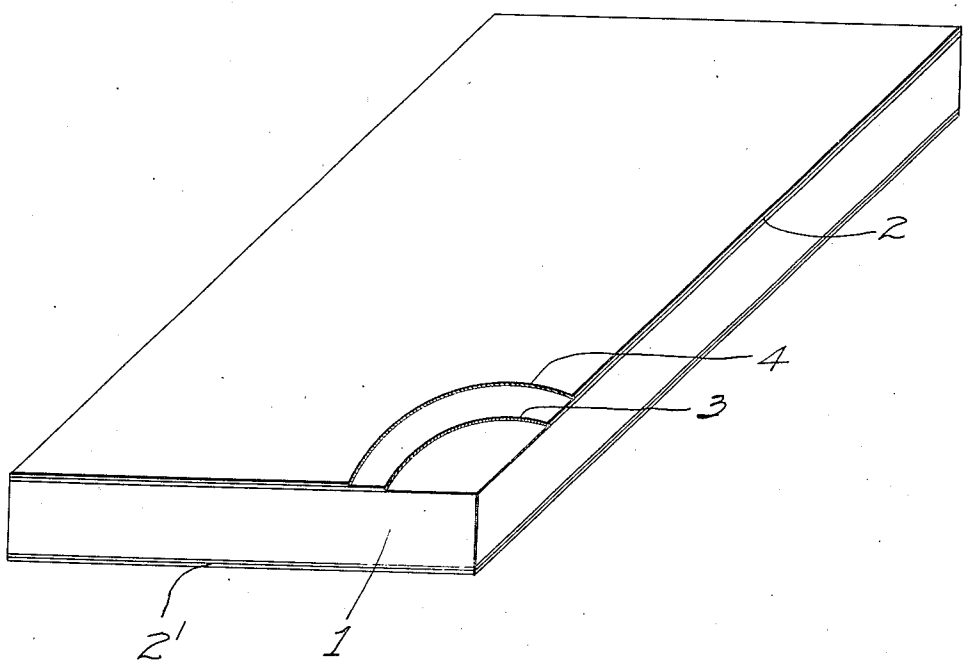
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DUPLEX METAL ARTICLE

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DUPLEX METAL ARTICLE

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5 Claims. (Cl. 29—181)

This invention relates to duplex metal articles, and it is particularly concerned with the production of an improved duplex metal comprising a base of aluminous metal (aluminum or aluminum alloy) provided on one or more of its surfaces with an aluminous metal coating resistant to deep pitting by corrosion.

It has heretofore been proposed to produce aluminous duplex metals, particularly of the type comprising a core of strong aluminum alloy provided with a coating consisting of pure aluminum or an aluminum alloy more resistant to corrosive attack than the core metal. The coating in these duplex metals is formed of a single layer of metal of substantial thickness which constitutes an appreciable part of the total thickness of the duplex metal. Upon exposure of such material to corrosive conditions, a local action takes place which may cause relatively rapid penetration through the coating to the base metal, forming pits which are relatively deep and of small circumference. The surface appearance of the duplex metal is materially impaired by this type of corrosion and the protection afforded the base metal is often partially destroyed.

It is an object of the present invention to overcome the difficulty of pitting in duplex metal surfaces and to provide an improved duplex metal article in which corrosive attack is distributed over a relatively wide surface area before penetrating to a substantial depth. A further object of my invention is to provide an improved duplex metal article having an aluminous metal base provided with an aluminous metal coating substantially resistant to pitting which retains a relatively smooth, even surface appearance under corrosive conditions. More particularly, it is an object of my invention to provide an improved duplex metal article consisting of an aluminous metal base provided with a coating composed of a plurality of aluminous metal layers or laminations.

I have discovered that if an aluminous metal base be provided with a laminated coating consisting of two or more layers of aluminous metal in which each layer possesses an electrode potential greater than that of the base metal and in which the successive layers of the laminated coating are so arranged that the electrode potential of the coating increases progressively from the surface of the base metal to the outer surface of the duplex metal article, an improved duplex metal article is obtained which is not subject to pitting by corrosion. In this type of article, upon corrosion, instead of forming deep pits which penetrate through the coating to the base metal, the corrosive attack spreads laterally after penetrating the first layer of the laminated coating and does not penetrate the second or successive layers of the coating material until the layer first penetrated is extensively corroded in a lateral direction. This effect is the direct result of the selection and arrangement of the materials of the successive layers of my improved duplex metal article with regard to the electrode potential of the aluminous metal employed in each layer. The electrode potential of the surface or other layer being always greater than that of the layer next below it, at any point where any two of these layers are exposed in contact with a corroding medium, the voltaic action set up causes a preferential attack of the metal of higher electrode potential, thus protecting the layer of lower electrode potential.

In forming the duplex metal articles of my invention the proper choice and arrangement of the aluminous metals to be used in combination depends upon a predetermined knowledge of the electrode potential of the various aluminous metals. These different potentials are readily measured, in accordance with the methods long known in the art, against a standard electrode. If the electrode potentials of the layers of the aluminous metal coating are electronegative with respect to the standard electrode, it is not necessary that the base metal be electropositive with respect to the standard electrode, but only that the base metal be less electronegative than the coating metal, and that the layers of the coating be successively more electronegative than the base metal. Therefore, throughout this specification and claims, when I say that the electrode potential of the various layers of the coating should be higher than that of the base metal, I mean that the aluminous metals of the various layers of the coating should be more electronegative with respect to the standard electrode than is the base metal. While no fixed potential difference is required between the electrode potential of the aluminous metal base and the coating, or between any two adjacent layers of the coating, it is desirable that there be a relatively wide difference in the electrode potential of any two adjacent layers, since I have found that with greater difference in electrode potential corrosive attack proceeds laterally to a greater extent and spreads the corrosion over a wider surface area, thus producing a material with greater resistance to penetration by pitting.

A convenient standard electrode for measuring

the potentials above mentioned may be readily selected from those now in regular use for similar measurements. For the purposes of this description of the invention a calomel electrode has been selected as a standard. In measuring the electrode potential in question, the aluminum alloy to be tested is made one element of an electrolytic cell. The calomel electrode is made the other element. The electrolyte is a normal solution of sodium chloride containing 0.3 per cent by weight of hydrogen peroxide. The circuit is closed and the potential difference of the elements is measured on a potentiometer. The calomel electrode used is made up in the usual way of mercury in contact with mercurous chloride and in contact with this a $\frac{1}{10}$ normal potassium chloride solution saturated with mercurous chloride.

The aluminous metals to be used in forming the laminations of the composite coating metal may be aluminum or substantially any of its alloys of suitable electrode potential. For the purpose of forming laminations of suitably graded electrode potentials I have found it particularly convenient to use alloys of aluminum and one or more of the metals silver, tin, indium, bismuth, calcium, barium, strontium, cadmium, zinc, platinum, and gallium in varying amounts. As is described in my copending U. S. Patent application, Serial No. 694,444, filed October 20, 1933, these metals have the property of increasing the electrode potential of aluminous metals without otherwise modifying their desirable properties, when added thereto in relatively small amounts. Consequently, by the addition of progressively increasing amounts of these metals to successive layers of the composite coating metal a coating material having the desired electrode potential properties may be readily produced. In general, the following amounts of metals of the class above described best serve the general purpose of this invention in producing the electrode potential desired without materially impairing other desirable properties of the aluminum alloys.

	Per cent
Silver	0.02 to 2.0
Cadmium	0.05 to 5.0
Platinum	0.02 to 2.0
Calcium	0.1 to 1.0
Barium	0.1 to 2.0
Strontium	0.1 to 1.0
Gallium	0.02 to 2.0
Indium	0.02 to 2.0
Bismuth	0.02 to 1.0
Tin	0.02 to 0.5
Zinc	0.2 to 10.0

The composite coating metal may be formed of any desired number of laminations of any desired thickness. In general, however, the surface appearance is better retained if the individual laminations are extremely thin and the desired thickness of the coating metal is built up by the use of a greater number of laminations. A suitable method of forming such a material is to first form a pack of superimposed sheets of the various aluminous metals which are to constitute the individual laminations, and then by a rolling operation reduce the thickness of the pack to the desired thickness. This reduction produces extremely thin laminations in the finished coating metal.

The base or core metal, that is to say the layer or body of metal from which the duplex metal articles of my invention derives its principal structural properties, may be any aluminum alloy having the properties which it is desired to obtain in the finished article. If, for example, it is desired that the article have high strength and hardness, an alloy of the duralumin type may be used as the base, such as alloys A, B, or C below mentioned; or if it is desired to obtain an article which combines the properties of extreme ductility with workability, alloys of the type D, E, or F below mentioned may be used. Also, other alloys possessing known combinations of properties may be employed, such as any of the following:

Alloy	Composition—Percentage by weight—Balance aluminum
A	4 copper, 1.25 silicon, 0.5 manganese, 0.5 magnesium.
B	4.4 copper, 0.8 silicon, 0.75 manganese, 0.5 magnesium.
C	1.0 silicon, 0.6 magnesium.
D	Commercial aluminum.
E	1.25 manganese.
F	1.25 manganese, 1.0 magnesium.
G	0.7 silicon, 1.25 magnesium, 0.25 chromium.
H	5 silicon.
I	4.0 copper, 0.5 magnesium, 2.0 nickel.
J	4.5 copper, 0.8 silicon, 0.8 manganese.
K	0.8 copper, 0.8 nickel, 12.5 silicon, 1.2 magnesium.
L	6 magnesium.
M	3 nickel.
N	10 silicon.
O	4.5 copper, 5.0 silicon.
P	14 silicon, 2.0 nickel, 1.0 magnesium.
Q	6.0 copper, 1.0 tin.
R	7.0 copper, 7.0 nickel, 7.0 silicon.
S	6.0 magnesium, 1.5 nickel, 1.0 manganese.

In some cases the composite coating metal prepared as above described may possess sufficient structural properties for the purpose of its intended application. In such case a composite laminated structure may be produced in which there is no single layer from which the structure derives its physical properties. In fact, it has been found that for certain applications a coating metal prepared as above described is useful without application to a base. It is to be understood, therefore, that the duplex metal articles of my invention contemplate articles which derive their structural properties from the properties of the aluminous metals forming each of the layers, as well as such duplex metal articles as derive their principal structural properties from a single base layer.

In forming the duplex metal articles of my invention, in which a relatively thin laminated coating is applied to a metal base having desired structural properties, any of the known methods of forming such duplex metal articles may be used. One method which I have found particularly satisfactory is to cast the base alloy against the formed laminated coating metal, as described in the patent of E. H. Dix, No. 1,865,089, issued June 28, 1932. The article may then, if desired, be mechanically worked, as for example by rolling or drawing or other suitable operation, to form the particular type of duplex metal article desired, such as sheet, rod, or other form of material. The working with intermediate heating incident to such forming operations tends to improve the bond between the laminations of the coating and between the coating and the base metal.

The duplex metal articles of my invention may be provided on any one or all of their exposed surfaces with the protective composite coating metal. For example, there is shown in the drawing a duplex metal article comprising a base 1 of an aluminum structural alloy provided on its top and bottom surfaces with a laminated coating metal 2 and 2^1. The base 1 may be formed, for example, of an alloy consisting of aluminum

and 1.25 per cent manganese. The laminated coating metal 2 and 2^1 in the specific example shown consists of two layers 3 and 4 shown in section where the corner of said coating is cut away. The layer 3 may consist of an alloy of aluminum and 0.05 per cent tin, the layer 4 being formed of an alloy of aluminum, 0.05 per cent tin, and 0.05 per cent bismuth.

I claim as my invention:

1. A duplex metal article consisting of a base of aluminous metal provided with a coating consisting of a plurality of aluminous metal layers, each of said layers having an electrode potential greater than that of the base metal and having said layers arranged in the order of increasing electrode potential from the base metal to the surface of said article.

2. A duplex metal article consisting of a base of aluminous metal provided with a laminated aluminous metal coating composed of a plurality of aluminous metal layers, each of said layers having a different electrode potential and all of said layers having electrode potentials greater than that of the base metal, said laminated coating having an electrode potential which increases progressively through successive layers from the base metal to the outer surface of said article.

3. A duplex metal article consisting of a base of aluminous metal provided with a laminated aluminous metal coating having an electrode potential which increases throughout its thickness from the base metal to the outer surface of said article, said coating being resistant to penetration by corrosion.

4. A duplex metal article consisting of a base of aluminous metal provided with a laminated aluminous metal coating having an electrode potential which increases throughout its thickness from the base metal to the outer surface of said article and being resistant to penetration by corrosion, said coating being composed of a plurality of extremely thin aluminous metal layers, each of said layers consisting predominantly of aluminum and at least one of the class of metals silver, cadmium, zinc, platinum, calcium, barium, strontium, gallium, indium, bismuth and tin, each of said layers having an electrode potential greater than that of the base metal.

5. A duplex metal article consisting of a base of aluminous metal provided with a laminated aluminous metal coating having an electrode potential which increases throughout its thickness from the base metal to the outer surface of said article and being resistant to penetration by corrosion said coating being composed of a plurality of extremely thin aluminous metal layers, each of said layers consisting predominantly of aluminum and at least one of the class of metals silver, cadmium, zinc, platinum, calcium, barium, strontium, gallium, indium, bismuth and tin, each of said layers having an electrode potential greater than that of the base metal and greater than that of substantially pure aluminum.

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