(No Model.) 2 Sheets—Sheet 1.

R. H. MATHER.

DYNAMO ELECTRIC MACHINE.

No. 268,255. Patented Nov. 28, 1882.

Fig. 1.

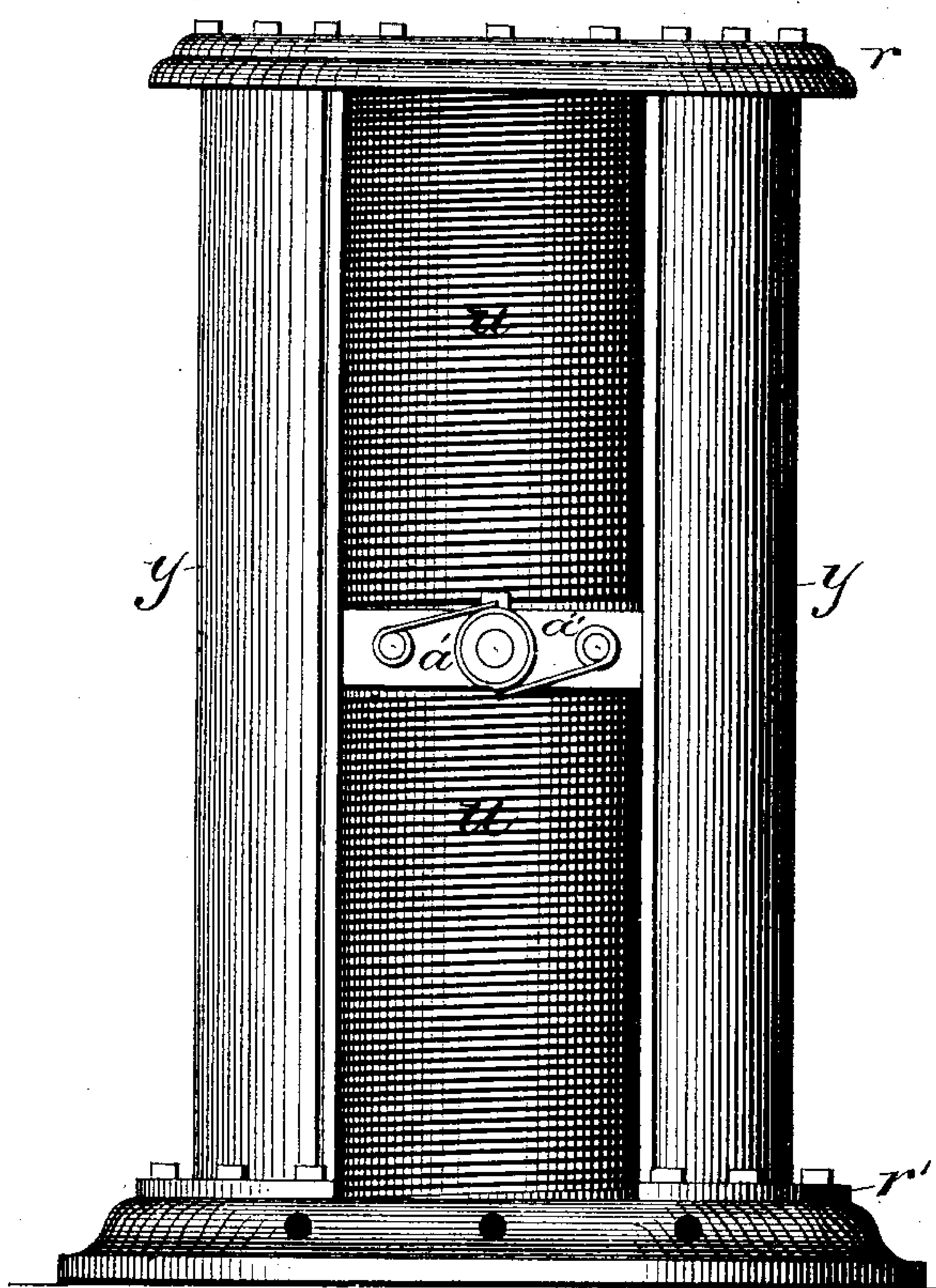


Fig. 2.

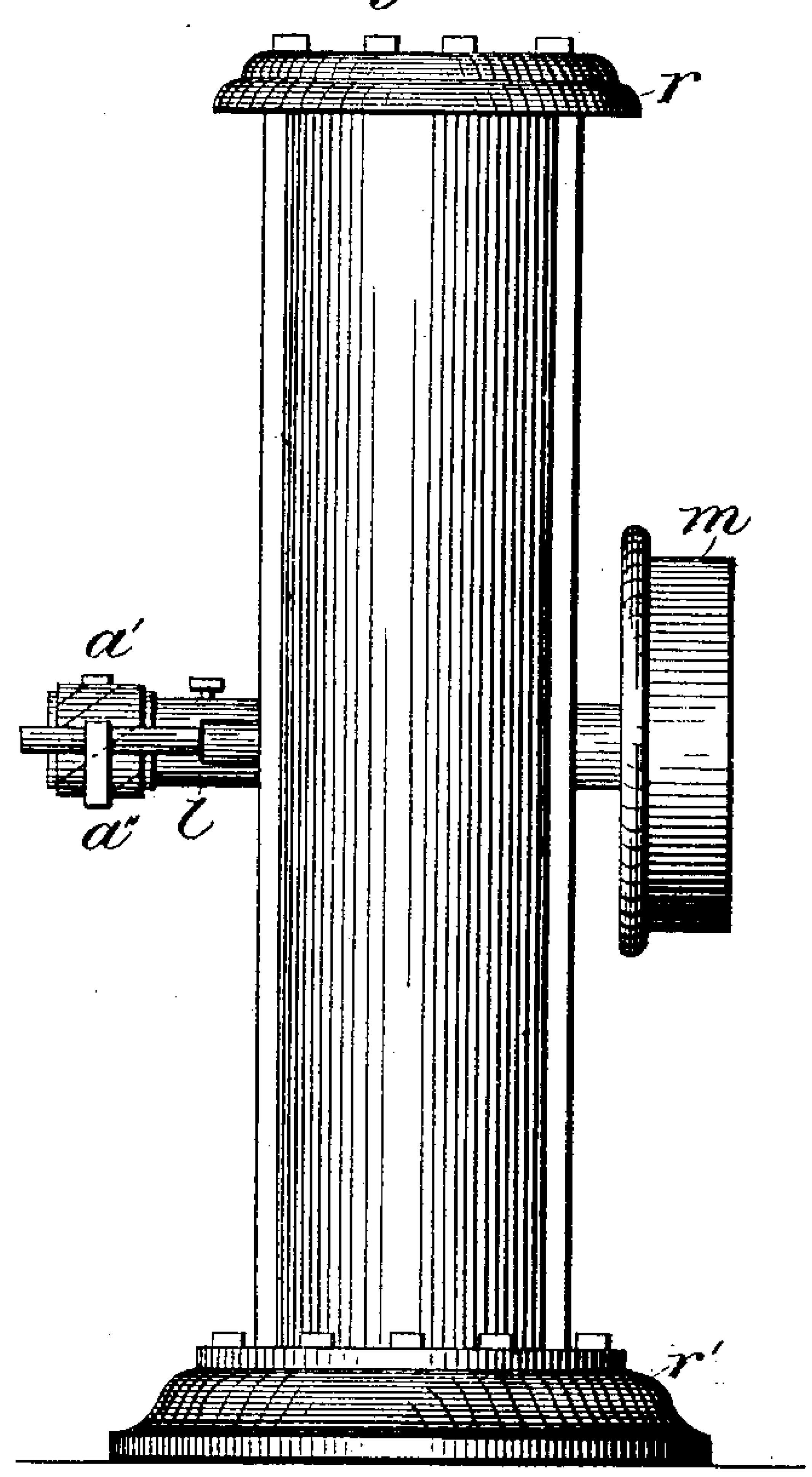
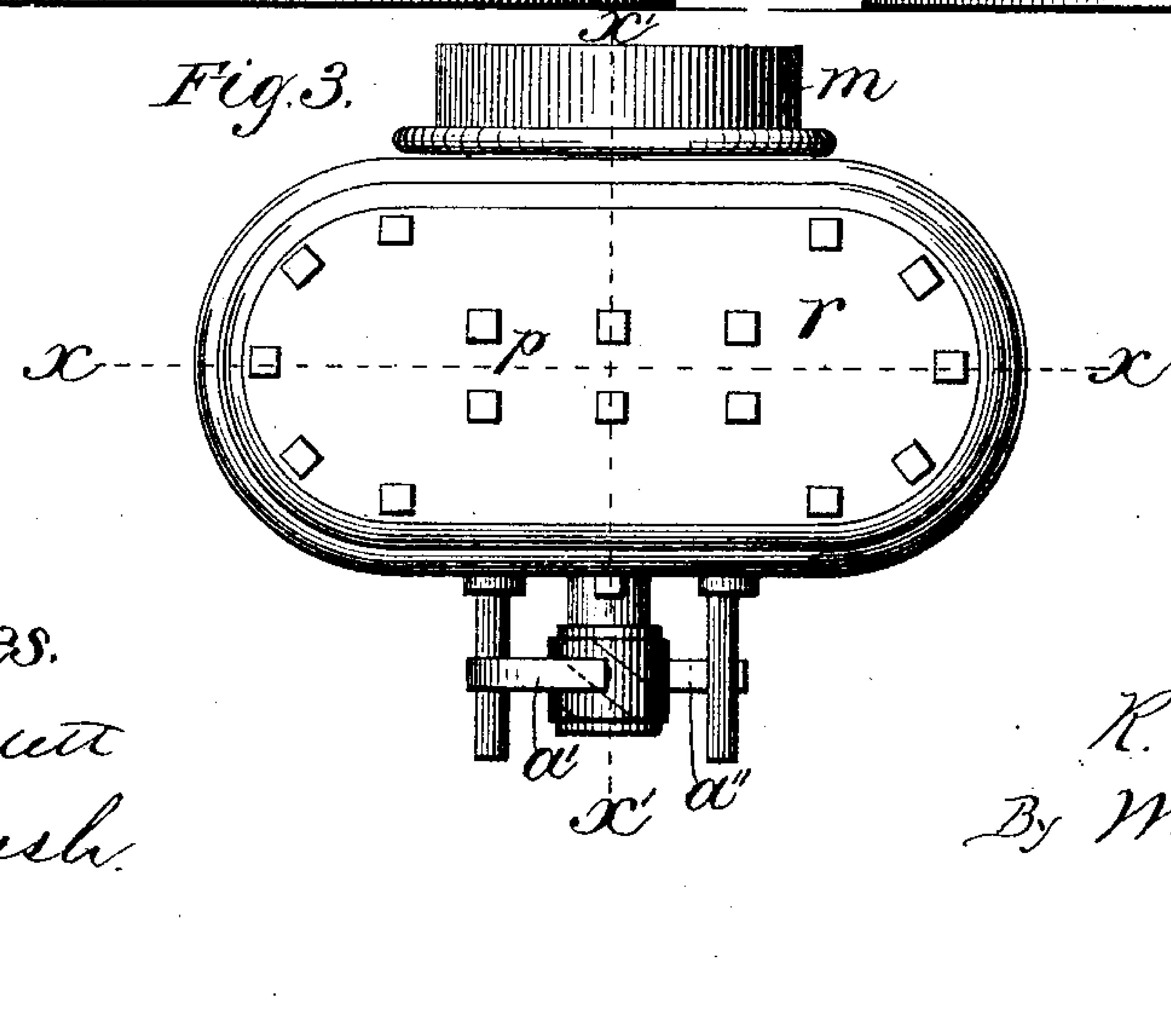


Fig. 3.



Witnesses.
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(No Model.) 2 Sheets—Sheet 2.

R. H. MATHER.

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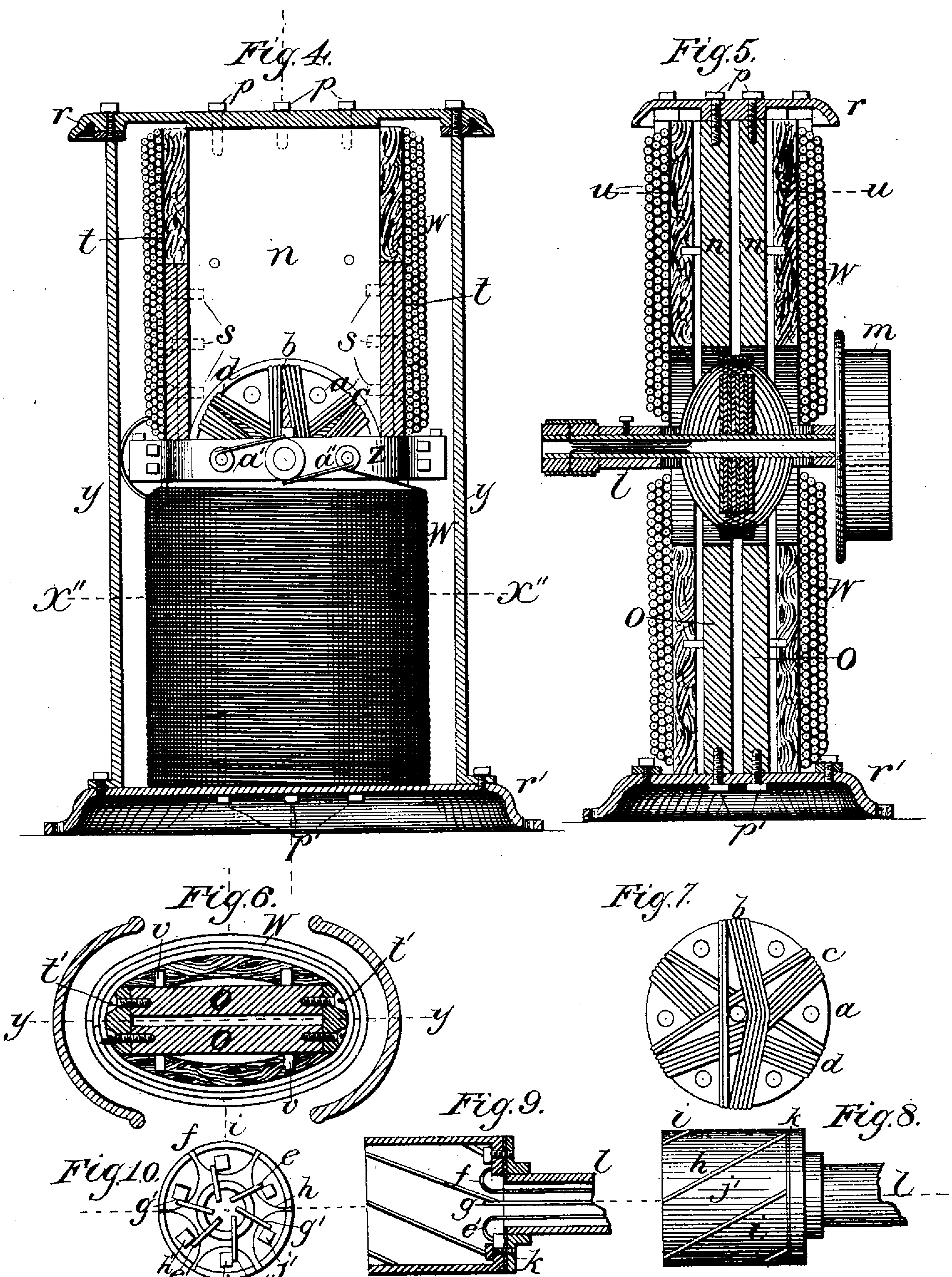

Witnesses.

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H. H. Marsh

Inventor:

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UNITED STATES PATENT OFFICE.

RICHARD H. MATHER, OF WINDSOR, CONNECTICUT.

DYNAMO-ELECTRIC MACHINE.

SPECIFICATION forming part of Letters Patent No. 268,255, dated November 28, 1882.

Application filed December 11, 1880. (No model.)

To all whom it may concern:

Be it known that I, RICHARD H. MATHER, of Windsor, (post-office address Hartford,) in the county of Hartford and State of Connecticut, have invented a certain new and useful Improvement in Dynamo-Electric Machines, of which the following is a description, reference being had to the accompanying drawings, where—

Figure 1 is what may be termed a "front view" of a machine embodying my said improvement. Fig. 2 is a side view of the same. Fig. 3 is a top or end view of the machine. Fig. 4 is a view of the machine in the same position as in Fig. 1, but with the exterior casing and substantially the upper half of the machine represented as cut in vertical section on the plane denoted by the broken line *x x* of Fig. 3. Fig. 5 is a view of the machine in vertical section on the plane denoted by the broken line *x' x'* of Fig. 3. Fig. 6 is a view of one part of the field-magnet in horizontal section on the plane denoted by the broken line *x'' x''* of Fig. 4. Fig. 7 is a side (front as to position of whole machine) view of the armature-core, with insulated wire wound thereon. Fig. 8 is an enlarged peripheral view of the commutator. Fig. 9 is an enlarged view of the commutator cut in axial section. Fig. 10 is an end view of the commutator.

The machine has a field-magnet in two parts, arranged in the same general longitudinal line, with the armature located and revolving between them in the same general line or plane.

The armature.—One of the peculiarities of this machine is the armature, the iron core of which is a flat disk, *a*, cross-mortised at regular intervals on its periphery to hold the coils of insulated wire in the case where three coils are used, which is the case represented in the drawings. There are six of these cross-mortises. Two of these mortises are seen in the armature in Fig. 5. The magnetic axis of this disk is at right angles to the axis of rotation—*i. e.*, parallel with the plane of rotation. Magnetism seldom or never extends far beneath the surface of a mass of iron, especially when the iron is in motion. In general magnetism does not extend more than an inch beneath the surface. Hence an armature in order to be very effective (which means the production of a high electro-motive force with a short length of wire on the armature-core) must have a considerable amount of surface as compared with the amount of metal contained in it. Moreover, the shape of the armature must be such that the wire may be readily coiled upon it.

Perhaps the most important condition as to an armature is that it should need and require but a small space for its rotation. Magnetism, like heat, tends to a state of diffusion, never to a state of concentration. If an armature is large, it requires a large magnetic field for it to rotate in. That means a great deal of iron and copper in the magnets. It also means a great many foot-pounds in the current used to charge the magnets. On the other hand, if a magnetic field is small it requires but little copper and iron, and but little force to maintain the current that charges the magnet. It is a general law that a small magnetic field can be more easily maintained than a large but equally intense one. It will therefore be readily comprehended that an armature in the disk form shown herein meets all the conditions. No part of the disk-armature can escape magnetization. The large surface, combined with the small thickness, the thickness not exceeding one-third the diameter, insures complete magnetic saturation. Moreover, there is no screening of one part of the armature by another part, such as is incident to the use of the ring and the cylinder forms of armature, in which also there is a great deal of space lost within the armature itself, owing to its being made hollow; but there would be no use in filling such hollow and making it solid metal, for the magnetism could not penetrate to such a depth beneath the surface as to utilize such metal. There is no such loss of space in a disk-armature, for the disk is either made solid or composed of thin plates or laminæ separated by non-conducting material—paper, for instance—to prevent the circulation of electric currents within the armature-core itself. In Fig. 5 of the drawings I show the armature-disk thus made of metal plates separated by paper plates. It is because there is no loss of space in this disk-armature that it occupies the least space of any armature yet devised, equal currents produced being understood. The number of peripheral mortises in the disk is proportional to the number of coils laid upon the armature—two diametrically-opposite mortises to each coil—and the number of coils is to be varied with the purpose to which the whole machine is to be applied. The width of one of these peripheral mortises will in general be equal to the distance between two neighboring mortises.

The letters *b*, *c*, and *d* denote the three coils laid upon the armature, one end of each of which communicates with one of the six plates upon the periphery of the commutator hereinafter described, and the other end of each of which communicates with another of the six commutator-plates which, on the commutator, is diametrically opposite the plate first mentioned. As these coils are laid upon the armature-core, each of them surrounds a diameter of the core. They are at the periphery of the armature-core at substantially equal distances apart. The invention is not limited to any specific number of coils on the armature. I prefer two. In one complete rotation of such an armature as is herein described two electric currents are produced in each coil—one positive and the other negative. The duration of each of these currents is slightly less than the duration of a semi-rotation of the armature. In other words, the length of time that the current lasts is almost identical with the time required by the armature to perform a half-rotation. Speed increases this difference, but does not increase it greatly when the speed is kept within practical limits. When this armature is rotated in a magnetic field the currents produced in each coil have a nearly-fixed strength for a good portion of each semi-rotation—that is to say, when the armature begins to make a certain semi-rotation the electric current in one of the armature-coils rises from zero to a maximum and remains constant, or nearly so, until near the end of such semi rotation, when it descends rapidly to zero again. The current does not pass immediately from zero to the maximum, nor does it pass immediately from the maximum to zero, but an appreciable time is required for each of these changes. Each of these currents has a nearly-fixed strength during two-thirds of a semi-rotation of the armature—*i. e.*, during one-third of an entire rotation of the armature.

The shape of the armature-core before the wire is wound upon it is, in plane view, that of a rectangle; but when the wire is laid upon it its shape is substantially that of an oval or ellipse. This is caused by the coils being laid one upon another at the center, where they cross one another. The major axis of this ellipse is the diameter of the armature.

Where the herein-described form or armature is situated with regard to the field-magnets, as herein described, every part of the wire laid upon the armature suffers induction. No part can be idle. Consequently a very high electro-motive force is produced by a short length of wire. Besides, the wire in the field-magnet coils acts directly upon the wire in the armature, producing currents by direct induction without the intervention of any metal whatever. The armature is, moreover, removed from all chance of injury. The poles of the field-magnets are inclosed, and, being within the coils, diffusion is prevented, so that the machine does not magnetize every magnetizable thing in its neighborhood. The advantages that flow from this form of construction are numerous and important.

The commutator.—The commutator used with the herein-described armature is of peculiar construction. As already mentioned, there are in the machine shown in the drawings three coils of insulated wire wound upon the armature-core. Each coil has two ends, making in all six ends, each of which communicates with an insulated metallic plate on the periphery of the commutator. These six ends are all seen in Fig. 10, *e* and *e'* being the two ends of one coil—say coil *b*—*f* and *f'* being the two ends of another coil—say coil *c*—and *g* and *g'* being the two ends of the third coil, say coil *d*. Each of these ends communicates with a peripheral plate of the communicator, which is separate and distinct and insulated from the other peripheral plates. It follows there are as many peripheral plates on the commutator as there are ends of armature-coils—*i. e.*, the number of peripheral plates on the commutator is double the number of coils in the armature—two for each coil, one for each end of each coil—and the two appurtenant to a coil are diametrically opposite each other on the commutator.

The letters *h* and *h'* denote the commutator-plates communicating with the coil ends *e* and *e'* and appurtenant to coil *b*. The letters *i* and *i'* denote the commutator-plates communicating with the coil ends *f* and *f'* appurtenant to coil *c*. The letters *j* and *j'* denote the commutator-plates communicating with the coil ends *g* and *g'* appurtenant to coil *d*. These commutator-plates are peripherally separated from each other by such an interval as is requisite for purposes of insulation, and together they form an open-end hollow cylinder—a construction which enables air to have access to all parts, and thus tend to prevent the heating of the commutator-plates. These plates are supported upon the disk *k*, preferably bolted thereto, as seen in Figs. 9 and 10, carried on the rotating armature-shaft *v*, the rotation of which shaft and the armature is given by a belt running on pulley *m*. The coil ends enter the hollow of the shaft near the armature and run lengthwise throughout the same to the commutator.

The letters *a'* and *a''* denote elastic strips of metal bearing at diametrically-opposite points on the periphery of the commutator as it rotates, commonly called "brushes." When the armature rotates in a magnetic field and the brushes are joined by a conductor electric currents are generated in the armature-coils. These currents are continuous and in one direction. It will be noticed that the brushes which collect the currents would bear upon each set of peripheral commutator-plates in the case when they are six in number, about o...

sixth, or sixty degrees, of the circuit in each semi-rotation if the commutator-plates were all of the same size (which they are) and their lines of separation were at right angles to the plane of rotation.

Theory and practice both show that the current in each of the armature-coils is produced or tends to be produced during about one-third or one hundred and twenty degrees of the circuit in each semi-rotation, and each set of the commutator-plates should be in contact with the brushes for the same duration, in order to attain the full efficiency of the armature-coils. To accomplish this it is necessary that each commutator-plate should extend about one-third of the entire distance around the circumference of the commutator, and to permit this the lines of separation between the commutator-plates are not at right angles to the plane of rotation, but are at some other angle thereto proportioned to the width of these plates and the width of the brushes. The one essential condition is that the angle shall be such that each commutator-plate shall extend substantially around one-third of the entire circumference of the commutator, and this is true whatever the number of armature-coils.

An advantage incident to the construction and operation of the armature and commutator herein described is that the spark generated when a brush quits a commutator-plate can be divided between the two brushes, and its hurtful influence greatly lessened.

The field-magnet.—Having largely disposed of the armature and commutator, I proceed to the field-magnet of the machine, which constitutes an important feature of the invention. The field-magnet is largely in two parts or poles lying in the same line of direction with the armature between them, which in effect is a part of the field-magnet considered as a whole. Each of said parts or poles is made up of two or more iron plates disposed side by side, communicating by metallic end and edge attachments, but not in direct contact, to the end that air may circulate between the plates.

The letters *n* and *n* denote two plates, which make up one of said parts or poles, and *o* and *o* denote two plates, which make up the other of said parts or poles. These plates have a width slightly greater than the diameter of the armature and a length considerably greater than such width. The length of these plates will vary under different circumstances, being generally from one and one-half to two times as great as the diameter of the armature. The combined thickness of these plates is considerably greater than the thickness of the armature-disk. The ends of these plates next the armature are substantially of the shape of the arc of a circle, and in the intermediate circular space the armature is located and rotates, the shaft thereof being hung in suitable bearings. The plates *n n* are supported and held in communication at the outer end by screws *p* running through the end piece *r* of the general frame of the machine, and on the edges by screws *s* running through the brass edge-plates *t*. The plates *o o* are correspondingly supported and held in communication at the outer end by screws *p'* running through the end piece *r'* of the general frame, and on the edges by the screws *s'* running through the brass edge-plates *t'*.

It is desirable that the figure in cross-section formed by the field-magnet parts other than the armature before the insulated wire is wound upon them shall be substantially the same as the cross-section shape of the armature after the wire is laid on it, so that the coils on the field-magnet can be brought very near to the armature, and yet have one shape throughout. To bring this about pieces of wood *u u u u*, flat or hollow on the inner side and convex or curved on the outer side, are disposed at the sides of the field-magnet and supported by pins *v*, with a space between these wooden pieces and the field-magnet plates for the circulation of air. Then a coil (or coils) of insulated wire, *w*, is wound over substantially the entire outside of the whole system, secluding the armature, as well as the field-magnet proper, except a small space at the longitudinal center, where the armature-shaft emerges. In this way the armature is magnetized directly by the coils of the field-magnet, as well as by the core of the field magnet; but this is not all, indeed but a small part, of the advantages which flow from this construction.

As has hereinbefore been stated, magnetism tends to a state of diffusion; but a state of concentration can be brought about by proper means, as well as heat can be concentrated by refraction. The way to prevent diffusion of magnetism is to prevent the core from projecting beyond the coil magnetizing it. The farther the core projects beyond the coil the more will the magnetism be diffused. To get the best effect, the end of the core should be within the cavity of the coil. When matters are arranged in this way, which is substantially the arrangement in the construction herein described, the magnetism seems to be concentrated to the very ends of the core. Lengthening the core also has a concentrating effect. When both these means are employed the magnetic energy is of wonderful intensity. The electric current employed in the coil surrounding the field-magnet may come either from the current generated by the armature or from a distinct source.

The letters *y y* denote metallic shells connecting the end pieces, *r* and *r'*, and protecting the inclosed parts.

The letters *z z* denote cross-bars forming bearings for the armature-shaft supported from the edge-plates *t t'*.

While the coils are moving in front of the poles of the field-magnet the coils are active—that is, they are generating electric currents—and the commutator-plates appurtenant to the coils are so located with reference to the points of contact with the brushes that the brushes pass from one commutator-plate to another while the coils, to which the last-mentioned plates are appurtenant, are thus active, so that the currents coming off the two contiguous commutator-plates at the time of the passage of a brush from one to the other are moving in the same direction, so that they flow off together and not from one plate to the other, so as to make a short circuit.

Certain constructions—to-wit, directly surrounding with a magnetizing coil or coils both the field-magnets and the rotating armature, an armature having a core of circular or similar outline on a shaft transverse to the plane of rotation of the armature and placed between the parts of the field-magnet, the ends of which next the armature being shaped to a corresponding outline, and a circular armature-core laterally wound with insulated wire, and in turn surrounded, so far as practicable, by the field-magnet coil or coils—being found in patent to Elihu Thompson, No. 233,047, dated October 5, 1880, I hereby disclaim the same as my invention.

I claim as my invention—

1. In a dynamo-electric machine, an armature-core composed of a disk the thickness of which does not exceed one-third its diameter, and having a substantially solid center or interior, and having coils of insulated wire wound laterally thereon, substantially as described.

2. In a dynamo-electric machine, a disk armature-core having peripheral mortises or sockets and coils of insulated wire wound into such sockets, substantially as shown and described.

3. In a dynamo-electric machine, the combination of an armature-core, two or more armature-coils, and a commutator having two peripheral plates for each armature-coil, respectively connected with the respective ends of the appurtenant coil, each of which plates extends substantially around one-third the circumference of the commutator, all substantially as described, and for the purpose set forth.

RICHARD H. MATHER.

Witnesses:
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JAMES J. GREENE.