

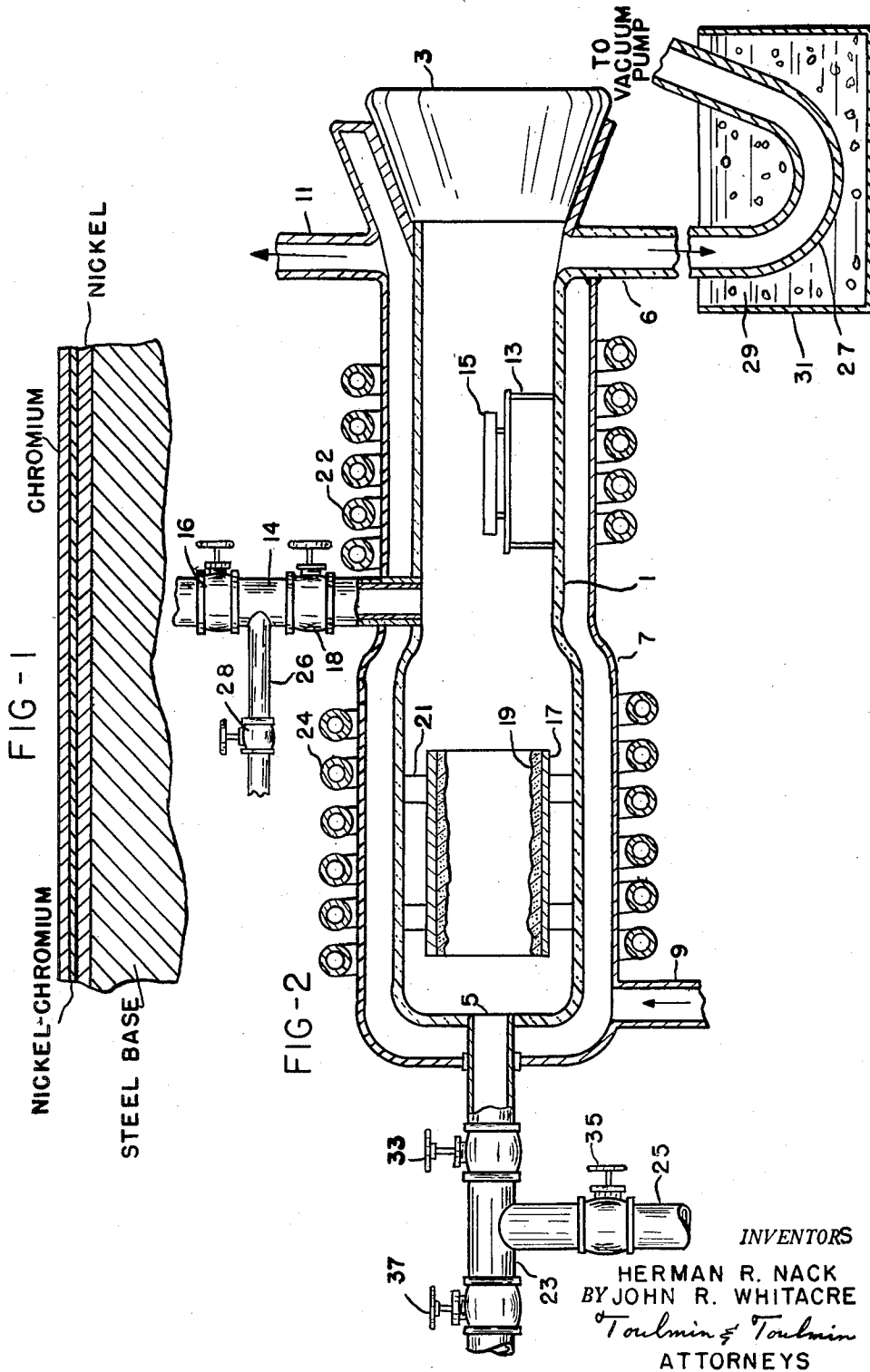
Aug. 4, 1959

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2,898,234

METHOD OF PRODUCING COMPOSITE METALLIC BODIES

Filed Aug. 14, 1953



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METHOD OF PRODUCING COMPOSITE METALLIC BODIES

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Application August 14, 1953, Serial No. 374,398

2 Claims. (Cl. 117-107)

This invention relates to composite metal bodies and to methods of producing the same. More particularly the invention relates to the coating of steel and ferrous base metals with chromium through the intermediary of a novel tie ply.

This application is related to our co-pending application Serial No. 316,695, filed October 24, 1952, now Patent No. 2,767,464, and assigned to the same assignee as the present invention.

In the said co-pending application there is described a method for coating steel with chromium and the process of that application is directed to solving a problem of adhesion between the steel and chromium which adhesion is normally poor, due most probably to the brittle characteristics of the chromium. In that application the method disclosed, very generally speaking, provides for the deposition from the gaseous state of a thin nickel coat upon a steel base, whereafter nickel plating is terminated and the chromium is plated onto the nickel. In that process, the nickel carbonyl is swept from the plating chamber with hydrogen prior to the introduction of the chromium bearing compound, and the deposited nickel is itself preferably subjected to heating and a flow of hydrogen before the chromium is deposited.

This invention contemplates the provision of improvements in the method of the above described process and this new method results in a superior product. Specifically in the new method the continuity of the process is not broken—that is, when the nickel layer has been deposited to any desired thickness the chromium and nickel gaseous bearing compounds are introduced together to the fresh nickel surface for a short period before the chromium alone is deposited. Thus the tie ply between the steel and chromium in this present invention is a ply not only of nickel but of nickel having on its surface a thin coating of nickel and chromium in combination.

The thickness of the nickel-chromium layer is not critical but should be maintained low, practically monomolecular, in order to secure optimum results. A material advantage of the procedure however is that the nickel layer may be as thick or thicker than the chromium and an excellent composite body of good adhesion characteristics will be obtained.

It is accordingly a primary object of this invention to describe a novel gas plating process for the production of a composite metal body.

It is an important object of this invention to describe a novel product, that is a composite body in which one layer thereof has a combination of metals, and which layer is bounded on each side thereof by one of the metals of the combination layer.

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

Figure 1 is a sectional view of the product of invention;

Figure 2 is an elevational view, partially in section,

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schematically illustrating apparatus useful in carrying out the inventive process.

Referring first to Figure 1 and the product of invention it is to be noted that the steel base is coated with a layer of nickel which is thicker than the uppermost layer of chromium and that a nickel chromium layer is positioned between the nickel and chromium components. This combination layer may have a thickness of about 0.001 to 0.002 of an inch, but is preferably substantially monomolecular.

In the practice of the invention it is preferred but not vital that the process described in co-pending application of Herman R. Nack, Serial No. 324,963, filed December 9, 1952, be followed for the deposition of nickel. While other nickel deposition processes may be used it has been shown that where the heat decomposable metal bearing compounds for effecting nickel plating are exposed to "active" nickel before contacting the workpiece a superior nickel-ferrous base adhesion is attained.

Referring now to Figure 2 there is shown at 1 a glass vessel having a removable stopper 3, an inlet 5 and an outlet 6. A water jacket 7 having an inlet 9 and outlet 11 substantially surrounds vessel 1. Positioned at the right hand end of the vessel is a small platform 13 on which may be mounted the base metal or hot rolled steel object 15 to be plated. Positioned at the left hand end of the vessel is a tubular member 17 coated internally with active nickel 19, the tube being supported in the vessel in any suitable manner as by member 21. Suitable induction heating coils 22, 24 surround the tube at the area of the support 13 and the support 21, respectively.

A conduit 23 for the passage of hydrogen and a conduit 25 for the passage of nickel carbonyl are illustrated at the far left of the figure and it is clear that gases passing through these conduits will contact the nickel 19 in the passage of the gases to the hot rolled steel object 15. The outlet conduit 6 terminates in a U-shaped portion 27 surrounded by dry ice or other cooling liquid 29 contained in a tank 31. The outlet of the portion 27 is connected to a vacuum pump to hasten the removal of gases from the vessel 1.

A heat insulated conduit 14 is provided between the heating coils 22, 24 adapted for the passage of chromium bearing gas such as chromium carbonyl to the steel object 15; this conduit 14 is provided with valves 16, 18 and is connected into conduit 26, which latter conduit is adapted for the passage of a carrier gas such as hydrogen. Conduit 26 is itself provided with a valve 28 for controlling or completely eliminating the flow of the carrier gas as desired.

In the operation of the apparatus indicated in Figure 2 with the vessel closed off by the closing of valves 33, 16 and 28 the vacuum pump is operated to completely remove gases from the vessel. During this period each of the coils 22, 24 may function to heat the interior components of the vessel to any suitable temperature to insure of the expulsion of all gases.

The workpiece itself prior to incorporation in the vessel 1 is chemically cleaned preferably with acid followed by an alcohol wash and the object is inserted into the vessel prior to the evacuation thereof in order that the object itself will be completely freed of any gases.

To insure of thorough cleaning of the workpiece and with only valves 33, 37 open hydrogen is passed to the interior of the vessel 1; at this time the metal tube 17, the nickel thereon and the workpiece are preferably highly heated; the tube 17 having a temperature of substantially 850° F. or more, and the temperature of the object being at least 500° F. This flow of hydrogen is continued for approximately 10 minutes at a rate of about one-tenth of

a liter per minute. While this flow rate is not critical it is believed that lower flow rates are more conducive to effective cleaning. The higher the temperature which the hydrogen attains the more rapid will be the cleaning.

When the object 15 is thus prepared and with the hydrogen still flowing the valve 35 is cracked open to permit a flow of nickel carbonyl and hydrogen into the chamber. At the same time the temperature of both the object 15 and that of the tube 17 are allowed to fall and the flow of nickel carbonyl is maintained very low, the total volume of the gas being about 10-20 cc. per minute, while the concentration of the carbonyl is about 35 percent of the gaseous mixture.

When the temperature of the tube 17 has reached a low of about 100° F. and the object 15 has reached a suitable temperature for the decomposition of nickel carbonyl, that is in the range of 250-450° F., the carbonyl flow is increased and the total flow of hydrogen and carbonyl may then be about one liter per minute, the concentration of carbonyl still being about 35 percent. The vacuum pump continues to operate throughout this process; the nickel as it strikes the hot workpiece decomposes and the presence of the active nickel in the tube 17 is effective to occasion a highly adherent nickel deposit. The nickel deposition is continued until the desired thickness of nickel has been achieved, actually about 3 mils, and which under the conditions noted above may be attained in about 20 minutes. When the desired thickness of nickel has been attained the flow of nickel carbonyl and hydrogen is reduced to approximately 10-20 cc. per minute and a flow of hydrogen and chromium hexacarbonyl are introduced into the chamber also at the very low flow rate of about 10-20 cc. per minute. This introduction takes place through conduit 14 and conduit 26 and is controlled by valves 16, 18 and 28.

The mixture of the nickel bearing and chromium bearing gases contacts the still heated nickel surface on the object 15 and a combination layer of nickel and chromium is deposited. This deposition may continue for about two minutes in order to provide an extremely thin layer of the combination of the metals. Thicker layers may on occasion be desired and where such is the case the initial flow should be very low and then the total flow of each of the carrier borne gases may be increased in order to reduce the time of plating. Under this condition a layer of about 2 mils may be deposited in about half an hour at a flow rate of approximately one liter per minute and a concentration of the metal bearing gas in each of the carrier gases of about 35 percent. Normally however a substantially monomolecular layer which may be attained in about two minutes at the flow rate mentioned will be entirely satisfactory.

When the combination layer has been attained the flow of nickel carbonyl is shut off at valve 35 and the flow of hexacarbonyl is increased in order to deposit a layer of chromium over the mixed layer of chromium and nickel. Preferably this flow rate is not increased until a sufficient time has elapsed to insure that all undecomposed nickel carbonyl has been withdrawn from the chamber; this may be effected by simply shutting off the nickel carbonyl flow, allowing the chromium carbonyl to flow for several minutes at a low rate prior to increasing the flow rate thereof.

The flow of chromium carbonyl and hydrogen may be continued until the desired thickness of chromium has been attained; thus if the concentration of the carbonyl is increased to about 40-50 percent by volume and the

object temperature is about 350 to 400° F. a thickness of about 2-3 mils is attainable in about 30 minutes.

When the plating operation has been completed valves 16 and 28 are closed off, the evacuation of the chamber is continued until all gases have been withdrawn therefrom and the plated product is removed from the chamber through stopper 3.

While the specific embodiment of the invention set forth has referred to the plating of a flat piece the process is equally adaptable for the plating of curved sections and accordingly the invention is effective for use in connection with gun barrels.

The product of invention is characterized by the high degree of adhesion between the various components, in fact substantially inseparable. The chromium provides a surface which is hard and due to the underlying layers lacks the brittleness which may be present when the chromium is plated onto steel or other ferrous base metal itself.

It will be understood that this invention is susceptible to modification in order to adapt 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. A gas plating process for a ferrous base metal which comprises heating the base metal under vacuum conditions to a temperature of about 250-400° F., contacting the base with gaseous nickel carbonyl to effect deposition of nickel on the base metal, contacting this freshly deposited nickel under substantially the same temperature and vacuum conditions and without interruption of the conditions with a gaseous mixture of chromium hexacarbonyl and nickel carbonyl to deposit on the nickel a combination layer of chromium and nickel, cutting off the flow of nickel carbonyl, and increasing the flow rate of the chromium carbonyl to deposit a layer of chromium on the combination layer.

2. A gas plating process for base metal which comprises heating the base metal to a temperature of about 250-400° F., contacting the base with gaseous nickel carbonyl to effect deposition of nickel on the base metal, contacting this freshly deposited nickel under substantially the same temperature and vacuum conditions, and without interruption of the conditions, with a gaseous mixture of two different metal carbonyls to deposit on said base metal a combination layer of the two metals of the metal carbonyl mixture, cutting off the flow of one of the metal carbonyls, and increasing the flow rate of the other metal carbonyl to deposit a layer of said last-mentioned metal of the metal carbonyl on the combination layer, said base metal being selected from the group consisting of iron and steel.

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