Oct. 15, 1935. F. KELLER ET AL 2,017,757

DUPLEX METAL ARTICLE

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Fig. 1.

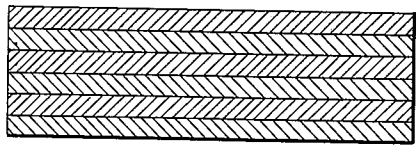
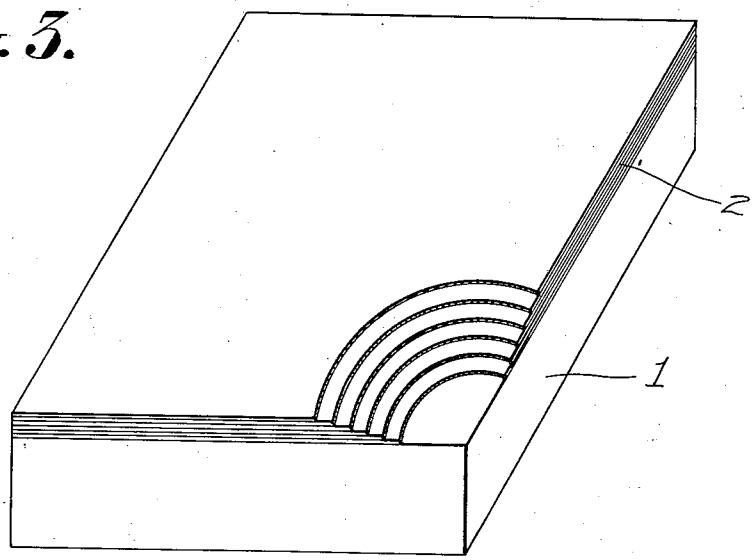


Fig. 2.

Fig. 3.



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DUPLEX METAL ARTICLE

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4 Claims. (Cl. 29—181)

This invention relates to duplex metal articles, particularly of the type comprising a base of aluminous metal (aluminum or aluminum base alloy) provided on one or more of its surfaces with an aluminous metal coating resistant to corrosion.

To obtain a high degree of corrosion resistance in aluminum alloy articles without sacrifice of the structural or other properties which recommend the particular alloy for its intended use, the structural alloys are coated on one or more surfaces with a layer of aluminum or an alloy of aluminum more resistant to corrosion than the base 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 extended exposure of such material to corrosive conditions, a localized type of corrosion takes place which penetrates through the coating to the base metal, forming pits in the surface of the article which are relatively deep and of small diameter. This pitting destroys the surface appearance of the duplex metal article and may, as well, impair the protection afforded the base metal by the coating.

It is an object of the present invention to provide an improved aluminous duplex metal article consisting of an aluminum or aluminum alloy base provided with an aluminous metal coating of improved inherent corrosion resistance which is also substantially resistant to pitting by corrosion. It is more particularly an object of this invention to provide an improved aluminous duplex metal article having an aluminous metal base provided with a laminated coating consisting of a plurality of layers of aluminous metal having an improved resistance to corrosion and to penetration by pitting.

This invention is predicated upon the discovery that a duplex metal consisting of an aluminous metal base provided with a laminated coating formed of a plurality of thin layers of aluminous metal is more resistant to corrosion and penetration by pitting than a duplex metal having a single-layer coating of an aluminous metal of a thickness equal to that of the laminated coating, and particularly good resistance to penetration by pitting is obtained if the sheet metal used in forming the laminated coating be oxide-coated, either naturally or artificially, prior to the formation of the laminated coating metal. In this type of article the inherent corrosion resistance of the metal of each layer of the laminated coating is increased. In that form of the article in which oxide-coated sheet metal is used in forming the laminated coating metal, the oxide is distributed throughout the coating metal in the form of more or less discontinuous layers, depending upon the amount of reduction imparted to the metal in forming the laminated coating.

In forming the multiple-layered laminated coating metal, aluminum or any of the wrought aluminum base alloys may be used, but it is preferable that high purity aluminum and aluminum alloys having high inherent corrosion resistance be used. It is necessary that the metal used be capable of being worked, as the formation of the composite laminated coating metal requires considerable working to reduce it to the desired thickness, and in order to obtain a good bond between the individual laminations. This material may be satisfactorily formed by pack rolling a number of superimposed sheets of metal corresponding to the number of laminations desired in the coating metal. Any number of laminations may be used, but for most purposes coatings containing about 3 to 8 layers are preferred.

To produce the coating metal by pack rolling, the desired number of sheets of the aluminous metal selected are stacked one upon the other and secured together by some suitable means. It is necessary to prevent relative movement of the sheets with respect to each other during the rolling operation in order to obtain a satisfactory bonding of the sheets. The pack of sheets is preferably hot rolled at a temperature of about 700° F. until its thickness has been reduced about 75 per cent. It may then be cold rolled to the desired gauge. It has been found desirable that during the hot rolling the reduction in thickness at each roll pass be relatively large in order to obtain good bonding. Satisfactory results may be obtained with reductions of 12½ per cent or more for each roll pass. There is produced a sheet metal consisting of a plurality of extremely thin laminations intimately bonded into an integral material. The formation of the laminated coating metal may be effected in this manner, whether or not the metal sheets used in forming it are oxide-coated, either naturally or artificially. When oxide-coated sheets are used in forming the laminated coating metal, the oxide coating, being relatively inelastic, is broken up by the rolling operation to form the discontinuous layer of small particles of aluminum oxide, between which particles metal bonds are formed from lamination to lamination.

When the laminated coating metal is to be formed from oxide-coated aluminum sheets, the oxide coating may be either a natural oxide coating, such as is formed on a clean aluminum surface by exposure to the atmosphere, or it may be an artificial oxide coating formed by any of the methods known in the art, such as by anodic oxidation in sulfuric or oxalic or chromic acid electrolytes, or by a simple immersion treatment in an oxidizing solution such as a hot solution of sodium carbonate containing potassium dichromate. The term "aluminum oxide" as used throughout this specification is to be understood therefore to include both aluminum oxide and such other compounds of aluminum as may be formed by such natural or artificial oxidation of aluminum surfaces. In forming the laminated aluminous metal coating having intermediate layers of aluminum oxide, it has been found most convenient, particularly in cases where artificial oxide-coated metal is used, to make up the sheet metal pack for rolling using alternate sheets of coated and uncoated metal. The bonding of the sheets by the rolling process is more readily effected if such a procedure is used.

The base or core metal, that is to say, the layer or body of metal from which these duplex metal articles derive their 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 ductility and workability, the alloys of the type of alloys D, C, and 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.
Q	14 silicon, 2.0 nickel, 1.0 magnesium.
S	6.0 copper, 1.0 tin.
T	7.0 copper, 7.0 nickel, 7.0 silicon.
U	6.0 magnesium, 1.5 nickel, 1.0 manganese.

In forming the duplex metal articles of this invention, any of the known methods of forming such duplex metal articles may be used. One method which we have found particularly satisfactory is to cast the base alloy in molds lined, in whole or in part, with sheets of the laminated coating metal, in the manner described in the United States patent to 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 produce a good bond between the laminated coating metal and the base metal.

The duplex metal articles of our invention may be provided on any one or all exposed surfaces with the protective laminated metal coating. Fig. 1 of the accompanying drawing shows a pack of sheets prior to rolling to form the laminated coating metal; and Fig. 2 shows the laminated coating metal obtained after rolling showing the reduction in thickness of the individual layers of metal as well as the total reduction in thickness from that of the original pack. Fig. 3 shows a completed duplex metal comprising a base 1 of an aluminum structural alloy provided on its top surface with a protective coating 2 of laminated metal.

We claim:

1. A corrosion-resistant duplex metal article consisting of an aluminous metal base provided with a laminated coating consisting of a plurality of intimately bonded layers of worked aluminous metal.

2. A corrosion-resistant duplex metal article consisting of an aluminous metal base provided with a laminated coating consisting of a plurality of intimately bonded layers of worked aluminous metal interspersed with discontinuous layers of aluminum oxide.

3. A corrosion-resistant duplex metal article consisting of an aluminous metal base provided with a laminated metal coating resistant to penetration by pitting comprising a plurality of alternate intimately bonded layers of aluminous metal and aluminum oxide.

4. A corrosion resistant duplex metal article consisting of an aluminous metal base provided with a laminated aluminous metal coating formed of a plurality of extremely thin aluminous metal laminations interspersed with discontinuous layers of aluminum oxide, said coating having the resistance to pitting by corrosion obtained by working together oxide-coated aluminous metal layers sufficiently to establish an intimate bond between said layers.

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