J. E. NOEGGERATH.

DYNAMO ELECTRIC MACHINE.

APPLICATION FILED JUNE 30, 1906.

959,959.

Patented May 31, 1910.

2 SHEETS—SHEET 1.

Fig. 1.

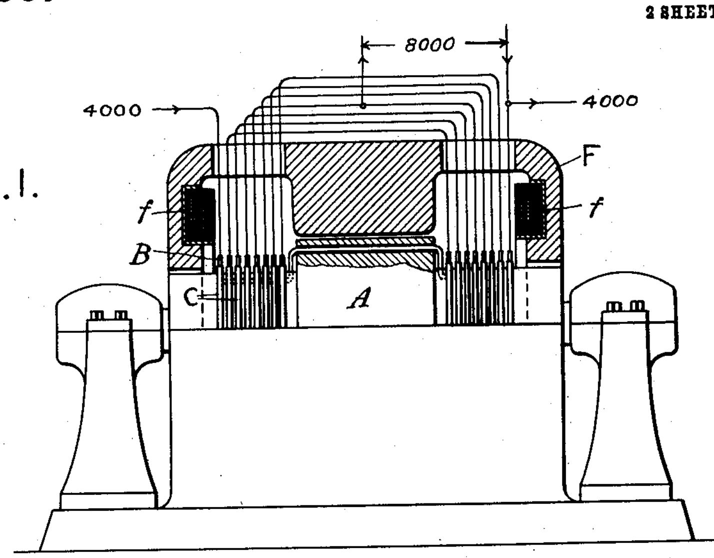


Fig. 2.

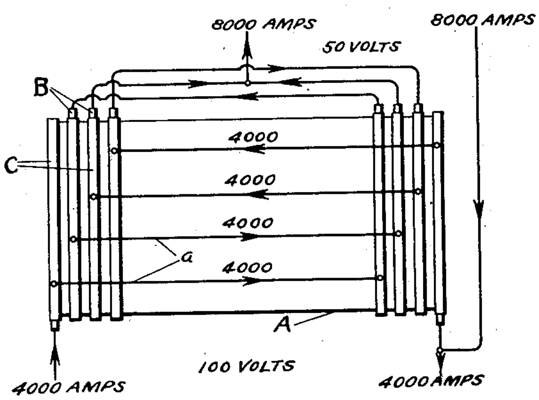
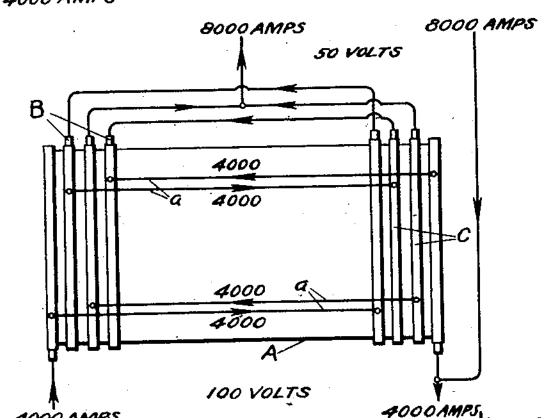


Fig. 3.



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2 SHEETS—SHEET 2.

FIG. 4.

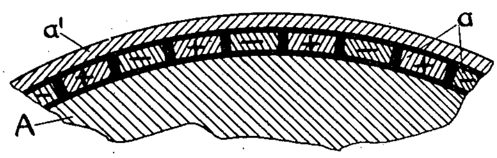


FIG. 5.

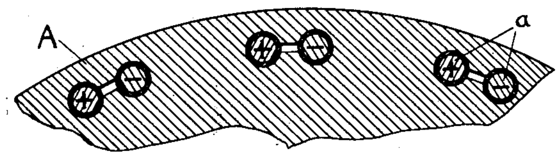


FIG. 6.

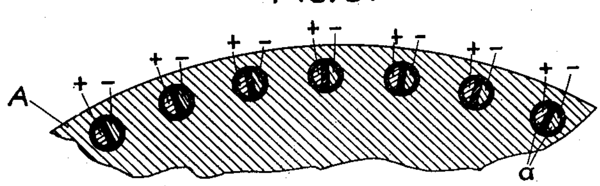
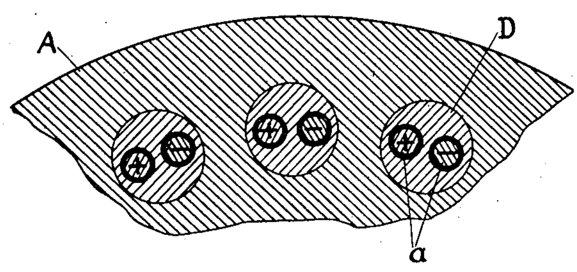


FIG. 7.



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UNITED STATES PATENT OFFICE.

JAKOB E. NOEGGERATH, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

DYNAMO-ELECTRIC MACHINE.

959,959. Specification of Letters Patent. Patented May 31, 1910.

Application filed June 30, 1906. Serial No. 324,262.

To all whom it may concern:

Be it known that I, JAKOB E. NOEGGERATH, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Dynamo-Electric Machines, of which the following is a specification.

My invention relates to dynamo-electric machines of the unipolar type, and its object is to adapt such machines for efficient operation as rotary transformers or compensators for transforming one voltage to another. A unipolar machine as ordinarily arranged, when used as a rotary transformer or compensator, is subject to certain losses which do not occur when the same machine is used as a generator or motor. This is due to the fact that while the direction of flow is the same in all the armature conductors when the machine is used as a generator or motor, this is no longer true when the machine is used as a rotary transformer.

If two parallel conductors are assumed to carry equal currents flowing in the same directions, it will be seen that the magnetizing effect of the current in one conductor upon the space separating the two conductors is opposed by the magnetizing effect of the current in the second conductor; the resultant magnetizing effect of the two currents being to create a flux surrounding both conductors and not passing between the two conductors. Consequently, in the case of an armature having parallel conductors distributed around its periphery, all carrying current in the same direction, the magnetizing effect of the current in each conductor upon the space immediately on each side of the conductor is partially neutralized by the magnetizing effect of the current in the adjacent conductor on each side. On the contrary, if two parallel conductors are arranged to carry currents in opposite directions, both currents assist in magnetizing the space between the two conductors. Consequently, in the case of an armature having parallel conductors distributed around its periphery, some carrying current in one direction and some in the other, as in the case of a unipolar machine employed as a rotary transformer, each two adjacent conductors carrying current in opposite directions tend to produce a flux in the space between them. If all the conductors carrying current in one direction are arranged on a certain portion of the armature and the remaining conductors on the other portion, the result is to produce a bi-polar field having its poles between the two portions; while if the conductors carrying current in opposite directions are intermingled a multipolar magnetization will be produced in the armature. In either case, the poles in the armature will produce strong eddy currents in the field structure, resulting in large losses.

The object of my invention is to prevent such losses, and I accomplish this by so arranging the armature conductors that the magnetizing effect of each conductor is neutralized by the current in an adjacent conductor or conductors. I accomplish this by placing each conductor carrying current in a given direction closely adjacent to a conductor or conductors carrying current in the opposite direction, so that the space between the conductors is restricted, and consequently of high reluctance. I further increase the reluctance of this space by removing all magnetic material therefrom, so that the adjacent conductors are separated either by an air-gap or by other non-magnetic material.

My invention will best be understood by reference to the accompanying drawings, in which:—

Figure 1 shows a unipolar machine adapted to be arranged for operation as a rotary transformer in accordance with my invention; Fig. 2 is an explanatory diagram; Fig. 3 shows diagrammatically the armature of a unipolar rotary transformer arranged in accordance with my invention; and Figs. 4, 5, 6, and 7 show different modifications of the arrangement of armature conductors in accordance with my invention.

In Fig. 1, F represents the field structure provided with the field coils *f* which extend circumferentially around the machine. A represents the armature carrying a plurality or armature conductors *a*, which are arranged in the usual manner distributed around the armature core near its periphery, and which are connected at each end to collector rings C; on which bear brushes B, by means of which the armature conductors may be connected in series.

Now, referring to Fig. 2, I have shown a diagram of the directions of current-flow in the armature conductors of a machine of the type illustrated in Fig. 1, when employed as a rotary transformer. I have shown only four armature conductors, for the sake of simplicity, and shall assume that the machine is of four hundred kilowatts capacity, and is transforming current at one hundred volts into current of fifty volts. The terminals at the bottom of the figure represent the leads from the supply-circuit. A current of four thousand amperes enters these terminals at one hundred volts. The upper terminals are supposed to represent the leads to the load-circuit, through which pass eight thousand amperes at fifty volts. Each armature conductor carries four thousand amperes; the direction of flow being as indicated by the arrow-heads. It will be seen that a strong magnetization will be produced in the space between the two middle conductors, since with respect to this space the armature conductors shown represent a magneto-motive force of eight thousand ampere turns. On the other hand, if the two middle conductors should be reversed in position a field would be produced between each two conductors corresponding in strength to a magneto-motive force of four thousand ampere turns. Either arrangement will produce a strong local magnetization of the armature, which, as the armature revolves, will produce heavy eddy currents in the field structure.

Now, referring to Fig. 3, I have shown an arrangement in which each armature conductor is placed closely adjacent to a conductor carrying an equal current in the opposite direction. If the two conductors in each group could be placed in exactly the same space their magneto-motive forces would exactly neutralize each other, and in practice by placing the conductors as close together as mechanical and electrical conditions permit and by making the space between them non-magnetic, a practically complete neutralization can be secured.

Figs. 4 to 7 show different arrangements for securing the desired neutralization. In Fig. 4 the armature conductors *a* are made flat, and are placed closely adjacent to each other, so as to form a complete cylinder of current-carrying material around the periphery of the armature held in place by a binding member *a'*. Conductors carrying current in opposite directions are placed adjacent to each other as indicated by the plus and minus signs. The space between the two conductors is very small and is filled only with non-magnetic insulating material, this arrangement practically neutralizes the magnetizing effect of the current in each conductor. This construction has the result of introducing in the magnetic circuit of the machine a second air-gap corresponding to the thickness of the conductors and consequently requires a strong field magnetization.

Fig. 5 shows an arrangement in which the conductors are carried in holes or tunnels in the armature core. Conductors carrying current in opposite directions are placed close together, as indicated by the plus and minus signs, and the space between the two conductors is partially cored out so as to make the flux path through that space of high reluctance.

Fig. 6 shows another arrangement, in which the conductors of special cross-section are employed so as to render it possible to place two conductors conveniently in a single round hole.

Fig. 7 shows another arrangement, in which round conductors may be employed with a plurality of conductors placed in a single hole. In this figure, D represents a tube or rod of non-magnetic material, which extends through the armature core, and which is provided with a plurality of tunnels or passages for receiving two or more conductors *a*; which arrangement, like the others, provides a restricted flux path of high reluctance between the adjacent conductors carrying current in opposite directions.

Although, for the sake of simplicity, I have shown my invention applied to a rotary transformer arranged for a 2 to 1 ratio of voltages, and consequently have shown only two conductors in each group, since with this voltage ratio half the conductors carry current in one direction and half in the other, and the currents in all the conductors are of equal strength, it will be seen that my invention is equally applicable to a machine arranged for practically any voltage ratio, the only requisite in each case being that each group of conductors shall contain a number of ampere conductors of one polarity equal to the number of ampere conductors of the opposite polarity. Furthermore, although I have shown my invention applied to a machine having a drum armature, it is obvious that in its broader aspects it is equally applicable to other types of armatures. Accordingly, I do not desire to limit myself to the particular construction and arrangement of parts here shown, but aim in the appended claims to cover all modifications which are within the scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. A rotary transformer having a unipolar field structure, an armature core, a plurality of armature conductors distributed around the armature core near its periphery, and collecting devices and cross-connections for placing said conductors in series, a circuit including all of said conductors, and a

second circuit including a portion of said conductors, each conductor included in the second circuit being arranged close to one or more of the remaining conductors, whereby the magnetizing effect of each conductor is neutralized by the current in adjacent conductors.

2. A rotary transformer having a unipolar field structure, an armature core, a plurality of armature conductors distributed around said armature core near its periphery, and collecting devices and cross-connections for placing said conductors in series, a circuit including all of said conductors, and a second circuit including a portion of said conductors, each conductor included in the second circuit being arranged close to one or more of the remaining conductors, and the space between adjacent conductors being arranged with high reluctance.

3. A rotary transformer having a unipolar field structure, an armature core, a plurality of armature conductors distributed around said armature core near its periphery, and collecting devices and cross-connections for placing said conductors in series, a circuit including all of said conductors, and a second circuit including a portion of said conductors, each conductor included in the second circuit being arranged close to one or more of the remaining conductors, and separated therefrom by a non-magnetic space.

4. In a dynamo-electric machine, a unipolar field structure, an armature core, a plurality of armature conductors distributed around said armature core near its periphery, collecting devices and cross-connections for placing said conductors in series, said conductors being grouped and the conductors in each group being placed close to each other so that the flux path between the conductors of each group is restricted.

5. In a dynamo-electric machine, a unipolar field structure, an armature core, a plurality of armature conductors distributed around said armature core near its periphery, collecting devices and cross-connections for placing said conductors in series, said conductors being grouped and the conductors in each group being placed close to each other and separated from each other by a restricted non-magnetic space.

6. In a dynamo-electric machine, a unipolar field structure, an armature core, non-magnetic tubes extending through said core, a plurality of armature conductors carried in each of said tubes, and collecting devices and cross-connections for placing said conductors in series.

7. A rotary transformer having a unipolar field structure, an armature core, a plurality of armature conductors distributed around said armature core near its periphery and arranged in groups, and collecting devices and cross-connections for placing said conductors in series, a circuit including all of said conductors, and a second circuit including a portion of said conductors, the conductors of each group being so connected to said circuits that the ampere conductors of one polarity in each group equal the ampere conductors of the opposite polarity.

In witness whereof, I have hereunto set my hand this 29th day of June, 1906.

JAKOB E. NOEGGERATH.

Witnesses:
B. B. HULL,
HELEN ORFORD.