In the process of bonding a coating of aluminum to  

1. In the case of low alloy steels containing about 1% of either molybdenum, or tungsten, the alloy bond thickness resulting from dipping such steel in molten aluminum of commercial purity has resulted in a bond alloy having a thickness not appreciably greater than about 0.4 to 0.6 mil, whereas a plain carbon steel dipped under the same conditions showed an undesirable alloy bond thickness of substantially 2.0 to 2.5 mils. Very small additions, i.e. from a trace to an amount not materially exceeding 1% of tungsten or molybdenum to a medium or low carbon steel resulted in a substantial reduction in the thickness of the alloy bond layer and the conditions are to be subjected to subsequent rigorous treatment we have found that the thickness of the alloy bond should preferably be less than 0.4 mil, indicating that for many purposes the percentage of molybdenum or tungsten need not materially exceed 1% by weight of the steel.

While molybdenum and tungsten vary in efficiency in controlling the thickness of the bonding alloy the combination of these metals as alloy bond controllers may advantageously be employed. We have observed that although in certain molten aluminum-containing metals the molybdenum tends to go into solution, nevertheless, molybdenum helps to control the thickness of the bonding alloy when coating molybdenum-containing steels designed for special purposes.

The term "aluminum" as used herein includes aluminum as well as aluminum-containing alloys, and particularly aluminum-base alloys, since the presence of the aforementioned metals in the steel article to be coated controls the alloying action between the ferrous metal of the body and the coating or layer of aluminum or aluminum alloy regardless of the presence of metals or non-metals that may be in the aluminum or aluminum alloy.

In carrying out the process of this invention, the ferrous metal body is alloyed with the indicated small percentage of molybdenum or tungsten, or combination thereof, whenever it is desired to control the thickness of the bonding alloy formed at the interface between the surface to be coated and the aluminum. The amount of the aforementioned bond-control metal determines the depth of the bonding alloy, without requiring the extremely accurate time and temperature control heretofore required for that purpose. For example, the temperature of the aluminum-containing metal can be maintained between the melting point of such metal and about 1350° Fahrenheit. With such alloy thickness control the strength of the bond is greatly augmented, since the beneficial effect of the coating is reduced in thickness and thus enables the composite metal article to be worked either hot or cold, or be subjected to wide temperature fluctuations, or both, without impairment of the bond.

Although a preferred method of controlling the depth of the alloy formation between the ferrous metal surface and aluminum-containing metals has been described herein, it is to be understood that the method of this invention may be used to control the depth of the alloying bond by proportioning the percentage of the alloy inhibiting metal in the steel so as to obtain an alloy at the interface of any desired thickness between that obtained without the use of the aforementioned heavy metals and that obtained with the maximum percentage which secures a bond of minimum safe thickness for rigorous treatment of the composite article. It is also to be understood that other variations in the invention may be made within the scope of the appended claims.

This application is a continuation-in-part of our application Serial No. 757,920, filed June 28, 1948, and now abandoned.

We claim:

1. In the process of bonding a coating of aluminum to
a plain carbon steel base by dipping said plain carbon steel base into a bath of molten aluminum to form a coating of aluminum thereon and a ferro-aluminum bonding alloy at the interface between said plain carbon steel base and said aluminum coating, the improvement comprising initially alloying in said plain carbon steel base about 1 per cent of a metal selected from the group consisting of molybdenum and tungsten, immersing the resulting alloyed body into a bath of molten aluminum maintained at a temperature not above about 1350° F, for a period to form the desired thickness of said coating, said bonding alloy being simultaneously formed and automatically controlled to a thickness not in excess of 0.6 mil, irrespective of the time of immersion in said molten bath.

2. In the process of bonding a coating of aluminum to a low alloy steel base containing about 1 per cent of a metal selected from the group consisting of molybdenum or tungsten by dipping said low alloy steel base into a bath of molten aluminum to form a coating of aluminum thereon and a ferro-aluminum bonding alloy at the interface between said coating and said base, the improvement comprising immersing said low alloy steel base into a bath of molten aluminum maintained at a temperature not above about 1350° F, for a period to form the desired thickness of said coating, said bonding alloy being simultaneously formed and automatically controlled to a thickness not greater than about 0.4 to 0.6 mil, irrespective of the time of immersion in said bath.

3. In the process of bonding a coating of aluminum to a ferrous metal article by dipping said article into a bath of molten aluminum to form a coating of aluminum thereon and a ferro-aluminum bonding alloy at the interface between said ferrous metal article and said coating, the improvement comprising initially alloying in said ferrous metal article about 1 per cent of a metal selected from the group consisting of molybdenum and tungsten, immersing the resulting alloyed body into a bath of molten aluminum maintained at a temperature above the fusion temperature of said aluminum but below 1350° F, for a period to form the desired thickness of said coating, said bonding alloy being thereby simultaneously formed and automatically controlled to a thickness not in excess of 0.6 mil.

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