

PATENT SPECIFICATION

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(54) DYNAMOELECTRIC MACHINES AND METHODS OF MAKING SAME

(71) We, GENERAL ELECTRIC COMPANY, a corporation organised and existing under the laws of the State of New York, United States of America, residing at 1 River Road, Schenectady 12305, State of New York, United States of America do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates generally to dynamoelectric machines and to methods of making the same.

It has long been recognized that many diverse and often conflicting criteria must be satisfied by dynamoelectric machines that are reliable and efficient in operation and yet economical to manufacture. For example, the stator housing must have sufficient structural integrity to protect the windings supported on a stator core from being damaged during manufacture, handling, or use of the completed machine.

According to the present invention in one aspect there is provided a dynamoelectric machine comprising a stator assembly including a stator core and at least one winding thereon, a rotor, at least one bearing mounting the rotor, and a housing which is bonded to and houses the stator assembly, supports and locates the bearing, and thus also connects the bearing and the stator assembly together, said housing comprising electrically insulating inert inorganic particulate material bonded together by an adhesive material to form an impact-resistant, thermally conductive, substantially rigid mass, at least 50% by weight of said particulate material having a particle size of from 40 to 100 mesh.

According to the present invention in another aspect there is provided a method of making dynamoelectric machine constructed as set forth in the immediately preceding paragraph, comprising positioning the stator assembly in a mould,

introducing said particulate material and said adhesive material into said mould and around said stator assembly, retaining the adhesive material in interstices between the particles, hardening the adhesive material to form said housing and to bond the housing to said stator assembly, removing the so-formed structure from the mould, positioning the rotor in operative relation to the stator assembly, and positioning the bearing relative to said housing to be supported and located thereby.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

FIGURE 1 is a rear elevation of a dynamoelectric machine according to the invention;

FIGURE 2 is a view taken along line 2—2 of Figure 1 with parts in section and parts broken away;

FIGURE 3 is an enlarged representation of a photo-micro-graph of the surface of the stator housing of the dynamoelectric machine of Figure 1;

Figures 4, 5 6, and 7 schematically represent the steps of a method exemplifying one form of the invention and which is utilized to manufacture the dynamoelectric machine of Figure 1;

Figure 8 is a perspective view of a stationary composite structure manufactured according to the method graphically represented in Figures 4 to 7;

Figure 9 is a graphical representation of another method exemplifying the invention;

Figure 10 is a rear view of another embodiment of the invention;

Figure 11 is a sectional view taken along the line 11—11 of Figure 10;

Figure 12 is a front view, with parts broken away, of the embodiment of Figure 10;

Figure 13 is a view taken along the line 13—13 of Figure 12;

Figure 14 is a rear view of still another

embodiment of the invention; and

Figure 15 is a view, partly in section and partly in full, taken along the line 15—15 of Figure 14.

Referring now to the drawings in more detail, and in particular to the form of the invention embodied in Figures 1 and 2, there is illustrated a single bearing motor 20 that includes a stationary composite structure 22 and a bearing structure 23 that comprises a bearing support 24 secured to the stationary composite structure, a sleeve bearing 26 pressed into the bearing support, a lubricating structure including a feed wick 27, and an oil cover 28. The motor also includes a rotor 29 and shaft 30. The rotor is built of laminated magnetic material and provided with a squirrel cage type secondary winding of conventional design. Secured to the bearing support, by spot welds, are mounting threaded studs 31, 32, and 33 which are used for securing the motor to an appropriate support during operation.

The lubricating structure includes wool felt disposed in a reservoir defined by the cover 28 and supplies a lubricant (e.g., motor oil) to the shaft and bearing structure of the motor through the felt feed wick 27.

The cover 28 is secured to the bearing support plate by an interlocking arrangement between apertures 34 on the bearing support 24 and expanded fasteners 36 formed in the cover.

The stationary composite structure includes a stator assembly that comprises windings supported on a stator core 37 made of a plurality of stacked laminations. The stator core is of the shaded pole type, having an annular yoke portion and angularly spaced apart integral teeth 38 arranged inwardly of the yoke portion, defining respectively enlarged winding accommodating slots between adjacent teeth. The tip portions of the teeth terminate in arcuate surfaces and form a rotor receiving bore 39.

The winding slots extend entirely through the stack of laminations and accommodate the sides of the windings which are in the form of coils 41 wound around the neck portions of the teeth. The coils are wound from a continuous length of insulated wire with the coils forming a four pole excitation winding having a predetermined number of turns arranged around each tooth and the free ends thereof connected to a termination structure. Elongated winding pins 40 of molded plastics material extend through the core and axially beyond each tooth adjacent the bore, and serve to retain the end turns of the individual coils away from the bore.

The termination structure is firmly and securely embedded in the stationary composite structure 22. More specifically it comprises conductive terminals 43, 44

secured to a generally planar insulating terminal support member 42 fabricated from a sheet of electrical insulating material such as fiberboard, thermosetting plastics material, or mica. The terminals each have a portion thereof attached to the support member 42 by an extruded rivet, and portions which extend outwardly beyond the stationary composite structure. Thus, the terminals form quick-connect terminals exposed for connection to a source of power.

Since the termination structure is firmly secured in the stationary composite structure, it is difficult, if not impossible, to dislodge the terminals 43, 44 from the structure 22. Even more importantly, it is virtually impossible to break the electrical connection between the winding and terminals. A review of field rejects of one conventional type of motor has shown that about fifty percent of such field rejects result from terminal failures. That is, the terminals have become loose or electrical continuity between the terminals and windings has been broken.

As will be understood, noise is generated during operation of a motor due to the mechanical movement of the rotor in the bore. In addition, the winding and stacked laminations in motors have a tendency to vibrate and buzz as a result of the excitation current in the windings. Furthermore, during operation, heat is generated within the stationary composite structure and bearing structure of a motor. The illustrated embodiment contributes to the solution of both of these problems and operates with improved heat dissipation characteristics without degradation of noise suppression characteristics.

The stationary composite structure 22 includes a housing in the form of an interstitial mass of inert inorganic particulate material packed around the stator core, the winding, and termination structure. An adhesive bonding material is disposed in the interstices of the mass and bonds the inert particles into a substantially rigid mass so that the interstitial mass is a self-supporting primary structure of the stationary composite structure 22. The adhesive material also bonds the substantially rigid mass to the stator core, winding, and termination structure.

A wide range of inert inorganic particulate materials may be used in the practice of the invention. The material selected should withstand the temperatures encountered during manufacturing operations and not deleteriously affect the stator core, winding, terminations structure, or insulation used on the winding or stator core. In addition, the inert material must not be electrically conductive or magnetic. In general, these same criteria also govern the

selection of the particular adhesive material used as a binder for the particulate material. One type of low cost particulate material commonly available in bulk form that is particularly suitable for use is granular refractory material. Examples of this type of material are mineral ores, various kinds of rocky material, and sand.

Figure 3 illustrates the physical structure of one preferred arrangement wherein particles of common sand are packed against each other in random fashion. Figure 3 is drawn from a photomicrograph of the surface of the housing of the stationary composite structure 22 illustrated in Figure 1, and the thermo-responsive adhesive material disposed in the interstices of the sand mass was essentially transparent.

However, it will be understood that as shown in Figure 3, the interstices between adjacent particles of sand, e.g., particles 47, 48, 49, 50, are occupied by bonding material that adheres to the sand particles as well as to the stator core 37 and winding coils 41 shown in Figure 2. The presence of small particles 51 in the structure was also observed, and these were believed to probably be extremely fine particles of sand or impurities in the sand mass.

Since the photomicrograph, of which Figure 3 is a full scale representation, showed a 70 power enlargement of the interstitial mass, it will be appreciated that the physical interrelationships of particles such as particles 47, 48, 49, 50 are not readily apparent to the naked eye. However, the particles are packed together as illustrated with the adhesive binder filling the interstices of the structure.

In general, the sand or other particulate material employed may have a wide range of particle sizes and particle size distribution. However, at least fifty percent by weight of

the particles must have a particle size of from 40 to 100 mesh, and it is preferred that such material have an American Foundrymen's Society (A.F.S.) fineness of from 45 to 55, since the surface textures of structures wherein the particulate material has a grain fineness in this range is difficult to distinguish from the surface texture of permanent mold cast iron structures.

The particulate material in the Figure 1 embodiment was river bed whole grain sand having a silica (SiO_2) content of from 90% to 98% by weight, substantially no metallic salts or copper, up to about 2% by weight clay, and traces of various elements and compounds. In preparing the sand for use, we found it to be desirable to dry the sand and then discard the extremely coarse particles in order to eliminate variable surface textures caused by large particles and to consistently record only the dry weight of the sand used. Accordingly, the sand was dried at 400° F in a conventional Ferris wheel forced air dryer. After this treatment, the moisture content of the sand was about .03% by weight and the dust level was about .3% by weight. Thereafter, the sand particles retained on a 30 mesh screen were discarded and the remainder used in the exemplification. A sieve analysis of a sample of the sand particles used in the exemplification is set out in Table I below which is presented for purposes of illustration. Standard procedures were followed in making the sieve analysis and, since 30 mesh size particles and larger were discarded prior to the analysis, 100% of the samples tested passed through a 30 mesh screen. The data for two samples is presented in Table I, and the last two columns in Table I represent an average value of the recorded data for the two samples.

TABLE I

Screen Mesh Size	% of Sample Retained		Cumulative % Passing Through		Average	
	Sample A	Sample B	Sample A	Sample B	Sample Retained %	Cumulative Passing %
30	0	0	100	100	0	100
40	16	18	84	82	17	83
50	26	24	58	58	25	58
70	32	34	26	24	33	25
100	20	20	6	4	20	5
pan	6	4	—	—	5	—

Although sand was used in the illustrated embodiment of the invention, it will be understood that other inert inorganic particulate materials may also be used although with probably not the same economy. No reasons are known by us as to why materials such as slate; chalk; zirconia; alumina; calcium carbonate; mica; beryllium oxide; magnesium oxide; or combinations of such materials; or naturally occurring combinations of minerals, e.g.; ores, could not be used. For example, we have used chromite ore in lieu of sand to produce structures black in color and having surface textures very similar to castings of permanent mold cast iron. The structural characteristics of these structures were comparable to the preferred exemplification.

For purposes of economy, sand having the previously noted size distribution was used in the exemplification, but we have found that satisfactory results are also obtained when the particulate material particles are of substantially uniform size. The primary criteria for our selection regarding particle size, in addition to economic factors, is the structural integrity and final appearance of the composite structures. We believe that if only particles larger than 30 mesh, used (i.e. outside the scope of the invention in having particles too large), the surface texture of the structure normally would be objectionably coarse and rough unless excessive amounts of adhesive materials are used to both bind the particles into a substantially solid mass and to smooth out the "valleys" between adjacent particles adjacent the surface of the mass. This in turn would be uneconomical and result in what we term an objectionable "resin-rich" surface which will be described more thoroughly hereinafter in the discussion of adhesive materials.

Based on test samples, we also believe that where all of the particulate material to be substantially finer than 100 mesh (i.e. outside the scope of the invention in having particles too small), there would be an objectionable loss of structural integrity of the final structure. A readily apparent manifestation of this loss is the occurrence of fissures and surface crazes in the structure after the adhesive material has hardened. It should be added, however, that structures having apparently satisfactory structural integrity (including surface texture) were obtained when substantially all of the particles of particulate material were 100 mesh size.

Many materials are suitable for use as an adhesive material for adhesively bonding the particles of the interstitial mass together and to the core and windings. We have found it to be necessary that the adhesive material, regardless of its exact com-

position, have the following attributes: that it economically bonds together the inert particles into a substantially solid mass; that it bonds the particles to the remainder of the composite structure; that it be compatible with and not adversely affect other component parts of the composite structure such as the electrical insulation, winding and the core (that is, it should be inert with respect to such other parts in the structure); and that it satisfactorily withstands temperatures to which it is to be subjected during fabrication, testing, and use of the completed machine. In addition, the viscosity of the adhesive material should preferably be such that it will be readily retained in the interstitial mass so as to form an essentially non-porous rigid structure after the adhesive material has hardened. We have found that two part thermosetting synthetic resinous type provide these attributes.

When a two part thermosetting resinous material is employed, suitable base resins for this material may include phthalic or non-phthalic type polyesters, epoxys (e.g., bisphenol A, novolac, cycloaliphatic), certain phenolics, polybutadienes, epoxy-acrylics, and epoxy-polyester resins.

A typical two part thermosetting resinous adhesive material we have found useful in practice includes in addition to a base resin as mentioned above, a component to increase the flexural strength of the adhesive material when cured, a catalyst to shorten the time required to cure or harden the adhesive material, and an agent to facilitate removal of the composite structure from a mold.

One specific adhesive material used in the exemplification included 55 parts by weight polyester resin as the base resin mixed together with 45 parts by weight of styrene (used to increase the flexural strength). To 99 parts by weight of this mixture was added 1 part by weight of a catalytic agent in the form of tertiary-butyl-perbenzoate and then 99.45 parts by weight of the foregoing 3 part mixture were mixed with .55 parts by weight of a mold release agent. A commercially available mold release agent is marketed under the name "Zelec" by the E. I. DuPont de Nemours and Company, Organic Chemicals Department, 7 South Dearborn Street, Chicago, Illinois. However, it should be specifically noted that satisfactory structures have been obtained without using any mold release agents both in "TEFLON" (Registered Trade Mark) coated molds and in uncoated molds.

One commercially available polyester resin that we have used is a non-phathic polyester comprising mono-basic and polybasic acids and polyhydric alcohols, and

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5 sold as polyester casting compound No. 519-C-111 by Con Chemco, 1401 Severn Street, Baltimore, Maryland. Another suitable commercially available base resin is marketed under the name "Derakane" (Registered Trade Mark) by the Dow Chemical Co. of Midland, Michigan. This particular material is described in detail in U.S. Patent 3,367,992, which discusses 10 2-hydroxyalkyl acrylate and methacrylate dicarboxylic acid partial esters and oxyalkylated derivatives thereof.

15 The housing of the stationary composite structure 22 was formed using about 71.2% by weight of sand and 28.8% by weight of the adhesive material. After the pores in the sand mass were permeated by the adhesive material, the adhesive material was retained in the pores or interstices of the sand mass and hardened by heating the stationary composite structure at 190° for 25 minutes. It will of course be understood that different temperatures and varying amounts of catalyst may be used to shorten or lengthen 20 the cure time as desired.

25 The actual percents by weight of particulate material and adhesive material may be varied and were determined in the exemplification by comparing the physical characteristics of stationary composite structures that were made in trials during which the proportion of adhesive to particulate material was varied. Since the adhesive material, particulate material, 30 stator core, and windings are compatible with each other, the more desirable relative proportions of the materials can be determined by physical inspection and structural testing. In general, we believe that the most economical use of materials, better heat dissipation characteristics, and better structural integrity (i.e., crack-free surfaces, uniform relatively smooth surface textures, resistance to crumbling, crushing, shattering, or breaking) result when we employ 35 a maximum amount of particulate material and a minimum amount of adhesive material. When this is done, there is no more resinous material than that required to occupy the voids or pores (i.e. the interstices) between adjacent particles of the particulate mass. If insufficient amounts of adhesive material are used, the structure will be porous, sand particles may be scraped from the surfaces; and, in extreme cases, the structure will crumble or fragment when dropped. Preferably, from 40 substantially 65% to 80% by weight of particulate material and from substantially 35% to 20% respectively by weight of adhesive material is employed.

45 The importance of preventing the release of even a single piece of particulate material from a surface of such structures in a motor will be appreciated when it is understood

that the air gap in the bore of a motor often is nominally only about .011 of an inch (.2794 mm). Thus, the presence of particulate material, and particularly abrasive refractory material such as sand, in the air gap during operation of the motor would result in severe damage, if not destruction of the motor. For example, noise, binding and freeze up of the shaft in the bearing, and locked rotor conditions may result. If too great an amount of adhesive material is used, the external surfaces of the composite structure will be "resin rich" and be smooth and glassy in appearance. This effect is particularly objectionable since other structural elements (e.g., bearing structure) are adhesively secured to the composite structure. 70

75 The volume of the interstitial mass is determined essentially by the apparent volume occupied by the particulate material. Thus the density or specific gravity of the interstitial mass permeated with adhesive material is greater than the bulk density of the particulate material. For example, the bulk density of the dry sand used in the exemplification was approximately 1.6 grams per cubic centimeter. However, the density of a section of the bonded sand mass in the stationary composite structure 22 after hardening of the adhesive material was approximately 1.9 grams per cubic centimeter. 80

85 In bulk form, the sand mass used in the exemplification has an interstitial volume, i.e., porosity or pore volume, of about 34%. Since the adhesive material desirably occupies the interstitial volume of the sand mass, a section of the rigid mass after curing of the adhesive material would comprise, on a volumetric basis, about 34% of adhesive material and about 66% of sand particles. 90

95 A motor according to the invention was then compared with a conventional cast iron motor to determine their relative heat dissipation characteristics and, in spite of the fact that the particulate material (sand) itself in the stationary structures of the exemplified motors is a relatively good heat insulator, the rigid mass of sand and adhesive is a relatively good heat conductor and the temperature rise of the windings in these motors was less than that of the conventional motors for a given power input. More specifically, it was determined that 100 motors corresponding to the exemplification dissipated .879 watts per °C rise in winding temperature, whereas the conventional motors dissipated .763 watts per °C rise in winding temperature for about a 30° rise in winding temperature above ambient. This data was obtained by determining the steady state power supplied to the motors in order to maintain a steady state winding temperature rise of 30° C for ambient tem- 105 110 115 120 125 130

peratures of 25° C and 40° C. In addition to monitoring the winding temperature, the steady state temperatures of the exterior surfaces of the stationary composite structures were found to be 150° C for the exemplified motors and 130° C for the conventional motors during locked rotor tests. Thus, the exemplified structures were over 15% more efficient in transferring stator core heat than the conventional motors, since, for a given winding temperature rise, over 15% more power could be supplied to them.

It is believed that the improved heat transfer characteristics of motors constructed according to the exemplification is at least partly due to the intimate and extensive physical contact that exists between the stator assembly and interstitial mass.

It is believed that it will be evident that dimensional tolerances between machined parts and susceptibility to rust and other forms of corrosion have been reduced or eliminated with the present invention.

Now having reference to Figures 4—8, the steps of one method exemplifying an aspect of the invention will be more particularly described. The method involves the steps of positioning a stator assembly comprising a stator core 61 and windings 62 in the cavity 63 of a mold 64 which in turn is resiliently supported by a spring 66 retained in a support 67 and surrounding a locating boss 68 carried by a frame 69 secured to the mold. In order to space the windings from the bottom of the mold cavity, the stator core is rested against a stop formed by a ledge 71 in the mold. Then a bore plug 72 having a surface configuration corresponding to the desired bore of the composite structure of Figure 8 is positioned in the bore of the stator core 61. Attached to the bore plug is a triangular plate 73 which provides a contoured surface on the composite structure as will be more fully described hereinafter. In those cases where winding pins may project into the bore, a taper, as indicated at 72b on the bore plug, may be used to move and hold the pins out of the bore.

After the core and windings are positioned in the mold, a predetermined amount of particulate refractory material, illustrated for purposes of exemplification as sand, is metered and distributed into the mold around the core and windings. The metering means includes a hopper 74 and a scale represented by dial 76 for indicating when a preselected amount of sand has been added to the hopper for transfer to a distributing chute 77. As a predetermined amount of sand 78 sufficient to fill the mold cavity is distributed from three filler tubes 79a, 79b, 79c and packs around the core 61,

the resiliently supported mold 64 is vibrated by vibrators 80a, 80b to reduce the amount of time required to distribute and pack the sand in the spaces between adjacent turns of the windings, and between the windings and core. The mold is vibrated horizontally as well as vertically, as shown, and the vertical vibrators 80b vibrate the mold through channel shaped plates 81a, 81b secured to the mold. The vibrations also cause a thin layer of sand to move between the ledge 71 and stator core. This results in the stator core being substantially completely surrounded by an interstitial sand mass.

After being filled with sand, the mold is transferred to a filling station as illustrated in Figure 6. Then, a cover plate 82 provided with an air admission port 83 and adhesive material admission port 84 is secured to the mold by a plurality of screws 86. Thereafter, a preselected amount of adhesive material is metered through a filter tube 87 from a reservoir 88 into the mold. The adhesive material 89 flows across the surface of the sand and effectively forms a pool and an air seal across the top of the mold cavity.

Although the adhesive material may be permitted to flow by gravity to permeate the mass in the mold, it is more desirable to accelerate the flow of the adhesive material through the mass of sand 78 by increasing the pressure differential across the sand mass. Accordingly, after a pool of adhesive material 89 is formed in the mold, air at a pressure of 4—6 psig is admitted to the mold through a pressure regulator 91. This pressure forces the adhesive material into the interstices of the sand mass, and the sand and adhesive material are packed into the mold by the air pressure. The air initially in the interstices of the sand is vented through a gap 92 between the end 72a of the bore plug 72 and the mold. The peripheral gap 92 provided for this purpose preferably is sufficiently small to prevent sand or excessive amounts of adhesive material from flowing out of the mold while a pressure differential of from 4—6 psig (28—42 kg/cm²) is maintained across the mold inlet and outlet. When said and adhesive material as described above in the preferred embodiment of Figure 1 are used in this process, the peripheral gap is about 0.0025 of an inch (.0635 mm).

Although it is preferable to form a pressure differential across the mold by the application of a positive pressure to the inlet side of the mold, it will be appreciated that such differential could also be formed by applying a negative pressure or vacuum to an outlet of the mold.

After the adhesive material 89 has permeated the mass within the mold cavity, it is cured, i.e., solidified or hardened, so that a self-supporting substantially rigid, impact

resistant composite structure 93 shown in Figure 8 capable of effective heat dissipation may be removed from the mold. To this end, the cover 82 is removed and the mold 64 is moved into an oven 94 as shown schematically in Figure 7 where the mold and composite structure is heated at 190° C for twenty-five minutes. At the end of this time, the composite structure is removed from the mold as a rigid, substantially solid mass having the configuration shown in Figure 8. It will be appreciated that the parameters of time and temperature in the oven may be varied and that the temperature of 190° C and time of twenty-five minutes are given for exemplary purposes only.

The recessed area 95 on the structure 93 is formed by the triangular plate 73. It will be understood that this plate may have any desired configuration that would correspond with the configuration of a bearing support to be positioned thereagainst.

After a composite structure has been formed, assembly of a complete motor may be accomplished. This method will be best understood by again referring to Figures 1 and 2. In these figures, after the stationary composite structure 22 has been formed with the interstitial mass forming the housing illustrated, the rotor 29 is secured in assembled relation with the bearing structure by lock washers 96, 97. An epoxy material 98 is applied to either the bearing support 24 or relieved stator assembly housing surface 99 underlying the support 24. The bearing support is then positioned against the surface 99 while the rotor 29 is centrally positioned in the bore 39 by removable shims. After the epoxy material 98 is cured, the shims are removed through the openings 34 in the bearing support 24. These openings are spaced around and axially aligned with the air gap around the rotor for this purpose. Then the lubrication structure is assembled and covered by the cover 28 that in turn is secured to the support 24 by means of the expanding fasteners 36 previously referred to.

After being assembled, the exterior surfaces of the motor may be prepared for painting by cleaning and etching or priming them. Thereafter, paint may be applied to the motor and dried. These steps may, however, be completely omitted if desired, since it is not necessary to apply a protective coating to the interstitial mass forming the housing of the motor 20, since this structure is resistant to corrosive agents and essentially unaffected by water. In addition, the refractory material and/or adhesive material may be used to give a desired final color to the motor 20. For example, chromite ore (as previously described) will provide a structure black in color. On the other hand,

white sand will provide a nearly white color, and brown river bed sands provide a buff or beige color. Desired colors may also be obtained by adding a dye or color pigment to the adhesive material which then becomes the color determining component in the structure.

Another method is schematically represented by Figure 9 wherein there is illustrated a mold 121 that comprises two mold parts 122, 123 held together by a mold clamp 124 and supported on a shaft 126 of a motor 127. The mold 121 is removably secured to the shaft by a screw 128 so that it can be rotated by the motor 127. Initially, the stator core 129 with windings 131 and termination structure 132 secured thereto is positioned in the lower mold part 123. Then the upper mold part 122 is positioned against the lower mold part 123 with the termination structure 132 projecting through an opening 133 formed in the upper mold part. Thereafter, the mold clamp 124 is fastened in place to secure the mold parts together.

The motor 127 is energized and, as the mold 121 is rotated at a desired speed, a retractable particulate material filler nozzle 134 is moved downwardly to the position illustrated in Figure 9 so that a predetermined amount of particulate material is discharged into the mold. In addition, an adhesive material filler tube 136 (also retractable) is positioned as shown in Figure 9 to discharge the adhesive material into the cavity of mold 121. The speed of rotation of the mold may be varied, depending on the specific particulate material and adhesive material being used.

When using the materials previously described for the exemplification of Figure 1, good results are obtained when the mold is rotated at a speed of 1600 rpm. As the sand 138 and adhesive material 137 are concurrently or substantially simultaneously discharged into the rotating mold, heat is applied to the mold and transferred to the structure therewithin by means of a blower 139 which directs hot air across the mold. The centrifugal forces exerted on the sand and adhesive material because of the mold rotation pack the sand and adhesive material against the walls of the mold, the stator core, windings, and termination structure. After predetermined amounts of sand and adhesive material have been admitted to the mold, the filler tubes 134 and 136 are withdrawn from the mold, the adhesive material is retained in the interstices of the sand mass, and rotation of the mold is continued until the adhesive material has cured an amount sufficient to permit removal of a rigid composite structure from the mold. The final configuration of the composite structure removed from

the mold is substantially the same as that of the structure 93 illustrated in Figure 8.

Although Figure 9 illustrates the sand 138 and adhesive material 137 being concurrently discharged into the mold it is alternatively possible to discharge the sand into the mold and subsequently add the adhesive material. In either case, during the cure cycle of the adhesive material, the rotational speed of the mold may be reduced to about 600 rpm after the sand and adhesive material are in place, without adversely affecting the structure within the mold.

Figures 10-13 depict still another embodiment of the invention wherein a motor 140 comprises a stationary composite structure 141 that includes a stator core 142, windings 143, terminations 144, 146, and a housing formed of an interstitial mass of particulate material. A rotor 147 of conventional construction is secured to a shaft 148 which in turn is supported for rotation by a pair of bearings 149, 151. In order to absorb end thrust during operation of the motor thrust rings, 152, 153 are also carried by the shaft 148 and co-act with the bearings. A bearing lubricant such as oil is stored in reservoirs illustrated as felt wicks 154, 156 which are retained within chambers 157, 158 formed by oil covers 159, 161, bearing supports 162, 163, and internal oil covers 164, 166. The covers 164, 166 include filler tubes 167, 168, respectively. In order to prevent loss of lubricant along the shaft 148, oil slingers 169, 171, 171a, are supported on the shaft 148 and operate in well known fashion.

As will be appreciated from an inspection of Figures 10 and 12, the bearing supports 162, 163 are plates which are secured by means such as a thermosetting resinous material, e.g., epoxy, to the exposed ends 172, 173 of the interstitial mass 174 which forms the stationary composite structure of the motor. This interstitial mass includes an adhesive material and particulate material bonded to the core and windings, and is made in the manner and with the materials previously described.

As best revealed in Figures 12 and 13, the front of the stationary composite structure is contoured so that the bearing support plate 163 is bonded to lands 176 and spaced from regions 177 of the stationary composite structure. With this arrangement, access to the oil chamber 158 through filler tube 168 is readily available and passages are provided for the flow of coolant such as air through the motor. It will be appreciated that this contouring of surfaces is now attainable as a practical alternative without requiring machining operations on the face of the stationary structure.

To further allow the flow of cooling air

through the motor and permit the facile removal of shims used to center the rotor 147 in the air gap during assembly, a plurality of angularly spaced apart openings 179, 181 are formed in the support plates 162, 163, respectively in axial alignment with the air gap around the rotor. These openings are sufficiently large to permit the removal of the shims and provide an unobstructed path to the air gap in the same manner as openings 34 in the exemplification of Figure 1.

The face 172 of the structure 174 is contoured as shown at 182 in Figures 10 and 11 so as to provide access to oil filler tube 167. Threaded studs 183 are secured to the plate 162 for mounting the motor during operation.

Figures 14 and 15 illustrate still another embodiment of the invention wherein bearing supports 201, 202 are adhesively secured to the end faces 203, 204 respectively of the housing of stationary composite structure 206. The structure 206 comprises an interstitial mass of sand particles bonded together as previously described. Other components in the motor such as the stator core 208, windings 209, oil retainers 211, 212 and oil covers 213, 214 provide known advantages as will be understood.

As best shown in Figure 15, end face 204 of the structure 206 is relieved at 205 to provide a clearance for the deformed heads 216 of threaded mounting studs 217. These studs may be riveted or welded to the bearing support 202. As in previously described embodiments, openings such as openings 218 shown in Figure 14 are provided to permit the easy removal of shims that were used to center the rotor 219 in the air gap 221 during assembly of the rotor and stationary composite structure.

It will be appreciated that the particles of the particulate material may be generally uniform in shape or non-uniform and irregular in shape as was the case of the sand particles in the exemplification.

Attention is drawn to our copending application No. 20134/71 (Serial No. 1351768) which describes and claims certain dynamoelectric machines using similar materials.

WHAT WE CLAIM IS:—

1. A dynamoelectric machine comprising a stator assembly including a stator core and at least one winding thereon, a rotor, at least one bearing mounting the rotor, and a housing which is bonded to and houses the stator assembly, supports and locates the bearing, and thus also connects the bearing and stator assembly together, said housing comprising electrically insulating inert inorganic particulate material bonded together by an adhesive material to form an impact-resistant, thermally conductive.

the mold is substantially the same as that of the structure 93 illustrated in Figure 8.

Although Figure 9 illustrates the sand 138 and adhesive material 137 being concurrently discharged into the mold it is alternatively possible to discharge the sand into the mold and subsequently add the adhesive material. In either case, during the cure cycle of the adhesive material, the rotational speed of the mold may be reduced to about 600 rpm after the sand and adhesive material are in place, without adversely affecting the structure within the mold.

Figures 10—13 depict still another embodiment of the invention wherein a motor 140 comprises a stationary composite structure 141 that includes a stator core 142, windings 143, terminations 144, 146, and a housing formed of an interstitial mass of particulate material. A rotor 147 of conventional construction is secured to a shaft 148 which in turn is supported for rotation by a pair of bearings 149, 151. In order to absorb end thrust during operation of the motor thrust rings, 152, 153 are also carried by the shaft 148 and co-act with the bearings. A bearing lubricant such as oil is stored in reservoirs illustrated as felt wicks 154, 156 which are retained within chambers 157, 158 formed by oil covers 159, 161, bearing supports 162, 163, and internal oil covers 164, 166. The covers 164, 166 include filler tubes 167, 168, respectively. In order to prevent loss of lubricant along the shaft 148, oil slingers 169, 171, 171a, are supported on the shaft 148 and operate in well known fashion.

As will be appreciated from an inspection of Figures 10 and 12, the bearing supports 162, 163 are plates which are secured by means such as a thermosetting resinous material, e.g., epoxy, to the exposed ends 172, 173 of the interstitial mass 174 which forms the stationary composite structure of the motor. This interstitial mass includes an adhesive material and particulate material bonded to the core and windings, and is made in the manner and with the materials previously described.

As best revealed in Figures 12 and 13, the front of the stationary composite structure is contoured so that the bearing support plate 163 is bonded to lands 176 and spaced from regions 177 of the stationary composite structure. With this arrangement, access to the oil chamber 158 through filler tube 168 is readily available and passages are provided for the flow of coolant such as air through the motor. It will be appreciated that this contouring of surfaces is now attainable as a practical alternative without requiring machining operations on the face of the stationary structure.

To further allow the flow of cooling air

through the motor and permit the facile removal of shims used to center the rotor 147 in the air gap during assembly, a plurality of angularly spaced apart openings 179, 181 are formed in the support plates 162, 163, respectively in axial alignment with the air gap around the rotor. These openings are sufficiently large to permit the removal of the shims and provide an unobstructed path to the air gap in the same manner as openings 34 in the exemplification of Figure 1.

The face 172 of the structure 174 is contoured as shown at 182 in Figures 10 and 11 so as to provide access to oil filler tube 167. Threaded studs 183 are secured to the plate 162 for mounting the motor during operation.

Figures 14 and 15 illustrate still another embodiment of the invention wherein bearing supports 201, 202 are adhesively secured to the end faces 203, 204 respectively of the housing of stationary composite structure 206. The structure 206 comprises an interstitial mass of sand particles bonded together as previously described. Other components in the motor such as the stator core 208, windings 209, oil retainers 211, 212 and oil covers 213, 214 provide known advantages as will be understood.

As best shown in Figure 15, end face 204 of the structure 206 is relieved at 205 to provide a clearance for the deformed heads 216 of threaded mounting studs 217. These studs may be riveted or welded to the bearing support 202. As in previously described embodiments, openings such as openings 218 shown in Figure 14 are provided to permit the easy removal of shims that were used to center the rotor 219 in the air gap 221 during assembly of the rotor and stationary composite structure.

It will be appreciated that the particles of the particulate material may be generally uniform in shape or non-uniform and irregular in shape as was the case of the sand particles in the exemplification.

Attention is drawn to our copending application No. 20134/71 (Serial No. 1351768) which describes and claims certain dynamoelectric machines using similar materials.

WHAT WE CLAIM IS:—

1. A dynamoelectric machine comprising a stator assembly including a stator core and at least one winding thereon, a rotor, at least one bearing mounting the rotor, and a housing which is bonded to and houses the stator assembly supports and locates the bearing, and thus also connects the bearing and stator assembly together, said housing comprising electrically insulating inert inorganic particulate material bonded together by an adhesive material to form an impact-resistant, thermally conductive,



substantially rigid mass, at least 50% by weight of said particulate material having a particle size of from 40 to 100 mesh.

5 2. A dynamoelectric machine as claimed in claim 1 wherein said substantially rigid mass comprises from substantially 65% to 80% by weight of said particulate material and from substantially 35% to 20% by weight of adhesive material.

10 3. A dynamoelectric machine as claimed in claim 1 or claim 2 wherein said particulate material comprises granular refractory material having an A.F.S. grain fineness greater than 45.

15 4. A dynamoelectric machine as claimed in any one of Claims 1 to 3 wherein the rotor is mounted in spaced relation from and within the stator assembly to form an annular air gap therebetween, and wherein a bearing support extends across one end of the stator assembly and is secured to the housing, said bearing support having a plurality of spaced apart openings in axial alignment with said air gap to provide an unobstructed path between the air gap and said openings in the bearing support, each of said openings being sufficiently large to permit access to the air gap for removing a shim therefrom during assembly of the dynamoelectric machine.

20 25 30 35 5. A method of making the dynamoelectric machine constructed as claimed in Claim 1, comprising positioning the stator assembly in a mould, introducing said particulate material and said adhesive

material into said mould and around said stator assembly, retaining the adhesive material in interstices between the particles, hardening the adhesive material to form said housing and to bond the housing to said stator assembly, removing the so-formed structure from the mould, positioning the rotor in operative relation to the stator assembly, and positioning the bearing relative to said housing to be supported and located thereby.

6. A method as claimed in Claim 5 including positioning the rotor relative to the stator assembly to establish a predetermined air gap between the rotor and the stator assembly, depositing an unhardened adhesive material along at least a portion of an interface between the housing and the bearing, and thereafter hardening the adhesive material.

7. A method as claimed in Claim 5 and substantially as described herein.

8. A dynamoelectric machine when made by a method as claimed in any one of Claims 5 to 7.

9. A dynamoelectric machine substantially as described herein with reference to Figures 1 and 2, or Figures 10 to 13, or Figures 14 and 15, of the accompanying drawings.

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