Dec. 31, 1968 G. ARUTUNIAN 3,419,388

SINTERED TITANIUM COATING PROCESS

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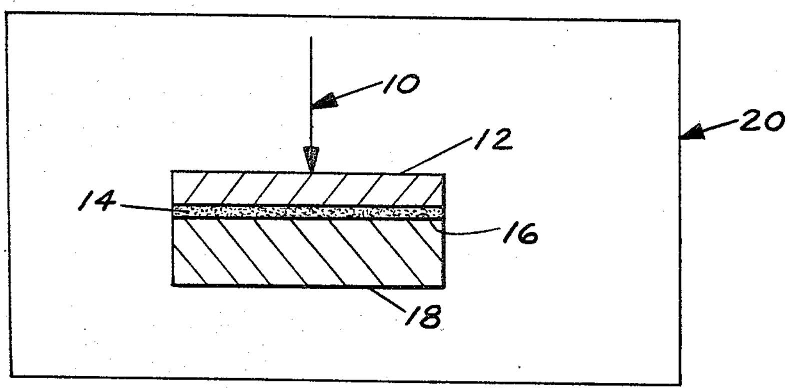

FIG. 1

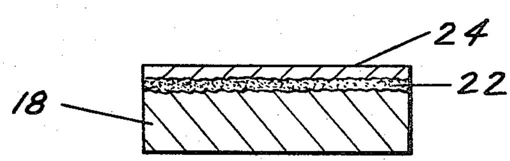

FIG. 2

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SINTERED TITANIUM COATING PROCESS

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ABSTRACT OF THE DISCLOSURE

This invention provides a novel method of applying a thick, machineable layer of corrosion resistant titanium to a ferrous substrate. The method comprises the steps of applying a layer of an oxygen and nitrogen free hard-facing metal compound powder to the substrate to be coated and applying pressure to the surface of the hard-facing metal compound powder layer via a pressure block or other suitable means while heating the entire combination in a nonreactive atmosphere to a temperature sufficient to yield pure metal and easily dispersed gases from the decomposition of the hard-facing metal compound. In the preferred embodiment, the hard-facing metal consists of titanium and its compound consists of titanium hydride.

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon or therefor.

The present invention relates to a method of producing hard-facing coatings on a ferrous metal substrate.

More specifically, the invention relates to a novel method of applying a greater thickness of corrosion resistant titanium, rare earth metals or alloys thereof to a ferrous metal substrate than has heretofore been possible.

Although titanium has many industrially applicable properties, corrosion resistance remains its most useful and desirable property.

In the prior art, as described in Patent Number 3,071,-491 granted to C. W. Horn et al., titanium metal was deposited upon ferrous substrates by vacuum evaporating the titanium metal from a tungsten source onto a heated steel surface. As the titanium vapors deposited upon the hot ferrous surface, re-evaporation of the titanium occurred limiting the thickness of the coating which could be applied to approximately 0.0025 inch. This limited thickness, while satisfactory for some purposes, is not sufficient for many of today's mechanical applications for corrosion resistance.

It is therefore an object of the invention to provide a method for hard-facing or metalizing ferrous metals.

Another object of the present invention is the provision of a method for metalizing a ferrous metal with a titanium coating.

Still another object of the present invention is the provision of a method for applying a titanium coating to ferrous metals to a greater thickness than possible with other known methods.

A further object of this invention is the provision of a more efficient and simple method of applying very thick layers of corrosion resistant titanium to ferrous substrates.

It should be noted that this process may also be used to metalize ferrous metal substrates with zirconium or rare earth metals and their alloys although the description below will be limited to titanium for the sake of simplicity.

In general, the coating process embodied in this invention consists of heating a metal hydride powder under mechanical pressure to 1600° F.–1900° F., while in contact with a steel surface in a vacuum or inert gas atmosphere. According to the preferred embodiment disclosed herein, the nitrogen and oxygen free hard-facing metal compound consists of titanium hydride, however any other suitable oxygen and nitrogen free hard-facing metal compound may be substituted therefor.

In order to provide an understanding of the principles of the invention, an example of how this invention may be implemented is presented in the accompanying drawing and described below. It is understood, however, that no limitation of the scope of the invention is intended thereby, since the invention is capable of being carried out in various alternate ways which will be obvious to one skilled in the art without deviating from the nature and spirit of the invention.

FIGURE 1 shows a cross-sectional view of one embodiment of the coating process of this invention.

FIGURE 2 of the drawing shows a fragmentary cross-sectional view of the article produced by the process of this invention.

More specifically, FIGURE 1 shows a force indicated by arrow **10** which is exerted upon a pressure block **12**. The pressure block in turn transmits the force evenly over the surface of a layer of titanium hydride powder **14** in immediate contact with the surface **16** of a ferrous metal substrate **18** being coated. The entire structure described above is enclosed in an oven **20** which is either evacuated or evacuated and refilled with an inert gas..

More specifically, the method is accomplished by applying a force of between 5,000 pounds per square inch (5 K s.i.) and 24,000 pounds per square inch (24 K s.i.) to the pressure block **12**. These force limits will be determined by the strength of the substrate being coated and the degree of diffusion bonding which is to be achieved. The lower limit indicated above assures sufficient diffusion to insure proper cladding. The higher limit indicated above is that above which most ferrous substrates suitable for such cladding will deform. The pressure block **12** need not necessarily be a block, but may consist of any suitable means of transferring force **10** evenly over the surface of titanium hydride powder layer **14**. Sintering presses as are presently utilized in magnet manufacture are suitable pressure blocks which may be utilized.

The titanium hydride powder, which decomposes at 960° F., is heated in the vacuum or inert atmosphere produced within over **20** to yield pure, oxide free metallic titanium. The particle size of the titanium hydride powder used is not critical, but it should be noted that a finer particle size will produce a better bond and also a less porous facing layer. Pure titanium powder is not suitable for application in this method since titanium powder readily combines with various oxides in the air and yields rather poor titanium to metal bonds. The same is true with some of the presently utilized pressure welding techniques for applying a bond facing of titanium to a ferrous metal substrate. The titanium hydride utilized in the present invention is readily purified and, when decomposed as indicated, generates chemically pure titanium in place without danger of oxide, or other contamination. Heating of the powder under the pressures indicated above and in an inert or evacuated atmosphere to a temperature of 1600° F. produces a mechanical type of bonding while heating to a temperature of from 1800° F.–1900° F. produces a metallurgical diffusion bond.

The heating period will vary according to the thickness of the hydride layer to be decomposed, and the degree of diffusion bonding which is to be achieved. As the heating time increases with increased temperature, the degree of diffusion bonding achieved will also increase.

FIGURE 2 shows the intermediate zone and the definite integrating of the titanium and the ferrous substrate which results from the diffusion of the titanium into the substrate. The thickness of the diffusion zone **22** which lies between the titanium cladding **24** and the ferrous substrate **18**, will vary with the temperature to which the substrate and titanium hydride are heated during decomposition of the latter compound. As noted above, as the temperature increases, the degree of diffusion will increase and the thickness of zone **22** will likewise increase.

Thus, through the thermal decomposition of titanium hydride powder under mechanical pressure a thick (according to some tests 1/16 of an inch) layer of corrosion resistant and machineable titanium, rare earth metals or their alloys may be applied to a ferrous substrate.

Since it is obvious that many changes and modifications can be made in the above-described details without departing from the nature and spirit of the invention it is to be understood that the invention is not limited to said details except as set forth in the appended claim.

What is claimed is:

1. A process for metalizing a ferrous metal substrate comprising the steps of:

(I) decomposing a powdered metal compound selected from the group consisting of titanium hydride and zirconium hydride in contact with said ferrous substrate at a temperature of from about 1600 to about 1900° F. to cause:

A. formation of:

(1) a metal selected from the group consisting of titanium and zirconium and,

(2) hydrogen gas; and

B. adhesion of said metal to said ferrous metal substrate, and

(II) simultaneously applying a mechanical pressure of from about 5 to about 24 K s.i. to compress said powdered metal compound against said ferrous substrate so as to form a diffusion bonded layer of said metal upon said ferrous metal substrate.

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24—182.3; 75—226