

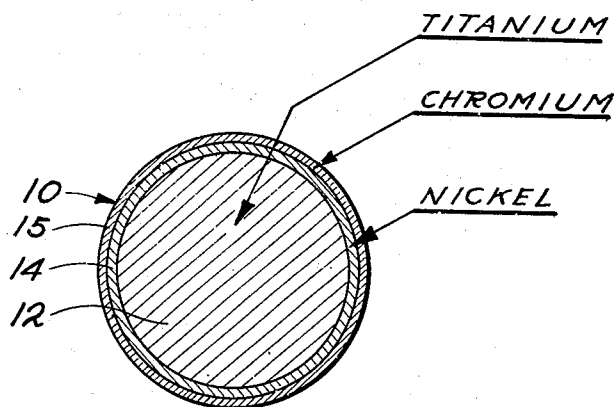
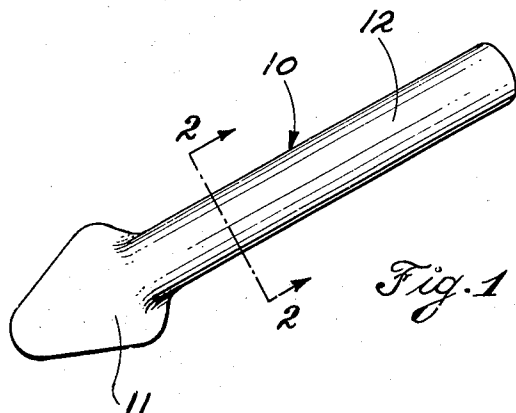
Aug. 25, 1959

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2,900,715

PROTECTION OF TITANIUM

Filed May 28, 1956



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2,900,715

PROTECTION OF TITANIUM

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Application May 28, 1956, Serial No. 587,712

1 Claim. (Cl. 29—528)

This invention relates to a method of protecting titanium metal against the deleterious effects of atmospheric gases at elevated temperatures and to titanium blanks that are protected from such effects. The invention is described herein with specific reference to the forging of titanium, but it is to be understood that the invention may also be utilized in connection with other operations on titanium and its alloys, such as hot forming, heat treating and the like, where it is important to protect the metal from the surrounding gases.

It is well known that titanium is adversely affected by furnace and atmospheric gases at forging temperatures, which are ordinarily of the order of 1200° to 1750° F. At such elevated temperatures, oxygen readily attacks titanium surfaces and nitrogen reacts with the titanium to form nitrides that are hard and brittle. Hydrogen, which is a common constituent of furnace gases, is soluble in titanium to a much greater extent than it is in steel, and adversely affects the basic properties of the metal, producing so-called hydrogen embrittlement which can make the metal entirely unsuitable for use under severe operating conditions. It has been proposed to protect forging blanks of titanium from these effects by enclosing them in electrodeposited envelopes of nickel. This proposal, however, has not met with success, apparently for the reason that nickel—at least in layers that are thin enough to flow with the underlying metal during forging operations—is not impervious to hydrogen and possibly is not impervious to other gases that are ordinarily found in heating furnaces of the types ordinarily employed or in air. In fact, it appears probable that nickel-plated titanium forging blanks are subject to greater damage by hydrogen than uncoated blanks; the reason for this seems to be that the surface of the titanium beneath the nickel is clean and substantially free from oxides and nitrides and can be penetrated by hydrogen more readily than contaminated surfaces, such as oxidized or nitrified surfaces. Thus, the protection of titanium from the effects of gases at elevated temperature has been a serious and continuing problem.

Accordingly, a general object of the present invention is to provide a method of protecting titanium and other metals from the effects of atmospheric and furnace gases during forging operations. Another object is the provision of a protective coating for titanium and other metals which can be applied economically and which has no deleterious effects on the underlying metal. A further object is the provision of such a coating that will adhere to and flow with the underlying metal during forging operations, yet can be readily stripped off after it has served its purpose. Another object is the provision of a coating that will not only protect titanium from the deleterious effects of gases, but which will also act as a lubricant to assist in the flow of the metal as it is being worked at elevated temperatures. Another object is the provision of forging blanks that are protected from cor-

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rosion by protective envelopes that are substantially impermeable to atmospheric and furnace gases.

According to a preferred form of the present invention, titanium blanks can be forged without substantial deleterious effects by protecting the forging blanks by means of a composite coating or envelope which consists of an underlying layer of electrodeposited nickel on the surface of the titanium and a layer of electrodeposited chromium over the nickel. The composite nickel-chromium envelope provides a substantially gas tight enclosure for the underlying metal which protects the forging blank not only from ordinary atmospheric gases such as nitrogen and oxygen, but also from hydrogen and the other gases that are ordinarily present in the furnaces in which the blanks are heated preparatory to forging.

More specifically, titanium enclosed in an envelope made up of an underlying electrodeposited nickel layer having a thickness of from about 0.0002 inch to about 0.001 inch (preferably about 0.0005 inch) and an outer electrodeposited layer of chromium having a thickness of about 0.0002 inch to 0.0005 inch may be heated in the reducing or other atmosphere of the furnace to forging temperature of from 1200° F. to 1750° F. and subjected to severe forging operations without substantial hardening, oxidation, or embrittlement of the underlying titanium—in fact, without any substantial degradation of the titanium by the furnace gas or by the atmosphere during the actual forging of the metal. The nickel-chromium envelope adheres firmly to the underlying base metal and remains intact while the blank is being heated in the furnace and handled preparatory to forging, effectively protecting the titanium against hydrogen as well as other gases. If the underlying metal is caused to flow substantially during the forging operation, the chromium layer, which is not as ductile as the nickel, may develop a pattern of cracks. However, even if cracks develop, the area of the titanium exposed by the cracks and the amount of hydrogen present are so small, and the time of exposure during forging and cooling so short, that no substantial increase in the hydrogen content of the titanium takes place during forging and subsequent cooling operations. The underlying nickel layer remains intact during the forging operation and thus protects the blank against oxygen and nitrogen not only during forging but also during subsequent cooling of the blank. Although the chromium coating is not particularly ductile at forging temperatures and may be subject to cracking during forging, the composite nickel-chromium coating unexpectedly functions in the manner of an excellent lubricant during the forging of the blank, with the result that the metal in a blank having a nickel-chromium coating can be caused to flow more readily with less wear on the dies than the metal in a similar but uncoated blank.

The thickness of the layers making up the envelope is not critical, but it is desirable to have the envelope as thin as possible so long as it is thick enough to be impermeable to the gases; thin envelopes withstand the forging operation better than thick ones and are more easily removed after the operation is completed. Good results are obtained with envelopes having a total thickness of from about 0.0010 inch to about 0.0015 inch.

A forging blank embodying the present invention is shown in the drawings, in which—

Figure 1 is a perspective of the blank, and

Figure 2 is a section taken along the line 2—2 of Figure 1.

As shown in the drawings, a titanium forging blank 10 for a turbine blade, for example, may consist of a root

portion 11 and a blade portion 12. The blank is forged at a temperature of from about 1200° F. to 1750° F. to provide a blade that can be made into the finished shape desired with a minimum of machining. In accordance with usual practice, the blank is heated to forging temperature in a furnace having a reducing atmosphere and is then forged while exposed to air. In order to protect the blank from oxidation and the effect of nitrogen and hydrogen, the entire blank is enclosed in an envelope made up of the underlying electrodeposited layer 14 of nickel and an outer layer 15 of electrodeposited chromium. These layers are preferably within the range of thicknesses specified above. The thicknesses of the layers are greatly exaggerated in the drawings.

Preparatory to plating, the forging blanks are cleaned as by sand blasting, pickling and electropolishing if desired, all in accordance with known practices. It is important to have good adherence between the titanium and the nickel layer 14 so the envelope will not separate from the underlying metal during the forging operation. Following the forging operation, the coating may be stripped from the forged blank, for example, by mechanical means, or by chemical or electrochemical means in which the coating materials are dissolved while the titanium remains untouched.

While the foregoing description is directed specifically to the forging of titanium, it is to be understood that the invention is also applicable to other operations wherein it is necessary or desirable to protect titanium from surrounding gases. For example, the invention is useful in connection with heat treating, stress relieving and like operations. In such cases where the metal of the coating is not worked, thinner coatings may be employed, flash

coatings of nickel and chromium being satisfactory. For other operations where there may be prolonged exposure of the blank at higher temperatures, say of the order of 1750° to 2000°, it is sometimes desirable to apply a layer of nickel over the chromium to protect the chromium from oxidation. An electrodeposited coating having a thickness of, for example, from about 0.002" to about 0.001" is satisfactory for this purpose.

While a specific embodiment of the invention is illustrated and described herein, it is to be understood that various changes and modifications may be made without departing from the spirit and scope of the invention. The essential characteristics are summarized in the claim.

I claim:

The method of hot forging titanium which includes the steps of electroplating the metal with a layer of nickel having a thickness of from about 0.0002 inch to about 0.001 inch, electroplating a layer of chromium having a thickness of from about 0.0002 inch to about 0.0005 inch over the nickel, heating the metal to forging temperature in a furnace having a reducing atmosphere, and forging the metal at an elevated temperature in air with the said layers thereon.

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