Feb. 7, 1933. A. E. MASKREY 1,896,411

CORROSION RESISTANT METAL PLATE AND PROCESS OF MAKING THE SAME

Filed April 3, 1931

Fig. 1.

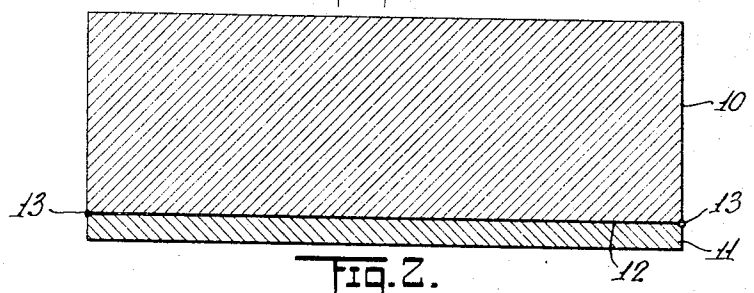


Fig. 2.

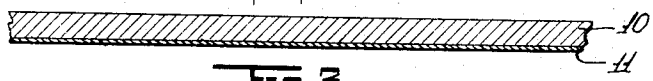


Fig. 3.

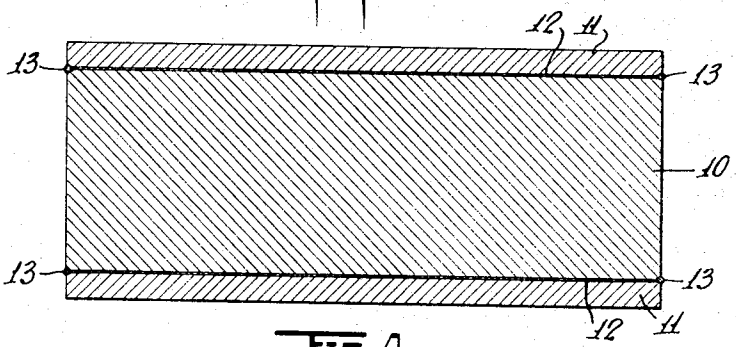


Fig. 4.

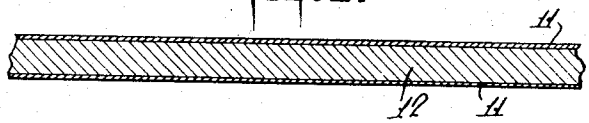


Fig. 5.

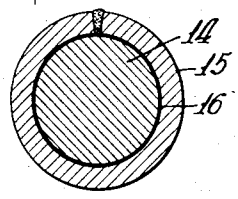


Fig. 6.



Fig. 7.

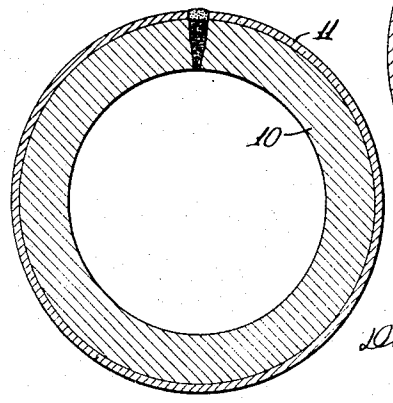
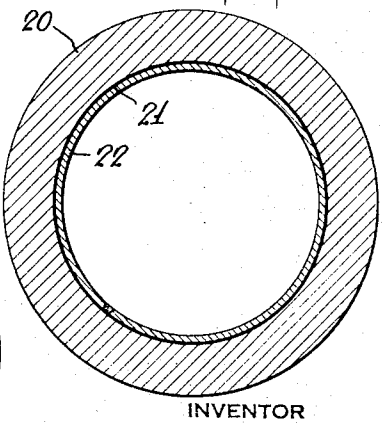


Fig. 8.



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D-37

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UNITED STATES PATENT OFFICE

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CORROSION RESISTANT METAL PLATE AND PROCESS OF MAKING THE SAME

Application filed April 3, 1931. Serial No. 527,610.

It is well known that certain alloys of iron and chromium, such as chrome steel, chrome iron, chrome nickel steel, chrome nickel molybdenum steel, and the like, are highly resistant to the action of acids, alkalies and other corrosive agencies or chemicals in liquid or gaseous form, which have destructive action on ordinary iron or steel. Such alloys are also capable of being highly polished and hardened. Non-corroding alloys of this kind are commonly known as stainless steels. Examples of such alloys are disclosed in the Haynes Patent 1,299,404 and the Brearley Patent 1,197,256.

The Haynes patent above referred to states that such alloys may be used as a facing layer for a body of iron or steel in the manufacture of cooking utensils, evaporating pans and other apparatus. The cost of the alloy as compared to the cost of a mild steel plate or sheet is comparatively high, and the desirability of making up plates and sheets of mild steel with a comparatively thin surface layer of the alloy, has long been recognized, because the steel may furnish the required strength and thickness for the vessel wall, while the surface layer of the alloy will offer the required corrosion resistant characteristics.

In order to produce sheets of any desired thickness depending upon the character of the articles or apparatus to be built or manufactured from such sheets, it has been proposed that the alloy layer be welded to the surface of the mild steel body, and that the composite slab be then rolled down to the desired thickness.

Although this has heretofore been suggested, attempts along that line have not been successful so far as I am advised. The alloy has a different coefficient of expansion from ordinary rolled steel, and a different crystalline or grain structure as well as different ingredients and different relative proportions of ingredients. There is a tendency of the separate layers of the steel and the alloy to separate, and more particularly during cold bending, drawing or other mechanical operations. Due to the strain to which they are subjected during changes in temperature through wide ranges, and also due to other causes there is a tendency of the plates to curl, particularly if rolled comparatively thin.

The main object of my invention is to provide, at low cost, integral composite plates or sheets having a surface layer of a corrosion resistant alloy of the chrome or chrome nickel type, and a mild steel body layer, the composite sheet being so constituted and its parts so firmly and uniformly united, that it may be bent, rolled, drawn, or otherwise treated, without the development of troublesome or destructive internal stresses, and without liability of curling or separating, either during manufacture or subsequently.

I have discovered that this result can be secured by employing a thin intermediate bond sheet of comparatively pure iron.

In the accompanying drawing I have illustrated certain embodiments of my invention. In this drawing

Fig. 1 is a transverse section of a composite slab or bloom before rolling, and having a corrosion resistant layer on one side only.

Fig. 2 is a transverse section of a plate made by rolling down the bloom shown in Fig. 1.

Fig. 3 is a section similar to Fig. 2, but showing the corrosion resistant layers upon opposite sides.

Fig. 4 is a section of the plate made by rolling the slab shown in Fig. 3.

Fig. 5 is a transverse section of a bar having a corrosion resistant jacket.

Fig. 6 is a section of the rod made by drawing down the bar shown in Fig. 5.

Fig. 7 is a transverse section through a tube having a corrosion resistant layer upon the exterior thereof, and

Fig. 8 is a transverse section through a tube having a corrosion resistant layer upon the interior.

In carrying out my invention the meeting surfaces of the steel base, the intermediate iron sheet and the alloy sheet or plate should be free from scale and other surface impurities or foreign matter, and should be comparatively smooth. The three layers are

then pressed tightly together and the edges welded in any suitable manner, for instance, by a torch and welding rod, or electric welding, so as to hold the layers together and to seal the edges so as to prevent the admission of any air between the sheets. The welding also serves to prevent any separation or relative movement during the rolling operation. The composite slab is then heated to the temperature commonly employed in rolling ordinary steel sheets and is passed through ordinary rollers for as many times as is necessary to reduce the sheet to the desired thickness. For instance, the slab may be heated to approximately 2000° to 2250° F., and preferably in the neighborhood of 2100° F. before rolling, and at the end of the rolling operation may be in the neighborhood of 900° F. The initial temperature may be as low as 1800° F., if the pressure be sufficient. It will be noted that this temperature is much below the melting temperature of the compositions of any one of the three individual layers employed in making up the composite slab.

After one or more passes through the rollers the parts will be completely and uniformly welded together throughout the entire area of their contacting surfaces, and further rolling reduces the several layers in thickness, maintaining their relative thicknesses in substantially the same proportions as in the original composite slab. Merely as an example, the steel plate 10, shown in Fig. 1, may be three-quarters of an inch, the chrome alloy sheet 11 may be one-eighth of an inch, and the intermediate iron sheet 12 may be nineteen gauge metal, which is about .042 inch. As another example, the mild steel slab may be six inches thick, the alloy plate three-quarters of an inch thick, and the intermediate plate of iron of twenty gauge. These separate layers are all of uniform thickness and the mild steel slab ordinarily is at least four times the thickness of the alloy plate.

The slab may be rolled down to any desired thickness as shown in Fig. 2, depending upon the articles to be manufactured from the composition plates or sheets, or the uses to which they are to be put.

The intermediate or bond sheet may vary in thickness, depending upon the thickness of the other layers, but is preferably between twenty-four and sixteen gauge. The thinness facilitates quick heating to the required temperature to give the desired bond.

The intermediate sheet may be of the type known as Armco or other commercially pure iron. The carbon content should be much lower than the carbon content of the steel base. For the best results it should be below about .06, and while intermediate sheets higher in carbon can be employed, generally speaking the lower the carbon the better. It is likewise desirable that the intermediate sheet be low in silicon.

One reason for keeping the carbon low in the bond sheet is that with more carbon higher temperatures must be used to effect the welding, and the employment of moderate temperatures is important to avoid injuring these alloys.

A further reason for keeping the carbon content low in the bond sheet is to prevent the formation of undesirable products from the carbon of the steel and one or more ingredients of the alloy.

In order to clean and smooth the surfaces of the individual sheets to be secured together, they may be ground, machined or otherwise treated. The separate sheets may be held together during the marginal welding 13 in any suitable manner, but preferably under pressure so as to exclude air. Although the welding and the thinning down of the slab are preferably by rolling, these, and particularly the welding, may of course be done by hammering or other equivalent operation. In order to insure the substantially complete removal of air from between the layers, a small gap may be left after the marginal welding and suction applied to remove any air from between the layers through the gap, and the gap then sealed off.

If it is desired that the final sheet be corrosion resistant upon both surfaces, the steel base may serve as the intermediate layer of five layers as shown in Fig. 3, two outer alloy sheets 11 and two intermediate comparatively pure iron sheets 12. The composite plate or sheet in its final form as shown in Fig. 4 may be bent cold or formed up in any desired manner in the manufacture of digestors, autoclaves, storage tanks, household boilers, soak drums or the like, or it may be bent to tubular form as shown in Fig. 7 and the edges welded by the use of a torch and welding rod of a corrosion resistant composition suitable for properly welding both the alloy and the mild steel base, or by electric welding with a proper electrode composition.

In rolling the composite slab or body down to the desired thickness the intermediate iron sheet may become so thin as to be invisible upon examining the edge of the composite sheet, but still serve its function. I do not know all of the reasons from a chemical, physical or metallurgical standpoint, as to why this intermediate sheet of low carbon iron permits of the securing of highly satisfactory results in the welding of a chrome alloy sheet to a mild steel base, but I believe that it is due primarily to the fact that chromium has an affinity for carbon and unites therewith to form a chromium carbide which is hard, relatively insoluble in the iron, frag-

ile, and non-workable, by bending, rolling or drawing.

In the ordinary corrosion resistant alloys containing chromium the carbon content is kept down to a very low point to avoid the formation of this chromium carbide in the alloy. If such a chromium containing alloy be applied to a steel sheet or plate and welded thereto by heat and pressure, there is a marked tendency of the chromium to diffuse into the steel where there is no chromium or the chromium content is very low, and a tendency of the carbon of the steel to diffuse into the alloy where the carbon content is lower. The chromium and carbon come together in the welding plane and form chromium carbide. When the final sheet is cold and an attempt is made to draw or bend it the chromium carbide fractures or pulverizes, and such weld as has been formed is destroyed and the layers separate either completely or over substantial areas. By using a bond sheet substantially free of chromium and of very low carbon content the chromium may diffuse into the bond sheet from one side and the carbon diffuse into it from the opposite side, but as such diffusions do not go to any considerable distance at the temperature and during the time of the hot rolling, none or practically none of the chromium and carbon comes together even where the bond sheet is of 19 gauge, and none of the highly undesirable chromium carbide is formed. Furthermore pure ferrite forming the main ingredients of commercially pure iron, is softer and more easily worked than either mild steel or the chromium alloy, and as it may be perfectly welded to both it may accommodate itself to movements of the steel and alloy during the welding of the layers together and during the later cold working, and the strains resulting from differences in expansion and contraction on changes in temperature, do not result in fracture or separation. The desirable and highly advantageous results accomplished by the use of the bond sheet of low carbon iron may be due at least in part to the different character of the crystalline structure of the three layers which permits relative movement of the crystals during the rolling or bending operations, and subsequently under thermal changes, without permitting separation of the parts or curling of the resultant sheets. The slag in the iron bond sheet is also believed to be beneficial.

Although the alloy sheet is preferably an alloy of iron and chromium, or iron, chromium, nickel, etc., other corrosion resistant or non-corrosive metals or alloys might be employed.

Composite sheets of the character above described may be made at far less expense than would be involved in making the entire sheet of the corrosion resistant alloy. The steel provides the desired strength while the surface layer of the alloy in most cases need be only sufficiently thick to prevent liability of being scratched or cut through to expose the steeel which will not resist corrosion.

The base need not be a flat plate, but might be a rod 14 having an outer corrosion resistant layer 15 and an intermediate low carbon iron layer 16 in the form of tubes made by bending the two layers around the rod and welding their edges together to enclose the same, the composite body being welded and drawn down to the desired diameter with heat and pressure. In Fig. 6 I have shown a rod resulting from the drawing down of the body shown in Fig. 5. Likewise, the body or base might be a tube with a corrosion resistant layer of tubular form on the inside or the outside, and with the intermediate flux or bond layer welded together in accordance with the invention. In Fig. 8 I have shown a pierced billet 20 with a thin tube 21 forming the flux sheet, and a corrosion resistant tube 22 telescoped therein. The composite tubular body may be drawn down to decrease its wall thickness and inside and outside diameters, and increase its length in the manner commonly employed in the drawing of seamless tubes. In fact, the bodies produced, as well as the articles of manufacture made therefrom, may be of any shape.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. The process of making a composite sheet, which includes forming a slab by assembling superposed rolled layers of steel and corrosion resistant metal with an intermediate rolled layer of iron, welding together the edges of the sheets or plates, and rolling said slab to the desired thickness.

2. The process of making a composite sheet having a corrosion resistant surface, which includes placing a layer of comparatively pure iron between layers of steel and corrosion resistant metal, welding the layers together at their edges to hold them in predetermined relative positions and to exclude air from between the layers, and subjecting the layers to pressure and heat.

3. The process of making a composite sheet having a corrosion resistant surface, which includes placing a layer of comparatively pure iron between layers of steel and corrosion resistant metal, welding the layers together at their edges to hold them in predetermined relative positions and to exclude air from between the layers, and subjecting the layers to pressure while heated to 1800° to 2200° F.

4. The process of making a composite sheet having a corrosion resistant surface, including assembling a plate of mild steel, a plate of chrome alloy of the acid resistant type, and an intermediate comparatively

thin sheet of commercially pure iron, welding the sheets together at their edges, rolling the slab thus formed at a temperature of 1800° to 2200° F. to weld together the contacting surfaces throughout their areas, and continuing the rolling at lower temperature to reduce the slab to the desired thickness.

5. The process of making a composite sheet which includes forming a slab by superposing layers of steel and a chromium containing alloy of the corrosion resistant type with an intermediate iron layer substantially free of chromium and having a low carbon content, heating said layers, and applying pressure to weld together the contacting surfaces throughout their areas, the intermediate layer serving to substantially prevent union of the chromium of the alloy and the carbon of the steel.

6. The process of making a composite sheet which includes superposing layers of steel and a chromium containing alloy with an intermediate layer of metal substantially free of chromium and having a low carbon content, securing together the edges of the outer layers, and welding together the contacting surfaces throughout their areas by heat and pressure.

7. The process of making a composite sheet which includes forming a slab by superposing a layer essentially of steel and substantially free of chromium, a second layer essentially of iron, but having a lower carbon content than the first mentioned layer and substantially free of chromium, and a third layer essentially of iron and containing at least 8 per cent of chromium, and welding together the contacting surfaces of said layers by heat and pressure.

8. A composite sheet including a base of rolled mild steel, a surface layer of rolled alloy of the corrosion resistant type containing chromium, and a thin intermediate layer of iron having a low carbon content and substantially free of chromium, said base and said layers being welded and permanently bonded together throughout their opposed contacting surfaces, and said intermediate layer serving to substantially prevent the union of the chromium of the alloy and the carbon of the steel by diffusion during said welding.

9. A rolled metal body including a base of rolled mild steel free of chromium, a surface layer of rolled corrosion resistant alloy containing chromium, and an intermediate layer of iron containing not to exceed .06% of carbon and substantially free of chromium, said base and said layers being welded together throughout their opposed contacting surfaces.

10. A rolled metal body including a base of rolled mild steel, a thinner surface layer of rolled, corrosion resistant, chromium containing alloy, and an intermediate still thinner layer of iron having chromium diffused thereinto from one side and carbon diffused thereinto from the opposite side, and substantially free of chromium carbide, each of said layers being of substantially uniform thickness.

11. A rolled metal body including a plurality of layers integrally connected and comprising a layer of rolled steel, a surface layer of rolled corrosion resistant alloy, and an intermediate layer of iron having a low carbon content in the surface portion the steel layer being at least four times the thickness of the alloy layer.

Signed at New York in the county of New York and State of New York this 2nd day of April A. D. 1931.

ALFRED E. MASKREY.