

UNITED STATES PATENT OFFICE

2,462,615

METHOD OF CHROMIUM PLATING AND
TREATING STEEL AIRPLANE PROPELLER
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Serial No. 578,552

2 Claims. (Cl. 204—37)

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This invention relates to methods for reducing the loss of fatigue strength of metals consequent upon the electrodeposition of chromium protective coatings thereon, and to metal parts, coated with electrodeposited chromium, which are subjected to severe strains in use.

While not commonly realized, chromium electrodeposited by usual methods, produces a high loss of the fatigue strength of metals on which it is deposited. It has not been possible to provide with a chromium plate many metal articles which are subjected to stresses and strains in use which approach the fatigue limit of the unplated article. A notable example is a hollow steel aeroplane propeller.

The desirability of chromium plate on steel aeroplane propellers has been well recognized and chromium plated steel propellers were put into use. After numerous accidents due to the failure of such chromium plated propellers (a frequent occurrence was the breakage of the propeller blade while in flight), the use of chromium plated propellers was discontinued and in fact prohibited by many users. Investigation showed that the failure of chromium plated steel propellers was due to the lowering of fatigue strength of the blade and that breakage started along the cracks in the chromium surface.

Protective coatings on steel aeroplane propellers are used to inhibit erosion and corrosion. Immersion in hot oxidizing caustic solutions is a method commonly used for providing such a coating. The superiority of chromium plate as a protective coating is well recognized. Since the prohibition of its use for such purpose, much effort has been made to find a way of using chromium electrodeposits on steel aeroplane propellers (and on many other parts subjected to severe stresses and strains) without affecting seriously the fatigue or endurance limit of the unplated metal. Protective coatings which do not reduce the fatigue or endurance limit of metal on which they are placed by more than 10% are acceptable to the aeroplane industry.

The present invention comprises a method of electrodepositing chromium on metals by which the fatigue or endurance limit of the metal on which the chromium is electrodeposited is not seriously affected by the chromium electrodeposit thereon. Steel aeroplane propellers with a chromium coating or plate, deposited according to the present invention, are satisfactory and overcome the objections heretofore existing to the use of chromium electrodeposited protective coatings on steel propellers and similar articles.

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According to the present invention, the chromium is electroplated on the metal article from an aqueous bath in which the ratio of grams per liter of chromic acid (CrO_3) to grams per liter of sulphate (SO_4) or equivalent catalyst acid radical is between about 230/1 and 160/1—optimum 185/1, and closely maintained. The concentration of the chromic acid is a contributing factor to the result sought, the benefit increasing with increase of concentration from a minimum concentration of about 500 g./l. On the basis of present knowledge, a concentration of 600 g./l. chromic acid is considered optimum for use in practical operation. Concentrations of 800 g./l. can also be used. Current densities from 1 to 4 amperes per square inch have been used. Bath temperatures higher than 104°F . (40°C .) should not be used. The lowest temperature which can be maintained in a plant in summer with natural cooling water, for example, 86°F . (30°C .), is recommended for practical use. Lower temperatures can also be used.

After the metal is provided with a chromium electrodeposit according to the present invention, it is heat treated to relieve stresses. A temperature of 500°F . applied for about two or more hours, depending upon the cross-section of the article, is used in practice. Temperatures up to 932°F . have also been used for the same purpose.

When chromium is electrodeposited according to the present invention on metals which are stress-relieved, no cracks after the aforementioned heat treatment are found in the chromium plate. Such a chromium plate is unique. No chromium electrodeposit without cracks after comparable heat treatment was heretofore known. This unique characteristic of the chromium electrodeposit is attributed to its composition or texture.

Reduction of the fatigue or endurance limit of the metal on which chromium is electrodeposited is progressive with the thickness of the electrodeposit. It is important in practice from the standpoint of resistance to corrosion and erosion, that substantial thicknesses of chromium be obtained without seriously reducing the fatigue or endurance limit of the metal on which the chromium is electrodeposited. According to the present invention such a result is attained. Tests show that the steel from which aeroplane propellers are made suffers a loss of less than 10% of its fatigue or endurance limit when provided with chromium coatings as thick as .001 of an inch, electrodeposited according to the present invention, and heat treated as described herein.

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Average test figures are 6% loss. Tests show that similar steel coated with .001 of an inch chromium electrodeposited under ordinary plating conditions, shows a loss in fatigue strength of 65%. Heat-treating such chromium electrodeposits does not overcome this.

An example of the method of the present invention applied to steel aeroplane propellers is as follows:

A chromium plating bath is used having the composition 600 g./l. chromic acid (CrO_3) and 3.24 g./l. sulphate catalyst acid radical (SO_4); ratio 185 to 1. The ratio is closely maintained during operation.

A steel aeroplane propeller, finished with the care taken in the manufacture of these articles, and cleaned by recognized methods to avoid hydrogen embrittlement, is immersed in the chromium plating bath, as cathode, and current passed thereto, with the bath at 86° F. (30° C.), at a current density of 2 amperes per square inch, until a coating of $\frac{1}{2}$ to 1 thousandth inch in thickness (as may be desired in a particular case) is electrodeposited. The coated propeller is then removed, rinsed, dried, and placed in an ordinary oven and heated to 500° F. for three hours. After cooling, ordinarily a coating of paint is applied over the electrodeposit. Wax and oil may be applied to the surface in service.

What is claimed is:

1. In a method for reducing the loss of fatigue strength of steels for aeroplane propeller blades

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consequent upon the electrodeposition of chromium protective coatings thereon, passing plating current from an anode to said steel part, as cathode, immersed in a cold aqueous bath below 40° C. containing from 500 g./l. upward to saturation of chromic (CrO_3) and sulphate catalyst acid radicals, the ratio between the chromic acid and the sulphate catalyst acid radical being between 230 to 1 and 160 to 1, electrodepositing from approximately .0005 to .001 inch chromium and heat treating the plated steel part to relieve stresses in the plated steel part.

2. A method according to claim 1, wherein the ratio between the chromic acid and the sulphate catalyst acid radical is approximately 185 to 1.

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