United States Patent Office 3,824,134 Patented July 16, 1974



3,824,134

# METALLIDING PROCESS

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No Drawing. Filed Oct. 12, 1971, Ser. No. 188,524
Int. Cl. C23c 11/12
U.S. Cl. 148—6 2 Claims

## ABSTRACT OF THE DISCLOSURE

A metalliding process for producing extremely hard metallic boride surface layers on steel bodies wherein the steel is carburized and treated with a nonferrous metal to produce a barrier layer of metallic carbide and boronized to produce the surface layer of metallic borides. This abstract is neither intended to define the invention of the application, which, of course, is measured by the claims, nor is it intended to be limiting as to the scope of the invention in any way.

This invention relates to a metalliding process, and particularly to a process for forming an extremely hard surface layer of metallic borides on a steel work piece.

In certain cases it is desirous that steel bodies be given extremely hard surface layers so as to minimize abrasion, wear, deformation, etc. It is well known that certain of the metallic borides are extremely hard. However, their use as a coating for steel or other ferrous metals has heretofore been limited because of the well-known diffusion characteristic of ferrous ions. If a hard boride, such as chromium boride, is plated onto a steel surface, the ferrous ions from the steel quickly diffuse into the boride layer forming ferrous borides and destroying the desirable extreme hardness of the coating layer.

It is, therefore, the principal object of the present invention to provide a method for the coating of steel surfaces with extremely hard metallic boride layers wherein means are provided for preventing the diffusion of iron from the steel body into the boride layer.

Another object is to produce on steel work pieces extremely hard metallic borides, the major metallic constituent of which is not iron boride ($Fe_2B$) and/or (FeB).

Another object is to provide such boride coatings by utilizing the iron diffusion blocking properties in metallic carbides.

In accordance with the present invention, it has been discovered that the imposition of a layerof certain of the metallic carbides, such as chromium carbide, between the steel work piece and the metallic boride layer has the effect of blocking diffusion of the ferrous ions into the metallic boride layer.

In the preferred form of the invention, the steel work piece is first carburized by any conventional process to diffuse carbon into the work piece to provide a surface layer of high carbon content. One conventional carburizing process, as disclosed in U.S. Pat. 2,659,685, is by packing the work piece in finely divided charcoal and heating to a very high temperature.

After carburizing, the work piece is electrolytically plated with any of certain nonferrous metals to diffuse said metal into the carburized layer to react with the carbon to form metallic carbides which act as a barrier to diffusion of the ferrous ions. The preferred nonferrous metal is chromium to form a barrier layer of chromium



carbide, but it is pointed out that other carbide layers, specifically those of tantalum, titanium, vanadium, zirconium and hafnium are also included in this disclosure as having sufficient iron diffusion retarding properties to obtain the desired end result.

The electroplating is preferably carried out in accordance with U.S. Pat. No. 3,232,853 which discloses a process for chromiding wherein a cathode of the metal to be treated and an anode of plating metal, in this case chromium, are immersed in a fluoride bath at high temperature and connected through an external electrical circuit. With a suitable temperature bath and suitable current passing in the system, the chromium from the anode is deposited on the cathode work piece and reacts therewith to form a surface layer of chromium carbides.

It will be noted that Pat. 3,232,853 teaches chromiding directly on a metallic base without previous carburizing. However, it is an important discovery in accordance with the present invention that the formation of a suitably impervious carbide layer, specifically chromium carbide, and more specifically $CR_{23}C6$ and $CR_3C2$ cannot be obtained using the patented metalliding process unless carbon is present in sufficient quantities in the base metal. Therefore, carburizing a chromided base metal work piece is not sufficient to produce this layer, but chromiding at approximately .65 amperes per square decimeter on a carburized surface at sufficiently high temperature (approximately 1000 to 1150° C.) will produce a dense, practically defect-free layer of chromium carbides. This layer is difficult to obtain in thicknesses greater than approximately 0.8 mils, because of the retarding effect of the layer on the diffusion of iron in the base metal. The diffusion of iron in the base metal is prerequisite to the formation of layers on the base metal, as those skilled in the art are aware.

After formation of the practically impervious layer of nonferrous metallic carbide on the work piece, the piece is then borided preferably by the same electrolytic process. The anode of chromium or other nonferrous metal is replaced with an anode of boron and current is again circulated through the fluoride bath at elevated temperature to deposit a layer of boron on the work piece which diffuses into and reacts with the chromium or other nonferrous metal to produce a layer of extremely hard metallic borides the major metallic constituent of which is not iron boride or $Fe_2B$. In the case of chromium carbide layers, the principal boride formed is $CrB_2$, it being understood that other and more complex borides can be present. The hardness of such surface layers has been found to be in the order of 4600 to 5500 $DPH_{256}$ (diamond pyramid hardness).

In addition to electroplating, the boriding step can also be carried out by other conventional cementation processes such as are well known to those skilled in the art.

It has been found that this method can be applied to both stainless steel of the straight chromium type, and to low alloy steels such as 4615 and 8620, and also to the low and medium carbon plain steels such as 1040 and 1020.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in materials and in details of the disclosed process may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A method for producing an extremely hard metallic boride layer on a steel work piece comprising the steps of

(1) diffusing carbon into said work piece to provide thereon a layer of high carbon content,

(2) diffusing into the work piece a metal selected from the group consisting of chromium, tantalum, titanium, vanadium, zirconium and hafnium to form thereon a layer of metallic carbide, and

(3) diffusing into the work piece boron to produce an extremely hard layer of borides of said metal.

2. The method of claim 1 wherein said work piece is of stainless steel and said metal is chromium.



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U.S. Cl. X.R.

148—16.5, 31.5