No. 753,422. PATENTED MAR. 1, 1904.

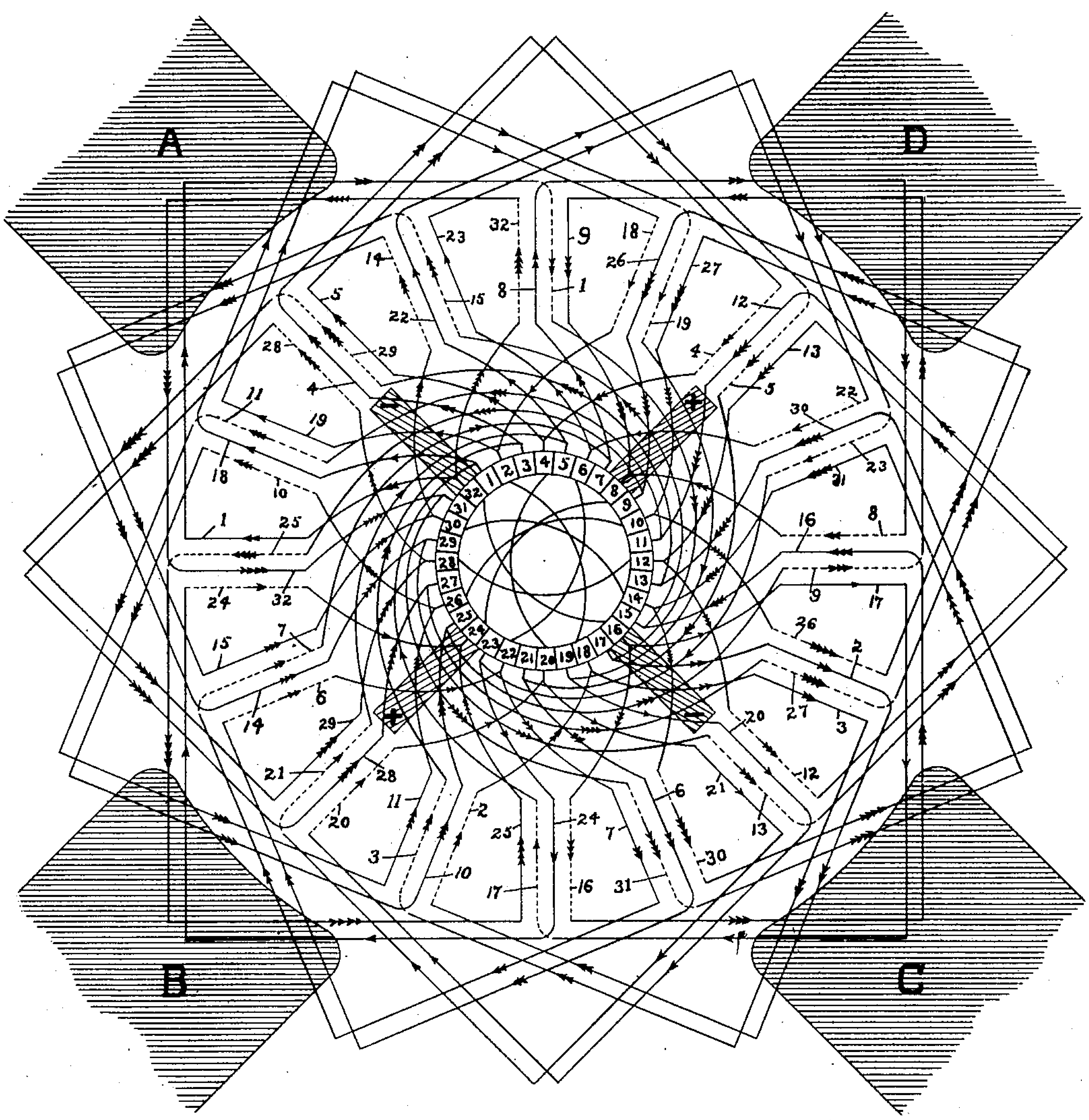
J. F. McELROY.

ARMATURE WINDING.

APPLICATION FILED NOV. 11, 1902.

NO MODEL. 3 SHEETS—SHEET 1.

Fig. 1.



Witnesses

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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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3 SHEETS—SHEET 2.

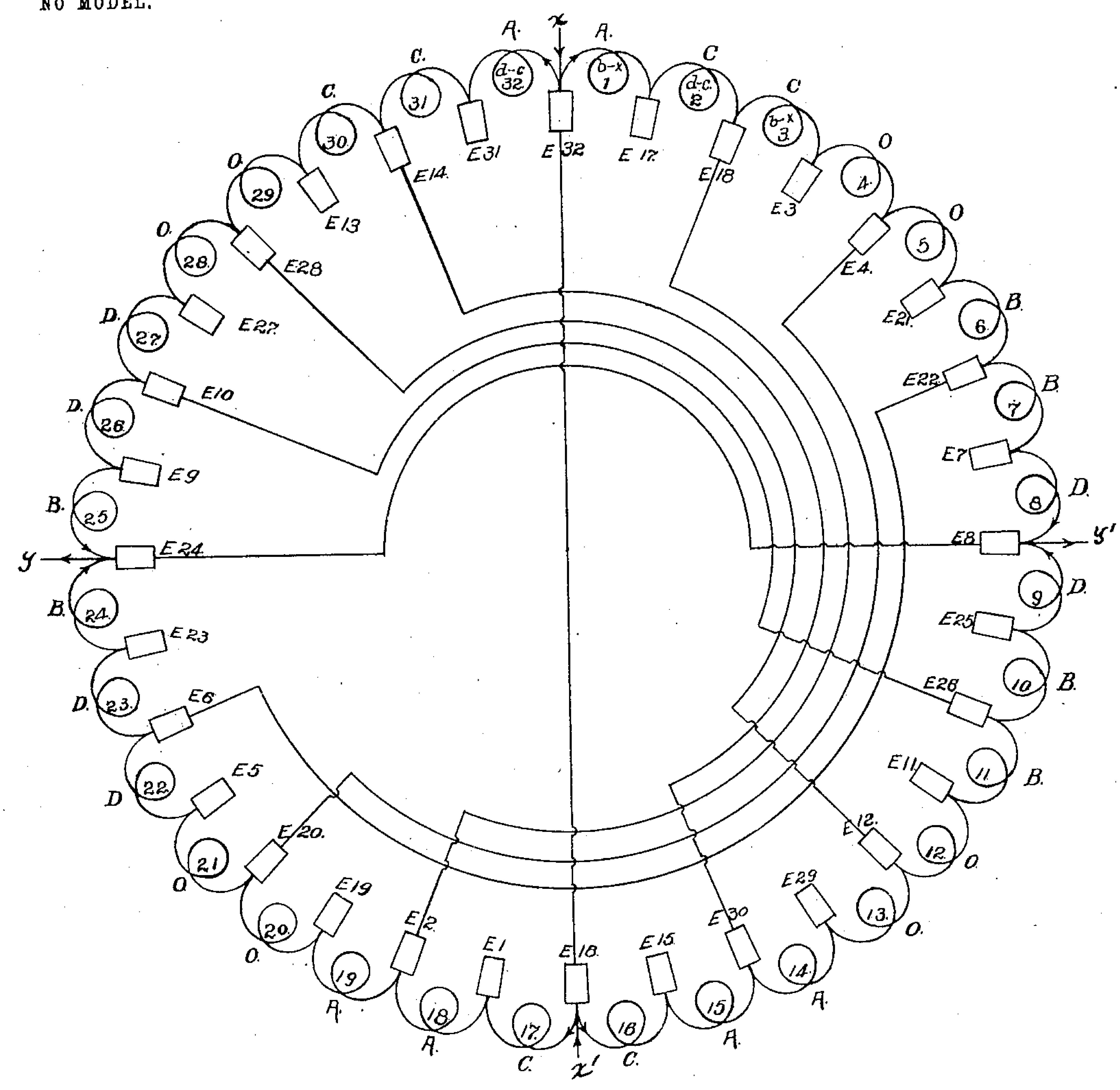

Fig. 3.

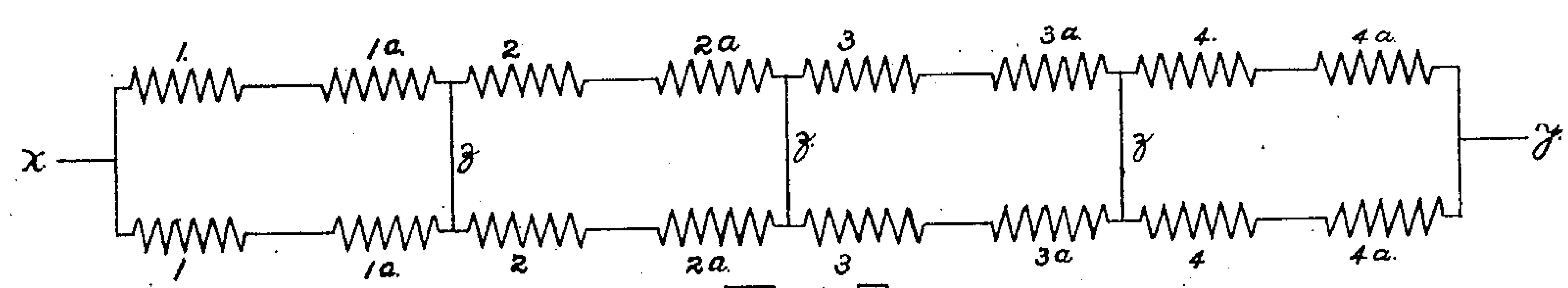

Fig. 2.

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NO MODEL. 3 SHEETS—SHEET 3.

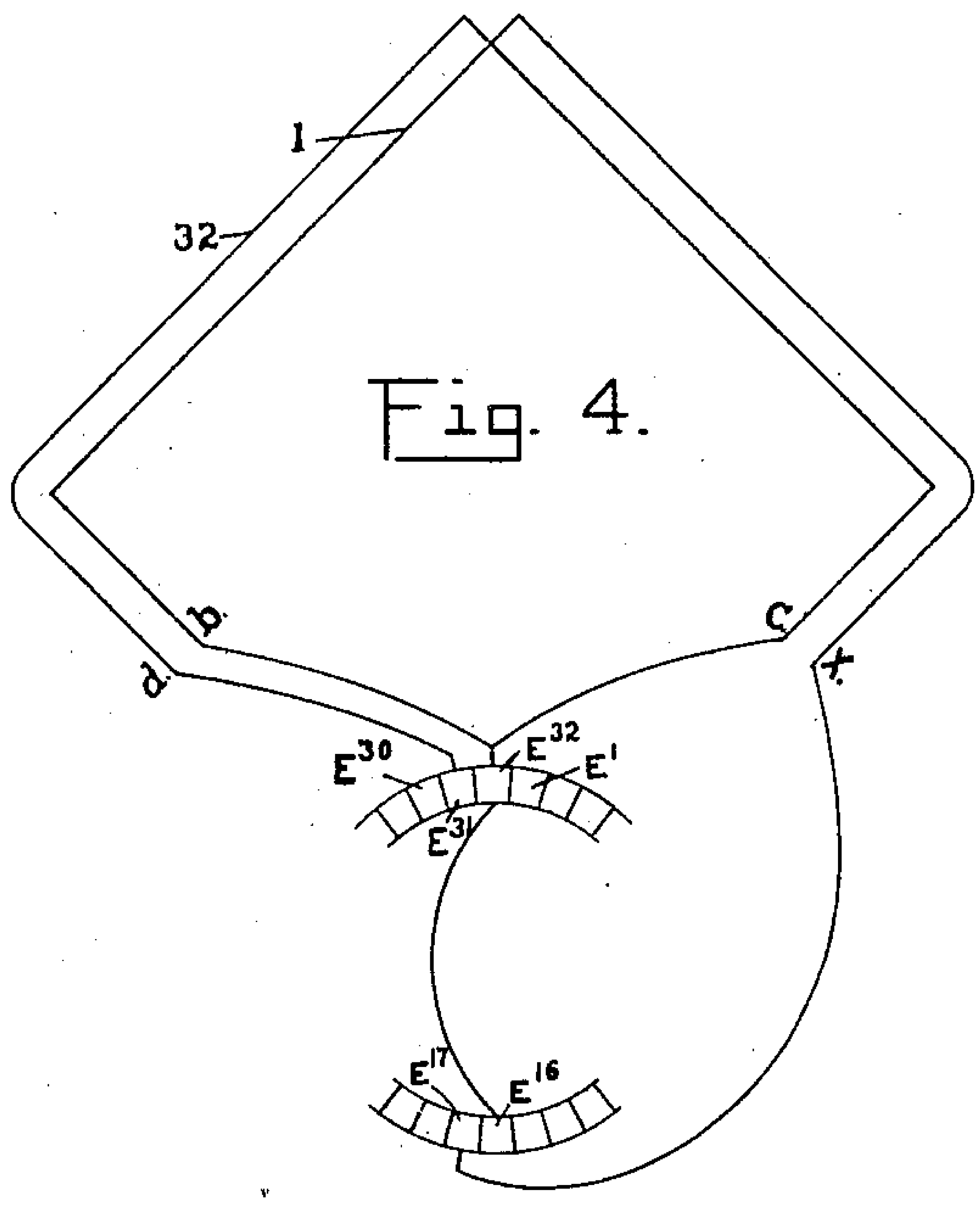
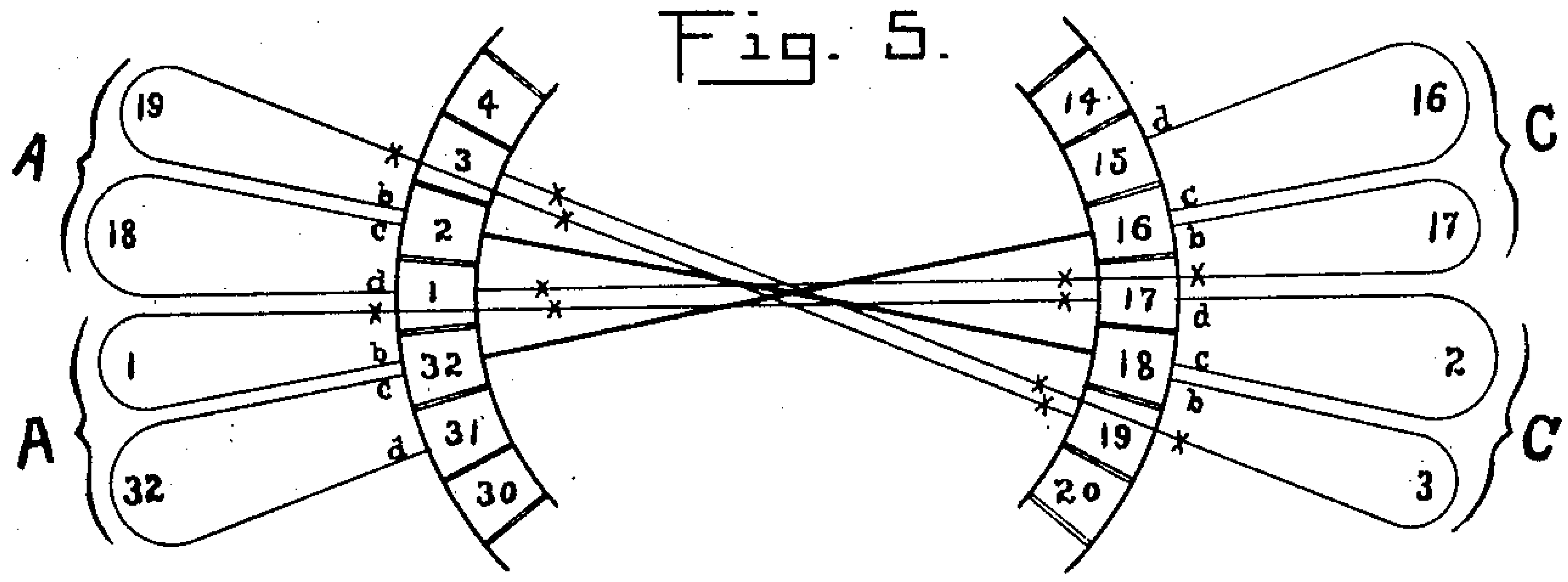


Fig. 4.

Fig. 5.



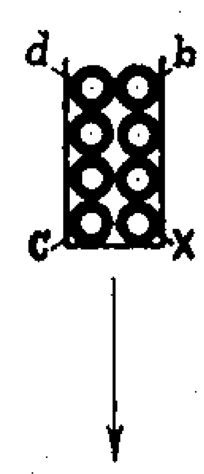


Fig. 6.

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No. 753,422. Patented March 1, 1904.

UNITED STATES PATENT OFFICE.

JAMES F. McELROY, OF ALBANY, NEW YORK, ASSIGNOR TO CONSOLIDATED CAR HEATING COMPANY, OF ALBANY, NEW YORK, A CORPORATION OF WEST VIRGINIA.

ARMATURE-WINDING.

SPECIFICATION forming part of Letters Patent No. 753,422, dated March 1, 1904.

Application filed November 11, 1902. Serial No. 130,836. (No model.)

To all whom it may concern:

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

In the drawings, Figure 1 shows a general diagram of my armature-winding, and Figs. 2 to 6 show diagrams illustrating the principle and the details thereof.

My invention comprises an armature-winding for multipolar dynamos and motors which is perfectly symmetrical and balanced and so cross-connected at intervals that the electromotive forces in corresponding parts of the winding are equal and uniform, the result being that the sparking at the commutator is materially reduced, the machine is loaded uniformly in all parts of the winding, and is not affected by any variation from exact concentricity of the armature with respect to the field-magnet poles. Moreover, the arrangement of the coils with respect to the field-magnets is such that one of the field-magnet coils can be short-circuited or the field pole-piece be removed altogether without injury to the armature, since in such event there are in my invention no coils left without electromotive force and in condition to short-circuit the remaining active coils.

More particularly, I provide an arrangement wherein the winding is cross-connected at succeeding points along its route from brush to brush and the said cross-connected points separated by generating-coils so disposed as to traverse in series the portions of both minimum and maximum density of the field-magnet flux. By this means the parallel or multiple portions of the winding are brought to the same potential at the cross-connected points, and between those points the multiple branches are caused to generate substantially identical electromotive forces. In practice I have employed this arrangement with a machine having in its armature an even number of coils, which is also an even multiple of the number of field-magnet poles, and having between the succeeding cross-connecting points aforesaid two or more coils in series placed, respectively, on different parts of the armature, so as to include in the series electromotive forces which may differ in value individually by reason of differences in the density of the magnetic flux which they respectively traverse, whether such difference is due to eccentricity of the armature with respect to the field-magnet or to any other cause. I also preferably place the said cross connections in the commutator, and in each armature-slot I place two coils, one connected between two commutator-bars adjacent to the said coil and the other connected between one of said adjacent bars and a bar on the opposite side of the commutator. It should also be mentioned that the aforesaid disposal with respect to the magnetic flux of the series coils is best secured by making up each set of coils (that is to be in multiple with other sets) of component coils equal in number in every phase of motion and similarly placed with respect to the fields of force, while in addition the active sides of coils that are in series in any section of the set shall be placed in similar positions with respect to the several fields, and, furthermore, that the said coils in series shall in a four-pole machine, for example, cut the entire flux as a whole in a quarter of a rotation or relatively in a corresponding part of a rotation in machines having a greater number of poles.

Referring to Fig. 2 of the drawings, let it be supposed that between the terminals x and y, which may represent the brushes of a machine, there are a number of generating-coils arranged in multiple series, each coil generating, say, ten volts and the eight coils in series eighty volts. If the parallel sets of coils are cross-connected by the wires z z z at points between succeeding pairs of coils, then at those points the potential will be equalized in the two series. Moreover, if the two coils 1 and 1^a, for example, are wound, respectively, on opposite sides of the armature, upon which sides the density of the magnetic flux may differ, then, since the coils are in series, any inequality in the electromotive forces of the two respective coils will be rendered innocuous. The total electromotive force of the two will remain constant, and since the opposite coils 1 and 1^a are of the same length and similarly disposed the two sets will be perfectly balanced, and little or no equalizing-current will flow over the cross-connecting wire *z*. The same is true of the succeeding pairs or sets of pairs of the series. This illustrates the fundamental principle of my invention, and it will be understood that this arrangement may be embodied in various ways, the number of coils in series between adjacent cross-connecting points and the number of parallel series being as numerous as may be desired and arranged in any manner suitable for eliminating the effect of variations in electromotive force of the individual coils due to differences of flux density around the armature or other causes. Moreover, the frequency of the cross connections may be whatever the constructor desires, there being between them a sufficient number of coils in series to bring them to substantially the same potential, which is, however, insured and maintained by the cross connections themselves. To embody this arrangement in a practical form, I have desired the construction shown in full in Fig. 1 and illustrated in principle in Fig. 3. In this case there are four field-magnet poles and thirty-two armature-coils, with thirty-two commutator-bars. In practice the number will ordinarily be much greater. Every other commutator-bar is connected directly to the bar diametrically opposite to it, there thus being eight cross connections which have the function already described. I show four brushes applied to the commutator ninety degrees apart, although, if desired, two of these brushes may be omitted and two brushes only ninety degrees from each other be utilized. In that case the aforesaid cross connections will also serve the purpose of the ordinary commutator cross connections, which permit the use of two brushes on a four-pole machine. In either case there will be in the winding four parallel branches from the negative to the positive brush, (or brushes,) each branch containing eight coils in series cross-connected, as described, at eight intervals between points of like potential.

Referring to Fig. 3, there will be found therein a diagram of the connections of the thirty-two coils and the commutator, although it should be understood that in this figure the relation of the several coils to the several field-magnet poles is only indicated by letter, those lying at a given time under the first pole being designated by A, those under the second pole by B, those under the third pole by C, and those under the fourth pole by D. The two brushes for the incoming current are denoted by the arrows *x* and *x′* at the top and bottom, respectively, and the two brushes for the outgoing current by the arrows *y* and *y′* at the right and left side, respectively. The several coils numbering from one to thirty-two are arranged in a circle, and between the several coils are connected, as usual, the respective commutator-bars E' E^2 E^3 to E^{32}, the even-numbered bars being cross-connected to the bars diametrically opposite, while the odd-numbered bars are not cross-connected at all. It should be noted that in this figure the bars are shown following the numerically-arranged coils without regard to the position they would occupy when arranged in their normal and practical order. Taking note now of the field-magnet poles, as indicated by the letters A, B, C, and D, it will be observed that between each two even-numbered commutator-bars there are two coils in series, one lying under or in a given relation to one pole and the other under or in a somewhat similar relation to the corresponding pole one hundred and eighty degrees distant. Thus between bars E^{32} E^{16} and E^2 E^{18} are on one side the coils 1 and 2, the former under pole A and the latter under the opposite but homonymous pole C, while diametrically opposite coils 1 and 2 are the coils 18 and 17, also under poles A and C, respectively, and likewise connected in series between bars E^2 and E^{16}, cross-connected to E^{18} and E^{32}, respectively. There is a similar relation between coils 31 and 32 and their opposites 15 and 16. Thus if by reason of wear in the journals the armature runs closer to pole A than to pole C, making a maximum flux at the former and a minimum flux at the latter pole, yet the two coils under the respective poles are in series, and the total electromotive force of the two remains the same or at least the same as that of the diametrically opposite two with which they are balanced, the deficiency of electromotive force in one being supplemented by the excess in the other. They therefore conform to the principle illustrated in Fig. 2. In like manner the coils in each quarter of the winding are balanced in pairs with those in the diametrically opposite quarter, and in general starting from one brush there is the same arrangement that will be found in starting from the diametrically opposite brush. Of course the foregoing reference to a coil as lying under a particular pole is only a means of indicating the direction of current flow therein. The coil may, in fact, have as many turns as desired, each turn coming under a different pole of the same name; but the total effect therein may be represented by one turn under one pole, as above. In order to bring about the described relation of the coils to the poles, I prefer to employ the following expedient: The coils are placed in pairs, each pair preferably spanning ninety degrees of the armature-circumference. Thus in Fig. 4 coils *d c* and *b x* are indicated as spanning ninety degrees and placed in the same pair of slots in the manner shown in Fig.

6. One of these two coils—to wit, *d c*—has its terminals connected to two adjacent commutator-bars E^{31} and E^{32}, lying just opposite the center of the pair of coils, while the second one—to wit, *b x*—has its terminals connected between the last of the said two adjacent bars—*i. e.*, bar E^{32} and a bar next beyond the one one hundred and eighty degrees from the said last bar. To repeat, the coil *d c* (corresponding to, say, coil 32 of Figs. 1 and 3) is connected between bar E^{31} and E^{32}, while coil *b x* is connected between bar E^{32} and bar E^{17}, which is next beyond bar E^{16}, which in turn is one hundred and eighty degrees from bar E^{32} and cross-connected thereto. If this simple rule of arrangement is carried out all around the armature, the conditions above described will be produced. In Fig. 5 the continuation of the connections of Fig. 4 is shown, the arrangement, starting clockwise from bar 31, being identical with that starting clockwise from bar 15. Thus coils 1 and 32 are under pole A and the latter—*i. e.*, coil 32—connected between bars 31 and 32. From bar 32, a point of cross connection, one branch containing two coils in series goes through coil 1, (under pole A,) thence across to bar 17 to coil 2 (under pole C) to bar 18, while the other branch, also containing two coils in series, goes from the bar 16 (cross-connected to bar 32) through coil 17, (under pole C,) thence across to bar 1, thence through coil 18 (under pole A) to bar 2, (cross-connected to bar 18.) This, it is manifest, follows out the arrangement diagrammed in Fig. 3 and contains the feature of coils in series, but under different poles, connected by the cross connections in the commutator in parallel with other coils in series under corresponding poles.

In Fig. 1 the complete winding is shown and corresponds to what has already been described. The parts are numbered correspondingly with the above description, and the circuits may readily be traced. It is not necessary to follow them out, as it would but duplicate the description already given.

It may be observed that the coils in series may have different electromotive forces, because of a difference in the density of the flux, due to eccentricity of the armature or due to a difference in the relation of the respective coils to like fluxes or to unequal number of ampere-turns in the field-coils; but whatever the occasion of a difference between the electromotive force in a coil at one part of the armature from that at another part it may be practically canceled out by distributing two or more coils in series around the armature at the respective points of difference in the manner clearly set forth.

Taking the winding of Fig. 1 as a whole there are four parallel branch circuits from the two negative brushes through the winding to the two positive brushes, each branch containing eight coils in series and divided by the cross connections into four sections of two coils each. Fig. 2 may be taken as representing two of such branch circuits, the other two branch circuits being a duplicate of the two shown, but only connected thereto at the brushes *x* and *y*. In Fig. 1 these four branch circuits are distinguished by differently-formed arrows, one circuit bearing single-headed arrows, another three-headed arrows, and the last four-headed arrows. Each of these four branch circuits will contain at all times a like number of coils. Whatever may be the phase of movement the coils in each branch are always equal in number to those in the other branches. Moreover, at every phase of movement the coils in one branch bear the same relation to the respective field-magnet poles as do the coils in the other branches. Again, in each two-coil section of each branch the four active sides of the two coils (each coil necessarily having two active sides) are in practice placed in similar positions with respect to the four poles. For example, coils 3 and 4 are in series with each other in the branch distinguished by the two-headed arrows. One side of coil 3 lies near the right-hand corner of pole C and its other side similarly near the corner of pole B, while the coil 4 would in practice have its two sides in corresponding relation to poles A and B, although with only the few coils that can be shown in the figure they come nearer the center than the corner of the respective poles. Finally, they are so arranged that each pair of coils in a section will in a quarter of a rotation cut the entire flux—that is to say, one of the pair will first include and then exclude the lines of force proceeding from one pole—say a north pole—while the other one of the pair will simultaneously include and then exclude the remaining lines of force proceeding from the opposite north pole. To this end the pole-pieces will embrace an arc of the armature circumference comprising a suitable number of degrees. This being carried out in all four branches, the electromotive forces in the branches will be identical. Each will contain the same number of active and the same number of inactive coil sides and the pairing of the coils in series will neutralize any inequality of distribution of the magnetic flux. In practice when the coils are numerous—say eighty instead of thirty-two—one of the four field-magnet pole-pieces can be removed entirely, giving the maximum distortion of the flux, which now enters at one north pole and is divided to two south poles, and no ill effect will follow beyond a small drop in the total electromotive force of the winding.

I am unaware of any previous windings in which in a multipolar machine the effects of unequal distribution of the flux between the different sets of poles is thus neutralized by coils in series embracing between them the entire magnetic flux, so that inequalities therein may be evened up and their effects canceled.

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

1. An armature-winding containing sets of coils in parallel cross-connected at intervals, there being in each set two or more coils in series between succeeding cross-connecting points.

2. An armature-winding containing sets of coils in parallel cross-connected at intervals, there being, in each set, two or more coils in series between succeeding cross-connecting points and the said two or more coils being placed respectively in different positions around the armature.

3. An armature-winding containing between succeeding cross-connecting points two coils in series placed respectively at points on the armature giving different electromotive forces at the same time, and connected in parallel with two coils correspondingly situated on the armature, the sets of coils aforesaid being in series with another set similarly arranged.

4. An armature-winding containing sets of coils in parallel cross-connected at intervals, there being in each set two coils in series between succeeding cross-connecting points, and the said two coils being placed respectively at magnetically-opposite points around the armature.

5. An armature-winding containing sets of coils in parallel cross-connected at intervals through the commutator, there being in each set two or more coils in series between succeeding cross-connecting points.

6. The combination with a commutator having cross-connected bars placed between bars not cross-connected, of an armature-winding having coils connected in series between two sets of cross-connected bars.

7. The combination with a commutator having alternate bars cross-connected, of an armature-winding having two coils in series connected between two sets of cross-connected bars and a connection from a point between the two series coils to a bar not cross-connected.

8. The combination with a commutator having cross-connected bars placed between bars not cross-connected of an armature-winding having two sets of coils, each set containing two coils in series, connected in multiple between two cross-connected bars.

9. The combination with a commutator having cross-connected bars placed between bars not cross-connected, of an armature-winding having two sets of coils, each set containing two coils in series, connected in multiple between two cross-connected bars and the two series coils composing each set placed respectively in different positions around the armature.

10. The combination with a commutator having cross-connected bars placed between bars not cross-connected, of an armature-winding having two sets of coils, each set containing two coils in series, connected in multiple between two cross-connected bars, the two series coils comprising each set being subject to different electromotive forces and connected at an intermediate point between them to a commutator-bar not cross-connected.

11. The combination with a cross-connected commutator-bar placed between bars not cross-connected, of two armature-coils similarly placed on the armature, both coils having their inner terminals connected to the said cross-connected bar and their outer terminals connected respectively to bars not cross-connected.

12. The combination with a cross-connected commutator-bar of two armature-coils similarly placed on the armature and both having their inner terminals connected to the cross-connected bar aforesaid and their outer terminals connected, one to a bar adjacent to the said cross-connected bar and the other to a bar on the opposite side of the commutator.

13. An armature-winding having its coils arranged in pairs around the armature, the two coils of each pair spanning substantially the same arc, and a commutator having cross-connected bars each connected to the winding at a point between the two coils of one of said pairs, and bars not cross-connected, each connected to one of the outer terminals of one of said pairs.

14. An armature-winding having its coils arranged in pairs, one coil of each pair connected between two adjacent commutator-bars and the other connected between one of said adjacent bars and a bar on the opposite side of the commutator.

15. In a multipolar dynamo an armature-winding having an even number of coils which is a multiple of the number of field-magnet poles combined with a commutator having cross-connected bars equal in number to a multiple of the field-magnet poles and bars not cross-connected sufficient to make the total number of bars equal to the number of armature-coils.

16. In a multipolar armature-winding the combination with four or more sets of series coils arranged in multiple between opposite brushes of cross connections between each two or more successive coils of each two sets.

17. In a multipolar armature-winding, the combination with four or more sets of series coils arranged in multiple between the opposite brushes and the several sets containing at all times an equal number of coils, of cross connections between each two or more successive coils of each two sets.

18. In a multipolar armature-winding the combination with four or more sets of coils connected in multiple between opposite

brushes and the coils of each set being in series with one another, of cross connections in each set at intervals between the coils comprising a set, the coils in one set bearing the same respective relation to the field-magnet poles as the coils of every other set.

19. In a multipolar armature-winding the combination with sets of coils in multiple, the coils of each set being in series with one another, of cross connections between the sets placed at intervals including two or more of the coils in series, the coils in series between cross-connected points being arranged to traverse the entire magnetic flux each time that they pass a set of field-magnet poles of the same name.

20. In a multipolar armature-winding the combination with sets of coils connected in multiple between opposite commutator-brushes, the coils of each set being in series, of cross connections placed at intervals including as many coils in series as there are field-magnet poles of the same name and the coils thus in series between cross-connecting points bearing respectively the same approximate relation to the respective poles of the same name.

21. In a multipolar armature-winding, the combination with sets of coils connected in multiple between opposite commutator-brushes, the coils in each set being in series with one another and the same in number in each set, of cross connections between such sets placed at intervals which intervals embrace as many coils in series as there are north poles in the field-magnet structure and the several coils thus in series between cross-connecting points bearing approximately the same definite relation to the said north poles respectively, whereby the said coils in series between cross-connecting points may traverse as a whole the entire magnetic flux proceeding from said north poles and again traverse as a whole the entire magnetic flux when passing next by the corresponding south poles.

In witness whereof I have hereunto set my hand, this 8th day of November, 1902, before two subscribing witnesses.

JAMES F. McELROY.

Witnesses:

Ernest D. Jansen,

William A. Morrill, Jr.