(No Model.) 5 Sheets—Sheet 1.

T. L. WILLSON.

DYNAMO ELECTRIC MACHINE.

No. 403,630. Patented May 21, 1889.

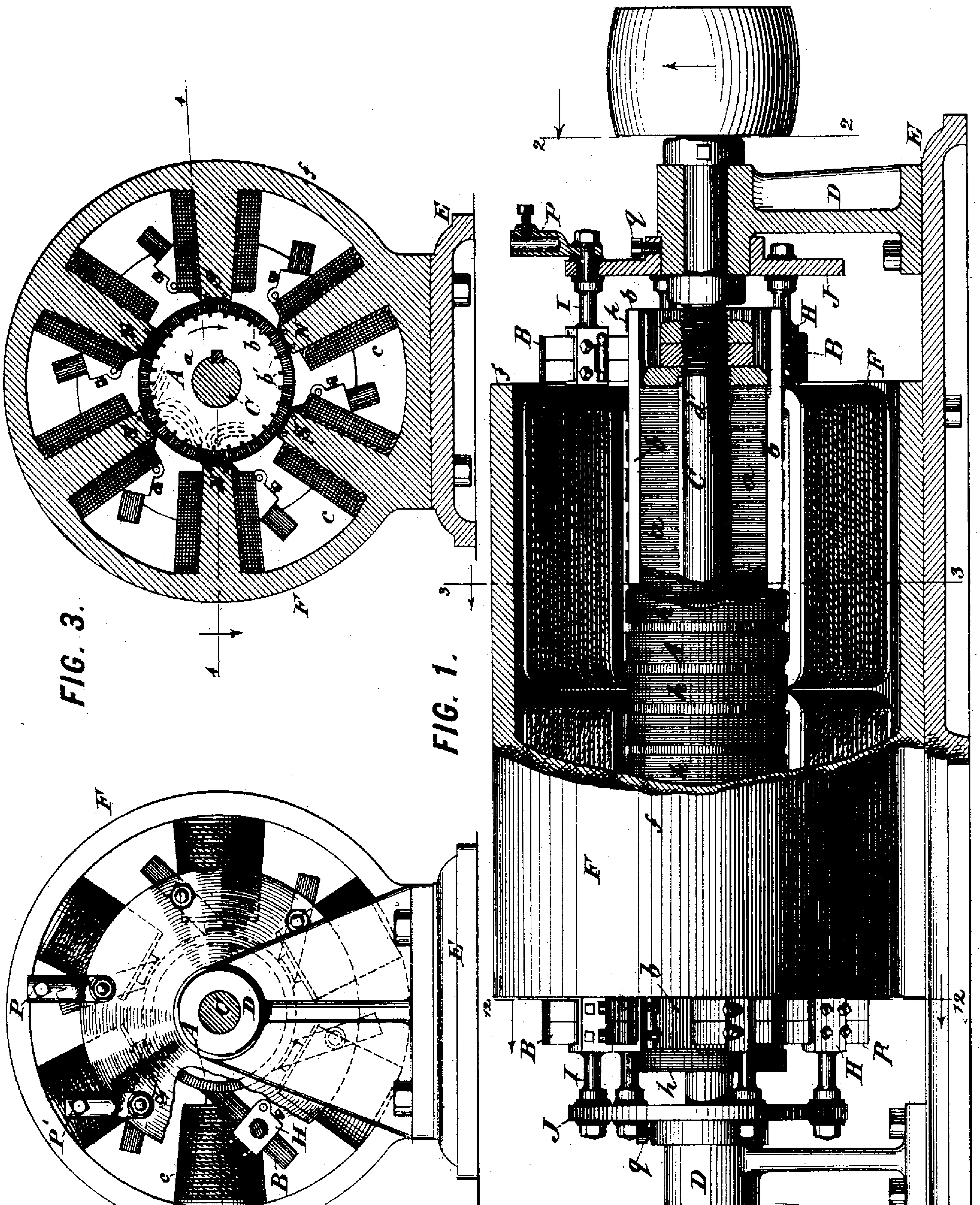

FIG. 1.

FIG. 2.

FIG. 3.

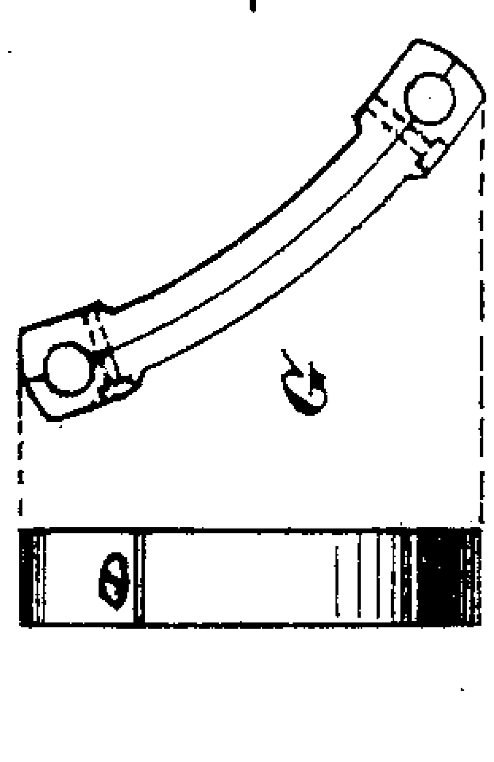

FIG. 9.

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FIG. 4.

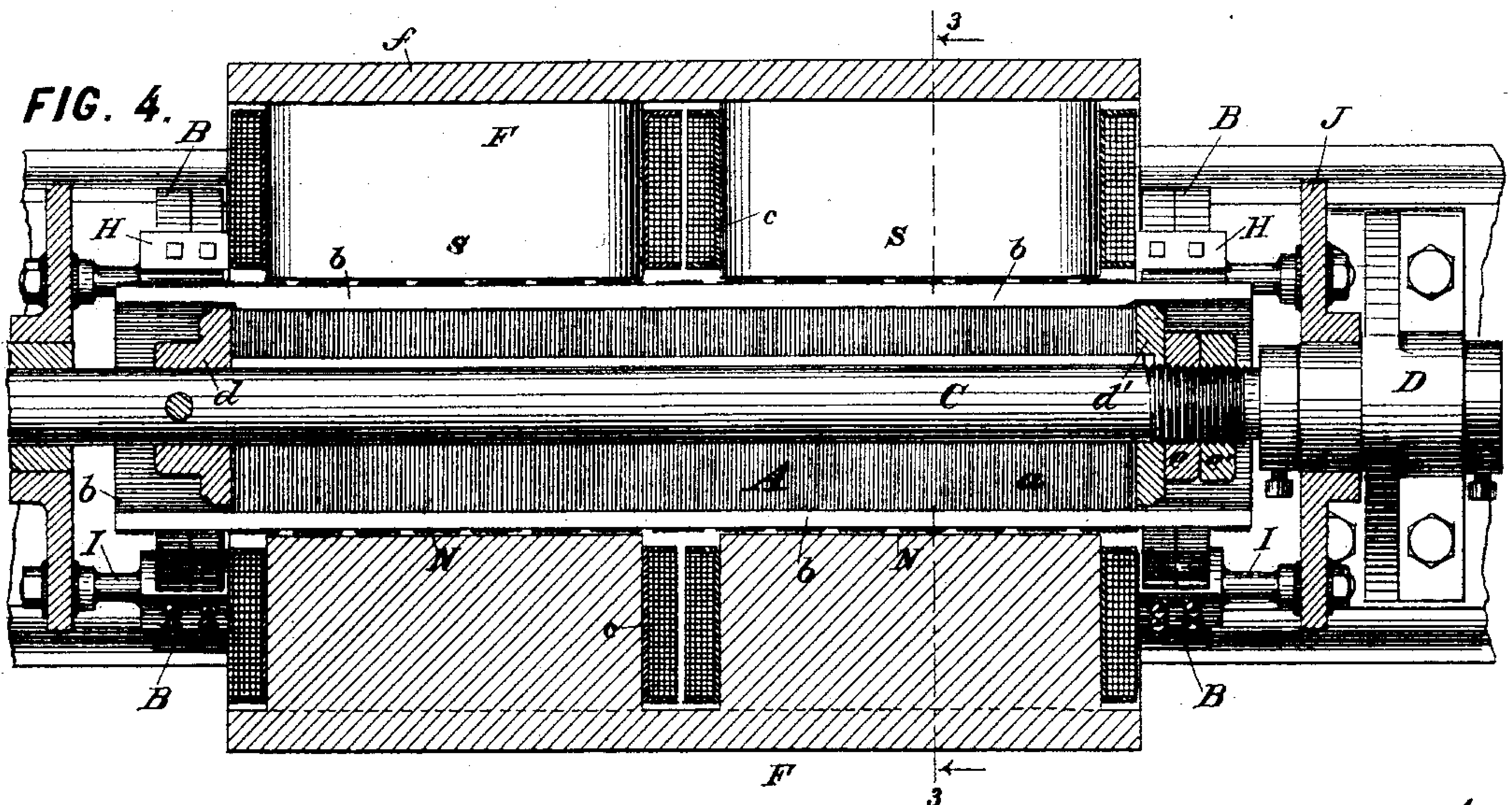

FIG. 5.

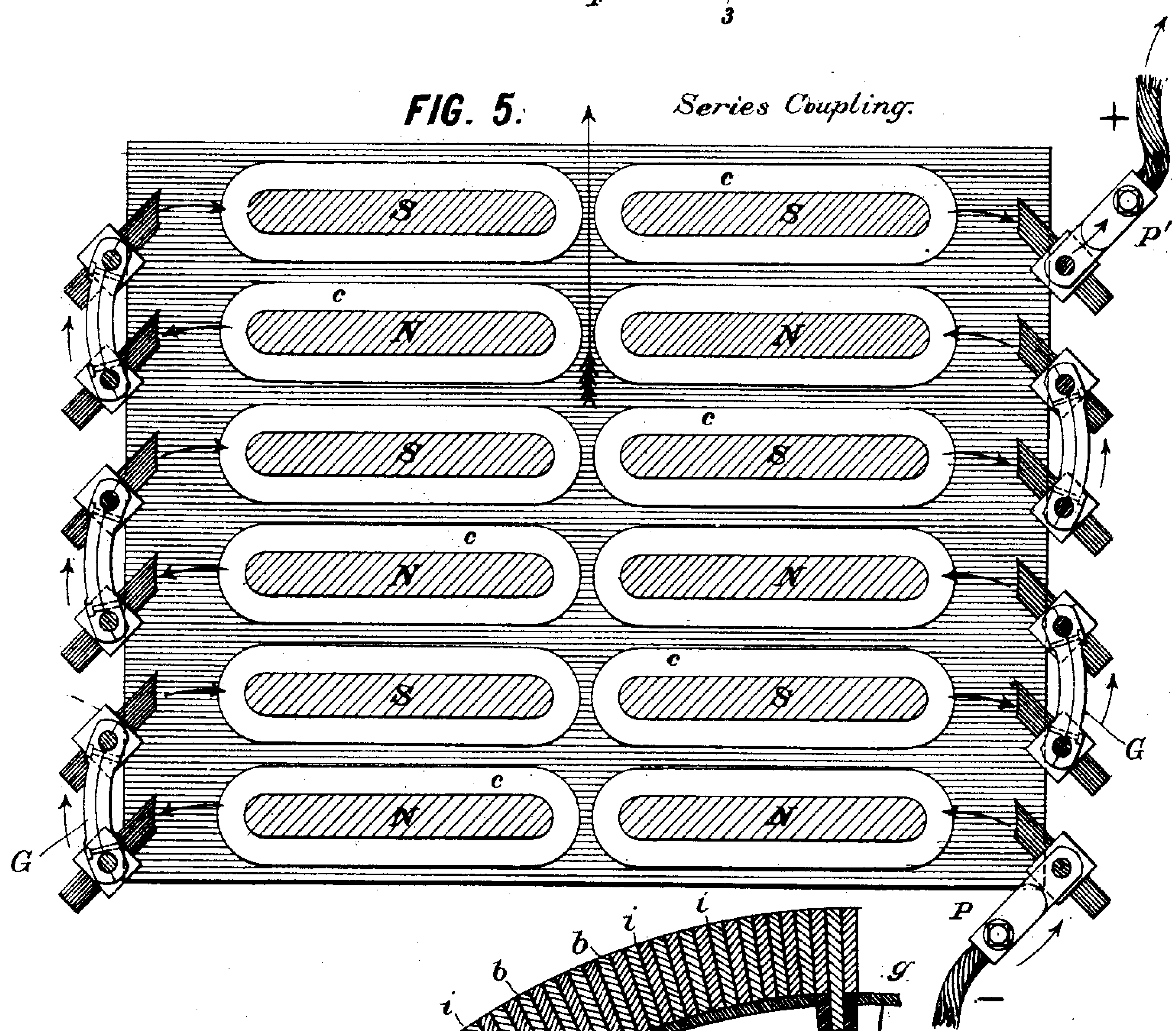

FIG. 6.

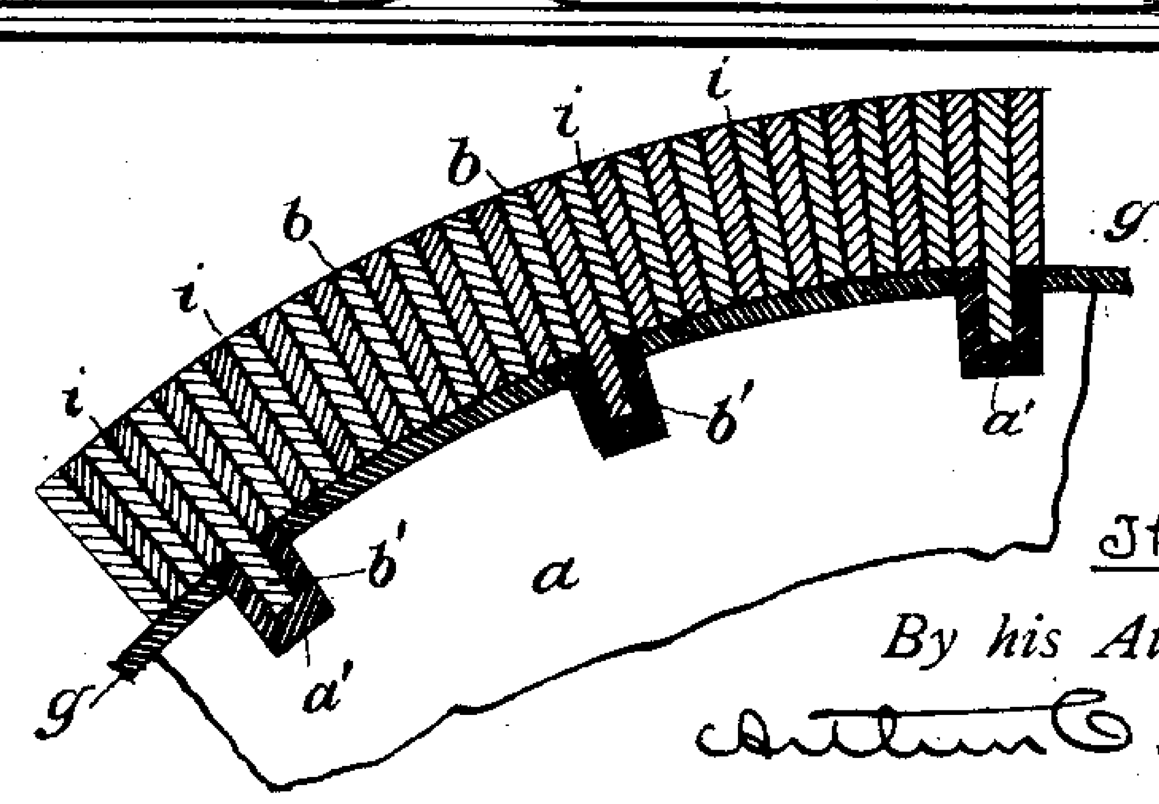

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FIG. 7.

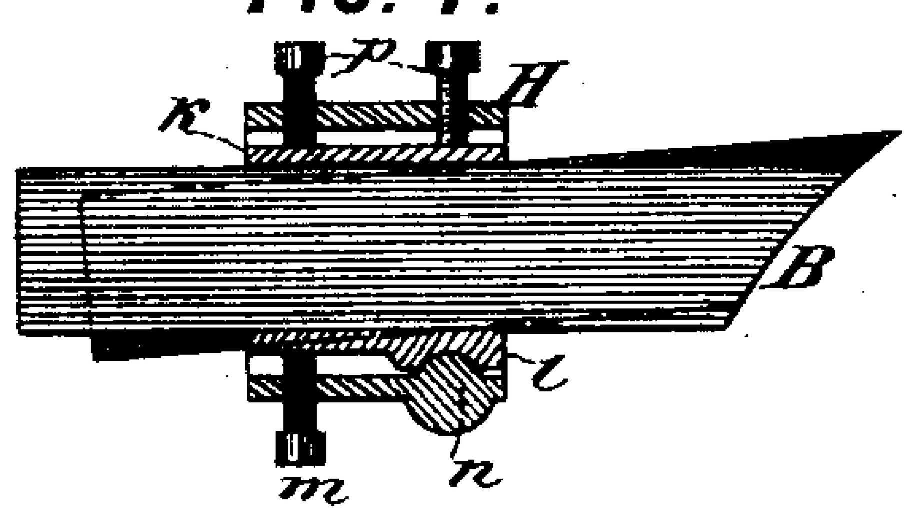

FIG. 8.

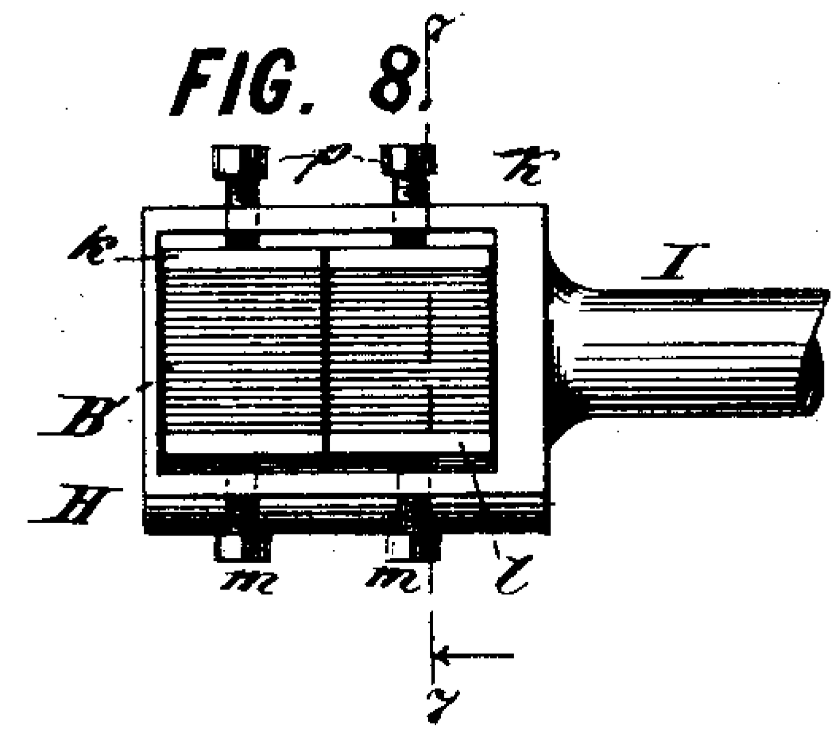

FIG. 10.

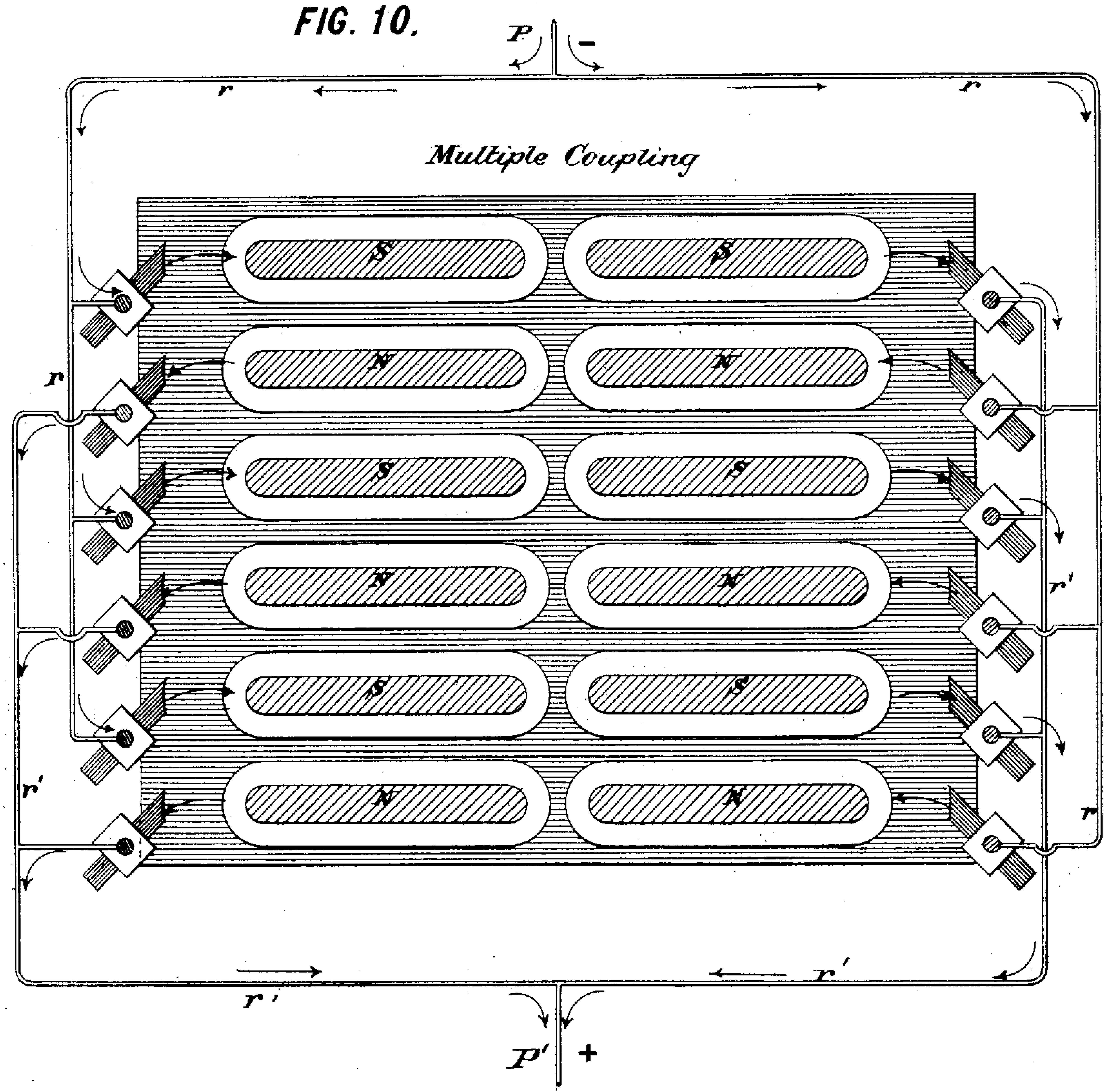

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FIG. 11. *Multiple-Series Coupling*

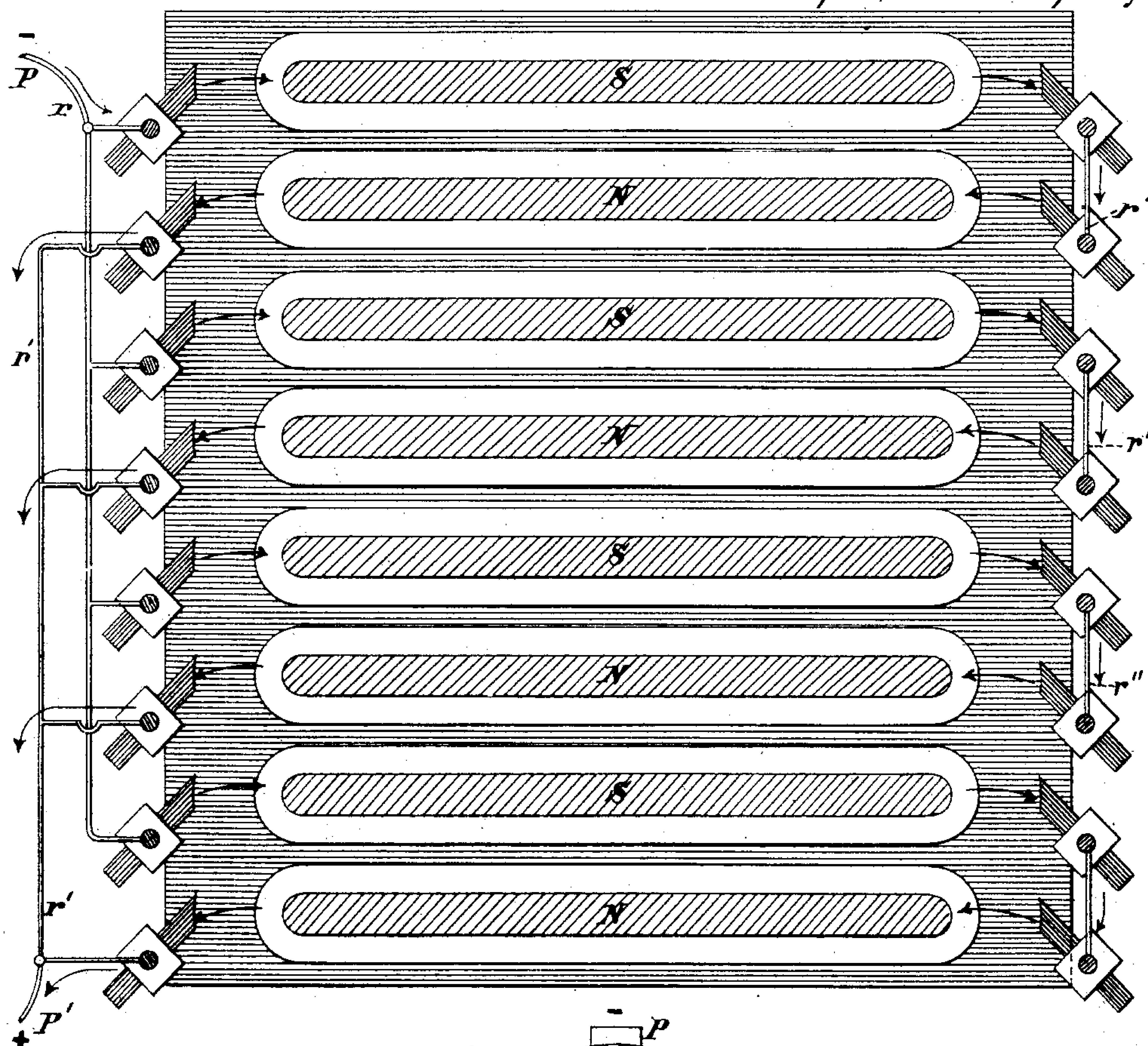

FIG. 12.

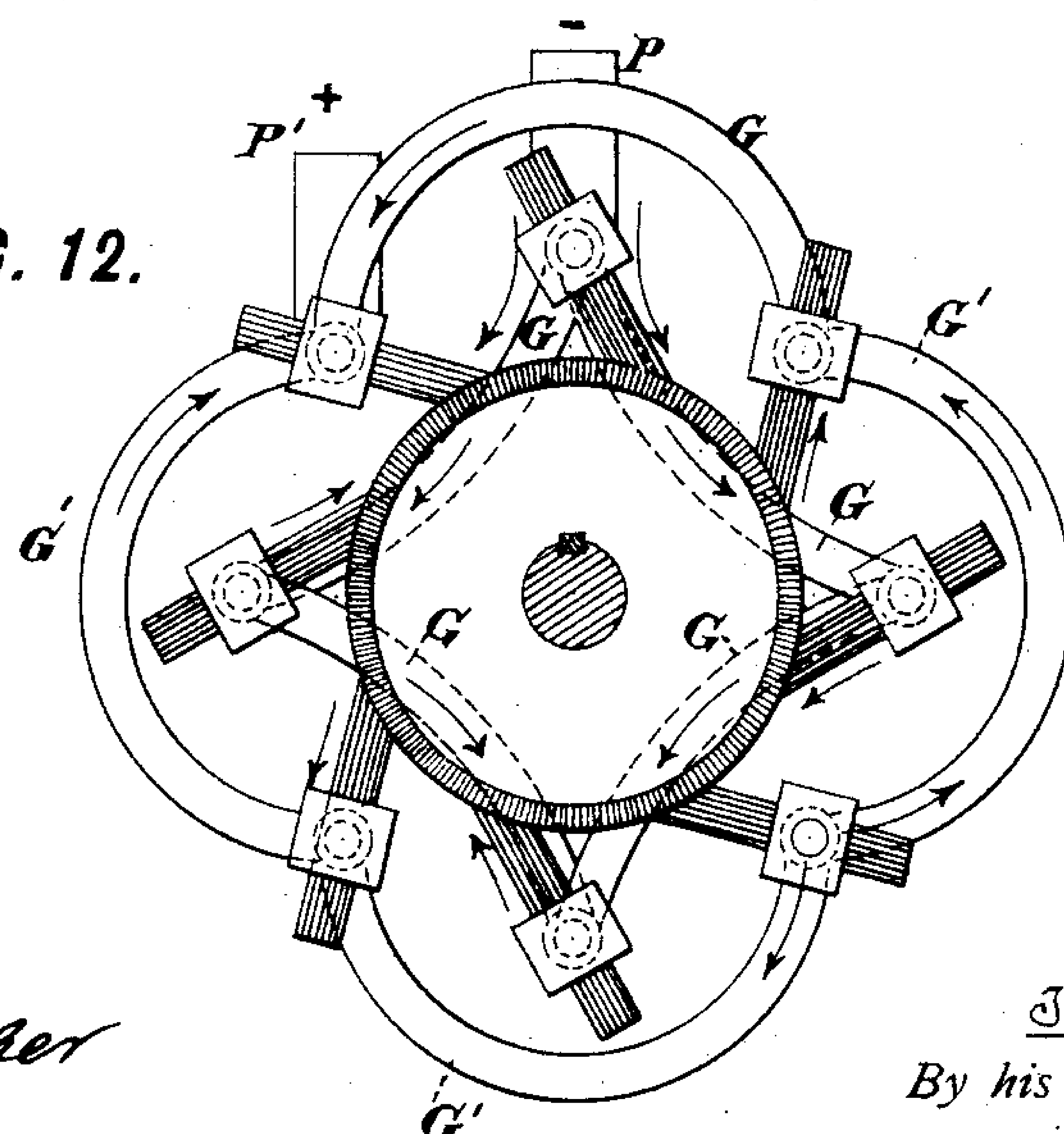

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FIG. 13.

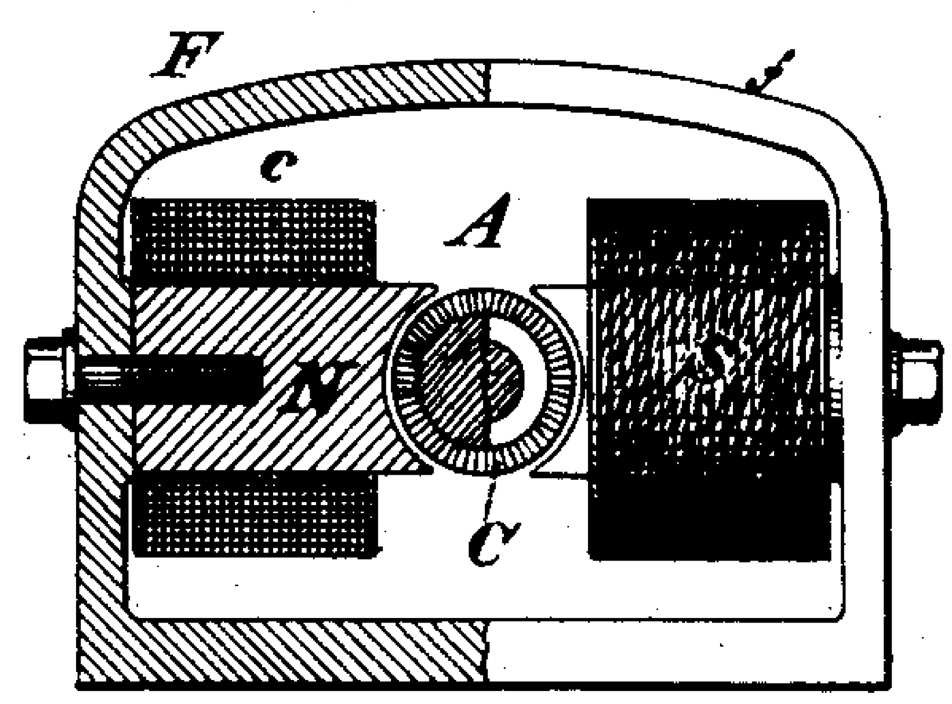


FIG. 14.

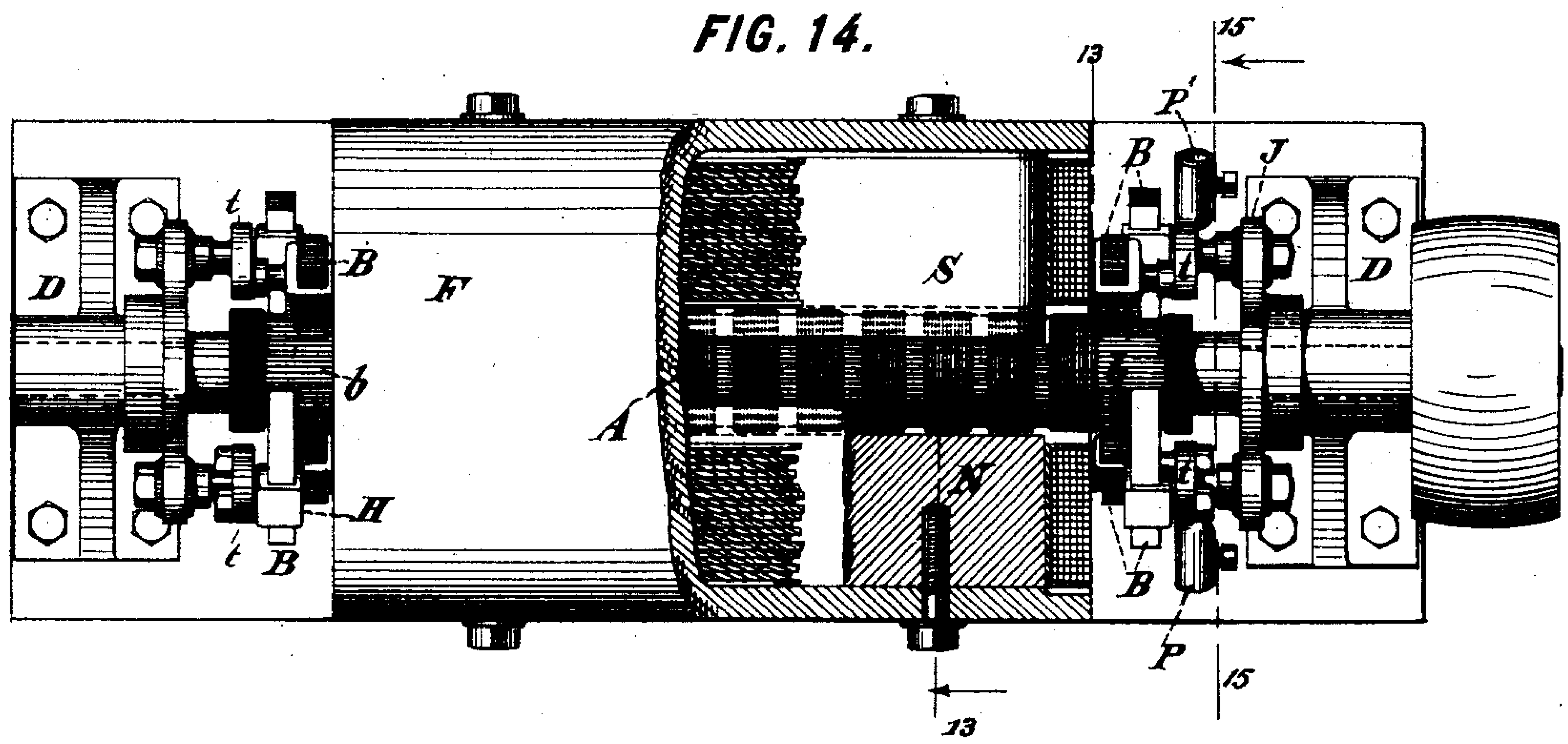
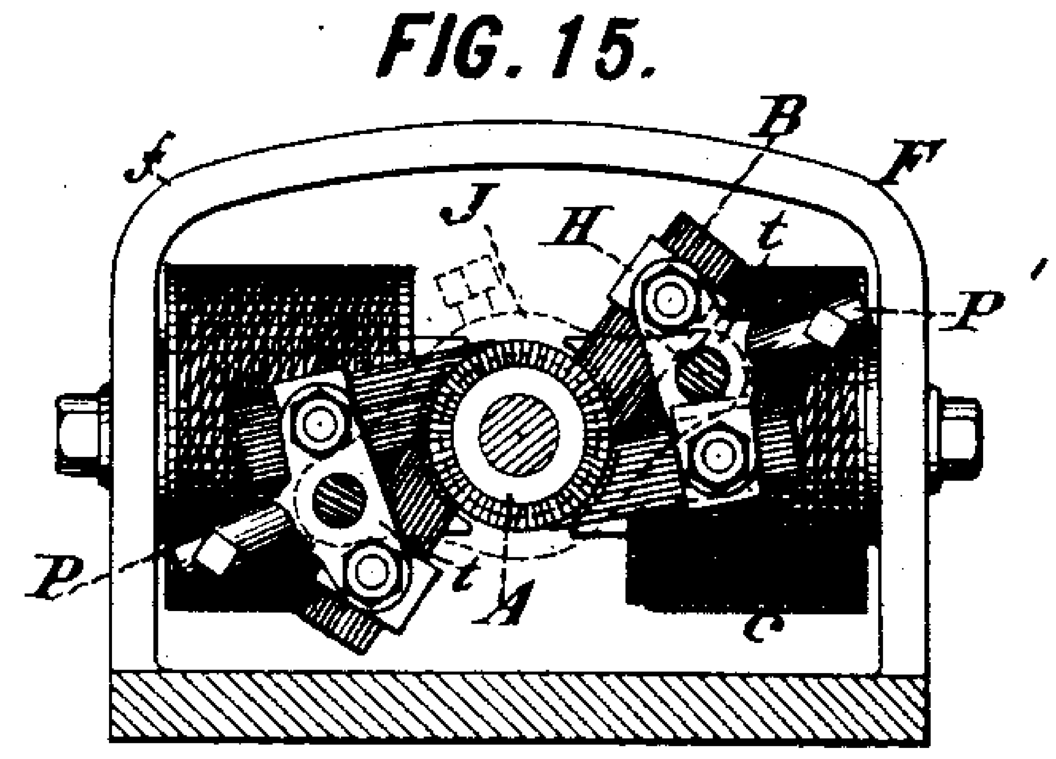


FIG. 15.



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UNITED STATES PATENT OFFICE.

THOMAS L. WILLSON, OF BROOKLYN, NEW YORK, ASSIGNOR TO JOHN C. McGUIRE, OF SAME PLACE.

DYNAMO-ELECTRIC MACHINE.

SPECIFICATION forming part of Letters Patent No. 403,630, dated May 21, 1889.

Application filed December 10, 1888. Serial No. 293,133. (No model.)

To all whom it may concern:

Be it known that I, THOMAS L. WILLSON, a citizen of the United States, residing in Brooklyn, Kings county, State of New York, have invented certain new and useful Improvements in Dynamo-Electric Machines, of which the following is a specification.

This invention relates to dynamos of the general class known as "open-coil" machines, or those in which the armature-conductors are cut out of the external circuit as soon as they pass out of the effective magnetic field of force and are left with open terminals during their period of inactivity. More specifically, it pertains to the special type of such dynamos characterized by the employment of a drum-shaped armature, the "winding" of which consists of a single layer of longitudinal conducting-bars insulated from each other, (each constituting, essentially, a separate "coil,") having commutating-brushes bearing upon them at one or both ends in line with the fields of force to conduct the current to and from each bar during its passage through the magnetic field. A machine of this type is exemplified in the so-called "Mouse Mill Dynamo" of Sir William Thomson. Heretofore dynamos of this type have had merely a theoretical existence, the only embodiments of them that have been actually made amounting to nothing more than laboratory experiments or philosophical curiosities, and being quite devoid of practicability. The impracticability of these machines has been due in part to their extremely low efficiency, resulting from the fact that the conducting armature-bars are necessarily idle during much the greater part of the time, and also in part to the current generated by them being of such slight volume as to be practically useless. These machines have also in the constructions heretofore proposed been subject to mechanical defects, which alone would have been sufficient to render them impracticable. My invention provides an improved and commercially-practicable dynamo of this type. It aims to improve upon the construction heretofore proposed both in mechanical and electrical features in order to render the machine efficient, economical of energy, and capable of yielding a large volume of current under sufficient electro-motive force to render it suitable for such purposes as incandescent electric lighting, electroplating, electric smelting, electric welding, &c.

The improvements introduced by my invention relate, chiefly, to the armature and to the commutating-brushes and their connections. They relate, also, in part to the field-magnet and the brush-holders and the means for adjusting the brushes.

In the accompanying drawings, Figure 1 is a side elevation of my improved dynamo-electric machine in its preferred form, the right-hand portion being in vertical mid-section. Fig. 2 is an end elevation looking in the direction of the arrow 2 in Fig. 1. Fig. 3 is a vertical transverse section in the plane of the line 3 3 in Figs. 1 and 4. Fig. 4 is a horizontal transverse section in the planes indicated by the line 4 4 in Fig. 3. Fig. 5 is a diagrammatic view, the armature-conducting bars or winding being developed in a plane, the field-magnet poles shown over them in section, and the field-magnet winding being indicated by white spaces inclosing the poles, and the commutator-brushes being turned sidewise. Fig. 6 is a fragmentary transverse section of the armature on an enlarged scale. Figs. 7 and 8 show the brush-holders, Fig. 7 being a section on the line 7 7 in Fig. 8, and Fig. 8 being a rear elevation. Fig. 9 shows one of the commutator-brush conductors or coupling-sections detached. Fig. 10 is a diagram similar to Fig. 5, but showing a modified method of coupling the commutator. Fig. 11 is a similar diagram of a modified construction of dynamo, showing a still further modification in the method of commutator-coupling. Fig. 12 is a sectional view cut in the plane denoted by the line 12 12 in Fi 1, and showing the arrangement of the brushes and the connections between them for the machine indicated in Fig. 11. Figs. 13 to 15 show a modified machine. Fig. 13 is a transverse section cut on the line 13 13 in Fig. 14. Fig. 14 is a plan partly in horizontal mid-section. Fig. 15 is an end elevation, partly in vertical section, on the line 15 15 in Fig. 14.

I will first describe the construction shown in Figs. 1 to 9, inclusive.

Let F designate the field-magnet as a whole, and A the armature as a whole. B B are the commutator-brushes. C is the armature-shaft. D D are the supporting-frames in which the shaft has its bearings, and E is the base-plate or support on which the machine is mounted.

The field-magnet F consists of a greater or less number of radial poles or pole-pieces S N S N, of alternately contrary polarities, converging toward the axis of rotation, and all in the construction shown connected together by a neutral portion, *f*, in the shape of a hollow cylinder. The radial pole-pieces are provided with field-exciting coils *c c*, formed on spools, which are slipped onto the pole-pieces and fastened thereon in any suitable manner. Preferably the pole-pieces and neutral portion *f* are all cast in one piece. This construction of field-magnet is not in itself new, being employed with some forms of alternating-current dynamos.

The armature A is mounted on the axial shaft C and rotates within the field-magnet. It is of barrel form, being cylindrical, or approximately so, and its ends project beyond the field-magnet. The armature is constructed with a cylindrical core, *a*, of soft iron, and an exterior winding, consisting of a single layer of longitudinal conducting-bars *b b*, surrounding the core fastened thereto. The soft-iron core may be made in any way in which armature-cores have heretofore been made, being preferably laminated, at least in large machines, in order to prevent eddy-currents. I prefer to build it up of disks or washers of thin sheet-iron interleaved with sheets of tissue-paper, the iron washers being formed with inner notches to constitute a keyway, and placed over the shaft C, which has a key fitting this keyway. The shaft is provided with a collar, *d*, fixed on it and coming against one end of the core, and with a loose collar or disk, *d'*, coming against the other end of the core, as shown in Fig. 4, the core being tightly compacted by means of nuts *e e'*, screwed on a threaded portion of the shaft against the collar *d'*. The length of the core thus formed is preferably equal to the length of the field-magnet, including its exciting-coils, as seen in Fig. 4.

The conducting-bars *b b* are preferably of copper, their sides being tapered to form radii from the axis of rotation; or, in other words, the bars are prisms the cross-section of which is a truncated sector. The bars are placed edgewise against the exterior of the armature-core *a*, a layer, *g*, of insulating material being interposed in order to insulate them from the core, as shown in Fig. 6. Between the bars are placed thin sheets of insulating material *i i*, Fig. 6, preferably of mica. The bars are held against the core by exterior bands, *h h*, of fine wire wound around the armature after the manner of the hoops on a barrel, an insulating layer being interposed between the exterior of the bars and these hoops or bands. In order to provide a driving-connection between the winding of bars *b b* and the armature-core, I make certain of the bars *b' b'* at intervals wider than the others, and cause their inner edges to project into longitudinal grooves *a'*, formed in the periphery of the armature-core, the intervening insulating-layer *g* being carried down into these grooves, as shown in Fig. 6. The grooves *a' a'* are preferably, formed after the armature-disks or laminæ have been combined and clamped in place on the armature-shaft, it being then easy to plow out the grooves *a' a'* by a planer. This feature of construction is not strictly necessary, as a frictional contact between the armature-winding and core will in most cases be sufficient.

The armature thus built up consists, electrically, of a winding of a great number of longitudinal copper bars, each bar constituting, essentially, a separate coil open at both ends and entirely disconnected from the other bars. This winding is superposed upon a soft-iron core, which forms a means for closing the magnetic circuit betweeen the field-poles, the lines of magnetic force flowing as indicated with reference to two of the poles by dotted lines in Fig. 3. As the armature is revolved, the conducting-bars *b b* are whirled through a succession of concentrated magnetic fields of alternately-reversed polarities, and thereby have potentials induced in them during the instant of their passage through these fields of force, which may be taken off in the form of electric currents by the application of commutator-brushes to the opposite ends of the bars, in such position as to bear upon the bars which are passing through the respective fields of force.

The commutator-brushes B B are arranged at the opposite ends of the field-magnet and bear upon the portions of the armature-bars which project beyond the field-magnet, these projecting portions forming, essentially, commutator-segments. The number of pairs of brushes is equal to the number of radial poles, this number being six in the construction shown. The two brushes of each pair are arranged at the opposite ends of the corresponding field-pole and bear upon the segmental bars for an angular distance equal to the width of the concentrated field of force emanating from the pole. In practice the brushes will have a slight lead in consequence of the deflection of the lines of force by the rotation of the armature.

Fig. 5 clearly shows the circuit arrangement when the commutator-brushes are coupled in series. The current passes from the negative binding-post P into the first brush-holder through the brush thereof into the armature-bars, and through the latter from right to left past the N pole of the field-magnet, thence out through the brush at the opposite end of the bars from the brush-holder thereof, through a coupling piece or section, G, into the next brush in advance at that end, back from left to right through the bars passing through the S field of force, out through the commutator-brush at the right-hand end of the machine, through a coupling-bar, G, to the next brush in advance, and so on back and forth, until finally the current passes out at the positive binding-post P′, its entire course being indicated by the tailless arrows in Fig. 5. The feathered arrow in this figure shows the direction of movement of the armature-bars by the rotation of the armature. As each bar enters the magnetic field of force its opposite ends pass into contact with the respective brushes, so that the potential induced by its movement through the field of force causes a current to flow through it from one brush to the other. Upon its passage out of the concentrated field of force, or into a feebler portion thereof, its ends pass out of contact with the brushes, so that during its movement into the next field of force it remains open-circuited. When the bar passes into the next field, which is of opposite polarity, the current generated in it is in the opposite direction.

The commutator-brushes B B are built up of a great number of sheets or leaves of copper in order to afford not only an extended face sufficient to bear upon all of the bars that are passing through one field of force, but also to constitute a conductor of extremely low resistance for carrying away the large volume of current generated in the armature. This is a practical requisite of great importance, since all of the parallel armature-bars *b b* which are traversing one of the fields of force are in effect one bar, since they are connected at both ends in multiple by reason of the brushes at both ends bearing upon the bars for the entire width of the field of force. Hence a current of very great volume is generated by reason of the large cross-section of the combined conductors in each field of force, and to carry off this current a conducting-brush of at least equal conductivity is required. In practice I give the brushes a conductivity considerably in excess of that of the bars upon which they bear in order to provide against the heating of the brushes. For the same reason it is requisite to construct the brush-holders in such way that the current in flowing from the brushes through the holders shall be insured a path of extremely low resistance. To meet these requirements, I have devised the construction of duplex brushes and brush-holders, which I will now describe.

In order to give the requisite area of contact between the brushes and the armature-conductors, the brushes are made broad, so as to bear upon a considerable length of the projecting portion of the armature. The total width of the brush is subdivided into two sections, which may be regarded as distinct brushes. These twin brushes are inclosed within a stationary holder-frame, H, Figs. 7 and 8, which is formed with a standard or stud, I. The holder-frame H is an open rectangular frame, through which the twin brushes are thrust. Each of the two brushes is clamped between two plates or gibs, *k*, above and *l* beneath, these plates being forced together by screws in order to compress the copper leaves or laminæ together. The plates *k* and *l* are of only the same width as the lamina upon which they bear, so that those of one of the twin brushes are movable independently of the other. The lower plate, *l*, is constructed to rock on a pivot, *n*, and is provided with an adjusting-screw, *m*, by which in connection with this pivot its angle relatively to the holder H may be varied, and thereby the angle at which the brush bears upon the armature may be adjusted. The upper plate, *k*, is provided with two screws, *p p*, by which to adjust it, whereby it is capable of assuming any angle to which the plate *l* has been set. Thus the twin brushes may be adjusted to different angles, as shown in Fig. 7, where one is given a slight lead over the other. This capability is practically useful in order to vary at will the width of contact of the brushes with the armature-conductors in originally adjusting the machine. When once adjusted, the screw *m* need not subsequently be touched, the adjustment of the brushes forward to take up wear being effected by loosening the screws *p p*.

The several brush-holders H H are mounted and supported by their studs I I being projected through holes in a disk-shaped yoke, J, as shown at the right hand in Fig. 1. The disks J are mounted rotatively on the bearing-frames D D, being fastened thereto by set-screws *q q*, so that if required they can by loosening these screws be slightly turned to alter the lead of the brushes and again fixed in position by tightening the screws. The positive and negative terminal brush-holders have binding-posts P P′ clamped on them for the attachment of the line-conductors, as shown in Figs. 1, 2, and 5. The connection between the brushes through the coupling-sections G G in Fig. 5 is not shown in Figs. 1 to 4, these connectors being omitted for the sake of clearness. One of the connectors is shown detached in Fig. 9. It consists of a subdivided sectional bar the parts of which are drawn together by screws so as to embrace between them the studs I I of the two brush-holders which it is desired to couple together.

It will be seen from an examination of Fig 4 that the projecting end portions of the armature-winding which constitute the commutators extend beyond the core *a* as well as beyond the field-magnet. This construction affords a recess at each end of the armature, in which recess collars *d d′* and nuts *e e′* are inclosed.

In view of the fact that in this machine the electro-motive force varies in direct proportion to the length of the bars *b b*, it is desirable in order to secure a suitable electromotive force to make the armature and field-magnet both as long as practicable. I hence use by preference a field-magnet considerably longer than the field-magnets of similar cross-section heretofore used with alternating-current machines. In thus elongating the field-magnet I subdivide its pole-pieces N S N S into sections, as clearly shown in Figs. 4 and 5, where each pole-piece S and each pole-piece N is divided longitudinally into two sections, each of which is provided with a separate exciting-coil, *c*. By this subdivision I secure in addition to mechanical advantages in construction a stronger and more equally distributed field of force. Preferably the exterior cylindrical neutral portion *f* is not longitudinally subdivided, although it may be, if desired. In machines having still longer field-magnets the pole-pieces may be subdivided into three or even four or more sections instead of two. In the diagram shown in Fig. 11 the pole-pieces are not subdivided.

The field-exciting coils *c c* may be wound in any manner known in the art, and may be coupled or connected together in series multiple arc or multiple series, as may be preferred, to adapt the machine to any desired service. It is one of the advantages of my invention that I produce a dynamo the armature resistance of which is reduced almost to zero, being so slight as to be practically inappreciable. This renders it possible to make the machine self-regulating by the employment of a simple shunt-winding for the field-magnet coils, a result which has been reached theoretically, but has never heretofore been realized in practice so far as I am aware.

I have shown in Figs. 5, 10, and 11 three different methods of coupling up the commutator-brushes. In Fig. 5 they are coupled in series, as already described, so that the electromotive force of the current from the machine becomes the product of that generated in one bar in passing through a field of force at a certain speed multiplied by the number of fields of force through which the armature-bars are simultaneously passing. When thus coupled, the quantity of current that the machine is capable of developing is proportional to the combined conductivities of the bars in contact with one pair of brushes.

In Fig. 10 the brushes are coupled together in multiple, so that the electro-motive force of the generated current is equal only to that generated in one armature-bar in passing through one field of force at a certain speed, or with six pole-pieces the electro-motive force will be one-sixth of that developed with the series coupling shown in Fig. 5, and the total current developed is proportional to the combined conductivities of all the armature-bars that are touched by the brushes, or with the number of field-poles shown the volume will be six times that resulting from a machine coupled as in Fig. 5. The coupling-connections in this figure are shown in diagram only as being wires or rods *r r*, leading from the negative terminal P to the alternate brushes at the opposite ends of the machine, and wires or rods *r′ r′*, leading from the remaining brushes to the positive terminal P′. It will be understood that the connections represented by these slender wires or rods will in practice be heavy coupling-connections of great conductivity. The direction of the current is denoted by arrows, the circuit being divided into as many branches as there are fields of force.

In Fig. 11 a multiple-series coupling is shown, the circuit being divided into as many branches as half the number of fields of force, and each branch traversing two fields of force. The terminal connections are made with the brushes at one end of the machine only, a conductor represented by the wire or rod *r* leading from the negative terminal P to every alternate brush, and another conductor represented by the wire or rod *r′*, leading from the intervening brushes to the positive terminal P′. At the other end of the machine the brushes are joined in pairs by conductors or coupling-sections *r″*, so that the current flowing toward the right through one field of force is permitted to pass back toward the left through the next field of force. Obviously all the brushes at the right might be connected together, since it is immaterial through which of the fields of force the current flows back. They might all be thus connected by connecting their brush-holder studs I I electrically with the disk-shaped yoke J at that end of the machine instead of insulating these studs from the yoke; or all the brushes from this end of the machine might be removed and all the armature-conducting bars *b b* be connected together at this end, as in Sir William Thomson's Mouse Mill Dynamo, before referred to. I prefer, however, the employment of brushes at this end and their connection together either in pairs, as shown in Fig. 11, or by connecting all the brushes together.

The machine represented by the diagrams, Figs. 11 and 12, has eight fields of force instead of six. Obviously my invention may be applied with any number of fields of force from two up; but the greatest efficiency is derived from the multiplication of the fields of force, so that each armature-bar passes as quickly as possible from one field of force into another, so that the least practicable portion of the time is wasted in idleness.

Fig. 12 shows the preferable way of making the connections at the left-hand end of the machine in a multiple-series coupling such as shown in Fig. 11, the connections being made by arc-shaped coupling-sections G G, communicating with the negative binding-post P, curving inwardly to avoid the intervening brush-holders, and by coupling-sections G′, communicating with the positive binding-post P′ and curving outwardly to avoid the negative brush-holders.

My invention is susceptible of considerable modification in respect both of its mechanical construction and of its electrical proportioning, and I therefore wish it to be understood that I do not limit myself to any of the details of construction or to any of the proportions hereinbefore stated, except such as are recited in the claims as being essential. I have illustrated an example of one such modification in Figs. 13, 14, and 15. The machine shown in these figures has a field-magnet with only two poles, arranged diametrically opposite, the pole-pieces embracing the armature between them and covering extended arcs thereof after the manner of dynamos of the Gramme ring or Siemens drum type. The armature-winding is laid directly upon the exterior of the shaft, the interposed laminated core shown in the previous construction being omitted. The shaft C becomes thus in effect the core of the armature. This construction of armature is suitable for small machines wherein but little difficulty is occasioned by eddy-currents. The commutator-brushes make contact with the armature-conductors in line with the fields of force, as before; but since the fields of force extend over a greater arc of the armature-surface it is necessary to employ two or more brushes for each field of force at each end of the machine. Two such brushes are shown in Fig. 15. Being necessarily set at different angles, they are required to be mounted in separate brush-holders; but both the brush-holders are electrically and mechanically connected through the medium of a bar or link, *t*, and the two diametrically-opposite links are mounted on a yoke, J, in the ordinary manner, or otherwise supported. In the construction here shown the field-magnet has its cores or pole-pieces N S made in separate pieces from the neutral portion *f*, which latter forms on the lower side the base-plate of the machine.

It will be understood that my invention may be applied as an electromotor to be driven by the passage of a current through it upon suitably altering the lead of the brushes, as is well known to electricians.

The armature of my dynamo is clearly distinguished from those of dynamos wherein armature-segments insulated from one another are revolved in an annular space between two contrary magnetic poles, so that they cut the radial lines of force traversing such space, by reason of the fact that in such dynamos the armature-bars are connected at their opposite ends to collector-rings, by means of which the current is continually conducted to and from them by means of brushes, so that the bars are continually in closed circuit, whereas in the case of my armature the bars are independent of each other and electrically disconnected at one or both ends, so that the bars are normally open-circuited and are made a part of the circuit only during the time when they are actually passing beneath the brushes.

I claim as my invention the improvements in dynamo-electric machines and electromotors substantially as hereinbefore specified, viz:

1. A dynamo-armature consisting of an iron core mounted to rotate on an axis, with a layer of independent and normally open-circuited conducting-bars insulated from each other extending longitudinally over the core and fastened thereto, so as to rotate therewith.

2. A dynamo-armature consisting of a cylindrical iron core mounted on a revolving shaft, and a layer of independent and normally open-circuited conducting-bars insulated from each other extending longitudinally over the cylindrical core and fastened thereto, so as to rotate therewith.

3. A dynamo-armature consisting of an iron core mounted to rotate on an axis, with a single layer of independent and normally open-circuited segmental conducting-bars applied over said core and fastened thereto, extending longitudinally thereof, insulated therefrom by an interposed insulating-envelope, and insulated from each other by being alternated with insulating-leaves.

4. A dynamo-armature consisting of a cylindrical iron core mounted on a revolving shaft, and a layer of independent and normally open-circuited conducting-bars insulated from each other applied around the exterior of the cylindrical core, fastened thereto to rotate therewith, extending longitudinally thereof, and projecting at the end beyond the end of the core.

5. The combination, with a field-magnet formed with converging poles of alternately-contrary polarities facing a central axis, of an armature consisting of a cylindrical iron core mounted to rotate on said axis, and a single layer of longitudinal conducting-bars insulated from each other fastened to said core, and extending at one end (or both) beyond the ends of the poles to form a commutating-surface, and a series of commutator-brushes equal in number to the field-poles arranged to bear on said commutating-surface in positions coincident with the respective fields of force.

6. The combination, with a field-magnet formed with converging poles of alternately-contrary polarities facing a central axis, of an armature consisting of a cylindrical iron core mounted to rotate on said axis, and a single layer of longitudinal conducting-bars insulated from each other, fastened to said core, and extending at both ends beyond the ends of the poles to form commutating-surfaces, and two series of commutator-brushes, one series arranged at each end to bear on said commutating-surface, and each series equal in number to the field-poles and arranged coincidently with the successive fields of force.

7. The combination of a field-magnet having converging poles of alternately-contrary polarities, an armature consisting of a cylindrical layer of longitudinal conducting-bars mounted to revolve within the field-poles, two

series of collecting-brushes, each equal in number to the field-magnet poles, arranged to bear against said bars in coincidence with the fields of force, and electrical connections with the respective brushes, whereby they are all coupled together between the positive and negative terminals of the machine.

8. The combination of a field-magnet having converging poles of alternately-contrary polarities, an armature consisting of a cylindrical layer of longitudinal conducting-bars mounted to revolve within the field-poles, two series of collecting-brushes, each equal in number to the field-magnet poles, arranged to bear against said bars in coincidence with the fields of force, and electrical connections between alternately-successive pairs of brushes in each series, the connected pairs in one series alternating with those of the other series, whereby the generated current is caused to flow back and forth through the armature and to traverse the several brushes serially.

9. The combination of a field-magnet having converging poles of alternately-contrary polarities, an armature consisting of a cylindrical layer of longitudinal conducting-bars mounted to revolve within the field-poles, a series of collecting-brushes, equal in number to the field-poles, arranged to bear against the said bars in coincidence with the fields of force, holders for the respective brushes, and segmental coupling-bars constructed for engagement at their opposite ends with the respective holders and adapted to form electrical connections between them.

10. The combination of a field-magnet having converging poles of alternately-contrary polarities, an armature consisting of a cylindrical layer of longitudinal conducting-bars mounted to revolve within the field of force, a series of collecting-brushes arranged to bear against said bars in coincidence with the respective fields of force, holders for the respective brushes, and a yoke or disk mounted on a rotative bearing carrying said brush-holders and adjustable on its bearing to vary the lead of the brushes.

11. In a dynamo of the described type, the combination, with the armature having its end projecting to form a commutating-surface, of collecting-brushes bearing on said surface, a holder for each of said brushes formed with a projecting stud, and a segmental coupling-bar adapted to electrically connect two of said holders, and constructed at its ends to be clamped upon the studs thereof.

12. In a dynamo, the combination, with a brush-holder consisting of a rigid open frame, of a commutator-brush passing freely through said frame, two clamping-plates within said frame embracing the brush between them, and adjusting-screws reacting against the frame for pressing said plates against the brush and adjusting their inclination relatively to the holder.

13. In a dynamo, the combination, with a brush-holder consisting of an open frame formed with a rocker-bearing within it, of a commutator-brush passing freely through said frame, two clamping-plates within said frame embracing the brush between them, and one of said plates rocking on said rocker-bearing, a screw engaging said latter plate for adjusting it on said bearing to different inclinations relatively to the holder, and a screw for pressing the opposite plate toward the rocking plate to clamp the brush between them.

14. A dynamo-armature consisting of an iron core mounted to rotate on an axis and formed with longitudinal grooves, with a layer of independent and normally open-circuited conducting-bars insulated from each other extending longitudinally over the core, and with certain of the bars at intervals made wider than the others and projecting into said grooves in the core, with an insulating-layer interposed between the core and said bars.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

THOMAS L. WILLSON.

Witnesses:
ARTHUR C. FRASER,
JNO. E. GAVIN.