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REMOVABLE PROTECTIVE COATING FOR ARTICLES OF MANUFACTURE, SUCH AS AERONAUTICAL PROPELLER BLADES

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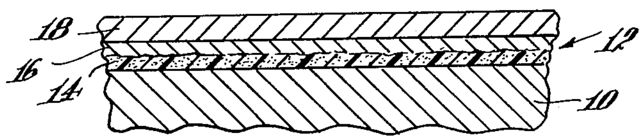

Fig. 1

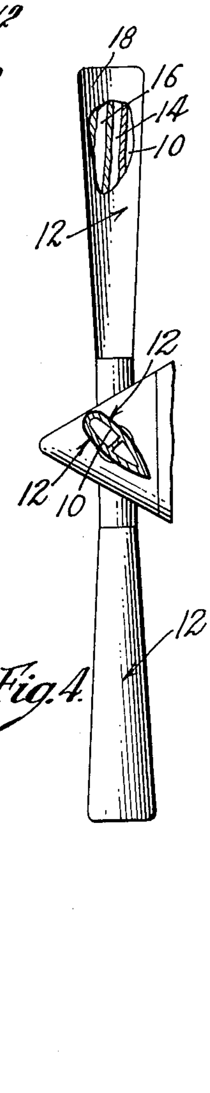

Fig. 4

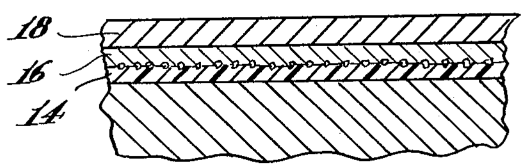

Fig. 2

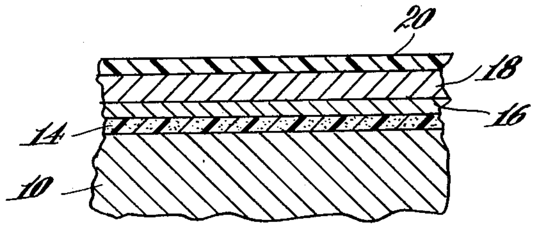

Fig. 3

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REMOVABLE PROTECTIVE COATING FOR ARTICLES OF MANUFACTURE, SUCH AS AERONAUTICAL PROPELLER BLADES

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This invention relates to articles of manufacture having a protective coating and to a method of applying the coating.

Many metals, which are otherwise suitable for structural purposes, do not have the desired surface resistance to erosion, oxidation, and the like. Thus, for example, aluminum alloy aeronautical propeller blades are strong and of light weight, however, they are not highly resistant to damage from the abrasive action of particles of water, sand, stones and other material prevalent on runways. Flame-sprayed coatings, such as disclosed in United States Patent No. 2,707,691, granted to William M. Wheildon, Jr., May 3, 1955, provide an excellent erosion-resistant surface; however, such coatings are not suitable for direct application to aeronautical propellers because in order to attain the high degree of adhesion necessary the surface must be modified, for example my mechanical roughing which is undesirable; because the propeller blades must frequently be inspected for incipient failure and once a coating has been applied, according to the foregoing method of application, it cannot be removed without damage to the propeller; and finally, because the coating is not entirely impervious and hence is a starting point for corrosion.

Objects of this invention are to provide an article of manufacture having a coating applied thereto which embodies the advantages of resistance to abrasion and oxidation of coatings of the kind disclosed in the Wheildon patent, and the further advantages that it is bonded to the surface without modification of the latter; that it is corrosion-resistant; and that it is removable without damage to the propeller. Other objects are to provide a method of attaching a flame-sprayed coating, such as described in the aforesaid Wheildon patent, without having to modify the surface to which it is to be applied preparatory to its application except for cleaning; to provide a method of attaching the coating in such fashion that it will adhere tenaciously for the purpose of use, but can easily be removed when desired; and to provide a method of making the coating corrosion-resistant.

In accordance with the foregoing, the article which may be a propeller comprises a rigid structure having a multi-layer coating applied thereto including an abrasive-resistant layer and a substantially corrosion-resistant bonding layer adhesively uniting the abrasive-resistant layer to the structure, but which may be degraded by means of an agent which is not harmful to the structure to permit removing the entire coating. The coating also includes an intermediate metal layer between the abrasive-resistant layer and the bonding layer and may optionally have an exterior layer applied to the abrasive-resistant layer to reduce porosity of the latter.

The method comprises cleaning the surface of the structure which is to be coated, applying a layer of synthetic liquid resin to the surface, allowing the resin layer to dry, and then curing it at a temperature below that which would adversely affect the physical properties of the structure. The method contemplates including with the resin an admixture of a powdered metal filler and, when the latter is employed, the surface of the layer, after curing, is roughened to expose the particles. Optionally,

the filler may be omitted and a powdered metal deposited on the resin layer before curing, so that it remains exposed on the surface. A flame-sprayed intermediate layer of metal is then applied to the rough surface of the resin layer and finally a flame-sprayed external layer of impact resistant material is applied to the intermediate layer.

The invention will now be described in greater detail with reference to the accompanying drawings wherein:

FIG. 1 discloses a section through a metal structure having a multi-layer coating applied to one side and in which the bonding layer includes a filler, it being understood that the coating may be applied to both sides of the structure;

FIG. 2 is a corresponding section in which the filler has been omitted from the bonding layer and powdered metal has been applied to the surface of the bonding layer prior to application of the intermediate layer;

FIG. 3 is a modification on which a sealing layer is applied to the external surface of the multi-layer coating; and

FIG. 4 is a side elevation of an aeronautical propeller with one of the blades shown in cross section.

Referring to the drawings, FIG. 1, there is shown a base 10 which has applied to it a coating 12 of multi-layer construction. While shown applied to one surface it is to be understood that the coating may be applied to as little or as much of the external surface of the base as is desired. The base itself is rigid and suitable for manufacture of structural members or articles. The coating 12 includes an inner bonding layer 14 next to the base, an intermediate layer 16 and an external abrasive-resistant layer 18.

The bonding layer 14 is a corrosion-resistant layer of adhesive synthetic resin in a cured condition containing metal powder particles, some of which are exposed at the surface of the resin layer. Alternatively, the metal powder particles may be applied only to the surface of the resin so that when the latter is cured they project part way out of the surface. A resin is chosen for the bonding layer which has a high adhesive strength and preferably is an epoxy resin.

The intermediate layer 16 is a flame-sprayed metal applied to the roughened surface of the bonding layer by well-known methods, for example, with a Schoop gun.

The external abrasive-resistant layer 18 may be of hard metals, refractory metal carbides or fused metal oxides, or combinations of metal oxides including silicon dioxide, flame-sprayed on the intermediate layer 16, according to the method disclosed in the Wheildon patent, 2,707,-691. According to the aforesaid patent a rod consisting of a stable metal oxide is fed into a flame hot enough to melt it, whereupon it is instantly atomized to form discrete molten particles and while still molten the particles are projected with a blast of gas onto the surface to be coated. Oxides and carbides applied in this fashion are extremely stable and highly resistant to impact abrasion.

Optionally, a sealing layer 20 (FIG. 3) may be applied to the layer 18 to reduce its porosity. An epoxy resin is preferred.

As thus made up, the multi-layer coating 12 embodies highly desirable characteristics for protecting structural members and articles in general and in particular aeronautical propellers for it provides high impact resistance to surface damage, is corrosion-resistant, may be applied without modifying the surface of the propeller preparatory to its application, and may be removed by degrading the bonding layer without damage to the propeller.

In its more specific application to aeronautical propellers and in accordance with the method herein disclosed, the aluminum alloy propeller is thoroughly cleaned after its surface has been anodized, whereupon a layer of synthetic resin is applied to the clean surface. The synthetic resin is preferably an epoxy resin, in particular, a liquid resin, such as that known under the trade name Araldite, however, it is to be understood that any resin having the same or equivalent properties of corrosion-resistance and adhesive strength may be employed. According to one method of preparing the bonding layer, a filler of powdered alumina or aluminum alloy is mixed therewith in approximately equal volumes. The admixture of resin and filler is then sprayed upon the surface to a thickness between 0.002" and 0.008" and preferably 0.005".

The layer of synthetic resin is allowed to dry and is then cured by heating the propeller at a temperature within the range of 80° C. to 100° C. By choosing a resin having a low curing temperature, curing may be effected without adversely affecting the physical properties of the propeller. After curing, the surface of the synthetic resin layer is mechanically roughed with shot or abrasive to expose particles of the aluminum filler.

Alternatively, the filler may be omitted and a layer of powdered aluminum or aluminum alloy, preferably dendritic is applied to the surface of the resin prior to curing, leaving the particles exposed to a depth of ⅔ of their diameter. As thus prepared the surface need not be roughened by mechanical means. The exposed particles, applied in either way, provide a keying surface which enhances attachment of the intermediate layer thereto.

The intermediate layer **16** is next applied by flame-spraying and consists of an aluminum or aluminum alloy deposited by means of a Schoop gun, or the like, on the rough surface of the resin layer. The flame-spraying of metals is well-known and the method using metal wire, referred to in the Wheildon patent, is preferred.

The impact resistance layer **18**, preferably is applied according to the method described in the Wheildon patent and may be comprised of fused metal oxide or combinations of metal oxides, including silicon dioxide. The layer is conveniently fused aluminum oxide and is between 0.010 and 0.025" thick and preferably 0.020" thick.

Optionally, a sealing layer of epoxy resin **20** may be applied to the abrasive-resistant layer and cured. This layer is between 0.002 and 0.005" thick and preferably 0.003". It has the effect of sealing the otherwise somewhat porous surface of the impact resistant layer and is not always necessary.

The epoxy resin employed for the bonding and sealing layers, referred to herein as Araldite, is manufactured by the Ciba Co., Inc., Plastics Division, Kimberton, Pennsylvania. Araldite is a solvent solution of an epoxy resin of the 4,4' bisphenylol glycidyl ether type having cold curing amine hardeners which can be accelerated by the application of heat. Epoxy resins are remarkable for the unusual combination of properties they possess and, in particular, they combine unsurpassed adhesive strength with hardness, impact resistance and flexibility. At the same time, epoxy resins may be degraded when exposed to acetone, ethyl acetate, sulphuric acid, and chlorinated solvents. One such solvent is sold under the proprietary name of Ardrox 20, manufactured by Brent Chemical Products Limited, Commerce Road, Brentford, Middlesex, England. Ardrox 20 is a mixture of methylene cellulose, ammonia, wax and methylene dichloride and is entirely soluble in water.

The multi-layer coating, as thus applied, has the effect of reducing the abrasion of the blades, adheres to the blades, even at the high rotational speed encountered, resists corrosion, and yet may be rendered removable for inspection of the blades by treatment with a resin degrading agent such as referred to above.

Sometimes it may be desirable to etch the propeller blades with an etch primer, such as that sold under the name of Celletch, manufactured by Canadian Pittsburgh Industries Limited, Paints Division, Montreal, Canada.

Celletch is a mixture of phenolic resin, polyvinyl butyrol, talc and zinc chromates with phosphoric acid and alcohol solvents.

It is to be understood that the term "aluminum alloy blade" is intended to include any blade of aluminum alloy, whether it has an oxide surface or not. In most cases, the aluminum alloy blades are anodized before applying the coating described herein.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

We claim:

1. The method of coating a rigid structural member which comprises, depositing a layer of corrosion-resistant adhesive resin on the surface of the member in an uncured liquid condition, curing the layer, applying a flame-sprayed layer of metal to the cured layer and then applying an impact resistant flame-sprayed layer of a member selected from the group consisting of stable metal oxides and refractory metal carbides.

2. A method according to claim 1 wherein the resin layer has admixed therewith a metal powder and the surface of the resin layer, after curing, is treated to expose the metal powder particles.

3. A method according to claim 1, wherein a layer of metal powder is applied to the surface of the resin layer prior to curing, so that the major portions of the powder particles project from the surface.

4. A method according to claim 1, wherein a sealing layer of synthetic resin is applied to the external surface of the impact resistant layer.

5. The method of coating an aluminum alloy propeller which comprises cleaning the blades, applying an uncured layer of epoxy resin thereto, curing the resin layer at a temperature below that which deleteriously affects the propeller, treating the resin layer to produce a roughened surface, applying a flame-sprayed layer of aluminum to the roughened surface of the resin layer, and thereafter applying an impact resistant flame-sprayed layer of a member selected from the group consisting of stable metal oxides and refractory metal carbides.

6. A method according to claim 5, wherein the propeller blades are initially anodized.

7. A method according to claim 5, wherein the propeller blades are initially etched.

8. A method according to claim 5, wherein the resin layer has admixed therewith a metal powder and the surface of the resin layer, after curing, is treated to expose the metal powder particles.

9. A method according to claim 5, wherein a layer of metal powder is applied to the surface of the resin layer prior to curing, so that the major portions of the powder particles project from the surface.

10. A method of operating an airplane propeller in an unusually abrasive environment wherein the propeller is protected by an abrasion resistant outer layer which must be removed from time to time for inspection of the propeller comprising depositing a layer of corrosion resistant adhesive resin on the surface of the member in an uncured condition, curing the resin layer in situ, applying a flame-sprayed layer of metal to the cured layer, then applying an impact resistant flame-sprayed layer of a member selected from the group consisting of stable metal oxides and refractory metal carbides, driving the propeller until inspection is required, and then degrading the cured resin and removing the flame-sprayed coatings to bare the propeller surface for inspection.

11. A method according to claim 10, wherein the resin layer has admixed therewith a metal powder and the surface of the resin layer, after curing, is treated to expose the metal powder particles.

12. A method according to claim 10, wherein a layer of metal powder is applied to the surface of the resin

layer prior to curing, so that the major portions of the powder particles project from the surface.

13. As an article of manufacture a rigid metal aeronautical propeller having a protective multi-layer coating applied thereto, said coating including a rigid external layer of material that is highly resistant to impact abrasion, said layer comprised of a member selected from the group consisting of stable metal oxides and refractory metal carbides and a bonding layer of from about .002" to .008" thickness, the adhesive strength between the successive layers and the propeller being sufficiently great to resist the centrifugal forces encountered during rotation of the propeller and said bonding layer being degradable by means of an agent which is not harmful to the propeller.

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