

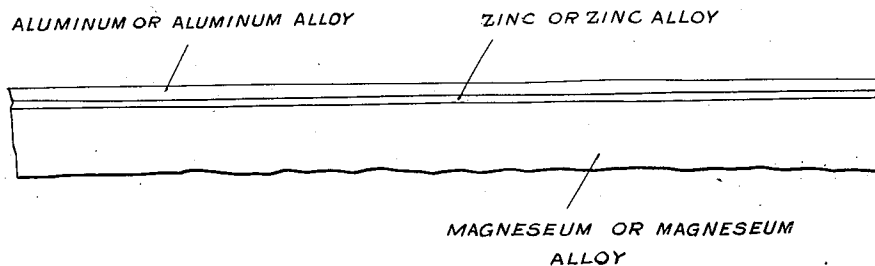
Nov. 10, 1942.

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2,301,332

ALUMINUM CLAD MAGNESIUM AND METHOD OF MAKING SAME

Filed April 26, 1940



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UNITED STATES PATENT OFFICE

2,301,332

ALUMINUM CLAD MAGNESIUM AND
METHOD OF MAKING SAME

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Application April 26, 1940, Serial No. 331,895

15 Claims. (Cl. 29—189)

This invention relates to the production of composite bodies of magnesium and aluminum.

A composite body composed of laminations of magnesium and aluminum is possessed of numerous important advantages in the electrical, mechanical and chemical arts, because of the relative and diverse characteristics possessed by aluminum and magnesium which particularly fit them for use as coating and core metals in composite metal structures. Thus aluminum is more resistant to galvanic action than magnesium and tends to preserve itself at the expense of magnesium; magnesium has a substantially lower specific gravity than aluminum, and therefore where lighter weight per unit of cross-sectional area or greater stiffness and strength per unit of the cross-sectional weight are desirable magnesium is a highly desirable body material, but magnesium corrodes easily and chemical treatments to render it resistant to corrosion increase the cost and impair some of the desirable characteristics of magnesium; while both metals are strong and have similar melting temperatures, coefficients of expansion and contraction, etc., aluminum has higher electrical and thermal conductivity, greater reflectivity, is more resistant to abrasion, chemical reaction, corrosion, etc.

The bonding of magnesium to aluminum presents grave practical difficulties. The high surface tension, tenacity and resistance to rupture of aluminum and magnesium oxide films, existing on aluminum and magnesium in the presence of air, render difficult the adhesion of magnesium to aluminum even though an effort be made to roll the two together under relatively high pressures and at elevated temperatures because of the difficulty of breaking through these tenacious oxide films. Furthermore when aluminum and magnesium are permitted to unite, by dispersion or otherwise, they form very brittle compounds, in fact so brittle that some of them will shatter like glass, while such compounds or mixtures are so hard as to make extremely difficult, if not impossible, the rolling down to thin sheets, foils and the like of layers of aluminum and magnesium united by an aluminum-magnesium bond.

It is an object of this invention to provide an improved method whereby magnesium may be satisfactorily used for the fabrication of a wide variety of articles where weight is important.

Another object of this invention is to provide an improved method whereby magnesium may be suitably protected against corrosion.

Another object of this invention is to provide an improved method whereby the rolling of mag-

nesium is facilitated and a greater variety of lubricants may be used.

Another object of this invention is to produce laminated magnesium and aluminum by a procedure which assures a substantially uniform bond throughout the contiguous surfaces of the laminations without establishing a hard or brittle aluminum-magnesium bond between the same.

Another object of this invention is to provide an improved method for producing laminated bodies of aluminum and magnesium wherein the bond connecting the laminations may be so formed as to prevent substantial dispersion of either the aluminum or the magnesium into the other.

Another object of this invention is to provide an improved method of the type characterized which is of such character that it may be efficiently performed in large-scale commercial operations.

Another object of this invention is to produce rolled plates, sheets, foils, etc., of aluminum coated magnesium wherein the laminations are united throughout contiguous surfaces thereof while preserving the desirable characteristics of the magnesium as a core metal and of the aluminum as a surface metal and avoiding hard or brittle layers of aluminum-magnesium compounds.

Another object of this invention is to provide an improved magnesium body which is completely and permanently coated with a corrosion preventing envelope and which can therefore be widely used where decreased weight or decreased corrosion or increased strength or stiffness per unit of cross-sectional weight is desirable.

Another object of this invention is to produce an improved aluminum coated magnesium which can be readily drawn, rolled, pressed, shaped and otherwise worked, and therefore fabricated into a wide variety of articles and applied to a wide variety of uses, but with the assurance that the bond between the laminations will not be of such a character that it will be destroyed by or interfere with such operations thereon.

Another object of this invention is to produce aluminum coated magnesium which, while preserving the desirable characteristics of magnesium as a core metal and aluminum as a surfacing metal, also secures various advantages to be derived from their association in laminations without interfering with or detracting from the desired characteristics of such composite metal because of compounds arising from the associa-

tion of these two metals into a laminated structure.

In Letters Patent No. 2,100,257 granted November 23, 1937, to Clayton E. Larson, for Composite bodies of magnesium and aluminum, and method of making same, one method of uniting cores of magnesium with an envelope or surface laminations of aluminum has been described, this method including the casting of a magnesium core into an aluminum envelope or between aluminum plates provided with zinc bonding layers. Owing to the small difference between the melting temperatures of aluminum and magnesium it is difficult to cast magnesium into such an aluminum envelope without effecting a substantial dispersion of the magnesium into the aluminum, notwithstanding the presence of the zinc layer, with the consequent development of hard aluminum-magnesium compounds. Furthermore experience has demonstrated that cast magnesium which has not been subjected to grain refinement is difficult to roll or otherwise work.

It is an object of the present invention to provide an improved method and an improved aluminum and magnesium laminated body which avoids the foregoing difficulties and which also enables the use of a magnesium core that is readily rolled or otherwise worked.

Other objects will appear as the description of the invention proceeds.

In conformity with the present invention a composite body of aluminum and magnesium is formed by effecting a substantially uniform bond between the two metals under such conditions as to substantially prevent dispersion of either of these metals into the other. To this end zinc or zinc alloy is first bonded to the surface of each of the aluminum and magnesium bodies which are to be united, and then said zinc surfaces are united under such conditions as to assure a substantially uniform bond throughout the united surfaces by integrating said zinc layers under conditions which substantially prevent dispersion of the magnesium and aluminum into each other. Thereby are avoided the discontinuities and irregularities of bond which would exist if the metals were rolled or otherwise pressed together, while at the same time no hard or brittle aluminum-magnesium layer is established between the two metals to interfere with satisfactory rolling and other working of the laminated metal. By suitably controlling the temperatures employed the character and thickness of bond may be closely controlled and predetermined.

For most purposes it is preferable to have the coating metal substantially coextensive with the outer face of the ultimate product, but it is within the contemplation of the present invention to provide an aluminum coating on one or more faces only. Furthermore, while it is preferred to form the laminated metal in the form of a billet block or slab, it is to be expressly understood that the invention is not restricted thereto as the composite metal may be formed, in conformity with the present invention, in other shapes that are appropriate for the ultimate products to be produced. Therefore the term "slab" as used herein is to be construed as a term generic to any suitable form of body in which the aluminum is united to the magnesium as hereinafter explained.

While a magnesium core may be cast in the form of a billet or block, it is preferred that the magnesium core be subjected before laminating the same to operations that refine the grain of

the metal as cast in order that the laminated metal may be more easily rolled or otherwise worked.

The surface layer or layers may be composed of pure aluminum or any suitable aluminum base alloy, depending upon the character of coating desired, and similarly the core may be composed of pure magnesium or any suitable magnesium base alloy, depending upon the character of core desired. Therefore it is to be expressly understood that when aluminum or magnesium are referred to herein it is intended to embrace not only the pure metals but any suitable alloys thereof. Furthermore, where zinc is herein referred to as used in the bonding layer it is to be understood, as will appear more fully hereinafter, that suitable zinc alloys may also be used, and therefore when the term zinc is used herein it is intended to embrace any suitable alloy thereof as well as the pure metal.

The preferred procedure in practicing the present invention is as follows:

A slab of magnesium or magnesium alloy, of any suitable size and dimensions, is first formed in any suitable way, as by procedures known to the art. Preferably the magnesium is first cast into a billet which is then turned on a lathe or otherwise suitably worked to remove the cast skin. The said cast billet is then extruded into a slab to refine the grain. The slab so formed may be of any suitable dimensions, say three inches thick, nine inches wide and fifty-four inches long. If a wider core is desired this slab may then be preheated to a temperature between 750° and 800° F., and then cross rolled to the desired width, for example, eighteen inches.

The rolled slab is then heated to any suitable temperature above the melting point of zinc, or the zinc alloy to be used, say a temperature on the order of 950° F., and then a layer of zinc or zinc alloy is applied to a face thereof, preferably by vigorously scratchbrushing the surface of the magnesium while molten zinc is uniformly distributed over the surface thereof, so that a strong and substantially uniform bond is established between the zinc and the magnesium. This layer may be composed of pure zinc or any suitable zinc alloy such as the magnesium zinc eutectic containing about 5% magnesium.

An aluminum facing sheet of the same size as the magnesium slab is prepared, either before or after the aforesaid preparation of the magnesium core, and this is also provided at its face which is to be united to the magnesium core with a similar layer of zinc or suitable zinc alloy. This zinc layer may be formed on the aluminum sheet in the same manner as that heretofore referred to for forming the zinc layer on the magnesium core, i. e., by vigorously scratchbrushing the surface of the aluminum heated to a temperature above the melting point of the zinc or zinc alloy to be used, say on the order of 950° F., while molten zinc or zinc alloy is uniformly distributed over the surface of the aluminum, to establish a strong and substantially uniform bond therewith. Here also, either pure zinc or a suitable zinc alloy such as the zinc aluminum eutectic containing approximately 5% aluminum may be used.

The aluminum facing layer may be of any suitable thickness, as the thickness may be varied within relatively wide limits, depending upon the use to which the composite metal is to be put, the desired characteristics in the ultimate product, etc. Thus for a magnesium slab say 1½ inches

thick the aluminum facing layer may be on the order of a quarter of an inch thick, but as before indicated this aluminum facing layer may be made materially thinner or materially thicker depending upon the characteristics and properties desired. The aluminum facing layer is preferably formed from hot rolled sheets, as this provides a facing layer which is well annealed and has a relatively clean surface. However, cold rolled aluminum sheets may be employed if preferred provided they are sufficiently annealed and the surface thereof properly cleaned to enable the carrying out of the herein described process.

The zinc layers applied to the magnesium and aluminum are preferably of such thickness that under the treatment by which they are applied the zinc does not disperse completely into the metal to which it is being applied, but there is a substantial layer of relatively pure zinc or zinc alloy remaining at the face when the treatment is completed, while effecting a strong and substantially uniform bond between the zinc or zinc alloy and the magnesium and aluminum respectively. To this end the preferred procedure is to heat the magnesium or the aluminum, as the case may be, to a temperature at least as high as and preferably somewhat above the eutectic melting points of the aluminum-zinc or magnesium-zinc binary systems respectively. The zinc is then applied, preferably in a molten condition although if preferred the heat of the slab or sheet may be used to melt the zinc, to that face of the magnesium or aluminum that is to be united with the other in such a way as to assure a uniform break down and detachment of the oxide film on the metal to which the zinc or zinc alloy is being applied while obtaining the desired depth of bond. To this end the metal to which the zinc or zinc alloy is being applied may first be treated with any suitable flux to break down the oxide, but a vigorous brushing of the molten zinc into the base metal, as by a suitable wire brush, after the molten metal, whether applied as such or melted by the temperature of the base metal, has been spread uniformly over the surface of the base metal, is preferred because it will by abrasion sufficiently break down the oxide film while protecting the surface of the base metal from contact with the air and avoiding the presence of foreign material that may have to be removed to avoid formation of gas or other interference with the desired establishment of a uniform bond between the laminations.

The depth of the bond formed can be varied depending upon the temperature of the base metal, the quantity of zinc or zinc alloy used in each layer, and the time and character of the mechanical or chemical work which is used in breaking down the oxide film and assuring the penetration of the zinc or zinc alloy into the metal to which it is applied. Ordinarily a relatively thin alloy layer is desired, because deep penetration of the zinc into the base metal creates a layer of alloy which is less ductile than the base metal, while a substantial coat of the zinc or zinc alloy at the surface of the slab or sheet is desired for the welding operation hereinafter referred to.

If, as preferred, the slab of magnesium is to be coated on both faces with aluminum the opposite face of the slab is similarly treated as above described and a similarly formed and treated aluminum layer is also formed. Assuming that the magnesium core is to be faced with aluminum at both faces thereof for the purpose of the en-

suing description, the magnesium core is disposed between the two aluminum facing layers with the zinc surfaces of the latter in contact with the zinc surfaces on the magnesium core, forming a sandwich of the magnesium between the aluminum laminations. This sandwich is then heated to a suitable temperature below the melting temperatures of the aluminum and magnesium and the contacting zinc layers are then united under pressure. Various procedures may be followed to effect this result.

According to one procedure the sandwich may be heated to a temperature above the melting temperature of the zinc or zinc alloy layers, but below the melting temperatures of magnesium and aluminum, say to a temperature of 900° F. The sandwich is then placed in a hydraulic or other suitable press and such pressure is applied thereto as to effect an integration of the molten zinc layers so as to produce a continuous and homogeneous weld between said zinc layers. The laminated metal is then allowed to cool below the melting temperature of the zinc, whereupon it may be rolled in the customary manner to sheets, foil, etc., of any suitable thickness. If wider sheets are desired, cross rolling may be employed. In these rolling operations the metal is preferably rolled hot but with the temperature sufficiently below the melting point of the zinc so that the heat produced during the rolling operation will not cause the zinc to melt and cause delamination of the aluminum and magnesium.

A second procedure that may be followed is to heat the sandwich while held together by steel straps, wires or the like to a temperature somewhat below the melting point of the zinc, say around 700° F., and then subject the sandwich to one or more rolling operations, utilizing the heat produced by the rolling operation to raise the temperature above the melting point of the zinc and thereby produce a welded bond. As soon as a secure bond has been established the straps, wires or the like may be removed and the rolling continued as above referred to.

The subsequent rolling operations may be performed in accordance with practices well understood in the art, with or without preheating, annealing, etc., between rollings, depending on the core metal used, the size and thickness of the laminated body, the character of the ultimate product desired, etc.

By suitably controlling the temperatures the depth and character of the bond between the laminations may be nicely controlled, but as substantial penetration of the magnesium into the aluminum or vice versa is undesirable, the temperature relationships are preferably so maintained, having regard to the character and thickness of the zinc or zinc alloy layers employed, that no appreciable dispersion of the magnesium and aluminum into each other is permitted. These same considerations should also govern the temperatures at which subsequent rollings and workings are effected, having regard also for the amount of heat generated as a result of such operations.

Aluminum coated magnesium plates, sheets, foils, etc., of suitable thickness may thereby be formed for fabrication into a wide variety of articles and the composite metal so formed possesses the advantages derived from the use of the lighter weight magnesium as a core material while the magnesium is properly encased and protected by the corrosion resistant aluminum.

The accompanying drawing illustrates dia-

grammatically on an enlarged scale, and without regard to proper proportions for the laminae, an aluminum coated magnesium sheet as produced by the present invention. While a facing layer is shown at only one side of the core, it will be understood that facing layers may be applied to both sides of the core.

The present invention therefore provides slabs or other bodies of aluminum coated magnesium wherein the magnesium and aluminum are united throughout their contiguous surfaces by a substantially uniform bond while avoiding relatively hard and brittle aluminum-magnesium layers that interfere with subsequent rolling and working of the composite metal. The composite metal is possessed of the various desirable characteristics inherent in the use of aluminum as a coating metal and magnesium as a core metal without detracting from their relative characteristics by the manner in which this composite metal is formed. The improved method of the present invention assures the establishment of the desired bond between the metals under conditions which may readily be carried out in large-scale operations and the resulting product, because of its characteristics as assured by the method of production, may be put to a wide variety of uses in the electrical, mechanical and chemical arts where the light weight of magnesium makes such desirable and a wide variety of objects may be made therefrom.

While the preferred procedure has been described with considerable particularity, it is to be expressly understood that the invention is not to be restricted thereto, as various departures therefrom will now suggest themselves to those skilled in the art. Other methods for establishing the zinc or zinc alloy layers and uniting them into a secure and permanent bond, and other methods of treatment of the resulting composite metal, will now readily suggest themselves to those skilled in the art. Reference is therefore to be had to the claims hereto appended for a definition of the limits of the invention.

What is claimed is:

1. The method of forming laminated sheets, plates and other bodies of aluminum coated magnesium which includes the steps of forming a magnesium core, substantially destroying the oxide film at the surface of the magnesium to be united to the aluminum by forming a zinc layer alloyed to the face of the magnesium, forming one or more aluminum sheets, substantially destroying the oxide film at the surface of the aluminum to be united to the magnesium by forming a zinc layer alloyed to the aluminum, placing said zinc layers on the magnesium and aluminum directly in contact, integrating said zinc layers, and thereafter rolling the laminated slab so formed.

2. The method of forming laminated sheets, plates and other bodies of aluminum coated magnesium which includes the steps of forming a magnesium core, substantially destroying the oxide film at the surface of the magnesium to be united to the aluminum by forming a zinc layer alloyed to the face of the magnesium, forming one or more aluminum sheets, substantially destroying the oxide film at the surface of the aluminum to be united to the magnesium by forming a zinc layer alloyed to the aluminum, placing said zinc layers on the magnesium and aluminum directly in contact and fusing said zinc layers together under heat and pressure, and thereafter rolling the laminated slab so formed.

3. The method of forming laminated sheets, plates and other bodies of aluminum coated magnesium which includes the steps of forming a magnesium core, substantially destroying the oxide film at the surface of the magnesium to be united to the aluminum by forming a zinc layer alloyed to the face of the magnesium, forming one or more aluminum sheets, substantially destroying the oxide film at the surface of the aluminum to be united to the magnesium by forming a zinc layer alloyed to the aluminum, placing said zinc layers on the magnesium and aluminum directly in contact while the laminations are heated to a temperature above the melting point of the zinc layers, welding said zinc layers together, and thereafter rolling the laminated slab so formed.

4. The method of forming laminated slabs and other bodies of aluminum coated magnesium which includes the steps of casting a magnesium body, refining the grain of the magnesium by extruding the cast magnesium body to form a magnesium slab, forming a substantially continuous predetermined layer of zinc on one or both faces of said slab, forming one or more aluminum sheets of substantially the size of said slab, forming a substantially continuous predetermined layer of zinc on a face of each sheet, placing said zinc layers on the magnesium and aluminum in direct contact, and integrating said zinc layers.

5. The method of forming laminated slabs and other bodies of aluminum coated magnesium which includes the steps of casting a magnesium body, refining the grain of the magnesium by extruding the cast magnesium body to form a magnesium slab, forming a substantially continuous predetermined layer of zinc on one or both faces of said slab, forming one or more aluminum sheets of substantially the size of said slab, forming a substantially continuous predetermined layer of zinc on a face of each sheet, placing said zinc layers on the magnesium and aluminum in direct contact, and fusing said zinc layers together under heat and pressure.

6. The method of forming laminated slabs and other bodies of aluminum coated magnesium which includes the steps of casting a magnesium body, refining the grain of the magnesium by extruding the cast magnesium body to form a magnesium slab, forming a substantially continuous predetermined layer of zinc on one or both faces of said core, forming one or more aluminum sheets of substantially the size of said slab, forming a substantially continuous predetermined layer of zinc on a face of each sheet, placing said zinc layers on the magnesium and aluminum in direct contact while the laminations are heated to a temperature above the melting point of the zinc, and welding said zinc layers together.

7. The method of laminating aluminum and magnesium to form malleable aluminum coated magnesium which includes the steps of forming a magnesium core, applying molten zinc to said magnesium core while breaking down the magnesium oxide film thereon to form a predetermined zinc layer on the magnesium, forming one or more aluminum sheets of substantially the same size as said magnesium core, applying molten zinc to the aluminum while breaking down the aluminum oxide film thereon to form a predetermined zinc layer thereon, placing said zinc layers on the magnesium and aluminum in direct contact, and integrating said zinc layers.

8. The method of laminating aluminum and magnesium to form malleable aluminum coated magnesium which includes the steps of forming a magnesium core, applying molten zinc to said magnesium core while breaking down the magnesium oxide film thereon to form a predetermined zinc layer on the magnesium, forming one or more aluminum sheets of substantially the same size as said magnesium core, applying molten zinc to the aluminum while breaking down the aluminum oxide film thereon to form a predetermined zinc layer thereon, placing said zinc layers on the magnesium and aluminum in direct contact, and fusing said zinc layers together under heat and pressure.

9. The method of laminating aluminum and magnesium to form malleable aluminum coated magnesium which includes the steps of forming a magnesium core, applying molten zinc to said magnesium core while breaking down the magnesium oxide film thereon to form a predetermined zinc layer on the magnesium, forming one or more aluminum sheets of substantially the same size as said magnesium core, applying molten zinc to the aluminum while breaking down the aluminum oxide film thereon to form a predetermined zinc layer thereon, placing said zinc layers on the magnesium and aluminum in direct contact while the laminations are heated to a temperature above the melting point of the zinc, and welding said zinc layers together.

10. The method of coating magnesium with aluminum in forming laminated sheets, plates and other bodies of aluminum coated magnesium which includes the steps of forming magnesium having alloyed to the face thereof a thin coating of zinc, forming aluminum having alloyed to the face thereof a thin coating of zinc, placing said zinc layers on the magnesium and aluminum in direct contact, and integrating said zinc layers into a malleable bond.

11. The method of coating magnesium with aluminum in forming laminated sheets, plates and other bodies of aluminum coated magnesium which includes the steps of forming magnesium having alloyed to the face thereof a thin coating of zinc, forming aluminum having alloyed to the face thereof a thin coating of zinc, placing said zinc layers on the magnesium and aluminum in direct contact, and homogeneously fusing said zinc layers together under heat and pressure into a malleable bond.

12. The method of coating magnesium with aluminum in forming laminated sheets, plates and other bodies of aluminum coated magnesium

which includes the steps of forming magnesium having alloyed to the face thereof a thin coating of zinc, forming aluminum having alloyed to the face thereof a thin coating of zinc, placing said zinc layers on the magnesium and aluminum in direct contact while the laminations are heated to a temperature above the melting point of the zinc, and homogeneously welding said zinc layers together into a malleable bond.

13. A malleable and ductile aluminum coated magnesium body composed of a relatively thin aluminum coating and a magnesium core united by a substantially continuous bond of zinc alloyed to the aluminum and the magnesium and of sufficient thickness to prevent substantial dispersion of the magnesium and aluminum into each other, said zinc layer being substantially coextensive with the contiguous surfaces of the magnesium and aluminum and directly and uniformly bonded to both.

14. The method of forming laminated sheets, plates and other bodies of aluminum coated magnesium which includes the steps of casting a magnesium body, extruding the cast magnesium body to form a magnesium slab, substantially destroying the oxide film at the surface of the magnesium to be united to the aluminum by forming a zinc layer alloyed to the face of the magnesium, forming one or more aluminum sheets, substantially destroying the oxide film at the surface of the aluminum to be united to the magnesium by forming a zinc layer alloyed to the aluminum, placing said zinc layers on the magnesium and aluminum directly in contact, integrating said zinc layers, and thereafter rolling the laminated slab so formed.

15. The method of forming laminated sheets, plates and other bodies of aluminum coated magnesium which includes the steps of casting a magnesium body, extruding the cast magnesium body to form a magnesium slab, substantially destroying the oxide film at the surface of the magnesium to be united to the aluminum by forming a zinc layer alloyed to the face of the magnesium, forming one or more aluminum sheets, substantially destroying the oxide film at the surface of the aluminum to be united to the magnesium by forming a zinc layer alloyed to the aluminum, placing said zinc layers on the magnesium and aluminum directly in contact, heating the laminations to a temperature above the melting point of the zinc layers, fusing said zinc layers together, and thereafter rolling the laminated slab so formed.

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