

[54] METHOD OF FABRICATING A
COMMUTATOR

[75] Inventor: Memorial Kalagidis, North Canton,
Ohio

[73] Assignee: Ametek, Inc., New York, N.Y.

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[52] U.S. Cl. 29/597, 117/212, 117/217,
117/227, 310/234, 310/236

[51] Int. Cl. H01r 43/00

[58] Field of Search 29/597; 117/217,
117/227, 212; 310/233, 234, 236, 237

[56] References Cited

UNITED STATES PATENTS

3,103,060	9/1963	Fay	29/597
3,393,446	7/1968	Hughes et al.	117/217 X
3,109,228	11/1963	Dyke et al.	117/217 X
3,023,390	2/1962	Moratis et al.	117/217 X
2,478,536	8/1949	Koonz	29/597 X
2,438,205	3/1948	Coates	117/212
3,622,385	11/1971	Stork	117/227

FOREIGN PATENTS OR APPLICATIONS

145,528	10/1921	Great Britain	29/597
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Primary Examiner—Charles W. Lanham

Assistant Examiner—Carl E. Hall

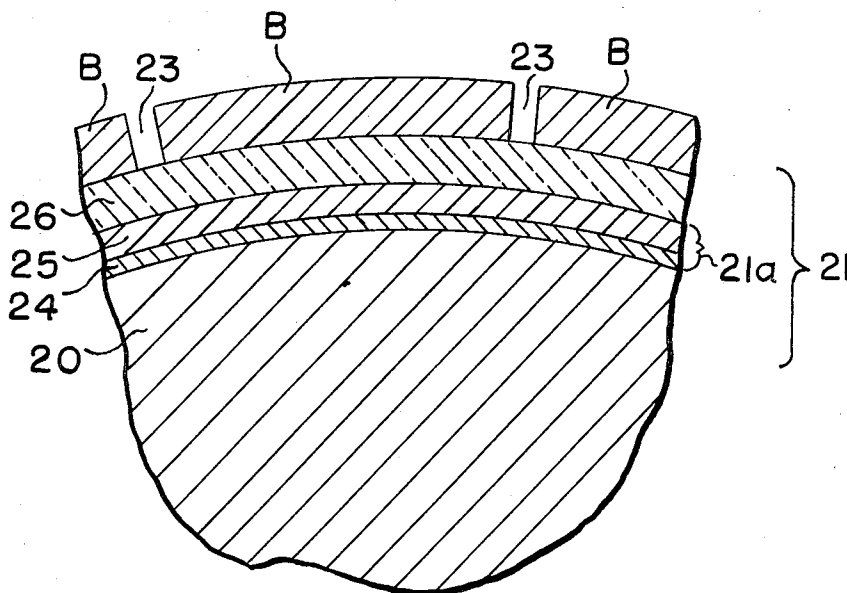
Attorney—Philip D. Golrick

[57] ABSTRACT

In fabrication of commutators by applying a thin insulation coating on a cylindrical support and thereafter applying a thin conductive layer ultimately providing the conductive segments by plasma or flame spray techniques, a bonding layer is layed before the insulating layer; and further electrical connections for armature coil leads, either in the form of tangs or direct connections are provided by applying to the insulating layer either a tang-originating preform or the lead ends before flame spraying of a copper layer for the conductive bars or segments and thereafter slotting to define the tanged or lead-connected segments. Alternatively, bar defining slots can be produced by masking the insulation coated blank before the final layer flame spray, wholly or in part eliminating slotting operations.

A dove tail interlock between the bars and core may be achieved by using a core with longitudinal trapezoidal section slots and carrying out the bar slotting centrally of each of the core slot locations.

9 Claims, 15 Drawing Figures



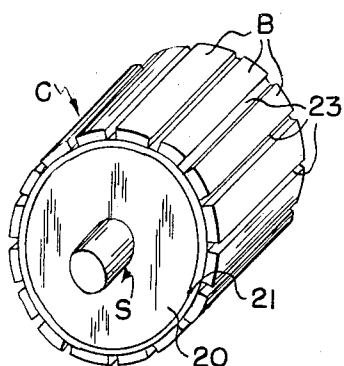


FIG. 1

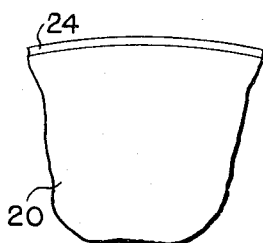


FIG. 2

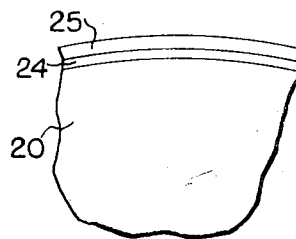


FIG. 3

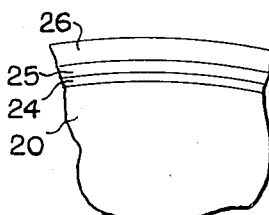


FIG. 4

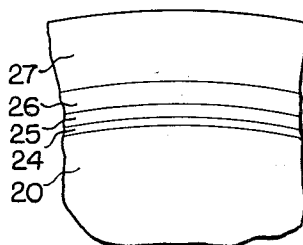


FIG. 5

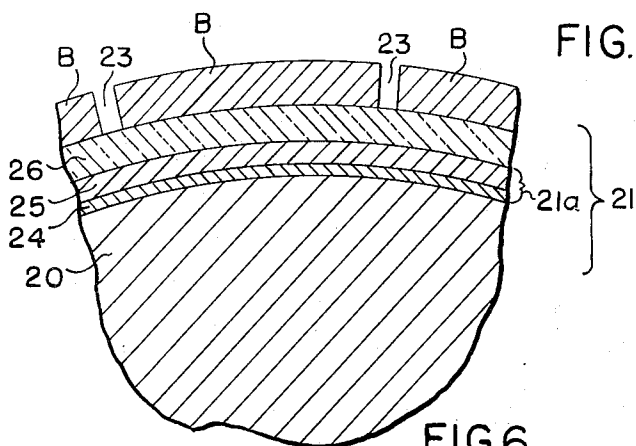


FIG. 6

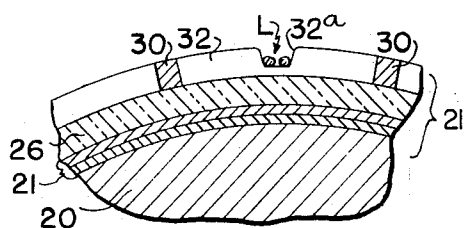


FIG. 7

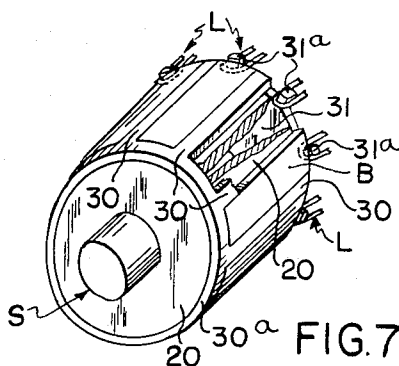


FIG. 8

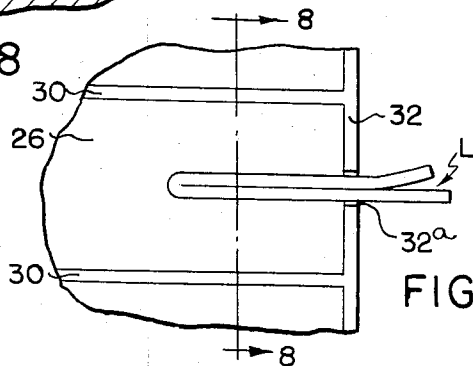


FIG. 9

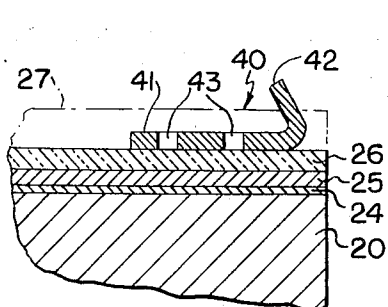


FIG. 10

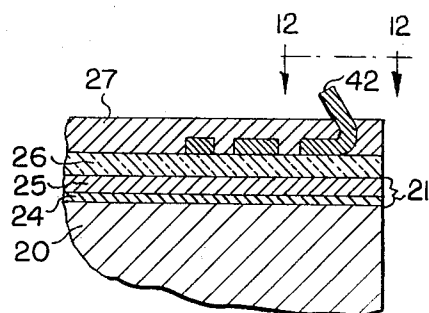


FIG. 11

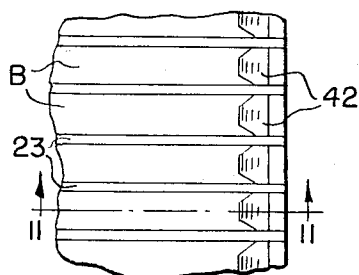


FIG. 12

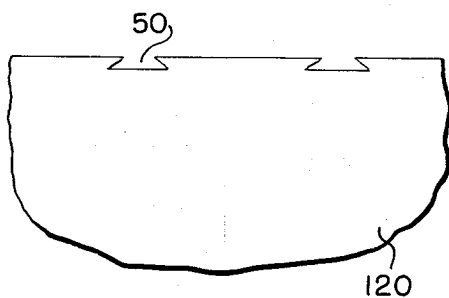


FIG. 13

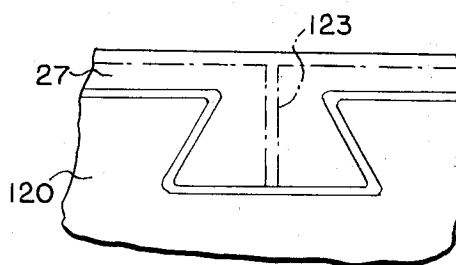


FIG. 14

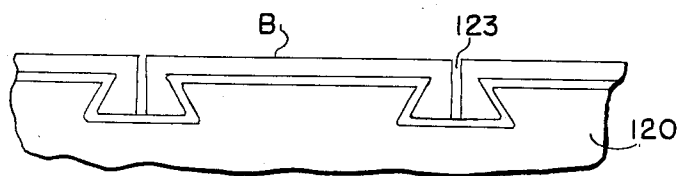


FIG. 15

METHOD OF FABRICATING A COMMUTATOR

The present invention will be discussed in terms of a commutator for an electric motor, but it is to be understood that a commutator or a similar structure for other environments are within the scope of various aspects of the invention. Also, though other metals may be used as specific requirements may dictate for the hereinafter referred to commutator segment building layer, for convenience and not restriction, the method here is described in terms of copper as applied for the conductive commutator bars or segments.

For motors or other dynamo-electric machines, it is obviously desirable that the costs be low both for fabrication of a commutator itself and for assembling and functionally connecting it into the final armature structure; and that the commutator have as small a size as possible for the function, the performance, and life required.

Especially for so-called "radial" commutators, to which the brush feed is directed more or less radially of the armature axis, conventional structures have limited possibility of size reduction, because in addition to metal thickness required in each commutator segment for conduction purposes, further depth or radial dimension is required for strength and particularly to provide inward projections anchoring the segments in an underlying core insulation.

It has been proposed by the prior patented art to fabricate a commutator by developing on a core blank a layer of insulating material, as by anodizing a cylindrical aluminum surface provided on a core member, or otherwise depositing an insulating ceramic layer; and thereafter to the insulating ceramic base applying a continuous layer of conductive metal such as copper or the like to be subsequently longitudinally slotted to form the commutator segments.

Such prior art proposals or practices involving flame spraying of copper or similar metal, to become the conductive segments of a commutator, onto a support or core provided with an insulating layer, especially ceramic insulating layers, have entailed certain advantages. Thus where an aluminum core or aluminum layer on a support is used as a source of alumina for the insulating coating or layer, a special procedure such as anodizing must be used. On the other hand where a ceramic material, such as alumina is deposited on the support as the insulating layer, it has been found that the ultimate composite structure, from the conductor segments to the base through such insulating layer, often fails in the commutator service or even in the fabrication step of slotting a circumferential continuously deposited copper layer.

With respect to this problem the present invention has found advantageous and proposes that before the ceramic layer there be laid down a bonding coating, comprising for example, a flash coating of nickel aluminate followed by a flash coating of copper, both applicable by flame spraying, onto which bonding coating the ceramic insulating layer is then applied.

By another aspect of the invention, it is proposed that, after a blank has been formed up to the completion of the ceramic layer, for example, with a partially formed commutator on the armature, the leads from the armature coil windings be located in appropriate spaced disposition on the ceramic layer, and then that flame spray application of the final conductive copper layer be carried out, so that the leads are mechanically

and electrically connected to the commutator structure.

Thus need for slotting to provide armature coil lead attachment points in the segments and further operations to secure the leads may be avoided.

In such cases with currently used magnet wires having polyurathane or Formvar-Nylon insulating coatings, there is no need to remove such insulation at the point of bonding.

For commutator structures upon which unusual performance demands are placed, further it is proposed that similar procedures be carried out on a core blank having, in appropriate number corresponding to the commutator segments desired, circumferentially spaced longitudinal slots of a dove-tailed type or trapezoidal cross section with the bonding coating and ceramic layer being carried continuously down the slot walls and bottom, and the flame sprayed conductive material filling the slots and integrally continuing to a circumferential continuous cylindrical layer. After truing operations, the slotting of the outer copper layer is carried out centrally at the core slot locations down to the ceramic layer, thereby to define commutator segments each longitudinally locked along respective edges in successively adjacent slots.

Further for a commutator with lead attaching tangs, the above described fabrication is carried out to completion of the ceramic layer, and then a grommet-like flanged short sleeve element, perforated in its cylindrical portion, is press fitted onto the ceramic insulated blank, and then with the flame spraying of the final copper layer carried out over the entire blank, the applied sprayed copper builds not only the commutator segment material, but also applied over the "grommet" bonds the latter not only endwise, but also through such apertures to the underlying insulating layer. Thereafter slotting carried out through the flange defines the tangs for the corresponding bar segments; the slotting being confined to the grommet region where masking is used to define the major intersegment slots.

It is the general object of the present invention to provide an improved method of forming a commutator for a dynamoelectric machine and the like.

It is another object of the invention especially to provide improvements in that method for fabricating the commutators, wherein there is applied to a metal support a thin spray-applied ceramic insulation base for a flame sprayed copper layer ultimately forming commutator segments.

A further object is the provision of a commutator forming method including flame spraying application of the segment-forming conductive material where the latter operation is carried out on a ceramic insulated commutator core positioned on an armature being fabricated after winding, whereby armature coil leads are electrically and mechanically connected to the commutator structure.

A still further object is the provision of novel forms of commutator structures of improved characteristics. Other objects and advantages will appear from the following description wherein:

FIG. 1 is a generalized perspective view of a commutator;

FIG. 2 is an enlarged fragmentary view of a portion of a commutator blank indicating completion of a first step of fabrication with a first layer for bonding coating applied;

FIG. 3 is a view similar to FIG. 2 showing completion of a second step applying a second layer completing a bonding coating;

FIG. 4 is a view similar to FIGS. 2-3 showing a third step of ceramic coating application completed;

FIG. 5 is a view similar to FIGS. 2-4 showing a completion of a further step of application of the conductive layer;

FIG. 6 is a view similar to FIGS. 2-5 showing completion of a slotting step;

FIG. 7 is a fragmentary view showing modification of the method aspects by masking for slot formation and in lead attachment;

FIGS. 8-9 are fragmentary views showing further modification in method from that of FIG. 7;

FIG. 10 is an axial fragmentary section showing a further modification of the method to provide lead attaching tangs, at completion of a step interpolated after completion of the insulation layer;

FIG. 11 is a view similar to FIG. 10 showing structure after flame spray application of the final copper layer;

FIG. 12 is a fragmentary plan view after completion of the commutator in process in FIGS. 10-11;

FIG. 13 is a fragmentary end view indicating a core and a method modification for a modified commutator structure;

FIG. 14 is an end view similar to FIG. 13 but further enlarged, indicating progression of the method to completion of application of the conductive layer; and

FIG. 15 is an end view similar to FIGS. 13-14 indicative of the finished form after slotting.

GENERAL STRUCTURE AND METHOD

In FIG. 1 of the drawings there is shown in generalized form a "radial" commutator C on the shaft S of an electric motor armature. The commutator includes a cylindrical core 20 which, for some applications of the invention, may be a shouldered enlarged diameter portion of the shaft S or a separate core element press-fitted and secured on the shaft as is conventionally done. Core 20 supports through an intervening continuous circumferential composite bonding and insulating layer 21, as hereinafter described and shown more particularly on other drawings, an external layer of copper material separated by equi-spaced longitudinal slots 23 into the conductive commutator bars B.

It is here noted that in the drawings the layer thickness are exaggerated for clarity and that there is no strict mutually scaled relation.

As shown by fragmentary FIG. 6 for the completed commutator structure the composite insulating and bonding layer 21 actually is comprised of three continuous circumferential layers of distinct materials, namely quite thin layer 24 of nickel aluminide applied directly to a core 20 (where the core is aluminum); a second thin but somewhat heavier layer 25 as a flash coating of copper applied to layer 24; and the yet heavier but still comparatively thin layer 26 of ceramic insulating material such as alumina, i.e., aluminum oxide. These may be considered as comprising but two functionally distinct layers, namely the ceramic layer 26 with the insulating function; and the layers 24-25 as a composite layer 21a having the primary and important function of ensuring a secure bond between the ceramic insulating layer 26 and the core 20.

By the process of fabrication, for example, of a fractional horsepower motor commutator of a diameter of

about 1.28 inches, to a hollow cylindrical aluminum core of about 1.13 inch outside diameter with the core concentric and appropriately sized for the intended shaft, by flame spraying there was first applied nickel aluminide as a continuous and substantially even circumferential layer 24 about 0.001 inches thick, (by a single relative rotational pass between core and flame spray nozzle) as indicated by FIG. 2; and a flash coating of copper next was similarly flame spray applied to a thickness of about 0.005 inches, thus producing composite bonding layer 21 indicated in FIG. 3. However, a lighter "flash" copper layer on the order of 0.002 inches thickness would be suitable. Thereafter plasma spray applied alumina was built up to a depth of 0.010 inches as the circumferentially continuous ceramic layer 26 as indicated by FIG. 4. Finally again by flame spraying, copper was applied evenly to a thickness of about 0.010 inches to form a continuous circumferential layer 27 as shown in FIG. 5. After the resulting commutator blank was turned down in a truing operation resulting in a final thickness of the external copper layer of about 0.007 inches, the outer copper layer was longitudinally slotted down to the insulating layer to provide the slots 23 thus resulting in a finished commutator with the bars B defined between the slots 23. The particle spray fusion operations, i.e., the operations of flame spraying and the plasma spraying of the various applied materials, were carried out by known techniques and equipment for these operations; and so also the turning and slotting were effected by methods and equipment conventional for such operations on commutators. Where the particle spray fusion applications, especially the final copper application, are carried out with close control, e.g., with proximity sensors, and good chucking of the blank internally, the turning to true may be avoided.

MASKING MODIFICATION

To eliminate the specific slotting operation, after the blank fabrication has reached completion of the stage of ceramic application as shown in FIG. 4, on a ceramic covered circumference there is placed a spider mask providing elongated thin bars or legs 30 extending longitudinally over the blank's ceramic surface and having mutual spacing and cross section dimensions corresponding to the desired bar-defining slots as fragmentarily represented in FIGS. 8 and 9. Thereafter the final copper layer is flame sprayed on and after the turning operation to true the commutator, the mask is removed.

The mask may have a cage-like form, and be molded, for example, of a suitable plastic for a single-use throw-away type; or made of a tool steel for more permanent reusable tooling. In either case as required a suitable release agent, such as one of the known mold release agents, is used on the mask to facilitate removal without unduly stressing the applied copper. As may be needed the copper layer 27 is turned down to appropriate dimension and concentricity; and for this purpose the throw away type mask is particularly useful, since less concern is then required for the character and use of the cutting tools.

INTEGRATION OF COMMUTATOR FABRICATION

WITH GENERAL ARMATURE FABRICATION

With further economic advantage, the application of

the copper layer 27 may be carried out by the previously described particle spray process on a partially fabricated armature assembly. A commutator core blank, with the ceramic layer applied, is positioned and secured on an armature shaft carrying the armature lamination stack and ready for winding with modern magnet wire insulated by a polyurthane or Formvar-Nylon insulation coating. The armature coil winding is carried out producing coil leads which are placed in appropriate locations on the proximate blank ceramic layer margin. The flame spray application of the copper penetrates and destroys the wire insulation on the ends of the leads and embeds the lead ends in the built up thickness of the sprayed on copper layer, thus effecting both the electrical and the physical mechanical connection of the leads to the commutator. Thereafter the remaining prior described steps are carried out, with turning to true and dimension concentrically the commutator surface; and finally either slotting or removal of the mask depending upon the approach taken to produce the bar-defining slots. Hence, end slotting or other formation or treatment of the bars for lead attachments and the specific operations for connecting the individual leads and bars are eliminated.

In the following examples the portion of the lead to each bar is so connected.

The fragmentary view of FIGS. 7, 8, and 9 commonly indicate first the circumferentially equi-spaced legs 30 of the mask defining successive commutator slots and therebetween space to be filled in with the sprayed on copper so to form respective bars. These legs 30 are joined into an integral cage-like structure by at least one end ring 30a at the outward commutator blank end; and against the other blank end, disposed towards the lamination stack, a disk of insulating material 31 in FIG. 7, 32 in FIGS. 8-9, supports the coil lead ends L. Midway between each pair of successive legs, the end disk 31 has a respective lead anchoring projection 31a about which the coil wire is looped in forming the respective lead L during the winding; while in disk 32 there are similarly located notches 32a through each of which is laid and wedges the respective lead L from the core winding.

For the usual armature, the end disk 31 (or 32), preferably a permanent element, is first placed on the shaft against a stop shoulder and the core blank pressed on thereagainst, either already provided with the bonding layer 21, or with this applied to the core on the shaft before lead placement. Then the mask is appropriately positioned on the insulated core blank and set in angular as well as axial sense either before or after the core winding operation; with the possibility that the leads L in the case of disk 32 may be machine-laid directly into the locating slot 32a as a part of the overall winding operation; or thereafter the leads may be bent down to their appropriate receiving notches. The flame spray application of the copper on to the edge of disk 31 embraces the lead loop and is sufficient.

For this purpose a throw-away or one-shot type mask made of a suitable plastic is applicable, preferably molded with a slight taper in longitudinal and radial directions to provide "draft" for safe, easy removal. In the case of a steel tooling type mask, obviously a release agent is to be applied before placement on the core blank to afford a simple mask form to be axially withdrawn from the finished armature, rather than a

complex mask designed to achieve a clearance with the sprayed on copper before axial withdrawal.

A plastic mask might be left in place as a permanent part of the structure where the commutator service is not demanding.

COMMUTATION WITH LEAD CONNECTOR TANGS

(FIGS. 10-12)

To produce a lead attaching tang construction, the structure and process may be modified as indicated in FIGS. 10-12, for either the preparation of the total commutator apart from the armature, or as above described partially incorporated in the armature assembling procedure.

Again after the method has advanced to completion of the ceramic layer application as represented by FIG. 4, a grommet-like short copper sleeve 40 reflexly flanged at one end (as indicated by the longitudinal cross section appearing in fragmentary FIG. 10) is applied to one end of the blank. The short cylindrical body 41 has a multiplicity of apertures 43 over much of its area, up to the somewhat inwardly reflected flange 42 at the right.

The grommet may be produced directly in annular form or be made as perforated strip formed and curled to the ring.

Preferably the sleeve 40, with at least a light press fit, is pushed on to one end of the ceramic coated blank to bring the flanged outer end slightly inward of the commutator edge. The copper is flame sprayed over the length and circumference of the commutator including the sleeve to the depth indicated by the dotted line 27. This thus builds not only the commutator bar or segment material, but in penetrating the extensively apertured area of the sleeve body 41 and by application near its outboard end, also secures the element 40 in position. Where no masking has been used, after truing turning, the longitudinal slotting, being carried through the layer 27 and through the now incorporated integrated element 40 and beyond the flange 42, not only provides the separate commutator segments, but also produces respective tangs resulting by the slotting division of the flange portion.

The slotting tool may be shaped not only to cut the slot as such through the layer 27 but also to work on each side to cut a triangular notch at the flange 42 to give a narrower tang projection for more convenient wire application.

On the other hand, if a masking procedure is used as might be done to define at least the major part of the length of the longitudinal slots, then after the turning operation, slotting may be carried out only as then required across the region formerly occupied by the element 40 to complete the slots and define the tangs.

Also it may be noted that the flame spray application of copper or other conductive metal may be used to secure individual lead tangs to carbon commutator segments or bars; or the described "grommet" structure may be bonded thereto as described above and thereafter slotted.

COMMUTATOR MODIFICATION AND FABRICATION

(FIGS. 13-15)

For a commutator requiring a more rugged structure,

or intended for heavier duty or demands of one type or another, rather than having the simple cylindrical surface as in the aforescribed forms and methods, the core, as indicated for the core 120 in FIG. 12 and FIG. 14, corresponding to the spacing of the ultimate slots dividing the commutator bar segments, has longitudinal slots 50 of a dove tailed type slot cross section, that is, with opposite longitudinal sides sloping towards each other.

Following the procedure previously described, for example, with respect to FIGS. 1-6, except as hereinafter noted, the layers 24, 25, 26 and 27 may be successively applied each not only to the cylindrical circumferential surface but also continuously there-with through the sides and bottom of each slot 50 to arrive at the structure shown in FIG. 14 wherein, for simplicity and clarity of representation, the resultant so-called "bonding insulating" layer is designated as the single layer 21. The final copper layer is flame sprayed not only for its circumferential continuity but also to fill completely the residual space of the coated slots 50.

After the blank is turned to dimension and concentricity as previously, the slots are now cut longitudinally through the copper down to the insulation layer at the bottom of groove locations 50, and precisely centrally of the location of each of the grooves 50 as indicated at 123 (dot-dash lines in FIG. 14; full lines in FIG. 15) providing then a finished commutator. Here it will be observed that the blank surface or core surface region between the successive grooves 50 now has formed in effect a dove tail type engagement with each commutator segment B, that is, opposite longitudinal edges of each segment B have a wedged interlock under the sloping shoulders of the respective grooves 50.

Certain aspects in the aforescribed processes and structures are as well applicable especially to commutators for lower performance demand where, for example, a bonding and insulating layer may be provided on a base core of aluminum, steel or other material, for example, by fluidized bed coating an epoxy resin on a blank such as that for the FIG. 1 type commutator or a FIG. 12-14 type commutator. To this as a simple insulating and bonding layer, there is then again flame sprayed the copper material to the appropriate thickness to provide the copper segments with the bar defining slots provided either by the masking or by slotting as previously described for FIGS. 1-15 inclusive.

I claim:

1. A method of making a cylindrical metal-cored commutator, comprising the steps of:

providing a generally circularly cylindrically surfaced metal core, and applying a bonding layer on the cylindrical surface of said core;

depositing a circumferentially continuous metal oxide insulating layer on the bonding layer, by particle spray fusion;

forming a plurally axially interrupted conductive layer of sprayed-on molten conductive metal particles fused together and fused onto said insulating layer, thereby to provide a circumferential array of commutator bars.

2. The method as described in claim 1, wherein said circumferential array is formed by masking said metal oxide layer with spaced thin longitudinally extending elements, then spraying on said molten particles,

and removing said elements after solidification and cooling of the sprayed on material.

3. The method as described in claim 1, wherein said circumferential array is formed by spraying on said molten particles to form a circumferentially continuous outer layer, and thereafter axially plurally slotting the last said layer down to the said metal oxide layer at equi-angularly spaced locations.

4. The method as described in claim 3, including the further step of turning said outer layer to concentricity with a rotational axis of said core before slotting.

5. A method as described in claim 2, including the further step of turning said outer layer to concentricity with a rotational axis of said core before removal of said elements.

6. The method as described in claim 3, wherein as said core there is provided an aluminum cylinder; said bonding layer is applied by flame spray deposition of first a thin layer of nickel aluminide onto the surface of said core

and then a layer of copper; said insulating layer is aluminum oxide; and said conductive layer is copper.

7. The method as described in claim 6, including a step of longitudinally dove-tail slotting said aluminum cylinder at equi-angularly spaced locations corresponding in number and spacing to desired commutator bars; before applying said bonding layer,

said bonding layer carried continuously down into and out of the resultant dove-tail slots, said molten particles being applied to said insulating layer in said dove-tail slots to fill the dove-tail slots as well as to build up said circumferentially continuous outermost layer to a substantially cylindrical form;

the plural slotting being carried out at the respective centers of the dove-tail slots.

8. The method as described in claim 6, including the further steps of

forming an outwardly flanged copper collar having a cylindrical body with numerous generally uniformly distributed apertures therethrough, the body having a length appreciably less than half the length of said core and an inside diameter to closely fit on said core after said insulating layer is applied;

fitting said collar, with flanged end trailing, onto one end of the insulated core with the flanged end slightly inboard of the core end face;

then carrying out the forming of the plurally axially interrupted layer by first flame spraying molten copper particles on the exposed portions of the insulating layer and over the body of the collar thereby to embed the body leaving the flange projecting from said outer layer, and then carrying out said slotting through the entire collar as well as the outer layer to define, by the slotting of the projecting flange, coil lead attaching tangs for respective commutator bars.

9. The method as described in claim 2, wherein at least the step of forming the interrupted conductive layer is carried out with said core emplaced on a shaft carrying an armature stack; and including the steps of winding the armature coils onto the armature stack, and placing the coil leads in equi-spaced locations to project over the said insulating layer at one end of the core, and

thereafter spraying on molten copper particles as said conductive metal particles to mechanically and electrically connect said leads into the resultant commutator structure.

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