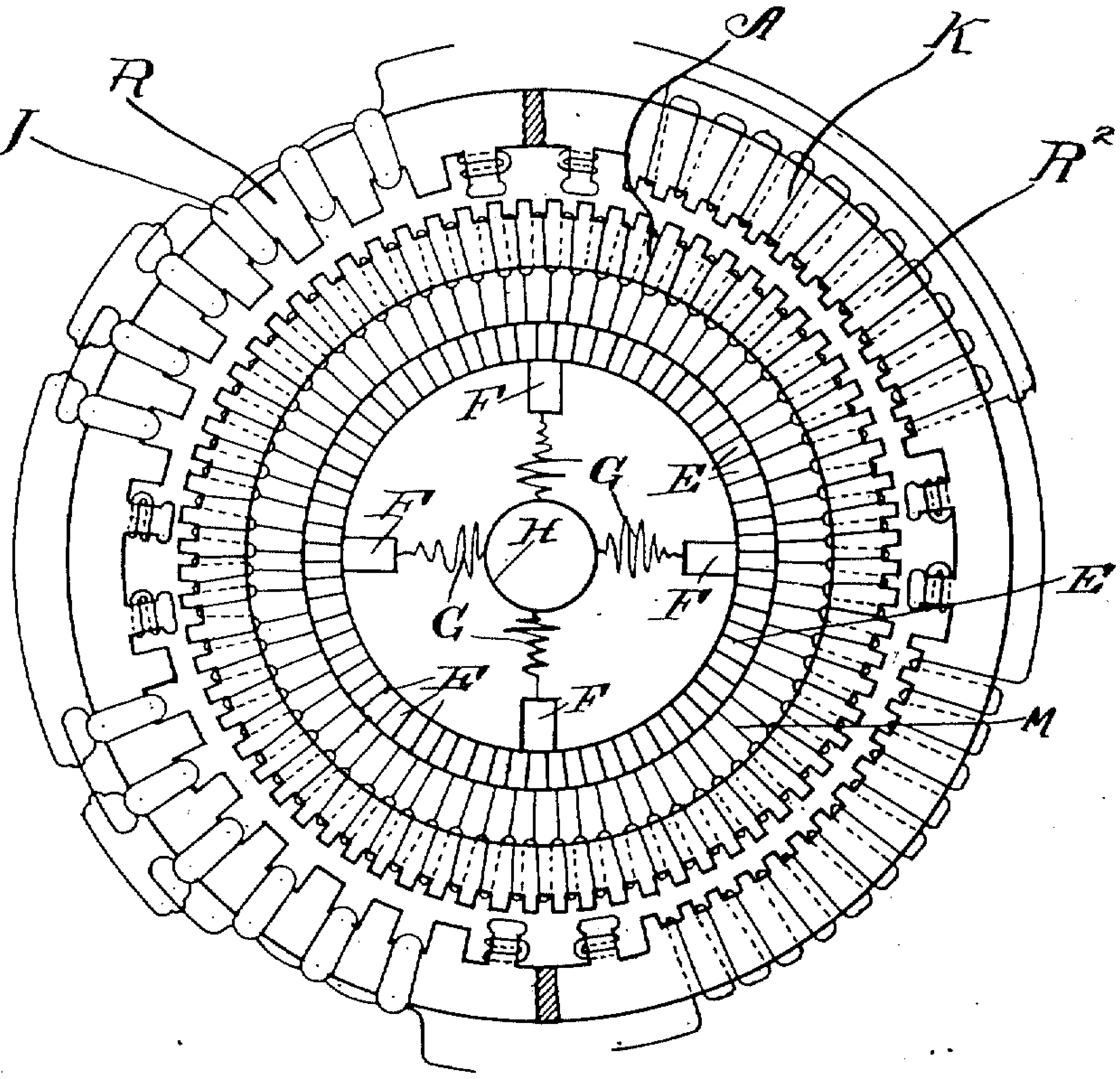
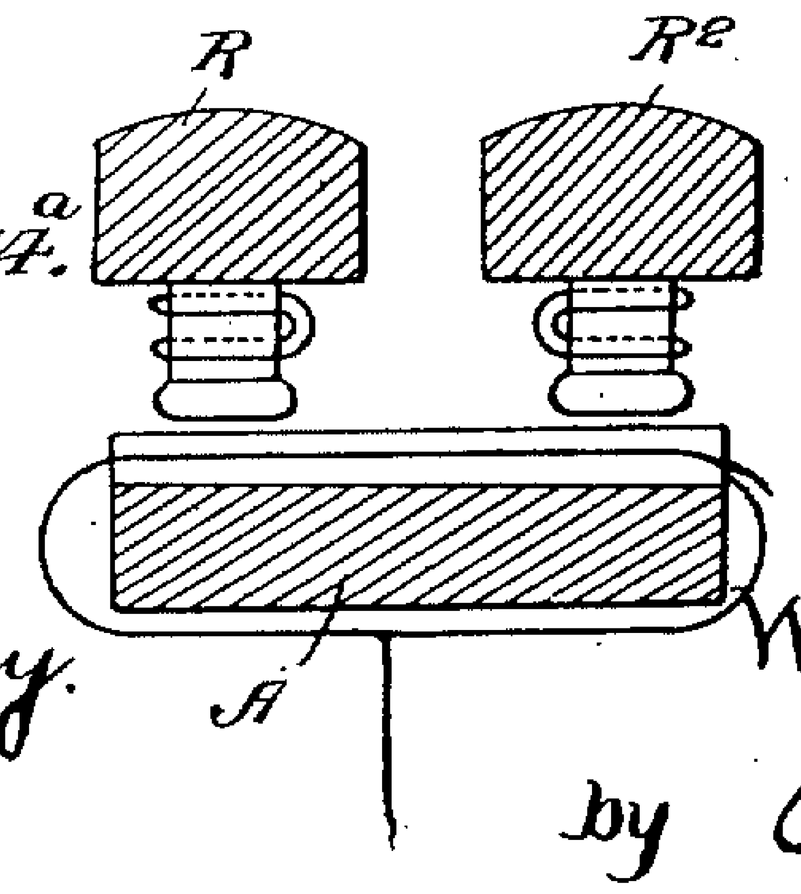


Fig. 14a.



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Patented Apr. 25, 1911.
10 SHEETS—SHEET 10.

Fig. 15.

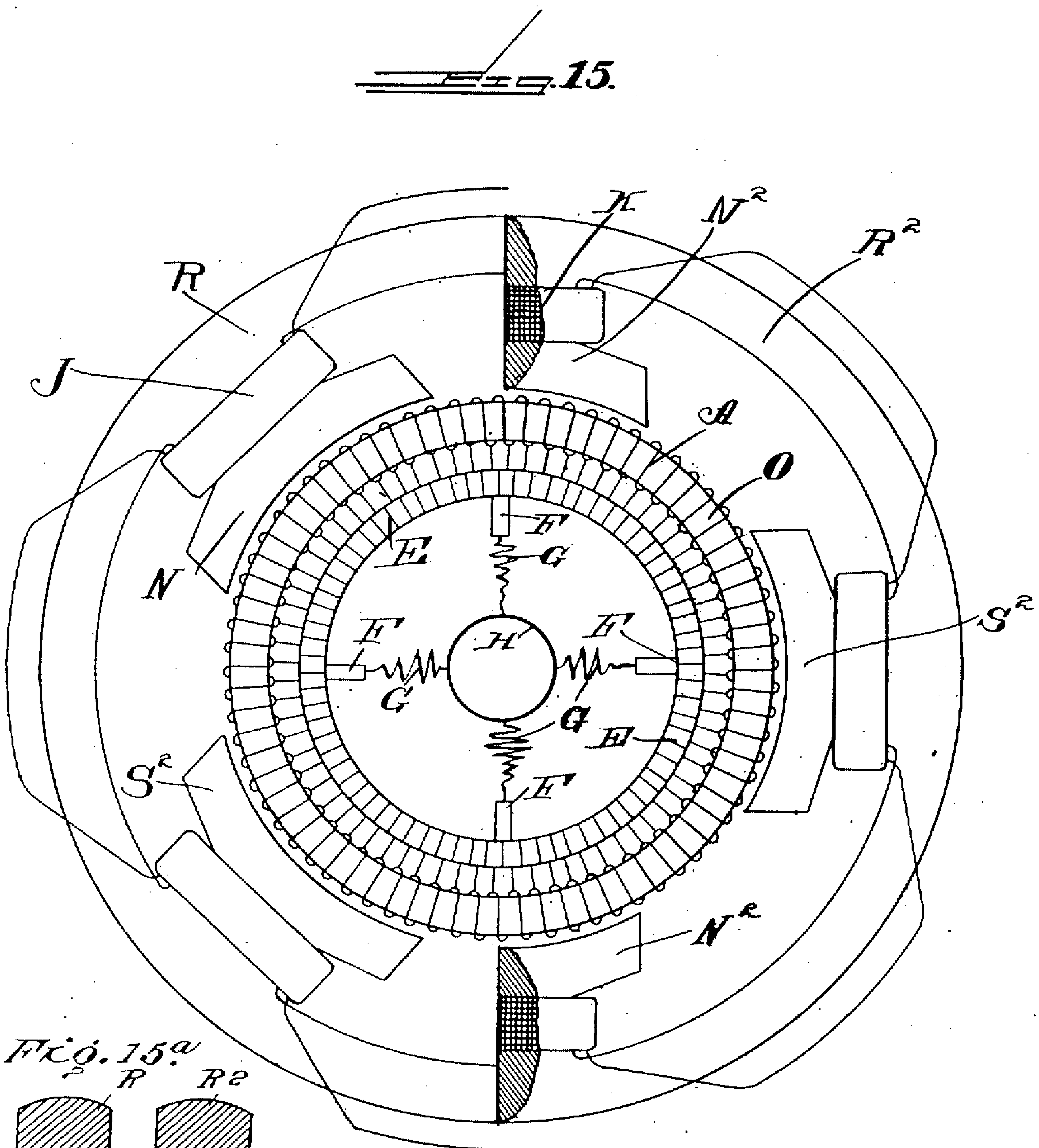
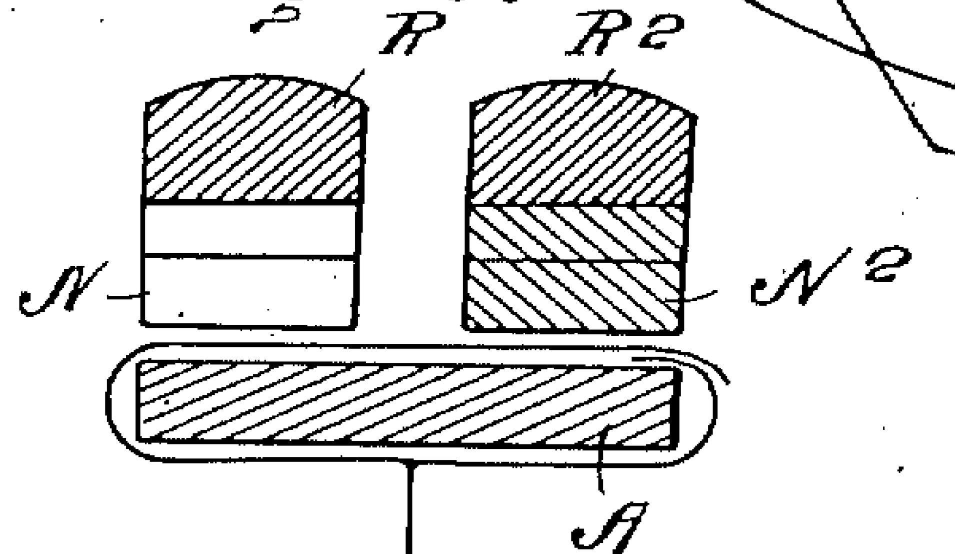


Fig. 15a.



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UNITED STATES PATENT OFFICE.

WINDER E. GOLDSBOROUGH, OF LA FAYETTE, INDIANA.

ALTERNATING-CURRENT MOTOR.

990,647. Specification of Letters Patent. Patented Apr. 25, 1911.

Application filed May 1, 1903. Serial No. 155,172.

To all whom it may concern:

Be it known that I, WINDER E. GOLDSBOROUGH, a citizen of the United States, residing at La Fayette, in the county of Tippecanoe and State of Indiana, have invented certain new and useful Improvements in Alternating-Current Motors; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

The object of the invention is to produce an improved form of alternating current motor, in which there is no electrical connection between the primary or field circuit of the said motor and the secondary or armature circuit of the said motor, and having characteristics which do not differ greatly from those of a direct current series motor. The motor may run at, below, or above, synchronous speed, when fully or partially loaded, or the motor may be run as an induction motor upon attaining synchronous speed.

In a pending application, Serial No. 136,171, I have shown and described the arrangement in common types of armatures of electric machines, of inductance neutralizing electro-magnets and commutating impedance coils. In this application, I set forth special applications of the said inductance neutralizing electro-magnets and commutating impedance coils in combination with new and useful improvements in alternating current motors.

In the drawings, forming a part of this specification, and in which like letters of reference indicate corresponding parts, I have illustrated several ways of carrying my invention into effect, it being understood that the forms of apparatus herein shown may be departed from and still be within the scope of my invention, and in these drawings: Figure 1 is a diagrammatic view, exhibiting one form of my single-phase alternating current motor, showing the field-coils and pole-face coils of the primary element and their connections, and also the coils, commutator, and connections of the secondary element, occupying the center of the figure, and also the brushes resting on the commutator of the said secondary element that are short-circuited upon one another; Fig. 2 is a diagrammatic view, exhibiting another form of the single-phase alternating current motor, the primary element forming the outer portion of the figure, and the secondary element the central portion of the figure. The magnetic circuit of the primary element is here given the form common to induction motors, and connections are shown whereby the direction of rotation of the secondary element can be reversed, or be made to run as a single-phase induction motor. Fig. 3 is a view exhibiting diagrammatically the arrangement of parts of a device whereby the commutator of the secondary element shown in Fig. 2 may be short-circuited; Fig. 4 shows another form of my invention, the primary element forming the outer portion of the figure, and the secondary element the central portion of the figure. Commutating impedance coils are here shown inserted in the commutator leads of the secondary element, and inductance neutralizing electro-magnets are shown superposed over certain of the commutating impedance coils; Fig. 5 is a view showing diagrammatically the arrangement of my commutating impedance coils with reference to my inductance neutralizing electro-magnets placed over the said commutating impedance coils at the points of commutation; Fig. 6 shows diagrammatically another arrangement of commutating impedance coils, with superposed inductance neutralizing electro-magnets; Fig. 7 shows diagrammatically my single-phase alternating current motor, in which two inductance neutralizing electro-magnets are used at each point of commutation, one of these inductance neutralizing electro-magnets being placed over the armature or secondary element in inductive relation to the armature coils between the pole-tips in the plane of commutation, and the other inductance neutralizing electro-magnet being placed in inductive relation at the points of commutation to the commutating impedance coils shown connected in the commutator leads of the coils of the armature of the secondary element, which coils are wound about a common core; Fig. 8 is a diagrammatic view of a part of a single-phase alternating current motor similar to that shown in Fig. 7, except that every slot of the secondary element contains the conductors of the secondary or armature coils, as well as the conductors of the commutating impedance coils, while above the teeth of the core of the said armature or secondary element, over the point of commutation, is placed an inductance neutralizing electro-magnet; Fig. 9 is a diagrammatic view of a part of an armature or secondary element that is provided with a double winding. By this arrangement, each slot contains the conductors of an armature or secondary coil, as well as the conductors of one of my commutating impedance coils. Above the teeth of the armature or secondary core and over the point of commutation is shown one of my inductance neutralizing electro-magnets; Fig. 10 is a diagrammatic view, showing an arrangement of the windings of the primary element whereby the polar projections and field coils shown in Fig. 7 have been dispensed with, the field coils being placed in deep slots cut into the inner side of a circular core, and the pole-face coils being placed in smaller slots cut into the faces of the teeth due to the presence of the deep slots. This field or primary core is shown fitted with inductance neutralizing electro-magnets magnetically insulated from the said core, the armature or secondary element being provided with a double winding. By this arrangement, every other slot contains the conductors of an armature coil, while the intermediate slots contain the conductors, of one of my commutating impedance coils. A device for short-circuiting the commutator leads of the coils of the armature or secondary element between the armature coils and the commutating impedance coils is shown diagrammatically, as is also a connection whereby the circuit through the pole-face coils can be cut out of the primary circuit; Fig. 10^b is a detail view, showing the arrangement of the parts for securing and controlling the position of the circular core referred to in the description of Fig. 10. Fig. 11 is a diagrammatic view of a single-phase alternating current motor, every other slot of the armature or secondary of which contains the conductors of the armature or secondary coils, while the intermediate slots contain the conductors of my commutating impedance coils connected to commutator bars and short circuited upon one another through brushes and brush leads, while above the teeth of the said armature or secondary element over the points of commutation are placed my inductance neutralizing electro-magnets, which are in this case made a part of, but separated from, the field-ring of the primary element of the said motor; Fig. 12 is a diagrammatic view of a primary element of a single-phase alternating current motor similar to that shown in Fig. 11, and provided with connections whereby the circuits of the neutralizing electro-magnets may be opened, and a connection whereby the circuits of the field or primary element can be rearranged so as to make them effective as the primary circuit of single-phase induction motor; Fig. 13 is a diagrammatic view of a primary element of my single-phase induction motor, similar to the primary element shown in Fig. 10, except that special connections are provided whereby the neutral plane may be shifted relatively to the position occupied by the inductance neutralizing electro-magnets and having the cores of the neutralizing electro-magnets made a part of the field ring of the primary element, which field ring is of the internal slotted type common in induction motor construction; Fig. 14 shows diagrammatically an arrangement of my invention whereby the primary element is made to consist of two cores placed side by side, one of these being wound with the primary field coils, and the other being wound with what I have termed the primary pole-face coils. The armature or secondary element is lengthened so as to present a continuous surface extending in front of both the primary cores; Fig. 14^a is a transverse section taken through Fig. 14; Fig. 15 is a diagrammatic view of an adaptation of my invention whereby two field rings with polar projections placed side by side and similar to those shown in Fig. 1, are used in combination with a secondary element which is so elongated as to bring its coils into inductive relation with the polar projection of both field rings. The polar projections of the two rings are so placed that the polar projections of one are at the side of, but between, the pole corners of the polar projections of the other field rings; Fig. 15^a is a transverse section taken through Fig. 15.

In the consideration of the above figures, it must be borne in mind that the principles therein contained may be combined into a variety of other single and multiphase alternating current motor combinations. Especially is this true when shape is being given to the primary element; then, as can be readily seen, field rings of the type of Figs. 1 and 2 can be placed side by side to produce a combination combining the features of the machines shown in Figs. 14 and 15, the pole-face coils in this case being eliminated from the field-ring of Fig. 1.

In my several devices, laminated metal should preferably be used in the construction of primary and secondary magnetic circuits. Further than this, either the primary or secondary can, in any case, be made either the rotating or stationary element, and the design of the cores modified accordingly.

Referring to the drawings and to Fig. 1 thereof, R designates the field ring, and N the north and S the south poles of the primary element of a single-phase alternating current motor. J designates the field-windings, and K the pole-face coils of the primary element. The conductors K^2 of the pole-face coils K are so placed relative to the pole-faces as to be brought into inductive relation with the conductors A^2 of the coils A of the armature or secondary element. As here shown, the secondary element is provided with a Gramme ring-winding, the coils of which are connected to the commutator segments E by non-inductive commutator leads M. The brushes F, F are placed in contact with the commutator segments, and are interconnected through the medium of the brush leads G, and the short-circuiting ring H. The brushes are so located as to bear upon the commutator segments which are connected with the armature-coils which are in such positions, relatively to the space between the pole tips, as to admit of their most successful commutation. By the connections shown, the field coils J are all connected in series, and the pole-face coils K are also all connected in series; and, further, the field coils J are connected in series with the pole-face coils K, thereby causing the alternating currents which are drawn from the source of supply to traverse all of the primary windings connected in series. The function of the field coils J is to produce a magnetic field varying in its intensity with the pulsations of the alternating currents from the source of supply. The function of the pole-face coils K is, by virtue of their position, to induce electric currents in the armature coils A, which by reaction with the magnetic fields of the poles N and S, produce relative motion of the surfaces of the primary and secondary elements. The pole-face coils are so arranged and connected as to tend to promote the same polarity at the pole tips N^2 and an opposite polarity at the pole tips S^2.

It is to be understood that Fig. 1 is merely diagrammatical. The armature, pole face, and field windings may be given the form of wave or lap windings, or such other common forms as may, in special cases, be deemed most effective.

The inductive action of the primary pole face coils K upon the secondary or armature coils A is such as to cause currents to pulsate through the armature windings in such manner as to produce natural points of commutation at or near the neutral planes between the pole tips, as in other forms of commutating electric machines.

It is to be understood that the field and pole face coils may be connected in a variety of ways. The field coils may all be connected in parallel, and this parallel system connected in series with a series arrangement of the pole face coils; or the field coils, all connected in parallel, may be connected in series with the pole-face coils also connected in parallel; or other arrangements may be used, as may be found in special cases most effective.

In Fig. 1, the single-phase alternating current motor there shown is equipped with four poles. It must be understood, however, that any even number of poles may be used successfully in this motor, other details as regards the number of brushes, etc., being arranged in conformity thereto.

Fig. 2 shows an adaptation whereby the field and pole-face coils are wound upon a field ring of the internal slotted type similar to that used in induction motor construction. Each slot is made to contain the conductors of both a field coil and a pole-face coil. The number of turns in the pole-face coils need not be the same as the number of turns in a field coil in any one slot, these factors depending upon the design of a specific motor. The effect of the combination of field coils and pole-face coils, as here shown, is, however, such that the field-coils J create magnetic fields which have greatest intensity at N, N and S, S, the magnetic fields at N being opposite in polarity to the magnetic fields at S. The fringe of the two fields combine to make neutral magnetic planes at or near N^2 and S^2. The tendency of the pole-face coils K is to promote magnetic fields permeating the air-gap between the primary and secondary elements at and about N^2 and S^2, the magnetic fields at N^2 being of opposite polarity to those at S^2. The coils A of the secondary element are, however, brought into such close inductive relation to the pole-face coils K as largely to neutralize their effect in producing the magnetic fields mentioned. In this motor, the secondary element is of the slotted core type, and is shown equipped with a Gramme ring-winding. Under ordinary circumstances, formed coils would be used in arranging both the primary and the secondary windings. In the construction here shown, the pole-face coils are preferably placed on top of the field coils, thereby bringing the former nearer the tops of the teeth of the primary core. In this motor, as in the one shown in Fig. 1, the function of the field-coils J is to create magnetic poles or fields. The function of the pole-face coils K is to induce electric currents in the armature coils A, which currents, by reacting magnetically upon the magnetic flux set up by the field coils J produce relative motion between the primary and secondary elements. Attention is called to the method of connecting up the field and pole-face coils of the primary winding. The switch X is the main switch connecting the motor leads X^2, X^2 with the source of electric energy. The switch Y is a double throw switch, by means of which the direction of rotation of the secondary element is reversed. Throwing the switch from the position shown in Fig. 2 to its other position reverses the currents through the pole-face coils K, and thereby reverses the reaction between the currents induced in the secondary element and the magnetic flux set up by the field coils of the primary element. The switch Z is used to reverse the direction of the flow of current in a portion of the field coils when it is desired to make the motor operate as an induction motor after the secondary element has approximated to synchronous speed. The short-circuiting ring U shown inside of the commutator E is an auxiliary in producing the induction motor effect. Under ordinary circumstances, when not running as an induction motor, the short-circuiting ring U would occupy the position shown at U^3 in Fig. 3. When, however, it is desired to make the motor act as an induction motor, the switch Z must be thrown into its other position, and the short-circuiting ring U advanced from its position at U^3 in Fig. 3 to the position U in Fig. 3. The effect of the short-circuiting ring U is to short-circuit the commutator bars of the commutator E, and thereby short-circuit the armature coils one upon another. It is understood that the operation of this motor as an induction motor is not essential to successfully carrying all loads from no load to full load. Its characteristics, however, as regards torque and speed, etc., are immediately changed when the transition is made by the operation of the switch Z and the short-circuiting ring U. In Fig. 2, a second set of brushes F^2, F^2 is shown. These are introduced to bring out the fact that, with proper care and design, the motor will operate equally well, no matter which set of brushes is employed during the running of the motor, inasmuch as the functions of the pole face coils and field coils are interchanged with reference to the two sets of brushes. The motor can also be made to operate with both sets of brushes in operative relation, their leads being separately interconnected, as shown.

In Fig. 4, a modification is shown, whereby the fields and pole-face coils are so wound upon a field-ring as to make every other coil a field coil, and the intermediate coils pole-face coils. In this case, the effect of the field coils J, through the medium of the connections, as shown, is to create magnetic fields which have greatest intensity at N and S, the magnetic fields at N being opposite in polarity to the magnetic fields at S. On the other hand, the tendency of the pole-face coils K is to promote magnetic fields N^2 and S^2, the magnetic fields at N^2 being of opposite polarity to those at S^2. The secondary element, or the armature, is located internally to the field or primary element. As here shown, the secondary element is supplied with a Gramme ring winding, the coils A of which are so located as to be in inductive relation to the pole-face coils K. In this motor, as in the one shown in Fig. 1, the function of the field-coils J is to create magnetic poles. The function of the pole-face coils K is to induce electric currents in the amature coils A, which currents electro-magnetically, by reacting upon the magnetic flux set up by the field coils J, produce relative motion between the primary and secondary elements. As regards all other matters, except as has been heretofore or may be hereinafter explained, the arrangements of the motor shown in Fig. 4 are similar, in all essential details, to those of the motor shown in Fig. 1.

Referring to Figs. 4, 5 and 6, attention is called to the commutating impedance coils B connected in the commutator leads of the armature coils, and the inductance neutralizing electro-magnets C^4 superimposed upon the commutating impedance coils B at the points of commutation. In order that the position of the inductance neutralizing electro-magnets C^4, relatively to the commutating impedance coils B, may be more clearly shown, the inductance neutralizing electro-magnet, which should have place at C^5 is removed, the position it should occupy, however, being indicated by the dotted lines. It must be understood that, as shown in Figs. 5 and 6, the combination of the core C^3 and the short-circuited coil C^2 wound thereon, constitutes one of my impedance neutralizing electro-magnets, and the core C^3 may, commercially, be so adjusted and designed as to admit of the air-gap L^2 between the core of the inductance neutralizing electro-magnet C^3 and the core P of the commutating impedance coil B to be made as large or as small as may be necessary to obtain the best results during the operation of the motor. It will be evident that the arrangement of the commutating impedance coils B relative to the inductance neutralizing electro-magnets C^4, the commutator-bars E and the brushes F, F, is such that currents delivered from or received by the armature coils, from the brushes, so react magnetically upon the cores C^3 of the inductance neutralizing electro-magnets C^4 as to induce currents in the coils C^2 of the said inductance neutralizing electro-magnets C^4; which currents thus induced in the coils C^2 so react upon the commutating impedance coils B as to neutralize, in great measure, the inductances of the said commutating impedance coils, thereby giving the commutator leads but a slight impedance to the passage of the armature currents. On the other hand, the position assumed by the commutating impedance coils B relative to the inductance neutralizing electro-magnets C^4 during the period of commutation is such that the currents which circulate in the armature coils during the time when they are short-circuited by the brushes F, F, react magnetically in such manner during their passage through the commutating impedance coils located in the commutator leads of said armature coils undergoing commutation as to add the inductance of the two commutating impedance coils connected in the commutator leads of each of the armature coils undergoing commutation, and place their combined inductance in series relation to the inductance of the armature coils undergoing commutation. By the arrangement shown, therefore, the inductance neutralizing electro-magnets C^4 are not effective in diminishing the inductance of the commutating impedance coils in the leads of the armature coils undergoing commutation, as related to currents which permeate the short-circuited armature coils.

The arrangement of parts shown in Figs. 4, 5 and 6 makes it evident that, by my invention, commutation of an armature coil is facilitated by the automatic introduction into the leads of the armature coils which are undergoing commutation, of inductances so great as to prevent the development of currents of any considerable volume in the said short-circuited armature coils. As shown, the inductance neutralizing electro-magnets embrace but two of the commutation inductance coils. They may, however, embrace a greater number of these coils with effectiveness. The position of the inductance neutralizing electro-magnets may be given an angle of advance or lag, as conditions may require, or as indicated in Fig. 4.

In Fig. 7, a combination of parts is shown whereby, through the introduction of suitable inductance neutralizing electro-magnets, the act of commutation may be facilitated, when desirable, in the motors of my invention. The commutating impedance coils B are wound over the slotted core P^2 and connected in between the junction points of the armature or secondary coils A (which are wound over the core O), and the commutator bars E. The impedance neutralizing electro-magnets C are so placed and adjusted as to neutralize the inductance of the armature coils A during commutation, while the inductance neutralizing coils C^4 are so placed as to neutralize the inductance of the commutating impedance coils B to the passage of currents to or from the armature coils A and the brushes F. On the other hand, the inductance neutralizing coils C^4 have no effect whatever in diminishing the impedance of the commutating impedance coils B in their function of reactance coils connected in series with the local circuit through the commutated coils A, the brushes F and the other elements linked therewith, as diagrammatically shown. By the arrangement of parts shown in Fig. 7, the counter-electromotive force which would ordinarily be developed in the coil A^2 by current vibrations taking place in it during the period of commutation is, in the present case, largely wiped out by the presence of the inductance neutralizing coil C in intimate relation with the said coil A^2, and the effectiveness of such portion of the said counter-electromotive force of self-induction which still remains in setting up a rush of current around through itself, the commutator bars E and the brush F is greatly diminished by an automatic introduction of commutating impedance coils B in the circuit through which the coil A^2 is short-circuited by the brushes F.

In Figs. 8 and 9, the arrangement of parts and the combinations provide for carrying out of functions which have been accorded to the commutating impedance coils, and the inductance neutralizing electro-magnets of Fig. 7 without the necessity of providing an additional core over which commutating impedance coils can be wound, or of bringing into play more than one inductance neutralizing electro-magnet at each point of commutation. As diagrammatically shown, the commutating impedance coils B so act magnetically when they are permeated by currents flowing either to or from the armature coils A and the brushes F as to set up reactive currents in the short-circuited coil of the inductance neutralizing electro-magnet C, which reactive currents set up in the coil C have the effect of neutralizing the inductance of the coils B to the passage of current to or from the armature coils A and the brush F. When, on the other hand, we consider the currents which permeate the coil A^2 during the time when its terminal bars E are bridged by the brush F, we find that the coil A^2 is brought into such inductive relation to the inductance neutralizing coil C as to induce in said coil C currents which react magnetically to neutralize the inductance of the coil A^2. Again, the presence of the coil C has no effect upon the inductance of the coils B, considered as acting in series with the coil A^2 during the time of its commutation, for and on account of reasons that have been explained. The number of coils embraced by the inductance neutralizing electro-magnet C vary under different conditions.

The arrangement of parts presented in Fig. 10 will be fully understood when considered in connection with descriptions of Figs. 1, 2 and 9. The construction of the primary winding removes the field coils from as intimate a relation to the pole-face coils as that which obtains in Fig. 2, thereby effecting a modification to be preferred under certain conditions. The core of the impedance neutralizing electro-magnet is magnetically insulated from the field-ring R by V, while being held rigidly to the said core by suitable supports. The core of the inductance neutralizing electro-magnet is entirely unaffected by the magnetic flux permeating the primary core R. The supports, however, admit of the core C being either raised or lowered, or moved with or against the direction of rotation of the secondary element. Fig. 10^b shows the arrangement of the said parts for securing and controlling the position of the core C. The part V^2 embraces the field core R and is secured thereto by the handwheel V^5 attached to the threaded pin R^3, which is embedded in the field ring R. The slot V^4 is cut in the support V^2, which permits the strip V carrying the core C to be moved either with or against the direction of rotation of the secondary element. In the extremities of part V^2, at V^6, are cut slots, through which project thumb-nuts V^7 securing the ends of the strip V, which is rigidly secured to the core C, and magnetically insulates the core C from the field core R. The thumb-nuts V^7 give opportunity for adjusting the core C so that it can be raised or lowered, and thereby be made to exert a greater or less inductive effect upon the coils in the secondary element. By the possibility of these adjustments, the effectiveness of the inductance neutralizing electro-magnet can be made a maximum for all conditions of loading of the motor. As diagrammatically shown, the armature coils A can be individually short-circuited by simultaneously closing the switches U^2. When the switches U^2 are closed, the winding on the secondary element is changed to that of a closed coil winding, and, under these conditions, the motor will operate with greater economy if the switch Z^3 is thrown to its other position and the pole face coils K thereby cut out of the primary circuit.

The arrangement of parts and connections shown in Fig. 11 will be thoroughly understood in view of explanations previously given, especially in connection with Figs. 2 and 8. The core of the inductance neutralizing electro-magnet is here so arranged as to admit of its being given a movement either in advance or lagging behind the neutral magnetic plane of commutation. Fig. 11 shows more forcibly the facility with which the parts of my invention can be modified and assembled to meet special conditions.

Fig. 12 shows an arrangement whereby the pole-face coils and a portion of the field coils may be permanently connected in series when it is desired to produce a motor operating only in one direction to be converted to the induction method of operation at discretion. In this case, those field coils through which normally, when the motor is starting, currents flow in opposition to the currents in the pole-face coils, are grouped together in series and connected with the pole-face coils through the reversing switch Z. Throwing the reversing switch Z causes the currents to flow through all coils in the same direction, thereby producing fields of maximum intensity at N^2 and S^2. In Fig. 12, the inductance neutralizing electro-magnets are made a part of the field ring and are immovable in their position. A connection is provided at Z^2 whereby the circuits of the induction neutralizing electro-magnets can be opened when the motor is operating as an induction motor, in order that no idle currents may be induced and caused to flow in these windings, which, when the switch Z^2 is closed, are short-circuited upon themselves and upon one another.

Fig. 13 shows an arrangement of field connections whereby the several field circuits of each polar winding are connected in parallel with one another and in series with the pole-face coils, which are, in turn, arranged in four parallel circuits. Connections are further provided through the medium of the switch Z^4 whereby the line of division between the several sets of field-coils can be either advanced or thrown back relative to the primary core. When the field switch Z^4 rests on the terminals Z^5, Z^5, the primary fields will have a maximum intensity at N^5 and S^5, and the neutral point will be at N^9 and S^9. When the switch Z^4 rests on the contact Z^6, Z^6, the maximum intensity of the field will be at N and S, and the neutral point at N^2 and S^2. When the switch Z^4 rests on the terminal points Z^7, Z^7, the fields of maximum intensity will be found at N^7 and S^7, and the neutral point will be at N^{11} and S^{11}.

The diagrammatic arrangement of the parts which is shown in Fig. 14 admits of an arrangement of the primary field winding and the pole-face coils which entirely removes them from an intimate electromagnetic relation. According to this construction there are two cores R, R^2, placed side by side and constituting the primary element. The core R is wound with the primary field coils J, and the core R^2 with the primary pole-face coils K. It will thus be seen that the field coils and pole face coils are wound upon independent cores; and it will be understood that the armature will be constructed of such length as to be in inductive relation to both cores. In the figure, one-half of each core has been illustrated, the line 14—14 cutting off half of the core R and permitting half of the core R^2 in rear to be seen. The functions of the field coils J and the pole-face coils K, herein shown, are precisely the same as those which have been accorded to these coils in the description of Figs. 1 and 2, etc., the coils J being effective in promoting magnetic fields so situated and placed that the currents which are induced in the secondary windings by primary currents flowing in the pole-face coils K through the medium of electro-magnetic induction or transformer action, will react in them to produce relative motion between the primary and secondary elements. The effect of the currents flowing in the coils A of the armature or secondary element is largely to neutralize the magnetizing effect of the currents flowing in the pole-face coils K of the core R^2 of the primary element, while the electro-magnetic effect of the currents flowing in the coils A on the secondary element is not greatly to change the intensity of the magnetic flux due to the currents which permeate the coils J of the primary element R.

The diagrammatic arrangement presented in Fig. 15 is applicable where it is not deemed desirable to make use of field rings such as are common in the construction of induction motors. Here again there are two rings R, R^2 constituting the primary element arranged side by side. The line 15—15 cuts off half of the core R, and the half of the core R^2 corresponding to the half of the core R removed appears on the other side of this line. In this case, the coils K of the primary element R^2 act magnetically upon the coils A of the secondary element to induce in them electric currents. These secondary currents in turn react magnetically upon the currents in the coils K largely to neutralize their effect in setting up magnetic flux around through the core O of the secondary element, and the core R^2 of the primary element. The coils J of the primary element R have the same function as the coils J of the primary element of Fig. 1. From this, it will be seen that the functions of the coils J and K have not, in this case, been changed in the least from those to which they are common in the diagrammatical arrangement of parts previously outlined in this specification.

As has been previously pointed out, I do not limit myself to a four-pole construction, inasmuch as my invention can be made to apply equally well to all forms of magnetic circuits whether they be bipolar or multipolar.

In all of the constructions presented herein, laminated rather than solid metal should, preferably, be used in building up the magnetic circuit, and commercially formed coils will be found preferable to the Gramme ring construction shown in the arrangement of the insulated windings of these motors.

Although not shown in the drawings, it is to be understood that, in the primary windings, all balance combinations of series and parallel adjustment between the field coils and pole-face coils can be used, inasmuch as the inductance of these circuits admit of a ready balance being maintained between the different parts thereof in the case of all parallel arrangements.

Having thus fully described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. In a commutating alternating current motor, the combination of energizing coils, inducing coils, an armature arranged within the influence of said several coils, a commutator, induction coils connected in series with the commutator leads of the armature of said motor, and short circuited coils arranged in inductive relation to said induction coils, as set forth.

2. In an alternating current motor, the combination of a field ring, an armature and an iron core having a short-circuited winding, and means whereby the said core having a short-circuited winding can be moved in or opposite to the direction of rotation of said armature, or be brought in closer or more distant inductive relation with said armature, while firmly attached to the field ring, as set forth.

3. In an alternating current motor, the combination of a field ring and armature, armature coils and impedance elements connected in lead wires from said armature coils; and of an iron core having a short-circuited winding in inductive relation to said impedance elements; and of means whereby the said core having the short-circuited windings can be moved in or opposite to the direction of rotation of the said armature to a predetermined extent, as set forth.

4. In an alternating current motor, the combination of a field ring and armature, armature coils and impedance elements connected in leads from said armature coils; and of an iron core having a short-circuited winding; and of means whereby the said core having a short-circuited winding can be brought into closer or more distant inductive relation with the impedance elements, as set forth.

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

WINDER E. GOLDSBOROUGH.

Witnesses:
JESSIE L. COWING,
S. ROUSE.