(No Model.)

10 Sheets—Sheet 1.

R. EICKEMEYER.

MAGNETO ELECTRIC AND ELECTRO MAGNETIC MACHINE.

No. 342,504. Patented May 25, 1886.

Fig. 1.

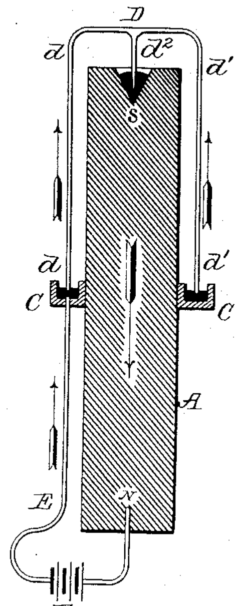


Fig. 2.

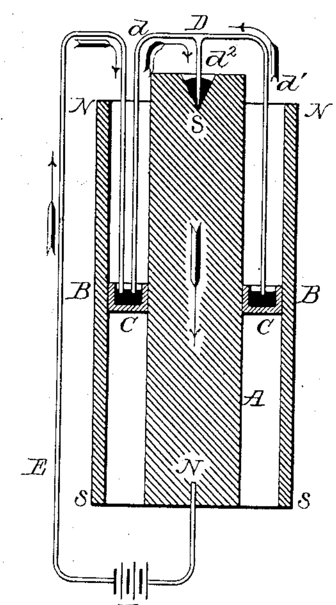
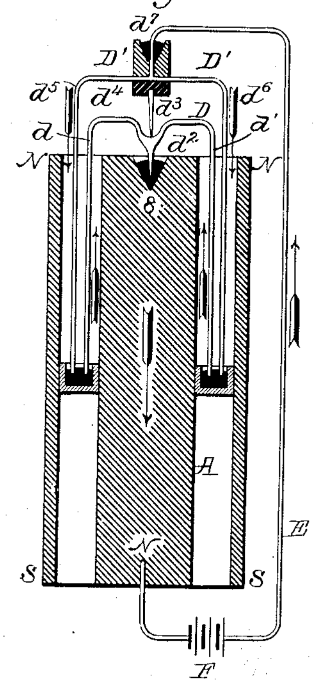


Fig. 3.



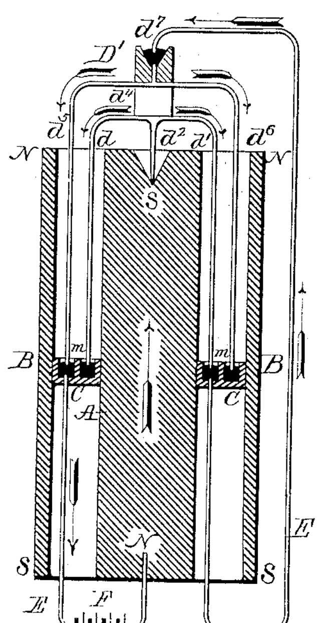
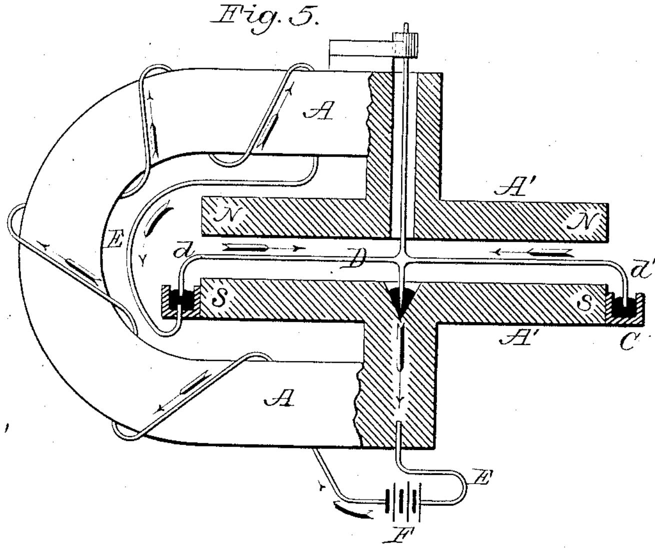


Fig. 4.

Fig. 5.



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Howell Bartle.

Inventor:

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Attorney.

(No Model.)

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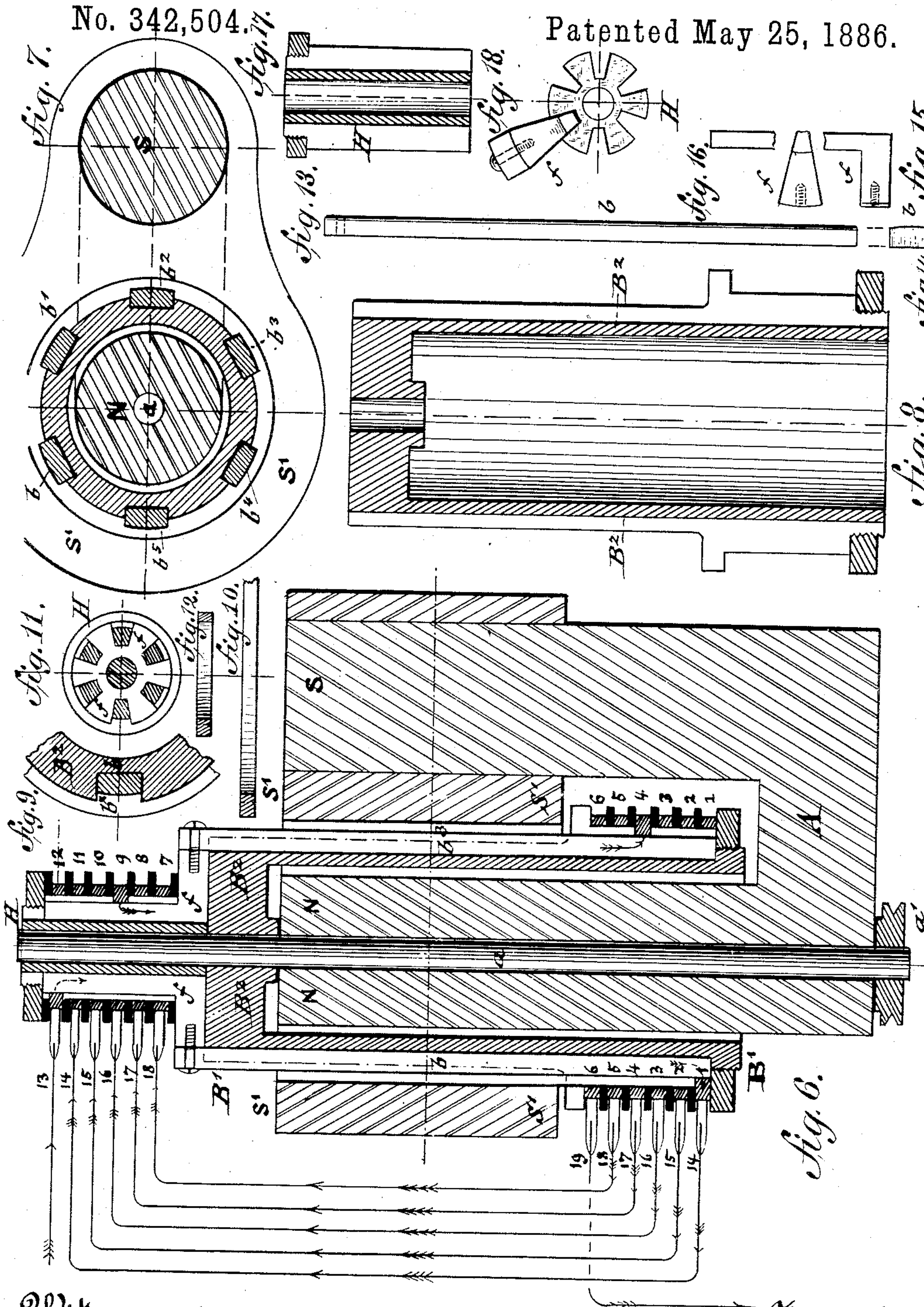
R. EICKEMEYER.

MAGNETO ELECTRIC AND ELECTRO MAGNETIC MACHINE.

No. 342,504.

Patented May 25, 1886.



Witnesses:

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Rudolf Eickemeyer

(No Model.)

10 Sheets—Sheet 3.

R. EICKEMEYER.

MAGNETO ELECTRIC AND ELECTRO MAGNETIC MACHINE.

No. 342,504.

Patented May 25, 1886.

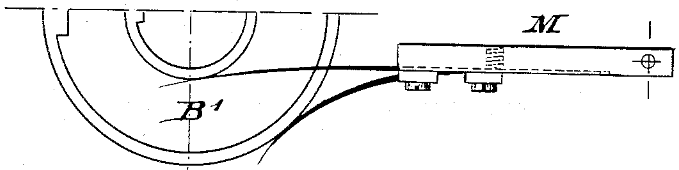
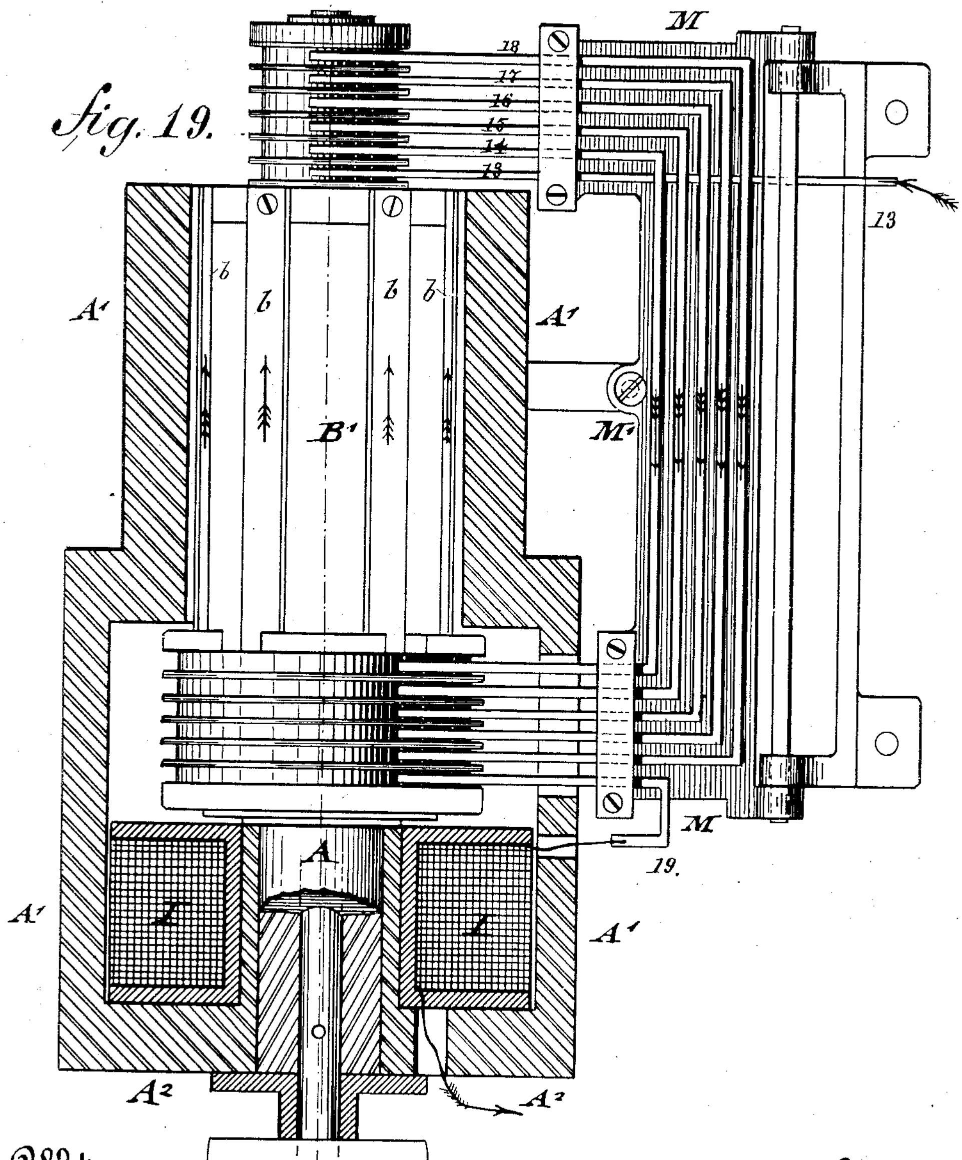


Fig. 20.

Fig. 19.



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10 Sheets—Sheet 4.

R. EICKEMEYER.

MAGNETO ELECTRIC AND ELECTRO MAGNETIC MACHINE.

No. 342,504. Patented May 25, 1886.

Fig. 21.

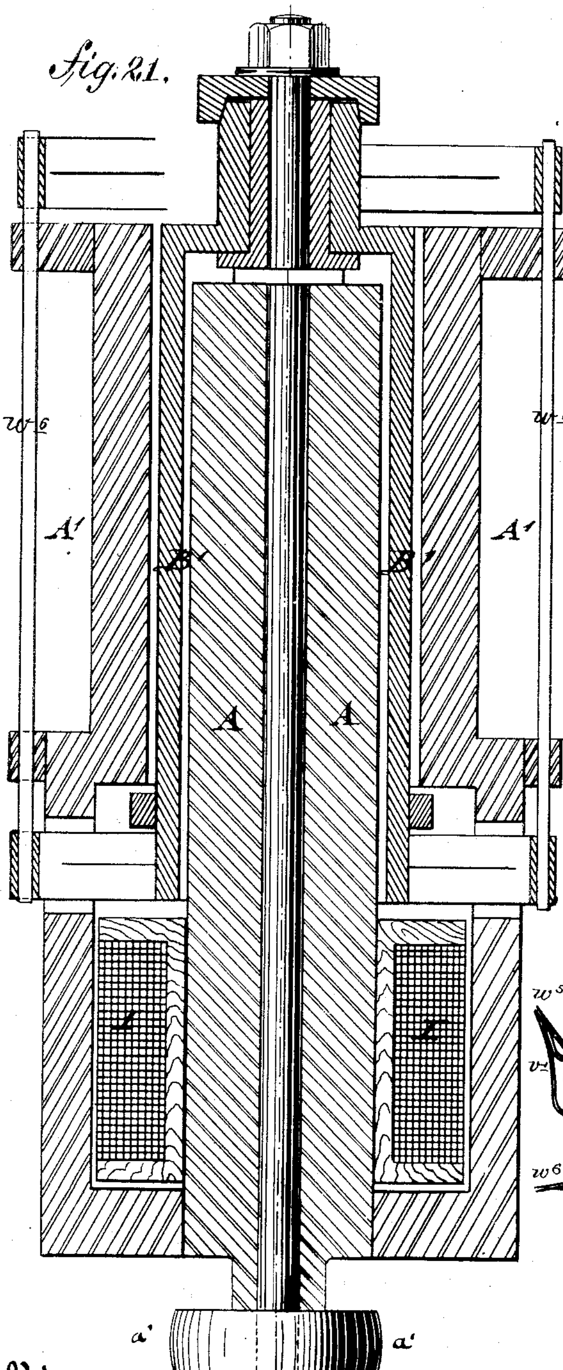


Fig. 21a

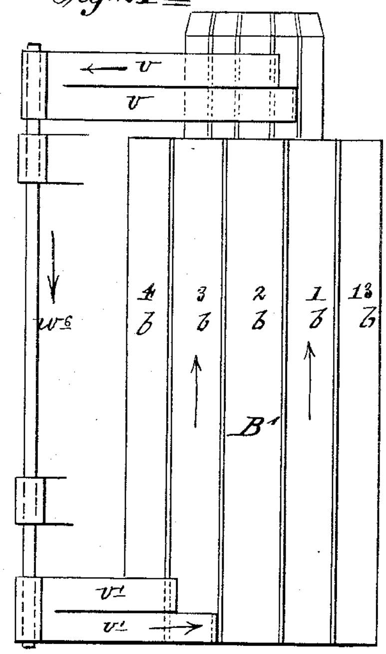
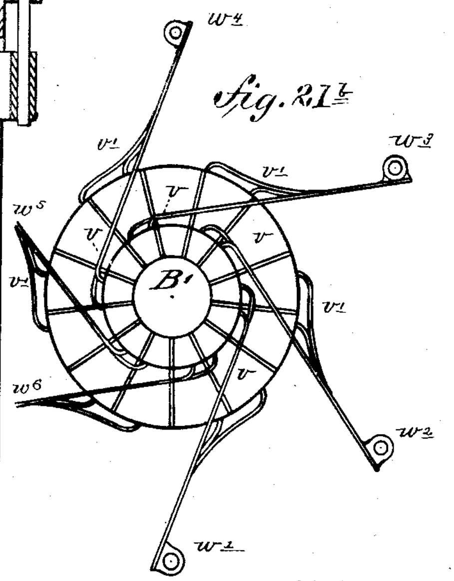


Fig. 21b



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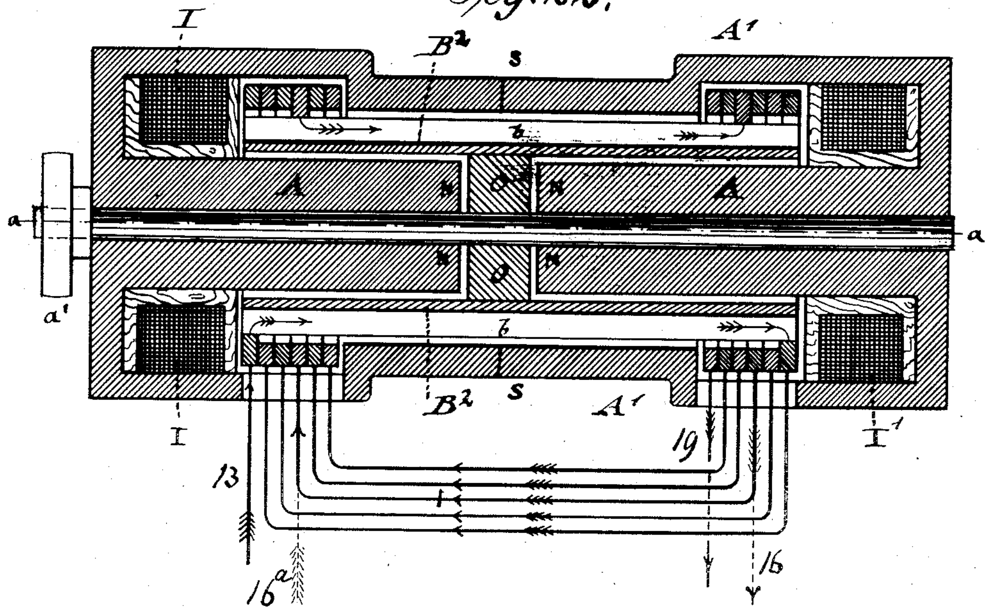
(No Model.) 10 Sheets—Sheet 5.

R. EICKEMEYER.

MAGNETO ELECTRIC AND ELECTRO MAGNETIC MACHINE.

No. 342,504. Patented May 25, 1886.

Fig. 22.



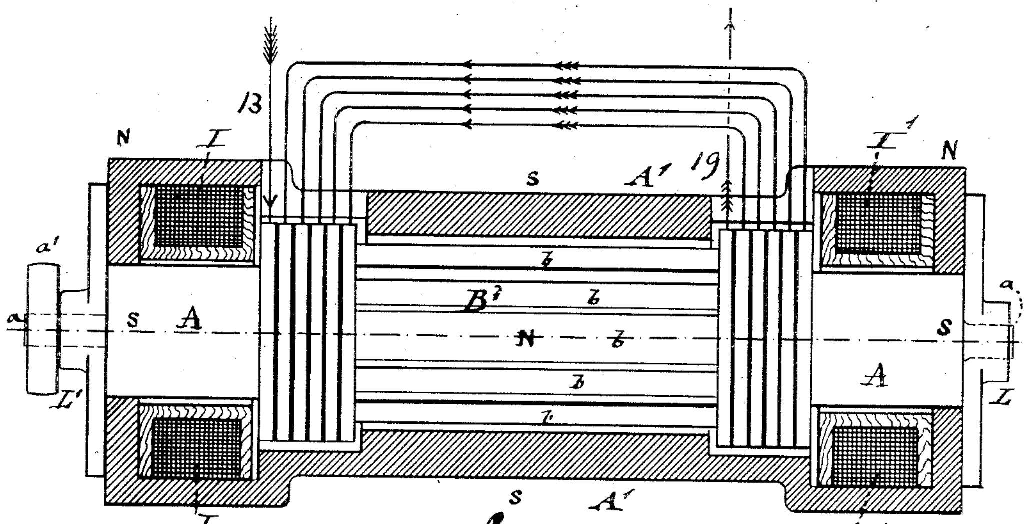


Fig. 22a

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10 Sheets—Sheet 6.

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MAGNETO ELECTRIC AND ELECTRO MAGNETIC MACHINE.

No. 342,504.

Patented May 25, 1886.

Fig. 23.c

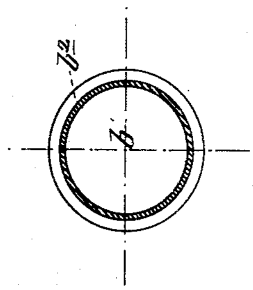


Fig. 23.a

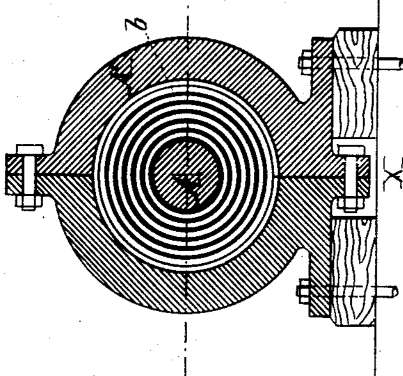


Fig. 23.b

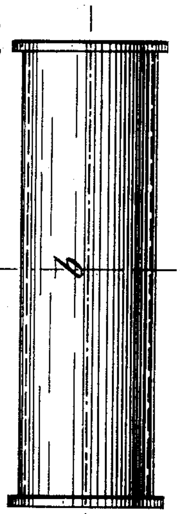
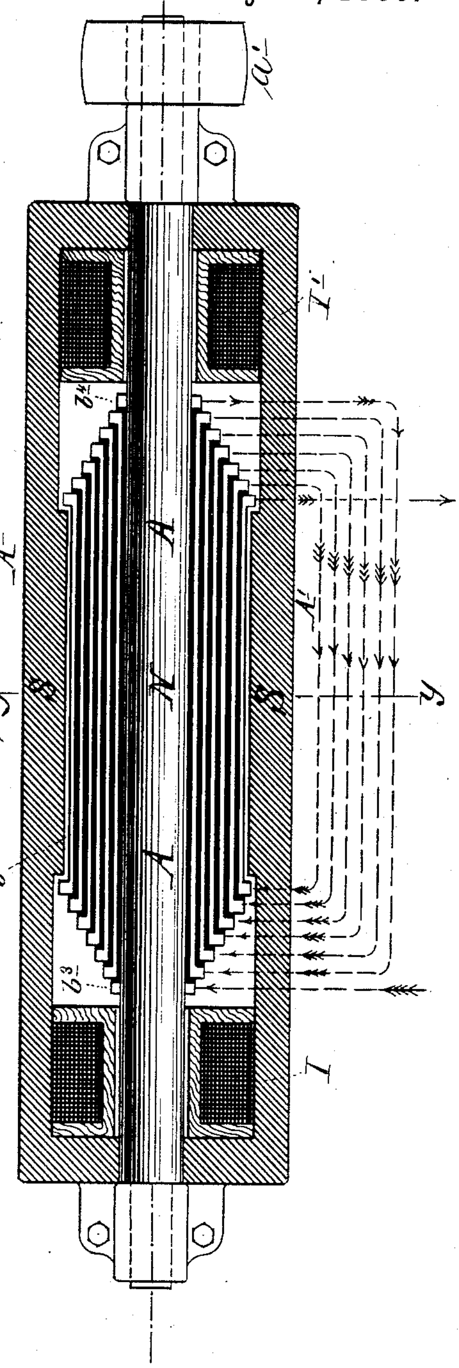


Fig. 23.



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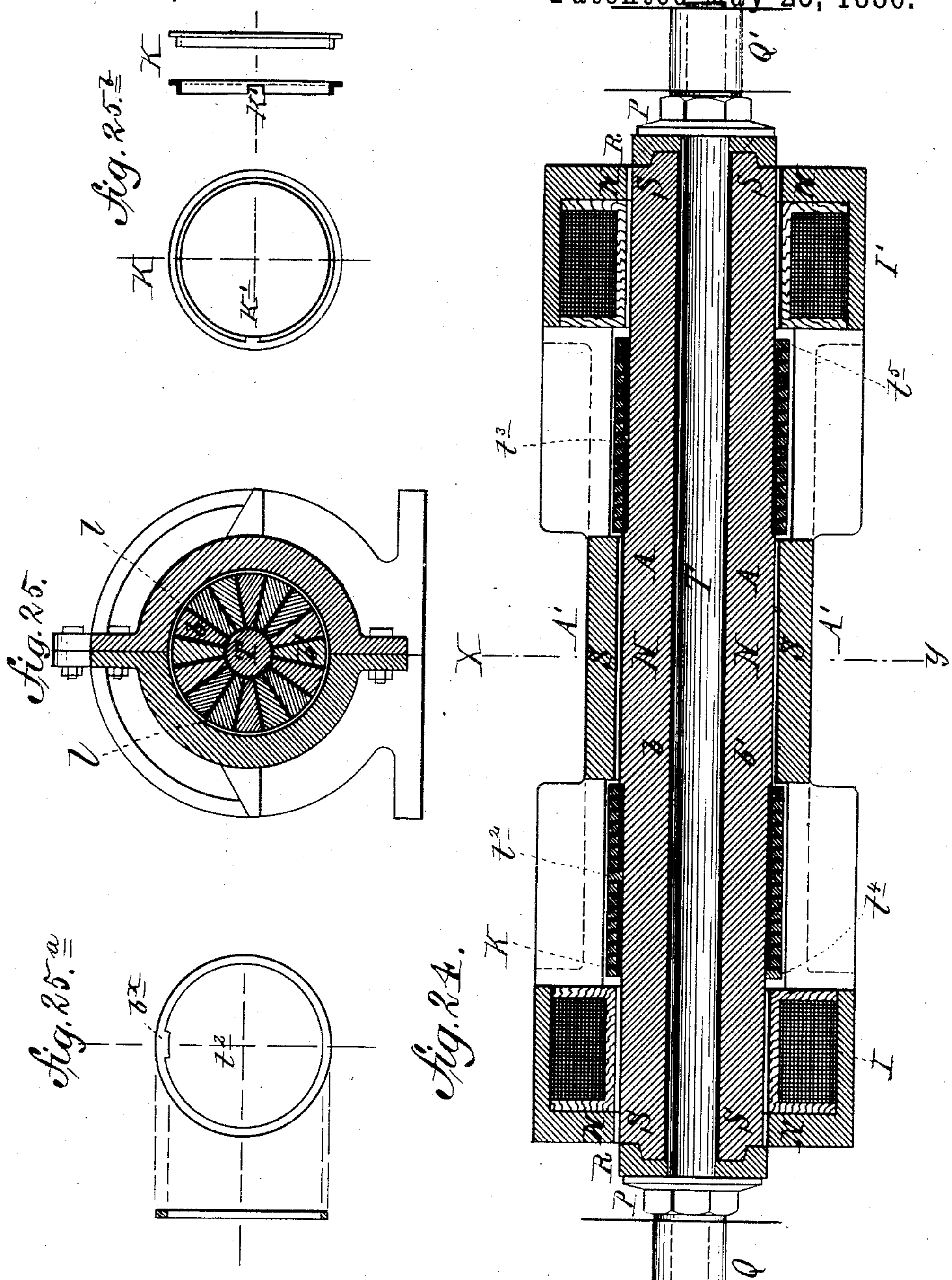
R. EICKEMEYER.

MAGNETO ELECTRIC AND ELECTRO MAGNETIC MACHINE.

No. 342,504. Patented May 25, 1886.



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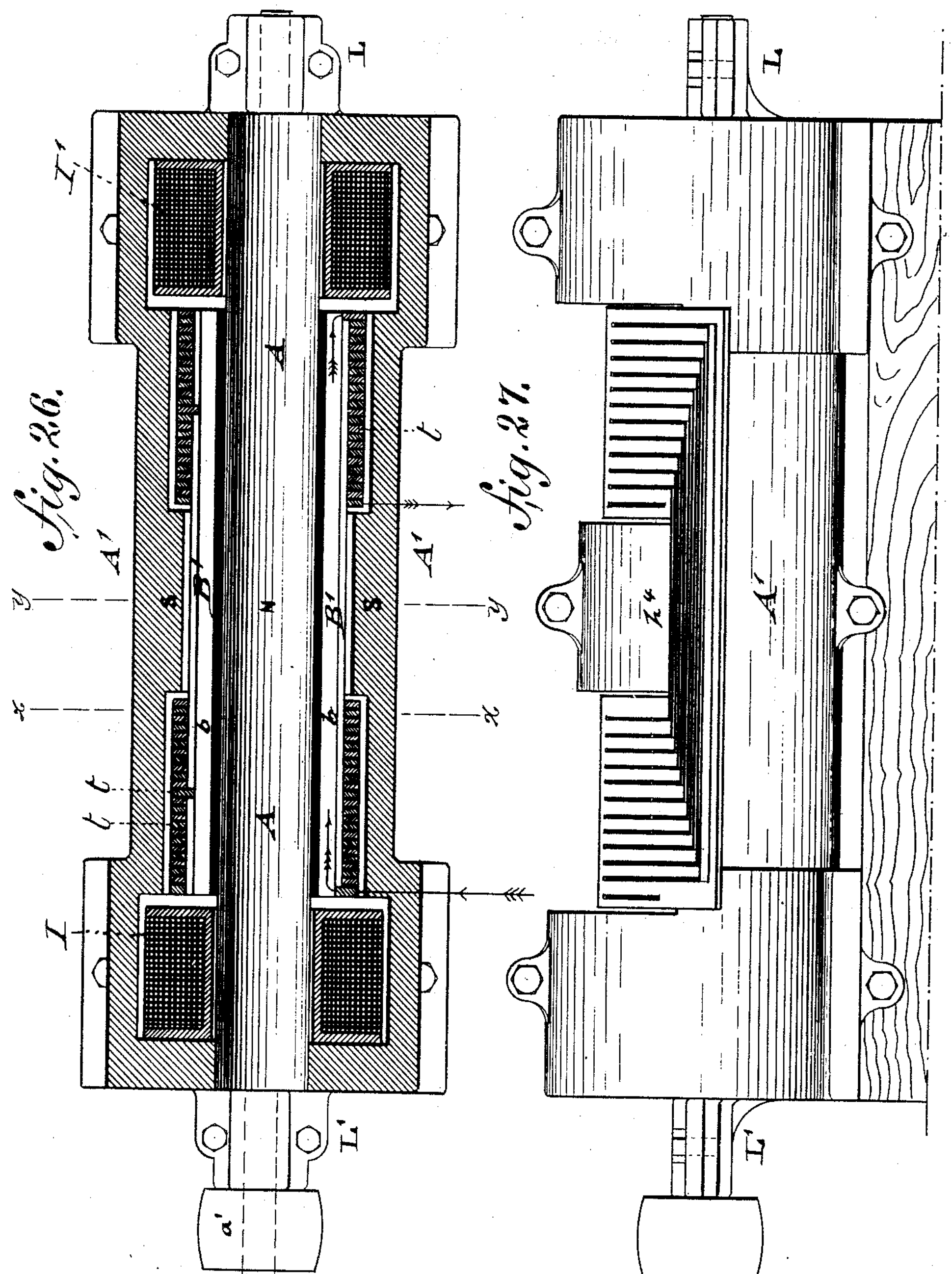
(No Model.) 10 Sheets—Sheet 8.

R. EICKEMEYER.

MAGNETO ELECTRIC AND ELECTRO MAGNETIC MACHINE.

No. 342,504. Patented May 25, 1886.



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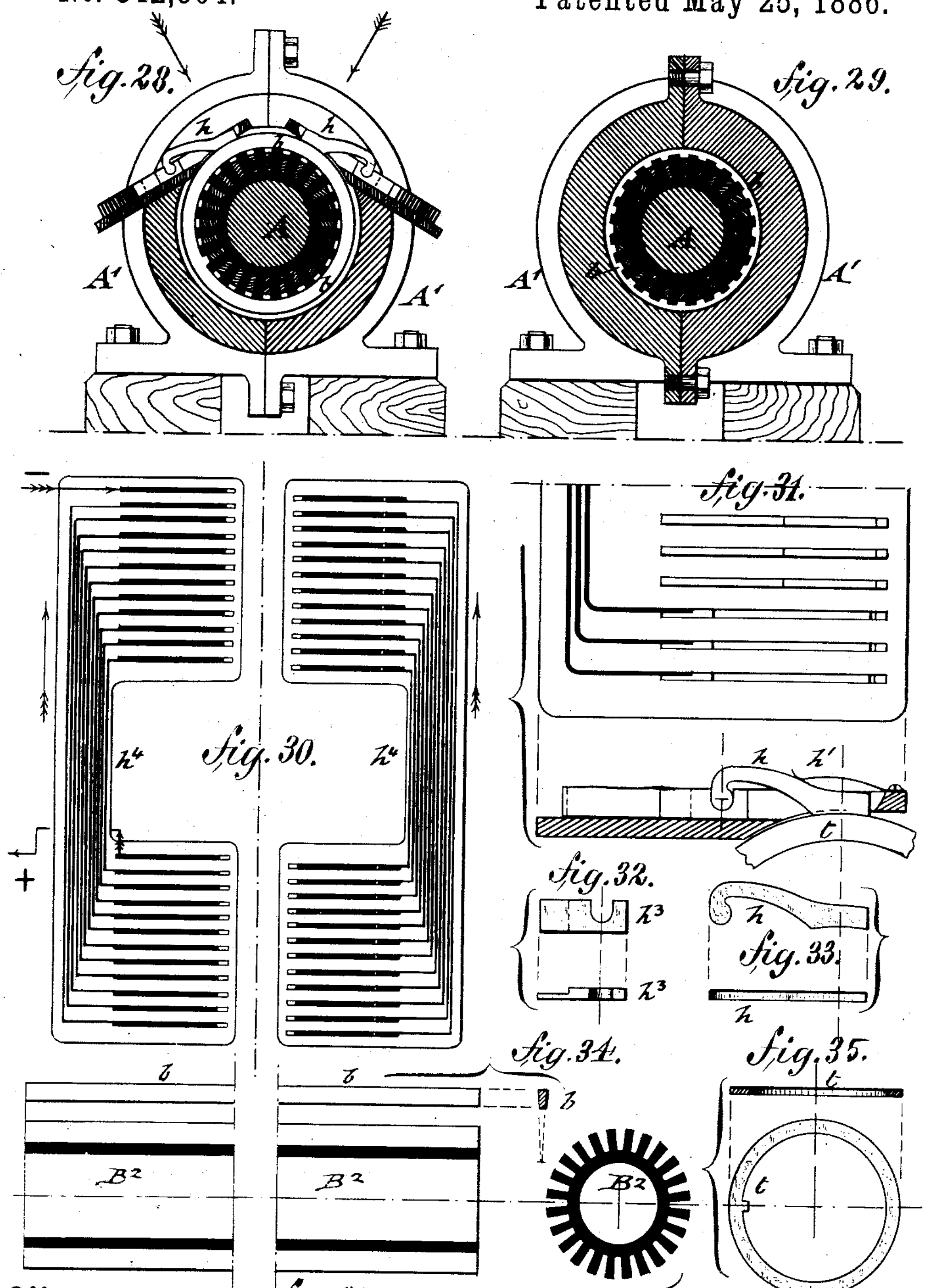
(No Model.)

10 Sheets—Sheet 9.

R. EICKEMEYER.

MAGNETO ELECTRIC AND ELECTRO MAGNETIC MACHINE.

No. 342,504. Patented May 25, 1886.



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R. EICKEMEYER.

MAGNETO ELECTRIC AND ELECTRO MAGNETIC MACHINE.

No. 342,504. Patented May 25, 1886.

Fig. 38.

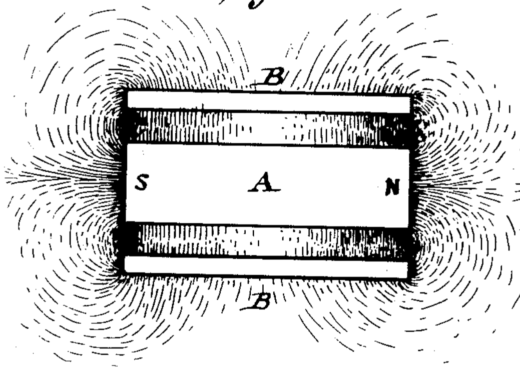


Fig. 37.

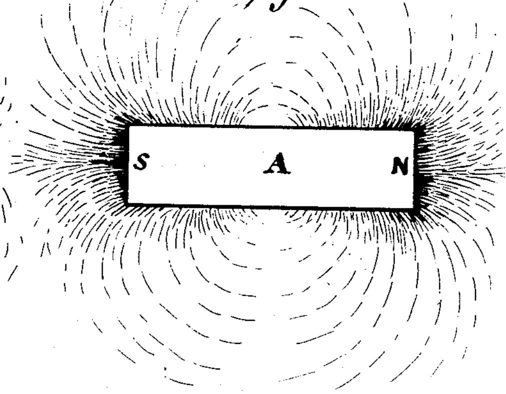


Fig. 40.

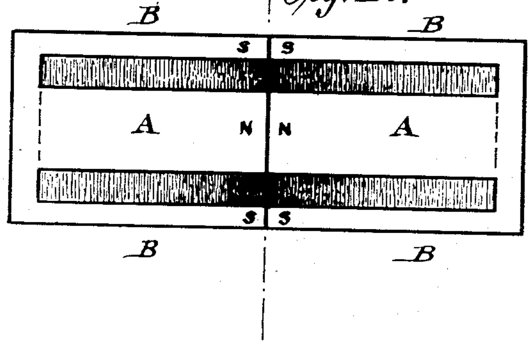


Fig. 39.

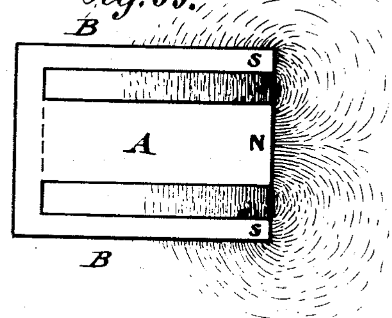


Fig. 41.

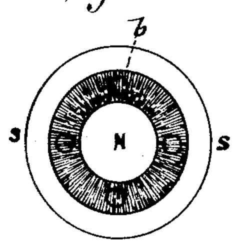
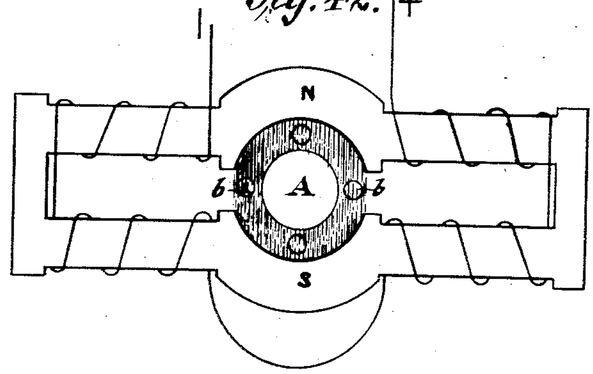


Fig. 42.



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Inventor
Rudolf Eickemeyer

United States Patent Office.

RUDOLF EICKEMEYER, OF YONKERS, NEW YORK.

MAGNETO-ELECTRIC AND ELECTRO-MAGNETIC MACHINE.

SPECIFICATION forming part of Letters Patent No. 342,504, dated May 25, 1886.

Application filed November 8, 1882. Serial No. 76,234. (No model.)

To all whom it may concern:

Be it known that I, RUDOLF EICKEMEYER, of Yonkers, in the State of New York, have invented an Improvement in Magneto-Electric and Electro-Magnetic Machines, of which the following is a specification.

In the magneto-electric machines which have been in general use the disposition of the conductor in which a current of electricity is to be induced with reference to the lines of force which it is to cut is such that in one portion of the revolution of the conductor the induced current will flow in one direction, while in the other portion of the revolution it will flow in the other direction; and in order that the current induced in the conductor shall flow at all times in the same direction in other parts of the circuit, it has been necessary to use a device called a "commutator" or "pole-changer," which shifts the two ends of the conductor to the opposite ends of the remaining part of the circuit when the change in the direction of the current takes place.

It has long been known that a conductor may be rotated around the pole of a magnet in such a manner as to induce a current constantly in one direction through the conductor, the disposition of the conducting-wire with relation to the lines of force being such that it cuts the lines of force in one direction, assuming that the direction of the lines of force is always to be taken from positive to negative, or the reverse, whatever their direction in space may be. In an apparatus of this kind no pole-changer is required; but it is necessary to make provision for keeping the movable part of the circuit in constant contact with the stationary part.

There are many disadvantages attending the use of a pole-changer and a conductor in which the circuit is alternately in opposite directions, which it is desirable to avoid, and which do not arise in the apparatus above referred to, in which the current is induced in the conductor constantly in one direction; but, so far as I am aware, no machine has been devised for practical purposes in the arts in which this latter mode of operation is embodied.

The object of my invention is to obtain such a machine.

I am aware that machines have heretofore been devised by which a feeble continuous current can be developed, and in which an annular magnetic field of force has been occupied by a rotating tubular armature from which the electric current was afforded, and also that such machines have embodied two annular magnetic fields of force and two of said rotating tubular armatures, which were connected in linear series, so that the current from one of said armatures traversed the other armature.

A characteristic feature of machines embodying my invention is the organization, with a magnet affording an annular field of force, of an armature which embodies two or more separate conductors, each of which during its movement within said field of force operates as an independent element, and is traversed by an electric current always in the same direction, and I have so organized said independent conducting elements that any two or more of them can be coupled in linear series.

Machines involving the main features of my invention may be widely varied in construction, and in some of the machines devised by me the two or more conducting elements embodied in the armature serve merely as conductors, and in other machines they constitute also a portion of the magnetic system, and are included within and form a part of the magnetic circuit.

In the accompanying drawings the figures of one series are designed to illustrate the principles on which my improved system of magneto and dynamo electric machines are based. Those of the next series represent different constructions of the improved machines, while the figures of still another series are diagrams, illustrating the lines of force which are obtained by magnets employed.

Figure 1 is a diagram illustrating the fundamental principle on which my invention is based. Figs. 2, 3, 4, and 5 are diagrams in which the said principle is adapted in an elementary manner to my improved system of magneto and dynamo electric machines. Figs. 6 to 18 show a magneto-electric machine embodying my invention, with details of the different parts of the same. Figs. 19 and 20 represent a horizontal section and a detail of a dynamo-electric machine constructed on my system. Figs. 21, 21^a, and 21^b show a dynamo-electric machine of modified form; so also do Figs. 22 and 22^a, and likewise Figs. 23, 23^a, 23^b, and 23^c, as do also Figs. 24, 25, 25^a, 25^b. Figs. 26 and 27 are respectively a horizontal section and a side elevation of a dynamo-electric machine complete in all its details constructed on my improved system. Fig. 28 and 29 are vertical transverse sections of the machine shown in Figs. 26 and 27, taken on lines x x and y y of Fig. 26. Figs. 30 to 36 are details of the last-mentioned machine. Figs. 37 to 42 are diagrams illustrating the lines of force of magnets of different forms.

Similar letters of reference indicate as nearly as possible corresponding essential parts in the machines of various forms shown as embodying the invention.

In the diagram at Fig. 1, A represents a cylindrical bar-magnet. At or near its neutral point, midway between the poles, is arranged an annular trough or cup, C, of suitable non-conducting material, which is filled with mercury. The ends of the arms d d' of a conductor, D, of inverted-U shape, dip into the mercury of the cup C, the said conductor being supported by a center-pin, d^2, at the upper or bridge part of the conductor in a conical center-bearing containing mercury at the S pole of the magnet A. The conductor is thus balanced on its center-pin and free to rotate around the pole of the magnet. If the conductor D and the magnet A be now placed by the wire E in circuit with a battery, F, or other source of electricity, which is accomplished by connecting the lower end of the magnet A with the interior of the mercury-cup C, a current will pass from the battery through the wire E to the mercury and the arms d d' of the conductor D and its supporting-pin d^2, to and through the magnet A, and back to the other pole of the battery. If a current of sufficient strength be used, the conductor D will rotate around the pole of the magnet in a direction depending upon the direction of the current and the polarity of the pole around which the rotation takes place. The disposition of the lines of force in this apparatus are illustrated at Fig. 37. The direction of the rotation of the conductor may be reversed by reversing the direction of the current, or by reversing the polarity of the magnet. If both the direction of the current and the polarity of the magnet be reversed, the direction of the rotation of the conductor will remain the same.

In Fig. 2 the magnet A and a movable conductor, D, are represented as inclosed within a hollow cylindrical magnet, B, whose polarity is opposite to that of the magnet A, so that the N pole of the magnet B surrounds the S pole of the inner magnet, A. The wire E is shown as entering the mercury-cup C from above, and passes through the magnetic field formed by the magnets A and B. The current from the battery F passes in the direction of the arrows through the conductor D and the interior magnet, A, so that the conductor D will rotate; but as there are two magnetic poles, (an outer and an inner one,) the speed of the conductor is considerably accelerated. I think it is doubled. The disposition of the lines of force in this apparatus is represented at Fig. 38. In that portion of the circular space between the ends of the poles the magnetic field of force is much more dense than in any part of the field of force around a magnet like the one shown at Fig. 37, assuming the magnetism to be equal in both cases.

At Fig. 41 the direction of the lines of force is shown to be radial, and it will be readily seen that a conductor rotating around the inner magnet in one direction parallel with the axis of the magnet will constantly cut the lines of force in one direction, to the right or left, as the case may be, and thus induce a current constantly in one direction.

At Fig. 39 a magnet is represented in which the outer cylinder (shown at Fig. 38) is in one piece with the inner cylinder, so that only two poles are formed, and these are opposed to each other in the same manner as at each end of the magnet shown at Fig. 38. The lines of force cross the space between the two poles in the same manner as they cross the space between the two poles shown at Fig. 41.

It will be observed that with the magnets shown at Figs. 38 and 39 a portion of the lines of force radiate from the outer surface and end of the outer cylinder and curve around to the end of the inner cylinder. At Fig. 40 there is shown an arrangement of magnets which do not present these external lines of force, but in which the lines of force are wholly concentrated within the annular space between the magnets. With this arrangement there are practically no external lines of force. Such as are present are extremely weak. At Fig. 40 two magnets of the kind shown at Fig. 39 are represented as abutting against each other with their like poles.

At Fig. 3 the same arrangement of interior and exterior magnets, A B, and mercury-cup C is shown that appears at Fig. 2, but with two movable conductors, D and D′. The center-pin d^3 of the second conductor, D′, rests in a cup-shaped center-bearing containing mercury in the conductor D, and is insulated from the conductor D′ by a non-conducting plate, d^4. The arms d^5 d^6 of the second conductor, D′, dip, like the arms of the first conductor, into the mercury cup C, and are in metallic contact with a mercury cup, d^7, so that the current from the battery F passes, as indicated, first downward through the conductor D′ in the direction of the arrows to the cup C, thence upward through the conductor D to the magnet A, and through the magnet back to the battery. As both conductors D and D′ are free to rotate, and as the current passes through them in opposite directions, they will rotate in opposite directions to each other. If a hole were made through the central magnet, A, at Fig. 3, and the conductor D were extended down through the magnet A and made to enter a mercury-cup placed in or upon the conductor at the lower end of the magnet, it might, by being furnished with a pulley, be made to rotate in either direction, and if at the same time a pulley were substituted for the cup d' the conductor D′ might be made to rotate in an opposite direction from the other conductor. Thus a continuous current would be induced in both conductors in the same direction.

At Fig. 4 the magnets A B and conductors D D′ are shown, as at Fig. 3, with a mercury-cup, C; but the latter is divided by a central partition, *m*, whereby the conductors D D′ are arranged to move each in a separate mercury-cup. The conductors D D′ are connected by a connecting-wire, E′, but are insulated from each other by a block, d^4, of non-conducting material. A current from the battery F passing in the direction of the arrows will pass through the magnet A down through the conductors D to the inner mercury-cup, thence through the conducting-wire E′ and the conductor D′ to the outer mercury-cup, and then through the wire E to the battery. As the direction of the current is the same in both conductors D and D′, both will rotate in the same direction with greatly accelerated speed. The conductors in this last case are connected in a linear series; consequently, if the number of conductors so connected is increased, the speed with which they rotate is correspondingly increased.

If the conductors D and D′ of Fig. 4 be rotated in the same direction, by external means, a continuous current in one direction will be induced in both.

By substituting for the magnets A and B shown at Figs. 2, 3, and 4 a magnet, A, with disk-shaped pole-pieces A′, which face each other, as shown at Fig. 5, and by surrounding the lower pole-piece by an annular mercury-cup, C, and arranging the movable radial conductor D, as shown, in suitable step and neck bearings and centrally to the pole-pieces A′ A′, so that the arms *d d′* of the conductor D dip into the mercury-cup, a current passing from the battery F around the magnet A in the direction of the arrows will excite the magnet and pass through the mercury and the arms of the radial conductor D to the center of the lower pole-piece, A′, and through the magnet to the battery. The conductor D is thereby caused to rotate in a certain direction, and if the current be reversed the rotation will continue in the same direction, since the reversal of the current will also reverse the polarity of the pole pieces.

If the mercury-cup C of Fig. 5 be divided by a partition, as shown in Fig. 4, and two radial conductors insulated from each other be also employed, substantially as shown in Fig. 4, so that a current will pass through both in the same direction, both conductors will rotate in the same direction, and their speed will be greatly accelerated.

In the apparatus thus far described the conductors are arranged to rotate around or about the magnet; but I have also found that rotation is produced if the conductors are applied to magnets which are themselves free to rotate. If, for instance, the conductor D of Fig. 2 be fastened to the magnet A and the latter be so pivoted as to be free to turn around its axis, rotation of the magnet and conductor will take place on the passage of a current through the conductor. So, if the conductor D of Fig. 3 be connected to the interior magnet, A, and the conductor D′ to the exterior magnet, B, and both magnets be arranged so as to be capable of rotation around their common axis, they will rotate in opposite directions when the current is passed through the conductors. So, also, if both conductors D D′ of Fig. 4 be attached to the magnet A, and that magnet be suitably mounted to rotate around its longitudinal axis, it will so rotate when a current passes through the conductors; and the same result is obtained when one or both disk-shaped pole-pieces A′ A′ of the magnet shown at Fig. 5 are capable of rotation and the conductor is fastened to one of them.

In all of the foregoing apparatus the magnets have been illustrated and described as used with independent conductors; but the magnets themselves may be made to serve not only as magnets, but as conductors, thus dispensing with independent conductors, as will hereinafter appear.

In all the foregoing illustrations the conductors are shown as arranged concentrically with the axis of the magnet or magnets and the magnetic field in which they rotate; but the conductors would also move in the same direction if the axis of rotation of the conductors should be eccentric to the center of the magnet or magnets. It would, however, be an irregular motion. The poles of the magnets in all these cases are represented as cylindrical; but the result would be the same were each of these poles composed of a number of magnets of the same polarity. Their location relatively to the center of rotation might be varied; but if the field of force be concentric with the axis of rotation it is most effective, producing a current of uniform strength during the whole rotation of each conductor, while an irregular or eccentric field of force produces a current of varying strength during the same rotation.

In the apparatus illustrated in the various figures to which I have referred, the conductors, if rotated, would cut the lines of force in the same direction—from right to left or left to right—during the whole period of rotation.

In Fig. 42 I exhibit the manner in which conductors cut the lines of force in machines which have hitherto been in general use—such as, for instance, the well-known Siemens and Gramme machines. Comparing the field of force shown in this figure with that shown at Fig. 41, it will be seen that the lines of force, instead of crossing the path of the conductor radially, are all parallel diagonal lines across the circle described by the rotating conductor; and it will be readily seen that a conductor moving from b at the left around the upper half of the circle will cut the lines of force from left to right, but in moving through the lower half of the circle it will cut the lines of force from right to left, and the currents induced in the movement through these two halves of the circle will be in opposite directions. It is this fact that renders the use of a commutator or pole-changer in such machines necessary.

Figs. 6 to 18, as before stated, illustrate an elementary form of magneto-electric machine. Machines of this type have been made the special subject of a divisional application filed May 13, 1883, Serial No. 94,900. A is a horseshoe-magnet having legs N S. In the center of the leg N is bored a hole, which forms a bearing for a shaft, a, to one end of which the armature is secured, as hereinafter described, while the other end is provided with a pulley, a'. This pulley serves to rotate the armature when the machine is used as a generator, and as a driving-pulley when the machine is used as a motor. To the leg S of the magnet A is applied a ring-shaped pole-piece, S′, which surrounds the armature and the N pole of the magnet. The pole-piece S′ serves to circumscribe and equalize the field; but it can be omitted, in which case the action of the machine would differ only in the strength of current from its action when furnished with the pole-piece. The armature consists of six metallic bars, b to b^5, embedded, as shown, in a cylindrical shell of hard rubber, B^2, which is rigidly secured to and rotates with the shaft a. These bars b to b^5 are placed in metallic contact each with one of six metal rings, 1 to 6, at or near their respective ends. In Fig. 9 a portion of one of these rings is shown on an enlarged scale, an inward projection, $b^\times$, of the ring forming such contact with the bar b. The ring of each bar is insulated from the remaining bars and from the rings of all the other bars. The conductors b to b^5 are also in metallic contact at their opposite ends with six shorter bars, f, which are embedded in a hard-rubber cylinder, H, as shown in detail at Figs. 17 and 18. Each short bar f is placed in metallic contact with one of six rings, 7 to 12, each ring being also supplied with a projection for that purpose, and being insulated from the remaining bars f and from the rings connected with them. Thus the metal ring 1, that is in contact with the bar b, and the bar f connected thereto, with its ring 12, form one conductor; and so the other conductor, b^3, which appears in Fig. 6, is represented in metallic connection with rings 4 and 9, while the remaining conductors, which are not shown in that figure, are in metallic connection with the remaining rings at the lower end and with corresponding rings at the upper end of the shaft a. A number of exterior connecting-wires, 13 to 19, are connected by suitable brushes with the two sets of rings, and when the wires 13 and 19 are placed in circuit with the battery or other source of electricity the current will take the following course: from wire 13 and its brush through ring 12 and bars f and b to ring 1, thence through wire 14, ring 11, and through the conductor which connects ring 11 to ring 2, and through wire 15 to ring 10, and so on until it passes out through wire 19. The armature as a whole, including the above-described means of connection between the bars, is marked B′. It will rotate when a current of sufficient strength is furnished by the generator in analogy to the rotation of the conductors of Figs. 2 and 4. If power is applied to the pulley a' and the armature rotated in the opposite direction to that in which it was rotated by the current of the generator, a current will be induced of the same direction as that before furnished by the generator or source of electricity.

At Fig. 19 there is shown a machine in which an electro-magnet, A A′, is substituted for the permanent magnet of the machine shown at Fig. 6, the central pole, A, being surrounded by the outer pole, A′, and provision is made, as shown, that the inner pole shall revolve within the outer. The electro-magnet A A′ is excited by the coil I, wound around the base of the inner pole, A, as shown. The armature is constructed substantially as in the machine shown at Fig. 6; but, instead of rotating around the central pole and between the two poles, it is fixed to the central pole, that it may rotate with it. The conductors in the armature are arranged at equal distances from each other, and are insulated and connected at both ends to metallic rings, which, like the conductors, are insulated from each other, all substantially as in the machine last described. Exterior wires 13 to 19 are employed, as before, but, with their brushes, are arranged upon a hinged supporting-plate, M, and provided at M′ with an adjusting-screw to regulate the pressure of the brushes upon the contact-rings. (See Fig. 20.) The brush on the wire 19 is put in circuit with the exciting-helix I. If, now, a current of sufficient strength be sent into the machine through wire 13, it will pass through all the movable conductors in one direction and through all the stationary conductors or exterior wires in the opposite direction, and finally through the helix I and back to the source of electricity, thereby polarizing the magnet A A′. This causes the armature and inner pole to rotate. If, on the contrary, power be applied to the pulley a' and a current be induced in the b conductors of the armature, this current, passing through the exciting-helix I, increases the magnetism in the magnet A A′, while the remaining portion may be used for external work, as in other dynamo-machines.

At Figs. 21, 21ª, and 21ᵇ another form of dynamo-electric machine is illustrated. In this case the armature is built up of thirteen b bars or conductors, which are insulated from each other and made in the same manner as the commutators of Gramme machines. The contact-rings employed in the machines illustrated in the other figures are dispensed with. To connect the bars in series, six exterior connecting-wires, w' to w^6, are arranged at equal distances from each other around the center of the machine. These exterior connecting-wires form contact each by two brushes at each end (v v and v' v') with the movable conductors in succession as the latter rotate, and thus connect them alternately in linear series. By using thirteen movable conductors and six exterior wires the amount of metal in circuit is kept constant, which would not be the case if twelve movable and six stationary conductors were used.

The results obtained by the machine shown at Figs. 21, 21ª, and 21ᵇ are substantially the same as those obtained from the preceding machines; and this last-described machine differs from the preceding ones only in so far that each movable conductor is brought into metallic connection with all the exterior conducting-wires in succession during each revolution of the armature, while in the other machines each movable conductor is in metallic connection with one of the connecting-wires at all times. A machine of this type has been made the subject of a separate application for Letters Patent filed March 7, 1885, No. 158,033.

At Fig. 22 there is shown a machine in which two electro-magnets substantially like those shown at Fig. 19 or 21 are combined, each magnet consisting of an inner cylinder or pole, A, and an outer shell or pole, A'. They are placed in line, as shown, and are so excited, respectively, by the helices I I' that both inner poles are N poles and both outer poles are S poles. The movable b conductors forming the armatures of this machine are straight bars embedded in a hard-rubber hollow cylinder, B^2, which surrounds the inner poles, A A, and is secured to a hub, O, which in turn is rigidly secured to the shaft a, having bearings in a hole bored through the inner poles, A A, as shown. Each movable b conductor is in metallic contact at each end with a separate ring, and each ring is insulated from every other conductor and every other ring, substantially as in machines already described. The b conductors and their respective rings are connected in linear series by brushes and outer stationary wires, as indicated, and a current which passes in at 13 and out at 19 will pass through all the b conductors in one direction and through all the outer stationary wires in the opposise direction, as indicated by the arrows. The armature will rotate when a current of sufficient strength thus passes through it, or a continuous current is induced in one direction through the conductors when power is applied to the pulley a' and uniform motion given to the armature. The current induced may be used to excite the magnets, or it may be used in part for that purpose and in part for outside work; or the exciting-helices may receive their currents from some other source, and the whole induced current may be used for outside work. This machine embodies certain features which in part constitute the subject of my aforesaid divisional application No. 94,900.

At Fig. 22ª I have shown still another modification. The outer magnet, A', is of substantially the same form as in the machine last described; but for the stationary inner pole I have substituted a cylindrical bar, A, provided with bearings at L and L'. This bar is reduced to a suitable size within the bearings, and to one end of it there is secured the pulley a'. The magnets are polarized by the helices I and I', so that the inner magnet, A, has its N pole at the middle and two S poles at the ends, while the outer magnet, A', has its S pole at the middle and two N poles at its ends. The armature, as shown, is constructed substantially as in the previous case, and its b conductors and their rings are connected in linear series, as already described many times herein when speaking of other machines. When a current passes through the circuit thus formed by the b conductors, their rings, and stationary wires or conductors, the armature and cylindrical inner magnet, A, will rotate, and if motion is given to the pulley a current in one direction will be induced in the circuit.

At Figs. 23, 23ª, 23ᵇ, and 23ᶜ I have shown another form of machine of the same general design. The outer and inner magnets, A' A, are constructed substantially as in the machine illustrated by Fig. 22ª, and, as in that machine, are polarized by the helices I and I', so that the inner magnet, A, has its N pole and the outer magnet, A', has its S pole at the middle; but for the six b conductors of the previous machines I have substituted six hollow metallic cylinders, b, a detached view of one of which is given at Figs. 23ᵇ and 23ᶜ. Each hollow metallic cylinder is provided with two rings, b^2, one on each end. The hollow b cylinders are of different lengths, and are insulated from each other and from the central magnet, A, to which they are attached. I have also put two metallic rings, b^3 and b^4, upon the magnet A, and have connected them in linear series with the hollow b cylindrical conductors by means of brushes and the exterior wire conductors. (Indicated by broken lines.) I have thus used the inner or central magnet, A, as one of the rotating conductors, and by its combination with the six cylindrical conductors have increased the efficiency of the machine.

Figs. 24, 25, 25ª, and 25ᵇ represent still another form of machine of the same general design; but in this machine the inner magnet is so constructd and arranged that it performs the functions of the magnet and also that of the b bars or tubes or b conductors of the other machines. Fig. 24 is a horizontal cross-section through the longitudinal center of the machine. Fig. 25 is a vertical cross-section on the line x y, Fig. 24. Fig. 25ª represents one of the metallic rings t^2 in the views. Fig. 25[b] represents in several views a flanged ring, *k*, made of non-conducting material.

In the machine shown at Fig. 24 and the other figures just enumerated the central magnet, A, is made up of sixteen longitudinal bars, either of iron or steel, *b* b' b^2, &c., mounted upon a shaft, T, from which they are insulated, while they are also insulated from each other. They are secured to the said shaft by two non-conducting rings, R R', held in place by screw-nuts P P. The shaft T has its bearings at Q Q'. The compound magnet A thus made up is polarized by the coils I and I', as shown, and is free to rotate within the outer magnet, A'. Each of the *b* bars thus forming a part of the inner magnet is connected with two metallic rings, as shown at Fig. 24, where the bar *b* is shown in metallic contact with the rings t^2 and t^3, while bar b' is shown in metallic contact with the rings t^4 and t^5. The remaining fourteen bars included within the magnet are also in like manner in contact each with two rings. The different bars which make up the magnet A are insulated from each other by strips, *l l* l', of insulating material between them and the shaft T, and the metallic rings t' t^2 t^3, &c., are insulated from each other by means of the non-metallic flanged rings *k*, recessed at k', Fig. 25[b], to allow the projection $b^{\times}$ of each *t* ring to make contact with one *b* bar only. These *b* bars of the magnet A are connected in linear succession in substantially the same manner as in the other cases.

The machine last described contains novel features which have been made the subject of a division hereof, filed December 26, 1884, Serial No. 151,178.

At Figs. 26 to 36, inclusive, there is exhibited a type of dynamo-machine embodying my improvements complete in all its details. In this machine the exterior cylindrical magnet, A', forms also the supporting-frame of the machine, and is composed of two semi-sections bolted together, as shown. In each end are bearings for the support of the inner rotating magnet, A, which carries the armature, which is constructed as presently described, and attached to the magnet A in such manner as to rotate in close contact with the outer surrounding magnet, A'. The inner magnet, A, carrying the armature, receives rotary motion from a pulley, a', at one end thereof. I and I' are coils for exciting and polarizing the magnets. The inner rotating magnet, A, is so polarized as to have an N pole in the middle and two S poles at its ends, and the outer magnet, A', is so polarized as to have its S pole in the middle surrounding the N pole of the inner rotating magnet, A, and two S poles at its ends. The armature consists of insulated conductor-bars *b*, (see Fig. 34,) embedded in a cylindrical shell of hard rubber, (see Fig. 36,) which has grooves to receive the conductor-bars, and is rigidly secured to the inner rotating magnet, A. Each bar *b* is placed in metallic contact with two rings, *t t*, &c., one at each end, by means of projections on the rings. (See Figs. 35 and 26.) The rings *t* at each end are insulated from each other, and each is insulated from all the conductor-bars *b* except its own. Accordingly, each conductor, with its two rings, forms one element in the series.

To connect the conductors *b* in series, contact-pieces of special construction are used. They are shown at Figs. 31, 32, and 33, and consist of a loose block or piece of metal, *h*, that is pressed by a spring, h', upon the ring of the conductor. The outer end of each contact block or piece *h* is rounded off and fitted loosely into the recess of a metal piece, h^3, that is attached to the end of an exterior wire or conductor, h^4.

The machine is shown as arranged with twenty-four conductors, which form the armature, and with twenty-four exterior wires, which are disposed of in two sets of twelve each at both sides of the exterior frame. The rotating conductors are connected in linear series by means of the contact-pieces *h* and h^3, and exterior conductors, h^4, so that the electric current passes through all the rotating conductors *b* in one direction, and through all the exterior stationary conductors, h^4, in the other direction. It is obvious, however, from the foregoing description that a portion of the rotating conductors may be connected in one linear series and another portion be connected in another linear series, each linear series having its own independent current of electricity. When motion is imparted to the armature, a current is generated which can be utilized in the usual manner. A number of the rotating conductors may be placed in one circuit and used to excite the coils I and I', while the circuit generated by the remaining conductors, which may be in one or more circuits, may be used for external work.

Instead of the separate magnet A and independent conductors shown in the machine last described, it is obvious that the compound magnet shown at Fig. 24 may be placed in the machine with equal if not better results.

It will be observed that in many of the machines illustrated the exciting helix or helices are inclosed within a mass of magnetic metal, which is chambered and which surrounds the armature, and that each helix is concentric with the axis of the armature, and these parts thus organized involve a novel feature, which I deem of value, in that the magnetic currents or forces are thereby practically restricted to the interior portions of the machine.

I have now described with more or less detail several machines in which I have embodied my improvements. In all of them I have shown the independent conductors as arranged concentrically about a cylindrical or hollow magnet, or both. Similar results, however, are obtained when the movable conductors are eccentric within the exterior pole or about the inner pole, or are acted upon by one pole only or by a large number of magnetic poles properly located in relation to the center of rotation of the armature. When, therefore, my invention is broadly considered, although, as will hereinafter appear, I claim as subordinate parts of it certain details of construction, I do not confine myself to the special arrangement of movable conductors shown, since they may be either parallel with the axis or radiating from the center of the pole, or partly parallel with and partly radial to said axis. So in all the machines shown or illustrated the conductors may be made of iron or steel. Nor, when my invention is broadly considered, do I confine myself to any particular form of conductors, for, as I have shown, they may consist of bars or tubes, and it is obvious that they may consist of disks or wires if properly connected in linear succession. It is also to be understood that magnets of other form and construction may be employed without departing from certain features of my invention. So, in any of the machines shown, roller contacts might be substituted for the brushes and contact-blocks shown and described.

Another modification within my invention, broadly considered, but forming the subject-matter of a subordinate claim, is illustrated at Fig. 22, where I have represented that the outside wire, 16, may be cut, as indicated, by the line crossing it in front of the horizontal arrow, and the ends straightened to form two terminals. (Marked 16 and 16[a].) There will then be two series of outside stationary conductors, the current of one entering at 13 and passing out at 16, while the current of the other enters at 16[a] and passes out at 19. Thus when the machine is used as a generator, each series may be made to do work independent of the other series, and in like manner an independent source of electricity may be used with either series when the machine is used as a motor. Again, it is obvious that when the rotating conductors of any of the machines shown are made of iron, they become portions of a compound magnet, and if they are attached to a rotating magnet they re-enforce that magnet; but, as hereinbefore stated, this particular feature is included within the claims of one of my divisional applications, filed December 26, 1884.

In the diagrams shown at Figs. 3 and 4 the D and D′ conductors, when made of iron and rigidly secured to either of the magnets A or B, may be considered a part thereof, and either A or B, to which they are attached, may be rotated, the other remaining stationary, or both magnets A and B may be rotated in contrary directions.

Having thus described my invention, I claim—

1. In an electro-magnetic or magneto-electric machine, an electric circuit in which two or more insulated bars mounted upon a rotative magnetized core are connected in linear series in the circuit.

2. In an electro-magnetic or magneto-electric machine, the combination of two cylindrical magnets, either simple or compound, one located within the other, the inner magnets carrying independent electro-conductors and capable of rotation, substantially as described.

3. In an electro-magnetic and magneto-electric machine, a magnet formed of two concentric cylinders closed at both ends and polarized to locate the neutral points at both ends of the cylinders, and affording an interior annular field of force for an armature, substantially as described.

4. In an electro-magnetic or magneto-electric machine, a stationary pole and a rotating armature composed of two or more independent conductors connected in one or more linear series and revolving around said stationary pole, substantially as described.

5. In an electro-magnetic or magneto-electric machine, a stationary pole, a rotating armature embodying two or more independent conductors connected in linear series, and an inclosing-magnet, substantially as described.

6. In an electro-magnetic or magneto-electric machine, a series of internal conductors connected in linear series by a series of outside conductors, substantially as described, whereby all of the internal conductors may be connected in one circuit, or any portion or portions of said internal conductors included in an independent circuit or circuits, substantially as described.

7. In a magneto electric or electro magnetic machine, the combination, substantially as hereinbefore described, of a revolving armature, an inclosing magnetic shell, and one or more exciting-helices housed within said shell and arranged concentrically with the axis of the armature.

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