

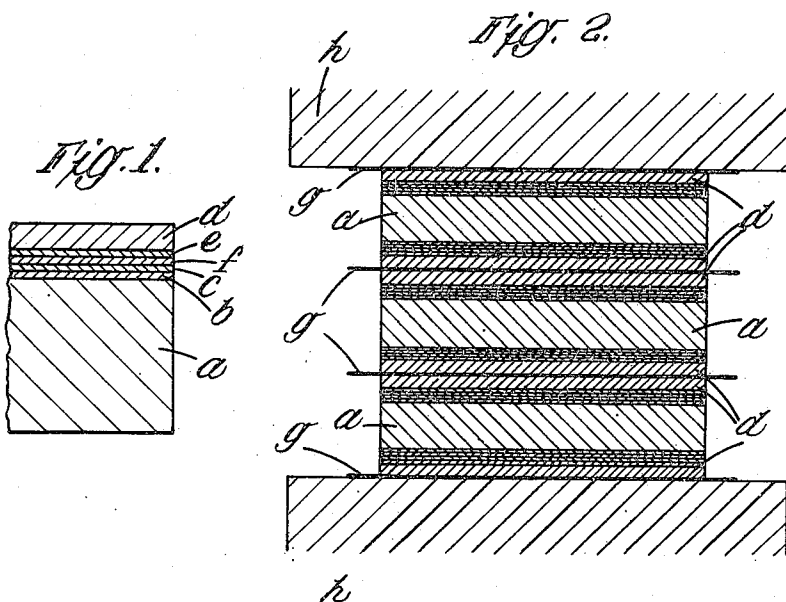
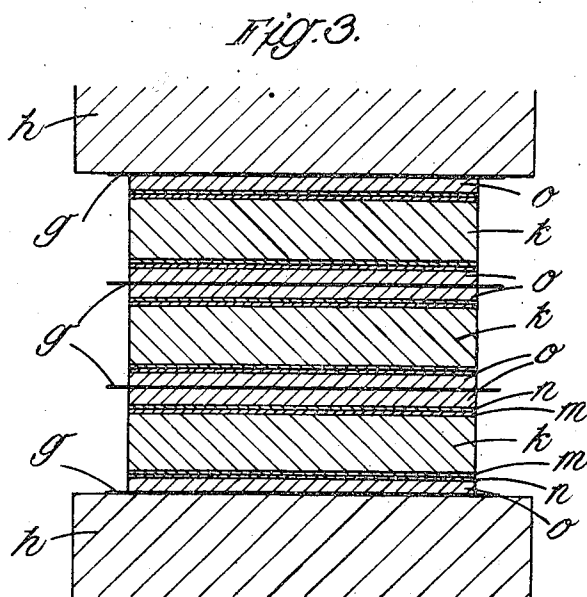
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PROCESS FOR CLADDING METALS AND THE PRODUCT THEREOF

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PROCESS FOR CLADDING METALS AND THE
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This invention relates to the plating of metal bodies such as ships' plates, sheet metal for the manufacture of containers and utensils, for the manufacture of shells or coverings for bullets and for like purposes.

In its broadest aspects, the present invention relates to the cladding of a body of metal with a superposed body of a cladding metal, with an intermediate sheet or layer of a high cuprous content metal, the base metal and the cladding metal being bonded together by diffusion of the intermediate layer. More specifically, the process relates to the making of a stainless-clad steel in which a body of plain steel is first electroplated with nickel and then with copper or a cuprous metal, the stainless steel, which is to form the cladding body, being then electroplated with a cuprous metal, and the two plated bodies superimposed one upon the other, with their cuprous faces contiguous, the stack so formed being then heated under heavy pressure at a temperature sufficient to cause the plating metals to form a diffusion bond between the stainless and plain steel bodies. In a modified form of the invention, a copper-clad steel is produced in which the plain steel is first electroplated with nickel and then with a cuprous metal, or the plain steel is directly electroplated with the cuprous metal, a sheet of copper being similarly plated and then superimposed upon the body of plain steel, the stack so formed being heated under heavy pressure and at a temperature sufficiently high to cause the plating metals to form a diffusion bond between the plain steel and the copper-cladding body.

It has already been proposed to cover metal bodies, such as those of iron, with layers of rustless steel (chromium-nickel steel) by applying a coating of nickel, or nickel alloy, to the one surface of a thin sheet of such steel, said sheet being then laid with the nickel-coated side downward, on the body to be clad, and the pack then subjected to pressure in a furnace at a high temperature. The object of such treatment is to cause the layer of nickel, or nickel alloy, to unite the two metals, between which it is located, by forming an alloy by diffusion, and thus establish, between the metal body and the cladding sheet, a mechanical union sufficiently strong to enable the clad metal body to be subjected to mechanical treatment, such as rolling, drawing, bending and the like in the hot or cold state, without the cladding sheet becoming detached therefrom. However, if the said alloy is to be formed by diffusion, a very high temperature is necessary and,

since some chromium-nickel steels, when heated to high temperatures, undergo such chemical and physical changes that their capacity to resist acids and rusting is more or less impaired, the said process is inapplicable for cladding a metal body with a covering of rust- or acid-proof steel.

According to the present invention, the cladding process, in which the pack, comprising the metal body and the cladding sheet, is heated under heavy pressure, is carried out by employing copper as the coating material for the formation of the uniting layer. If, however, the materials composing the metal body and the cladding sheet are liable to suffer damage, through being penetrated by the copper, when heated under pressure, there is provided between the copper coating and said materials, a coating of a metal or metal alloy, which protects the material of the parts to be united against the injurious influence of the copper, and is adapted to form by diffusion with said materials and with the copper, when heated under pressure, an alloy capable of withstanding subsequent deformation treatment, such alloy being formed at a temperature which does not injure the mechanical and physical properties of the parts to be united.

In cladding an iron body with chromium (rustless) steel, the two parts may be provided, according to the invention, first with a coating, preferably by electroplating, of nickel, or other metal with similar properties, and with a coating of copper. If the two parts are then superimposed, so that the coatings of copper are in contact, and the pack is heated under pressure, a considerably lower temperature than when a simple intermediate layer of nickel is employed, will suffice to effect the union of the two layers of copper, and also the formation of alloys by diffusion—at least at the boundaries between copper and nickel. If—as is the case when an electroplated coating of nickel is concerned—the nickel coating already adheres firmly, both to the metal body, which may be iron plate, and the cladding sheet, the intermediate layer, consisting of copper, or copper-nickel alloy, ensures such a firm union between the cladding sheet and the metal body, that it becomes directly possible to subject the compound body to all kinds of mechanical treatment, both in the cold and hot condition. Despite such mechanical treatments, the union of the parts is maintained, because the intermediate layer has a higher ductility than iron and steel, or than an iron-nickel alloy.

In any event, however, the temperature required

for the formation of the diffusion alloy between copper and nickel is so low that it cannot impair the properties of the steel sheet. For example, with heavy pressure heating at about 1000° C. for some 2-3 hours is sufficient.

Heating under corresponding heavy pressure can also be applied in the case of packs consisting of a plurality of metal bodies with cladding sheets in the known manner. Plating sheets may be applied to one or both sides of the metal body.

Various metals can be employed, both for the metal body and the plating sheets. In any event, however, owing to the fact that a copper coating is provided over the nickel coating, the temperature required for the formation of the alloy by diffusion is lower than would be needed to form such an alloy between nickel and iron. The process is therefore also advantageous in cases when no risk must be incurred of the metals employed suffering damage through excessive heating as the diffusion is formed at a relatively low temperature, (under 1000° C.).

An advantage of the original work being thin is that thin sheets which are intended to be superimposed and heated under pressure, for cladding purposes, can be more easily pressed tightly together than is the case with thicker sheets. The surfaces of the sheets which are to be united are never absolutely even, but thin sheets fit together more easily under pressure than thick sheets, and the union produced by means of the alloy formed by diffusion is therefore more uniform and stronger.

The layers of nickel and copper should be as thin as possible, as compared with the thickness of the metal body and of the plating sheet. In the case of iron or steel, the presence of an intermediate layer of nickel between the copper and the iron, or steel, has the advantage of preventing the penetration of copper into the iron, or iron alloy, and the resulting adverse influence on the properties of said metals.

In place of nickel, other metals (such as silver) with similar properties may be used as the first coating material for the two pieces of work to be united.

If an iron body is to be clad with copper, nickel, or their alloys, the said body can be provided with a thin coating of brass, red brass or the like, whilst the plating sheet is given a thin coating of alloys of copper and tin, or copper and zinc. If the plating metal has a high copper content, this latter metal may be omitted entirely from the intermediate layer, and consequently, there is no need to apply any coating, at all, to the cladding sheet.

When, owing to the properties of the materials employed, or to the thickness of the metal body, or of the plating sheet or sheets, considerable differences in ductility between the metal body and the plating sheet are to be expected during the subsequent deformation treatment, the intermediate bonding layer formed by the diffusion alloy will be unable to absorb the resulting stresses, if said layer consists solely of the usual thin metallic coatings formed by electroplating. In such event, the intermediate layer is not sufficiently great in cross-section—even if the diffusion alloy is exceedingly ductile—to allow the material to undergo displacement, in the direction at right angles to the thickness, to an extent corresponding with the difference of ductility of the metal body and the cladding sheet during

rolling or drawing, without disruption of the intermediate bonding layer.

Conditions of this kind arise, for example when an iron or steel plate with a thickness of about 30 mm. is plated with a sheet of chromium steel about 3 mm. thick, and this work is to be subjected to various deformation treatments. In such an event, coating the metal body and cladding sheet, to be superimposed, with a thin electrodeposited coating of nickel, and of copper respectively only, a few thousandths of a millimetre thick, is not sufficient to produce, when heated under pressure, an intermediate layer of diffusion alloy capable of absorbing the stresses set up through the difference in the ductility of such workpieces, in the operation of rolling. In the case of a thick metal body and a thick plating sheet, i. e. heavy plating, the intermediate layer uniting the metal body and the plating sheet should be of such thickness as to enable displacement of the material, in the direction perpendicular to the thickness, to occur—without destroying the intermediate layer—during rolling, drawing or other deformation treatment, as the result of the different elongation—due to the thickness—of the metal body and cladding sheet.

In order to obtain such thick intermediate layers, a correspondingly heavy galvanic deposit could be provided. In some cases, however, the intermediate layer must be very thick if it is to conform with the aforesaid conditions, for example, in the case where a metal body 30 mm. thick is to be clad with a chromium steel sheet 3 mm. thick. In such a case, the intermediate layer must have a thickness of about 1 mm., since experience has shown that the thickness of the intermediate layer should be about one-third that of the plating sheet. Electroplated coatings for the formation of an intermediate layer of the prescribed thickness would, however, be uneconomical, apart from the difficulties attending their production.

According to the invention, the coatings applied to the metal body and cladding sheet are of the usual thickness only, but, prior to the heating under pressure, there is laid, between the superimposed surfaces of said body and sheet, a copper plate, adapted to form a diffusion alloy with the coatings, whilst also possessing the requisite mechanical properties and being so dimensioned as to form, in conjunction with the coatings, a layer of such a thickness as is needed, for technical reasons, to produce a union capable of withstanding any deformation treatment of the work. Materials highly suitable for the intermediate sheet are: copper-zinc alloys (red-brass, brass, or the like), or silver-copper alloys. If, in the example above mentioned, the metal body be provided with a nickel and copper coating, 0.015 mm. and 0.030 mm. respectively, and the cladding sheet with a nickel and copper coating, 0.005 mm. and 0.015 mm. respectively, an intermediate sheet of red brass, about 0.8 mm. thick, may be used.

In the case of work intended to be annealed, the intermediate layer must be so constituted as to withstand the annealing temperature, and the intermediate sheet must therefore have a melting point of at least 1000-1040° C.

The invention is illustrated by the diagrammatic drawing, wherein Fig. 1 is a cross section of a pack constituted of a body to be plated and having a plurality of layers of materials superposed thereon prior to subjecting the pack to heat and pressure; Fig. 2 shows, in section, a plurality of packs within the platens of a press;

and Fig. 3 is a similar view, but of differently constituted packs of body and plating material.

Referring more particularly to the drawing:

In Figure 1 *a* represents a mild steel body to be plated, *b* a protective layer of nickel applied galvanically to the body *a*, *c* a layer of copper applied galvanically to the layer *b*, *d* a sheet of rustless steel with which the body *a* is to be plated, *e* a protective layer of nickel applied galvanically to the sheet *d*, and *f* a layer of copper applied galvanically to the layer *e*. The sheet *d* is superposed on the body *a* with the layer *e* contiguous with the layer *c* and the pack so formed is subjected to heat and heavy pressure.

Figure 2 shows a plurality of bodies *a*, with plating sheets *d*, on opposite sides of each body *a*, each pack *d*, *e*, *f*, *c*, *b*, *a*, being separated from the adjacent pack by a layer *g* of insulating material and the assemblage of packs located between the head *h* and base *j* of a press.

Figure 3 shows an assemblage of packs similar to that shown in Figure 2, but in this case *k* is a soft-steel body, *m* is a protective layer of nickel applied galvanically to the body *k*, *n* is a layer of copper applied galvanically to the layer *m* and *o* is a plating sheet which contains more than 50% of copper.

The heating of the metal pack is carried out in known manner in a suitable furnace, the usual precautions being employed to prevent oxidation of the metal surfaces, as by conducting the heating in a more or less evacuated space or in a space filled with an inert atmosphere or by welding or otherwise protecting the free edges of the superposed metal layers, or otherwise.

I claim:

1. The process of making a composite metal clad body which comprises plating the surface of a base metal sheet with nickel, plating the surface of a cladding metal sheet with nickel, superposing a layer of a high copper content metal upon the nickel plated surfaces of both the base and cladding sheets, superposing said base and cladding sheets with their copper surfaces contiguous, and heating under heavy diffusion pressure the pack so formed at a temperature sufficiently high to cause the plating metals to form a diffusion bond between the base sheet and the cladding sheet.

2. The process of making a composite metal clad body which comprises plating the surface of a base metal sheet with nickel, plating the surface of a cladding metal sheet with nickel, superposing a layer of copper upon the nickel plated surfaces of both the base and cladding sheets, superposing said base and cladding sheets with their copper surfaces contiguous, and heating under heavy diffusion pressure the pack so formed at a temperature sufficiently high to cause the plating metals to form a diffusion bond between the base sheet and the cladding sheet.

3. The process of making a composite metal clad body which comprises plating the surface of a base metal sheet with nickel, plating the surface of a cladding metal sheet with nickel, plating a layer of copper upon the nickel plated surfaces of both the base and cladding sheets, superposing said base and cladding sheets with their copper surfaces contiguous, and heating under heavy diffusion pressure the pack so formed at a temperature sufficiently high to cause the plating metals to form a diffusion bond between the base sheet and the cladding sheet.

4. The process of making a composite metal clad body which comprises plating the sur-

face of a base metal sheet with nickel, plating the surface of a cladding metal sheet with nickel, plating a layer of a high copper content metal upon the nickel plated surfaces of both the base and cladding sheets, superposing said base and cladding sheets with their copper surfaces contiguous, and heating under heavy diffusion pressure the pack so formed at a temperature sufficiently high to cause the plating metals to form a diffusion bond between the base sheet and the cladding sheet.

5. The process of making a composite metal clad body which comprises plating the surface of a base metal sheet with nickel, plating the surface of a cladding metal sheet with nickel, superposing a layer of a high copper content metal upon the nickel plated surfaces of both the base and cladding sheets, superposing said base and cladding sheets with their copper surfaces contiguous, and heating at a temperature of about 1000° C., and under heavy pressure, the pack so formed to cause the plating metals to form a diffusion bond between the base sheet and the cladding sheet.

6. The process of making a composite metal clad body which comprises plating the surface of a base metal sheet with nickel, plating the surface of a cladding metal sheet with nickel, superposing a layer of copper upon the nickel plated surfaces of both the base and cladding sheets, superposing said base and cladding sheets with their copper surfaces contiguous, and heating at a temperature at least 50° C. below the melting point of the cladding metal, and under heavy pressure the pack so formed to cause the plating metals to form a diffusion bond between the base sheet and the cladding sheet.

7. The process of making a stainless-clad steel which comprises plating the surface of a body of plain steel with nickel, plating the surface of a body of stainless steel with nickel, superposing upon the nickel plated faces of said two bodies a layer of metal of high copper content, superposing said bodies with their cuprous surfaces contiguous and heating under heavy diffusion pressure the pack so formed at a temperature sufficiently high to cause the plating metals to form a diffusion bond between the stainless and plain steel bodies.

8. The process of making a stainless-clad steel which comprises plating the surface of a body of plain steel with nickel, plating the surface of a body of stainless steel with nickel, superposing upon the nickel plated faces of said two bodies a layer of copper, superposing said bodies with their copper surfaces contiguous, and heating under heavy diffusion pressure the pack so formed at a temperature sufficiently high to cause the plating metals to form a diffusion bond between the stainless and plain steel bodies.

9. The process of making a stainless-clad steel which comprises plating the surface of a body of plain steel with nickel, plating the surface of a body of stainless steel with nickel, plating the nickel plated faces of said two bodies with a layer of metal of high copper content, superposing said bodies with their cuprous surfaces contiguous and heating under heavy diffusion pressure the pack so formed at a temperature sufficiently high to cause the plating metals to cause a diffusion bond between the stainless and plated steel bodies.

10. The process of making a stainless-clad steel which comprises plating the surface of a body of plain steel with nickel, plating the surface

of a body of stainless steel with nickel, plating the nickel plated faces of said two bodies with a layer of copper, superposing said bodies with their copper surfaces contiguous, and heating under heavy diffusion pressure the pack so formed at a temperature sufficiently high to cause the plating metals to form a diffusion bond between the stainless and plain steel bodies.

11. The process of making a stainless-clad steel which comprises plating the surface of a body of plain steel with nickel, plating the surface of a body of stainless steel with nickel, superposing upon the nickel plated faces of said two bodies a layer of a metal of high copper content, superposing said bodies with their cuprous surfaces contiguous and heating at a temperature of about 1000° C. and under heavy pressure the pack so formed to cause the plating metals to form a diffusion bond between the stainless and plain steel bodies.

12. The process of making a stainless-clad steel which comprises plating the surface of a body of plain steel with nickel, plating the surface of a body of stainless steel with nickel, superposing upon the nickel plated faces of said two bodies a layer of copper, superposing said bodies with their copper surfaces contiguous, and heating at a temperature at least 50° C. below the melting point of the cladding metal and under heavy pressure the pack so formed to cause the plating metals to form a diffusion bond between the stainless and plain steel bodies.

13. The process of making a stainless-clad steel, which comprises superposing a layer of metal of high copper content upon a body of plain steel, plating the surface of a body of stainless steel with nickel, superposing a layer of metal of high copper content upon the nickel plated face of said body of stainless steel, forming a pack of said plain steel and stainless steel bodies with their cuprous surfaces contiguous, and heating under heavy diffusion pressure the pack so formed, at a temperature sufficiently high to cause the plating nickel and cuprous metal to form a diffusion bond between the stainless and plain steel bodies.

14. The process of making a copper-clad steel which comprises plating the surface of a body of plain steel with nickel, superposing a layer of a high copper-content metal upon the nickel surface, and heating under heavy diffusion pressure the laminated sheet so formed at a temperature sufficiently high to cause the cuprous layer to diffuse into the protective nickel layer and the latter in turn to diffuse into the steel body.

15. The process of making a copper-clad steel which comprises plating the surface of a body of plain steel with nickel, superposing a layer of copper upon the nickel surface, and heating under heavy diffusion pressure the laminated sheet so formed at a temperature sufficiently high to cause the cuprous layer to diffuse into the protective nickel layer and the latter in turn to diffuse into the steel body.

16. The process of making a copper-clad steel which comprises plating the surface of a body of plain steel with nickel, superposing a layer of a high copper-content metal upon the nickel surface, and heating at a temperature of about 1000° C., and under heavy pressure the laminated sheet so formed to cause the cuprous layer to diffuse into the protective nickel layer and the latter in turn to diffuse into the steel body.

17. A process for making a composite metal-clad body, in which the process of plating

with nickel and a layer of a high cuprous content metal as set forth in claim 1 is duplicated on both sides of the base metal sheet.

18. A process for making a stainless-clad steel, in which the process of plating with nickel and a layer of a high cuprous-content metal as set forth in claim 7 is duplicated on both sides of the body of plain steel and at least one side of the body of stainless steel.

19. The process of making a composite metal-clad body which comprises plating the surface of a base metal sheet with a thin layer of a metal which will readily diffuse into the metal of the base sheet, superposing a layer of a high copper content metal upon said plating layer, the intermediate plating layer constituting a protective material against the influence of the copper upon the base sheet and forming, by diffusion with the base sheet metal and with the copper, when heated under heavy pressure, an alloy capable of withstanding subsequent deformation treatment, plating the surface of another metal sheet, constituting the cladding material, with a thin layer of the same protective metal and then with a high copper content metal, superposing said sheets with their copper surfaces contiguous, and heating under heavy pressure, at a temperature which will not have an effect of altering the mechanical and physical properties of the parts to be united, the pack so formed, to cause the copper layers to form a diffusion bond between the base metal sheet and the cladding metal sheet.

20. The process of making a stainless-clad steel which comprises plating the surface of a body of plain steel with a thin layer of a metal which will readily diffuse into the plain steel, superposing a layer of a high copper content metal upon said plating layer, the intermediate plating layer constituting a protective material against the influence of the copper upon the plain steel and forming, by diffusion with the plain steel and with the copper, when heated under heavy pressure, an alloy capable of withstanding subsequent deformation treatment, plating the surface of a body of stainless steel, constituting the cladding material, with a thin layer of the same protective metal and then with a high copper content metal, superposing said bodies with their copper surfaces contiguous, and heating under heavy pressure, at a temperature which will not have an effect of altering the mechanical and physical properties of the parts to be united, the pack so formed, to cause the copper layers to form a diffusion bond between the plain steel and the cladding stainless steel.

21. The process of making a copper-clad steel which comprises plating the surface of a body of plain steel with a thin layer of a metal which will readily diffuse into the plain steel, superposing a layer of a high copper content metal upon said plating layer, the intermediate plating layer constituting a protective material against the influence of the copper upon the plain steel and forming, by diffusion with the plain steel and with the copper, when heated under heavy pressure, an alloy capable of withstanding subsequent deformation treatment and heating under pressure, at a temperature which will not have an effect of altering the mechanical and physical properties of the parts to be united, the laminated sheet so formed, to cause the copper layer to diffuse into the protective metal layer and the latter in turn to diffuse into the steel body.

22. A composite metal-clad body compris-

ing a base of ferrous metal, a surface plating of electrodeposited nickel, and an electrodeposited layer of copper, upon said plating of nickel, the cuprous layer being diffused into the nickel and the nickel in turn being diffused into the base of ferrous metal.

23. A composite metal clad body, comprising a base of ferrous metal, a surface plating of electrodeposited nickel upon said base, an electrodeposited layer of copper upon said plating of nickel, a superposed layer of a high copper content metal upon the electrodeposited layer of copper and a cladding metal sheet of high cuprous content having an electrodeposited layer of copper on the surface thereof in contact with said superposed layer of copper.

24. A composite metal clad body comprising a base of ferrous metal, a surface plating of electrodeposited nickel upon said base, an electrodeposited layer of copper upon said plating of nickel and a cladding metal sheet of high cuprous content and having an electrodeposited layer of copper on the surface thereof in contact with the electrodeposited layer of copper upon said plating of nickel.

25. A stainless-clad steel block comprising a base of plain steel, a surface plating of nickel, a layer of metal of high cuprous content upon said plating of nickel, a sheet of stainless steel similarly plated on one face with nickel and a plated layer of metal of high cuprous content upon said plating of nickel, the plated stainless steel sheet being in juxtaposition with the plated plain steel, with the cuprous surfaces thereof contiguous, and the plating metals constituting a diffusion bond between the stainless and plain steel bodies.

26. A stainless-clad steel block comprising a base of plain steel, a surface plating of nickel, a layer of copper upon said plating of nickel, a sheet of stainless steel similarly plated on one face with nickel and a plated layer of copper upon said plating of nickel, the plated stainless steel sheet being in juxtaposition with the plated plain steel, with the cuprous surfaces thereof contiguous, and the plating metals constituting a diffusion bond between the stainless and plain steel bodies.

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