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DYNAMO-ELECTRIC MACHINE.

APPLICATION FILED JUNE 10, 1919.

1,430,862. Patented Oct. 3, 1922.

Fig. 1.

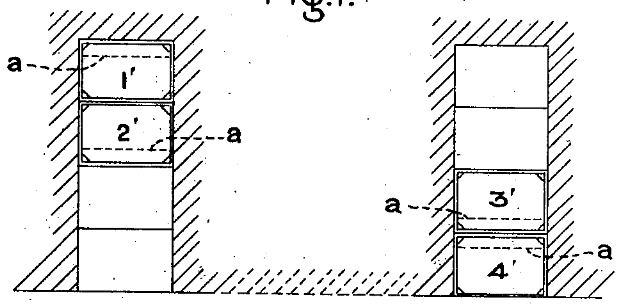


Fig. 2.

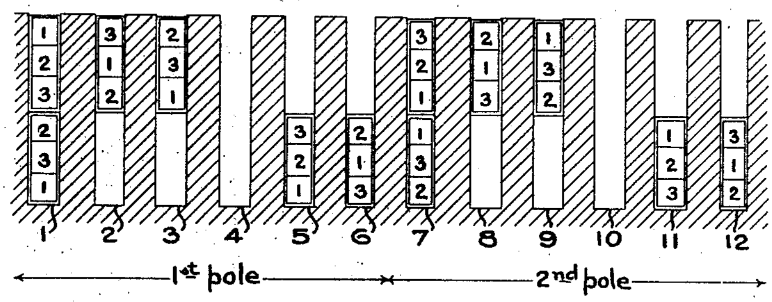
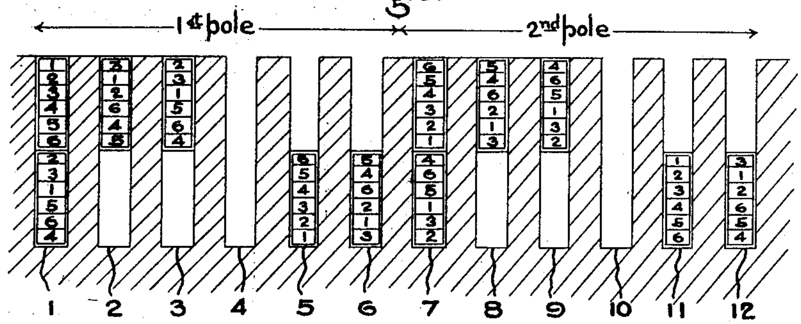


Fig. 3.



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UNITED STATES PATENT OFFICE.

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DYNAMO-ELECTRIC MACHINE.

Application filed June 10, 1919. Serial No. 303,101.

To all whom it may concern:

Be it known that we, Henry William Taylor, a subject of the King of Great Britain, residing at Bilton, England, Frederic Horton Clough, residing at Hillmorton, England, and Frank Percy Whitaker, residing at Rugby, England, subjects of the King of Great Britain, have invented certain new and useful Improvements in Dynamo-Electric Machines, of which the following is a specification.

Our invention relates to dynamo-electric machines and more particularly to the windings of alternating-current machines.

In large alternating-current generators in which the windings disposed in the armature slots, consist of conductors of considerable depth, the magnetic flux across the slot arising from the current in the conductors gives rise to a parasitic voltage within the conductors which is liable to cause local or unbalanced currents, thereby producing undue heating of the conductors and causing the copper in the armature to be inefficiently utilized.

It has hitherto been proposed to limit the current which will flow as a result of these parasitic voltages, first of all by dividing the conductors into a number of separate multiple bars or laminations, and secondly by continuing this lamination of the complete conductor through the complete coil, and so connecting the ends that the order of the bars in the conductors of the upper portion of the coil is the reverse of the order of the bars in the conductors in the bottom portion of the coil. It is found, however, that on large machines with very deep conductors, the local currents which flow even when these provisions are made are still excessive and impose limitations on the design of the machines.

It has also hitherto been proposed to limit the current which will flow as a result of parasitic voltage first of all by dividing the conductor into a number of separate multiple bars or laminations, secondly by continuing this lamination of the complete conductor throughout the winding, and in addition thirdly by transferring the top lamination of the conductor to the bottom at the end of each coil, the number of laminations having been previously chosen to correspond say to the number of coils per pole per phase or the number of coils per phase. It is found, however, that with large machines with fractional pitch or chorded windings, local currents will flow even when these provisions are made and these impose limitations on the design of the machine.

The magnetic flux which extends through the body of the bottom conductor of a slot at any instant depends only upon the current being carried in this conductor and increases gradually from zero at the bottom of the conductor. The flux extending through any other conductor nearer the mouth of the slot depends not only upon the current which that conductor is carrying, but also upon the amount of current in the conductors below the one in question. The flux passing across such conductor therefore may be considered to be partly variable depending upon the current in the conductor and partly constant depending upon the total current in the number of conductors below the conductor in question. The flux here mentioned as extending through the body of a conductor is that which upon the rise and fall of current cuts the bottom of the conductor but not the top.

According to the present invention therefore, we arrange to continuously insulate separate bars of which the conductor consists, throughout a coil, or throughout the complete winding, as the case requires, and to connect these separate bars at the ends of the half turns or at the ends of the coils, so that the amount of constant flux linking the conductor in one or more half turns is exactly opposed by the amount of constant flux linking the conductor in another or in the rest of the half turns.

In the accompanying drawings, Figs. 1, 2 and 3 diagrammatically illustrate forms of our invention.

In carrying our invention into effect according to the modification illustrated in Fig. 1 in which we have shown two slots containing the conductors of a 2-turn coil of a 2-layer winding, we connect the ends of the various multiple bars so that the parasitic voltages generated between the bars of conductors 1′ and 4′ are cumulative and are in opposition to the cumulative parasitic voltages generated between the bars in conductors 2′ and 3′. By cumulative voltages are meant those tending to produce currents flowing in any bar in one conductor in the same direction as those flowing in the same bar in another conductor. The voltages are in opposition when these currents tend to flow through any bar in opposite directions. It will be understood that the two slots illustrated are not adjacent slots but occupy positions around the armature a full pole pitch apart or nearly a pole pitch apart according to whether the winding has a full or a fractional pitch. The lamina *a* of the conductor 1′ is shown at the bottom of the conductor and it will be seen that *a* is also on the lower side of conductor 4′, that is the side nearest the bottom of the slot, whereas it is on the upper sides of conductors 2′ and 3′. It will be seen that the constant flux and therefore parasitic voltage arising therefrom in conductor 1′ is zero owing to the fact that there are no conductors below it while the constant flux in conductor 4′ to which conductor 1′ is cumulatively connected is 3 as there are three conductors beneath it, two of these however belonging to another coil. On the other hand the constant flux in conductor 2′ is 1 and in conductor 3′ which is cumulatively connected to it is 2 making a total of 3 in opposition to the 3 in conductors 1′ and 4′ so that the effect of these fluxes in producing eddy currents between the laminations is in this case eliminated. The invention, however, may be similarly applied to coils of any number of turns, so that the parasitic currents which flow between the laminations may be either completely eliminated or reduced to a negligible value.

Where it is not convenient to make the connections described within the coil itself, the separate laminations or bars of the conductors may be continued from coil to coil and the bars so connected and reversed in successive coils, or in successive groups of coils that the parasitic voltage generated in every conductor in every slot is always practically counterbalanced by a similarly placed conductor in another slot.

In the type of winding with multiple bar conductors in which the single bars of the conductor occupy successive positions in the conductor in successive turns, the parasitic voltages are entirely eliminated when the coils of the winding span a complete pole pitch. When, however, the coil spans a fractional portion of a pole pitch the parasitic voltages are not completely eliminated in the usual manner in which this type of winding is constructed.

In applying our invention to this type of winding therefore, we arrange for the bars of the conductor to occupy successive positions toward the mouth of the slot on one pole or group of poles of the machine, and after completely reversing the order of the bars, we arrange for the bars to occupy successive positions away from the mouth of the slot on the next pole or group of poles of the machine. Fig. 2 illustrates this form of our invention and in it we have shown the method of winding a 2-phase machine having two poles, the winding having a pitch of four-sixths. The winding of only one phase is shown, the slots and portions of slots left empty are to be occupied by the coils of the second phase constructed in a similar manner. The bars of the conductor are designated by the numerals 1 to 3. From the drawing it will be seen that in the upper half of slot 1, the bars are arranged in sequence, 1 being at the top of the slot. The bars then complete the turn by passing along the bottom of slot 5, when it will be seen that they are reversed in order, bar 1 being now at the bottom of the slot as is usual in this type of winding. Passing now from coil to coil it will be observed that after being successively transferred over the coils of one pole the laminations of the conductor are reversed in order and are successively transferred in the opposite direction over the conductors of the second pole.

It will be apparent that the construction is not limited to a coil with one turn only but the same elimination of parasitic currents between the bars of the conductor is effected in a multi-turn coil whenever the order of the conductors and also the manner of transference is reversed in passing through the coils of the second pole, the individual transference taking place as in the usual construction at the end of each coil.

We do not limit ourselves, however, in the choice of the number of separate bars in which the conductor is divided to the number of turns or slots per phase in any one pole but we may arrange for the number of bars in the conductor to be equal to the total number of coils in series on all the poles in any one phase, and by dividing the conductors into two groups of bars, we successively transfer the bars in each group in one direction in one portion of the winding, and then reversing the order of the bars in each group and also reversing the order of the groups, we successively transfer the bars in the opposite direction in the other portion of the winding. Fig. 3 illustrates this form of our invention and in it as in Fig. 2 we have shown the method of winding a 2-phase machine having two poles, the winding having a pitch of four-sixths. The conductor in this case however is divided into six bars corresponding to the total number of coils per phase, the individual bars of the conductor being designated by the numerals 1 to 6. From the drawing it will be seen that in the upper half of slot 1 these bars are arranged in sequence, 1 being at the top of the slot. The conductor then passes through the bottom slot 5 where it will be seen that it is reversed, bar 1 being now at the bottom of the slot, as is usual in this type of winding. In subsequent coils we then arrange that the individual bars occupy successive positions in the slots, so that firstly in the 12 bottom half slots each bar occupies every position in the slot, and secondly with regard to the 12 top-half slots, the order of the bars of each group is reversed in the one pole with regard to the order of the bars in the same group of the other pole, as for instance in the top of the second coil of the first pole the order of the top group of bars is 3, 1, 2, 6, 4, 5, while in the top of the second coil on the second pole the order of the same group of bars is reversed and is 5, 4, 6, 2, 1, 3, so that whatever the phase of the current in the bottom of the second slots on each pole, the effects upon the winding occupying the top portions of these slots, is eliminated and no eddy current loss results from this cause.

While we have illustrated and described above the best embodiments of our invention of which we are now aware, it will be understood that these embodiments are illustrative merely and that our invention is not limited thereto, but that our invention is set out in the following claims.

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

1. A dynamo electric machine having slots and a plurality of windings located therein, said windings being formed of conductors composed of a plurality of insulated laminations, certain of said slots containing conductors of different windings adapted to carry currents which differ in phase, there being for every arrangement of the laminations of a conductor in a slot under the influence of flux elements due to the presence of currents in other conductors in the same slot a reversed arrangement in the second slot under the same influence of flux elements due to the currents in other conductors in the second slot.

2. An armature provided with slots and a winding located therein, said winding comprising a plurality of pairs of turns, the conductors of one turn of each pair occupying slots spaced from the slots occupied by the corresponding conductors of the other turn by a full pole pitch, the said conductors being formed of a plurality of insulated laminations so connected and arranged that the effect of the constant flux elements upon one of a pair of turns is eliminated by the effect of the constant flux elements on the other of said pair.

3. An armature provided with slots and a winding located therein, said winding comprising a plurality of pairs of turns, the conductors of one turn of each pair occupying slots spaced from a slot occupied by the conductors of the other turn by a full pole pitch, the said conductors being formed of a plurality of insulated laminations so connected and arranged that the effect of the constant flux elements upon a half turn of one of a pair of turns is eliminated by the effect of the constant flux elements upon a half turn of the other of said pair of turns.

4. An armature provided with slots and a winding located therein, said winding comprising a plurality of pairs of turns, the conductors of one turn of each pair occupying slots spaced from the slots occupied by the conductors of the other turn by a full pole pitch, the said conductors being formed of a plurality of insulated laminations, the order of the laminations in the conductors being reversed in the two turns of each pair in slots which are spaced apart by a full pole pitch.

5. In an armature winding formed of conductors consisting of a plurality of insulated laminations, a series of coils occupying successive slots and a second series of coils occupying successive slots spaced from said first slots by one pole pitch, the laminations being successively transferred in adjacent slots and the order of the laminations in a coil of one series in one slot being the reverse of the order in a coil of the other series in the slot one pole pitch distant therefrom.

6. An armature winding of an alternating current machine having fractional pitch comprising conductors consisting of a plurality of insulated laminations, the order of the laminations being reversed as a whole between poles and the laminations being successively transferred in opposite directions under successive poles.

7. An armature winding of an alternating current machine having a fractional pitch, comprising conductors consisting of a plurality of insulated laminations divided into groups, the order of the groups being reversed between poles and the laminations being successively transferred within its group in the opposite direction under successive poles so that each lamination occupies each and every position in the conductor throughout the winding.

8. An armature winding comprising conductors consisting of a plurality of insulated laminations, the order of the laminations being reversed as a whole between poles and the laminations being successively transferred in opposite directions under successive poles.

9. An armature winding comprising insulated conductor laminations assembled in groups, the order of the groups being reversed between poles.

10. An armature winding comprising conductors consisting of a plurality of insulated laminations divided into groups, the order of the groups being reversed between poles

and the laminations being successively transferred each within its group under the same pole.

11. An armature winding comprising conductors consisting of a plurality of insulated laminations divided into groups, the order of the groups being reversed between poles and the laminations being successively transferred each within its group in the opposite direction under successive poles.

12. An armature winding comprising conductors consisting of a plurality of insulated laminations divided into groups, the order of the groups being reversed between poles and the laminations being successively transferred each within its group in the opposite direction under successive poles so that each lamination occupies each and every position in the conductor throughout the winding.

13. An armature winding of an alternating-current machine having a fractional pitch, comprising conductors consisting of a plurality of insulated laminations divided into groups, the order of the groups being reversed between poles and the laminations being successively transferred each within its group under the same pole.

14. An armature having a winding comprising coils of conductors formed of laminations which are divided into groups within the conductor and are continued from coil to coil, the laminations being transferred within the groups and the groups transferred within the conductors such that the effect of the constant flux linking each conductor in every slot is counterbalanced by the effect of the constant flux linking a similar conductor in another slot.

In witness whereof we have hereunto set our hands this 14th day of May, 1919.

HENRY WILLIAM TAYLOR.
FREDERIC HORTON CLOUGH.
FRANK PERCY WHITAKER.

Witnesses:
DOROTHY WHITE,
CHARLES H. FULLER.