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K. W. McEuen ETAL

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CLADDING OF STEEL PLATES WITH TITANIUM

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Fig. 1.

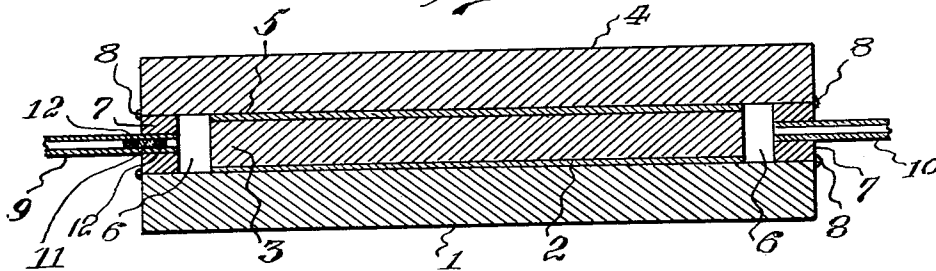


Fig. 2.

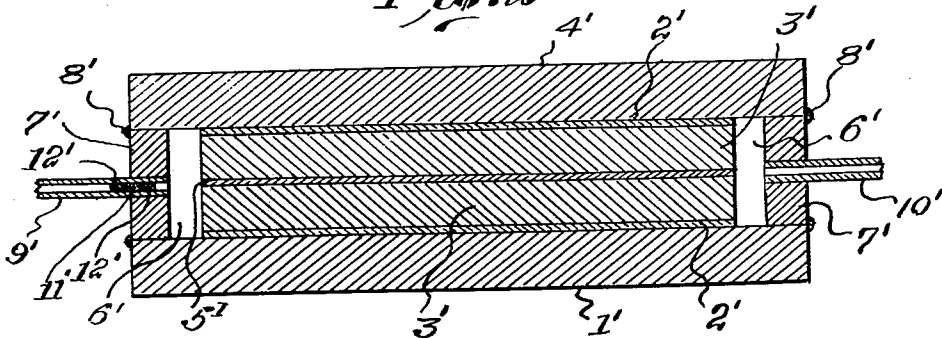
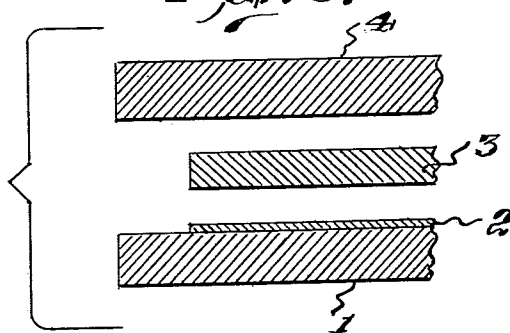


Fig. 3.



INVENTORS.

K. W. McEuen

BY E. M. Smith.

Samuel E. Go

ATTORNEYS.

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CLADDING OF STEEL PLATES WITH TITANIUM

Kenneth W. McEuen, Malvern, and Eugene M. Smith, Coatesville, Pa., assignors to Lukens Steel Company, Coatesville, Pa., a corporation of Pennsylvania
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5 Claims. (Cl. 29—470.9)

This invention relates to the production of composite metal products and, more particularly, to improvements in the cladding of steel plates with titanium.

Metals such as steel clad with titanium have been found to be highly desirable for many uses. However, it has been found that titanium has certain properties which make it difficult to bond to steel by the use of the conventional pack rolling procedures. This difficulty is particularly apparent when the clad product is exposed to a subsequent heating operation, as for example, when it must be welded to another metallic member. The properties of titanium which make it difficult to clad this metal are its affinities for oxygen, nitrogen, hydrogen, water vapor, and carbonaceous gases at temperatures above approximately 1300° F., the high rate of inter-diffusion between titanium and most other metals having melting points compatible with those used in the making of steel, such as copper, nickel, iron, molybdenum and silver, and the existence of brittle inter-metallic compounds in the alloy systems of these metals. The reaction of titanium with most gases which are not inert is not the only source of difficulty in cladding titanium notwithstanding the fact that solution of these gases in titanium results in brittle bonds. Another difficulty experienced in cladding titanium to steel is that diffusion is very rapid between titanium and other metals when they are brought into contact at temperatures of approximately 1300° F. and above. This contact at these temperatures results in the formation of weak and brittle bonds due to the formation of inter-metallic compounds between the bonding metal and the titanium or the steel. Accordingly, it has been found that if an attempt is made to clad steel with titanium by rolling a pack of these metals in the usual manner, a weak alloy will form somewhere in the diffusion zone between the titanium and steel during the rolling or heating of the pack, and an unsatisfactory bond will result.

After much experimental work, we have found that strong and ductile bonds between titanium and steel separated by an interlayer of nickel can be made if the nickel is bonded to the steel, as by plating, and the titanium plate is applied directly to the nickel layer or plating. The bonds between titanium and nickel plated backing steel have been found to possess the highest mechanical properties and to be superior to bonds obtained between titanium and uncoated low carbon steel, titanium and chromium plated steel, titanium and chromium-iron alloys containing 11.5% to 35% chromium, and titanium and nickel-chromium-molybdenum stainless steel in shear strength and bend ductility.

The atmosphere inside the pack must be free of oxygen, nitrogen, hydrogen and water vapor to promote a good bond and to prevent the embrittlement of the titanium layer by these gases. The pack is flushed during the heating period with argon, helium or other inert gas. The gas is purified by passing it through a section of titanium sponge mounted in the gas inlet pipe and heated in the range of 1600° F. to 1800° F., and it has been found that this practice resulted in a larger yield of bonded area than previously obtained.

The diffusion of iron, chromium and nickel into titanium results in the formation of inter-metallic compounds of these metals with titanium, and these compounds make the

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bonds weak and brittle. In the case of titanium and nickel plated steel, such as disclosed in this application, such diffusion can be minimized by limiting the heating of the pack to a temperature of 1700° F. for thirty minutes or 1600° F. for one hour. It has been found that even if bonds made according to our method contain minor amounts of inter-metallic compounds, they are capable of withstanding reheating to 1400° F. for periods up to two hours without decreasing their strength or ductility. Parting compounds commonly used in stainless steel packs are satisfactory for titanium, and roll bonding of this metal to nickel plated steel within the range of 1600° F. to 1700° F. is practicable.

The principal object of this invention is the provision of novel improvements in the cladding of other metals with titanium.

A further object is the provision of improved procedures for satisfactorily cladding steel with titanium.

Other objects will appear hereinafter throughout the specification.

Referring to the drawing:

FIGURE 1 is a sectional view of one form of pack in which a single titanium clad steel plate is made.

FIGURE 2 is a view similar to FIGURE 1 but showing a pack from which a pair of titanium clad steel plates are made, and

FIGURE 3 is an exploded fragmentary view of the plates of FIGURE 1 before they are assembled but after the base plate has been plated.

In FIGURES 1 and 3 of the drawing, 1 indicates a rectangular steel base plate which has a coating 2 of nickel plated on its upper face. Mounted on the nickel plated face of the base plate is a rectangular titanium plate 3 which is separated from the rectangular steel cover plate 4 by a layer of parting compound 5. As clearly shown in FIGURE 1, the edges of the plate 3 terminate short of the corresponding edges of the plates 1 and 4 to provide spaces 6 for spacer bars 7 which are mounted between the edge portions of the plates 1 and 4 on all four sides of the pack. As indicated in FIGURE 1, the bars 7 do not completely fill the spaces 6 to provide gas passages through the pack when the plates and spacer bars have been completely assembled, and the pack welded as indicated at 8. The welds 8 serve to seal hermetically the periphery of the pack. Mounted at each of two opposite sides of the pack and in communication with the peripheral space is a pipe, the pipe 9 being an inlet pipe for gas and the pipe 10 a gas outlet. By this arrangement of the pipes 9 and 10 an inert gas may be passed through the pack, as desired. In order to purify thoroughly the gas passed through the pack, a portion of the inlet pipe adjacent the pack is provided with a quantity of titanium or other active metal sponge or porous mass 11 held in place by plugs 12 of stainless steel wool and heated to a temperature of 1500° F. to 1800° F. If the gas is not sufficiently pure, it has been found that there is a tendency for the impurities therein to react with the titanium insert and the nickel plated steel plate causing them to tarnish.

After the pack has been flushed by the gas, it is charged into a preheated furnace, heated in the range of 1400° F. to 1800° F. until uniform in temperature and then compressed by pressing. While pressing is preferred, rolling may also be used. The reduction in thickness may vary from 7% to 50% or more.

It has been found that titanium clad steel plate withstood bending 180° at room temperatures over a radius of approximately one and one-half times its thickness. Bends were made in which the titanium layer was in tension, and others with the titanium in compression, and still others with the bond zone in shear.

While the plates used to make up the pack have been

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described as being rectangular in shape, it will be understood that any suitable shape of plate may be used.

In the pack of FIGURE 2, the steel base plate 1', the nickel plating 2', the titanium plate 3', and the parting material 5' are the same as in FIGURE 1, but a second layer of nickel plating 2' has been added to the cover plate 4', and a second titanium plate 3' has been placed between the nickel plating on the plate 4' and the parting material 5'. By using this method, two clad steel plates may be formed at the same time. Otherwise, this pack is substantially the same as that of FIGURE 1 in that it shows a space 6' around the titanium plates and the spacing and sealing bars 7' secured to the base and cover plates by the welds 8'. As in FIGURE 1, the pack is provided with an inlet pipe 9' and the outlet pipe 10', the inlet pipe being provided with a titanium sponge section 11', and holding plugs 12' of steel wool to maintain the sponge in place.

The above description and drawings disclose two embodiments of the invention, and specific language has been employed in describing the figures. It will, nevertheless, be understood that no limitations of the scope of the invention are thereby contemplated, and that various alterations and modifications may be made as would occur to one skilled in the art to which the invention relates.

We claim:

1. A process for producing a composite metal pack including a metallic base plate, a titanium cladding plate and a cover plate which comprises bonding a coating of nickel on the upper face of the base plate, placing a plate of titanium on said coating, applying a parting material to the upper surface of said titanium plate, placing a cover plate over and in contact with said parting material, hermetically sealing the peripheral edges of said pack, providing the interior of said pack with an inlet means and an outlet means, filling a part of said inlet

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means with an active metal porous mass, heating the mass in said inlet means to a temperature of between 1500° F.-1800° F., then flushing the pack with a gas which is inert to said titanium plate when heated to thereby heat said pack to a temperature range of from 1400° F. to 1800° F., compressing said pack to reduce the thickness of the pack and to bond the plates to each other except those which are separated by said parting material.

2. A process as defined in claim 1, wherein said base plate is made of steel, and said coating of nickel is plated on said base plate.

3. A process as defined in claim 2, wherein said cover plate is steel, and said metallic mass in said inlet means is a titanium sponge.

4. A process as defined in claim 3, wherein said gas is argon, and said inlet means and said outlet means are formed as pipes.

5. A process as defined in claim 3, wherein said pack is reduced in thickness by the compressing step from 7% to 50%.

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