Aug. 13, 1963 D. G. VANDENBURGH 3,100,581

DUPLEX ALUMINOUS METAL ARTICLE

Filed April 21, 1959

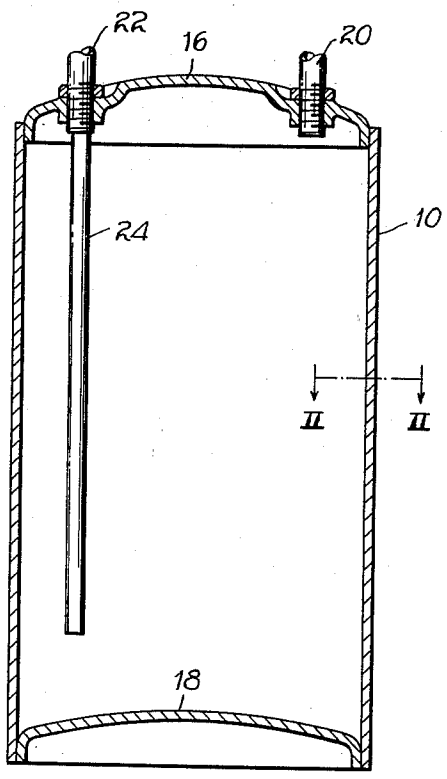


Fig. 1.

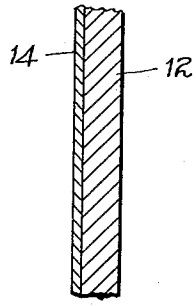


Fig. 2.

INVENTOR
David G. Vandenburgh
BY
ATTORNEY

United States Patent Office 3,100,581 Patented Aug. 13, 1963

3,100,581

DUPLEX ALUMINOUS METAL ARTICLE

David G. Vandenburgh, Lower Burrell, Pa., assignor to Aluminum Company of America, Pittsburgh, Pa., a corporation of Pennsylvania

Filed Apr. 21, 1959, Ser. No. 807,893
6 Claims. (Cl. 220—64)

This invention relates to protecting an aluminous metal member against corrosion by hot water of the type used for domestic and industrial purposes.

Aluminum and aluminum-base alloys have been successfully used for storage tanks and pipes for handling water at ordinary temperatures but some alloys have exhibited unexpectedly large amounts of corrosion in systems carrying water at temperatures above 140° F. The hot water appears to alter the surface of these alloys and render them more susceptible to corrosion. According to the electrochemical theory of corrosion some particles in an aluminum base alloy may have a higher electrode potential than the surrounding metal thereby creating a minute galvanic cell, the current flowing from the anodic or higher potential component to the surrounding lower potential or cathodic areas in the presence of an electrolyte such as water. Exposure to hot water at temperatures above 140° F. appears to increase the difference in potential between the particles and the matrix.

One very effective means of protecting an aluminum base alloy structural member against corrosion is to clad it with a thin layer of a different aluminum alloy which has a higher electrode potential, i.e., one which is anodic to the alloy constituting the structural member. Thus where both portions of the duplex articles are exposed to a corroding medium, the cladding, which is anodic is attacked preferentially, and is gradually consumed, thereby substantially preventing attack of the cathodic structural or core member. Electrolytic protection of this character is particularly beneficial at the edges of a sheet or where the cladding becomes perforated in service and exposes the base or core metal. It has been found, however, that some conventional cladding alloys are less effective in the presence of hot water than would have been expected from their behavior in contact with water at room temperature. This failure of the cladding to adequately protect the base or core metal is manifested in those spots where the cladding is perforated and instead of preventing penetration of the base member by lateral enlargement of the opening, as would normally be expected, the pit becomes deeper. Such pitting or penetration of the base or core portion of a hot water pipe or tank wall is, of course, undesirable since in extreme cases it may weaken the wall and even result in perforation. The explanation of this behavior seems to be that the cladding fails to prevent the core alloy from becoming anodic in hot water.

One of the problems encountered in tank construction in addition to resistance to corrosion is that of providing a strong but inexpensive alloy. An aluminum-magnesium-manganese type alloy in the cold rolled condition meets the strength requirements for many purposes but under severe corrosive conditions a cladding is necessary which is anodic to the structural alloy. A commercial duplex product has been available that consists of a core or base having a commercial composition of 1% magnesium, 1.2% manganese and balance aluminum and a cladding of an alloy nominally consisting of 1% zinc and balance aluminum containing 0.4 to 0.7% impurities. This product has given satisfactory service in many geographical locations for handling domestic and industrial hot water, but it has not offered satisfactory service in other areas because of excessive corrosion. In addition, it has not possessed the desired level of strength for some structures. To overcome this disadvantage it has been proposed that a base composition be employed consisting essentially of 2 to 4% magnesium, 0.5 to 1% manganese and balance aluminum. Such an alloy in the cold rolled condition has a typical tensile strength of 44,000 p.s.i. and a yield strength of 35,000 p.s.i., which is considerably higher than the strength values for commercial products referred to above.

The new and stronger alloy has created a problem in cathodic protection because the cladding used on the commercial product does not provide adequate protection. In order to obtain the structural benefits of such an alloy a different cladding must be employed and having a higher electrode potential than the commercial cladding referred to above.

It is an object of this invention to provide a duplex aluminous metal article which possesses a superior resistance to corrosion by hot water under severe conditions.

A particular object is to provide a duplex aluminuous metal article that resists penetration of the base or core portion of the article when exposed to the action of hot water.

Another particular object is to provide a duplex aluminous metal article having an aluminum-magnesium-manganese type alloy base that is adequately protected against corrosion by hot water by an aluminum-magnesium-zinc alloy cladding.

Another specific object of the invention is to provide a material for the construction of hot water tanks and pipes that possesses a very high degree of resistance to corrosion by the hot water.

These and other objects and advantages are achieved by employing a high purity aluminum-magnesium-zinc alloy as a cladding on a base or core member composed of an aluminum-magnesium-manganese type of alloy. In this combination the aluminum-magnesium-zinc alloy prevents any reversal of the relative electrode potential of the core alloy in hot water. The superiority of the new duplex article has been demonstrated under extremely adverse conditions such as those encountered where the hot water is acidic and may contain heavy metal salts and deposition of the heavy metal may occur on the aluminous metal surface in contact with the hot water. In referring to hot water, it is to be understood that this means water within the temperature range of about 120 up to 190 or 200° F.

The base or core portion of the duplex article should consist of an aluminum base alloy consisting essentially of aluminum, 2 to 4% by weight of magnesium and 0.5 to 1% by weight manganese. In addition to the magnesium and manganese components, the alloy may also contain 0.1 to 0.5% copper. For the purposes of refining the grain and improving the corrosion resistance it may be advisable to incorporate 0.05 to 0.5% of chromium. The alloy may contain as impurities a maximum of 0.25% iron, 0.25% silicon, 0.25% zinc and

0.2% titanium and the total of all other impurities should not exceed 0.15%.

The cladding or coating layer applied to the foregoing base or core should consist of a high purity aluminum-magnesium-zinc alloy containing from 1 to 4% magnesium and 0.5 to 2% zinc. Although the alloy is useful over the entire range of composition, those in which the magnesium content equals or exceeds the zinc content are preferred in order to gain a high strength product. In respect to the impurities, the iron should not exceed 0.08%, the silicon should not be more than 0.10% and the copper should not be over 0.02%, with a maximum of 0.01% each for manganese, nickel and chromium and 0.02% for titanium. The total of all of these impurities should under no circumstances exceed 0.15% by weight. It is by reason of these very low limits that the alloy is referred to herein as being of a high purity.

The coating or cladding should be metallurgically bonded to the base metal. This can be accomplished in a known manner with heat and pressure by such operations as rolling, pressing, forging or extrusion. These methods of producing the duplex article result in plastic deformation and create a worked condition as distinguished from a cast or unworked condition. For most purposes the coating should have a thickness of about 2 to 20% of the total thickness or cross section of the duplex article, a thickness of from 5 to 10% being preferred. For the manufacture of tanks, pipes or vessels for handling hot water, it is usually desirable to employ a duplex material having a thickness of from 0.025 to 0.25" in thickness. The cladding or coating may be employed on either one or two sides of the duplex article depending upon its ultimate use.

The use of the duplex product in the construction of a hot water tank is illustrated in FIG. 1. The tank has a cylindrical vertical wall portion **10** with end walls or caps **16** and **18** welded or otherwise joined to the top and bottom, respectively, of the cylindrical shell. The cold water inlet tube **24** is suspended in a fitting **22** threaded into a suitable opening or spud in the cap **16** while a shorter tube **20** is provided as the outlet for the hot water, the latter also being threaded or otherwise joined to the cap. The duplex character of the cylindrical wall and top and bottom caps is illustrated in the enlarged view seen in FIG. 2 taken on line II—II of FIG. 1. The base or core **12**, composed of an aluminum-magnesium-manganese type alloy, is clad on the inner surface with a high purity aluminum-magnesium-zinc alloy **14**.

The effectiveness of a high purity cladding in protecting the underlying metal as compared to a low purity cladding is illustrated in the following example.

Panels of duplex sheets, 0.064 inch in thickness were fabricated for tests involving immersion in hot water. The core or base portion of each panel composed 80% of the total thickness, and the cladding on each surface composed 10% of the total thickness. The core consisted of a commercial alloy having a nominal composition of 3% magnesium, 1% manganese and balance aluminum and impurities. The cladding in one case (A) consisted of aluminum, 3.5% magnesium, 1% zinc, and 0.4% total of the impurities iron, silicon, copper, etc., and in the other case (B) the cladding consisted of aluminum, 3.5% magnesium, 1% zinc, and a total of only 0.10% of the same impurities.

The duplex sheets having the A and B claddings were immersed in acidic water (pH of 4.0) at a temperature of 176° F., the test being extended over a period of 35 days. At the end of the test period, the sheets were examined and the nature and depth of any pits were noted. The results of the examination are given below in Table 1:

TABLE I

Corrosion of Sheet Specimens Exposed to Acidic Water

Cladding	Maximum depth of pits-inches	Cladding thickness-inches	Penetration of core-inches
A	0.019	0.006	0.013
B	0.007	0.006	0.001

It is evident that where the pits in the cladding extended to the core there was considerable penetration of the core in the case of the A cladding but substantially no penetration in the B cladding. Moreover, it was observed that the diameter of the pits was larger in the case of the high purity cladding thus indicating more effective protection.

Having thus described my invention and certain embodiments thereof, I claim:

1. A duplex aluminous metal article comprising a base portion composed of an alloy consisting essentially of aluminum, 2 to 4% magnesium and 0.5 to 1% manganese, and a coating bonded to said base that provides electrolytic protection therefor in the presence of hot water, said coating consisting of an alloy of aluminum 1 to 4% magnesium, 0.5 to 2% zinc and containing not more than 0.15% of all impurities, said article characterized by a resistance to corrosion by hot water.

2. A duplex aluminuous metal article according to claim 1 wherein said base portion also contains 0.05 to 0.5% chromium.

3. A duplex aluminous metal article according to claim 1 wherein said base portion also contains 0.1 to 0.5% copper.

4. A duplex aluminous metal article according to claim 1 wherein the magnesium content in said coating equals or exceeds the zinc content.

5. An aluminous metal hot water tank, the walls of which are composed of a duplex metal product comprising a base portion composed of an alloy consisting essentially of aluminum, 2 to 4% magnesium and 0.5 to 1% maganese, and a coating bonded to said base portion on the side forming the inner surface of the tank wall, said coating providing electrolytic protection to the said base portion in the presence of hot water and consisting of an alloy of aluminum, 1 to 4% magnesium, 0.5 to 2% zinc and containing not more than 0.15% of all impurities, said tank wall being characterized by a resistance to corrosion by the hot water contents in said tank.

6. An aluminous metal hot water tank according to claim 5 wherein the magnesium content in said coating equals or exceeds the zinc content.

References Cited in the file of this patent

UNITED STATES PATENTS

1,785,774	Hybinette	Dec. 23, 1930
1,975,105	Keller et al.	Oct. 2, 1934
1,997,165	Brown	Apr. 9, 1935
2,079,786	Beck	May 11, 1937
2,122,535	Nock	July 5, 1938
2,184,693	Beck et al.	Dec. 26, 1939
2,566,138	Osterheld	Aug. 28, 1951

FOREIGN PATENTS

337,558	Great Britain	Nov. 6, 1930
380,152	Great Britain	Sept. 15, 1932
634,492	Great Britain	Mar. 22, 1950

OTHER REFERENCES

Edwards et al.: "Aluminum Industry," vol. II, pp. 780, 781, 1930.