R. V. MORSE.

DYNAMO ELECTRIC MACHINE.

APPLICATION FILED MAR. 18, 1912.

1,271,061.

Patented July 2, 1918.

2 SHEETS—SHEET 1.

Fig. 1.

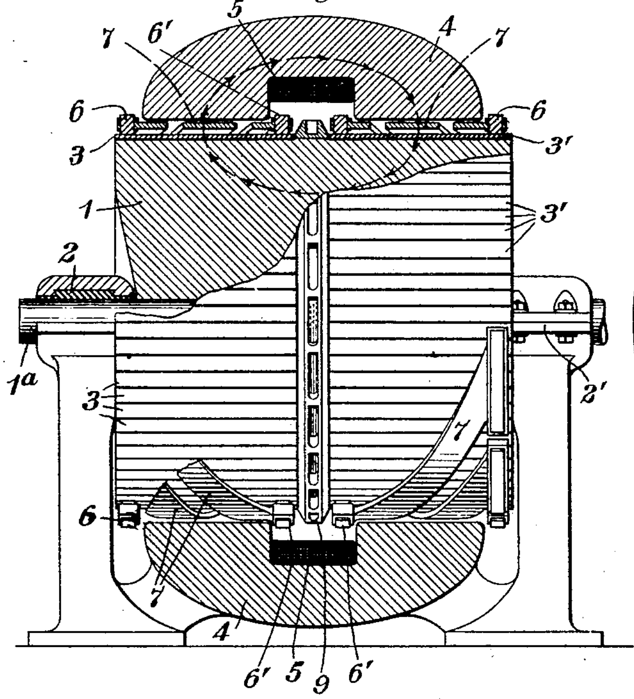


Fig. 2.

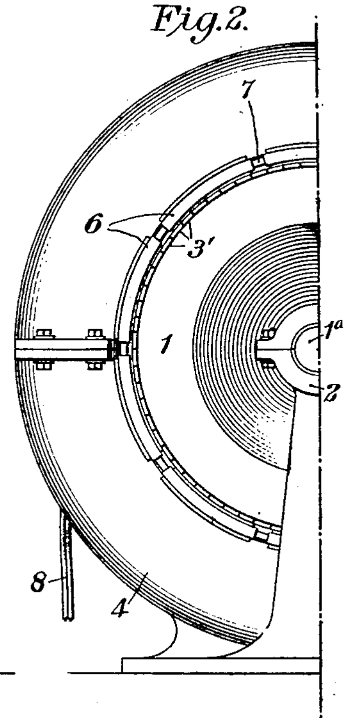
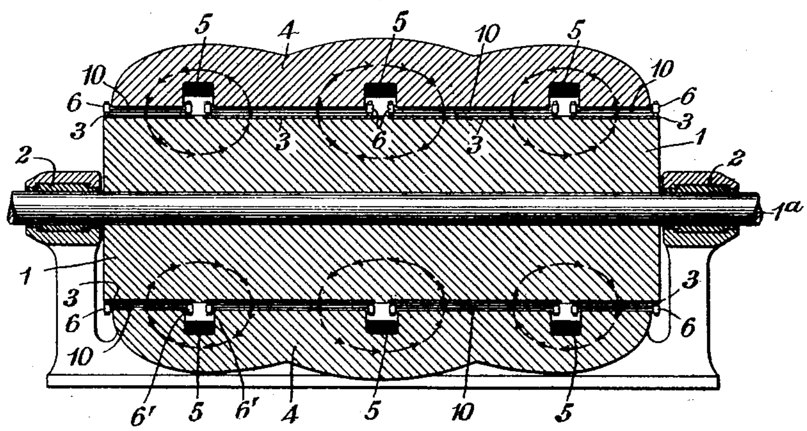


Fig. 3.



Witnesses:

C. L. Belcher

J. Snowden Bell.

Inventor

Robert V. Morse

by Edward A. Wright Atty.

R. V. MORSE.

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2 SHEETS—SHEET 2.

Fig. 5.

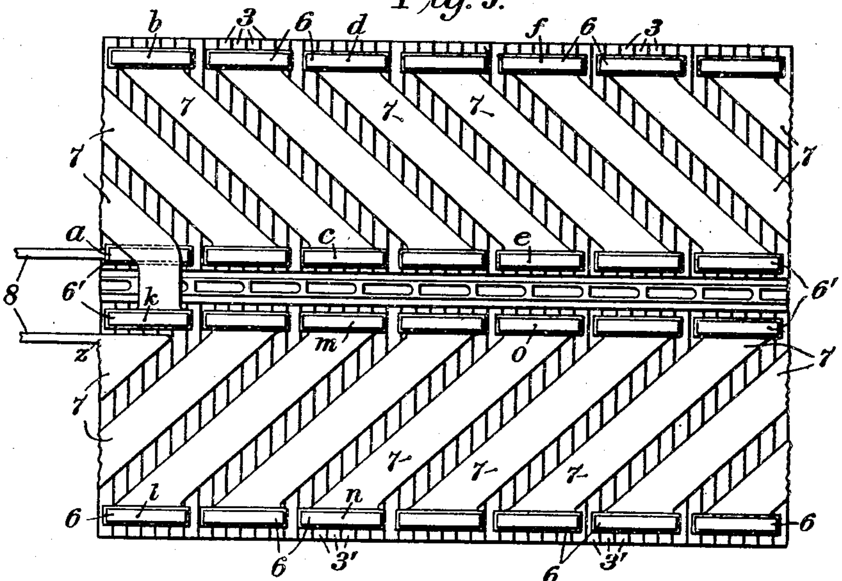


Fig. 6.

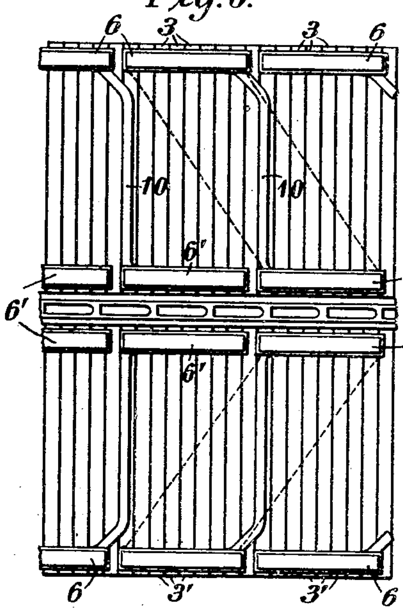


Fig. 4.

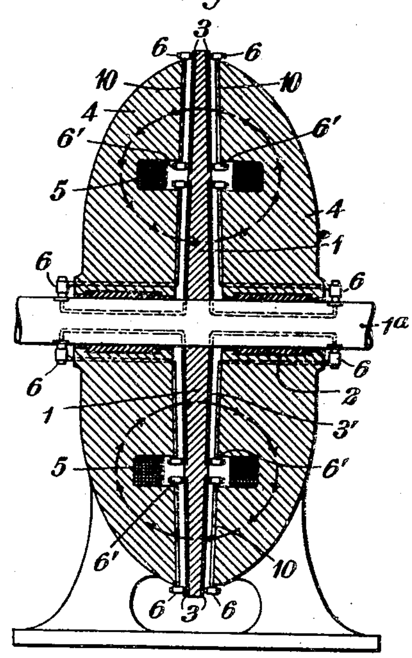
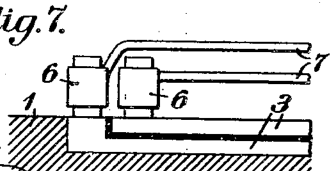


Fig. 7.



Witnesses:

C. L. Belcher

[signature]

Inventor

Robert V. Morse

by Edward A. Wright Atty

UNITED STATES PATENT OFFICE.

ROBERT V. MORSE, OF ITHACA, NEW YORK.

DYNAMO-ELECTRIC MACHINE.

1,271,061. Specification of Letters Patent. Patented July 2, 1918.

Application filed March 18, 1912. Serial No. 684,433.

To all whom it may concern:

Be it known that I, ROBERT V. MORSE, a citizen of the United States, residing at Ithaca, in the county of Tompkins and State of New York, have invented new and useful Improvements in Dynamo-Electric Machines, of which the following is a specification.

This invention relates to dynamo-electric machines of the type having a continuous current flow,—that is, not depending for its action on any periodic reversal of current in either the field or armature circuit.

The objects of my invention are to simplify the construction and to increase the utility of such machines so that they may be adapted for general use; to increase the length of the series armature circuit while reducing the length of the magnetic circuit; to extend the polar arc and area to a maximum so as to reduce the size of the machine to a minimum; to increase the voltage and range of speeds of the machine while retaining its minimum size and compact form; to dispense with laminations, improve the regulation, and various other objects as will appear.

In general, I attain these objects by using a plurality of homopolar fields having magnetic circuits in common, in combination with an armature having numerous narrow conductors which contact successively in changing groups with bands of series connected brushes. This gives a non-commutating dynamo-electric machine capable of running at any desired speed with any ordinary voltage, and having a polar arc of substantially the maximum possible,—360°,—extending the full lineal dimension of the machine, thus reducing the size of the machine to a minimum.

To improve the regulation by strengthening the field while partly neutralizing the armature reaction, the return conductors may be run helically so that the current will have a component in the same general direction as the current in the field coils.

Another feature of my invention relates to the manner of arranging narrow stationary conductors parallel to the armature conductors at certain places on the pole face, by means of which the field is so weakened as to minimize the sparking at the brush tips. This feature may be used either independently of or in combination with the feature of the helically wound conductors above mentioned. Though these features relating to the stationary return conductors are desirable, they are by no means essential to the principal invention first mentioned as the ordinary arrangements of exterior conductors may be used.

In the accompanying drawings: Figure 1 is a view, partly in section and partly in elevation, with certain parts broken away, of a dynamo-electric machine embodying my invention; Fig. 2, a half end elevation of the same; Fig. 3, a longitudinal section showing a modification in which a plurality of fields are combined; Fig. 4, a section of my improved type of field adapted for use with radial or disk armatures; Fig. 5, a development of the armature conductors, stationary conductors, and brushes, showing one method of connecting the armature conductors in series; Fig. 6, a development, showing another method of connecting the conductors, by which sparking at the brush tips is minimized; and Fig. 7, a detail view showing brushes for double conductors.

As shown in Figs. 1 and 2, the armature, 1, preferably formed of unlaminated magnetic material, is mounted on shaft 1^a, journaled in the bearings, 2 and 2′, and carries on its periphery two sets or zones of numerous insulated conducting bars, 3, 3′. The field structure, 4, which surrounds the armature and is of substantially the same length, is provided with an annular recess in which is seated the field coil, 5, thus forming two annular pole faces. Upon the opposite ends of each set of armature conductors, 3, 3′, are mounted the brushes, 6, 6′, closely spaced circumferentially around the armature, and the brushes are connected by the helical stationary conductors, 7, on the pole faces. The conductors and brushes may be connected up with the lead wires, 8, as shown in Fig. 5. If desired, a ventilating fan, 9, may be mounted on the armature for circulating air over the armature.

The coil, 5, encircles the armature, as does the field structure, 4, in which it is embedded. The field coil when suitably connected, will produce a magnetic flux passing within the coil in one direction and outside the coil in the opposite direction, as is represented by the circuit of arrows in Figs. 1, 3, and 4. This flux enters the field structure on one side of the field coil and leaves it on the other. Since the field structure extends completely around the machine, this flux gives two annular fields of opposite polarity. Each field is of uniform polarity throughout, so that an armature conductor may rotate in a field of constant polarity, permitting a unidirectional current, such a field being called "homopolar." The homopolar fields which have heretofore been used are of such construction that the magnetic flux is cut, by the armature conductors, when it is going in only one direction, and each magnetic circuit gives an effective field of but one polarity. Since it is desirable that the flux have an iron circuit, the field structures have therefore extended approximately twice the distance of the armature conductors; or in other words, the armature conductors have been limited to about half the length of the field structure.

Now referring to Fig. 1, it will be seen that the armature conductors, 3 and 3′, extend practically the full length of the machine. A single magnetic circuit then gives two effective homopolar fields, though of opposite polarity. In other words, the same flux is cut twice, while going in approximately opposite directions. This doubles the effective field area without proportionate increase in the size of the machine. Since a single magnetic circuit gives two effective unidirectional fields of opposite polarity, this may be called a "bihomopolar" field to distinguish it from the former types.

The distinguishing feature of the armature is that the armature currents, though unidirectional in each armature conductor, flow in generally opposite directions in adjoining zones, while the armature conductors in each zone are successively connected in series in such a manner as to retain the full length effective field. In Fig. 1, for example, since the annular fields are of opposite polarity, it is evident that the direction of current flow in conductor, 3, is opposite to that in 3′,—say from the two ends of the armature toward the middle. I therefore, (see Fig. 1), place brushes, 6, 6, at the extremities of the armature, and also brushes, 6′, 6′, at the middle of the armature near the field coil. These brushes are connected in series or parallel as desired, and are described more in detail later.

The bihomopolar type of field may be used with almost any shape of armature, as the drum armature or cylindrical armature in Fig. 1, or the disk armature in Fig. 4.

In the case of the disk armature shown in Fig. 4, the conductor bars may be mounted radially upon the disk and the coil, 5, be embedded in an annular recess in the face of the field transverse to the shaft, and one end of the armature conductors may be connected to collector rings and brushes situated at a considerable distance from the armature, by means of conductors running through the shaft to one set of brushes, 6, as shown.

The operation is similar to the case of the cylindrical armature, *i. e.*, the flux is cut going in both directions; there are two effective unidirectional fields of opposite polarity both in the same magnetic circuit; the armature conductors extend the full length, (or in this case the full diameter), of the field structure; the current flows in different directions in different zones on the armature, though it is unidirectional in each particular armature conductor; and there are brushes connecting near the extremities of the armature conductors, and also at some mid-point near the field coils.

It will be evident to those skilled in the art that there may be many other constructions within the spirit of my invention, yet not exactly containing all the features mentioned above.

If it is desired, more than one of these bihomopolar fields may be combined in the same machine. For example, in Fig. 3, there are shown three such fields combined. In this case, the six fields merge to form two large and two small fields. That these are not the combination of four homopolar fields, but are the combination of three bihomopolar fields, will be evident from tracing out the magnetic circuits, which shows that fields of both polarities lie in the same magnetic circuit. Also if desired, the bihomopolar field may be used in combination with other types of field.

A bihomopolar field structure may be excited in innumerable ways, the method being used which is the most convenient from a constructive standpoint. In general, a bihomopolar field structure may be excited in the same manner as a single homopolar structure.

Another feature of my invention has to do with the elimination of collector rings. Perhaps the future development of high armature speeds together with the use of bihomopolar fields, may make the number of collector rings no longer a serious problem. Even at present with electric furnace work, electric welding, certain electrolytic processes and other work where the voltage is not high, the bihomopolar or homopolar machine might use an armature having broad, flat conductors connected to collector rings at each end, with suitable brushes on the rings. But since each armature conductor connected in series requires two separate collector rings, the number of collector rings in cases of fairly high voltage is prohibitive.

To permit the use of bihomopolar or homopolar machines with higher voltages, I use a more simple and compact method of connecting the desired number of armature conductors in series. Instead of having the armature carry several broad conductors, each with its pair of collector rings, I employ a large number of narrower conductors, the ends of which make contact with brushes, 6 and 6′, which are arranged circumferentially around the armature. The brushes, 6, 6, which are separated by just sufficient space to prevent short-circuiting through an armature conductor, form a practically continuous ring around the armature. A similar set, 6′, 6′ encircles the other end of the armature conductors. By connecting these brushes with suitable stationary conductors, the armature conductors may be connected as many times in series as there are pairs of brushes.

One such method of connecting them is shown in Fig. 5, which represents a development of the armature conductors, 3 and 3′, stationary conductors, 7, and brushes, 6 and 6′, the armature being of the bihomopolar type. The current entering at the brush *a* would pass out through the armature conductors 3 to the brush *b*, then back through the stationary conductor 7 to the brush *c*, then similarly to *d*, *e*, *f*, and so on until, having completed the circuit of that armature zone, it crosses to the brush *k*, then through the armature conductors 3′ to *l*, *m*, *n*, *o*, and so on until it leaves the machine at *z*. The brushes might be connected in any other order that would give the desired result, as for example in Fig. 6, where 10 represents the stationary conductors. In general, the ends of the armature bars come in contact with the different brushes in succession as the armature revolves, and by connecting the brushes appropriately in series, the voltage is accordingly built up. Of course, the brushes may also be connected in parallel if it is so desired. It will be seen that the brushes at the two extremities of an armature conductor are opposite each other, so that as the armature conductor comes under a brush which sends in current of a new voltage, it simultaneously makes connection with another brush by which the current may leave.

If the armature conductors were constructed in a double layer—that is, one set lying over another, and if the two layers carried different potential, there would be a double set of brushes as shown in Fig. 7; and similarly for several layers. Brushes might also be arranged side by side and in parallel as in present types of commutating machines. If desired, the brushes might also be staggered slightly.

With this method, where brushes connect directly with the armature bars or conductors, instead of through collector rings, an armature bar as it passes from one set of brushes to the next, will still carry the same amount of current in the same direction, but it will be of a higher voltage if the stationary conductors are in series. The same armature conductor then carries current of different voltages at different periods in its rotation. Thus the armature conductors have a different function than in the previous types of homopolar machines, or in the type having a commutator where the current is continually reversed.

The brushes are not commutating, because the current is not reversed in the armature conductors, and also differ in that they need not be set in a particular position in order to operate, and so may be closely spaced around the armature. It is desirable however to have them equally spaced, so that the current which flows in equal amount through the circuit will be carried in equal amount by the separate armature conductors. Since the armature currents are not reversing it is not necessary to provide for adjusting the brushes through a considerable arc as is done in commutating machines, but it may be desirable to allow a slight adjustment.

The compactness of this method of arranging brushes is evident,—a number of brushes taking the place of a number of collector rings, while occupying the space of one. The machine can therefore be made shorter, and the length of the magnetic circuit reduced. The minimum size bihomopolar field structure is thus retained with a series armature circuit of any desired length. Such a bihomopolar field combined with the type of series brushes above described is the principal feature of this invention, since that combination gives a non-commutating machine which may be built for any desired speed or voltage without appreciably increasing its size and without losing its inherent compactness.

The stationary conductors that connect the brushes in series may be arranged as shown in Fig. 6, or as shown in Fig. 5, or both of these arrangements may be used in combination. The arrangement which has to do with the prevention of sparking, consists in a separate single conductor from each brush, extending across the pole face parallel to the armature conductors, and lying over the armature conductor which is between brushes, or slightly to one side of that conductor. Such an arrangement is shown in Fig. 6, which is a partial development of a bihomopolar armature, in which 3 and 3′ are the armature conductors, 6 and 6′ are the brushes, and 10 are the stationary conductors under consideration. The circuit will be evident from the explanation given for Fig. 5. The current in a stationary conductor 10 will produce a local field which will distort the main field, strengthening it on one side of the stationary conductor, and weakening it on the other side. Now by so placing the stationary conductor that the weakened part of the field will occur between the brushes, an armature conductor will be in a weak field at the instant when there might be a tendency to spark at the brushes. Since there is a stationary conductor for each pair of brushes, the stationary conductors in general may be summed up as consisting of single, separate, rather narrow return conductors for each pair of brushes, lying approximately between each pair of brushes and parallel to the armature conductors.

To improve the regulation I use another method of arranging the stationary conductors. It is known that the drop in voltage with increasing load is partially due to the field set up by the current in the armature, which distorts and weakens the main field. But if the stationary conductors are made broad enough to cover the pole face, the currents in them, flowing in a direction directly opposite to that in the armature conductors, will create an opposing field to neutralize the effect of the armature reaction. If the return conductors are similar to the armature conductors, the neutralization of the armature reaction is all that is accomplished, and if any compounding is also desired it must be accomplished by another part of the series circuit.

By my invention these stationary conductors on the pole face serve the double purpose of neutralizing the armature reaction and compounding the field. This I accomplish by winding the stationary conductors in helical paths on the pole face. The stationary conductors may be narrower than the corresponding armature conductors; but being wound helically, they are made to cover practically the entire pole face. The general arrangement is partially shown in Fig. 1, and a typical development in Fig. 5, the general direction of the stationary conductors being inclined at an angle to the armature bars. With a cylindrical armature this would give them a helical path, and with disk armatures a spiral path.

Where the stationary return conductors are thus arranged at an angle to the armature conductors, they bear the same relation to said armature conductors as the hypotenuse does to one of the other sides of a right angle triangle. Consequently, the stationary conductors are of greater length than the corresponding armature conductors, and since the current is the same in both, and the number of magnetic lines of force is proportional to the length of the conductor—each unit of length being encircled by the same number of lines of force—it is plain that the stationary conductors have in the aggregate more magnetic lines of force than the corresponding armature conductors. But as the respective currents do not flow in directly opposite directions, only a component of the opposing current can have an effect on the armature reaction. By mathematical calculation, it will be found that this greater length of the stationary conductor just compensates for the component lost due to the direction, and that the inclined return conductors, by reason of their greater ampere feet, therefore have the same neutralizing effect as would return conductors located parallel to the armature conductors. This substantially neutralizes the undesirable effect of the so-called armature reaction upon the field, and thereby improves the regulation.

The helical pole face conductors have the advantage over former types in that they also aid the regulation as a series field circuit. By running the helix in the same general direction that the current is flowing in the field coils, the current in the stationary pole face conductors will act to a certain extent as a compound winding or series field to increase the field strength with increasing load. The helical winding also permits the armature conductors to rotate in a more uniform field. When the stationary conductors are arranged similarly to the armature conductors, *i. e.*, parallel to them, the distortion of the field caused by the insulating space between the stationary conductors acts on the full length of an armature conductor. But with a helical winding of the stationary conductors, such local distortions also have a helical path, and hence cross from one conductor to another so that the disturbing effect is distributed and equalized.

Such helical windings may be combined with the narrow, straight conductors 10 shown in Fig. 6, by winding the helical conductors as described, and then putting the straight, narrow conductors where desired. The latter may be excited from the same or a separate source.

With helical windings, the order in which the brushes are connected, and the angle of the helix, may differ in different machines to suit practical requirements, and the helical winding is equally applicable to homopolar or bihomopolar machines, with or without collector rings.

By supplying alternating current to the field, the dynamo-electric machine which has been described may be used as an alternating current generator, with its frequency independent of its rotative speed; and by supplying both armature and field with alternating current it can be run as an alternating current motor, with its speed independent of frequency; but of course the magnetic circuit should be laminated when alternating current is used.

These various features of my invention are equally applicable to motors, generators, rotary D. C. potential transformers, instruments, all of which, and many others are included under the general term "dynamo-electric machines."

Having now described my invention, what I claim as new and desire to secure by Letters Patent, is:—

1. In a dynamo electric machine, means for producing a plurality of annular fields in the same magnetic circuit, in combination with plurality of corresponding zones of numerous narrow armature conductors, and series connected brushes bordering said zones, the armature conductors being arranged to make electrical connection successively in rotation with different series connected brushes.

2. A dynamo electric machine having means for producing a plurality of annular fields of different polarity in combination with an armature having a corresponding plurality of zones of armature conductors, bands of brushes bordering said zones and arranged to successively connect electrically with different armature conductors in rotation.

3. A dynamo electric machine having a field magnet with two effective homopolar fields of different polarity in a common magnetic circuit, a zone of numerous armature conductors in each field, series brushes electrically connecting with successive armature conductors in rotation, said conductors carrying current of different voltage when connecting with different series brushes.

4. In a dynamo electric machine, a field structure having two effective unidirectional fields of opposite polarity in the same magnetic circuit, a zone of numerous armature conductors in each field, brushes connected in series with each other electrically connecting with successive armature conductors in rotation, whereby a short magnetic circuit is retained with a long series armature circuit.

5. In a dynamo electric machine, a field structure having unidirectional fields, and an armature with a plurality of unidirectional zones each consisting of numerous narrow armature conductors, the current flowing in opposite directions in adjacent zones and the armature conductors in each zone carrying current of different voltages at different points in the cycle of rotation.

6. In a dynamo electric machine, the combination of a field structure producing two or more homopolar fields with common magnetic circuits, an armature having a zone of armature conductors in each homopolar field, each zone comprising a large number of insulated armature conductors, brushes arranged to make electrical connection with a number of armature conductors simultaneously and with all the armature conductors of a zone successively, and means connecting the brushes in series.

7. In a dynamo electric machine, a homopolar field, an armature having a plurality of parallel conductors, brushes for said conductors, and stationary conductors on the pole face inclined at an angle to the direction of the armature conductors and connecting the brushes.

8. In a dynamo electric machine, a homopolar field, an armature having a plurality of parallel conductors, brushes for said conductors, and stationary helical conductors on the pole face connecting the armature conductors in series, the helix running in the same general direction as an exciting current within the magnetic circuit.

9. In a dynamo electric machine, homopolar fields of different polarity, an armature having conductors arranged in zones, brushes for each zone of conductors, and stationary series conductors wound helically on the pole faces, the angle of inclination of said stationary conductors alternating in adjacent zones and inclining in the same general direction as an exciting current within the magnetic circuit.

10. In a dynamo electric machine, a homopolar field, an armature having numerous parallel insulated conductors, brushes arranged in pairs for said conductors and adapted to connect shifting groups of the armature conductors successively in parallel, and stationary conductors connecting the brushes in series and extending across the pole face in curved paths inclined at an angle to the armature conductors in the same general direction as an exciting current within the magnetic circuit.

11. In a dynamo electric machine, a homopolar field, an armature having a plurality of parallel conductors arranged in zones, brushes arranged in pairs for the conductors of each zone, and stationary conductors connecting the brushes and extending over the pole faces in curved paths inclined at an angle to the armature conductors in the same general direction as an exciting current within the magnetic circuit.

12. In a dynamo-electric machine, a field structure having a plurality of homopolar fields with two of said fields effective in the same magnetic circuit, in combination with an armature having a plurality of zones, each zone containing numerous armature conductors, and brushes arranged to electrically connect the armature conductors of a zone successively in parallel in shifting groups.

13. In a dynamo-electric machine, a field structure having a plurality of homopolar fields with two of said fields effective in the same magnetic circuit, in combination with an armature having a plurality of zones, each zone containing numerous armature conductors, and brushes arranged to elec-

trically connect the armature conductors of a zone successively in parallel in shifting groups, and means for connecting said groups in series.

14. In a dynamo-electric machine, a field structure having a plurality of homopolar fields with two of said fields effective in the same magnetic circuit, in combination with an armature having a pluraltiy of zones, each zone containing numerous armature conductors, and brushes electrically connecting groups of armature conductors in parallel, said conductors in each zone passing in rotation successively from one group to the next.

15. In a dynamo-electric machine, a field structure having a plurality of homopolar fields with two of said fields effective in the same magnetic circuit, in combination with an armature having a plurality of zones, each zone containing numerous armature conductors, brushes electrically connecting groups of armature conductors in parallel, said conductors in each zone passing in rotation successively from one group to the next, and means for connecting said groups in series.

16. In a dynamo-electric machine, a field structure having a plurality of homopolar fields with two of said fields effective in the same magnetic circuit, in combination with an armature having numerous armature conductors, brushes arranged to connect the armature conductors in series, said conductors in rotation being arranged to pass successively under different brushes, those of the brushes lying within the common magnetic circuit between said effective fields being arranged in a narrow belt, whereby a short magnetic circuit is retained with a long series armature circuit.

17. In a dynamo electric machine, the combination of a homopolar field structure, a cylindrical armature having a zone of numerous narrow armature conductors near the cylindrical surface of the armature, said conductors extending in a general axial direction, closely spaced brushes electrically connecting groups of the armature conductors in parallel, said conductors passing in rotation successively from one group to the next in the zone, the closely spaced brushes being separated peripherally only by the approximate width of a narrow armature conductor so as to form substantially continuous bands entirely encircling the armature, whereby there is produced a substantial uniformity of armature reaction and a corresponding uniformity of magnetic flux distribution.

18. In a dynamo-electric machine, the combination of a homopolar field structure, an armature having numerous insulated armature conductors, a brush for carrying current into the armature conductors, a brush for carrying current out from the armature conductors, a second intake brush for carrying current into the armature conductors at a different voltage, and a corresponding brush for carrying current out from the armature conductors, the first mentioned pair of brushes being spaced sufficiently from the second mentioned pair to prevent a short circuit between them through an armature conductor as it passes in rotation from connection with the first pair to connection with the second pair, and conductors on the pole face extending parallel to the armature conductors and arranged to weaken a field along an armature conductor as it passes out of connection with the first mentioned pair of brushes.

19. In a dynamo electric machine, the combination of a field structure producing two effective homopolar fields in the same magnetic circuit, a substantially cylindrical armature which the magnetic flux enters and leaves in a substantially radial direction so that the effective fields are cylindrical and extend axially, numerous narrow armature conductors insulated from each other extending in a general axial direction and arranged in zones corresponding to the effective fields, bands of closely spaced brushes bordering the zones and encircling the armature, the spaces between succeeding brushes of a band being only wide enough to prevent a short-circuit through a narrow armature conductor whereby the bands are substantially continuous and produce a uniformity in the magnetic flux distribution, the armature conductors passing in rotation successively under the different pairs of brushes of their zone, each pair of brushes connecting a group of armature conductors in parallel circuit with each other, so that as each conductor in rotation leaves a group there are the other conductors of the group in parallel circuit with it to carry the interrupted current and minimize sparking at the brush tips, and stationary conductors exterior to the rotating armature connecting the brushes in series.

In testimony whereof I have hereunto set my hand.

ROBERT V. MORSE.

Witnesses:
EDWARD N. JACKSON,
H. V. HINCKLEY.