

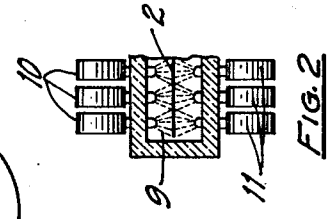
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METAL CLADDING BY SPRAYING

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METAL CLADDING BY SPRAYING

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My invention relates to improved methods of cladding or coating a metal surface with a second metal, and while it is to be understood that the invention is not limited to the cladding of metal in any particular form, it especially relates to the coating of metal in the form of strip or sheets. It further relates to a method of continuously coating metal in such forms.

Several methods of forming clad or bi-metal products have been proposed. Most of these methods involve the welding or fusing together, in the form either of an ingot or a slab, bodies of each metal of substantial thickness. From these products sheet bars are formed for the rolling of sheet or strip products. Such methods of manufacture are not continuous and failures are frequently encountered due to the difficulty in maintaining an effective bond between the different metals. It is very difficult to maintain perfectly clean surfaces of the metals which are being united and this is particularly true where the initial union of the metals takes place when the metals are in the form of ingots, billets or slabs or even sheet bars preparatory to rolling.

It is also a common practice to build up a layer of one metal on the surface of another metal by spraying it thereon in the form of initially highly heated particles. But due to the fact that these hot particles are very fine and pass a substantial distance through the air before they are deposited on the surface to be coated they are not only highly vulnerable to oxidation but are deposited at relatively low temperature with the result that, instead of building up a layer of substantially pure metal or alloy, the layer comprises large quantities of oxides of the sprayed metal. The surface of the sprayed metal or metal oxides is never smooth in any case, and where smoothness is required the surface must be ground or otherwise finished. Furthermore, the coating of sprayed metal is brittle and quite porous.

One of the objects of my invention is to provide a simple method of applying a substantially pure metal or alloy coating to a metal base in such a way that a greatly improved bond is obtained between the coating and the base. Another object is to provide a method whereby a pure metal or alloy coating may be continuously applied to a preformed sheet or strip of base metal and whereby the surface of the coating instead of having the characteristic granular surface of sprayed metal can, in the same operation, be provided with a smooth, planished surface characteristic of a cold rolled product.

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Another object is to provide a method of coating one metal with another whereby, in the finished product, the porosity of the layer of coating metal will be greatly reduced. Another object is to provide a method whereby the thickness of the metal coating may be quite accurately controlled and whereby coatings much thinner than is possible by present methods may be applied to a base metal. A further object is to provide a method whereby two or more different metals may be successively or substantially simultaneously applied to a metal base.

I accomplish these objects, in general, by spraying the cladding metal on a suitable base metal having a specially prepared surface and under conditions such that oxidation either of said surface or the sprayed particles is avoided. Thereafter the sprayed metal is subjected to high pressure, either cold or at high temperature, to compress it into a dense, smooth-surfaced mass and to form an interlocking bond between it and the base.

In the accompanying drawing—

Fig. 1 is a diagrammatic side elevation partially in section of one form of apparatus which may be used to practice my invention;

Fig. 2 is a fragmentary cross-section view of Fig. 1;

Fig. 3 is a highly magnified, longitudinal, cross-section view of a fragmentary portion of a base metal strip before cladding or coating;

Fig. 4 is a view similar to that shown in Fig. 2 after the metal surface has been applied to the base by spraying; and

Fig. 5 is a view similar to those shown in Figs. 3 and 4 illustrating the finished product.

Referring to the drawing 1 represents a coil of thin gauge metal strip 2 which is drawn from the coil in the direction of the arrow. As illustrated, the strip passes vertically upwardly through slots in the compartment forming means 4. Within the compartment are blasts 5 and 6 of sand or other grit which are positioned one on each side of the strip 2 and which are directed to impinge thereon at an angle somewhat less, preferably about 10 to 15° less, than 90° to the plane of the strip. This blasting treatment not only cleans the surface of the metal but also produces therein minute hooks or key points 15 (see Figs. 3 and 4) which facilitate the formation by pressure, of a strong interlocking bond between the coating and the base. After leaving the blasting compartment the strip passes over an idler 7 and into a heating unit 8 where the strip is preferably but not necessarily heat-

ed, by means of high frequency induction coils 3, to a temperature suitable for hot rolling. This temperature of course varies with the material but for ordinary commercial, low carbon iron or steel strip may be 1500 to 1700° F. The temperature is also limited by the melting point of the metal being sprayed and should of course be kept below the fluid point of the metal. While I prefer to use medium or low carbon, soft, steel strip as a base, because of its relatively low cost, it is to be understood that any desirable base metal may be employed. The strip may be heated by any suitable means such as induction, high frequency, or even in a gas fired heater of the annealing type.

However, it is quite essential that oxidation of the surface of the metal strip, which has been cleaned and roughened by the blasts 5 and 6, be prevented and therefore the atmosphere in the heater 8, and also throughout the spraying chamber and the second heater which will be hereinafter described, is preferably nitrogen or some other neutral or reducing gas adapted to prevent oxidation of the surface of strip 2 and also oxidation of the metal particles which pass therethrough in the form of spray.

The heated strip 2 passes from the heater 8 into the spraying chamber 9 where a plurality of metal spraying guns 10 and 11 are arranged to spray metal on one or both sides thereof as it moves along. Of course, if only one surface of the strip is to be coated the guns on the other side of the strip may be omitted or shut off, and the number of guns employed in any case, of course, depends on the width of the base metal strip and the thickness of the layer to be applied. The gun nozzles are preferably inclined to the plane of the strip at an angle somewhat less than 90° so that the particles of hot metal are projected under the hooks or key points 18 in the surface of the strip. After leaving the spraying chamber 9 the strip may pass immediately between one or more pairs of rolls, such as 12 and 13, where it is subjected to pressure at least sufficient to compress the metal coating into a dense, smooth-surfaced mass or, before rolling, it may pass through a second heater 14 where it is heated to suitable temperature for rolling. After rolling, the strip passes over the idler 15 and is recoiled on roll 16. It is not necessary that the rolling immediately follow the spraying and be done while the strip is hot. If desired, the strip, after spraying may be merely coiled and thereafter subjected either to a hot or cold rolling process in an ordinary strip mill.

When the strip is rolled under high pressure the particles of metal in the sprayed coating 17 which ordinarily impart to the surface a characteristic granular appearance are rolled down smoothly and a firm interlocking bond between the coating 17 and the base strip 2 is formed, as shown in Fig. 5.

Any metal that can be obtained in wire or powdered form suitable for spraying may be employed, and my process is particularly adapted for applying coatings of stainless steels to various base metals. In fact, the very best of the austenitic stainless steels, such as those containing about 18% of chromium and 8% of nickel, are most amenable to application by my process. Cold working of these steels causes them to harden, and where very much working is necessary the steel must be softened by heat treating it between the various workings. These steels, as distinguished from ordinary carbon steels, are

rendered soft and easy to work by heating to high temperature and cooling rapidly and this is substantially what occurs in building up a coating of stainless steel according to my process. The particles of steel when they leave the gun are very hot and the coating remains at high temperature until the strip passes out of the spraying chamber 9 and heater 14. Thereafter it is cooled very rapidly by contact with the air and hence is rendered comparatively soft. Thus, whether the coated strip is immediately rolled, or rolled at some later time is substantially immaterial because it is comparatively soft and remains soft until after it has been compressed by the rolls into a hard, dense, smooth-surfaced mass. The bond between the stainless steel and the ordinary carbon steel base is excellent as is also the integrity of the stainless steel coating itself, and the composite strip may be bent, embossed or die-formed into various shapes without rupturing either the bond or the stainless coating.

It will be obvious that all of the spray guns need not be simultaneously employed nor need each of the guns spray the same metal or alloy. Thus, it may be desirable first to apply to the base strip a coating of a low melting point metal or alloy such as aluminum, lead, tin or zinc and thereafter to apply a coating of stainless steel or other metal over the aluminum. In this case the metal sprays which first contact the strip may be of the low-melting point metal and the following sprays of stainless or other metal. Aluminum is a readily oxidizable element and the deposit made when aluminum is sprayed under the ordinary practice consists largely of oxides which are very hard. When sprayed in a neutral or non-oxidizing atmosphere the deposit is of substantially the same purity as the metal before spraying.

There are various types of metal spray guns. Some in which the metal is supplied to the guns in the form of powder and others in which the metal is supplied in the form of wire. Various gases such as acetylene, propane and ordinary illuminating gas are used in combination with oxygen to supply the necessary heat for melting the metal to be sprayed and care should be exercised to see that the volume of oxygen employed is not in excess of that necessary to produce satisfactory combustion with the gas employed.

The propelling medium employed in the present practice is compressed air which results in some oxidation of the metal particles irrespective of the atmosphere into which the spray is projected. However, where air is used oxidation is very substantially reduced by spraying into a non-oxidizing or neutral atmosphere, and may be avoided entirely by using compressed nitrogen instead of air as a propelling medium.

The last step of compressing the sprayed coating, preferably by rolling the product, is very important in my process because it greatly reduces the inherent porosity which is characteristic of sprayed metal films and at the same time reduces the characteristic fine, granular-appearing surface to one having a reasonably smooth planished finish. Furthermore, in those cases where a relatively high melting point metal or alloy is applied following the application of a softer metal or alloy of much lower melting point, a particularly effective bond is established with the base strip, and the film of applied metal, after rolling, is particularly dense because the softer metal is forced into the somewhat porous understructure of the superposed film.

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The process is particularly adapted for producing a composite stainless steel strip in which the base may comprise an alloy steel containing comparatively low chromium to which a film of .003 or .004" of an alloy having extremely high resistance to corrosion, such as chrome-nickel stainless steel, or Nichrome or other non-ferrous alloy, is applied by my process.

The rolling step is not limited to a single pass between the rolls and, where it is necessary in the rolling process to anneal the composite steel the usual annealing methods may be employed without danger of rupture or let-go of the bond between the two metals.

Many metals having comparatively low melting points and which are quite volatile at high temperature cannot be successfully sprayed under the present methods because of high oxidation and vapor losses. This is particularly true of tin. However, under my process such metals may be easily sprayed, and when deposited on a base metal strip which is heated to a temperature approximating the fusion or melting point of the low-melting point metal, either at the time the low-melting point metal is deposited thereon or after a higher melting point metal has been sprayed over the lower melting point metal and before the composite structure is subjected to pressure, the lower melting point metal, under pressure, forms a sort of fusion bond between the base and the outer layer of metal and serves effectively to seal the pores in the metal between the surface and the base. Thus, a layer of aluminum between a metal base and an outer layer of stainless steel or Nichrome forms an efficient bonding seal when subjected to pressure.

From the foregoing it will be apparent that

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my process is subject to many modifications, and that the pressure for the purpose of densifying the sprayed metal need not necessarily be rolling pressure except in cases where the large surface areas or continuous processing is involved and it is thus possible to produce high pressure per unit of area by means of a roll that would otherwise be quite impracticable in a press.

While I have described my invention in its preferred embodiment it is to be understood that the words which I have used are words of description rather than of limitation and that changes within the purview of the appended claims may be made without departing from the true scope and spirit of my invention.

What I claim is:

1. The method of cladding the surface of an elongated metal product, such as a bar or strip, with a chrome-nickel, austenitic, stainless steel which comprises roughening said surface, continuously moving said product lengthwise thereof, electrically heating said moving product approximately to hot rolling temperature in a non-oxidizing atmosphere by inducing high frequency currents therein, spraying a coating of said steel on the roughened surface of said moving product while hot and still in said non-oxidizing atmosphere, rapidly cooling said coated product, whereby the steel coating thereon is rendered soft and workable, and thereafter hardening said coating and compressing it into a dense, smooth-surfaced mass by cold rolling said product.

2. The method set forth in claim 1 in which a non-oxidizing gas is employed as a propellant for spraying said steel.

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