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2,392,802

CAST CORE MEMBERS FOR ELECTRICAL APPARATUS

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2 Sheets-Sheet 1

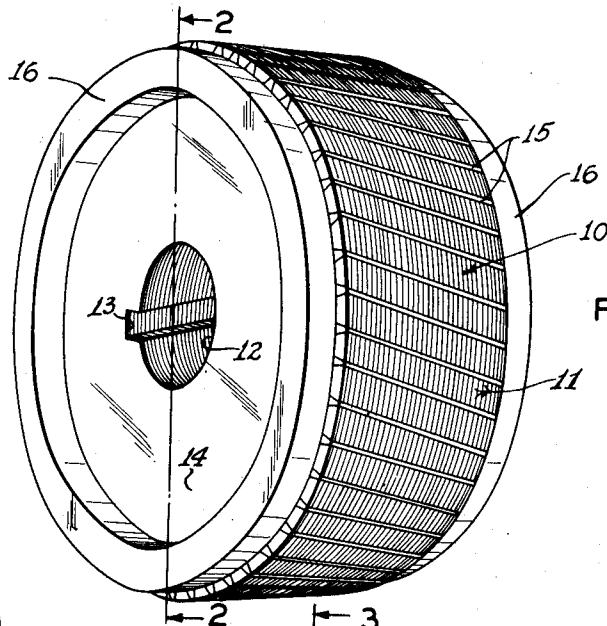


FIG. 1.

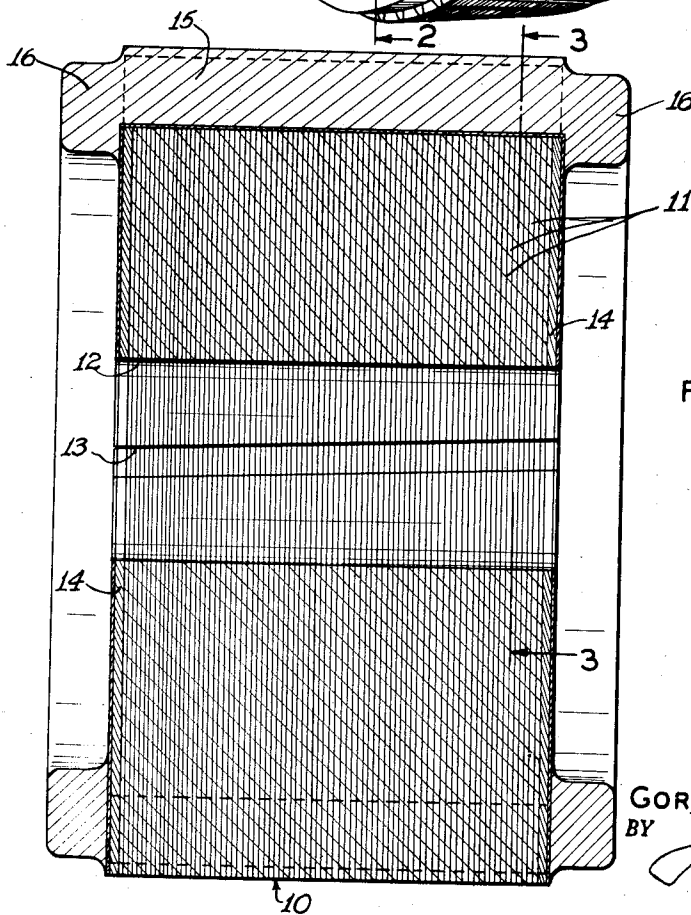


FIG. 2.

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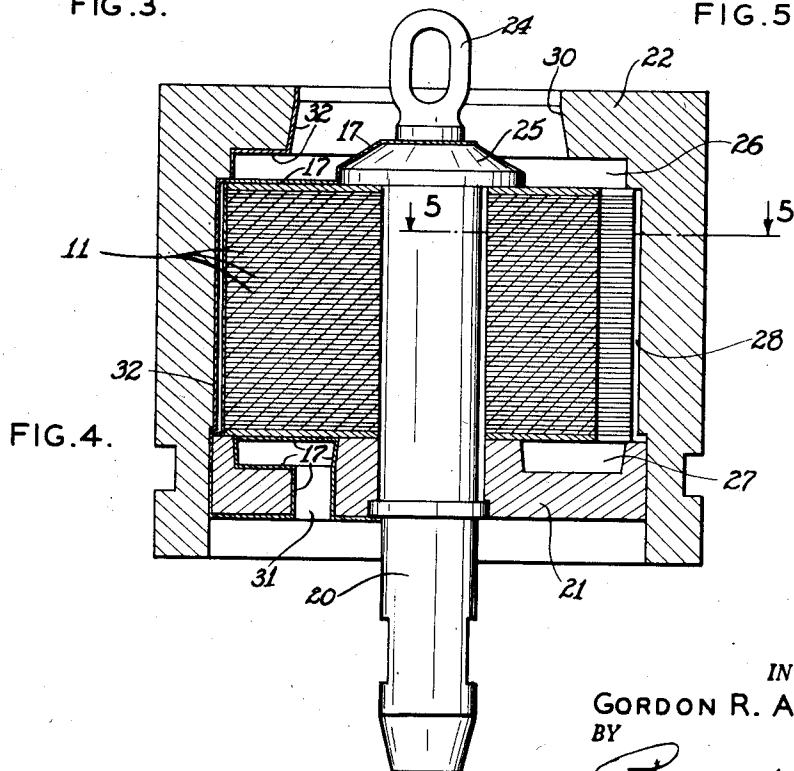
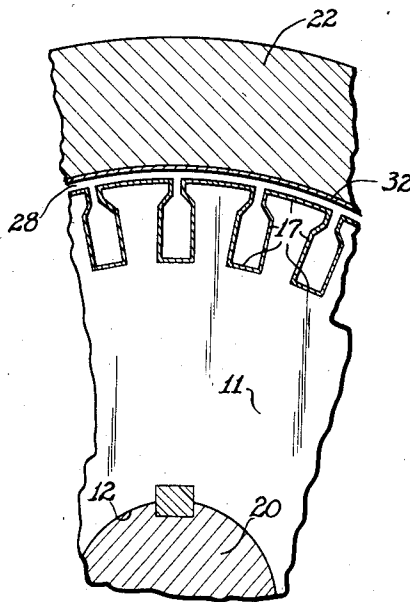
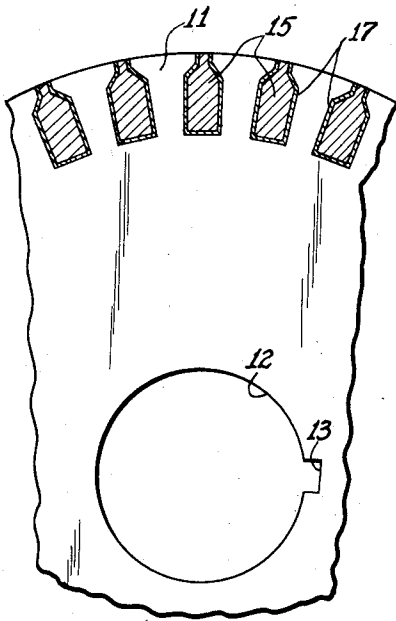
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CAST CORE MEMBERS FOR ELECTRICAL APPARATUS

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2 Sheets-Sheet 2



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CAST CORE MEMBERS FOR ELECTRICAL APPARATUS

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Application May 18, 1942, Serial No. 443,335

4 Claims. (Cl. 172-120)

This invention pertains to electric machines, and more particularly to a centrifugally cast rotor structure in which the cast portion of the rotor structure consists of a plurality of conductor bar elements and end ring members composed of an alloy of copper possessing improved electrical characteristics and physical homogeneity of a high degree.

An important object of the invention resides in the provision of a rotor having the conductor bar elements and end ring members integrally cast in situ and formed of a copper base alloy of greatly improved electrical characteristics.

A further object of the invention resides in the employment of, as the conductive metal comprising the conductor bars and end rings in a rotor of the noted type, a copper base alloy for the purpose of obtaining a rotor exhibiting an electrical characteristic predictable within practicable working limits, according to the selected percentage combination of the alloying elements.

Yet another object of the invention resides in the selection of a copper base alloy consisting essentially of copper and tin which is particularly well adapted to the technique of centrifugal casting and which may be utilized in the production of rotors possessing electrical characteristics substantially determined by the percentage composition of the alloy.

Still another object of the invention resides in the application of a properly selected and conditioned mineral-like refractory material to the surfaces of the magnetic core of the rotor which are adjacent the conductor bar elements and end ring members and which would otherwise be contacted thereby, for the purpose of providing a permanent electrical insulating coating and physically impervious barrier thereon, such that the alloy casting metal will be unaffected by superficial fusion or undesirable alloying effects with the metal of which the magnetic core is composed.

Further objects and advantages will appear in the following description of a preferred embodiment of the present invention when taken in connection with the accompanying drawings, in which:

Fig. 1 is a perspective view of the finished rotor member which constitutes an important part of the present invention;

Fig. 2 is a sectional elevation of the rotor member as seen at line 2-2 of Fig. 1;

Fig. 3 is a fragmentary plan of the rotor showing the refractory coating in the rotor bar slots as seen along line 3-3 of Fig. 2;

Fig. 4 is a sectional illustration of the mold and

core assembly showing the complete assembly and refractory coating of the mold cover and contents, and

Fig. 5 is a fragmentary section illustrating the extent of the refractory coating in greater detail as seen along line 5-5 of Fig. 4.

In the interest of brevity of description it may be noted that the present subject matter, except for utilization of alloys particularly selected for predictable conductivity, and particularly adapted for centrifugal casting, is related to the subject matter described and claimed in a companion application, Serial No. 443,334 filed concurrently herewith, on May 18, 1942, by this applicant. It may further be noted that the bimetallic structure presently described is or may be formed by utilization of the method or process described and claimed in application Serial No. 348,093 filed July 29, 1940, by this applicant, this application now having issued as Letters Patent #2,304,067, dated December 8, 1942. Serial No. 443,334, constitutes a divisional application of Serial No. 348,093. Accordingly, for a complete description of one method by which a bimetallic structure such as a rotor may be produced, the description of method in Serial No. 348,093 is incorporated herein by this reference.

In carrying out the principles of the present invention, reference will be had to the drawings in which the same reference numerals will indicate similar elements or features.

Referring to the drawings, the completed cast rotor having a one-piece centrifugally cast copper base alloy bar and end ring structural unit is shown in Figs. 1 and 2. The structural unit is cast on a magnetic core 10 comprised of peripherally slotted steel sheets or laminations 11, having a centrally located shaft aperture 12 and a keyway 13. The end or face laminations 14 of the core 10 are preferably constructed of a heavier gauge sheet metal for the obvious purpose of greater rigidity in the end zones of the core. The structural unit consists of bars 15 seated in the core slots, and end rings 16 integrally united with the bars at the respective ends thereof, the bars and end rings being formed at one time, and by a single operation. A refractory coating in the core slots of the rotor 10 is indicated at 17, Fig. 3. Further details of this important feature will be hereinafter noted.

In describing the preferred agencies and general steps of the practice involved in producing the improved rotors, reference will be had to Fig. 4 in which is illustrated a suitable form of mold utilized in the centrifugal casting of the bars and

end rings of the rotor. As shown, the laminations 11 collectively forming the core proper are stacked over an arbor or mandrel 20, the latter extending through a bottom plate 21 of the mold structure. The assembled arbor and bottom plate, with the laminations stacked thereon, is inserted into the lower end of the hollow mold body 22 in such manner that the plate 21 serves as a bottom closure therefor. Threadedly engaging the upper end of the arbor 20 is a screw eye 24 which, when threaded up upon a washer-like disc 25, serves to compress the laminations 11 between the disc 25 and the bottom plate 21. As will appear from Figs. 4 and 5, the resulting cavities in the mold include the several spaces 26 and 27 receiving the molten casting metal for the end rings, and the annular space 28, together with the lamination slots, which serve to receive the molten casting metal which results, upon freezing, in formation of the bars 15. It further appears from Fig. 4 that there is provided a pouring throat 30 for the introduction of the molten casting metal to the mold, and that there is provided in the bottom plate 21 a suitable passage 31 for the escape of air and gases during the pouring and casting operations. By preference, a plurality of such passages 31 are provided in plate 21, but for clarity of illustration only one thereof has been indicated.

In the production of rotors as above described and by means of the agencies pointed out, it is contemplated that an alloy of copper be employed to form the conductor bars and end rings. While other metals and alloys thereof may be employed, the utilization of an alloy of copper is more desirable from the viewpoint of the electrical and physical characteristics of the completed rotor. The preferred alloy has been selected from a Phosphor-bronze group which consists essentially of tin with a small addition of phosphorus, for metallurgical reasons, and high grade copper. It is important to note that this alloy is composed of two metals which have about the same density and hence do not segregate when subjected to centrifugal action created during the casting thereof. More importantly it is believed that the tin passes into solution in the molten copper, thereby forming a substantially perfectly homogeneous alloy, and one which possesses greatly improved electrical characteristics, as well as physical characteristics conducive to better than average casting results. Further, this preferred alloy is well adapted to machine tool work. The most desirable alloy mixes to be obtained from this Phosphor-bronze group and for the purposes to be hereinafter noted, fall within the amounts of from 0.25% to 8.0% tin, 0.15% phosphorus and from 91% to 99% or higher, of copper. From this, it will be noted that the phosphorus content is maintained substantially constant and therefore the useful alloys obtained by varying the tin and copper content. Therefore, if it is desired to obtain a maximum electrical conductivity, the tin will be reduced to 0.25% and the balance, besides phosphorus to make up 100% of the alloy, will be copper. It follows from this, that by increasing the tin content the conductivity can be reduced so that a possible minimum conductivity is obtained with 8% tin, 0.15% phosphorus and the balance copper. Actual production experience indicates that a sufficiently broad range of conductivity values, without any appreciable overlapping thereof, may be obtained by selecting a group of these alloys in which the tin content is approximately 0.25%, 0.50%, 2.0%, 4.0% and 8.0%, the conductivity values for each of these alloys

being graduated from a maximum to a minimum, respectively. The method as practiced with alloys last above specified, conduces to dependability and uniformity of electrical conductivity throughout the integrated bar and end ring structure constituting the rotor winding.

It is greatly preferred, in fact may be regarded as essential, not only to prevent, throughout production, all adverse contaminating effects on the alloy, but also, for the purpose of obtaining a closely predictable result expressed in terms of electrical conductivity, to utilize as a source of copper, prior to alloying a metal of better than usual commercial purity. The copper accordingly should not contain more than a trace of arsenic and not more than a trace of iron, with low total impurities. It is desirable where at all possible, to utilize a copper averaging at least 99% purity. While electrolytic copper is a preference, the specific mode of its initial production is immaterial, so long as the raw metal conforms to the requirements expressed.

The preparation of the copper, tin and phosphorus for pouring and casting requires a special technique such that contamination of the ingredients will be prevented and such that the ingredients may be brought together at the proper time and in the preferred sequence to form an accurately compounded and a homogeneous alloy. The handling of the tin and phosphorus is of particular importance in the attaining an alloy composition as determined upon, since the alloy must be physically and electrically uniform, and must be rendered sufficiently fluid to penetrate all of the mold recesses and core cavities. The preferred sequence of operations includes the preparation and melting of the copper prior to any mixing or alloying thereof with the tin and phosphorus. The copper is first melted in a suitable furnace and raised to a temperature of the order of 2400 degrees F. to assure the requisite pouring fluidity. Having properly conditioned the copper, the tin and phosphorus, preferably in granular or pebble form, are next placed in a non-metallic ladle, such as one formed of graphite or lava, and the molten copper poured into this ladle. The molten copper poured over the pebbles of tin and phosphorus rapidly reduces these elements such that they penetrate and intimately unite with the copper. The rapid and sudden reduction of the tin and phosphorus by the heat of the molten copper, together with the action of the copper in covering and confining the tin and phosphorus, produces an even and homogeneous alloy of a uniform and accurate composition. Ordinarily the tin and phosphorus evaporate at a relatively low temperature compared to the melting temperature of the copper; however the covering and confining action of the molten copper effectively prevents escape or loss by evaporation of the tin and phosphorus.

Immediately after the preliminary mixing of the tin and phosphorus in the molten copper, as above described, the entire mix is poured into the mold where the spinning motion thereof further aids the alloying and mixing process. Just prior to the steps of alloying and pouring of the tin, phosphorus and copper, the mold and core are conditioned by heating, in order to assist the flow and penetration of the alloy into all the mold recesses and core cavities. Preferably the mold and core are heated in any suitable furnace to a temperature of the order of 1850 degrees F. then reduced to a temperature of the order of 1400 degrees F. At this latter temperature, the pour-

ing begins, and concurrently therewith the mold and contents are rotated, to a speed preferably within the range of 1100 to 1800 R. P. M.

Prior to the final assembly and positionment of the mold and core for casting, there is an important step to be taken. The exposed surfaces and cavities of both the core and mold plate assembly including the top mold, must be coated with the insulating refractory material before noted in the objects.

The selection of a suitable refractory material is based upon factors governed by the working temperatures involved in centrifugal casting of molten copper, the resistance to erosive and mechanical forces created by rapidly flowing molten metal, and insulating properties best adapted to aid in the control of the transfer of heat between masses or bodies of differing temperatures, as well as electrical insulating properties desirably a feature in electrical rotor members generally. There are several materials which possess the above noted characteristics; notably among these is a mineral-like refractory material known commercially as "Red Bull Talc," and it is this latter material which is herein preferred. A quantity of this finely powdered, mineral-like refractory material is mixed with a ten percent aqueous solution of sodium silicate, such that a mixture or aqueous suspension of approximately 14° Baumé gravity results. This refractory suspension was determined upon after repeated experimentation, and found to possess all of the requisite characteristics above noted. Since this material is not to any great extent a true solution, it is advisable continually to agitation the liquid in order to maintain an even consistency or density thereof.

The coating step in the preparation of the core and mold is effected by dipping the assembled core 10, mold plate 21 and arbor 20 into the tank, so that the surficial and recessed surfaces thereof receive a thin, even coat. This coating is then permitted to dry. Such a refractory coating is indicated at 17, and referred to generally in connection with Fig. 3; other locations of the coating appearing in Figs. 4 and 5. A similar coating 32 is applied by hand painting, spraying or in any other convenient manner to the inside surfaces of top mold 22, and is indicated as covering the pouring mouth or throat, end-ring-forming recesses and core-receiving recess (Fig. 4). When the refractory coating has dried sufficiently, the two major parts of the mold are assembled, as indicated in Fig. 4, and bottom mold plate 21 is retained in its seating recess in top mold 22, as by a press fit or by frictional engagement of the mating surfaces thereof.

It is regarded as conducive to best results to employ as a refractory lining for both core slots and mold body, as well as other surfaces with which the molten alloy comes in contact, a highly stable substance or plurality thereof, such that when the mold and core assembly, prior to pouring, is raised to a temperature approaching the melting point of the alloy, there results at least a surficial fusion or sintering of the refractory coating or lining, thereby forming a barrier which is physically resistant and relatively impenetrable by the molten alloy. This phenomenon, with attendant physical and electrical advantages in the finished product, is believed to be attained in the use of the talc suspension above described. A definite physical advantage results from this fact, in that the refractory

coating becomes more or less unified and thermally integrated, and constitutes in effect, a shell, rather than a mere powder which might be locally disturbed or removed from position incident to pouring the hot casting metal, or perhaps also due to the physical disturbance occurring by reason of high speed spinning. By so selecting a refractory or mineral material and subjecting it to the best range of preheating temperatures, there is accordingly further prevented any possible localized alloying effects, which might otherwise take place between the alloy and the ferrous metal of the laminations of the core. It can be said that the talc or mineral-like material is fused at least on its surface portions adjacent the windings, and fused at least to a sintered stage, such that a barrier layer is formed which is unpenetrated by the casting metal forming the winding elements.

The mold and contents, now fully prepared for further operations, are placed in a heating furnace, and the whole assembly raised to a temperature of the order of 1850 degrees F., then permitted to cool to say 1400 degrees F., when the assembly is ready for spinning and the step of pouring the alloy, as described.

A measured quantity of molten copper is ladled out of the melting furnace and poured into a second ladle in which the proper quantities of tin and phosphorus have been placed, this second ladle is then moved to the mold mouth and the contents introduced to the mold and core. The mold rotation is continued until the casting alloy metal has completely solidified or set. Upon cooling to ambient temperature, the mold and core are separated in any convenient manner and the cast core unit then subjected to roughing and finishing machine operations.

It may here be observed that bimetallic rotors, specifically those for induction type motors, have been successfully produced in appreciable commercial quantities by utilization of the method or process hereinabove described in detail. As a result of this experience it has been found that the rotors thus produced, attain fully each of the several objects hereinabove stated as well as many other objects implied from the ensuing description. By way of still further characterizing some of the outstanding advantages attained by the disclosed improvements, it will have been observed that it is impossible, during any production stage, for the alloy of copper to be contaminated in any noticeable degree by impurities introduced in the course of casting and handling the molten metal. This condition is assured in each of the several steps throughout the whole process. For example, the copper is melted in an induction furnace of any suitable type wherein the copper comes in contact with no metal other than itself, in any zone of the furnace. The molten metal, in being transferred from the furnace to the mold, is transported in non-metallic ladles which precaution prevents absolutely any metallic contamination in this step. Again, and very importantly, in the mold itself, it has heretofore appeared that the mold parts are carefully and completely lined, and thus shielded to preclude any contaminating or alloying contact between the body of the mold and the alloy of copper which later forms the winding of the rotor. Any undesired introduction of metallic impurities is further obviated by the refractory treatment of the winding slots of the laminations constituting the rotor body, all

as heretofore specifically pointed out. Thus it appears that from raw material through the finishing stages, and hence in the finished product, the alloy of copper is kept and remains uncontaminated by any substances adversely affecting the desired standard of conductivity.

In order still further to distinguish the present product or apparatus from those resulting from earlier attempts at centrifugal casting of comparable products, it may be noted that such earlier and unsuccessful experience in centrifugal casting of conducting copper alloy elements, has resulted only in windings of a wide and uncontrolled degree of variation in conductivity. It is to be noted after an extensive experience with the improved apparatus and product that it is now possible for the first time, dependably to obtain any desired conductivity in rotor after rotor, on a production basis, with but inconsequential variations. Furthermore, it is now possible to predetermine the conductivity value best suited to a given condition of service of the product, and thereafter to produce the rotor or apparatus having such a value, without altering the procedure or changing the production apparatus to be employed in the manufacture thereof. These results are due in large measure to the fact of the several described steps for preventing loss or evaporation of the alloying constituents and the pickup of any undesirable impurities in any stage of the process from the melting and alloying stage through the pouring and casting stage to the complete formation of the winding structure on the rotor core.

Although the invention has been presently described in considerable detail by reference to structure of bimetallic or alloy rotors resulting from an improved process of production, it will be understood that essentially the same principles may be utilized in the production of other bimetallic units of apparatus for use in electrical equipment generally. It should further be understood that the present detail of description is to be regarded solely in an instructive and not in a limiting sense, since numerous changes may be made within the scope of the claims hereunto appended.

I claim:

1. A rotor for an electric machine, comprising a laminated core providing bar-receiving slots in the periphery thereof, an integral casting carried by the laminated core and comprising end

rings and bars seated in the core slots and bridging the end rings, the integral casting being constituted of an alloy composed of copper, tin and phosphorus, and a mineral-like refractory material, thermally integrated and sintered at least to a stage of surficial fusion, disposed on the end surfaces and in the slots of the core so as to underlie the end rings and bars carried thereby.

2. A rotor for an electric machine, comprising a slotted core, a unitary casting carried by the core and consisting of end rings and bars seated in the core slots and bridging the end rings, said unitary casting being composed of a copper-tin-phosphorus alloy consisting of at least 99% copper, .25% tin and .15% phosphorus; and a thermally integrated, mineral-like refractory bonded to the core and disposed thereon to provide an insulating barrier between the core and the adjacent bars and end rings.

3. In a cast-core element for an electric machine, a laminated, peripherally slotted core, cast conductor bars in the core slots and end rings integrally cast with the conductor bars, said conductor bars and end rings being composed of a copper-tin-phosphorus alloy consisting of at least 91% copper, tin in an amount of the order of 8%, and phosphorus in an amount of the order of .15%; and a talc mixture, thermally integrated at least to a stage of surficial fusion, the talc mixture being disposed between the core and the adjacent bars and end rings, and substantially unpenetrated by the alloy casting metal forming the bars and end rings.

4. A rotor for an electric machine comprising a laminated core providing bar-receiving slots in the periphery thereof, an integral casting carried by the laminated core, the casting including end rings, and bars bridging the end rings and seated in the core slots, the integral casting being composed of a Phosphor-bronze alloy consisting of substantially iron free copper with tin and phosphorus in the proportions of at least 91% copper, not less than 0.25% nor more than 8% tin, and 0.15% phosphorus; and a mineral-like material formed substantially of talc, and sintered at least to a stage of surficial fusion, said material being disposed between the core and the adjacent bars and end rings and substantially unpenetrated by the alloy casting metal forming the bars and end rings.

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