J. F. McELROY.

ARMATURE WINDING.

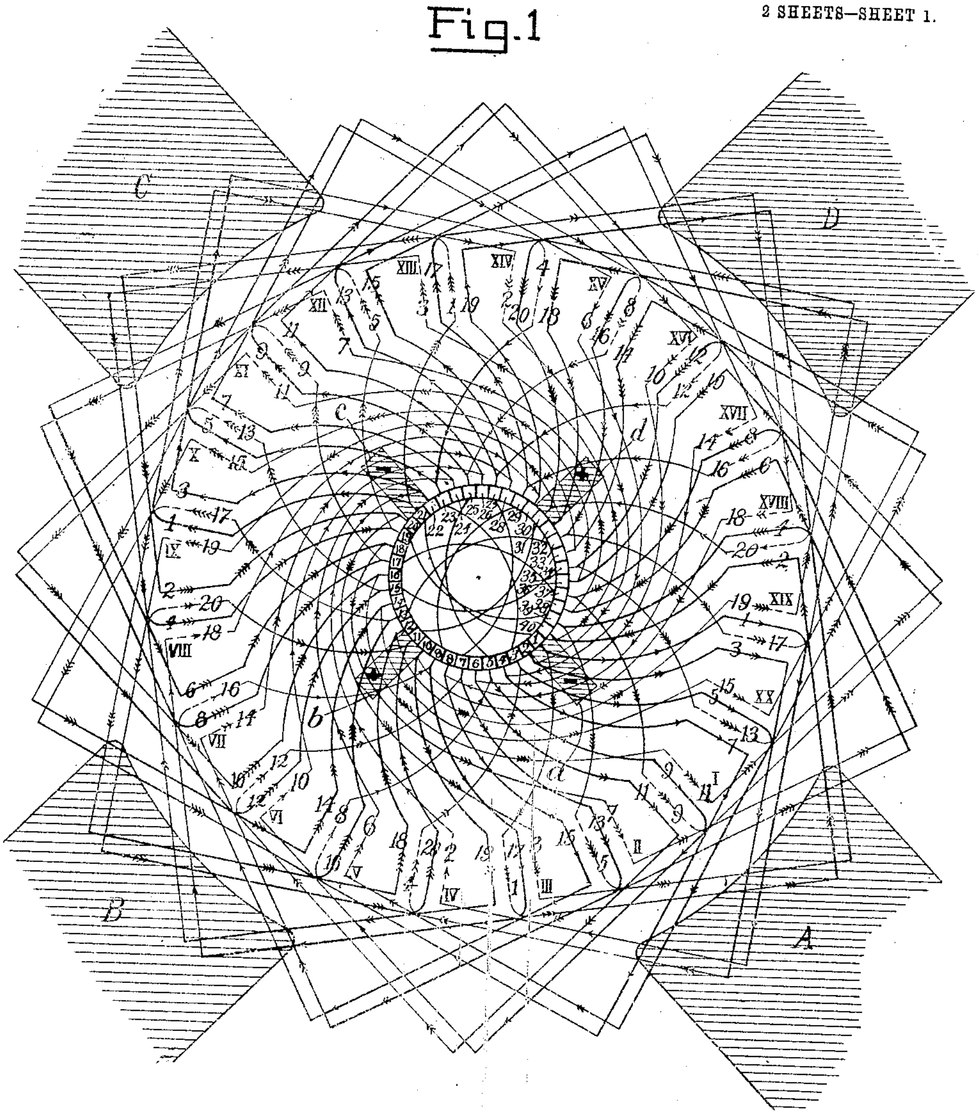
APPLICATION FILED OCT. 21, 1905.

1,039,307.

Patented Sept. 24, 1912.

2 SHEETS—SHEET 1.

Fig.1



Witnesses

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2 SHEETS—SHEET 2.

Fig. 2

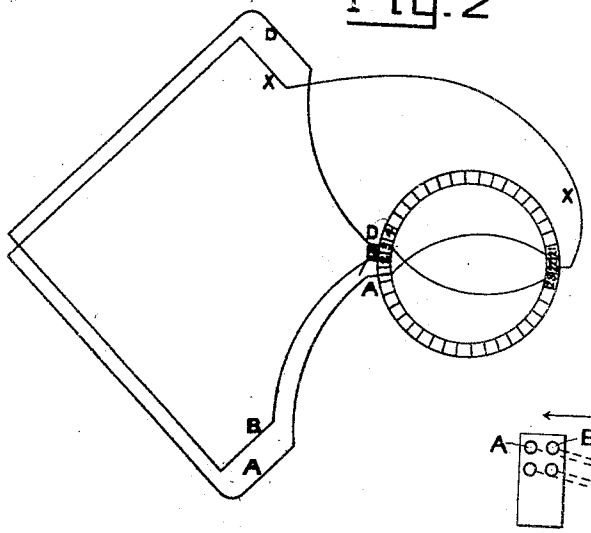


Fig. 3

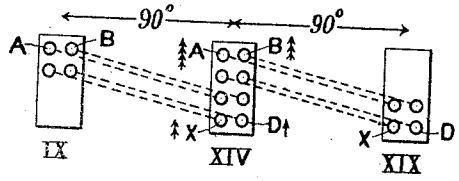
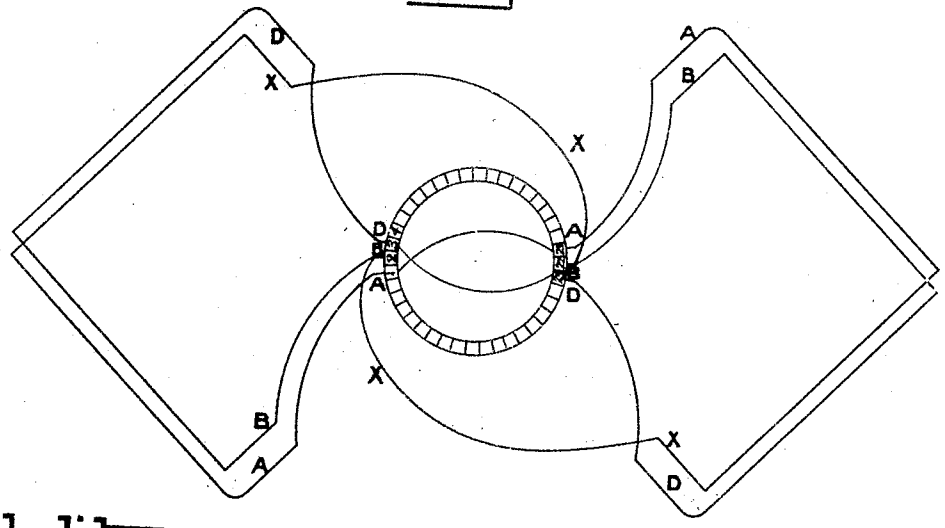


Fig. 4



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ARMATURE-WINDING.

1,039,307. Specification of Letters Patent. Patented Sept. 24, 1912.

Application filed October 21, 1905. Serial No. 283,735.

To all whom it may concern:

Be it known that I, JAMES F. McELROY, a citizen of the United States, residing at Albany, in the county of Albany and State of New York, have invented certain new and useful Improvements in Armature-Windings, of which the following specification and accompanying drawing illustrate the invention in a form which now regard as the best out of the various forms in which it may be embodied.

Figure 1 of the drawing shows a diagram of my winding, Figs. 2, 3 and 4 show details.

My invention relates to an armature-winding similar to that of my Patent No. 753,422, of March 1, 1904, wherein the winding comprises a number of multiple branches between the opposite brushes, the potential being equalized between these several branches at certain specified points. The coils are so arranged that each multiple branch will include between the said points the entire magnetic flux from a multiplicity of field magnet poles, so that any inequalities of distribution of this flux between the several poles may be neutralized in each of the said branches. In addition the equipotential points are electrically cross-connected to further insure the desired equality.

My present invention involves a winding of the same general character and consists in so arranging the winding, that in each slot of the armature there will be a wire (or several wires forming succeeding turns of a coil) from each one of the several multiple circuits of which the winding is composed. By this contrivance, I am enabled to effectively balance the entire winding, locally and as a whole, so that the cross connections employed in the winding of my former patent may be omitted, although such cross connections will still be required in the event of the machine being used with a number of brushes less than the number of magnet poles.

My invention applies to multipolar machines having any desired number of poles, but, for simplicity of illustration, I show it applied to a four-pole machine and the following description will be addressed to a machine of that character. The application of the invention to machines having more than four poles will be apparent to those familiar with armature windings.

Turning to the diagram found in Fig. 1 of the drawing, the four field-magnet poles are lettered respectively A, B, C, and D, and according to well known principles, will be of alternate polarities, A and C, for example, being north poles and B and D south poles. E represents the commutator which, as a matter of illustration, is shown as provided with 40 segments corresponding to 40 coils, the two sides of each coil lying respectively in slots in the armature 90° apart. There are four brushes, two positive and two negative, represented as bearing upon the commutator at 90°-intervals, while the commutator is shown as cross-connected in the manner exhibited in my former patent aforesaid—that is to say—every other segment is cross connected to a segment diametrically opposite. The winding is divided into four parallel paths, each containing 10 coils in series. There are also 20 slots in the armature. The four parallel circuits just mentioned are distinguished in the drawing by the number of darts marked thereon to indicate the route of the current from an incoming to an outgoing brush. Thus the first circuit is marked with single darts, the second circuit with two darts, the third circuit with three darts, and the fourth circuit with four darts. Each one of these four circuits passes in its course through all of the 20 slots of the armature entering in order the corresponding slots under the several poles in succession and moreover, in passing through these slots one after another, it alternates in position lying at the top of one slot and at the bottom of the next succeeding slot along its course, which is preferably 90° from the preceding slot. By "top" and "bottom" of a slot I mean positions in the upper and lower parts of the slot respectively and not necessarily the extreme top or extreme bottom. It also changes its

position with respect to the sides of the slots, which may be designated respectively as the front side and rear side with respect to the rotation of the armature which we may regard as being in a clockwise direction. In each slot also the current is of the same direction in all of the wires in that slot. Thus each circuit in its course from brush to brush, not only passes under all of the four poles, as in my former arrangement so as to embrace the entire flux, but in addition it traverses all of the armature slots in a systematic order so as to have what may be termed the same distribution of its several turns within the flux that is found in every other one of the several multiple circuits, and furthermore its aforesaid alternation and change of position in the slots with respect both to the top and bottom of the slots and to the back and rear sides of the slots affords a balance, that portion of its length which lies in the tops of the slots being balanced by a corresponding portion which lies in the bottoms and that portion which lies in the front sides of the slots being balanced by a corresponding portion which lies in the rear sides. By this means each of the multiple circuits not only embraces the entire flux but has the same local relation thereto as every other one of the multiple circuits.

In the drawing each circuit is numbered at the point where it passes through a slot, the numbers being arranged in order from 1 to 20, the numbers not only indicate the route of the circuit, but also indicate the potential attained at different points. Thus if one volt were generated in the circuit at each slot, the total electromotive force would be 20 volts and the difference of potential between any two points of the same circuit, or between points of two different circuits, will be indicated by the difference between the numbers at the respective points. Thus, between a point marked 2 on one circuit and a point marked 4 on the same or on another circuit there will be a potential difference of two volts. I prefer to wind the coils composing these circuits in pairs, there being between two wires in any one pair but a small difference of potential. For example, in the slot I, directly under the center of pole A, the two wires lying in the bottom of the slot (indicated by dotted lines) are numbered respectively 9 and 11, while the pair of wires lying in the top of the slot (indicated by the full lines) are also numbered respectively 9 and 11. This means that there is a potential difference of two numbers between the wires of each pair. This will be found to be true of the wires in each of the 20 slots, although in some of the slots there will be a greater difference of potential between the wires of the different pairs. Thus in the slot IV the two wires of the bottom pair are marked 2 and 4 and those of the upper pair 18 and 20. By following any one of the four circuits, its route from brush to brush may be readily traced. For example, we may trace the first circuit (distinguished by the single darts) from the brush *a*, whence it goes, first, to the slot XIX, thence to the slot IV, where it is marked 2, thence to the commutator segment 22, thence to the slot IX, where it is marked 3, thence to the slot XIV, where it is marked 4, thence to commutator segment 23, thence to the slot X, where it is marked 5, thence to the slot XV, where it is marked 6 and around to the opposite side of the commutator to segment 4. Thence it goes to slot XX, where it is marked 7, to the slot V, where it is marked 8, and so on through each one of the 20 slots until it terminates at commutator segment 31 under the opposite brush *d* (shown as cross connected to brush *b*). It thus appears that this single-dart circuit not only passes under each one of the four poles in its course from brush to brush, but also traverses all of the 20 slots. Now if we trace this same circuit again, it will also appear that its 20 excursions through the 20 slots are distributed systematically and in a corresponding relation to the four poles. Thus, if we assign five slots to each of the four poles A, B, C and D, the circuit will at the beginning traverse the first slot under pole A, then the first slot under pole B and so on, after which it will traverse in order the second slots under the four poles, then the third, fourth and fifth slots. This may be described by saying that each circuit traverses in order the corresponding generative positions under each pole of the field magnet. Again, these 20 excursions of the circuit through the 20 slots in series are half of them through the top portions of the slots and half of them through the bottom portions, and they are moreover equally divided between the front or forward sides of the slot and the back or rearward sides. Thus, referring again to Fig. 1, the aforesaid single-dart circuit starting from commutator segment 1 goes first to slot XIX which we may regard as the first slot under pole A, where, as shown by full lines, it lies in the top of this slot and, as shown by its relation to the wire 3 in the same slot, it lies to the rear or backward side of the slot (the said wire 3 lying on the forward or leading side of the slot) assuming that the armature is rotating in a clockwise direction. Bearing these indications in mind the entire route of this single-dart circuit from brush *a*, bearing on commutator segment 1, to brush *d*, bearing on commutator segment 31, may be shown by the following table which also shows the position of each turn in the armature flux (by the columns

entitled "Pole" and "Polar order"), and the position of each turn in the slot both vertically and laterally.

Turn No.	Pole.	Polar order.	Slot No.	Position in slot.	Commutator segment.
1	A	First	XIX	Top, rear	From 1
2	B	"	IV	Bottom, rear	To 22.
3	C	"	IX	Top, front	
4	D	"	XIV	Bottom, front	" 23.
5	C	Second	X	Top, rear	
6	D	"	XV	Bottom, rear	" 4.
7	A	"	XX	Top, front	
8	B	"	V	Bottom, front	" 5.
9	A	Third	I	Top, rear	
10	B	"	VI	Bottom, rear	" 26.
11	C	"	XI	Top, front	
12	D	"	XVI	Bottom, front	" 27.
13	C	Fourth	XII	Top, rear	
14	D	"	XVII	Bottom, rear	" 8.
15	A	"	II	Top, front	
16	B	"	VII	Bottom, front	" 9.
17	A	Fifth	III	Top, rear	
18	B	"	VIII	Bottom, rear	" 30.
19	C	"	XIII	Top, front	
20	D	"	XVIII	Bottom, front	" 31.

In the same manner, each one of the four parallel circuits will be found to pass through all of the 20 slots in going from one brush to the electrically opposite brush. The result of this is that all of the four parallel circuits are subjected to the same conditions, in that each one, taking its route as a whole, experiences the condition existing at each and all of the 20 slots. Not only is the total e. m. f. in each of the four circuits the same, but the electromotive forces in the four are equalized at each slot. In other words the distribution as well as the total of electromotive force is the same in each of the four circuits. It therefore becomes possible to run the armature at unequal distances from the four poles with the magnetic distribution thereby greatly distorted, or to even remove one of the four pole pieces entirely, when, outside of some diminution in the electromotive force of the machine, there will be no ill effects produced from the magnetic inequality, since that inequality affects each of the four circuits equally at whichever of the several slots it may occur.

It will be noted that in the illustration I have given, the number of slots is a multiple of the number of field magnet poles and that each coil spans an arc of exactly 90° This is my preferred arrangement, although some departure from such proportions is permissible.

By reference to Figs. 2, 3 and 4 the fundamental scheme upon which the structure composing the winding above described is based can be understood. In Fig. 2 there are indicated two coils A X and B D connected to the commutator E, and shown in the drawings in the order in which they are arranged in the slots. Of these two coils A X has its terminals connected respectively to the two commutator segments 1 and 22, the latter being the segment next beyond the one which is 180° from the former; whereas the coil B D has its terminals connected to the adjacent commutator segments 2 and 3. These two coils I bind together, so that the slot-wires A and B will rest in the top of a slot as indicated at Fig. 3, (showing 2-turn coils) while the slot-wires X and D, 90° from A and B, will rest in the bottom of their slot. The order of the wires in the slot is that shown in Fig. 2 which serves to give the final degree of absolute uniformity in the relation of the coils with respect to the magnetic flux. In Fig. 4 I have shown a duplication of the two coils illustrated in Fig. 2, the second set being placed diametrically opposite the first set and symmetrically connected to the commutator. An inspection of this figure will show that the coil A X on one side is in series with the coil B D on the opposite side; and that a pair of coils thus connected in series will embrace the entire magnetic flux of the machine, according to the principle laid down in my patent aforesaid, so that any greater density of the flux on one side, and a consequent greater electromotive force of the coil on that side, will be evened up by a less dense flux and a consequent lower electromotive force on the opposite side. When a series of these sets of coils are applied in the same manner around the entire armature it will be found that they compose a winding having the character set forth in the preceding explanation. I may add that there will also be the same direction of current in all the wires contained in any one slot, and in all of the slots pertaining to any one pole. The reversal in passing from one pole to another will be simultaneous in all of the wires in a slot, which is not the case in my former arrangement, nor in ordinary windings heretofore employed. There is also the minimum difference of potential between wires that are wound together and included in the same slot.

What I claim as new and desire to secure by Letters Patent is:

1. An armature-winding for dynamo electric machines of the multipolar type, having a plurality of circuits in multiple, equal in number to the number of field magnet poles, each of the multiple circuits containing coils in series embracing two or more branches of the magnetic flux, and each circuit traversing all of the generative positions on the face of the armature, and each generative position including a wire from each circuit.

2. An armature-winding for dynamo electric machines of the multipolar type, having a plurality of circuits in multiple equal in number to the number of field-magnet poles and each circuit embracing two or more branches of the magnetic flux and traversing each generative position on the face of the armature an equal number of times.

3. An armature-winding for dynamo elec-

tric machines of the multipolar type, having more than two circuits in multiple, each circuit comprising coils in series embracing two or more branches of the magnetic flux, and each circuit traversing each generative position on the armature an equal number of times in the same relation to the flux as every other one of the said circuits.

4. In an armature for dynamo electric machines of the multipolar type, a slotted core, more than two circuits in multiple, each embracing two or more branches of the magnetic flux and traversing all of the armature-slots the same number of times, and bearing the same relation to the flux as every other circuit and passing alternately through the top and bottom portions respectively of the slots traversed successively by it in its course.

5. In an armature for dynamo electric machines of the multipolar type, a slotted core, a plurality of circuits in multiple the number of which is equal to the number of field magnet poles, said circuits embracing two or more branches of the magnetic flux and composed of coils arranged in the armature-slots in pairs, the wires of a pair lying alternately in the top and bottom of the slots and a coil of one pair being connected in series with the coil of a diametrically opposite pair.

6. In an armature for dynamo electric machines of the multipolar type, a slotted core, a plurality of multiple circuits the number of which is an integral multiple of the number of field magnet poles, each circuit embracing the several branches of the magnetic flux and traversing each one of an even number of armature slots the same number of times in passing from the positive to the negative terminal of the circuit.

7. In an armature for dynamo electric machines of the multipolar type, a slotted core, a plurality of circuits in multiple, the number of which is a multiple of the number of field magnet poles, each circuit embracing the several branches of the magnetic flux and traversing each one of an even number of armature slots the same number of times in passing from the positive to the negative terminal of the circuit, and having as a whole the same relation to the magnetic flux as each of the other ones of the said circuits.

8. In an armature for dynamo electric machines of the multipolar type, a slotted core, more than two multiple circuits each embracing two or more branches of the magnetic flux and traversing all of the slots or generative positions on the face of the armature and each circuit comprising coils in series of which each two series-coils terminate in commutator segments on opposite sides of the commutator.

9. In an armature for dynamo electric machines of the multipolar type, a slotted core, more than two circuits in multiple embracing two or more branches of the magnetic flux and arranged in armature-slots, each slot containing the same number, one or more, of wires from each of the several multiple circuits.

10. In an armature for dynamo electric machines of the multipolar type, a slotted core, more than two circuits in multiple embracing two or more branches of the magnetic flux and arranged in an even number of armature-slots each of which contains one or more wires from each of the several multiple circuits.

11. In an armature for dynamo electric machines of the multipolar type, a slotted core, more than two circuits in multiple embracing two or more branches of the magnetic flux and arranged in an even number of armature-slots each of which contains one or more wires from each of the several multiple circuits, the wires being arranged in the same order in each slot.

12. An armature-winding for a multipolar dynamo electric machine, having more than two circuits in multiple, each circuit embracing two or more branches of the magnetic flux and the conductor composing each circuit traversing in order the corresponding generative positions under each pole of the field magnet.

13. In an armature for a multipolar dynamo electric machine, a slotted core, more than two circuits in multiple, each circuit embracing two or more branches of the magnetic flux and traversing in order the corresponding generative positions under each pole of the field magnet, and also occupying balanced or compensating positions in the several slots through which it passes.

14. An armature winding for a multipolar dynamo electric machine, having a plurality of circuits in multiple equal in number to the number of field magnet poles, and each circuit embracing two or more branches of the magnetic flux and the conductor composing each circuit traversing in order the corresponding generative positions under each pole of the field magnet.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses, the 18th day of October, 1905.

JAMES F. McELROY.

Witnesses:

BEULAH CARLE.

ERNEST D. JANSEN.