

April 9, 1935.

R. H. BROWN

1,997,165

DUPLEX METAL ARTICLE

Filed Oct. 20, 1933

Fig. 1.

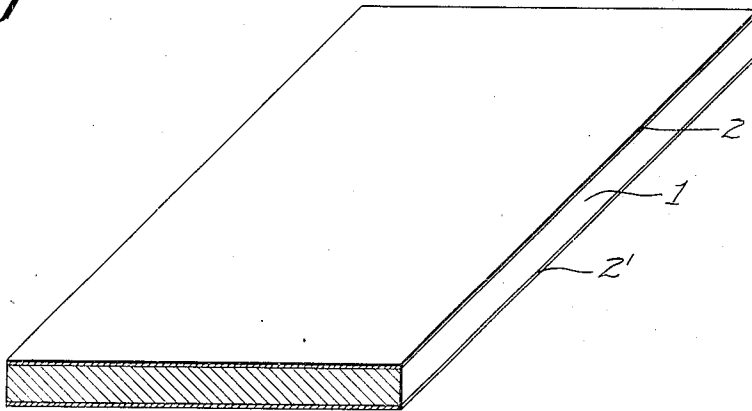
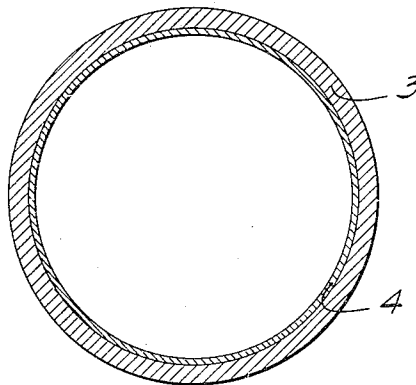


Fig. 2.



INVENTOR
Robert H. Brown
BY

ATTORNEY

UNITED STATES PATENT OFFICE

1,997,165

DUPLEX METAL ARTICLE

Robert H. Brown, New Kensington, Pa., assignor
to Aluminum Company of America, Pittsburgh,
Pa., a corporation of Pennsylvania

Application October 20, 1933, Serial No. 694,444

7 Claims. (Cl. 29—181)

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

It has heretofore been proposed to produce aluminum duplex metals, particularly of the type comprising a core of a strong aluminum alloy, provided with a coating consisting of pure aluminum or an aluminum alloy more resistant to corrosive attack than the core metal. In some cases, however, such duplex metals possess the disadvantage that at any point where the core material is exposed in contact with the coating metal, as for example along a cut edge of the material, or where the coating has been perforated, an electrolytic type of corrosion is set up which causes a preferential attack of the base metal with a consequent impairment of one or another of the structural properties, for example strength, elongation, or yield point, which such materials are designed to preserve. This preferential or selective attack on the core metal can occur when the core metal has an electrode potential greater than that of the coating metal, whereby voltaic action may be set up between the two metals in contact with the corroding medium, thus causing a flow of current which tends to dissolve the core metal. This type of corrosive action has militated seriously against the use of aluminum and certain of the aluminum alloys as a core or base metal for duplex metal articles.

It is an object of this invention to provide a duplex metal article consisting of an aluminum or an aluminum alloy base and a coating of an alloy consisting substantially of aluminum, in which galvanic attack will be directed to the coating alloy in preference to the underlying base metal. Another object of the invention is to provide a duplex metal article in which the base metal is aluminum or aluminum alloy and the coating is an alloy consisting substantially of aluminum but having an electrode potential greater than that of the base metal. Another object is to provide a corrosion-resistant duplex metal article in which aluminum or practically any aluminum alloy may be used as a base metal whereby any desired set of structural properties may be obtained.

The invention is predicated upon my discovery that by the addition of certain metals to aluminum, the electrode potential of the aluminum may be substantially increased without seriously modi-

fying the inherent properties of the aluminum itself, particularly its corrosion resistance. More particularly I have found that by the addition to aluminum of one or more of the class of elements, silver, gallium, bismuth, tin, zinc, platinum, indium, cadmium, calcium, strontium, and barium, an alloy may be obtained having an electrode potential greater than that of most aluminum base alloys while retaining the characteristics inherently valuable in the aluminum when it is used as the coating portion of duplex metal articles of the type described, so that a duplex metal article formed of such an aluminum alloy coating and an aluminum or aluminum base alloy base of the desired structural properties will have substantially improved corrosion-resisting properties, the coating being attacked in preference to the base metal when exposed to corrosive agents in electrolytic contact therewith.

The class of elements above defined, namely, silver, gallium, bismuth, tin, zinc, platinum, indium, cadmium, calcium, strontium, and barium, are all possessed, in this connection, of the common characteristic of raising the electrode potential of the aluminum with which they are alloyed, but the reason why this particular group should have this particular effect is not entirely clear since as will be immediately noted these elements do not belong to any periodic classification nor do they lie in any given position with respect to aluminum in the electromotive force series of metals. These metals raise the electrode potential of the aluminum in varying degree depending first upon the particular metal or metals used and, second, upon the particular amounts which may be added to the aluminum. The choice of the proper aluminum alloy to be used as the coating material in combination with a base of any given aluminous metal depends upon a predetermined knowledge of the electrode potential of the base metal in question. The coating aluminum alloy containing one or more of the class of metals above described should have an electrode potential greater than that of the base metal. These different potentials are readily measured, in accordance with methods long known to the art, against a standard electrode. If the potential of the coating metal is electro-negative with respect to the standard electrode, it is not necessary that the base metal be electro-positive with respect to the standard electrode but only that the base metal be less electronegative than the coating metal in order to be satisfactory for the purpose of my invention. There-

fore, throughout this specification and claims when I say that the electrode potential of the coating metal should be higher than that of the base metal, I mean that the coating metal 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 base metal and that of the coating metal, and substantial protection may be given any base metal by a coating metal of higher electrode potential, it is generally desirable that there be a relatively wide difference in the electrode potential of the two metals, since I have found that with greater differences in potential there usually occurs less attack on the base metal, and by suitable adjustment of the potential difference I have been able to afford the base metal complete protection.

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 aluminous metal 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 tenth normal potassium chloride solution saturated with mercurous chloride.

The addition of one or more of the metals of the class above described to the aluminum for the purpose of forming the coating alloy may be made in any amount necessary to attain the desired electrode potential, so long as other desirable properties of the aluminum itself are not materially impaired, and likewise other elements not deleteriously affecting the desired potential properties and other desirable characteristics of the aluminum may be added. In general the following amounts of the metals of the class above described best serve the general purposes of this invention in producing the electrode potential desired without materially impairing other desirable properties of the aluminum alloy coating:

Metal	Percent by weight in coating metal	Preferred percent by weight in coating metal
Silver.....	0.02 to 2.0	0.05 to 0.1
Cadmium.....	0.05 to 5.0	0.2 to 1.0
Platinum.....	0.02 to 2.0	0.05 to 0.1
Calcium.....	0.1 to 1.0	0.1 to 0.5
Barium.....	0.1 to 2.0	0.2 to 0.8
Strontium.....	0.1 to 1.0	0.1 to 0.5
Gallium.....	0.02 to 2.0	0.05 to 0.1
Indium.....	0.02 to 2.0	0.05 to 0.1
Bismuth.....	0.02 to 1.0	0.05 to 0.1
Tin.....	0.02 to 0.5	0.02 to 0.1
Zinc.....	0.2 to 10.0	1.0 to 3.0

The base or core metal, that is to say the layer or body of metal from which the duplex metal article of my invention derives its principal structural properties, may be any aluminous metal 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 and workability, alloys of the type of alloys D, E, 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 article of my invention, 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 coating alloy, 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 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 coating and base metal. Duplex material may also be produced by spraying or otherwise placing a coating alloy on the base metal. This method may be used to advantage where irregular shapes such as castings are to be coated.

The duplex articles of my invention may be provided on any one or all exposed surfaces with the protective coating alloy, as for example are shown in Figs. 1 and 2 of the drawing. Fig. 1 shows a duplex article comprising a base 1 of an aluminum structural alloy provided on its top and bottom surfaces with an aluminum alloy coating 2 and 2'. In Fig. 2 is shown in cross section a duplex article in tubular form comprising the base 3 of an aluminum structural alloy provided on its inner surface with an aluminum coating alloy 4. This type of material is useful, for example, in the manufacture of pipes used to conduct a material corrosive to the structural alloy.

I claim:

1. A duplex metal article consisting of a base of aluminous metal provided with a coating of an alloy 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, the alloy of the coating having an electrode potential higher than that of the base metal as determined by reference to a standard electrode.

2. A duplex metal article consisting of a base of aluminous metal provided with a coating of an alloy consisting predominantly of aluminum and at least one of the class of metals silver, cadmium, platinum, calcium, barium, strontium, gallium, indium, bismuth, tin, and lead, in the following proportions: silver 0.02 to 2.0 per cent, cadmium

0.05 to 5.0 per cent, zinc 0.2 to 10.0 per cent, platinum 0.02 to 2.0 per cent, calcium 0.1 to 1.0 per cent, barium 0.1 to 2.0 per cent, strontium 0.1 to 1.0 per cent, gallium 0.02 to 2.0 per cent, indium 0.02 to 2.0 per cent, bismuth 0.02 to 1.0 per cent, tin 0.02 to 0.5 per cent; the alloy of the coating having an electrode potential higher than that of the base metal as determined by reference to a standard electrode.

3. A duplex metal article consisting of a base of aluminous metal provided with a coating of an alloy 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, the alloy of the coating having an electrode potential higher than that of substantially pure aluminum and higher than that of the base metal as determined by reference to a standard electrode.

4. A duplex metal article consisting of a base of aluminous metal having an electrode potential at least equal to that of substantially pure aluminum provided with a coating 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, the alloy of the coating having an electrode potential higher than that of the base metal as determined by reference to a standard electrode.

5. A duplex metal article consisting of a base of aluminous metal substantially free from copper provided with a coating of an alloy consist-

ing predominantly of aluminum and at least one of the class of metals silver, cadmium, zinc, platinum, calcium, barium, strontium, gallium, indium, bismuth, and tin, the alloy of the coating having an electrode potential higher than that of substantially pure aluminum and higher than that of the base metal as determined by reference to a standard electrode.

6. A duplex metal article consisting of a base of aluminous metal provided with a coating of an alloy 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, the alloy of the coating being substantially free from copper and having an electrode potential higher than that of substantially pure aluminum and higher than that of the base metal as determined by reference to a standard electrode.

7. A duplex metal article consisting of a base of aluminous metal substantially free from copper provided with a coating of an alloy 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, the alloy of the coating being substantially free from copper and having an electrode potential higher than that of substantially pure aluminum and higher than that of the base metal as determined by reference to a standard electrode.

ROBERT H. BROWN.