(No Model.) 3 Sheets—Sheet 1.

R. EICKEMEYER, Dec'd.

R. EICKEMEYER, JR., Executor.

DYNAMO ELECTRIC MACHINE.

No. 564,559. Patented July 21, 1896.

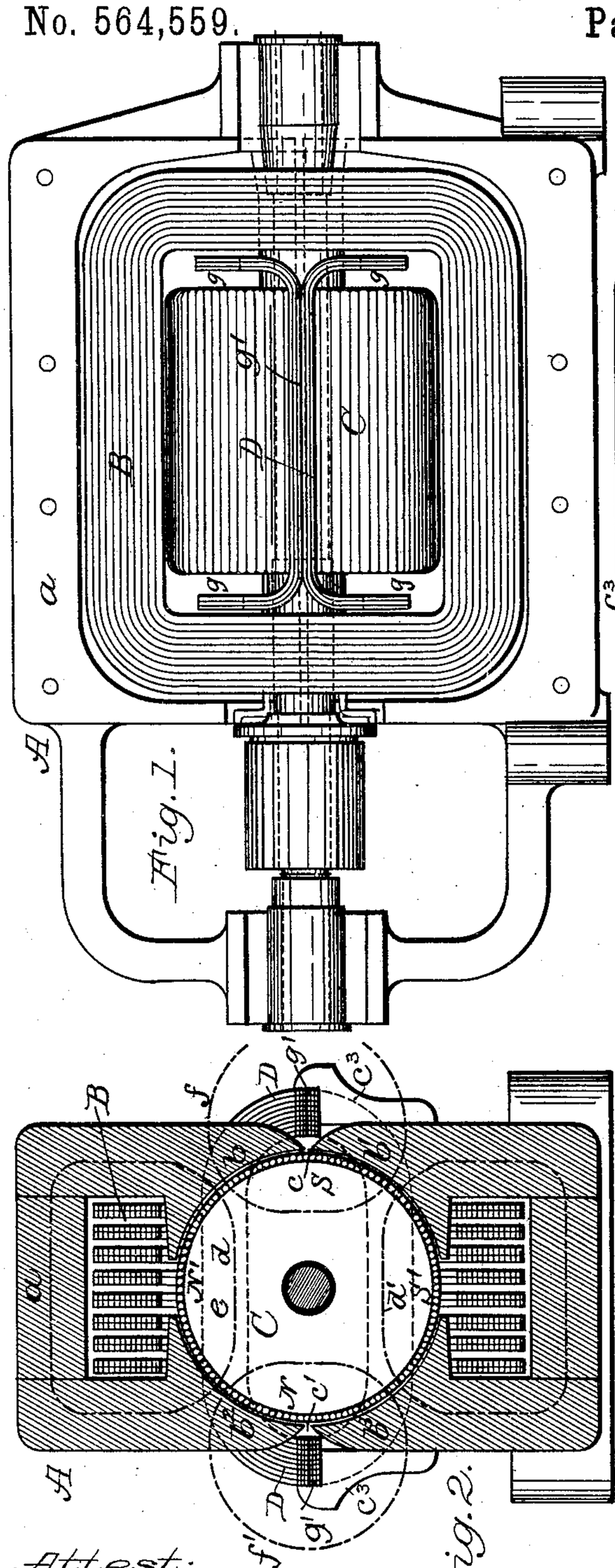

Fig. 1.

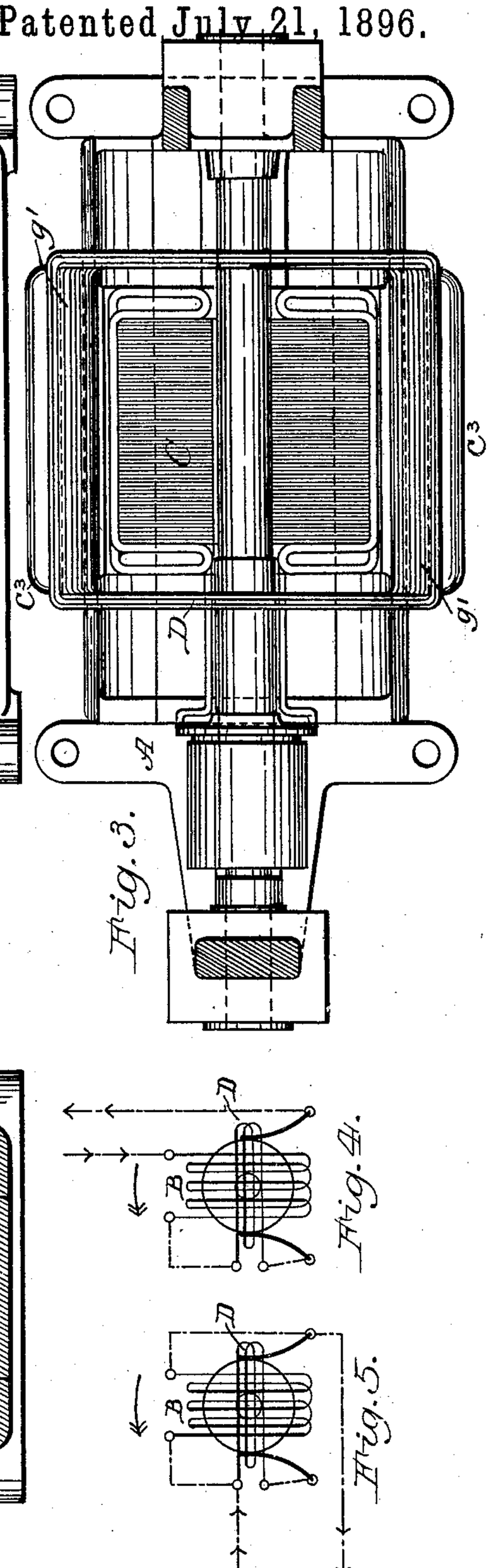

Fig. 3.

Fig. 2.

Fig. 4.

Fig. 5.

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(No Model.) 3 Sheets—Sheet 2.

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DYNAMO ELECTRIC MACHINE.

No. 564,559. Patented July 21, 1896.

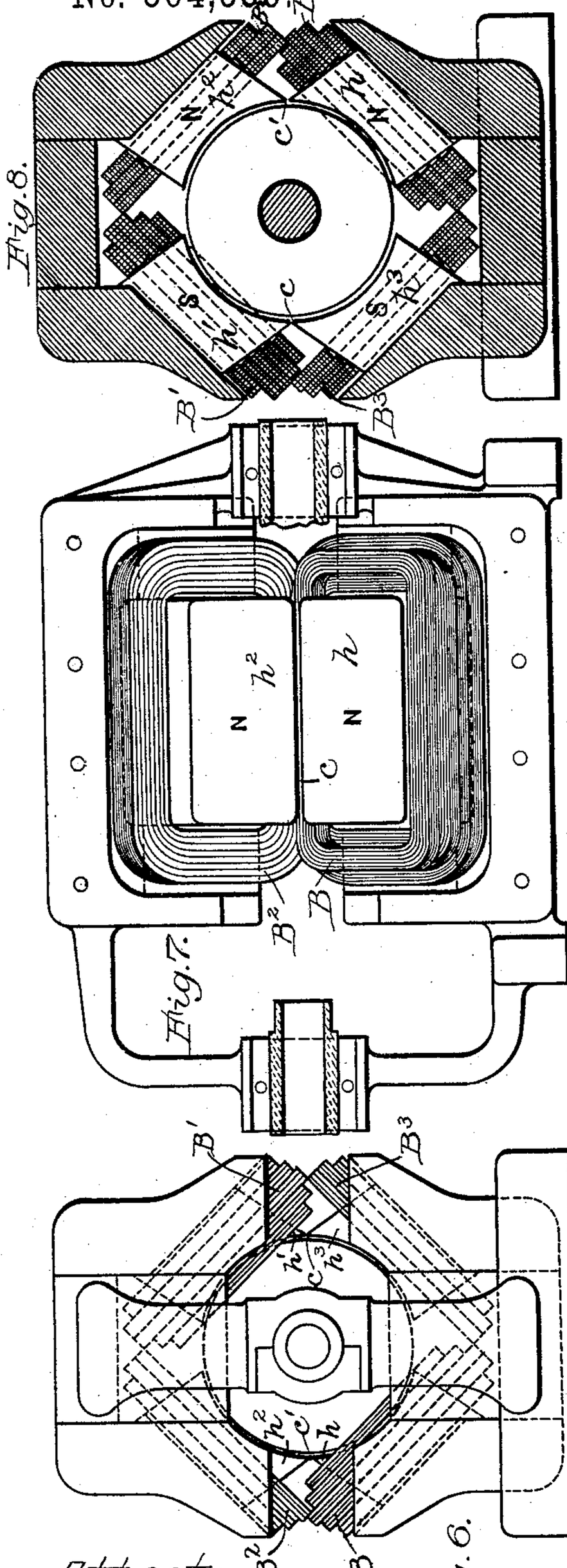

Fig. 8.

Fig. 7.

Fig. 6.

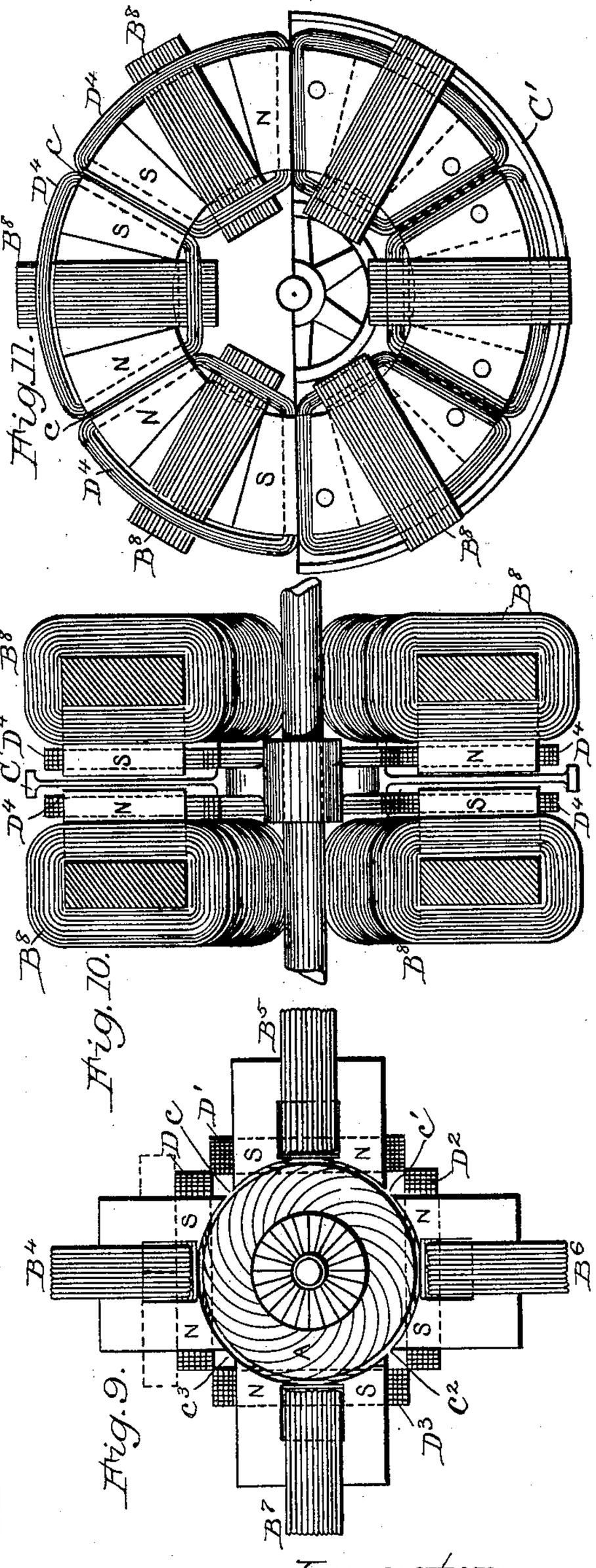

Fig. 11.

Fig. 10.

Fig. 9.

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DYNAMO ELECTRIC MACHINE.

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Fig. 12.

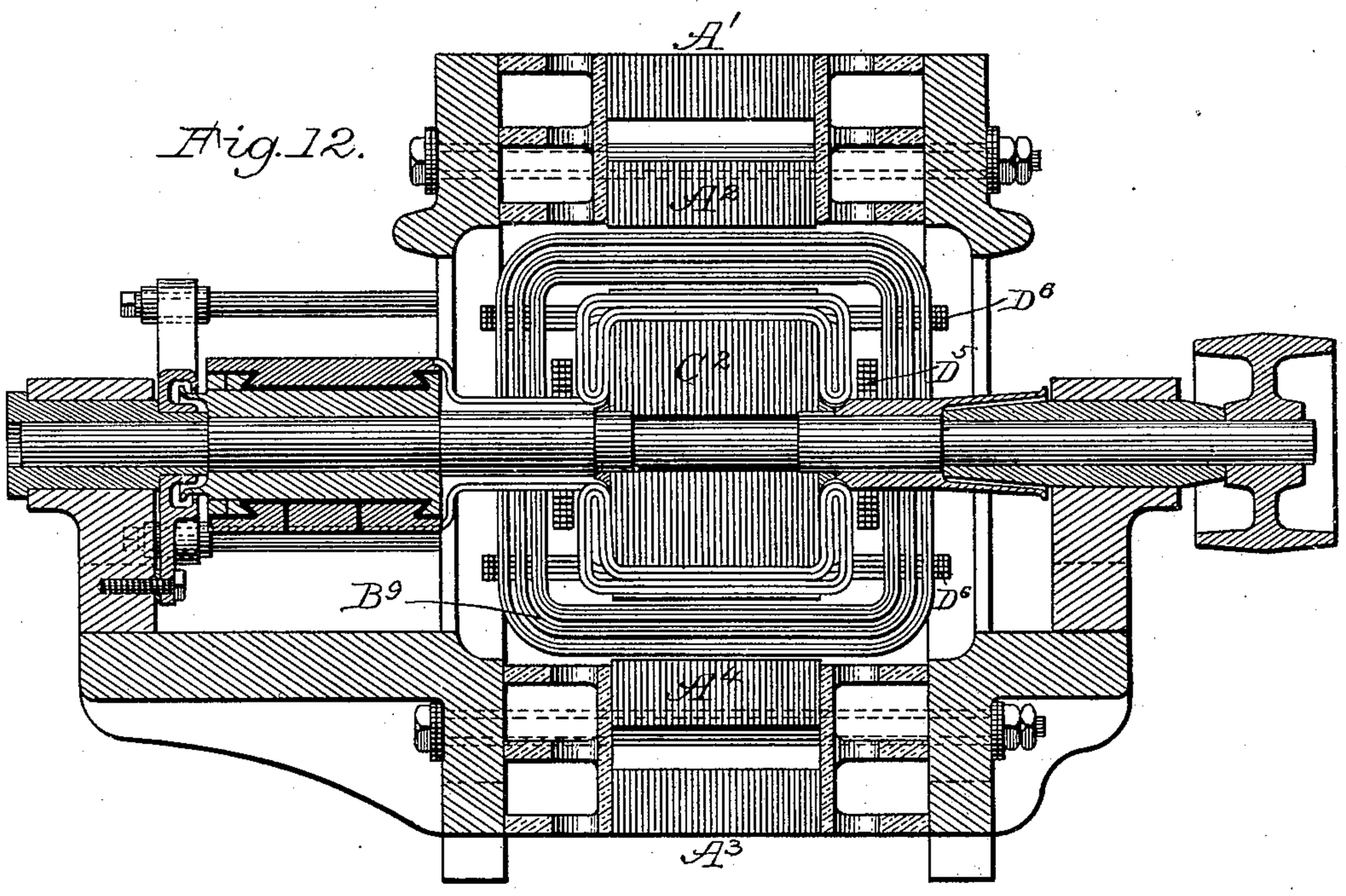
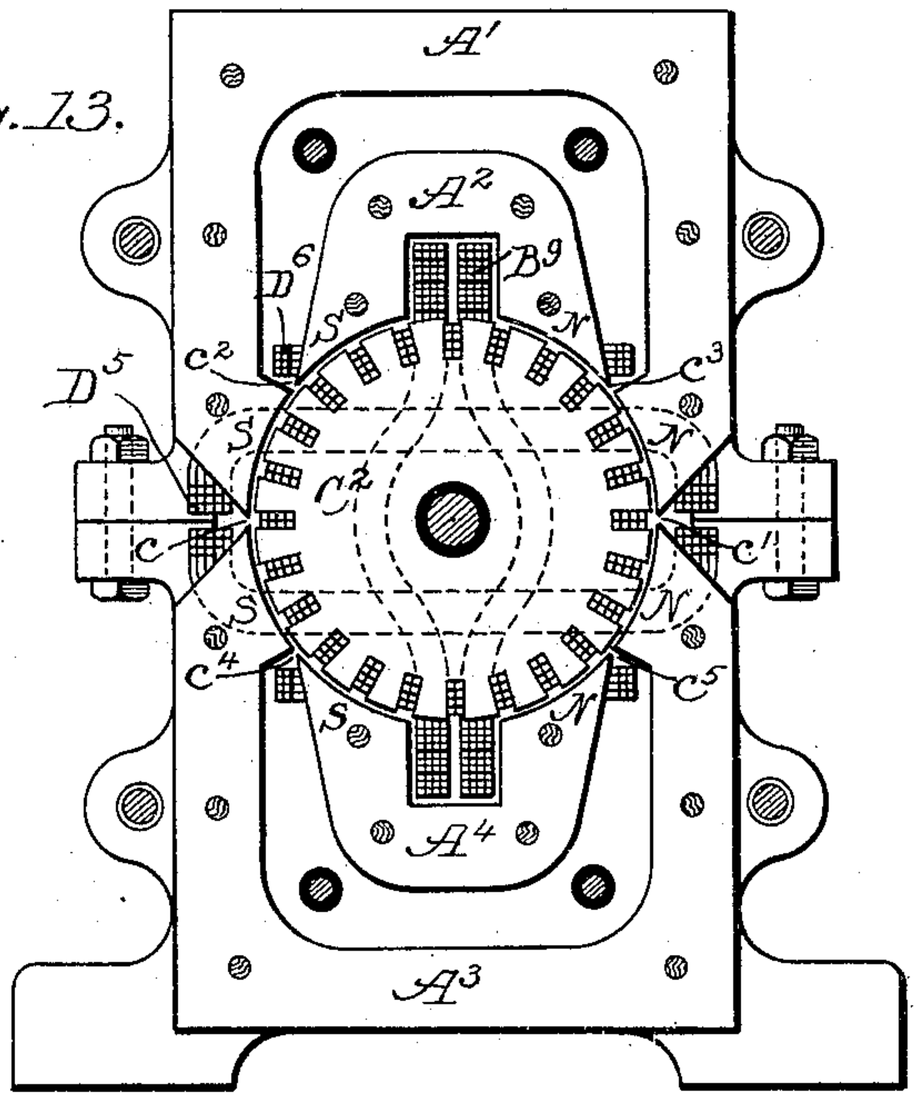


Fig. 13.



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By Munn & Co. attorneys.

UNITED STATES PATENT OFFICE.

RUDOLF EICKEMEYER, OF YONKERS, NEW YORK; RUDOLF EICKEMEYER, JR., EXECUTOR OF SAID RUDOLF EICKEMEYER, DECEASED.

DYNAMO-ELECTRIC MACHINE.

SPECIFICATION forming part of Letters Patent No. 564,559, dated July 21, 1896.

Application filed October 7, 1891. Serial No. 407,976. (No model.)

To all whom it may concern:

Be it known that I, RUDOLF EICKEMEYER, of Yonkers, in the county of Westchester and State of New York, have invented certain new and useful Improvements in Dynamo-Electric Machines; and I do hereby declare that the following specification, taken in connection with the drawings furnished and forming a part of the same, is a clear, true, and complete description of the several features of my invention.

Certain features of the improvements herein disclosed are widely applicable to dynamo-electric machines however largely they may be varied in matters of form, general construction, and capacity, and whether designed for alternating or for constant current service, and whether the machines be bipolar or multipolar, or organized to operate as generators or as motors.

In my application for Letters Patent filed December 31, 1890, Serial No. 376,361, I disclosed certain portions of my said improvements as organized by me in certain alternating-current machines, which have been proved to possess high and practically valuable efficiency.

Broadly stated, the object of my present invention is to obviate, prevent, or neutralize such magnetization as is not required for securing the proper operation of dynamo-electric machines, and which, as I believe, operates adversely or obstructively to the attainment of the results desired from or in the use of such machines.

It is well known that an electric current flowing in certain sections or portions of an armature-circuit induces in adjacent portions of the field-iron, as well as in portions of an armature-core, more or less magnetism, which operates so adversely to the magnetism induced by electric current in the field-coils as to cause a shifting of the line of commutation under variations in load and speed, with consequent sparking at the commutator-brushes and impairing operative efficiency.

I have accomplished the objects hereinbefore stated and secured a practically permanent or fixed line of commutation, with absolute freedom from sparking at the brushes, regardless of variations in load or speed, and a consequent greater efficiency, by a novel organization of the magnetic systems of dynamo-electric machines, which consists in combining with an armature (in any of the well-known forms and regardless of its character) and field-coils (however they may be arranged and applied) of masses of magnetic metal, affording cheek-pieces appropriately arranged with relation to the armature, and having similarly-magnetized cheeks closely adjacent to each other, but separated by spaces parallel with the armature-winding; and counter field-coils, each having a portion thereof located in an appropriate space between two similarly-magnetized cheeks (*i. e.*, of the same polarity) and parallel with adjacent sections or portions of the armature-winding, these counter field-coils being supplied with an electric current, which, in those portions occupying said spaces, flows in a direction opposite to the flow of the electric current in the adjacent portions or sections of the armature-winding, said spaces affording air-space resistance in the field metal occupied by the magnetic circuits induced by said adjacent armature-sections, and the counter field-coils affording a magnetic flow opposite in direction to the flow of magnetism induced by said armature-sections. This air-space magnetic resistance and the counter field-coils have been embodied by me as described in machines wherein the field-coils directly magnetize the iron core of the armature, and in which the cheek-pieces are polarized by induction from said core; also in machines wherein the cheeks are portions of separate electromagnets having field-coils which directly polarize the cheek-pieces, which in turn polarize the armature by induction, and also in machines wherein the armature contains no magnetic metal, and therefore I have illustrated my improvements as applied to continuous-current machines of a type devised by me, and disclosed in different forms in my Letters Patent No. 358,340, dated February 22, 1887, and No. 413,337, dated October 22, 1889, and also to other forms of bipolar and multipolar machines, including alternating-current machines.

After describing in detail the several machines illustrated, the main feature of my in-

vention and certain specific features deemed novel and appropriate to this application will be duly specified in the several clauses of claim hereunto annexed.

Referring to the drawings, Figure 1 illustrates a bipolar machine embodying in a preferred form my present invention, the same being in side view, but with one of its sides or pair of correspondingly polarized cheek-pieces removed. Fig. 2 is a central vertical cross-section of the machine. Fig. 3 is a central horizontal section of the armature with the upper cheek-piece and the field-coils removed. Figs. 4 and 5 in diagrams illustrate the electric portions of the machine, respectively arranged to operate as in series machines and as in shunt-machines. Fig. 6 in end elevation illustrates another form of bipolar machine containing separate electromagnets and embodying my invention. Fig. 7 illustrates the frame and field-coils of the same with the cheeks at one side removed. Fig. 8 illustrates the same in vertical cross-section. Fig. 9 diagrammatically illustrates my invention applied to a multipolar machine having a drum-armature and four separate electromagnets. Figs. 10 and 11 illustrate my invention as applied to a multipolar machine having a disk-armature and twelve separate electromagnets. Figs. 12 and 13 illustrate in vertical central section and also in lateral vertical section an alternating-current machine embodying the main features of my present invention.

Referring to the specially desirable form of machine illustrated in Figs. 1 to 3, inclusive, it is to be understood that the central portion *a* of the iron frame A and the cheek-pieces bolted thereto, and the substantially rectangular field-coils B, surrounding the armature C diametrically, and housed within the frame, and directly magnetizing the core of the armature, involve certain features of invention disclosed in my Letters Patent Nos. 358,340 and 413,337, and also certain features disclosed and claimed in my application for patent, Serial No. 277,161, (Patent No. 454,336.) This machine, however, differs from my said prior machines in that the magnetic metal is divided into four cheek-pieces, each similarly-magnetized pair being separated, so as to afford magnetic resistance as now desired by me. These pairs of divided cheek-pieces may be termed "upper" and "lower" cheeks or sections *b* and *b'* on one side, and these are similarly magnetized by induction from the armature-core and are of one polarity; the sections b^2 and b^3 on the other side, both similarly polarized from the core, are of another polarity. These upper and lower cheeks or sections are separated by intervening vertical open spaces, as at *c c'*, preferably on a horizontal line parallel with the axis of the armature and with the adjacent winding thereon. These spaces *c* and *c'* closely adjacent to the armature are quite narrow, but they are gradually widened outwardly, because of receding exterior surfaces of the cheek-piece sections, as clearly indicated in Fig. 2. The longitudinal lines of these spaces may be somewhat inclined or spiraled with respect of the armature without departure from my invention, as they would then be substantially parallel with the adjacent portions of the armature-winding and serve the purposes intended. This division of the cheek-pieces and the resulting magnetic resistance afforded to a valuable extent by the air-spaces results in reducing that objectionable magnetization of the cheeks which is due to the currents in adjacent portions of the armature-winding, inasmuch as the number of lines of force developed in a magnetic circuit by a given electric current depends upon the magnetic resistance encountered in said circuit.

The main field-coil B is constructed in sections, and it surrounds the armature longitudinally and diametrically, and its sides are inclosed by the magnetic metal which affords the divided cheeks. The dotted lines *d* and *d'* illustrate the magnetic circuits afforded by the field-coils B, and, as indicated, the iron contained in the frame, in the cheek-pieces, and in the core *e* of the armature affords a complete circuit in which no magnetic resistance is encountered except at the narrow annular space in which the armature-winding is located and travels. These magnetic circuits being thus well shortened or concentrated, and as free from magnetic resistance as possible, are as dense and as strong as it is practically possible for these field-coils to develop under the most favorable electric conditions.

The objectionable magnetization induced by the armature-winding flows in magnetic circuits at *f* and *f'*, (these being also indicated in dotted lines,) and it will be seen that by separating the cheeks and affording the air-spaces *c c'* no portion of these magnetic circuits can be completed in magnetic metal. In other words, each of said circuits traverses a portion of the armature-core *e* and lateral portions of the cheek-sections, but the air-space resistance, being interposed between the similarly-magnetized sections, compels each of these circuits to complete itself by traversing external air-space with corresponding resistance, and thus proportionately reducing the number of magnetic lines in said circuits far below what would otherwise be due to the electric current in the armature-circuit. Having thus weakened these objectionable magnetic circuits, I still further completely neutralize them by means of a coil, which may be termed either an "auxiliary field-coil" or a "counter field-coil."

The auxiliary field-coil D is similar as to its rectangular form to the main field-coils B, and it longitudinally surrounds the armature, but is at right angles to the main coil, and it is much smaller, and need contain but

little, if any, more wire than is contained in that portion of the armature-winding which induces the objectionable magnetization in the armature-core. The coil D, at its ends g, lies between the ends of the armature and the ends of the main coils, but its sides g' are wholly outside of the magnetic metal or frame and snugly occupy the cheek-dividing spaces c c' at the sides of the machine. The sides of the auxiliary coil have supports upon suitable brackets c^3. It is now to be understood that the electric current in this auxiliary coil develops a magnetic circuit adjacent to its sides g', which in the direction of flow will be opposite to the flow of the magnetic circuit induced at that point by the electric current in the adjacent portions or sections of the armature-winding, and these magnetic circuits will neutralize or balance each other, thus practically eliminating from the armature-core all of that polarization which, when present, is obstructive to the most effective operation of the machine.

Referring to Fig. 2, it will be assumed that the electric current in an appropriate direction in the main field-coil will induce magnetism, so as to produce N polarity in the armature-core at the left-hand side of the armature-shaft and S polarity at the right hand, as designated. The electric circuit in the armature-coils, under correspondingly appropriate conditions, will produce N polarity at N′ in the armature-core above the armature-shaft and S polarity at S′ below, as indicated in the drawings. An appropriate electric current in the auxiliary field-coil will develop at N′ and at S′ opposite polarity, and it therefore counteracts or eliminates from the armature-core and the adjacent field metal all of that magnetization which is not and cannot operate in harmony with the magnetization induced by the main field-coils, and hence no sparking will occur at the brushes, because there can be no shifting of the line of commutation under variations in load and speed, and hence the commutator-brushes will require no variation in position under variations in load or of speed, or in changing the direction in which the machine may be driven.

The diagrammatic Figs. 4 and 5, respectively, illustrate machines wound in series and in shunt, the field-coils B and counter field-coils D being therein clearly indicated. By thus having the electric current in those portions of the counter field-coils which occupy the spaces between similarly-magnetized cheeks flowing in a direction opposite to the current in adjacent sections of the armature-winding the magnetism induced by the counter field-coils flows so as to strengthen the magnetic field at diagonally opposite cheeks of both pairs and weakens the field at the other diagonally opposite cheeks, the pairs thus respectively affected varying according to the direction in which the armature may be rotated.

In Figs. 6, 7, and 8 I have shown the main parts of a bipolar machine embodying separate electromagnets, and in which appropriate portions of the field-coils are made to do the same duty as is performed by the auxiliary or counter field-coil in the form of machine first described. In this instance the masses of magnetic metal afford four cheek-pieces, which are the cores of two separate electromagnets, and the similarly directly magnetized cheek-pieces are separated by horizontal narrow spaces c c', as before described, and each radially-disposed core is surrounded by a field-coil, the four cores h h' h^2 h^3 having the four field-coils B B′ and B² B³. The coils B and B′ are diagonally opposite each other, and they are each composed of five sections, which vary from each other in size merely to enable them to be properly massed within the space provided for them. The coils B² and B³ are also diagonally opposite each other and are each composed of three sections, and they are located at right angles to the coils B B′. With the coil B² and three sections of the coil B supplied with an electric current which will induce N polarity in both of the cheek-pieces h h^2, and with a current in coil B³, and in three sections of the coil B′, which will induce S polarity in cheek pieces h' h^3, a magnetic field will be afforded which will correspond to that which is usual in bipolar machines.

When the machine is operated with the current in the armature-circuit flowing in a certain direction, the upper S pole and the lower N pole will be weakened and the line of commutation shifted, that being the defect which my invention obviates. In this form of machine I avoid that defect by so coupling two sections of the coil B and two sections of the coil B′ in series with the armature that these will then operate as auxiliary or counter field-coils, so that the variable exciting current passing through these four sections of counter field-coil will appropriately strengthen the N and S magnetism in the diagonally opposite cheeks h^2 h^3 in proportion to the extent to which they would have otherwise been weakened by the current in the armature-coils, the other two diagonally opposite cheeks being duly weakened, and hence shifting of the line of commutation is obviated and no sparking can occur at the brushes during any possible variation in load. As thus organized, however, the machine would be adapted to operate in but one direction, and to provide for a reversible motor of this type, for instance, will involve only the addition of two sections each to the coils B² and B³ and providing a cut-out which will place those two pairs of counter field-coil sections in circuit with the armature which would be appropriate to the particular direction in which the machine was to be driven, the counter field-coils in service being then so coupled in circuit with the armature that appropriate cheeks would be magnetically

strengthened or weakened, according to the direction of rotation by the armature. If in this machine each of the four field-coils had an equal number of sections, the ends sought would be also secured by the use therewith of an auxiliary or counter field-coil, which, as in Figs. 1, 2, and 3, would be of the same form as therein shown, and have its sides occupy appropriate positions in close proximity to the spaces c c', which in this machine, as in the machine first described, separate similarly-magnetized cheek-pieces.

The machine illustrated in Fig. 9 is a multipolar machine, and it embodies four electromagnets grouped around a drum-armature. Each of said four magnets affords two cheeks, respectively polarized N S, but two of the N cheeks, being side by side, constitute in substance a cheek in two parts similarly magnetized, and the other two N cheeks constitute another two-part N cheek diagonally opposite the first. Two S pole-faces are also afforded, each embracing two adjacent S pole-cheeks. In this machine the main field-coils are designated B^4 B^5 B^6 B^7, and each magnet closely adjacent to its cheeks is provided with an auxiliary coil, as at D, D', D^2, and D^3. Each two of the adjacent and similarly-magnetized cheeks are separated from each other by a narrow space, as at c c' c^2 c^3, as in the other machines, and portions of the auxiliary or counter field-coils are located as nearly adjacent to said spaces and to the armature as may be practicable, and therefore these coils, being coupled with the armature and appropriately proportioned to the armature-winding, will, as in the other machines, eliminate the magnetic reaction of the armature and prevent the shifting of the lines of commutation, and thereby obviate sparking at the commutator under variations in load.

Referring again to Fig. 9, it will be seen that if each of the field-coils (of the B series) should be divided into two sections and separately applied to the two legs of the magnets, as indicated in dotted lines at the uppermost magnet in said figure, the adjacent counter field-coils (of the D series) would in like manner be divided, and each part would surround its appropriate portion of the magnet-leg between the adjacent field-coil and the armature, and also properly occupy effective positions at or adjacent to the air-gaps c, c', c^2, and c^3.

In Figs. 10 and 11 I show another multipolar machine, having a disk-armature C' and twelve electromagnets, each having its own field-coil B^8, and the whole being so organized as to afford six fields of force. As in the machine last described, two adjacent N pole-cheeks in this machine constitute in substance one N pole-face divided into two parts, and these alternate in the same plane with similarly-divided S pole-faces, as clearly indicated in the upper half of Fig. 11, the N pole-faces on the one side of the armature being located opposite other S pole-faces at the other side, as clearly indicated in Fig. 10. In this machine each electromagnet has an auxiliary or counter field-coil D^1, which is, in this case, at right angles to the adjacent main field-coil and surrounds the two cheeks of the magnet, and is located between the main field-coil B^8 and the armature. So, also, in this machine, as before indicated, each pair of similarly-magnetized cheeks constitute in substance one cheek separated into two parts by one of the spaces c, and each of said spaces is occupied by appropriate portions of two auxiliary field-coils, substantially as in the other machines; and so, also, are the separating-spaces c parallel with the main portion of the armature-winding, which in this case is radial and has its path between the two sets of magnets, or, in other words, in front of all of the pole-faces, and hence these auxiliary coils will and do operate when properly excited, as before described, in preventing the shifting of the lines of commutation and obviating sparking at the commutator, regardless of variations in load.

It is now to be understood that the machines illustrated in Figs. 6 to 11, inclusive, embody novel combinations which may not be appropriately claimed herein, and therefore said features will be made the subject of a separate application for Letters Patent filed herewith. (See Serial No. 407,977.)

Although my aforesaid prior application, Serial No. 376,361, contains a full disclosure of alternating-current machines embodying certain of the improvements herein more extensively disclosed, I shall deem it proper, in view of the intended scope of this specification and of certain of the claims to be hereinafter annexed, to illustrate and briefly describe one of my alternating-current machines.

As shown in Figs. 12 and 13, the magnetic field metal is so disposed that the upper and lower portions thereof are each in two separate masses of laminated iron A' A^2 and A^3 A^4, each mass being substantially in horseshoe form, and one mass A^2 or A^4 being within a larger mass A' or A^3, but separated from each other. The cheeks afforded by these four masses of iron constitute in one sense two cheeks divided into two similarly magnetized parts, those at one side being of N polarity and those at the other of S polarity, as indicated. These pole-cheek divisions are separated by air gaps or spaces, as hereinbefore described, as at c, c', c^2, c^3, c^4, and c^5.

The counter field-coil D^5 is located adjacent to the gaps c and c', and a second double counter field-coil D^6 is constructed in two widely-separated sections, one of which has its sides adjacent to the gaps c^2 c^3, and the other has its sides adjacent to the gaps c^4 and c^5. The armature C^2 has its sections of winding in suitable grooves, in a laminated iron core, and the field-coil B^9 directly magnetizes said core, and the field metal is magnetized by induction.

It will be obvious that in machines of this type the air-gaps and the counter field-coils operate, in the main, substantially as in the other forms of machine, and they have been proved to possess special value in alternating-current motors.

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

1. In a dynamo-electric machine, the combination substantially as hereinbefore described, of an armature; field-coils; masses of magnetic metal affording cheek-pieces appropriately arranged with relation to the armature, and having similarly-magnetized cheeks adjacent to each other, but separated by spaces parallel with the armature-winding; and counter field-coils, each having a portion thereof, located in and adjacent to, an appropriate space between two similarly-magnetized cheeks, and parallel with the adjacent sections or portions, of the armature-winding, and supplied with an electric current, which, in the portions of said counter field-coils occupying said spaces, flows in a direction opposite to the current in the adjacent portions of the armature-winding, said spaces affording air-space resistance in the magnetic circuits induced by said adjacent armature-sections, and the counter field-coils, inducing a magnetic flow opposite in direction to the flow of magnetism induced by said armature-sections.

2. In a dynamo-electric machine, the combination substantially as hereinbefore described, of a drum-armature; field-coils; masses of magnetic metal affording two pairs of cheek-pieces located on opposite sides of the armature, each pair being similarly magnetized, but separated centrally by a space parallel with the armature-winding; and a counter field-coil which encircles the machine on a line with said spaces, and induces a magnetic flow which strengthens the magnetism in diagonally opposite cheeks of both pairs, and weakens the magnetism in the other diagonally opposite cheeks.

3. In a dynamo-electric machine, the combination substantially as hereinbefore described, of a drum-armature having a core of magnetic metal; field-coils which surround the armature longitudinally, and directly magnetize the armature-core; and magnetic metal surrounding the armature and field-coil, and affording cheek-pieces, polarized by induction from the armature-core, and arranged in similarly-magnetized pairs on opposite sides of the armature, the cheeks of each pair being separated from each other by a space substantially parallel with adjacent portions or sections of the armature-winding.

4. In a dynamo-electric machine, the combination substantially as hereinbefore described, of a drum-armature having a core of magnetic metal; field-coils which surround the armature longitudinally and directly magnetize the armature-core; magnetic metal surrounding the armature and field-coils, and affording cheek-pieces polarized by induction from the armature-core, and arranged in similarly-magnetized pairs on opposite sides of the armature, the cheeks of each pair being separated from each other by a space substantially parallel with adjacent portions or sections of the armature-winding; and a counter field-coil surrounding the armature longitudinally at right angles to the field-coil, and having portions thereof located at the spaces between said similarly-magnetized cheeks, and parallel with the adjacent sections of the armature-winding.

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