

June 17, 1969

R. P. BURR

3,450,918

COPPER-ALUMINUM ARMATURES

Filed May 9, 1966

Sheet 1 of 5

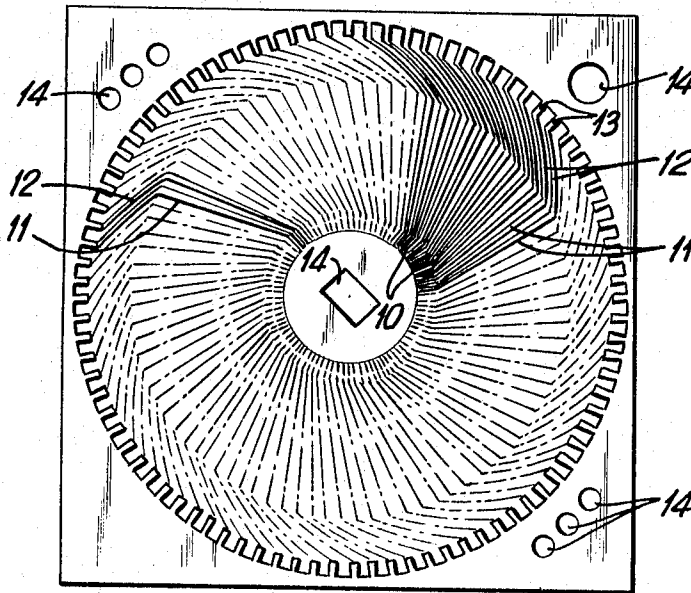


FIG. 1

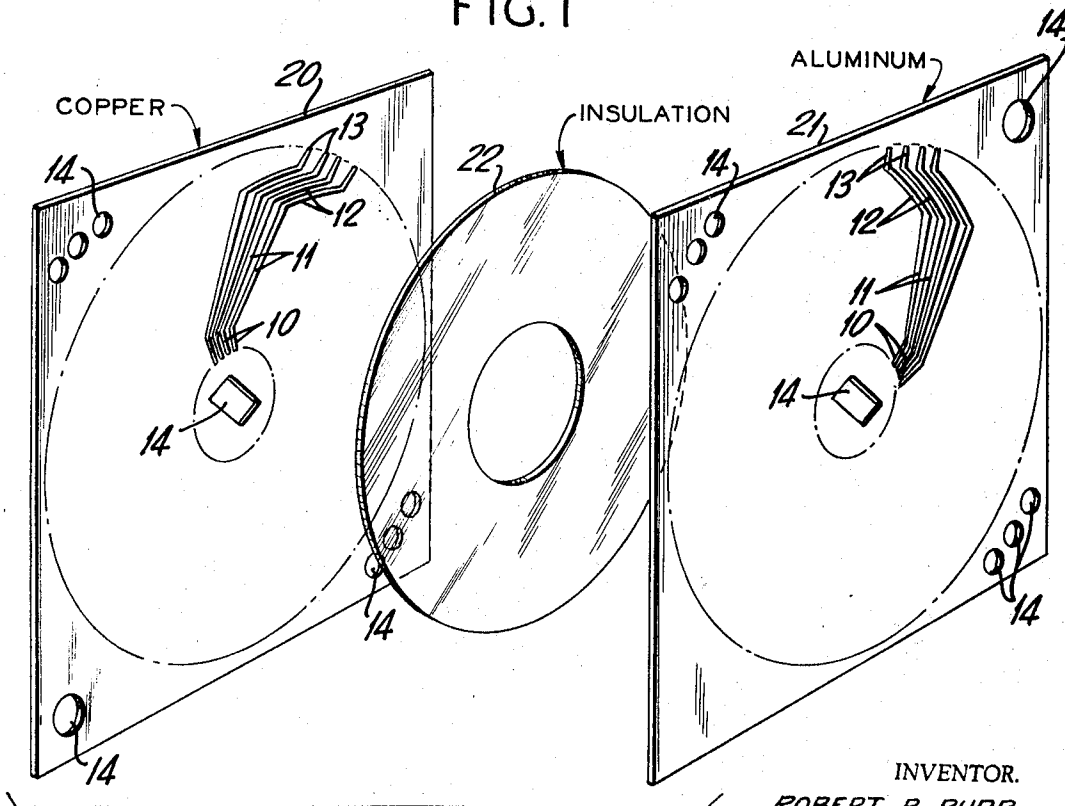


FIG. 2

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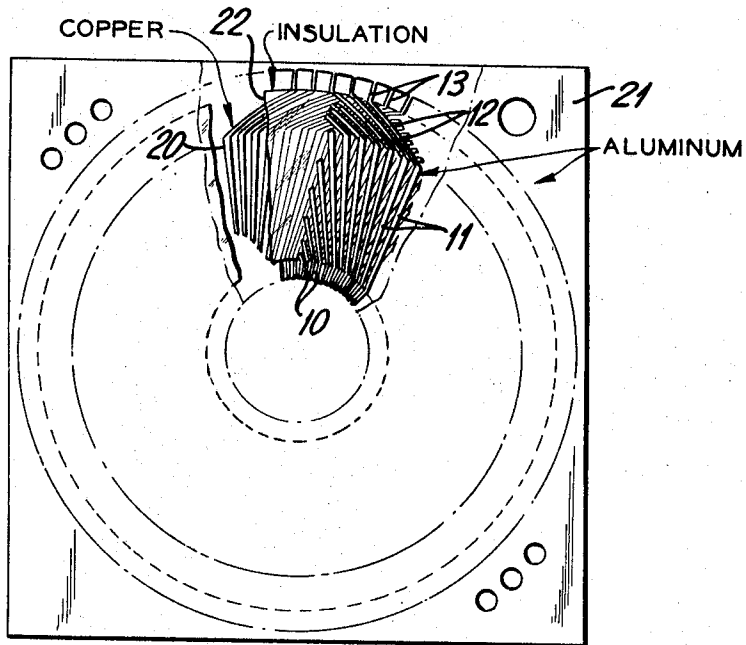


FIG. 3

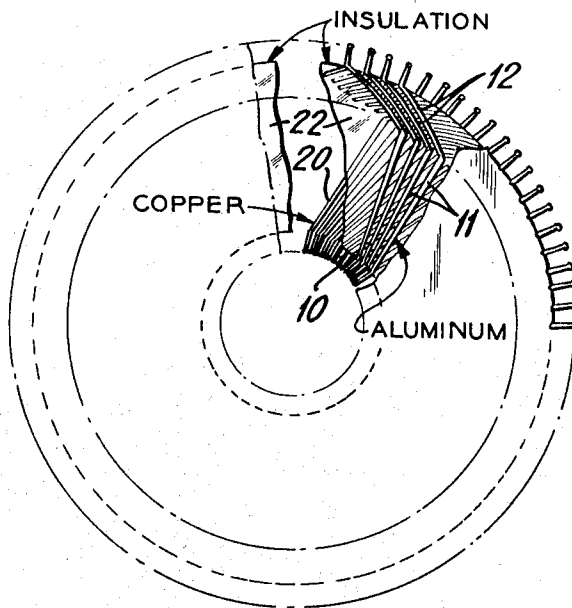


FIG. 4

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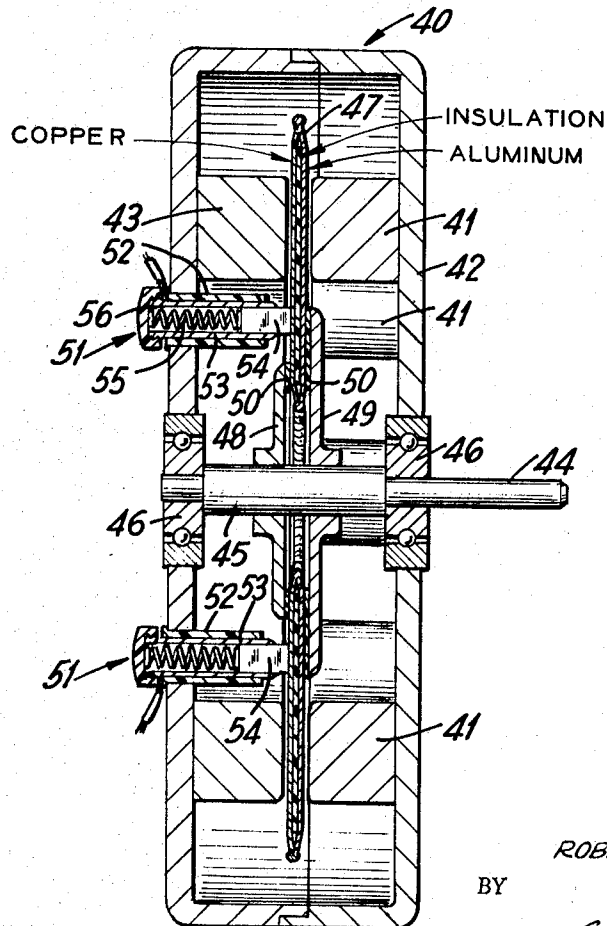
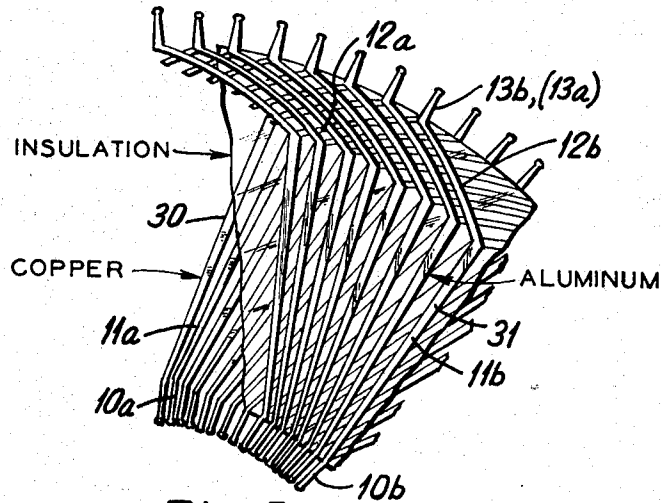
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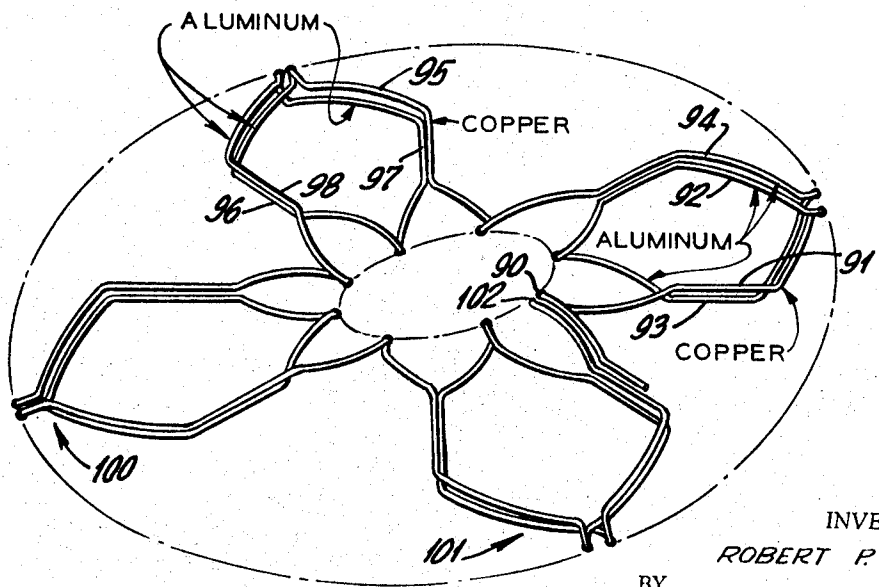
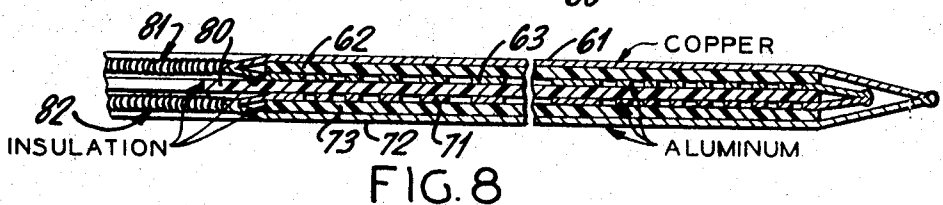
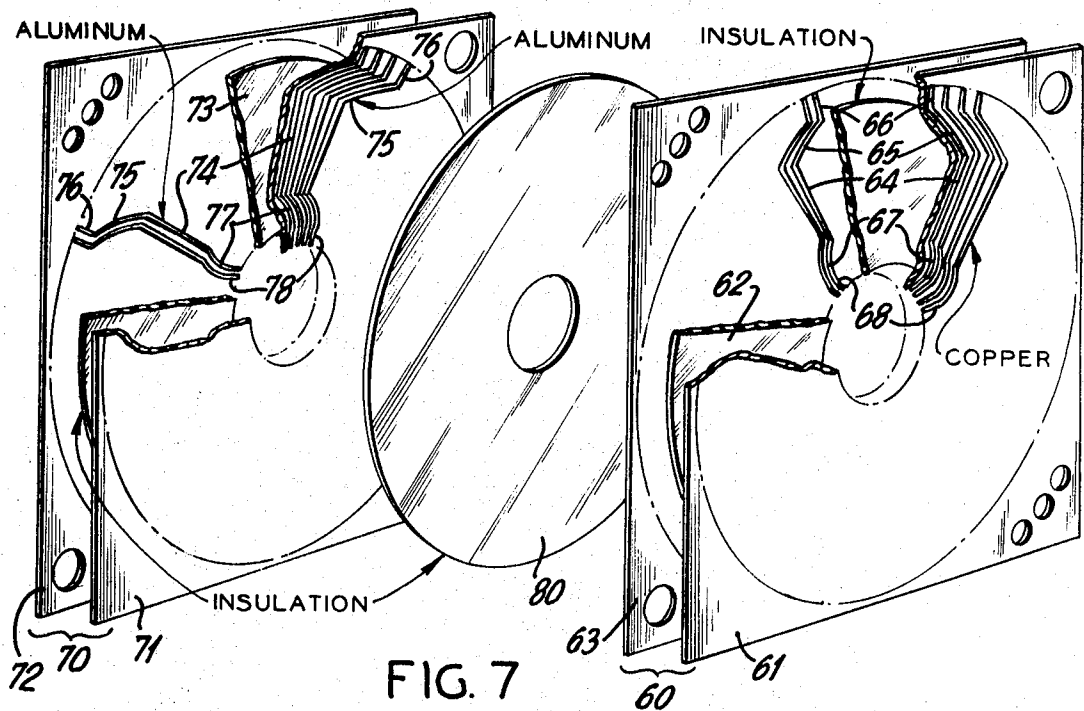
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Sheet 4 of 5



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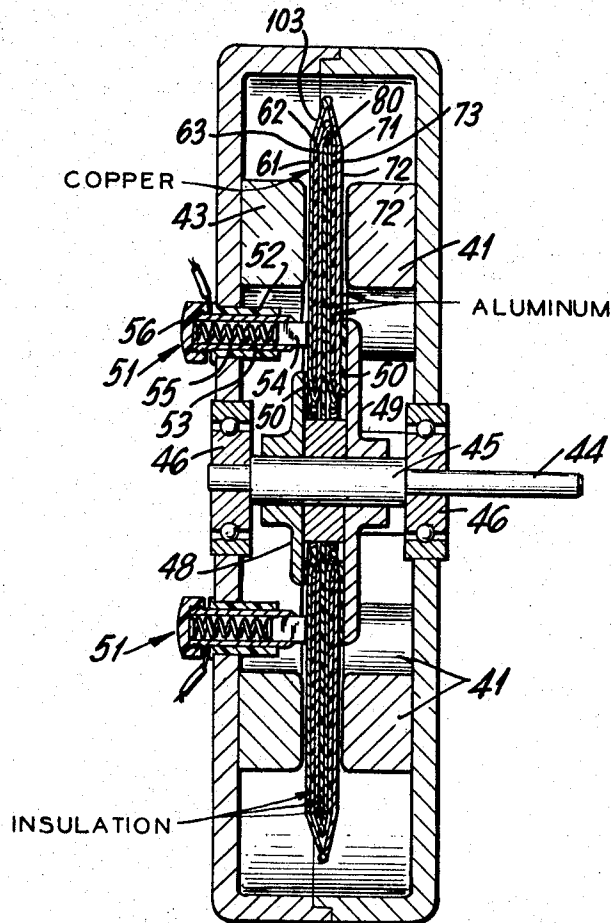


FIG. 10

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COPPER-ALUMINUM ARMATURES

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Int. Cl. H02k 1/22, 13/04; H01r 39/00

U.S. Cl. 310—268

9 Claims

ABSTRACT OF THE DISCLOSURE

A two or more layer armature in which one layer is copper to provide a commutating surface and the remaining layers are aluminum. The conductor patterns forming the layers of the armature are made on a notching press, are then bonded to an insulating carrier, and the conductors are thereafter interconnected by welding.

This invention relates to electrical rotating machinery of the type having a disc shaped armature. Machines of this general type are disclosed in U.S. Patent 3,144,574 issued to J. Henry-Baudot on Aug. 11, 1964, the disclosure of which is incorporated herein and forms a part hereof.

In a disc type electrical machine the armature conductors are usually located in two or more separate planes which lie on opposite sides of an insulating carrier. Half of each armature turn is located on one side of the carrier and the other half is located on the other side of the carrier so that an entire armature winding can be constructed without crossing conductors on the surface of the carrier. The armature is energized (in the case of a motor) by brushes bearing directly on the flat, closely spaced armature conductors thereby eliminating the need for a separate commutator. The resulting electrical machine normally does not include iron in the armature and as a result it is a low inertia machine with essentially linear acceleration and deceleration characteristics.

It is an object of this invention to provide an electrical machine of the disc armature type which can be constructed at a lower cost.

It is another object of the invention to provide a disc type electrical machine in which the armature inertia is further reduced.

In the armature structure in accordance with this invention aluminum is used to replace copper in certain portions of the winding to take advantage of the lower cost and lighter weight. Aluminum is not used in the commutating area, however, since aluminum tends to oxidize and form a highly resistive surface coating. The array of conductor surfaces which cooperate with the brushes to form the commutator is made from copper whereas the conductors in all other areas are made from aluminum. The resulting armature is lighter and less expensive than a comparable all copper armature and does not suffer any significant disadvantages.

The invention is described in greater detail in the following specification which sets forth several illustrative embodiments of the invention. Although the invention is described with respect to electrical motors, it is also applicable to generators on other electrical equipment. The drawings form part of the specification wherein:

FIGURE 1 is a plan view illustrating the metal stamping used to form the conductor arrays in the armature;

FIGURE 2 is a perspective assembly diagram illustrating the manner in which two such stampings and an insulated carrier are assembled to form an armature unit;

FIGURE 3 is a plane view with portions broken away illustrating the armature unit after the center has been

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blanked and the inner bridging connections completed;

FIGURE 4 is a plan view with portions broken away illustrating the armature unit after surrounding excess material has been removed and the outer bridging connections completed;

FIGURE 5 is an enlarged partial plan view of the completed armature structure;

FIGURE 6 is a cross sectional view of a completed disc type motor including the armature assembly constructed in accordance with FIGURES 1-5;

FIGURE 7 is a perspective assembly drawing illustrating the manner in which a four layer armature is constructed;

FIGURE 8 is a cross sectional view of the four layer armature;

FIGURE 9 is a perspective view illustrating the configuration of an armature loop in the four layer armature winding; and

FIGURE 10 is a cross sectional view of a completed motor including a four layer disc type armature.

The armature in a disc type machine includes a large number of generally radially extending winding segments distributed evenly about an annular area that will be adjacent the magnetic pole faces in the completed machine. These winding segments are interconnected to form a continuous closed armature winding. Successive winding segments are displaced by distance approximately equal to the distance between adjacent pole centers of the associated magnetic structure and are interconnected so that current flow is in one direction across the north magnetic poles and in the opposite direction across the south magnetic poles.

The armature constructed in accordance with this invention includes radially extending winding segments arranged in at least two parallel arrays conveniently located on opposite sides of an insulated carrier disc. One such array of winding segments is made from copper to provide a commutating surface and the remaining arrays are made from aluminum.

An array of radially extending winding segments for the armature is conveniently formed by means of a metal stamping such as shown in FIGURE 1. The stamping can be formed in a single stamping operation, or by a notching operation wherein the metal sheet is indexed and the metal between adjacent winding segments is stamped out in successive operations. Each of the winding segments in the completed stamping includes an inner tab 10, a generally straight radial portion 11, an outer tab 13 and an arcuate portion 12 between the straight portion and the outer tab. The angular distance between the inner and outer tabs of a winding segment is approximately equal to the distance between adjacent pole centers of the associated magnetic pole structure. In the completed stamping the winding segments remain attached to the surrounding metal via the inner and outer tabs 10 and 13 respectively. The stamping is provided with various apertures 14 which facilitate the assembly operations and provide registry when the stampings are aligned.

As illustrated in FIGURE 2, a two layer wave type armature is assembled using a pair of these stampings, one such stamping 20 being made from copper and the other stamping 21 being made from aluminum. It should be noted that the two stampings have identical configurations but that one stamping is reversed over with respect to the other, or in other words, one stamping is rotated 180° about an axis in the plane of the stamping. As a result, when the stampings are aligned as shown in FIGURE 2, the arcuate portions of the winding segments in the stamping 20 extend from the outer tab in a clockwise direction whereas the arcuate portions of the winding segments in stamping 21 extend from the outer tabs in a counterclockwise direction.

A dielectric disc 22 is inserted between the stampings to serve as the winding carrier. This carrier is constructed from any suitable electrically insulating material and is in the shape of an annulus. The diameter of the central opening and the outer diameter of the disc are selected so that the carrier fits between the inner and outer tabs of the stamping.

The stampings are brought together to form a sandwich as indicated in FIGURE 3 including the insulating carrier between the stampings. The positions of the stampings are then adjusted so that the inner and outer tabs come into alignment. Next, the central portions of the stampings are blanked out to free the ends of the individual inner tabs 10. Adjacent tabs in the upper and lower stampings are then welded together to form the inner bridging connections between the winding segments.

The excess material surrounding the conductor segments is next removed by a suitable blanking operation and the adjacent outer tabs in the two stampings are then welded together by similar process to form the outer bridging connections. The completed armature structure appears as shown in FIGURES 4 and 5.

As can best be seen in FIGURE 5, radial winding segment 30 from the copper stamping including its inner tab 10a, straight radial portion 11a, arcuate portion 12a and outer tab 13a is on one side of the carrier and is joined to winding segment 31 from the aluminum stamping including its outer tab 13b, arcuate portion 12b, straight portion 11b and inner tab 10b located on the opposite side of the carrier. These winding segments are joined by the bridging connection formed by tabs 13a and 13b and when joined form an armature turn. The spacing between the radial portions of the winding segments of an armature turn is approximately the same as the spacing between pole centers of the associated magnetic pole structure. In an eight pole machine, for example, an armature turn spans approximately 90°. Inner tab 10b is connected to the beginning of the next armature turn and four such successive armature turns make up an armature loop which spans slightly less than 360°. The actual span of an armature loop is selected so that the end of the armature loop is at the proper point for the beginning of the adjacent armature loop and therefore the winding progresses with successive armature loops being slightly clockwise with respect to the preceding one. The armature winding is therefore evenly spread about the annular carrier surface and eventually returns to the starting point to thereby provide a closed winding.

The completed motor assembly is shown in FIGURE 6 and includes a housing 40 having two similar members each including a circular base plate and an integral cylindrical portion extending from the periphery of the base plate. The illustrative motor is an eight pole machine and therefore eight cylindrical slugs 41 of an aluminum-nickel-cobalt alloy material such as Alnico are secured to one of the base plates 42. These magnetic slugs are evenly distributed to form an annular array of pole faces and are each secured to the base plate by means of an adhesive such as Epoxy cement. The magnetic slugs are magnetized to provide pole faces of alternating north and south magnetic polarities. An iron ring 43 is positioned directly opposite the annular array of pole faces to complete the magnetic path between adjacent pole faces and to provide a working air gap between the ring and the magnetic slugs which accommodates the armature winding.

The armature is mounted on a shaft 44 provided with an increased diameter portion 45 positioned between a pair of ball bearings 46 to prevent axial movement. The bearings are centrally mounted within suitable openings in the base plates. The armature 47, constructed in the manner illustrated in FIGURES 1-5, is clamped between a pair of flanges 48 and 49 of a hub structure which are rigidly secured to shaft 44. Dielectric spacers 50 are positioned to insulate the armature winding from the hub structure.

Each of the brush holders 51 includes an insulated bushing 52 having an annular shoulder at one end so that the bushing can conveniently be inserted through a suitable opening in one of the base plates. A conductive metallic sleeve 53 is secured within the bushing and is dimensioned to accommodate a rectangular brush 54. The brush is urged toward the armature by means of a compression spring 55 located between the brush and an insulated cap 56 threaded on to the end of sleeve 53 which extends beyond the end of brushing 52. The armature is positioned so that the copper winding segments are adjacent the brushes. The electrical leads are attached to conductive sleeves 53 and the electrical circuit to the copper winding segments is completed via sleeves 53 and brushes 54. Flange 49 preferably has sufficient diameter to provide structural backing for the armature opposite the brushes. The number of brushes and the position relative to the pole faces depends upon the armature winding configuration and the current carrying requirements of the brushes.

Disc type armatures can similarly be constructed to include more than two layers. Increasing the number of layers has the desirable effects of increasing the number of series turns in the winding to thereby increase the operating voltage, and of increasing the aluminum to copper ratio since only one of the layers need be made from copper.

To construct a four layer armature, a pair of two layer subassemblies 60 and 70 as shown in FIGURE 7 are first constructed. Subassembly 16 includes two stampings having the same configuration, one stamping 61 being made from copper and the other stamping 63 being made from aluminum. These stampings are placed on opposite sides of a dielectric carrier 62. The winding segments of the stampings each include a straight portion 64, an outer arcuate portion 65 connected to an outer tab 66, and an inner arcuate portion 67 connected to an inner tab 68. One of these stampings is reversed with respect to the other so that the inner and outer arcuate portions of stamping 61 extend from the outer tabs in a clockwise direction (as viewed in FIGURE 7), and the inner and outer arcuate portions of stamping 62 extend away from the outer tabs in a counterclockwise direction.

The stampings are formed in the manner previously described. A sandwich is then formed including a pair of the stampings with the dielectric disc in between. Dielectric disc 62 is in the shape of an annulus with the central opening and outer diameter selected so that the annulus fits between the inner and outer tabs of the stampings. After the tabs are aligned, the centers of the stampings are blanked out and adjacent inner tabs are welded to form the inner bridging connections.

The other two layer subassembly is constructed in similar fashion and includes a pair of identical aluminum stampings 71 and 72 with a dielectric disc carrier 73 in between. Stampings 71 and 72 differ somewhat from stampings 61 and 63. Each winding segment of stampings 71 and 72 includes a straight portion 74, an outer arcuate portion 75 connected to an outer tab 76, and an inner arcuate portion 77 connected to an inner tab 78. One of the stampings is reversed so that in the completed subassembly the arcuate portions of stamping 71 extend from the straight portion in a counterclockwise direction (as viewed in FIGURE 7), and the arcuate portions of stamping 72 extend away from the straight portion in a counterclockwise direction. It should be noted that the angular distance between the inner and outer tabs of stampings 61 and 63 is approximately equal to the distance between pole centers of the associated magnetic stator structure. In stampings 71 and 72 the inner and outer tabs are substantially aligned on the same radius with straight portions 74 being offset with respect to the tabs. After stampings 71 and 72 have been formed they are aligned and the centers are blanked out. The inner tabs are then welded to form the inner bridging connections.

The two subassemblies are then brought together on

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opposite sides of a third dielectric carries disc **80**. This carrier disc is also in the shape of an annulus. The central opening has a diameter somewhat less than the opening inside the inner tabs of the subassemblies. The outer diameter of the disc is selected so that the disc fits within the arrays of outer tabs. The outer tabs are aligned and the assembly is then clamped. The excess material surrounding the outer tabs is removed and the outer tabs are then welded to form the outer bridging connections. As shown in FIGURE 8, dielectric disc **80** fits between the two separate arrays of inner tabs **81** and **82**, and therefore prevents shorting contact between these tabs. The outer tabs are adjacent one another in a single array (one set of outer tabs **83** is shown inside the other set **84**, but this is merely for clarity of illustration). The arrangement shown in FIGURE 8 with two separate inner tab arrays and a single outer tab array is preferable since the available spacing between inner tabs is less than that between the outer tabs.

In the completed four layer armature the winding segments are interconnected as shown in FIGURE 9 wherein one armature loop including eight armature turns is shown for an eight pole machine. The armature loop can be traced beginning at point **90** and proceeding through a copper segment **91** of the top layer, and then through an aluminum winding segment **92** in the third layer to complete one armature turn. The next armature turn is in essentially the same annular position in the armature and includes an aluminum winding segment **93** in the fourth layer and another aluminum winding segment **94** in the second layer. The first pair of armature turns span approximately 90°. Winding segment **94** is connected to the beginning of the next pair of armature turns which similarly include a copper winding segment **95** followed by three aluminum winding segments **96-98**. The third and fourth pairs of armature turns **100** and **101** follow in succession to complete the first armature loop. This armature loop spans slightly less than 360° and ends at point **102** which will be the beginning of the next adjacent armature loop. The winding continues in this fashion and eventually returns to the starting point **90** to complete an evenly distributed armature winding.

The complete motor is illustrated in FIGURE 10 and is essentially the same as that previously described in FIGURE 6 except for the armature. The armature **103** includes the four layers of winding segments, that is, it includes layer **61** of copper winding segments and three adjacent layers **63**, **71** and **72** of aluminum winding segments. The armature is positioned so that the copper winding segments are adjacent brushes **54**. With the four layer armature, a bushing **104** is placed surrounding the shaft between flanges **48** and **49**. The inner diameter of the center carrier disc **80** which extends beyond the inner tabs has the same diameter as the bushing and therefore acts to center the armature relative to the shaft.

While only a few illustrative embodiments have been described in detail it should be obvious that there are numerous variations within the scope of this invention. It should be noted that the armature can be constructed without carrier discs as is more fully described in co-pending application Ser. No. 554,262, filed on May 9, 1966, in the name of Robert Page Burr. The invention is more particularly described in the appended claims.

What is claimed is:

1. An armature for an electrical machine having a multipole stator structure comprising:
 - an armature disc presenting a closed loop armature winding including;
 - a substantially uniform array of copper winding segments lying in a first plane each winding segment extending in a generally radial direction;
 - a substantially uniform array of aluminum winding segments lying in a second plane parallel and adjacent said first plane, each winding segment extending in a generally radial direction;

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means insulating said aluminum array of winding segments from said copper array of winding segments; bridging connections for interconnecting said winding segments to form armature turns in at least one series circuit with successive winding segments being in different arrays and spaced apart circumferentially approximately in accordance with the distance between pole centers of the associated stator structure, said array of copper winding segments being disposed to present a commutating surface for said armature.

2. An armature in accordance with claim 1 wherein said insulating means is a dielectric carrier positioned between said arrays.

3. An armature for an electrical machine having a multipole stator comprising:

an armature disc presenting a closed winding and including,

a substantially uniform array of copper winding segments lying in a first plane perpendicular to the axis of rotation for the machine, each winding segment extending in a generally radial direction,

a plurality of substantially uniform arrays of aluminum winding segments each lying in a different plane parallel to said first plane, each of said aluminum winding segments extending in a generally radial direction,

means insulating each array of winding segments from winding segments in other arrays,

bridging connections for interconnecting said winding segments to form armature turns in at least one series circuit with successive winding segments being in different arrays and spaced apart circumferentially approximately in accordance with the distance between pole centers of the associated stator structure, said array of copper winding segments being disposed to present a commutating surface for said armature.

4. An armature in accordance with claim 3 wherein said armature includes one array of copper winding segments and three arrays of aluminum winding segments.

5. A rotating electrical machine comprising:

a stator structure having magnetic poles distributed to form an annular air gap, said poles alternating in magnetic polarity,

a disc shaped rotor mounted for rotation in said air gap and including a closed loop armature winding having

a substantially uniform array of copper winding segments lying in a first plane within said air gap, said copper winding segments extending transversely of said annular air gap,

at least one substantially uniform array of aluminum winding segments lying in a different plane within said air gap, said aluminum conductors extending transversely of said annular air gap,

means insulating winding segments in one of said arrays from winding segments in the other of said arrays,

bridging connections for interconnecting said winding segments to form a closed armature winding including at least one series circuit with successive winding segments being in different arrays and spaced apart circumferentially in accordance with the distance between centers of said magnetic poles,

brushes disposed to engage said copper conductors, and means physically securing said brushes to said stator structure.

6. An armature for an electrical machine having a multipole stator comprising:

an armature disc presenting a closed winding and including

a first substantially uniform array of copper winding segments lying in a first plane perpendicular to the axis of rotation for the machine, each of said copper winding segments extending in a generally radial direction;

second, third and fourth substantially uniform arrays

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of aluminum winding segments lying in separate planes parallel to said first plane, each of said aluminum winding segments extending in a general radial direction;

a center dielectric carrier between said second and third arrays and additional dielectric carriers between said first and second arrays and between said and fourth arrays;

bridging connections for interconnecting said winding segments to form armature turns in at least one series circuit with successive winding segments being in different arrays and spaced apart approximately in accordance with the distance between adjacent pole centers of the associated stator structure and including;

inner bridging connections between said first and second arrays lying on one side of said center carrier,

inner bridging connections between said third and fourth arrays lying on the opposite side of said center carrier, and

outer bridging connections between said first, second, third and fourth arrays,

said array of copper winding segments being disposed to present a commutating surface for said armature.

7. An armature in accordance with claim 6 further comprising a shaft and wherein said center carrier has a central opening adapted to cooperate with said shaft to center said armature thereon.

8. In a disc armature for an electrical machine includ-

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ing a plurality of parallel layers of generally radially extending winding segments interconnected by bridging connections passing from layer to layer to form a closed armature conductor pattern, the improvement comprising such an armature conductor pattern wherein at least one exterior surface of said conductor pattern is copper to provide a commutator surface and the remainder of said conductor pattern is aluminum.

9. In a disc armature for an electrical machine including a plurality of parallel stamped layers insulated from one another, each such layer including generally radially extending winding segments which are interconnected by bridging connections passing from layer to layer to form a closed armature winding, the improvement comprising such an armature winding wherein an exterior one of said layers is made from copper and wherein the remaining layers are made from aluminum.

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