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COMPOSITE METALLIC BODIES AND METHOD OF PRODUCING THE SAME

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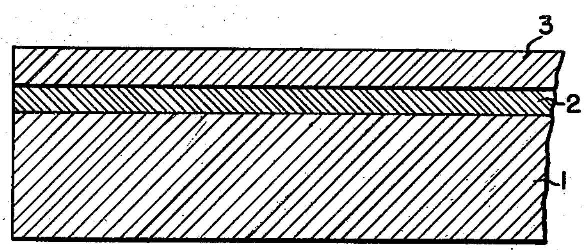


FIG-1

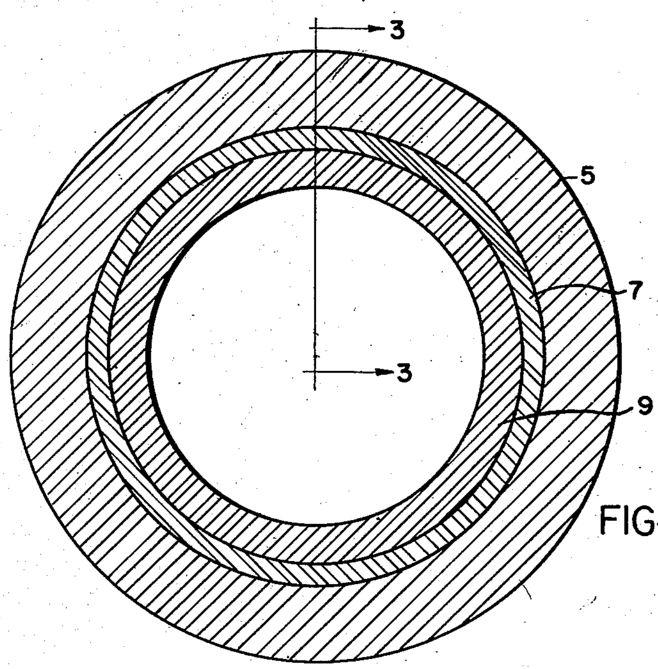
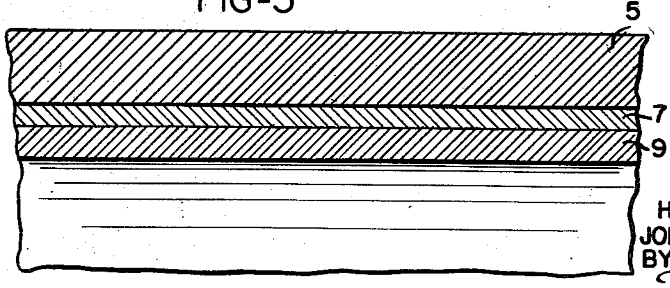


FIG-2

FIG-3



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COMPOSITE METALLIC BODIES AND METHOD OF PRODUCING THE SAME

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10 Claims. (Cl. 29—194)

This invention relates to composite metallic bodies and to methods of producing the same. More particularly the invention relates to the coating of steel with chromium through the intermediary of a nickel tie ply or bonding layer.

Chromium is a rust-defying metal, hard but relatively brittle; in the plated condition whether attained by electrolytic or gas plating methods it shows adherence to some degree for steels. This adherence however, probably due to the brittle characteristic is not entirely satisfactory for applications involving high stresses and temperatures such as may occur in gun barrels.

It is a particular object of this invention to describe a novel method for attaining improvement in the characteristics of chromium plated objects.

It is an important object of this invention to describe a novel composite metal product of improved physical characteristics having a wear surface of chromium.

These and other objects of the invention are attained by coating the object to be plated with metal or metals deposited from the vapor state by the thermal decomposition of metal bearing compounds; in the present instance a thin adherent coating of nickel is first deposited on the object to be plated and thereafter chromium is similarly deposited over the nickel.

The product attained by the generally described method comprises a base layer, a thin nickel layer preferably having a thickness of less than one mil, and a heavy chromium layer. The chromium is thus supported on nickel which is considerably more ductile and malleable than the chromium. Accordingly under the application of stress the nickel will have a slight tendency to yield and take up the effects of the applied forces relieving to a degree the strains in the upper more brittle chromium layer.

The thickness of the nickel layer may be important in connection with some applications but is not to be considered as critical; it should however be thin relative to the chromium and the only limitation is that the nickel under the applied stresses should not flow to an extent that permanent deformation occurs. A layer of nickel which approaches the monomolecular is considered to be satisfactory.

The thickness of the chromium coat is preferably at least several times that of the nickel layer and the ratio may be as much as 10:1. With greater ratios the ability of the nickel to absorb stresses sufficiently quickly will be impaired.

The process of invention is particularly adapted for the plating of steel objects of substantially all qualities and characteristics and the invention will accordingly be described with particular reference thereto. However other materials capable of withstanding the temperature involved may be similarly treated and the inventive concept is not to be considered as limited to steel and various iron alloys.

In the practice of the invention then the steel surface is first cleaned and activated as described hereinafter and

is then brought to a suitable temperature range capable of promoting the thermal decomposition of the selected nickel bearing gaseous compound.

Adherence of the nickel plate to the steel is promoted by maintaining the initial deposition rate low. While high plating gas flow rates and high plating gas concentrations produce acceptable results it is presently considered that adherence and uniformity of coating are improved by first securing a microscopic coating over which additional nickel deposition may suitably take place at a relatively fast rate. This microscopic or monomolecular coating is favorably attained as described with particularity hereinafter when both the gas concentration and plating gas flow rates are maintained relatively low.

The "plating" gas is to be understood as the metal bearing gas; the process is conducted with the aid of a carrier gas and while hydrogen is preferred for such purpose due to its tendency towards a reducing action others such as nitrogen, carbon dioxide and carbon monoxide may be suitably employed in the practice of this invention.

Upon attainment of the required nickel coating the airtight plating chamber is preferably swept free of all gases, and to insure of a completely free nickel surface the same may be subjected to heating to evolve all gases. Thereafter the gaseous chromium compound is introduced with the aid of a carrier gas. Apparently adhesion will also be facilitated if the initial chromium plating is performed slowly the rate being increased after an initial chromium layer has been deposited.

Alternatively where desired the nickel coated body may be removed from the plating chamber before the chromium is applied, but if this procedure is followed thorough deoxidation with hydrogen or other reducing agent should take place prior to chromium deposition.

The gaseous sources of the nickel and chromium are not critical to this invention; however nickel carbonyl and chromium hexacarbonyl are preferred as the sources of nickel and chromium respectively.

The invention will be more fully understood by reference to the following detailed description and the accompanying drawing wherein:

Figure 1 is a sectional view of an object coated with chromium and nickel in accord with the precepts of this invention;

Figure 2 is a sectional view of a cylindrical workpiece coated in accordance with this invention; and

Figure 3 is a view taken on line 3—3 of Figure 2.

As a specific example of the process of invention a steel workpiece is first heated in an atmosphere of hydrogen to a temperature of between about 800–900° F. for a period of a few minutes which temperature is well above the normal plating range of nickel carbonyl; then with hydrogen flowing over the workpiece the temperature thereof is reduced to about 350–400° F. and nickel carbonyl is slowly bled into the apparatus, the stream of hydrogen now acting as a carrier. The total gas flow at this time may be about 155 cc./minute approximately one-third of the gaseous volume being nickel carbonyl.

The carbonyl upon contacting the heated workpiece decomposes to deposit nickel in a very thin coating over the steel surface. In the dilute concentration set out above a flow for about 10 to 15 minutes will deposit a sufficient amount of nickel to serve as the intermediate bonding layer.

At the end of the above indicated, or similarly suitable period of time which may vary somewhat with the nickel thickness desired, the nickel carbonyl flow is halted and hydrogen is again fed through the system while the temperature is raised to approximately 500–600° F. to insure of complete removal of all nickel carbonyl and decomposition gases thereof. The workpiece temperature is then again reduced to 350–400° F. which is the normal plating range for chromium hexacarbonyl.

With the hydrogen still flowing chromium carbonyl is vaporized and carried slowly into the system; the concentration of the chromium hexacarbonyl may be as low as 10–15% in the initial stages of chromium metal deposition and this concentration may be increased to 40–50% by volume as plating progresses. It is not essential that the concentration be so regulated but it appears that initial plating at low concentration may result in superior bonding without blistering.

The plating at higher concentrations may be continued for a sufficient length of time to acquire the necessary uniform coating a thickness of 2–3 mils being obtainable generally in about 30 minutes.

The interior of steel surfaces may be plated with suitable apparatus such as that described in co-pending application of Peter Pawlyk, Serial No. 250,306, filed October 8, 1951, and assigned to the same assignee as the present invention, although it is to be understood that the invention is not to be limited thereto, since the process is clearly equally adapable to the production of coatings on the exterior surfaces of articles.

Referring to the drawing, Figure 1 shows a steel base **1** coated with a very thin layer which may be taken as substantially monomolecular, of nickel having thereon a layer **3** of chromium. In the structure of Figures 2 and 3 the steel base **5** in cylindrical form is provided with a nickel layer **7** over which is positioned the cylindrical layer **9** of chromium deposited from the vapor state.

It is to be noted that while other gases may be substituted for the hydrogen in its action as a carrier in the production of the product that a reduction gas, e. g. hydrogen, is considered necessary to the preliminary steps involving cleaning and de-oxidation of the steel or other similar surface.

The product thus produced will have, due to the noted ductility and malleability of the nickel, superior service characteristics.

It will be understood that this invention is susceptible to modification in order to adopt it to different usages and conditions and accordingly, it is desired to comprehend such modifications within this invention as may fall within the scope of the appended claims.

We claim:

1. In a process of gas plating nickel upon steel the steps of heating the steel briefly in an atmosphere of hydrogen at between about 800°–900° F., cooling the steel into the plating range of nickel carbonyl, introducing nickel carbonyl to the steel to effect deposition of nickel thereon, and depositing onto the resultant nickel plated steel chromium metal by subjecting the same to gaseous chromium carbonyl at a temperature to effect decomposition of the chromium thereon to a thickness of from about 1 to 10 times that of said nickel.

2. In a process of gas plating nickel upon steel the steps of heating the steel briefly in an atmosphere of hydrogen at between about 800°–900° F., cooling the steel to between about 350°–400° F., introducing nickel carbonyl to the steel to effect deposition of nickel thereon, and subjecting said nickel plated steel to gaseous chromium carbonyl at a temperature to effect decomposition of the chromium carbonyl and deposition of the chromium thereon to a thickness of from about 1 to 10 times that of said nickel.

3. In a process of producing a gase plated composite metal body the steps of successively depositing on a metal base from heat decomposable gaseous metal bearing carbonyl compounds nickel and chromium, and heating the base in an atmosphere of a reducing gas to a temperature well in excess of normal plating temperatures prior to each metallic deposition.

4. In a process of producing a gas plated composite metal body the steps of successively depositing on a metal base from heat decomposable gaseous metal bearing carbonyl compounds nickel and chromium, and heating the base in an atmosphere of hydrogen to a temperature well in excess of normal plating temperatures prior to each metallic deposition.

5. In a process of producing a gas plated composite steel body the steps of briefly heating the steel in an atmosphere of hydrogen at between about 800–900° F., cooling the steel into the plating range of nickel carbonyl, introducing the nickel carbonyl to the steel to deposit a thin substantially monomolecular film of nickel thereon, heating the steel and nickel composite to a temperature well above the normal plating range of chromium hexacarbonyl in the presence of hydrogen, cooling to the plating range of chromium hexacarbonyl, and introducing chromium hexacarbonyl to the composite body to effect deposition of chromium of a greater thickness than said deposited nickel on said nickel, said chromium deposit being on the order of between about 1 to 10 times the thickness of said nickel.

6. In a process of producing a gas plated composite steel body the steps of briefly heating the steel in an atmosphere of hydrogen at between about 800–900° F., cooling the steel to between about 350–400° F., introducing nickel carbonyl to the steel to deposit a thin substantially monomolecular film of nickel thereon, heating the steel and nickel composite to a temperature well above the normal plating range of chromium hexacarbonyl in the presence of hydrogen, cooling to the plating range of chromium hexacarbonyl, and introducing chromium hexacarbonyl to the composite body to effect deposition of chromium on said nickel, said chromium deposit being on the order of between about 1 to 10 times the thickness of said nickel.

7. In a process of producing a gas plated composite steel body the steps of briefly heating the steel in an atmosphere of hydrogen at between about 800–900° F., cooling the steel to between about 350–400° F., introducing nickel carbonyl to the steel to deposit a thin substantially monomolecular film of nickel thereon, heating the steel and nickel composite to between about 500–600° F. in the presence of hydrogen, cooling to between about 350–400° F., and introducing chromium hexacarbonyl to the composite body to effect deposition of chromium of greater than a monomolecular thickness on said nickel, said chromium deposit being on the order of between about 1 to 10 times the thickness of said nickel.

8. In a process of gas plating, the step (*a*) heating a steel workpiece, the step (*b*) plating from a heat decomposable gaseous nickel bearing compound a substantially monomolecular coating of nickel onto said workpiece, and the step of (*c*) plating from a heat decomposable gaseous chromium bearing compound a coating of chromium greater in thickness than said nickel upon said nickel, said chromium deposit being on the order of between about 1 to 10 times the thickness of said nickel.

9. A composite metal body produced in accordance with the process of claim 3.

10. A composite metal body produced in accordance with the process of claim 4.

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