Oct. 2, 1956 R. B. MEARS 2,764,805

DUPLEX METAL ARTICLE

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FIG. 1.

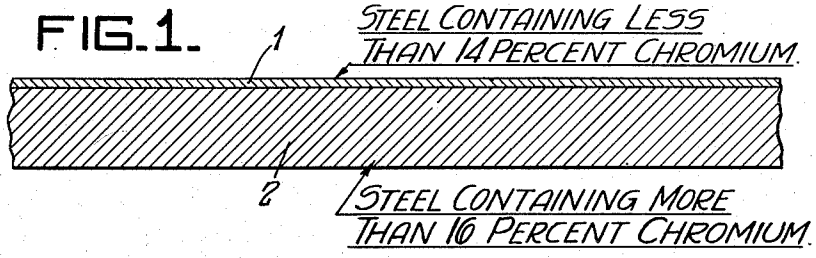
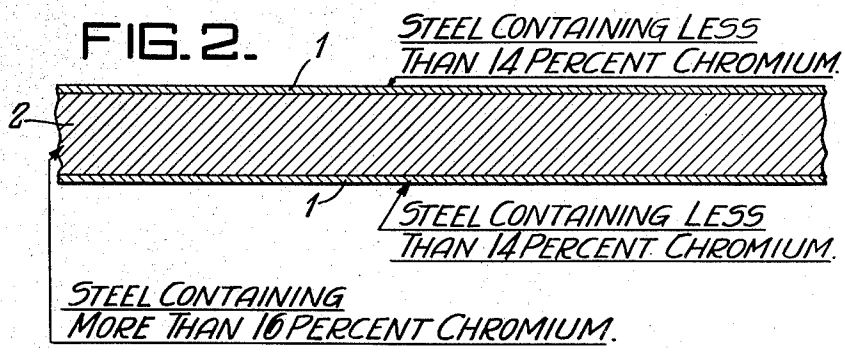


FIG. 2.



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DUPLEX METAL ARTICLE

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2 Claims. (Cl. 29—196.1)

This invention relates to duplex metal articles and in particular to a structural material comprised of a stainless steel clad with a layer of stainless steel of lower chromium content.

Stainless steel alloys containing more than about 16% chromium either with or without nickel and other alloying elements are extremely resistant to corrosion under most conditions. However, when exposed to chloride solutions, e. g., sea water, these alloys are subject to severe localized pitting attack. This susceptibility to putting in chloride solutions is well known to those who have studied the corrosion of stainless steels. The pitting is especially likely to occur at edges, sharp corners, and at areas of the surface which are wholly or partially shielded from oxygen, i. e., the areas of contact at overlapping joints and the spots beneath barnacles or other solid materials in intimate contact with the surface.

Except for this localized attack, the overall corrosion of stainless steels in sea water is negligible. However, the rate of corrosion at pits is very rapid and perforations, necessitating costly repairs, soon develop. Perforation at critical points has resulted in failure of entire structures even though only isolated areas thereof were affected by the corrosion. The tendency to localized attack also increases the susceptibility to stress-corrosion cracking and failure from this cause often occurs before perforation is complete.

The above behavior is characteristic of the stainless steels and has prevented their utilization in marine stills, condensers, channel-buoys and similar structures, uses for which they are otherwise ideally suited.

It is an object of the present invention to provide a new structural material possessing the overall corrosion resistance of stainless steel plus resistance to perforation when exposed in chloride solutions such as sea water and the like.

Another object is to provide a stainless steel article which is more resistant to stress-corrosion cracking than such articles available heretofore.

These and other objects will become apparent from the following specification when read in conjunction with the attached drawings in which:

Figure 1 shows one form of my invention, adapted to service in which only one surface of the article is subjected to the chloride salt solutions; and

Figure 2 shows an alternate form adapted to service wherein both surfaces of the article will be in contact with the corroding medium, as for example, the tubes of a marine still.

As indicated in the drawings the present invention contemplates combining layers of stainless steels of certain specific chromium contents. In general, I have discovered that when a layer 1 of a stainless steel containing less than 14% chromium is superimposed on a layer 2 of stainless steel containing more than 16% chromium, the resulting duplex metal possesses excellent overall corrosion resistance and does not perforate when exposed to solutions containing chloride salts. Any such pitting as may occur is confined to the low chromium layer and furthermore the progress of the pits is arrested at the interface of layers 1 and 2, so that the pits do not become "stress-raisers," consequently stress-corrosion cracking is completely avoided.

To achieve these results the layer 2 must contain not less than 16% chromium and the chromium content of the layer 1 must be sufficiently less than 16% so as to establish this layer as at least 0.1 volt more anodic than layer 2 when immersed in the chloride solution. To achieve this necessary minimum difference in solution potential imposes a maximum of chromium content on layer 1. While this varies somewhat with the composition of the corroding medium, it has been found that layer 1 should never contain more than 14% chromium. Decreasing the chromium content of layer 1 from the aforementioned maximum increases the difference in solution potential of the layers, however, the overall-corrosion resistance of layer 1 also decreases with decreasing chromium content and the layer must contain not less than 4% chromium for this reason. For most conditions of service a chromium content of layer 1 of about 12% has been found to afford an optimum balance between protective effect and overall corrosion resistance.

Increasing the chromium content of layer 2 has negligible effect on difference in solution potential of the layers. However chromium contents higher than 16% are often necessary to achieve other mechanical properties in the duplex. For this reason it is contemplated that layer 2 may contain up to 30% chromium as well as quantities of Ni, Mo, Cu and other alloying elements added for their known effect.

The method of combining the layers 1 and 2 forms no part of the present invention. Any of several known methods may be used. However, the process of cladding in which metal slabs of the required analyses are heated to welding temperature and rolled together to bond the slabs together and form a duplex metal is particularly adapted to my purposes.

As an example of the practices and results of the present invention, a slab of AISI type 304 austenitic stainless steel may be clad on both sides with AISI type 410 and rolled to about ¼ inch plate having a central section containing about 18% chromium, about 0.168 inch thick and outer layers containing 12% chromium, about 0.026 inch thick. The central, 18% chromium, layer of this duplex is unpitted, even at the cut (unclad) edges thereof, after 1100 hours of exposure to aqueous solutions containing as much as 3% sodium chloride plus 2.0% hydrogen peroxide. Some pitting of the 12% chromium layers occurs but the pits terminate at the interfaces of the low and high chromium layers. In contrast, both of the materials of the duplex are deeply pitted and perforated when exposed separately to the above conditions. Similar results are obtained by cladding AISI type 430 with type 410; and by cladding AISI types 310 and 446 with the 12% chromium alloy, clearly indicating that the results are dependent on effects arising from the difference in chromium content of the layers and are relatively independent of the nickel and/or other alloy content thereof.

While the materials in the foregoing examples are commercial alloys, such have been chosen for convenience in describing the invention and the analyses of the layers need not be limited thereto except as previously set forth. The duplex metals of the examples are particularly adapted to service in sea water wherein a cladding of 12% chromium alloy has been found to provide an optimum balance of protection against pitting and overall corrosion resistance. The latter is of particular importance in the construction of, for example, marine stills and

the like wherein contamination of the water or other liquid being treated with ferrous oxides must be avoided. However, as previously mentioned, the cladding alloy must be at least 0.1 volt more anodic than the base or core section, and since the solution potentials vary to some degree with the nature and concentration of the chloride salts of the corroding medium, it is preferable, in the general utilization of my invention, to measure the half-cell potentials of various chromium alloys in the particular solution to be encountered in service, and then select an alloy for the cladding material having sufficiently low chromium content to provide at least the required minimum potential difference. A potential difference of 0.2–0.3 volt anodic is preferred and larger differences should be avoided since the chromium content of the cladding and therefore its overall corrosion resistance is unduly lowered. Moreover larger differences are unnecessary, e. g., type 410 (12% chromium) stainless steel is 0.19 to 0.41 volt anodic to type 304 (18% chromium-8% nickel) stainless steel in an aqueous solution of 3% NaCl and 2% H_2O_2 yet when type 304 stainless steel is clad on one side only with type 410 in accordance with this invention, I have found the unclad side remains unpitted when exposed to sea water and other chloride solutions.

The fact that such remote areas of the high chromium layer are protected also indicates that thickness of the cladding is not critical insofar as the initial protective effect is concerned. Thickness of the cladding, however, governs the permanency of the protection. Thicknesses of the order of 0.02 inch are recommended for most services. In some instances, of course, thinner claddings will give satisfactory service life, while in others, where long life is the basic consideration, a much heavier cladding will be desirable. In all instances the thickness of the base metal (high chromium layer) is dictated by the strength requirements of the article or structure for while the cladding, being itself a structural material, will contribute to the strength of the article, this contribution will vary greatly from point to point on the article during the life thereof since the cladding is corroded and the corrosion is non-uniform i. e., localized as previously explained.

The peroxide-containing sodium-chloride solutions referred to in the foregoing examples are by way of illustration only. Such solutions are considerably more corrosive than ordinary brines and/or sea water, and therefore provide an accelerated test of the materials. The fact that duplex metals of my invention do not perforate in 1100 hours exposure to such solutions indicates a service life of many years in sea water or the like. Further, while my invention and results are described as respects chloride solutions it will be evident to those skilled in the art that similar results will be obtained in aqueous solutions of the other halogen salts, the behavior of the chromium stainless steels in such media being quite similar.

I claim:

1. In manufactures of the class described, laminated structures composed of layers of stainless steel, which manufactures are highly resistant to perforation and stress corrosion cracking when exposed to halogen salt containing solutions and comprise a base layer of stainless steel containing between 16 and 30% chromium and a facing layer of stainless steel bonded thereto and adapted to be directly exposed to the halogen salt containing solution, said facing layer containing about 12% chromium and having a solution potential at least 0.1 volt more anodic than the base layer when immersed in the halogen salt containing solution.

2. In manufactures of the class described, laminated structures composed of layers of stainless steel, which manufactures are highly resistant to perforation and stress corrosion cracking when exposed to halogen salt containing solutions and comprise a base layer of stainless steel containing not less than 16% chromium and a facing layer of stainless steel bonded thereto and adapted to be directly exposed to the halogen salt containing solution, said facing layer containing at least 2% less chromium than the base layer and having a solution potential at least 0.1 volt but not more than about 0.4 volt more anodic than the base layer when immersed in said halogen salt containing solution.

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