APPLICATION ACCEPTED AND AMENDMENTS ALLOWED 2-5-90

CONVENTION

599212

AUSTRALIA

Patents Act

APPLICATION FOR A STANDARD PATENT

~~I~~/We Societe Anonyme dite Alsthom

of 38 avenue Kleber,
78754 PARIS CEDEX 16,
FRANCE.

hereby apply for the grant of a standard patent for an invention entitled:

A METHOD OF APPLYING A PROTECTIVE COATING TO A TITANIUM ALLOY BLADE, AND A BLADE OBTAINED THEREBY

which is described in the accompanying complete specification.

Details of basic application

Number of basic application: 87 03 172

Convention country in which basic application was filed: FRANCE

Date of basic application : 9 March 1987

Address for Service:

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FEE STAMP TO VALUE OF $130 ATTACHED
MAIL OFFICER

LODGED AT SUB-OFFICE
- 4 MAR 1988
Melbourne

Dated: 29 February 1988

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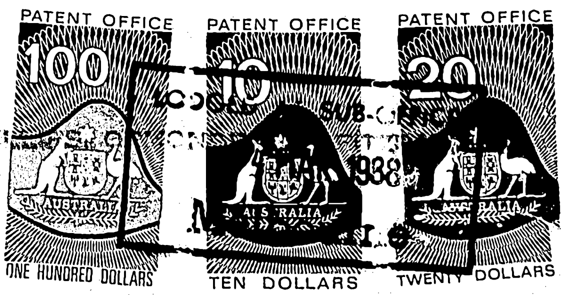
Attorneys for:
Societe Anonyme dite Alsthom

By:



Our Ref : 85711
POF Code: 1501/70625

6012q/1

AUSTRALIA F° 15804

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DECLARATION FOR A PATENT APPLICATION

▼ INSTRUCTIONS
(a) Insert "Convention" if applicable
(b) Insert FULL name(s) of applicant(s)

In support of the (a) CONVENTION application made by
(b)
Société Anonyme dite : ALSTHOM

(c) Insert "of addition" if applicable
(d) Insert TITLE of invention

(hereinafter called "applicant(s) for a patent (c) for an invention entitled (d)

A METHOD OF APPLYING A PROTECTIVE COATING TO A TITANIUM ALLOY BLADE, AND A BLADE OBTAINED THEREBY

(e) Insert FULL name(s) AND address(es) of declarant(s) (See headnote*)

I, Michel DALSACE, Agent with power of attorney
of 14-16 rue de la Baume 75008 PARIS, FRANCE

do solemnly and sincerely declare as follows:

1. XXXXXXXXXXXXXXXXXXXXXXXX
   (or, in the case of an application by a body corporate)
1. I am/XXXXXX authorized to make this declaration on behalf of the applicant(s).
2. XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   (or, where the applicant(s) is/are not the actual inventor(s))

(f) Insert FULL name(s) AND address(es) of actual inventor(s)

2. (f)
   André COULON, of 1 rue des Bleuets 90160 BESSONCOURT, FRANCE

(g) Recite how applicant(s) derive(s) title from actual inventor(s) (See headnote**)

is/are the actual inventor(s) of the invention and the facts upon which the applicant(s)
is/are entitled to make the application are as follows :

(g)

The applicant is the assignee of the invention from the said actual inventor.

(Note: *Paragraphs 3 and 4 apply* only *to Convention applications)*

(h) Insert country, filing date, and basic applicant(s) for the/or EACH basic application

3. The basic application(s) for patent or similar protection on which the application is based is/are identified by country, filing date, and basic applicant(s) as follows:
   (h) FRANCE, March 9, 1987
   by Société Anonyme dite : ALSTHOM

4. The basic application(s) referred to in paragraph 3 hereof was/were the first application(s) made in a Convention country in respect of the invention the subject of the application.

(k) Insert PLACE of signing
(l) Insert DATE of signing
(m) Signature(s) of declarant(s)

Note: No legalization or other witness required

Declared at (k) PARIS

Dated (l) February 22, 1988

(m) [signature]

Michel DALSACE
Fondé de Pouvoir
en Brevets d'Invention

To: The Commissioner of Patents

P18/7/78

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(12) PATENT ABRIDGMENT (11) Document No. AU-B-12729/88
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(54) Title
A METHOD OF APPLYING A PROTECTIVE COATING TO A TITANIUM ALLOY BLADE, AND A BLADE OBTAINED THEREBY

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(71) Applicant(s)
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(56) Prior Art Documents
AU 594279 83033/87 B22F 7/08
AU 596050 83032/87 F01D 5/28
AU 585800 70411/87 F01D 5/28

(57) Claim

1. A method of applying a protective coating on a titanium alloy blade, wherein the portion of the blade to be coated has pure vanadium powder deposited thereon and the temperature of the powder is raised to a temperature which is slightly higher than the melting point of vanadium in order to form a layer of vanadium having a thickness between 0.5mm and 1.5mm, thereafter, a heterogeneous powder mixture is deposited on the vanadium layer, said powder mixture is deposited on a vanadium layer, said powder comprising about one third by weight of titanium carbides, titanium nitrides, or titanium borides, bonded by a martensitic or austenomartensitic stainless steel, the heterogeneous powder being raised to a temperature which is greater than its melting temperature and less than the melting temperature of vanadium.

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4. The method according to any preceding claim, wherein the powders are projected and melted under an inert atmosphere using a laser beam.

5. A titanium alloy blade, including on its periphery a coating layer which is at least 1 mm thick and which includes about one third by weight titanium carbides, or titanium nitrides, or titanium borides bonded by a martensitic or austenomartensitic stainless steel, said coating layer covering an under layer of vanadium having a thickness lying between 0.5 mm and 1.5 mm.

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COMPLETE SPECIFICATION
(ORIGINAL)

	Class	Int. Class
Application Number:		
Lodged:		

Complete Specification Lodged:
Accepted:
Published:

Priority

Related Art:

This document contains the amendments made under Section 49 and is correct for printing.

APPLICANT'S REFERENCE: F 15804/PV

Name(s) of Applicant(s):

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FRANCE.

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Complete Specification for the invention entitled:

A METHOD OF APPLYING A PROTECTIVE COATING TO A TITANIUM ALLOY BLADE, AND A BLADE OBTAINED THEREBY

Our Ref : 85711
POF Code: 1501/70625

The following statement is a full description of this invention, including the best method of performing it known to applicant(s):

A METHOD OF APPLYING A PROTECTIVE COATING TO A TITANIUM ALLOY BLADE, AND A BLADE OBTAINED THEREBY

The present invention relates to a method of applying a protective coating on a titanium alloy blade, and to a blade obtained thereby.

Titanium alloy blades have the advantage of having a high strength/density ratio and also of having remarkable mechanical performance in highly corrosive surroundings.

However, titanium alloy blades used in steam turbines, in particular when their peripheral speeds are high, are rapidly damaged by the droplets of water that form in the steam.

It is therefore necessary to protect the peripheries of such blades.

The present invention provides a titanium alloy blade, including on its periphery a coating layer which is at least 1 mm thick and which includes about one third by weight titanium carbides, or titanium nitrides, or titanium borides bonded by a martensitic or austenomartensitic stainless steel, said coating layer covering an under layer of vanadium having a thickness lying between 0.5 mm and 1.5 mm.

This coating is applied by the following method: vanadium powder is deposited on the portion of the blade to be coated, and the temperature of the power is raised to a temperature which is slightly higher than the melting point of vanadium.

Thereafter, a heterogeneous mixture of powder comprising about one third by weight titanium carbides or titanium nitrides or titanium borides bonded by a martensitic or austenomartensitic stainless steel including, in particular, chromium and optionally cobalt and/or molybdenum and/or nickel is deposited on the layer of vanadium; this powder is raised to a temperature which is higher than its melting temperature but less than the melting temperature of vanadium.

By this method, a minimal quantity of vanadium is diluted in the titanium alloy blade during the first stage. Similarly, during the second stage, the dilution of the alloy in the vanadium under layer is very limited. Further, the melting of this alloy layer has no effect on the bonding already achieved between the vanadium under layer and the blade.

The present invention also provides a method of applying a protective coating on a titanium alloy blade, wherein the portion of the blade to be coated has pure vanadium powder deposited thereon and the temperature of the powder is raised to a temperature which is slightly higher than the melting point of vanadium in order to form a layer of vanadium having a thickness between 0.5mm and 1.5mm, thereafter, a heterogeneous powder mixture is deposited on the vanadium layer, said powder mixture is deposited on a vanadium layer, said powder comprising about one third by weight of titanium carbides, titanium nitrides, or titanium borides, bonded by a martensitic or austenomartensitic stainless steel, the heterogeneous powder being raised to a temperature which is greater than its melting temperature and less than the melting temperature of vanadium. Preferably, the stainless steel includes 9% to 18% chromium.

By this method, a minimal quantity of vanadium is diluted in the titanium alloy blade during the first stage. Similarly, during the second stage, the dilution of the alloy in the vanadium under layer is very limited. Further, the melting of this alloy layer has no effect on the bonding already achieved between the vanadium under layer and the blade.

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In order to limit dilution as much as possible, it is preferable to use rapid and localized heating, for example high frequency induction heating (using a moving inductor) or laser beam heating.

An implementation of the invention is described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a blade in accordance with the invention;

Figure 2 is a section through the Figure 1 blade;

Figure 3 is a fragmentary view of the Figure 2 section; and

Figure 4 shows apparatus for implementing the method in accordance with the invention.

The steam turbine blade shown in Figure 1 comprises a root 1 and a twisted vane 2 including a leading edge 3 and a trailing edge 4. A protective coating layer 5 has been deposited at the top of the blade along the compression side of the leading edge 3. This coating layer on the leading edge may extend over the suction face of the vane 2. An under layer 6 of vanadium is disposed between the vane and the final coating (Figure 2).

The blade is made of a titanium alloy comprising 6% aluminum and between 3.5% and 4.5% vanadium.

The method of applying the protective coating in a non-limiting laser beam re-melting example, is as follows:

The surface of the blade to be coated is prepared in conventional manner and then substantially pure (> 98%) vanadium powder is projected onto said surface, under a laser beam, said powder being constituted by spherical grains which are less than 0.5 μm in size. The quantity deposited by remelting is sufficient to ensure that the thickness of the final vanadium under layer 6 is greater than 1 mm.

A CO_2 laser beam 9 is directed onto the surface of the vane 2 of the blade to be coated. The beam 7 is surrounded by an inlet 10 for an inert gas, e.g. argon, which also strikes the vane 2 (see Figure 4).

A nozzle 11 projects the powder onto the surface of the vane that is to be coated.

The inert atmosphere serves to avoid unwanted reactions with oxygen, hydrogen, or nitrogen.

The temperature of the vanadium powder is thus raised to between 1950°C and 2000°C. The melting temperature of vanadium is 1900°C while the melting temperature of the titanium alloy is about 2400°C. As a result the vanadium melts while the titanium alloy substrate remains semisolid, and this is ideal for obtaining perfect fastening with low dilution of vanadium into the substrate. The titanium alloy which contains about 4% vanadium can tolerate a limited quantity of vanadium by dilution (see Figure 3) giving rise locally to a "beta" Wydmanstätten type laminar structure.

The thickness of this layer 7 of vanadium diluted alloy is very low (less than 1/10 mm).

After cooling, a powder of alloy associated with a binder is then deposited on the vanadium under layer 6.

By weight, this heterogeneous powder comprises one third hard substances which may be titanium carbides, titanium nitrides, or titanium borides, together with a binder constituted by martensitic steel containing chromium (9% to 18%) together with possible additions of molybdenum (1% to 3%) and of cobalt (1% to 8%) in order to confer stainless properties thereto, or an austenomartensitic steel further including 3% to 8% nickel.

The grain size of titanium carbides should be less than 0.5 μm while the grain size of titanium borides or nitrides should be less than 0.2 μm and preferably about 0.1 μm.

This heterogeneous powder is deposited up to 3 mm or 4 mm from the edges of the vanadium under layer in order to ensure that contact never occurs between the titanium alloy of the vane and the alloy containing titanium carbide, nitride, or boride.

When using laser remelting, the Figure 4 apparatus is used to project the powder onto the vanadium under layer and to melt it by heating it to a temperature which is 50°C greater than the melting temperature of the alloy (1400°C - 1500°C). Since this temperature is much less than the melting temperature of vanadium, the alloy layer is diluted very little into the vanadium (see Figure 3) and the vanadium/substrate bond is kept intact, with the layer 8 of vanadium that includes diluted alloy being very thin (less than 1/10 mm thick).

The layer of deposited alloy is about 1.5 mm thick. Thereafter, conventional strain-releasing treatment is performed at about 700°C. When the binder includes 3% to 8% nickel, the layer based on titanium carbides, nitrides, or borides is subjected to a hardening treatment by being maintained at between 450°C and 500°C for a period of four hours in order to obtain an HRC Rockwell hardness which is greater than 60.

When the binder includes less than 3% nickel, the treatment performed consists in quenching at a temperature of more than 1050°C in a nitrogen atmosphere in order to obtain a Rockwell hardness which is greater than 60.

Although the coating method is preferably implemented by projecting powder in a laser beam while projecting inert gas, it is possible to use other means, in particular to proceed by remelting the powder projected under inert gas by means of a plasma or melting the powder under inert gas using high frequency induction heating.

When using induction heating, it is preferable to use a high frequency induction oven provided with a moving inductor. With the oven under a vacuum or under an inert atmosphere (e.g. argon), and containing the blade, the oven is preheated and then the layer of powder is heated by means of a 30 mm diameter spot while keeping the spot stationary for 20 seconds to 75 seconds and then advancing in 20 mm steps.

As mentioned, the layer of vanadium powder is heated in a first operation in order to melt it. Then, during a second cycle, after the alloy powder has been deposited on the vanadium layer, said alloy layer is heated in order to melt it without melting the vanadium.

The claims defining the invention are as follows:

1. A method of applying a protective coating on a titanium alloy blade, wherein the portion of the blade to be coated has pure vanadium powder deposited thereon and the temperature of the powder is raised to a temperature which is slightly higher than the melting point of vanadium in order to form a layer of vanadium having a thickness between 0.5mm and 1.5mm, thereafter, a heterogeneous powder mixture is deposited on the vanadium layer, said powder mixture is deposited on a vanadium layer, said powder comprising about one third by weight of titanium carbides, titanium nitrides, or titanium borides, bonded by a martensitic or austenomartensitic stainless steel, the heterogeneous powder being raised to a temperature which is greater than its melting temperature and less than the melting temperature of vanadium.

2. The method according to claim 1, wherein said stainless steel includes 9% to 18% chromium.

3. The method according to claim 1 or claim 2, wherein a powder of titanium nitrides or titanium borides is used having a particle diameter of about 0.1 μm.

4. The method according to any preceding claim, wherein the powders are projected and melted under an inert atmosphere using a laser beam.

5. A titanium alloy blade, including on its periphery a coating layer which is at least 1 mm thick and which includes about one third by weight titanium carbides, or titanium nitrides, or titanium borides bonded by a

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martensitic or austenomartensitic stainless steel, said coating layer covering an under layer of vanadium having a thickness lying between 0.5 mm and 1.5 mm.

6. The method according to claim 1, substantially as herein described with reference to the accompanying drawings.

7. The titanium alloy blade according to claim 5, substantially as herein described with reference to the accompanying drawings.

DATED: 24 APRIL, 1990

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FIG.1

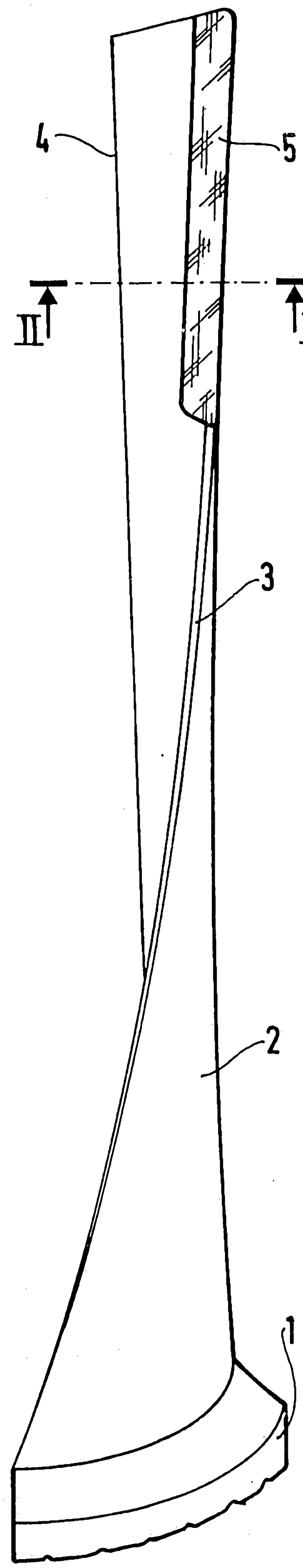

FIG.2

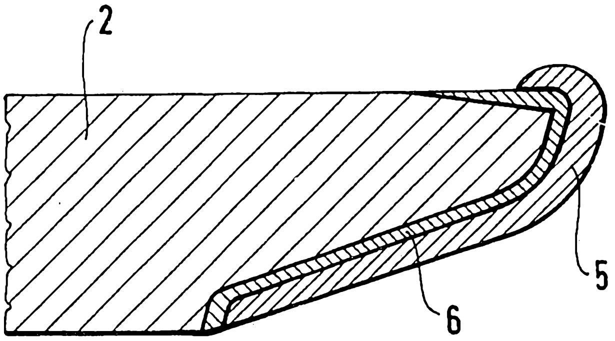

FIG.3

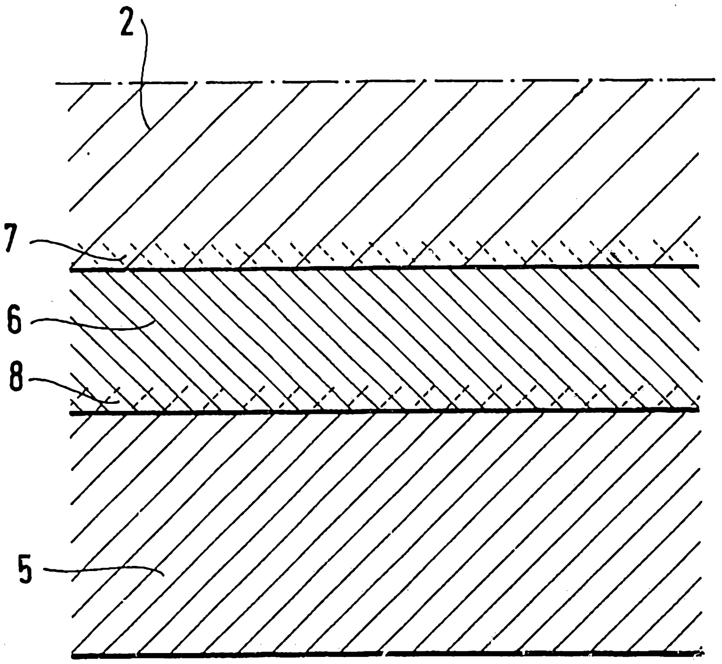

FIG.4