NICKEL PLATED PROPELLER BLADE

FIG. 1.

FIG. 2.

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NICKEL PLATED PROPELLER BLADE

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This invention relates to an improved aluminum or aluminum alloy aeronautical propeller blade and to the process of plating the blade with a hard wear resistant metal.

While aluminum and aluminum alloy aeronautical propeller blades may be characterized as strong and durable and of lightweight construction, they are not entirely satisfactory in their present state. Due to the relatively soft nature of aluminum and aluminum alloys suitable for propeller construction, they are susceptible to erosion and abrasion damage from water, sand and other airborne particles. Although it has been known to protectively plate such aeronautical propeller blades with hard wear resistant metals such as nickel, in order to overcome these disadvantages, blades so plated have not been completely satisfactory.

Heretofore, aluminum and aluminum alloy aeronautical propeller blades have been nickel plated in accordance with a process whereby succeeding layers of resilient organic materials are affixed to the aluminum or aluminum alloy base blade and serve to prevent crack propagation from the final layer of nickel to the base blade. It has been known practice to coat or impregnate the outermost organic layer with an electro-conductive substance which serves as the cathode in a conventional electrolytic bath wherein the nickel is deposited thereupon to the desired thickness.

Certain disadvantages are known to be associated with this type of plating technique and with propeller blades plated in accordance therewith. The relatively thin layer of electro-conductive substance, which is relied upon as a cathode in the nickel plating bath, does not render efficient service. Deposition of the nickel normally commences at the point where electrical contact is made with the electro-conductive surface and slowly grows outward therefrom. As a consequence of this relatively slow deposition of nickel upon the electro-conductive surface, absorption of the electrolyte into the organic materials may be permitted and corrosion of the aluminum or aluminum alloy base blade may result.

Furthermore, the delay in deposition of the nickel over the entire blade surface results in contamination of the plating bath by components of the organic materials. Since this contamination is in turn passed on to the deposited hard metal and results in undesirable impurities therein, it is in most cases necessary that the plating be accomplished in two or more stages with new plating baths being utilized for each stage.

Finally, the nickel plated blade, comprising an outer and an inner electrically conductive material separated by a dielectric layer of organic material exhibits the characteristics of an electrical condenser, a highly undesirable feature when the eventuality of lightning striking the blade is considered.

It is the general object of the invention to provide an improved method of hard plating an aluminum or aluminum alloy propeller blade wherein the plate can be applied more rapidly than has heretofore been the case and without causing any damage to the aluminum body and without dissipating the purity or high quality of the plating material so that the finished propeller blade is more wear resistant and has a longer life than generally similar blades.

It is a more specific object of the invention to provide in a hard plated aluminum propeller blade a resilient material between the blade body and its plate which serves to expedite the plating process during blade fabrication and which serves in the finished blade as a shock cushion between the plate and the body and one which will not create a condenser in the blade construction as has heretofore been found to be highly undesirable.

The drawing shows a preferred embodiment of the invention and such embodiment will be described, but it will be understood that various changes may be made from the construction disclosed, and that the drawing and description are not to be construed as defining or limiting the scope of the invention, the claims forming a part of this specification being relied upon for that purpose.

Fig. 1 is a plan view of an exemplary propeller blade incorporating the features of the present invention and which is nickel plated in accordance with the present invention; and

Fig. 2 is an enlarged scale fragmentary sectional view showing the laminations of the nickel plate, the organic materials and an undercoating of zinc plate on the body of the blade.

Generally speaking, it may be said that the propeller blade 10 of this invention is produced in accordance with a process which includes a plurality of steps wherein succeeding layers of zincate 12, zinc plate 14, organic materials 16, 18 and 20, all of which are electro-conductive throughout their thickness, and a final layer of nickel 22 are affixed to the surface of an aluminum or aluminum alloy aeronautical propeller blade 10.

As used in the following description, the terms “aluminum blade,” “blade” and “base blade” are meant to include a conventional aluminum or aluminum alloy propeller blade whether the blade surface is untreated, has an oxide surface as a result of natural formation or has been sandblasting process, or has a protective plating of corrosion-resistant metal, such as zinc. The latter two alternatives of blade condition are preferred over the first since the galvanic corrosion protection provided thereby is thought to be highly desirable. Of these two, the corrosion protection provided by zinc plating is found to be most effective and, accordingly, this construction as illustrated in the drawing which forms a part of this application comprises the preferred embodiment of the invention and will be described hereinafter.

A first coating of zinc 12 may be provided by first immersing the aluminum base blade 10 in a strong alkaline-type bath containing zinc ions, a method of chemically depositing zinc commonly referred to as a "zincating process." A further layer of zinc 14 is then electrolytically deposited on the zinc immersion coating 12 in an acid-type electrolytic bath. It has been found desirable to immerse the blade after zincating in the electrolytic zinc plating bath with the electric current on in order to reduce chemical action of the zinc plating solution with the zinicate film 12.

Before any conductive organic material is applied to the zinc plated surface 14 or to the blade surface 16, as the case may be, the surface is thoroughly cleaned in accordance with accepted practices to insure that all foreign or undesirable materials are removed.

The first organic material applied, in a layer 16, is an electro-conductive synthetic rubber resin adhesive, preferably including as its principal constituents a selected mixture of a buta-N type synthetic rubber such as acrylonitrile, a phenolic resin and carbon black dispersed uniform-
ly throughout the mixture. The synthetic rubber while it imparts resiliency to the mixture is not characterized by good strength characteristics. The phenolic resin, on the other hand, while it does exhibit relatively good strength characteristics, has rather poor ductility qualities. By combining the two constituents in a desirable compromise of strength and ductility is obtained whereby the resultant material is sufficiently resilient to inhibit crack propagation therewith and yet does not allow shifting of succeeding layers of material. The carbon black, which is dispersed in fine particles uniformly throughout the mixture serves, as would be expected, to impart the characteristics of an electrical conductor thereto. The mixture has the property of adhering firmly to zinc as well as to the resin modified neoprene cement, which constitutes the next applied layer 18.

The said adhesive mixture which is used in the layer 16 is thinned with methylethylketone to a suitable consistency for spraying and is then sprayed upon the blade to a thickness of .0001 to .0005 of an inch. It is preferred practice to apply the electro-conductive synthetic rubber adhesive in two coats to insure uniform and complete coverage of the blade. Ten to fifteen minutes air drying time is customarily allowed after application of each coat to permit evaporation of the solvents therefrom.

The above described layer 16 may be appropriately referred to as a "primer coat". Its purpose is to insure optimum adhesion to the zinc surface 14. It is to be understood at this point that while the particular conductive synthetic rubber resin adhesive utilized is chosen for reasons of its excellent adhesion to zinc, its adhesion characteristics with respect to untreated and oxidized faced aluminum are also quite satisfactory. Furthermore, it is considered to be within the scope of the inventive concept to utilize for this purpose other organic adhesives which may be considered to have superior adhesion characteristics with respect to such aluminum surfaces.

The second organic material, applied in a layer 18, is a conductive resin modified neoprene cement. Its principal constituents are preferably neoprene synthetic rubber, phenolic resin and carbon black, dispersed uniformly throughout the mixture. The phenolic resin included in the cement serves to render the mixture compatible with the conductive synthetic rubber resin adhesive, which comprises the preceding layer 16. As a result, excellent adhesion therebetween is obtained and the conductive neoprene rubber cement which comprises the next succeeding layer 20 is also firmly bonded by virtue of its compatibility with the neoprene synthetic rubber which comprises the second principal constituent of the adhesive layer 18. Here, once again, the intermingled carbon black serves to provide electrical conductivity.

The adhesive mixture which is used in the layer 18 is thinned with methylethylketone to obtain a consistency suitable for spray application. Two coats are then applied with an air drying time of from ten to fifteen minutes following each. It is believed preferable that the minimum thickness of this layer 18 be approximately .0002 of an inch and the maximum thickness be approximately .001 of an inch.

The final layer of organic material 20 is comprised of electro-conductive neoprene rubber cement with carbon black dispersed uniformly throughout. It is thinned with a suitable solvent such as toluene, at a ratio of approximately four to one, or as required to obtain satisfactory spray patterns. Successive coats are then sprayed upon the blade to obtain the desired thickness. The minimum limit of thickness is presently thought to be approximately .001 of an inch, the maximum limit of thickness approximately .004 of an inch, and the optimum thickness from .002 to .0025 of an inch. An air drying time of approximately ten hours followed by baking for a period of from three to five hours at a temperature ranging from 150° to 190° F. will serve to insure evaporation of all solvents and to partially cure the neoprene rubber. While baking may be accomplished by any of a number of well known means, it has been found that infra-red lamps provide adequate and appropriate means for the purpose. Therefore, well suited for the purposes of this invention.

This final layer 20 of organic material has as its primary function the prevention of crack propagation from the nickel plate 22 which is of a relatively brittle nature to the base blade 10. In this connection, it is carefully selected so as to have the desired resiliency and the thickness limits are somewhat critical. If, on one hand, the layer 20 is of insufficient thickness, it will be incapable of accomplishing its function of prevention of crack propagation. On the other hand, if the layer is too thick, the nickel plate may tend to shift under certain applied conditions and bring shear stress into the adhesive system as a material consideration. Since the characteristics of the layer 20 in this respect are, of course, predicated upon the inherent resiliency of the material as well as the thickness, it is essential also that the material selected have the desired resiliency. The neoprene rubber cement utilized in this invention is found to be particularly well suited to this use.

After baking, the blade is permitted to cool and is rinsed with water, then the conductive neoprene rubber cement surface is rubbed lightly with an abrasive paper to present a smooth function bearing to insure optimum adhesion to the zinc surface. The blade is then disposed in a conventional electrolytic nickel plating bath with the base blade connected as the cathode. Since all of the aforementioned blade covering layers are conductive throughout their respective thicknesses and since the aluminum base blade serves as an efficient cathode by virtue of its low resistance to current flow, deposition of the nickel commences over the entire blade surface simultaneously and the plating process is accomplished in its entirety much more quickly than has heretofore been the case. As indicated above, previously used plating processes of this type depended upon a relatively thin layer of conductive material disposed on the outermost organic layer as the cathode in the nickel plating bath. With the blade of this invention, the resistance to current flow in the base blade 10 and outwardly therefrom to the surface of the outermost organic layer 20 is of course much lower than in the case where the current must flow over the entire blade area within a thin conductive coating. Thus, it will be seen that a distinctive feature of this invention is the utilization of the base blade 19 as the cathode in the nickel plating bath wherein the final nickel plate layer 22 is applied.

As a result of the rapid deposition of the nickel layer 22 over the entire blade surface, there is insufficient time for the plating bath to become contaminated as a result of chemical action of the bath with the organic materials. As a consequence, it becomes unnecessary to remove the blade from the bath, substitute a clean bath and continue with the operation as was heretofore the practice. The nickel plating process is thus accomplished much more rapidly and, furthermore, due to the absence of contamination in the electrolytic bath, an extremely pure nickel plate is achieved.

As a further result of the rapid plating achieved over the entire blade surface, there is considerably less danger of the plating bath components permeating the organic materials and causing corrosion of the base blade.

It will be quite apparent that the nickel plated aluminum aeromotive propeller blade provided in accordance with the aforesaid described specific process will comprise an aluminum airfoil body surrounded by layers of corrosion resistant zinc 12 and 14, a body of electro-conductive organic material comprising the layers 16, 18, 20 and an outermost layer of nickel 22 or some other suitably hard and wear-resistant metal. More specifically, the electro-conductive organic materials comprise, in inner to
An aeronautical propeller blade which is electrically conductive throughout and which comprises a nickel plated aluminum airfoil body having a body of rubber-like material interposed between the aluminum body and the nickel plate, the said body of rubber-like material being electrically conductive throughout and including a plurality of layers of adhesives which layers comprise in inner-to-outer order a layer of a synthetic rubber resin adhesive particularly suited for bonding with aluminum, a layer of a resin modified synthetic rubber cement particularly suited for bonding with synthetic rubber resin adhesives and with synthetic rubber adhesives and a layer of a synthetic rubber adhesive.

An aeronautical propeller blade which is electrically conductive throughout and which comprises a nickel plated aluminum airfoil body and a layer of zinc and a body of rubber-like material interposed between the aluminum body and the nickel plate, the said body of rubber-like material being electrically conductive throughout and including a plurality of layers of adhesives which layers comprise, in inner-to-outer order, a layer of synthetic rubber resin adhesive particularly suited for bonding with zinc, a layer of a resin modified synthetic rubber cement particularly suited for bonding with synthetic rubber resin adhesives and with synthetic rubber adhesives, and a layer of a synthetic rubber adhesive.

An aeronautical propeller blade which is electrically conductive throughout and which comprises a nickel plated aluminum airfoil body and a layer of a resin modified neoprene rubber cement and neoprene rubber cement, it is to be understood that other adhesives having similar characteristics may be employed provided that an electro-conductive substance is dispersed uniformly throughout the same. In this connection, it is to be understood that wherever the terms "synthetic rubber" and/or "neoprene rubber" are used, it is contemplated that natural rubber products may be utilized interchangeably therewith.

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