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METHOD OF COATING METALS

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This invention relates to the coating of metal on metal bases, and, in particular, to composite layers of metals. Such metal composites are often also known as "clad metals."

Although many metals can be electro deposited onto other metals such electro deposition is not economically feasible when moderately thick coatings are desired. As an example, we may cite the fact that copper or brass coated steel sheet, with the coating representing about 10% of the total, has great potential commercial demand, but electro deposition methods are much too expensive for practical operation. In addition to such combinations as are technically feasible, though commercially unprofitable, there is a large number of metals which, by their very nature, cannot be electro deposited, for example, stainless steel, etc.

Such coatings, or composite metals have occasionally been made in the past from massive metal by the simultaneous rolling of carefully cleaned and machined slabs of the two metals, rolled face to face at high temperature. However, the practical difficulties standing in the way of such co-rolling are numerous, and have made the use of this process quite expensive where it is at all feasible; in many instances it is, to all intents and purposes, commercially unworkable altogether. Copper or brass coating of steel, already cited, is one case where the simultaneous rolling of metal slabs has proven ineffective. This is probably due to the fact that copper and iron have little if any alloying tendencies at the temperature necessary for the operation. In this connection, it is worthy of note that those cases where the present method of co-rolling of slabs is moderately successful technically are represented by metals which are easily alloyed with iron—e. g., nickel—and which have relatively high melting points, so as to enable the co-rolling to take place at temperature high enough to effect, simultaneously, surface alloying.

It is obvious that, to obtain most efficient bonding between the two metals, it would be far more desirable that one of the metals—preferably the one smaller in volume quantity—pass through the fused state. When, however, attempts are made to flow molten copper or brass onto a steel base, the copper or brass collects in large globules, much as would mercury on a glass surface, and there is no coverage of the steel. This, in paraphrase, reflects a failure of the cuprous metal to wet the steel surface. Theoretically, the addition of a flux, such as borax, to the steel surface prior to flowing the copper or brass should

suffice to effect a wetting action between the metals, but practical difficulties are great. It has proven practically impossible, specifically, to bring the proper quantity of flux to each unit of area, and almost as difficult is controlling the flow of the flux with respect to the steel base. Comparatively little progress, therefore, has been made along these lines, and what few composite metals are to be found commercially today are being made by the co-rolling of solid slabs rather than through the pouring-on of one metal, in fused form, on another in solid form.

Our invention, by making possible the wetting of the base metal by the fused cladding metal, removes the fundamental barrier to commercial operation of this method of cladding, and permits the forming of composite ingots which can subsequently be co-rolled as a single unit. In our invention, we subject the base metal, which at all times remains in the unfused state, to the action of a vaporized flux of the type to be elucidated below, and, while such base is under the protection of such flux, the second, or cladding metal is contacted, in fused form, with the surface of the base metal.

As an example, we can again consider the coating of steel with copper. A slab of steel about one inch in thickness is subjected to an oxyacetylene flame carrying, by entrainment, a volatile flux like methyl borate, either pure or as the methanol azeotrope. While the steel is under the influence of such oxyacetylene flame and the entrained flux, copper in the form of small pellets is dropped into the heated zone. Immediately upon melting, these copper pellets flow into continuous sheet-like form, with perfect wetting of the steel base and consequently equally perfect adhesion to it. As each unit of area is covered with copper, the flame is moved on to a fresh zone, and the process repeated until the whole surface is covered. The thickness of the copper coating can, of course, be easily regulated by increasing the quantity of copper per unit area. We have found it difficult to obtain a consistently thin coating less than about $\frac{1}{16}$ th of an inch in thickness, and prefer coatings of greater thickness than this. After the copper has been completely flowed on the steel, the resulting composite steel-copper unit is ready for rolling by the usual technics.

It is obvious that the steel may first be coated on one side, and then on the other, thus forming a "sandwich" of steel, protected by copper on both sides.

While the cladding metal must, in our inven-

tion, at some point in the operation pass through the molten state, we wish to point out that it is not at all necessary that such metal be actually handled in the fused condition. In the example already cited, copper was used in the form of pellets; the process would have been otherwise identical if copper powder were used or wire or sheet. Similarly, the copper can be poured on in liquid form, having been previously molten by independent heat. This last method has the great advantage of economy, since the heat of fusion of the metal is obtained by cheap direct heat. When solid metal is used—as pellets, wire, sheet, etc.—heat of fusion must be obtained from the heat of the torch which, as oxygen and acetylene, or even as natural gas and air is relatively expensive. Whether solid metal is used, or liquid, will depend upon the proper balancing of convenience against cost of operation.

While the basic theory of our invention is that of contacting the solid base metal with the molten cladding metal while the zone under entrainment is subjected to a vaporizable flux, it has already been pointed out that the cladding metal can be added in solid form, being brought to the fused state as part of the cladding procedure. Similarly the exact procedure of maintaining the local temperature during cladding can also be varied. The oxyacetylene torch, as already mentioned, is a very convenient method and the vaporizable flux can be entrained in the stream of air, gas or oxygen, as may be chemically desirable. Other combustible gases—methane, hydrogen, etc.—can also be used, either with oxygen or with air, in flame torches of the same type.

We do not limit ourselves, however, to flame torches. The electric arc of the type used in arc welding can be equally efficiently used as a source of heat during such cladding; in such a case, an auxiliary feed tube is necessary to convey the vaporizable flux either alone as such,

or conveyed by an inert or combustible gas to the cladding zone. An electric arc torch of such type, carrying a vaporizable flux of this nature has been described in our co-pending application Serial No. 247,224.

The volatile alkyl borates lend themselves very well to the purposes of this invention; examples which may be cited are methyl and ethyl borate, or preferably because more readily obtained, the asetrotes of these materials with their corresponding alcohols. Even more to be preferred because of factors set forth in those applications, are the improved types of vaporizable flux described in co-pending applications Serial No. 228,398 and No. 220,560. Any of the fluxes described in these applications are equally usable in our invention.

Other modes of applying the principle of our invention may be employed instead of the one explained, change being made as regards the product and method herein disclosed, provided the step or steps stated by any of the following claims or the equivalent of such stated step or steps be employed.

We therefore particularly point out and distinctly claim as our invention:

1. A method of making a composite metal slab which consists in preheating a slab of steel to a desired temperature by means of a combustible gas containing a vaporized flux and then applying a metal predominant in copper and in solid, finely divided form onto said preheated slab of steel.

2. A method of making a composite metal slab which consists in directing a combustible gas containing a vaporized flux onto the upper surface of the slab and then applying a second metal, in solid, finely divided form onto said slab.

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