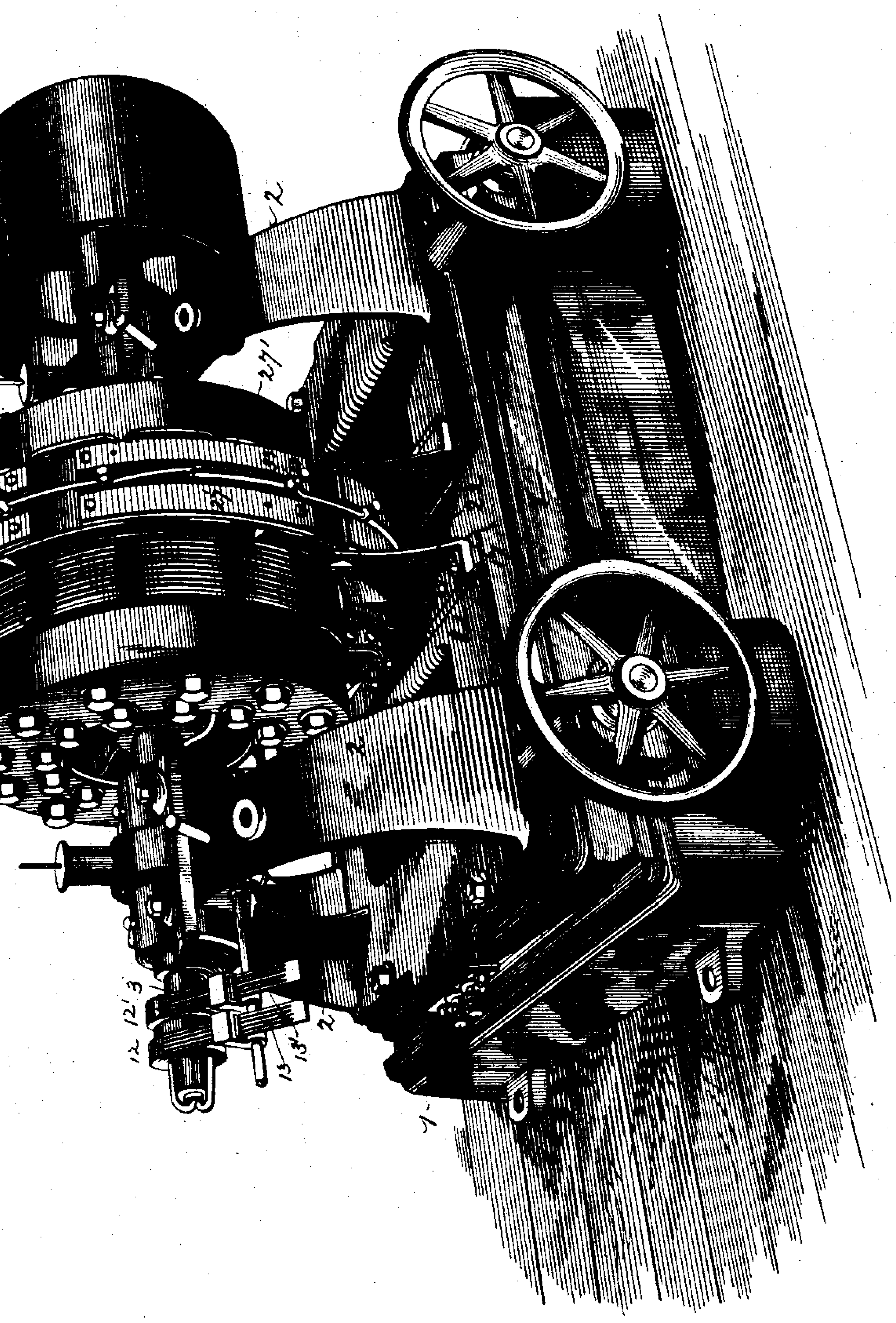
(No Model.) 6 Sheets—Sheet 1.

G. PFANNKUCHE.

DYNAMO ELECTRIC MACHINE.

No. 413,148. Patented Oct. 15, 1889.

Fig. 1



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(No Model.) 6 Sheets—Sheet 2.

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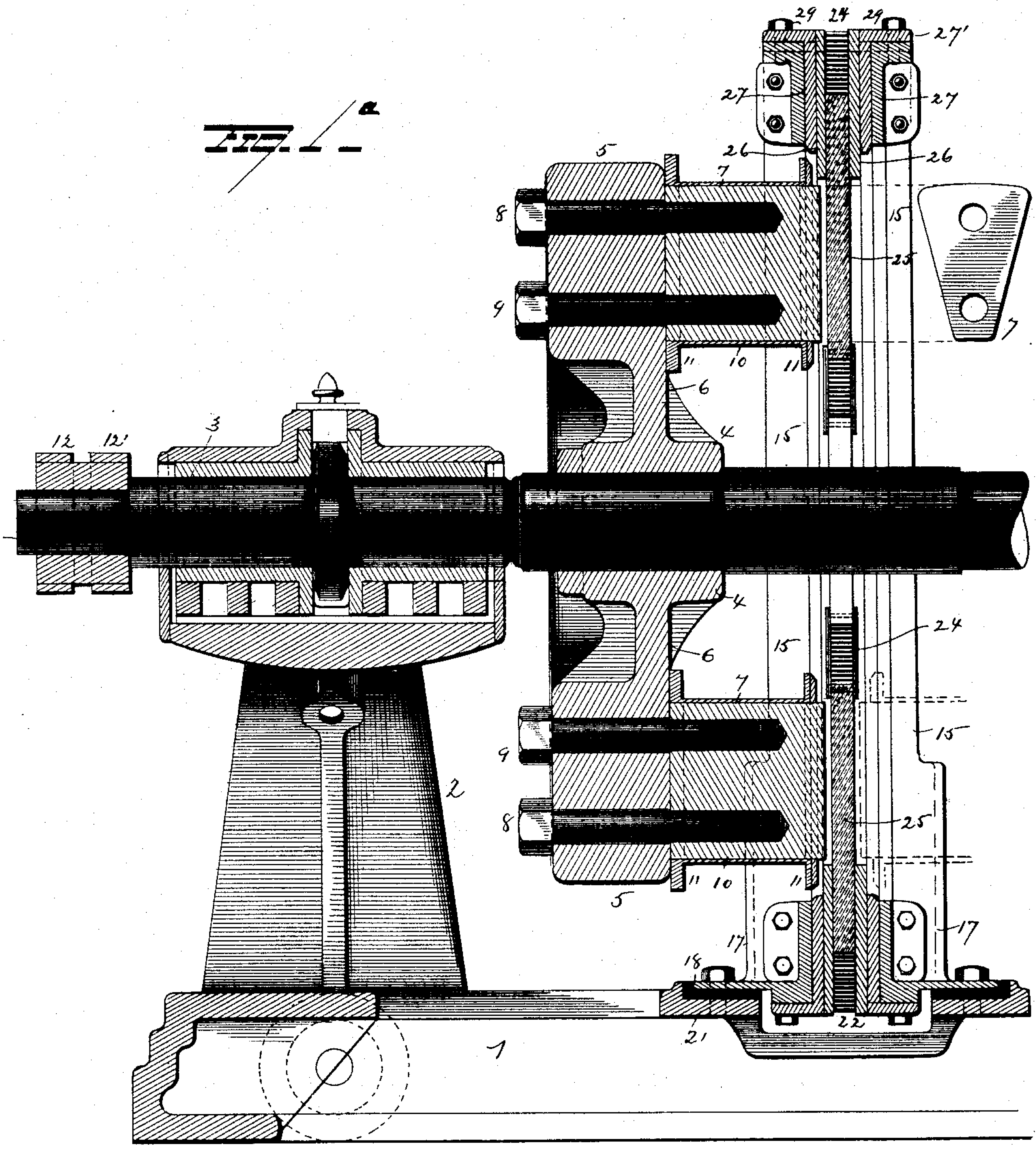

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DYNAMO ELECTRIC MACHINE.

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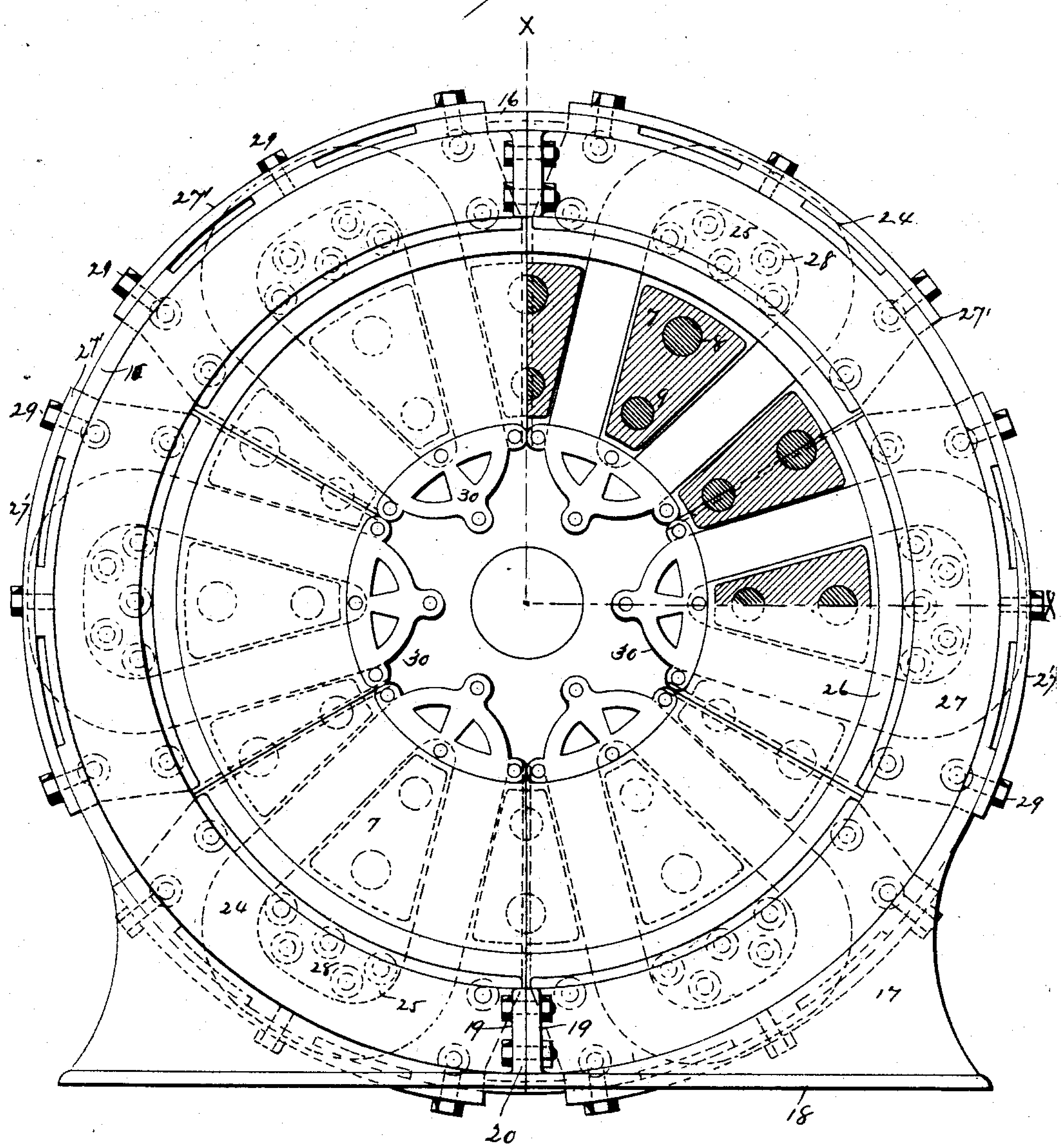
Fig. 2.



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No. 413,148. Patented Oct. 15, 1889.

Fig. 3.

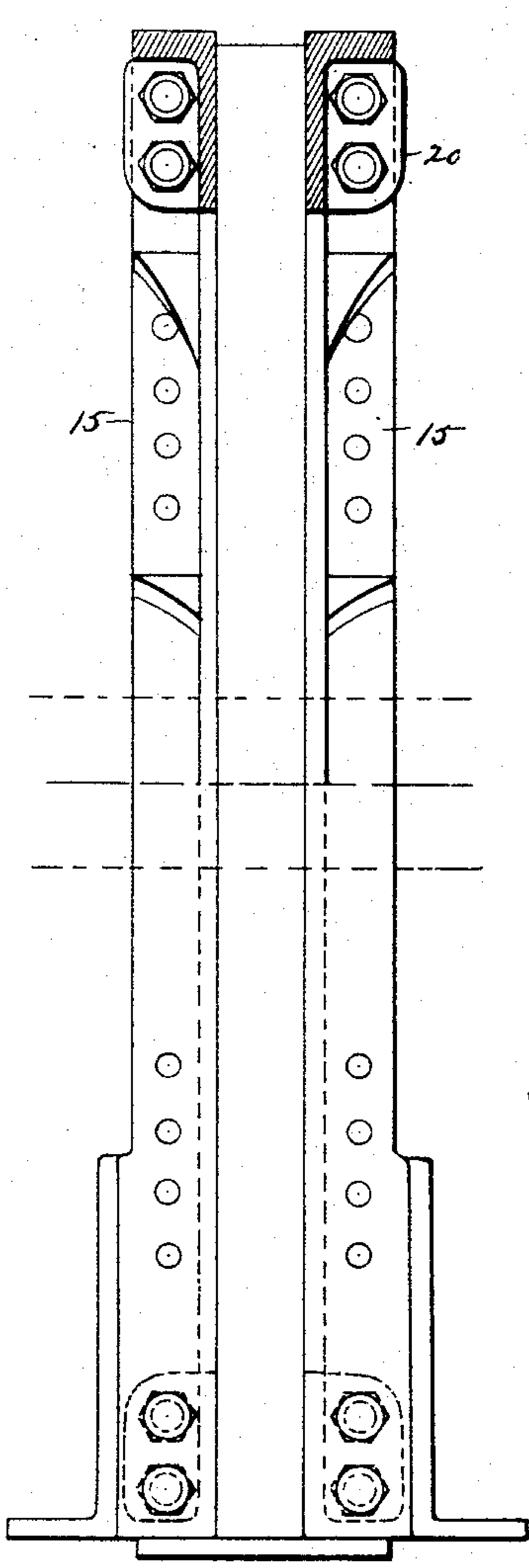


Fig. 4.

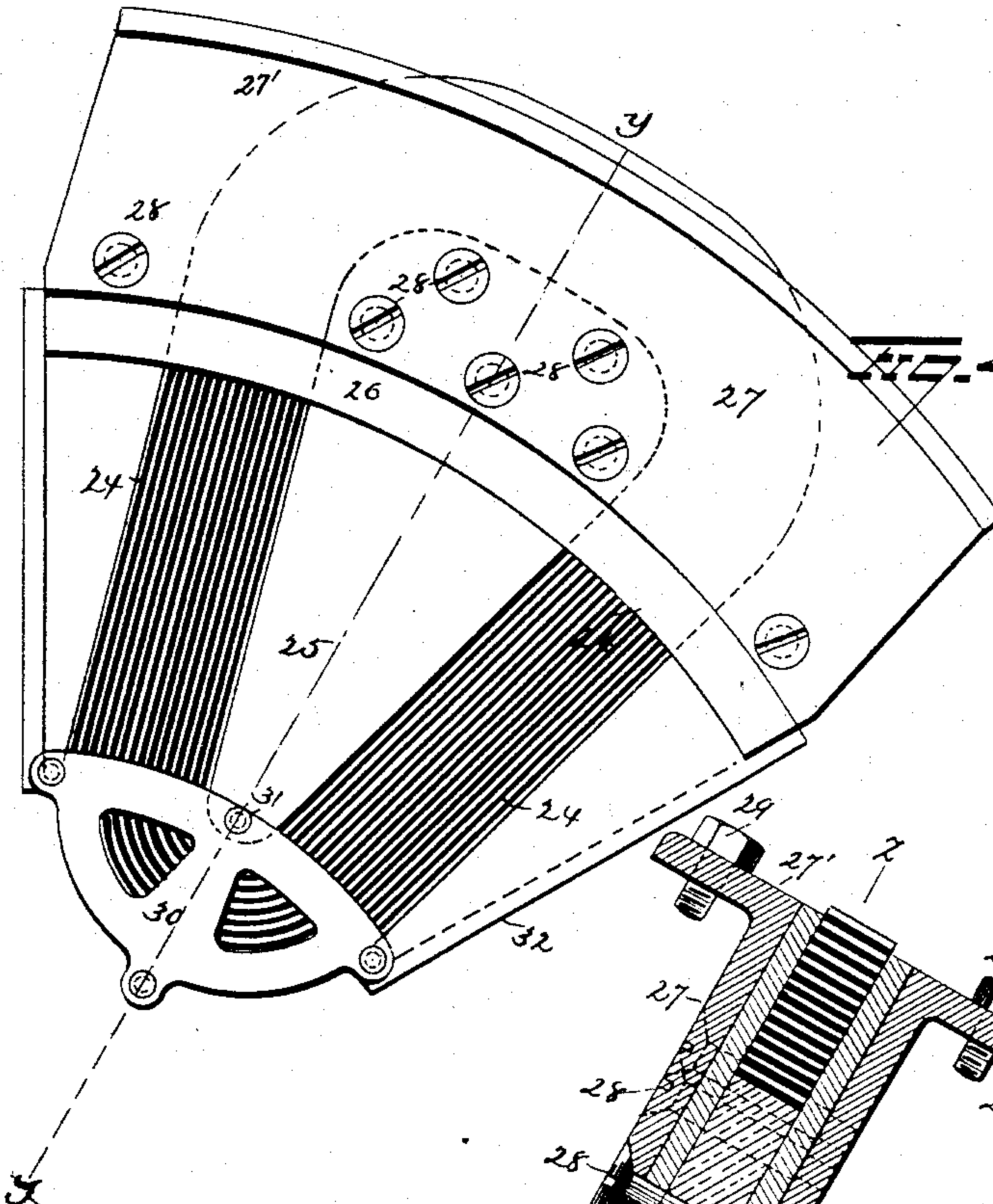
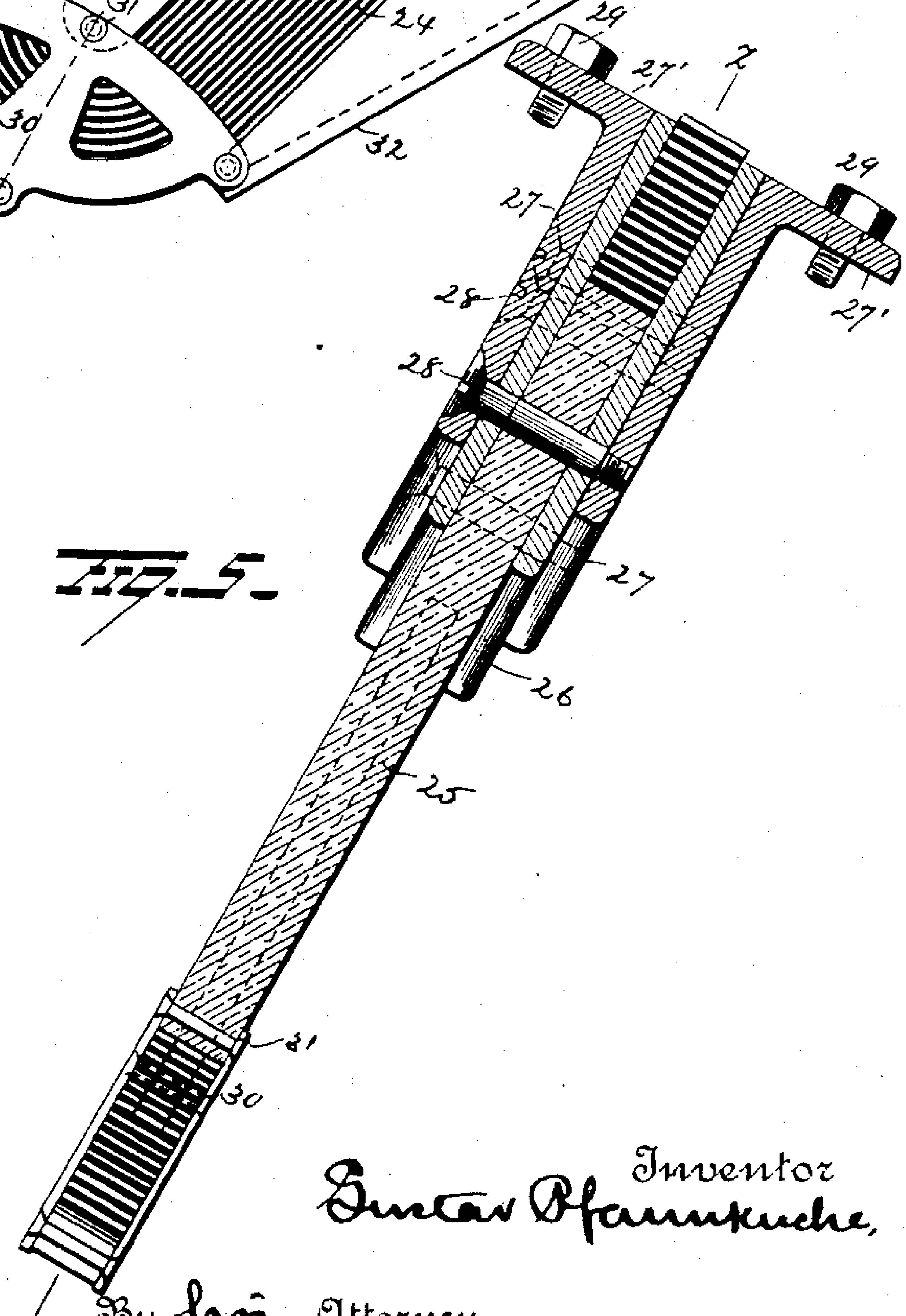


Fig. 5.



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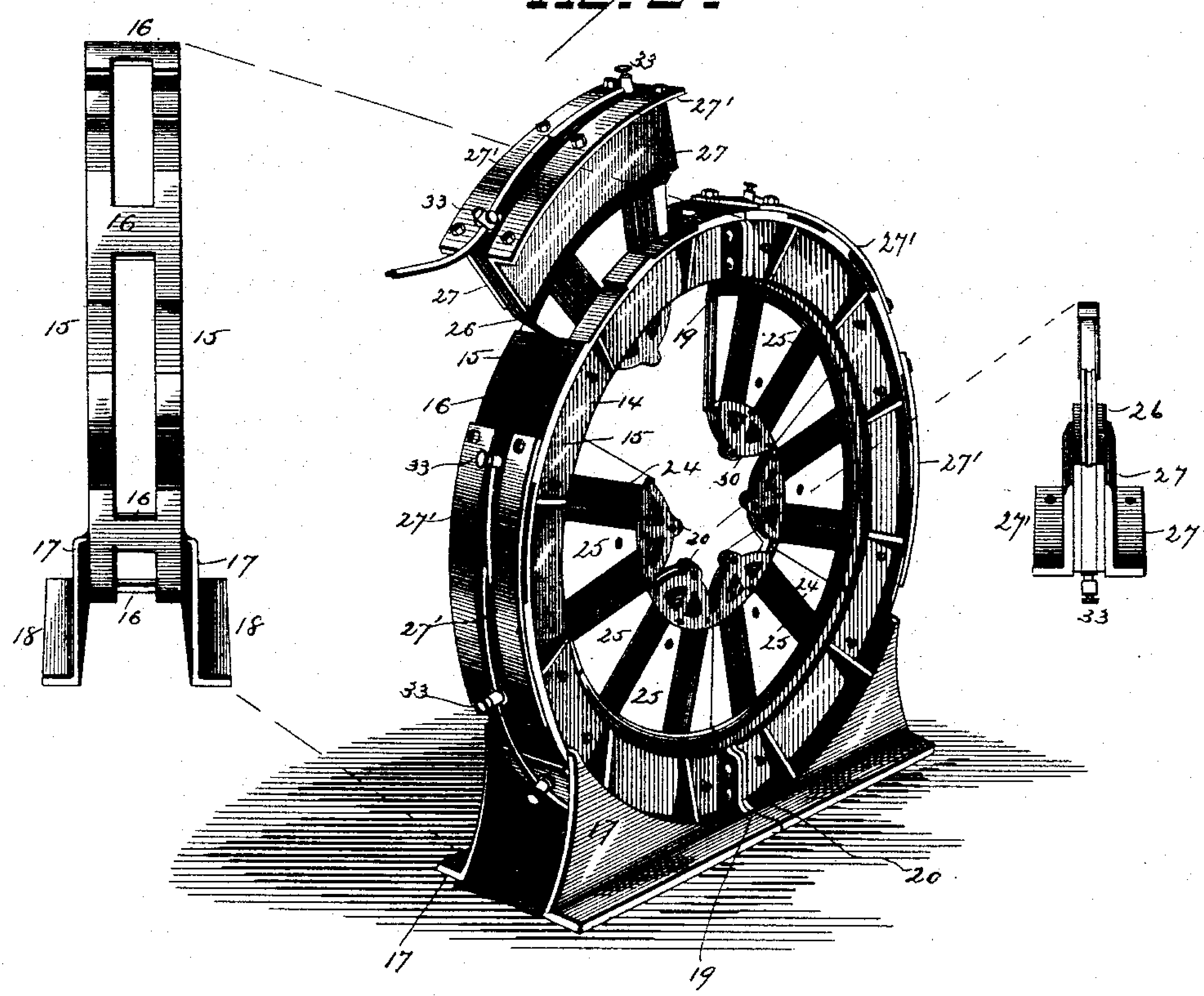
DYNAMO ELECTRIC MACHINE.

No. 413,148. Patented Oct. 15, 1889.

Fig. 5.



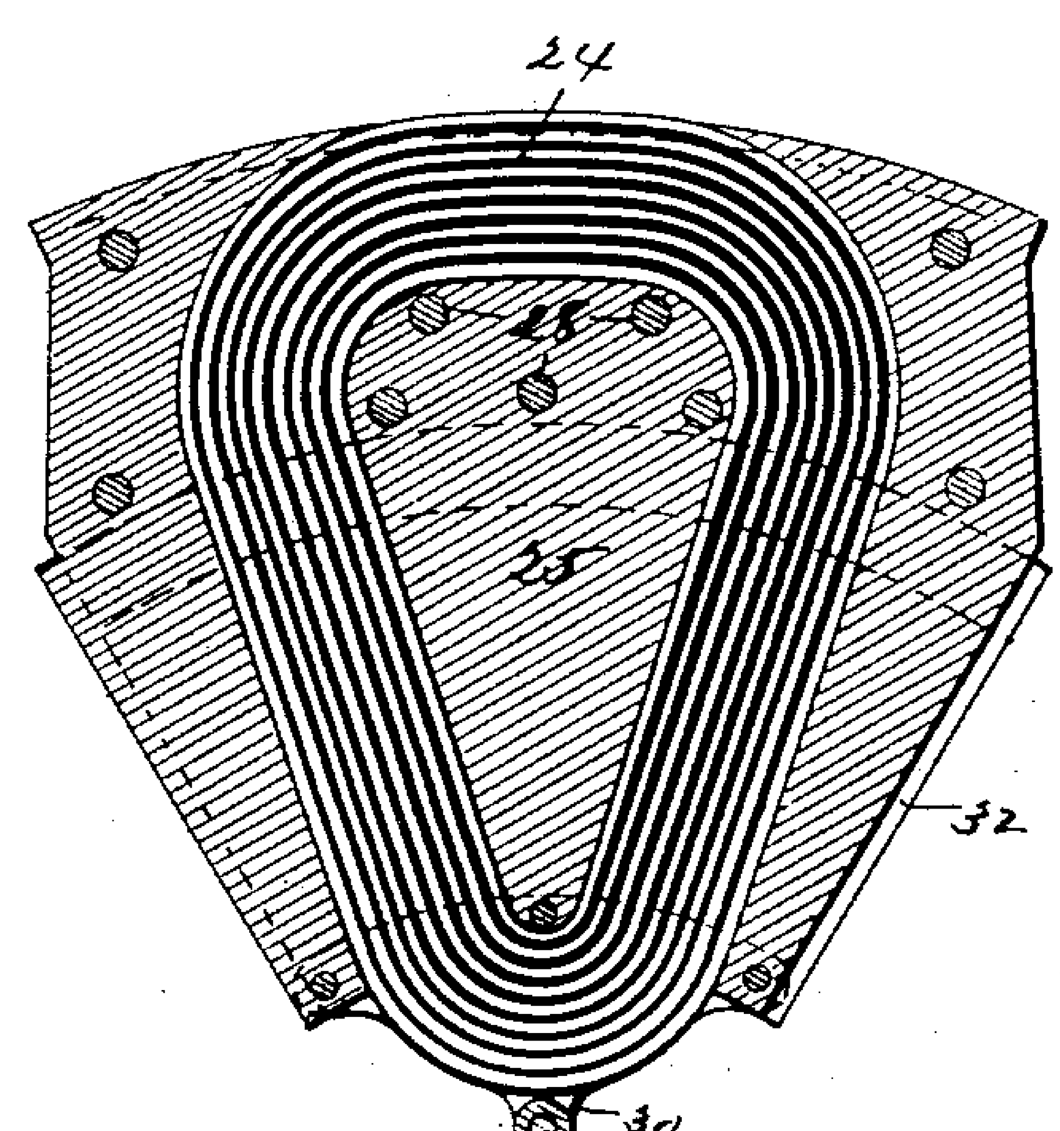


Fig. 7.

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DYNAMO ELECTRIC MACHINE.

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Fig. 8.

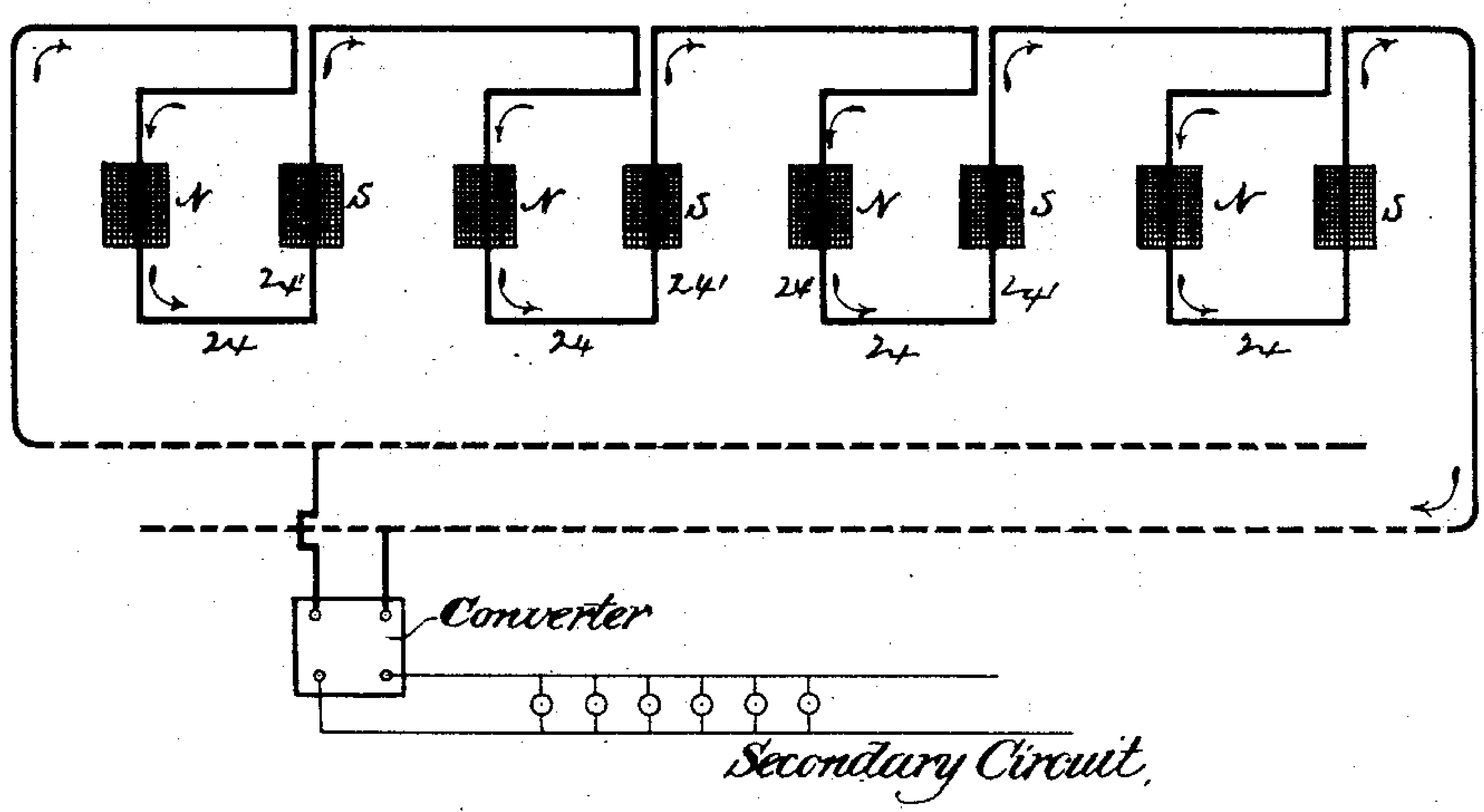
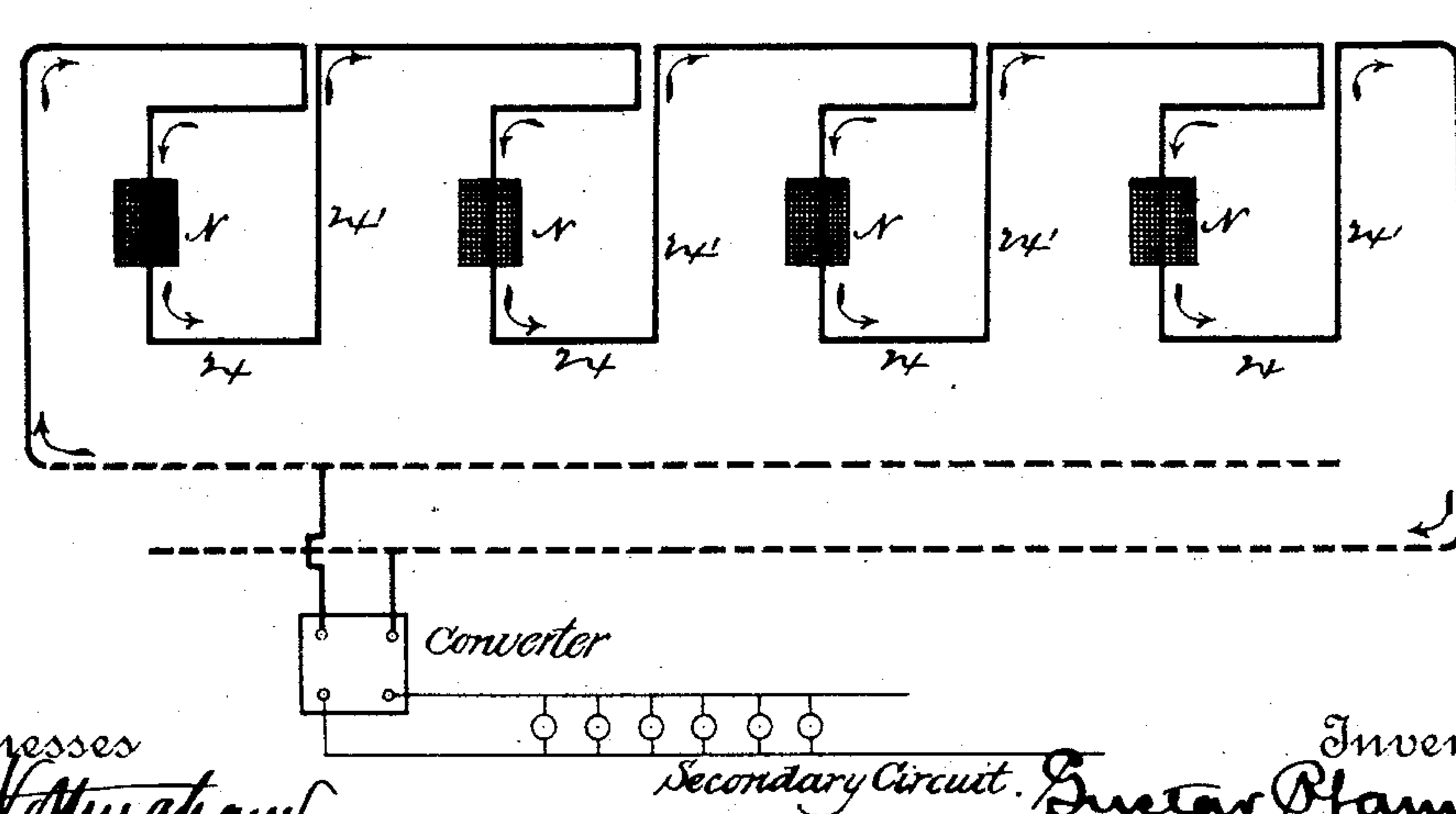


Fig. 9.



Witnesses

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UNITED STATES PATENT OFFICE.

GUSTAV PFANNKUCHE, OF CLEVELAND, OHIO.

DYNAMO-ELECTRIC MACHINE.

SPECIFICATION forming part of Letters Patent No. 413,148, dated October 15, 1889.

Application filed May 18, 1889. Serial No. 311,231. (No model.)

To all whom it may concern:

Be it known that I, GUSTAV PFANNKUCHE, of Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in Dynamo-Electric Generators; 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.

My invention relates to that class of electric generators known under the generic name of "dynamo-electric generators;" and it more particularly relates to that specific form of dynamo-machines known as "alternating-current generators," although it is applied with advantage to dynamo-machines the current from which in the external circuit is what is known in the art as "a straight current;" and the particular object of my invention is to produce a dynamo-electric generator in which the generating-armature embodies in its construction neither iron nor any other magnetic metal, either for the purpose of strengthening the mechanical structure of the machine or for the purpose of intensifying the inducing influence of the field-magnets. At the same time the unavoidable metallic parts for supporting the armature are so located that they are beyond or outside of the effective portion of the magnetic field, so that the latter acts upon the armature-coils alone, thus avoiding any inducing effect on any other part of the armature except the armature-coils.

In addition thereto, and as part of my invention, the armature is constructed to be stationary, while the field-magnets rotate, and this arrangement enables me to reduce the weight and the mechanical rigidity and strength of the armature, since the same is subjected to but little mechanical strain.

I am aware that prior to my invention dynamos have been constructed wherein the armatures were devoid of iron cores and structural supports—as, for instance, in the Brush machine described in Patent No. 302,319, and in the Siemens alternating-current generators. The Arago disk generator is also a specimen of this type. In all of these generators, however, the armature was the rotating member, while the field-magnets were stationary.

I am also aware that alternating-current dynamos of the Gordon or Gramme type have been constructed wherein the armature is stationary and the field rotates; but in these heavy masses of iron constitute the cores of the armatures, and the rapid and violent molecular changes taking place in the cores generate a great amount of heat, whereby the efficiency of such dynamos is lowered to such extent as to make them practically useless for the requirements of the modern state of the art. When in machines of this character the armatures are rotated and the field-magnets made stationary, the former must be made of unreasonable weight and size for a given output, and the liability of destruction by heat is increased to a dangerous extent. All this is avoided by my invention, and in addition thereto I reduce the Foucault currents, which are a deplorable source of waste, to a minimum. The rotation of the field-magnets can be effected without trouble and danger, for the reason that these magnets are invariably made, and must in the nature of things be made, very strong and heavy, and they will therefore resist the action of centrifugal force, which, when the armature revolves, might be and often is destructive, and the absence of these forces in the stationary armature permits the same to be built extremely light and thin, without metallic hubs, spiders, or spokes, or any other metallic supports projecting within the effective magnetic field of the rotating magnets.

The possibility of keeping the armature very thin is one of the main objects of my invention, since by this construction it is very easy to bring a very powerful magnetic field to bear on the stationary induced coils. Owing to the absence of any metal exposed to the effective field excepting the armature-coils, the field can be made exceedingly dense or concentrated where it intersects the effective portion of the armature-coils, and thus produce a high electro-motive force with short lengths of conductors and low resistance of the same, and in the absence of heating and wasteful induction high electrical and commercial efficiency, as well as the safety of the machine, is insured. All this will more fully appear from the following detailed description with reference to the accompanying drawings, which form a part hereof, and in which I have illustrated one form of machine constructed in accordance with my invention.

Figure 1 is a perspective view of my improved dynamo. Fig. 1ª represents a longitudinal vertical section of my improved dynamo with some of the field-magnets on one side and the driving-pulley omitted. Fig. 2 is an end elevation of the armature with some of the field-magnet cores shown in section and with relation thereto. Fig. 3 is a front view of the armature-frame with a segment x x (indicated by dotted lines in Fig. 2) cut away. Fig. 4 is an end elevation of one of the armature-coils mounted on its segmental support. Fig. 5 is a section on the line y y of Fig. 4. Fig. 6 is a perspective view of the armature with one of the segmental armature-sections about to be inserted and another section removed. Fig. 7 is a sectional view on line z z of Fig. 5, and Figs. 8 and 9 are diagrams illustrating the inductive relations of armatures and field-magnets.

Like numerals of reference indicate like parts throughout the drawings.

The base 1 of the machine is a hollow casting of suitable shape, the upper plate of which is in the nature of a skeleton frame, from the two ends of which rise the standards 2 2, on which bearings for a shaft 3 are formed. This shaft 3 extends at each end beyond the bearings, and the driving-pulley of the machine is secured to one of these extensions, and the collector rings or sleeves are mounted upon the other extension, as will hereinafter more fully appear. A suitable distance from the middle of the shaft and on each side thereof is keyed an iron disk composed of a central hub 4 and a heavy rim 5, connected to the hub by radial spokes 6. It is not essential that the hub and spokes be made of iron, so long as the rim 5 is made of that material or of any other magnetic material; but by preference, and chiefly for the sake of cheapness, the whole disk is cast of one piece of iron; but since the essential part of said disk is the rim of the same, which, considered by itself, is an annulus, and which carries the field-magnets proper, as will presently appear, said rim will hereinafter be referred to as the "annular yoke" of one set of the field-magnets.

The field-magnet cores 7 are segmental in cross-section, as shown, and are screwed by bolts 8 9 to the inner face of the annular yoke, properly spaced.

In the drawings twelve magnet-cores are shown on each yoke, but any other number may be used. The segmental cores are secured to the yoke in radial positions, and they are each supplied with a thin sleeve 10 and with flanges 11, both of insulating material, and the energizing-coils are wound upon said sleeve between the flanges in the usual well-known manner. The free pole-faces of the magnet-cores project a short distance beyond the flanges, and the two sets of field-magnets are so mounted upon the shaft 3 that a small space is left between the opposing faces of the magnet-cores, and, as will hereinafter more fully appear, this space is occupied by the effective portions of the armature-coils.

The field-magnet coils are connected on each side, either in series or in parallel arc, and the coils of one set are connected with the coils of the other set, either in series or in parallel arc, this connection being made within the shaft, which for this purpose is made hollow, or the wire connecting one set of magnet-coils with the other magnet extended between the two hubs 4 4, suitably secured to the outer face of shaft 3. One terminal of the field-magnet coils extends through the hollow shaft, and where it projects from the same it is bent upon itself and is secured to one of the collector-sleeves 12, and the other terminal similarly extending through the hollow shaft is secured to the other collector-disk 12′. Brushes 13 13′, constituting the terminals of an exciter, bear upon the collector-sleeves 12 12′. It will now be understood that if the exciter furnishes current the same will pass to and through the field-magnet coils in series or in parallel, or in any other way, according to the connections of the field-magnet coils, and will energize the magnet-cores according to the direction of the winding. This winding may be so that the successive pole-faces of each set are alternately of south and north polarity, while the pole-faces of the opposing sets have a north and south polarity, so that there will be as many distinct magnetic fields as there are opposing sets of pole-faces. Another mode of winding would be such as will produce like polarity in all the pole-faces of one set of magnets and the opposite polarity in the pole-faces of the other set of magnets, in which case the shaft or the supporting-frame would form the medium for completing the magnetic circuit. If, now, the shaft 3 is rotated by power applied to the driving-pulley, the two sets of field-magnets participate in that rotation, and a conductor extending radially within the space between the opposing pole-faces will have currents of alternating direction generated within itself, as is well understood by those skilled in the art, and such radial generating conductor or conductors are provided in dynamo-machines by what is technically known as the "armature" of the machine.

In accordance with my invention the armature is stationary, and is constructed as follows: There is an annular skeleton frame 14, which will hereinafter be referred to as the "armature-frame," and which is made of German silver or other non-magnetic metal of high electrical resistance. This frame is made in sections, and by preference in two sections, which may be bolted together and taken apart with ease. Each half of the armature-frame is composed of two semicircular angular flanges 15 15, the plane faces of which are parallel to each other and held a suitable distance apart by bridge-pieces 16 16, which may either be cast in one piece with the flanges or may be separately screwed onto the curved faces of the same, and they are of such width and so spaced as to leave a number of equal segmental slots between the two flanges of the armature-frame, and the arrangement is such as to provide as many free slots as there are armature-coils to be used in the machine, for these slots are intended to receive the armature-coils, as will presently appear. Each half of the armature-frame has formed upon it at the lower end thereof an expanded foot 17, terminating below in a straight flange 18, and the diameter faces of each half of the frame are also provided with flanges 19 19, by which the two halves are bolted together by bolts and nuts, as shown at 20. On the base of the machine there is provided a central bridge 21, in which a wide slot 22, extending all the way across the machine under the middle of the shaft 3 and at right angles thereto, is formed, and on each side of the slot the bridge-piece is recessed and planed off smoothly, and into these recesses fit the plane flanges of the feet 17 of the armature-frame, so that each half of the latter can be moved to and from the middle of the machine. When the armature-coils have been mounted in the frame, as will hereinafter more fully appear, each half of the frame is inserted with its flanged feet in the recesses formed on the bridge-piece, and they are then moved toward each other until the flanges 19 19, formed on their diameter faces, meet, when the bolts 20 are inserted and the two halves of the armature-frame secured together. The frame as a whole is then secured to the base by bolts 23, passing into holes in the flanges of the feet, registering with similar holes in the bridge-piece.

The armature-coils 24 24, &c., are wound as segmental flat disks upon segmental cores 25, of insulating material—such as vulcanized fiber, asbestus board, or wood—but I preferably use segmental cores composed of porcelain, china, glass, or other silicious or equivalent material, and to each flat side of the upper wider portion of the coil is applied an insulating-plate 26, of segmental shape, extending on each side beyond the coil, and to each such insulating-plate is applied a segmental flange-plate 27, of German silver or other non-magnetic material of high electrical resistance. Screw-bolts 28 28, &c., passing through the metal and insulating plates, secure these mountings to the outer part of the armature-coil, so that the latter is securely clamped in its mountings, the curved flanges 27′ of the metal plates 27 projecting on each side laterally. These flanges 27′ have holes formed in them, and screw-bolts 29 are used for securing these flanges to the curved faces of the angular flanges 15 15 of the armature-frame after the coil has been inserted in the slots provided in said frame, hereinbefore referred to. The lower narrower portion of each armature-coil has applied to each side a semicircular or similarly-shaped plate 30, of German silver or other non-magnetic metal, and screw-bolts 31, passing through these plates, secure the same together and to the armature-coil. Between the upper and lower mountings of each armature-coil are inserted segmental pieces 32 32, of insulating material, which may be made of the same material the cores 25 are made of, one radial edge of which bears upon the outer edge of the coil, while the other edge of the insulating-piece is either grooved or tongued, so that there will be a groove on one of these pieces and a tongue on the next adjoining one. The projecting ends of the insulating-plates 26 and of the segmental flange-plates 27 are cut off parallel to each other, so that the distance between these two ends is equal, or nearly so, to the distance between the edges of one bridge-piece 16 and the edge of the next succeeding bridge-piece 16. If, now, an armature-coil thus mounted is slipped into one of the slots in the armature-frame between two bridge-pieces 16 16 and secured in place by the bolts 29, as above described, the next succeeding armature-coil, with its mountings, when inserted in the next slot in the armature-frame, will engage with the tongue on the edge of one of its segmental insulating-plates 32 a groove formed in the radial edge of the adjacent insulating-plate 32 of the coil already in position, and when these armature-coils are inserted in all the slots provided for them in the armature-frame they will be all interlocked, and when in position between the opposing pole-faces of the field-magnets they will present on each side an annular recess, within which the pole-faces can be brought very close up to the faces of the coils without touching the same. The free ends of the armature-coils are secured to binding-posts 33, mounted upon but insulated from the curved flanges of the segmental plates 27; and these coils may be connected up in series or in quantity, or in any other desired way, by conductors extending between the binding-posts of the successive armature-coils, and the currents generated in the armature-coils are carried from the machine to the external circuit in a manner well understood by those skilled in the art.

From the foregoing description it will be seen that the armature, when built up and in position for operation, consists, essentially, of a skeleton frame of non-magnetic material concentric to but outside of the effective inducing influence of the magnetic fields of force. The induced coils extend, with their active generating portions, radially through the space between the opposing pole-faces of the two sets of field-magnets, and the wider inactive portions of these coils are arranged concentric with but outside of the effective inducing influence of the magnets, similar in this respect to the body of the armature-frame. The narrower and inner portions of the induced coils are also arranged concentric to the annular space occupied by the magnetic fields; but, being arranged upon a smaller circle, they are not subjected to the action of the effective part of the magnetic field.

The annular space between the opposing pole-faces of the field-magnets can be made as narrow as desired, and this space being completely occupied by the active generating portions of the armature-coils, and by the insulating spacing blocks or plates 32, the magnetic lines of force will be substantially straight lines extending between the opposing pole-faces. Consequently the magnetic fields will be of uniform density throughout, and will act almost exclusively upon the radial portions of the induced coils. No substantial part of the magneto-electric induction will, therefore, be consumed in unproductive work, and the maximum useful effect will be obtained.

In a dynamo-machine constructed in accordance with my invention each armature-coil may be used as an independent entity and without connection with or dependence upon the other coils, and each may be removed and inserted without affecting the functions of the others, since, if so desired, each coil may furnish currents to an independent external circuit. All that is necessary for this purpose is to open the connection between the adjacent coils and to connect the binding-posts of each coil with a separate external circuit. These binding-posts being readily accessible, even when the machine is running, the desired changes can be made without stopping the machine.

For inspection or repair the whole armature can be removed with ease, and without cutting of wires, by simply withdrawing the bolts 20 20 and 23 23 and sliding each half of the armature-frame outwardly, the connections between the adjacent binding-posts of the coils next to the diameter faces of the two halves having been first removed.

In the drawings I have shown twice the number of pole-pieces in each set of field-magnets that there are armature-coils, each coil extending over two successive pole-faces. When this construction is employed, the successive pole-faces have alternately south and north polarity; but I am not limited to this construction, since I may use as many armature-coils as there are pole-faces in each set of field-magnets, in which case, however, one radial branch only of each coil will at any time be in inductive relation to the field-magnets. When this construction is employed, the windings of the field-magnets will be such as to produce the same polarity in all pole-faces of one set and the opposite polarity in all pole-faces of the other set, while the shaft or the supporting-frame would be the medium for completing the magnetic circuit. The two arrangements are diagrammatically illustrated in Figs. 8 and 9.

In Fig. 8 one set of pole-faces (represented by shaded squares) is marked, successively, N S, N S, &c., and the armature-coils 24 are each shown as a single solid line and as bridging the space between two successive pole-faces, and with each radial branch 24′ over one of these pole-faces. This represents the arrangement shown in detail in the other figures of drawings, which is used by preference. The external circuit is indicated by dotted lines, showing also a converter. The primary coil is fed by the alternating current from the dynamo, while the secondary coil of the converter is connected with a working-circuit.

In Fig. 9 there are shown in one set of field-magnets as many pole-faces of the same polarity as there are armature-coils 24. The coils, however, in this instance have only one of their radial branches 24′ at the same time in inductive relation to the field-magnets, for the latter are now spaced so far apart that a single coil cannot bridge the space between two of them. The external circuit is here shown in the same manner as in Fig. 8.

Some features of construction herein shown and described may be employed with advantage in ordinary dynamos, wherein the armature rotates between stationary field-magnets, and hence I would have it understood that with reference to such features of improvement as are applicable to both stationary and rotary armatures I claim them in either.

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

1. In a dynamo-electric generator, the combination of rotating field-magnets and a stationary armature made of non-magnetic material, substantially as described.

2. A dynamo-electric generator consisting, essentially, of rotating field-magnets and a stationary armature, the generating portions of which are exposed to the inductive action of the magnets, and the inactive and structural portions of which are beyond the inductive sphere of the same, substantially as set forth.

3. A dynamo-electric generator consisting, essentially, of annular series of rotating field-magnets and an annular series of stationary armature-coils arranged with their active portions within the field or fields of force and with their inactive portions outside of said field or fields, substantially as described.

4. In a dynamo-electric generator, the combination of annular series of rotating field-magnets with an annular series of stationary armature-coils mounted upon a non-magnetic support and wound upon insulating-coils, said coils being arranged with their active portions within the field or fields of force and with their inactive portions outside of said field or fields, substantially as described.

5. In a dynamo-electric generator, the combination of two annular series of rotating field-magnets forming an annular magnetic field of force or an annular series of magnetic fields of force between the opposed pole-faces of the magnets, with an annular series of stationary segmental armature-coils wound upon non-magnetic cores, and occupying, with their radial branches, the magnetic field, while their inactive portions are outside of said field, substantially as described.

6. In a dynamo-electric generator, the combination of two annular series of rotating field-magnets forming an annular magnetic field of force or an annular series of magnetic fields of force between the opposed pole-faces of the magnets, with a stationary annular armature-support of non-magnetic metal composed of detachable segments and located in the plane of the magnetic field, but beyond the inductive influence of the same, substantially as described.

7. In a dynamo-electric generator, the combination of two annular series of rotating field-magnets forming an annular magnetic field of force or an annular series of magnetic fields of force between the opposed pole-faces of the magnets, with a stationary annular armature-support of non-magnetic metal composed of detachable segments and located in the plane of the magnetic field, but beyond the inductive influence of the same, and a series of segmental armature-coils removably mounted in the annular support, with their radial branches exposed to the action of the field and with their peripheral portions beyond the inductive sphere of the magnets, substantially as described.

8. In a dynamo-electric machine, the combination of a series of rotating field-magnets with a series of stationary armature-coils mounted on a non-magnetic support, the conductor of the armature-coils being disposed in a plane parallel to the plane of rotation of the field-magnets, substantially as described.

9. In a dynamo-electric machine, the combination of a series of rotating field-magnets with a series of stationary armature-coils mounted on a non-magnetic support, the conductor of the armature-coils being disposed in a plane parallel to the plane of rotation of the field-magnets, and the outer portion of the coils being faced with insulating material, substantially as set forth.

10. In a dynamo-electric machine, the combination of a series of rotating field-magnets with a series of stationary armature-coils mounted on a support located outside of the field of force, substantially as set forth.

11. In a dynamo-electric machine, the combination of a series of rotating field-magnets with a series of stationary armature-coils mounted on a non-magnetic support located outside of the field of force, substantially as set forth.

12. In a dynamo-electric machine, the combination of a series of rotating field-magnets with a stationary supporting-frame encircling the field of force, and armature-coils removably secured thereto, substantially as set forth.

13. In a dynamo-electric machine, the combination, with a series of rotating field-magnets, of a series of stationary armature-coils mounted on a non-magnetic support, the inner ends of said coils arranged to encircle but out of contact with the shaft of the field-magnets, substantially as set forth.

14. In a dynamo-electric machine, an armature consisting in the combination, with a supporting-frame, of a series of radially-detachable coils secured at their outer ends to said frame, substantially as set forth.

15. In a dynamo-electric machine, an armature comprising a supporting-frame, and a series of armature-coils connected together by interlocking plates and secured at their outer ends to said supporting-frame, substantially as set forth.

16. In a dynamo-electric machine, an armature comprising a supporting-frame, a series of armature-coils provided with tongue-and-groove plates for connecting together the adjacent coils, said coils being secured at their outer ends to the supporting-frame, substantially as set forth.

17. In a dynamo-electric machine, the combination, with a support, of a series of radially-disposed armature-coils connected with said support, said armature-coils mounted on interlocking supports, substantially as set forth.

18. In a dynamo-electric machine, an armature composed of a series of armature-coils, each having a plate of insulating material secured to its side, which plates are furnished with interlocking tongues and grooves, substantially as set forth.

19. In a dynamo-electric machine, the combination of rotating field-magnets with a stationary annular armature-support of non-magnetic metal surrounding the field of force and provided with equally-spaced slots, and armature-coils removably seated in said slots and extending into the fields of force, substantially as described.

20. In a dynamo-electric generator, the combination of rotating field-magnets with a stationary annular armature-support of non-magnetic metal surrounding the field of force and provided with equally-spaced slots, armature-coils clamped at their inactive ends between non-magnetic plates seated in said slots, and interlocking spacing-plates of insulating material between the coils, substantially as set forth.

21. In a dynamo-electric generator, the combination of field-magnets carried by a rotating shaft with an annular armature-support of non-magnetic metal concentric to but not in contact with the shaft and composed of two semicircular sections detachably secured together upon the line of a diameter, whereby the armature may be removed from

the machine without disturbing the shaft, substantially as described.

22. In a dynamo-electric generator, the combination of field-magnets carried by a rotating shaft, and a series of armature-coils mounted upon the two semicircular detachable sections of an annular support of non-magnetic material, each semicircular section being movable upon guides at right angles to said shaft, substantially as described.

23. In a dynamo-electric machine, a stationary armature composed of a series of segmental coils removably seated in an annular skeleton support of non-magnetic metal composed of flanged plates parallel to each other, with bridge-pieces extending between them, whereby the support is divided into a number of equally-spaced seats for the coils, substantially as described.

24. In a dynamo-electric machine, the combination of parallel annular series of rotating field-magnets with an armature composed of a series of segmental coils removably seated in a stationary annular skeleton support of non-magnetic metal in the plane of but beyond the inductive influence of the magnetic field of force, said support consisting of flanged plates arranged parallel to each other, with bridge-pieces extending between them, whereby the support is divided into a number of equally-spaced seats for the coils, substantially as described.

25. In a dynamo-electric machine, an armature provided with coils wound upon cores composed of silicious or other equivalent material, substantially as set forth.

26. In a dynamo-electric machine, an armature provided with coils wound upon cores of insulating material, said coils being provided with interlocking plates composed of silicious or equivalent material, substantially as set forth.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

GUSTAV PFANNKUCHE.

Witnesses:
JOHN C. DOLPH,
W. A. PALLANT.