Aug. 20, 1935. R. H. BROWN ET AL 2,011,613

MAGNESIUM DUPLEX METAL

Filed Oct. 6, 1934

Fig. 1.

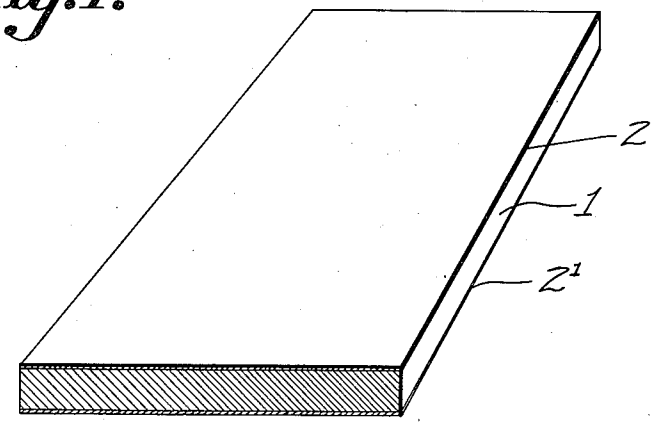
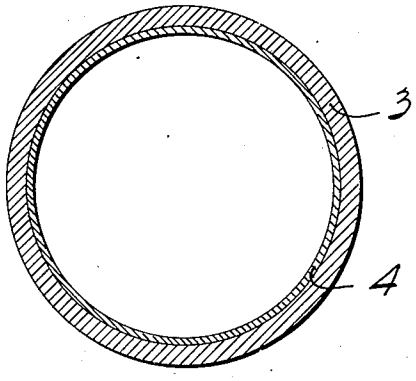


Fig. 2.



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MAGNESIUM DUPLEX METAL

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7 Claims. (Cl. 29—181)

This invention relates to duplex metal articles and is particularly concerned with the production of improved duplex metals comprising a base of magnesium alloy provided on one or more of its surfaces with a coating of a magnesium metal (magnesium or magnesium alloy).

The commercial application of magnesium base alloy sheet and tubing has been considerably restricted because of their relatively low resistance to corrosion, particularly in salt atmospheres. Various types of paint and chemical coatings have been used to overcome this difficulty. Coatings of more corrosion resistant metals, such as zinc and aluminum, have also been suggested for this purpose. These coatings have not, however, provided entirely satisfactory protection, particularly under severe corrosion conditions, such as in the presence of chloride solutions. The protection afforded the magnesium base metal by such coatings is a purely mechanical protection which prevents contact of the corrosion medium with the base metal. Consequently, at any point where the corrosion medium penetrates the coating, the corrosion of the magnesium base metal may proceed unrestricted under the coating. In such case the structural properties of the article may be substantially impaired, thus creating an undesirable and at times dangerous condition where the utility of the article is dependent upon the retention of its structural properties.

This difficulty is particularly pronounced in duplex metal articles having a magnesium alloy base provided with a coating of a more corrosion resistant metal, such as aluminum or zinc. It has been found that at any point where the magnesium alloy base metal 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 and accelerated corrosion of the magnesium alloy base metal. This preferential or selective attack of the core metal results from the fact that the core metal has an electrode potential greater than that of the coating metal, whereby galvanic action is 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.

It is a primary object of this invention to provide a duplex metal article consisting of a magnesium alloy base and a metallic coating in which the magnesium alloy base has an electrode potential lower than that of the coating metal, so that in addition to the mechanical type of protection afforded by the coating metal, the selective attack of the base metal exposed to the corroding medium in contact with the coating metal is eliminated. More particularly it is an object of this invention to provide a duplex metal article in which the coating metal is magnesium or a magnesium base alloy and the base metal is a magnesium base alloy having an electrode potential less than that of the magnesium metal coating. Another object of this invention is to provide a method for the production of a duplex metal article of improved corrosion resistance consisting of a magnesium alloy base provided with a coating consisting of magnesium or a magnesium alloy having an electrode potential greater than that of the magnesium alloy base.

This invention is based upon the discovery that certain metals have the property, when incorporated in magnesium or a magnesium base alloy, of producing a magnesium alloy of lower electrode potential than the magnesium or magnesium alloy to which it has been added. More particularly we have found that by the addition to magnesium or a magnesium alloy of one or more of the class of metals comprising sodium, potassium, barium, calcium, tin, aluminum, zinc, lithium, cadmium, manganese, copper, strontium, bismuth, silver, cobalt, nickel and silicon, an alloy may be obtained having a lower electrode potential without deleteriously modifying the other properties of the alloy, which recommend it as a base metal for a duplex metal article. Thus a duplex metal article may be formed of such magnesium alloy base and a magnesium or magnesium alloy coating which 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, thus preventing direct corrosive attack on the base metal and preserving its structural properties.

While these elements have the common property of lowering the electrode potential of magnesium and magnesium alloys, they do so in varying degrees, depending upon the particular metal or metals used, as well as upon the amount in which they are used. The addition of these elements may be made in any amount necessary to obtain the desired electrode potential in the base metal, so long as other properties of the base metal are not deleteriously affected. The other elements of the base metal should be such as will not prevent the action of these metals in lowering the electrode potential, as, for example,

by combining with them to form intermetallic compounds which may not have the property of lowering the electrode potential of the magnesium alloy.

The choice of the proper alloys to be used in combination in forming the duplex metal articles of our invention depends upon a predetermined knowledge of the electrode potential of magnesium and its various alloys. These different potentials are readily measured in accordance with the methods long known in the art against a standard electrode. If the electrode potential of the magnesium metal coating is electronegative with respect to the standard electrode, it is not necessary that the magnesium alloy base be electropositive with respect to the standard electrode but only that the coating metal be more electronegative than the base metal. Therefore, throughout this specification and the appended claims, when it is said that the electrode potential of the base metal should be lower than that of the coating metal, it is meant that the base metal should be less electronegative with respect to the standard electrode than is the coating metal.

While no fixed potential difference is required between the magnesium alloy base and the coating metal, it is desirable that there be a relatively wide difference in the electrode potential of the two layers, since with greater differences in electrode potential there usually occurs less attack on the magnesium alloy base, and by suitable adjustment of the potential difference it is possible to afford the base metal substantially complete protection. Care should be taken, however, not to make the difference in electrode potential between the coating metal and the alloy base so great that the electrolytic action is unnecessarily accelerated, since excessive attack of the coating metal will then take place. Duplex metal articles in which the coating metal has an electrode potential of the order of 0.01 to 0.1 volts greater than the electrode potential of the magnesium alloy base are particularly resistant to galvanic corrosive action.

A convenient standard electrode for measuring the potential difference may be readily selected from those now in regular use for similar measurements. For the purpose of this description of the invention, a calomel electrode has been selected as a standard. In measuring the electrode potential in question, the magnesium metal to be tested is made one element of an electrolytic cell; the calomel electrode is made the other element. As electrolyte, a normal solution of sodium chloride containing 0.3 per cent by weight of hydrogen peroxide may be used. 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.

In forming the duplex metal article, any of the known methods of forming such duplex metal articles may be used. One method which we have found particularly useful is to roll together the coating alloy and the base alloy in sheet or slab form. It is satisfactory to cast the base metal in an ingot mold lined with the coating alloy. 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 operation generally tends to improve the bond between the coating metal and the base metal. Duplex material may also be produced by spraying or otherwise placing the coating metal on the base metal. This method may be used to advantage where irregular shapes, such as castings, are to be coated.

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

We claim:

1. A duplex metal article consisting of a base of a magnesium alloy containing at least one of the metals of the class consisting of sodium, potassium, nickel, cobalt, barium, calcium, bismuth, strontium, silver, aluminum, manganese, tin, zinc, copper, lithium, cadmium and silicon, and provided with a coating of a magnesium metal, said magnesium alloy base having an electrode potential lower than that of the magnesium metal coating, as determined by reference to a standard electrode.

2. A duplex metal article consisting of a base of a magnesium alloy containing at least one of the metals of the class consisting of sodium, potassium, nickel, cobalt, barium, calcium, bismuth, strontium, silver, aluminum, manganese, tin, zinc, copper, lithium, cadmium and silicon, and provided with a coating of a magnesium metal, said base having an electrode potential lower than that of the magnesium metal coating and lower than that of magnesium, as determined by reference to standard electrode.

3. A duplex metal article consisting of a base of a magnesium alloy containing at least one of the metals of the class consisting of sodium, potassium, nickel, cobalt, barium, calcium, bismuth, strontium, silver, aluminum, manganese, tin, zinc, copper, lithium, cadmium and silicon, and provided with a coating of magnesium, said base having an electrode potential lower than magnesium, as determined by reference to a standard electrode.

4. A duplex metal article consisting of a base of a magnesium alloy containing at least one of the metals of the class consisting of sodium, potassium, nickel, cobalt, barium, calcium, bismuth, strontium, silver, aluminum, manganese, tin, zinc, copper, lithium, cadmium and silicon, and provided with a coating of a magnesium alloy, said base having an electrode potential lower than that of the magnesium alloy coating, and said magnesium alloy coating having an electrode potential less than that of magnesium, as determined by reference to a standard electrode.

5. A duplex metal article consisting of a base of a magnesium alloy containing at least one of the metals of the class consisting of sodium, potassium, nickel, cobalt, barium, calcium, bismuth, strontium, silver, aluminum, manganese,

tin, zinc, copper, lithium, cadmium and silicon, and provided with a coating of a magnesium alloy, said base having an electrode potential lower than that of the magnesium alloy coating, and said coating having an electrode potential lower than that of magnesium, as determined by reference to a standard electrode.

6. A duplex metal article consisting of a base of a magnesium alloy containing at least one of the metals of the class consisting of sodium, potassium, nickel, cobalt, barium, calcium, bismuth, strontium, silver, aluminum, manganese, tin, zinc, copper, lithium, cadmium and silicon, and provided with a coating of a magnesium metal, said magnesium alloy base having an electrode potential 0.01 to 0.1 volts lower than that of the mgnesium metal coating, as determined by reference to a standard electrode.

7. A method of producing a magnesium duplex metal of improved corrosion resistance comprising incorporating in the magnesium alloy of the base at least one of the metals of the class consisting of sodium, potassium, nickel, cobalt, barium, calcium, bismuth, strontium, silver, aluminum, manganese, tin, zinc, copper, lithium, cadmium and silicon in an amount sufficient to produce a magnesium alloy having an electrode potential about 0.01 to 0.1 volts lower than that of the magnesium coating metal as measured by reference to a standard electrode.

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