July 5, 1938. J. A. NOCK, JR 2,122,535

DUPLEX METAL ARTICLE

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Fig. 1.

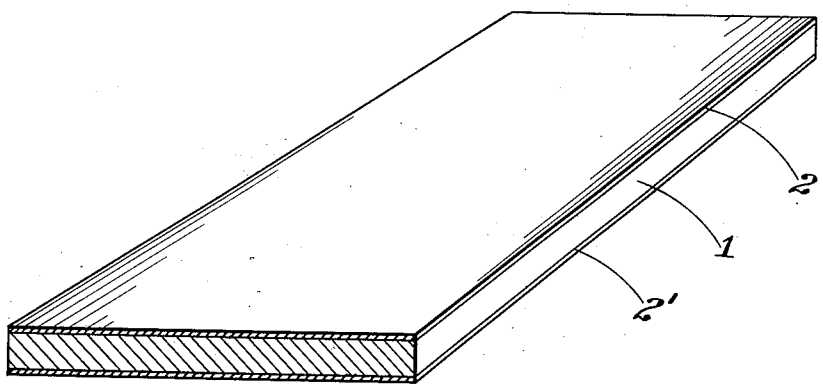
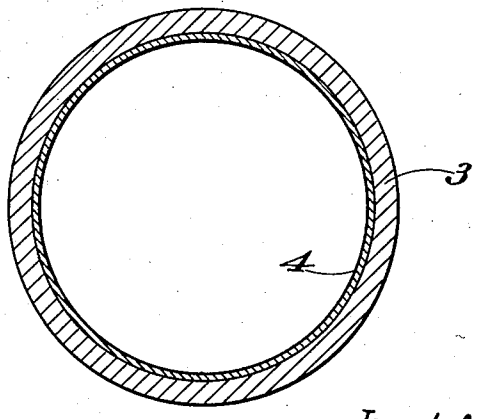


Fig. 2.



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DUPLEX METAL ARTICLE

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6 Claims. (Cl. 148—31)

This invention relates to aluminous duplex metal articles having a thermally treated and precipitation hardened aluminum base alloy as the base or core portion, and a non-precipitation hardened aluminum base alloy as a protective coating.

Solution heat treated and precipitation hardened aluminum base alloys have found a wide field of use because of their relatively high strength and hardness. Alloys of this class which contain from 3 to 5.5 per cent copper, 0.25 to 2 per cent silicon, 0.1 to 1.5 per cent manganese and 0.1 to 1 per cent magnesium are particularly useful where a high yield strength is desired in a wrought product without a subsequent cold working of the material. To attain this high yield strength, these alloys must be hardened by artificial aging rather than by spontaneous aging at room temperatures. This improvement, however, is gained at the expense of a somewhat diminished resistance to corrosion as is to be generally expected in most artificially aged alloys. Hence, in order to utilize the high strength in structures where severe corrosive conditions are encountered it is desirable to provide some surface protection. A very effective method of thus protecting these alloys is to coat them with high purity aluminum in the manner described in U. S. Patent No. 1,865,089. Greater electrolytic protection can be secured by adding certain elements to the aluminum used for the coating material as described in U. S. Patent No. 1,997,165. The undesirable effects of any diffusion of copper from the core alloy into the coating may also be neutralized by the addition of chromium to the coating metal as shown in U. S. Patent No. 1,975,105.

Although the foregoing methods are effective in affording protection to the underlying metal it is still desirable to provide even better protection and thus permit a greater use of the high yield strength alloys under particularly severe corrosive conditions. My invention is directed to providing improved protection for these alloys against corrosive attack.

My invention is predicated upon the discovery that if from 0.05 to 0.5 per cent chromium, and 0.05 to 0.5 per cent cadmium are present in the aluminum alloy coating on a thermally treated core alloy consisting of aluminum, 3 to 5.5 per cent copper, 0.25 to 2 per cent silicon, 0.1 to 1.5 per cent manganese, 0.1 to 1 per cent magnesium, the resulting duplex metal article has a greater resistance to corrosion than if either chromium or cadmium is used alone in the coating alloy. The duplex articles are of course nearly always subjected to a solution heat treatment and artificial aging in order to develop the maximum strength in the core. Since the coating is joined to the core prior to subjecting the article to the aforesaid thermal treatment, the coating is necessarily exposed to the same treatment. However, it does not respond to the treatment in the same manner as the core because of the very limited solid solubility of chromium and cadmium in aluminum. The thermal treatment changes the solution potential of the core, and hence it is desirable to provide a coating having the proper protective qualities to effectively protect the high strength alloy.

The solution and precipitation treatments referred to hereinabove are of the conventional type, namely, an initial heating at 450 to 550° C., followed by a rapid cooling, usually to room temperature, and a reheating to 100 to 200° C. for a long enough time to produce the desired strength in the core alloy. This treatment produces the maximum strength and hardness which is attainable by thermal treatment alone, but the resistance to corrosion is somewhat lower than where the low temperature aging treatment is omitted. The thermal treatment also develops a characteristic internal structure in the core alloy that is easily recognizable under the microscope.

An alloy composition which has proved to be a satisfactory core material for many purposes is one having a nominal content of about 4.4 per cent copper, 0.8 per cent silicon, 0.75 per cent manganese, 0.35 per cent magnesium, and the balance aluminum. The range of composition which is preferred for this type of alloy is as follows: 4 to 4.7 per cent copper, 0.75 to 1.25 per cent silicon, 0.5 to 1 per cent manganese and 0.25 to 0.5 per cent magnesium. Within this range are found the alloys having the most satisfactory combination of mechanical properties, workability and resistance to corrosion.

A coating alloy which has been found to afford satisfactory protection to alloys lying within the aforesaid range of composition is one containing 0.25 per cent chromium and 0.25 per cent cadmium. It is preferred that both the chromium and cadmium contents should lie between 0.2 and 0.4 per cent.

The aluminum to be used in making the coating alloys may be of ordinary purity, that is containing up to 1 per cent of impurities, but for the best results metal of a higher purity containing less than 0.5 per cent iron is desirable. I prefer, however, to limit the total impurities to 0.3 per cent.

Illustrations of the effectiveness of combining chromium and cadmium in the coating alloy are found in the following examples. In each case a core alloy was used which had a nominal composition of 4.4 per cent copper, 0.8 per cent silicon, 0.75 per cent manganese, 0.35 per cent magnesium and the balance aluminum. This alloy was cast in a mold lined with plates of the various compositions indicated below, in accordance with the practice described in U. S. Patent No. 1,865,089. The duplex ingot thus formed was then rolled to sheet 0.017 inch in thickness in the usual manner and given a solution heat treatment at 500° C. followed by quenching and aging at 171° C. for 10 hours. Samples cut from the various duplex sheets were exposed to a severe corrosion test consisting of alternately immersing the specimens in a solution and elevating them above the liquid in 1.5 minute cycles. The aqueous solution employed contained 5.27 per cent by weight of sodium chloride and 0.3 per cent by volume of hydrogen peroxide. After exposing the samples to this corroding medium for 72 hours, they were removed and subjected to the usual tensile tests. The differences in strength and elongation of the duplex material before and after corrosion were compared and the losses expressed in terms of per cent reduction from the original values. The composition of the coating, the original properties and the per cent loss are given in the table below.

Percent composition of coating	Original properties		Percent loss in properties	
	Tensile strength lbs./sq. in.	Percent elongation	Tensile strength	Elongation
Al	64,125	7.8	−60	−96
Al+0.25Cd	59,020	7.0	−24	−89
Al+0.25Cr	61,485	7.7	−17	−87
Al+0.25Cr+0.25Cd	61,855	7.7	−6	−58

From the foregoing tests it will be seen that the combination of chromium and cadmium is more effective in decreasing corrosion losses than either element alone. Not only was the improvement apparent in this respect but it could also be seen in the diminished attack on the surface and along the edges of the specimens.

The duplex articles made in accordance with my invention may be coated on one or more sides with the coating alloy as shown in Figs. 1 and 2 of the accompanying drawing. Fig. 1 shows a duplex article having a base 1 of an alloy capable of being hardened by thermal treatment, and provided on its top and bottom surfaces with an aluminum alloy coating 2 and 2' containing chromium and cadmium. In Fig. 2 is shown a cross section of a duplex article in tubular form having a base 3 of a thermally treated and hardened aluminum base alloy provided with a coating alloy 4 on its inner surface. The latter form of duplex article is useful for pipes carrying certain corrosive liquids or gases.

Having thus described my invention and the manner in which it may be performed,

I claim:

1. A duplex metal article consisting of a core of an aluminum base alloy composed of from 3 to 5.5 per cent copper, 0.25 to 2 per cent silicon, 0.1 to 1.5 per cent manganese, 0.1 to 1 per cent magnesium and the balance aluminum, said core being provided with an aluminum base alloy coating composed of 0.05 to 0.5 per cent chromium, and 0.05 to 0.5 per cent cadmium, the balance being aluminum.

2. A thermally treated duplex metal article consisting of a core of an aluminum base alloy composed of from 3 to 5.5 per cent copper, 0.25 to 2 per cent silicon, 0.1 to 1.5 per cent manganese, 0.1 to 1 per cent magnesium and the balance aluminum, said core being provided with an aluminum base alloy coating composed of 0.05 to 0.5 per cent chromium, 0.05 to 0.5 per cent cadmium, and the balance aluminum, said article being characterized by a structure resulting from a thermal treatment comprising heating said article to between 450 and 550° C., rapidly cooling to substantially room temperature and reheating to 100 to 200° C. for a long enough period to produce the desired strength in the core alloy.

3. A duplex metal article consisting of a core of an aluminum base alloy composed of from 4 to 4.7 per cent copper, 0.75 to 1.25 per cent silicon, 0.5 to 1 per cent manganese, 0.25 to 0.5 per cent magnesium and the balance aluminum, said core being provided with a coating composed of 0.05 to 0.5 per cent chromium, and 0.05 to 0.5 per cent cadmium, the balance being aluminum.

4. A duplex metal article consisting of a core of an aluminum base alloy composed of from 4 to 4.7 per cent copper, 0.75 to 1.25 per cent silicon, 0.5 to 1 per cent manganese, 0.25 to 0.5 per cent magnesium and the balance aluminum, said core being provided with a coating composed of 0.2 to 0.4 per cent chromium, and 0.2 to 0.4 per cent cadmium, the balance being aluminum.

5. A thermally treated duplex metal article consisting of a core of an aluminum base alloy composed of from 3 to 5.5 per cent copper, 0.25 to 2 per cent silicon, 0.1 to 1.5 per cent manganese, 0.1 to 1 per cent magnesium and the balance aluminum, said core being provided with an aluminum base alloy coating composed of 0.2 to 0.4 per cent chromium, 0.2 to 0.4 per cent cadmium, and the balance aluminum, said article being characterized by a structure resulting from a thermal treatment comprising heating said article to between 450 and 550° C., rapidly cooling to substantially room temperature and reheating to 100 to 200° C. for a long enough period to produce the desired strength in the core alloy.

6. A duplex metal article consisting of a core of an aluminum base alloy composed of 4.4 per cent copper, 0.8 per cent silicon, 0.75 per cent manganese, 0.35 per cent magnesium and the balance aluminum, said core being provided with a coating composed of 0.25 per cent chromium and 0.25 per cent cadmium, the balance being aluminum.

JOSEPH A. NOCK, JR.