June 4, 1935. E. G. FAHLMAN 2,003,587

ROTOR FOR ELECTRIC MOTORS

Filed July 7, 1932

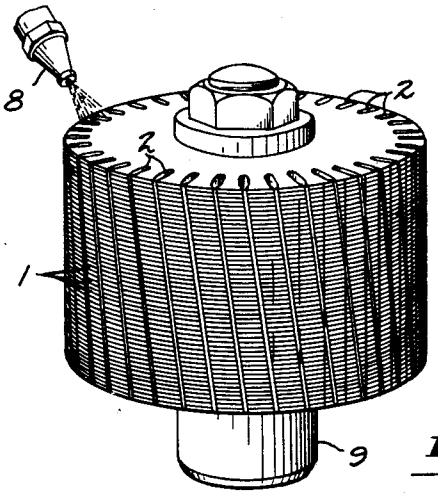


Fig. 1.

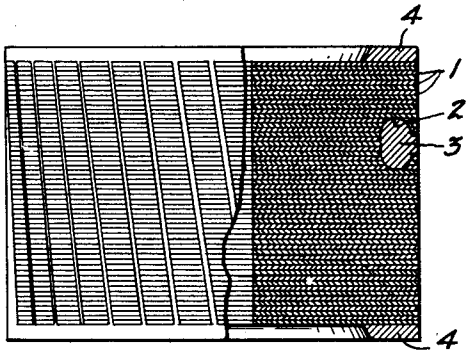


Fig. 2.

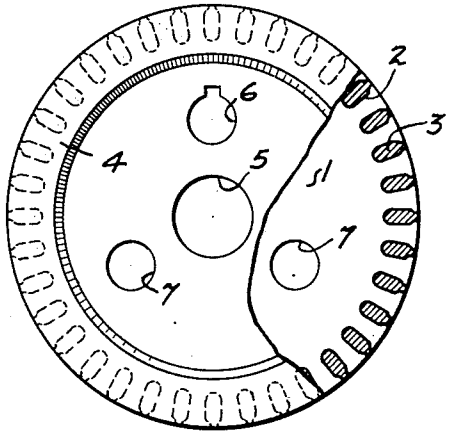


Fig. 3.

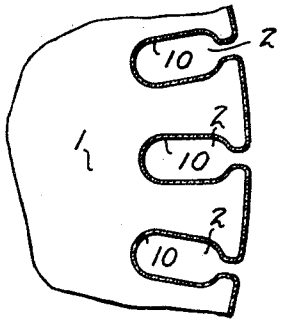


Fig. 4.

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UNITED STATES PATENT OFFICE

2,003,587

ROTOR FOR ELECTRIC MOTORS

Everett G. Fahlman, Cleveland, Ohio, assignor to The Permold Company, Cleveland, Ohio, a corporation of Ohio

Application July 7, 1932, Serial No. 621,186

1 Claim. (Cl. 172—120)

My invention relates to rotors for electric motors, and more particularly to rotors having cast conductor bars or end rings formed of a conductive metal or alloy.

This application is a continuation in part of my application Serial No. 558,056, filed on August 19, 1931.

An object of my invention is to provide an integral cast rotor structure having improved electrical characteristics.

Another object of my invention is to provide a rotor having a thin layer of heat and electrical insulating material interposed between the core of the rotor and the conductor bars.

A further object of my invention is to provide a rotor in which the conductor bars are formed of commercially pure, electrolytically refined aluminum.

A still further object of my invention is to provide a rotor having a core with longitudinal passages coated with a layer of electrical and heat insulating material so that when a conductive metal, such as aluminum or aluminum alloys, is cast in the passages to form conductor bars, the insulating material will serve as a heat insulating material during the casting operation and act as an electrical insulator between the conductor bars and the core in the finished rotor.

Another object of my invention is to provide an improved rotor structure having conductor bars and end rings formed of a conductive metal, such as aluminum or aluminum alloys, the conductor bars being insulated from the core of the rotor in such a manner that the rotor will have improved electrical characteristics.

A still further object of my invention is to provide an improved rotor having a laminated core formed of ferrous material and conductor bars or end rings formed of a conductive metal, such as aluminum or an aluminum alloy, the conductor bars being insulated from the laminated material in such a manner that the rotor shall have improved electrical characteristics.

In forming rotors for electrical motors having a core formed of ferrous material, such as iron or a ferrous alloy, and conductor bars and end rings formed of aluminum or an aluminum alloy, it has been the practice to cast conductor bars in passages or slots formed in the laminations and to cast end rings adjacent to the outer margin of the end laminations to form an integral structure. In order, however, to produce castings having uniform electrical and physical properties, it is highly desirable to introduce the metal uniformly at substantially the same temperature throughout the casting cavity and to regulate the cooling so that the conductor bars shall have uniform electrical and physical properties. When aluminum or aluminum alloys are cast in the conductor bar cavities formed in iron or ferrous alloys, the high heat conductivity of the adjacent ferrous metal has the tendency to cool the molten casting metal very rapidly and castings are produced having voids, cold shuts and other imperfections. It is, of course, desirable that the metal should cool fairly rapidly in order that the castings shall have a fine grain structure, but if the cooling is too rapid, satisfactory castings will not be produced.

I have made the discovery that if the laminations of the rotor are assembled in aligned relationship, the assembly heated to a comparatively high temperature, and a thin coating of a heat and electrical insulating material is sprayed or otherwise applied to the ferrous metal surrounding the longitudinal passages before the casting operation is performed, the insulating material will prevent too rapid cooling of the casting metal and conductor bar castings may be produced which are free from voids, cold shuts and other imperfections. The electrical insulating property of the material is also instrumental in providing a rotor having improved electrical characteristics.

This feature not only enables the use of aluminum or aluminum alloys but renders it possible to employ other metals having a comparatively high conductivity, such as copper, magnesium or certain of their alloys. I prefer, however, to utilize aluminum or aluminum alloys, because they may be cast at a comparatively low temperature and have a comparatively high conductivity. In view of its high conductivity, electrolytically refined aluminum is highly desirable.

My invention will be better understood by reference to the accompanying drawing, in which:

Figure 1 is a perspective view of a rotor core showing the laminations disposed in aligned relationship, and means for providing an insulating coating in the conductor passages;

Fig. 2 is an elevational view, partly in cross section, of my improved rotor showing the end rings and conductor bars;

Fig. 3 is an end view of the rotor shown in Fig. 2; and

Fig. 4 is an enlarged plan view of a laminae showing the insulating material in section.

Referring to Figs. 2, 3 and 4 of the drawing, my improved rotor comprises a core composed of a plurality of laminations 1 having aligned slots 2 in which conductor bars 3 formed of

aluminum or aluminum alloys are cast. End rings 4 formed of aluminum or aluminum alloy are also cast around the peripheral margin of the end laminations, and the conductor bars and end rings serve to hold the laminations in place. The rotor is also provided with a central shaft-receiving aperture 5, slotted apertures 6 and an aperture 7.

In manufacturing my improved rotor, the laminations are placed upon a mandrel 9 so that the slots may be in aligned relationship. The laminations are then heated to a temperature of approximately 250° to 300° F., and a solution of a heat and electrical insulating material is sprayed downwardly through the passages and around the peripheries of the rotor, as illustrated in Fig. 1 of the drawing, by means of a suitable spray 8. Instead of spraying the material in the passages, however, the assembled laminations and mandrel may be dipped in an aqueous suspension of the electrical and heat insulating material. If the slots or passages are spaced from the periphery, it will of course be understood that the insulating material will be sprayed directly through the slots or passages in which case it will not be necessary to spray the outer peripheral surface of the rotor with insulating material. The heated laminations cause the coating to dry quickly, and a thin smooth lining of the heat and electrical insulating material 10 is formed on, and closely adheres to, the surface of the metal surrounding the slots and the outer periphery of the laminations.

While I do not desire to be limited to any particular heat and electrical insulating material, I have found that a suspension of aluminum oxide, or a suspension of china clay, in an aqueous solution of sodium silicate, are suitable. A suspension of china clay in an aqueous solution of sodium silicate not only acts as a good heat insulating medium during the casting operation, but serves as an excellent insulator in the finished rotor. I have found that if the assembled laminations are first heated to the temperature specified and the walls of the passages are sprayed with such a suspension, the coating will dry rapidly and a thin uniform layer of a heat and electrical insulating material will be provided which closely adheres to the walls of the conductor bar passages.

After the heat insulating layer has been applied, the laminations are heated to a temperature of approximately 600° to 1000° F., placed in a mold, and molten aluminum or aluminum alloy is poured into or caused to flow upwardly through the conductor bar passages, and into the mold cavities, to form the conductor bars and end rings. The particular temperature to which the laminations are heated will depend upon the volume of the laminations, the volume and surface area of the conductor bars to be cast, and the surface area of the mold. Before the laminations are placed in the mold, the mold is also heated to a temperature of approximately 600° to 1000° F., depending upon the temperature to which the laminations are heated, in order that the chilling effect of the mold will not tend to cause cold shuts and the like but yet may be sufficient to cause the metal to solidify under advantageous permanent mold conditions. The mold is generally heated to a temperature approximating but usually exceeding the temperature of the laminations. After the mold has been heated for the first casting in a run, the heat imparted to the mold from the poured casting metal and the heated laminations is ordinarily sufficient to maintain the mold at the proper molding temperature. As a rule, the temperature of the mold will be considerably less than the temperature of the laminations and will vary through a temperature cycle during the casting operation of some magnitude. While the optimum temperature to which the laminations of rotors of different construction should be heated varies over a considerable temperature range in accordance with the factors specified, the temperature to which the laminations of a rotor of specified construction or a series of rotors of approximately the same construction should be heated before the casting operation, is held within a comparatively narrow range. For example, after the optimum temperature to which the laminations should be heated has been ascertained, the heating temperature to which the laminations of the rotor, or other rotors of a similar construction are heated before the casting operation, is not permitted to vary more than approximately 50° F. from that temperature.

In view of the heat insulating properties of the lining and because the laminations are heated to a comparatively high temperature, the cooling of the metal in the conductor bar passages is retarded and castings free from voids, cold shuts and other imperfections will be produced.

By the use of a heat insulation and by separately heating the assembled laminations of the rotor to a temperature which is usually higher than the mold before placing the assembly therein, it is possible to form rotors with a cast conductor system of commercially pure aluminum containing less than 1% total impurities or even electrolytic aluminum in which the impurities are less than .25%. In previous practice, it has heretofore not been possible to utilize commercially pure aluminum of such a grade of purity or electrolytic refined aluminum because of the difficulty of casting the metal. It is preferred, however, in the manufacture of rotors to utilize commercially pure aluminum because substantially pure aluminum has a greater electrical conductivity than aluminum alloys or aluminum containing larger amounts of impurities. Furthermore, when metal of greater conductivity is employed, the cross sectional area of the conductor bars may be reduced, which permits the use of a greater amount of magnetic material in the rotor.

It is well known, however, that pure aluminum is more difficult to cast than aluminum alloys or aluminum containing a larger amount of impurities because of its higher crystallization shrinkage. The heating of the laminations before being placed in the mold and the use of the insulations renders the formation of rotors having conductor bars formed of commercially pure or electrolytically refined aluminum not only possible but commercially practicable.

In forming the castings, I prefer to cause the molten metal to flow into the lower end ring cavity to form the end ring 4, and upwardly through the conductor bar passages to form the conductor bars, and into an upper end ring cavity to form the end ring 4' as disclosed in my application Serial No. 558,056 filed on August 19, 1931, of which this application is a continuation in part.

From the foregoing specification, it will be apparent that the insulating material in the conductor bar passages performs a dual function; that is, provides a heat insulating coating during the casting operation to prevent too rapid cooling of the metal, and serves as an electrical insula-

tion in the finished rotor. A rotor having improved physical and electrical properties is therefore provided.

It will also be seen that my invention provides a unique manner for controlling casting conditions, whereby castings heretofore formed with difficulty may be produced commercially.

Furthermore, it will be noted that the casting metal in the slots and end rings also serves to hold the laminations in position, thus providing a substantially integral structure.

It will further be noted that by my invention I have provided an integral cast rotor for induction motors involving new and improved electrical characteristics, whereby an electric circuit of uniform conductivity and hence uniform torque may be obtained.

Furthermore, it is to be understood that the particular form of apparatus shown and described is presented for purposes of explanation and illustration, and that various modifications can be made without departing from my invention as defined in the appended claim.

What I claim is:

A rotor comprising a laminated core formed of ferrous material having a plurality of circumferentially arranged conductor bar passages extending through said laminations, an integral casting selected from a group comprising cast aluminum and a cast aluminum alloy disposed in and substantially filling said passages and a relatively thin coating of chain clay adherently secured to the walls of said passages with silicate of soda.

EVERETT G. FAHLMAN.

CERTIFICATE OF CORRECTION.

Patent No. 2,003,587. June 4, 1935.

EVERETT G. FAHLMAN.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, line 14, the claim, for "chain" read China; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 9th day of July, A. D. 1935.

(Seal)

Bryan M. Battey

Acting Commissioner of Patents.

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