

Oct. 13, 1959

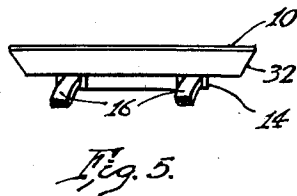
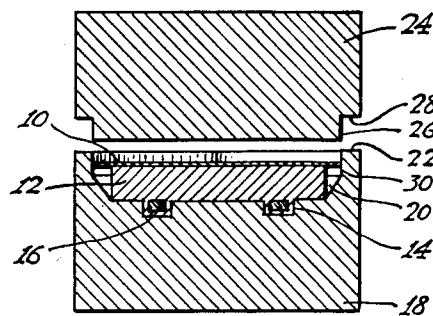
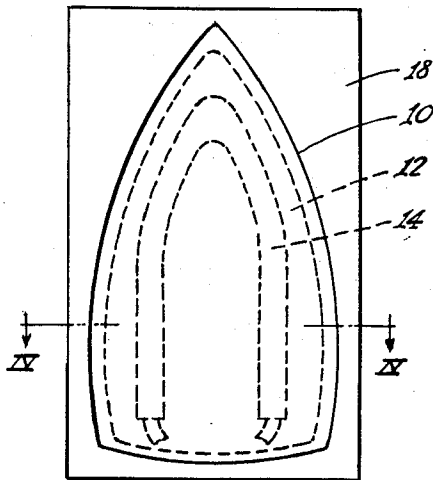
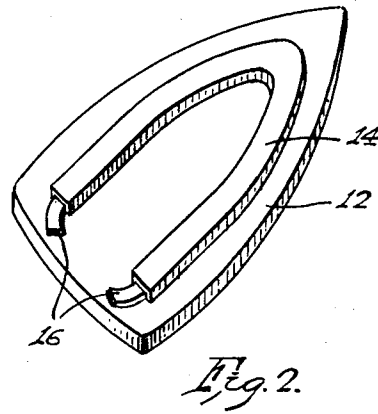
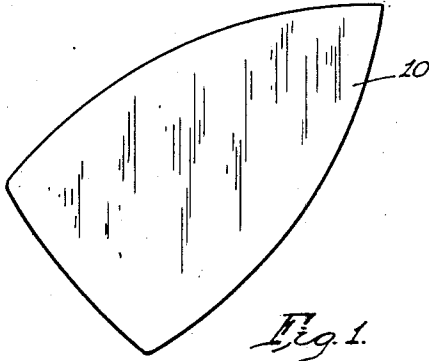
C. H. DULIN

2,908,073

METHOD OF BONDING ALUMINOUS METAL TO DISSIMILAR METAL

Filed June 7, 1957

2 Sheets-Sheet 1



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METHOD OF BONDING ALUMINOUS METAL TO DISSIMILAR METAL

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2 Sheets-Sheet 2

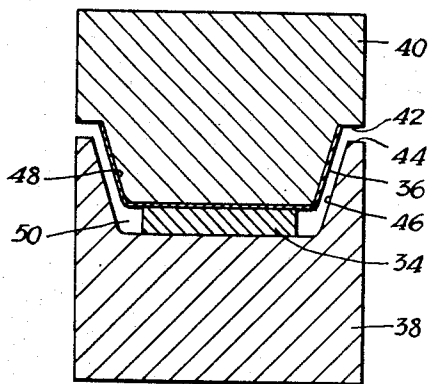


Fig. 6.

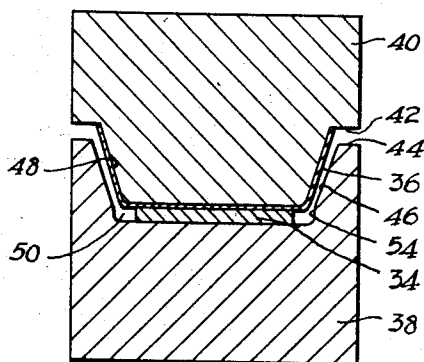


Fig. 9.

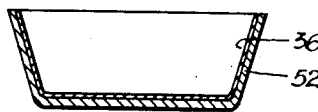


Fig. 7.

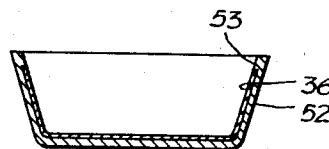


Fig. 8.

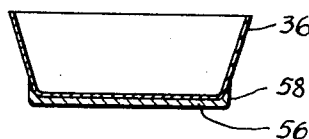


Fig. 10.

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2,908,073

METHOD OF BONDING ALUMINOUS METAL TO DISSIMILAR METAL

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Application June 7, 1957, Serial No. 664,890

10 Claims. (Cl. 29—488)

This invention relates to the manufacture of composite articles consisting of aluminous metal and a dissimilar metal having a higher melting point than aluminum and it is more particularly concerned with bonding a relatively broad thin integral body of the dissimilar metal, referred to herein as a sheet, to a relatively thick aluminous metal base. The term "aluminous," as used herein, refers to aluminum and those alloys in which aluminum constitutes at least 80% of the total composition. The term "dissimilar metal" refers to the ferrous metals, including carbon, alloy and stainless steels, and the non-ferrous metals copper, nickel, titanium, and zirconium and the alloys wherein these metals predominate. All of these metals are characterized by having higher melting points than aluminum. The term "stainless steel," as used below, identifies those ferrous metal alloys containing a substantial amount of chromium or chromium and nickel which are highly resistant to corrosion and are commonly referred to as being of the austenitic, martensitic and ferritic types. The term "sheet" as used herein refers to an integral layer of the dissimilar metal having a thickness of 0.005 to 0.250 inch and which is applied in integral form to the aluminum metal body.

Various kinds of composite products of aluminous metal and iron and other metals have been known for many years. For example, it has been a common practice to coat ferrous grate bars or other articles subjected to elevated temperatures with aluminum. More recently, aluminum coated iron sheet has become a commercial item as a replacement for galvanized iron sheet. Composite engine and machine parts have also been made wherein the aluminous metal is cast against an iron member or a ferrous insert is embedded in an aluminous metal casting. In making these and other composite articles, three general methods have been employed: (1) the molten aluminous metal is brought into contact with the other metal having a higher melting point and then is allowed to solidify thereon; (2) the high melting point metal body is heated in contact with solid aluminum particles or the body is first sprayed with aluminum and then heated whereby an alloyed coating is produced; or (3) separate sheets of the two metals are hot rolled in contact with each other and the resulting product treated to improve the bond. Broadly speaking, those articles which are to be made in substantially final size and form are produced by either one of the first two methods whereas if the articles must be drawn or otherwise shaped to develop the final form, semi-finished products manufactured by the third process are used. The invention described below is concerned with the production of composite articles in substantially final form which generally require no further shaping operation. According to my method separate solid pieces of the two metals are hot pressed together in such a manner that there is a lateral or radial flow of the aluminous metal over the surface toward or beyond the periphery of the dissimilar metal component. The dissimilar metal component is usually provided in substantially the finished shape with the result that no further

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shaping is needed after the aluminous metal has been applied thereto. However, some degree of shaping can be accomplished, if desired, during the hot pressing operation.

In spite of the attention given to the manufacture of composite articles in which aluminous metal is one component, no product has been made, as far as I know, wherein this metal and a dissimilar metal of higher melting point are simultaneously bonded and fabricated to final form without the fusion of the aluminous metal. In particular, it has been found difficult, even impossible, to fabricate a composite product from a relatively thick aluminous metal component and a thin dissimilar metal component. An example of such an article is the sole plate of a conventional hand flat iron. In such applications it is highly desirable to use aluminous metal because of its light weight and excellent heat conductivity, but on the other hand it does not have the abrasion resistance often required for service. I have discovered a method of making stainless steel clad aluminous metal sole plates, cooking utensils, and other articles having a relatively thin coating of a dissimilar metal.

It is the general object of this invention to provide a method of bonding a relatively thin, broad, integral layer of a dissimilar metal to a relatively thick aluminous metal body.

Another object is to provide a method of bonding a sheet of dissimilar metal to a relatively thick, rigid, aluminous metal body whereby the dissimilar metal component is uniformly bonded to the latter.

A further object is to provide a method of bonding a sheet of dissimilar metal to a relatively thick aluminous metal body while simultaneously deforming the body to a final shape.

Still another object is to provide a method of bonding a thin flexible member of dissimilar metal to a wrought or cast aluminous metal having an edge contour substantially corresponding to that of the dissimilar metal member and the final product.

Another object is to provide a composite aluminous metal stainless steel article which is covered on at least one surface with a cladding of stainless steel, the aluminous metal being relatively thick and rigid.

The foregoing objects and other advantages will become apparent from the following description of the invention taken in conjunction with the accompanying drawings which illustrate embodiments thereof.

In the drawings:

Fig. 1 is a perspective view of a thin stainless steel sheet cut in the outline of a flat iron sole plate.

Fig. 2 is a perspective view of a relatively thick aluminous metal sole plate having an embedded heating element, the plate having the outline of the final product and the stainless steel sheet seen in Fig. 1;

Fig. 3 is a plan view of the lower die in which the composite sole plate is formed from the stainless steel sheet and aluminous metal sole plate with the sheet and blank in position for pressing;

Fig. 4 is a section taken on line IV—IV of Fig. 3 with the lower die in registry with the upper die of a press; Fig. 5 is an end view of the finished composite sole plate;

Fig. 6 is a sectional view of a die assembly wherein a circular composite aluminous metal-stainless steel pan is formed, the aluminous metal blank being in position for pressing against the stainless steel shell;

Fig. 7 is a cross-section of the hot pressed composite pan of Fig. 6;

Fig. 8 is a cross-section of a hot pressed circular composite pan, similar to that in Fig. 7 except that the aluminous metal extends above the top edge of the stainless steel component;

Fig. 9 is a sectional view of a die assembly wherein a

circular composite aluminous-stainless steel pan is formed, the aluminous metal only extending over the bottom portion of a stainless steel shell, the aluminous metal blank being in position for the pressing operation, and

Fig. 10 is a cross-sectional view of the hot pressed composite pan of Fig. 9.

My invention is based on the discovery that a broad thin layer of dissimilar metal having a higher melting point than aluminum can be firmly and uniformly bonded to at least a portion of the surface of a relatively thick aluminous metal body by hot pressing the two components together in a confined space at a temperature between 700° F. and the temperature of incipient fusion of the aluminous metal (melting point of the lowest melting constituent in the aluminous metal) under conditions such that there is lateral or radial flow of the aluminous metal in all directions from the aluminous metal blank over the dissimilar metal component toward or beyond the periphery of said component and any shaping of the composite article is effected during the pressing operation. It is to be understood that the metal may flow upwardly or downwardly after it has moved laterally from its initial position. The pressure is applied simultaneously over all portions of the surface of the aluminous metal body which are to be bonded to the other metal with the result that the aluminous metal spreads out and there is a reduction of at least 10% in thickness of that body. In the course of pressing, the aluminous metal spreads outwardly and over the area of the dissimilar metal not initially covered by the aluminous metal. By means of this process a composite article is produced which has a firmly adherent relatively thin dissimilar metal coating free from wrinkles, blisters or other bond defects. The bond between the two metals is so strong that no subsequent heating is required to establish a satisfactory bond. The bond obtained by the hot pressing and lateral flow of aluminous metal is strong and ductile and extends over the entire interface between the two components.

The strength of the bond can be determined by cutting a strip from the article and attempting to peel the cladding from the aluminous metal. On a strip 2 inches in width a good bond is considered to exist when a force of 100 lbs. is needed to effect separation by peeling. Metallographic examination generally reveals no intermetallic compound at the interface between the two metals. If any is formed it is too thin to have any significant effect upon the bond.

The aluminous metal body blank used to form the composite article should have lateral dimensions or contour which are smaller than those of the finished article, but it should have a thickness greater than that of the bonded component in the final product. It is essential in any case that the blank have a sufficient ductility at the bonding temperature to permit flow of the metal without cracking or developing other discontinuities which can adversely affect the uniformity of the bond. Ordinarily, the aluminous metal blank should have a thickness of not less than about 0.25" but generally thicker sections are preferred.

The aluminous metal blank may be in the form of a sand, permanent mold or die casting, a forging, rolled plate, or other prefabricated shape. The surface of the blank which is to be placed against the dissimilar metal member should be smooth but not necessarily flat. The term "smooth," as used herein, means that there should be no raised portions or obstruction to the flow of the aluminous metal. This does not mean, however, that there may not be a recess or depressed portions in the blank which at the outset are not in contact with the cladding component when the two components are positioned in the die. Such a recess or depressions do not interfere with the flow of the metal, in fact they may promote more rapid flow in the portions in contact with the dissimilar metal because the pressure will be greater per unit area

of contact. As mentioned above, the blank should also have a lateral contour broadly approximating that of the final product but the lateral dimensions should be smaller than those of the dissimilar metal component in order to obtain the necessary flow of aluminous metal. Since the blank has a contour related to that of the dissimilar metal component and the final product, the blank is considered to be pre-shaped.

In referring to the shape of the aluminous metal blank it is to be understood that the blank may include portions which are not to be clad. Thus, a cup-shaped blank may be clad with a dissimilar metal on only the bottom surface and in such a case only the bottom portion would be pressed against and spread over the dissimilar metal layer. The bottom portion of the aluminous metal blank would therefore undergo a reduction in thickness of at least 10% as mentioned below.

The aluminous metal blank may contain embedded inserts such as electrical heating elements in the sole plate of a hand flat iron. Any inserts should not be close enough to the aluminous-dissimilar metal interface to interfere with the flow of the aluminous metal under pressure nor should they be positioned so that they are displaced to any substantial degree during the hot pressing operation. In the production of stainless steel clad flat iron sole plates, it has been found that there was no lateral displacement of the embedded electrical heating elements. Generally, any inserts can be located adjacent the side of the blank opposite that where metal flow occurs and the press die be designed to maintain the insert in desired position.

The aluminous metal employed may consist of aluminum or any one of the common aluminum base alloys used for making cast or wrought products. Among the common alloying elements employed either singly or in combination in aluminum base alloys are copper, silicon, zinc, magnesium and manganese. Generally speaking, the copper content lies between 0.1 and 12%, the silicon between 0.5 and 15%, zinc between 0.1 and 10%, magnesium between 0.1 and 15%, and manganese between 0.1 and 2%. In addition the usual grain refining elements, such as titanium and boron may be employed in amounts of 0.01 to 0.25%. It is imperative that any alloys selected possess adequate ductility to undergo the working incident to bonding without rupture. Aluminum base alloys which can be deformed by working at elevated temperatures are well known in the art.

No preliminary heat treatment of the aluminous metal blank is required to prepare it for bonding to the dissimilar metal component. It is important, however, that the surface of the aluminous metal blank be clean and free from any contaminating substances. Any cleaning means may be used providing it leaves no residue or film which interferes with the subsequent bonding of the two metal components.

To insure a satisfactory bond, it may be desirable to lightly abrade the surface of the aluminous metal. The nature of surface and the alloy employed with usually determine the extent of the abrasion required.

The dissimilar metal component should be a broad relatively thin integral body, such as a rolled sheet. Sheets having a thickness between about 0.010 and 0.050" are quite satisfactory since they are, of course, flexible and therefore adapted to follow any contours of the die surface. The dissimilar metal layer may be thicker than 0.050", up to 0.250" as mentioned heretofore, but it should still possess a sufficient flexibility at the hot pressing temperature to conform to the die contour. The sheet may be in any temper, for example, annealed, hard rolled, or heat treated, the choice of temper being determined by the composite product to be made. The dissimilar metal component should be cut to the lateral dimensions required in the composite body since it does not undergo any change in size during the bonding operation.

A large number of dissimilar metal compositions may

be employed, such as carbon steels, alloy steels, stainless steels, copper, brasses, bronzes, nickel, zirconium and titanium and the alloys wherein the last three metals predominate. Such nickel base alloys as Monel and Inconel are suitable, also the titanium base alloys Ti-140A, Ti-6Al-4V and Ti-7Mn, and the zirconium base alloy Zircaloy. The dissimilar metals are defined herein as consisting of iron, copper, nickel, titanium and zirconium and the alloys wherein these metals predominate. Among the most useful metals for cladding purposes are the stainless steels. A variety of stainless steel compositions may be employed, both the 300 and 400 AISI series being satisfactory. In those alloys where chromium is the principal added element, it is present in amount of from about 11 to 27% with a maximum carbon content of about 1%. Where both nickel and chromium are employed, the nickel is present in amounts from 6 to 22% and chromium is within the range of 16 to 26%, the maximum carbon content being 0.20%. It is to be understood that such alloys may also contain small amounts of other well known elements such as manganese, molybdenum, titanium, columbium, aluminum and copper, the total amount of these optional elements varying with the type of stainless steel selected.

The surface of the dissimilar metal component which is to be united with the aluminous metal body should be prepared by grinding, sanding, or wire brushing or by suitable chemical treatment, the purpose being to remove any superficial oxide and leave a slightly roughened surface.

As the first step in one method of bonding the two metal components, the aluminous metal blank and the dissimilar metal component are brought together in a confined space, such as an open face die, with the prepared surfaces in contact with each other. The assembled components are then heated to a temperature between 700° F. and the temperature of incipient fusion of the aluminous metal. Generally, however, a temperature between 700 and 950° F. is preferred. By maintaining the components in contact with each other, no oxidation of the interface occurs which will prevent bonding. It is unnecessary to hold the assembly within this temperature range for any appreciable period of time for as soon as the desired temperature has been attained, the requisite pressure is applied to the assembly to effect bonding. Instead of heating the two components to the desired bonding temperature after they have been placed in the die, they may be preheated before being positioned in the die. Thus, they may be heated to some temperature below the bonding temperature, transferred to the die and the heating completed in the die. It is also possible to heat the components to the bonding temperature and then place them in bonding relationship in the die, care being taken during transfer to avoid allowing the temperature to drop below 700° F. where no heating means are provided in or around the die to maintain the components at the desired temperature. In such cases the die itself must be maintained at a sufficiently high temperature to avoid chilling the components to a temperature below 700° F. Under some circumstances where the aluminous metal mass is large enough it may be sufficient to heat the aluminous metal blank by itself, either in the die or outside of it, and place the dissimilar metal component on the hot blank, enough heat being absorbed within a very short time to raise the temperature of the component to the point where bonding can be effected. Where any heating is done outside the die it is generally desirable to protect the surface of the component which is to be bonded by covering it with a plate or sheet of aluminum or other metal or to employ a protective atmosphere of inert or reducing gas and thus prevent or hold to a minimum any oxidation that might otherwise occur. It should be emphasized that deleterious oxidation should be avoided as far as possible during the heat-

ing operation. Also, that in all cases bonding should be accomplished within the prescribed temperature range, and preferably between 700 and 950° F.

The pressure required to establish a bond is ordinarily that necessary to cause flow of the aluminous metal to the lateral and upwardly or downwardly extending walls of the confined space and thus fill the space when the closing member of die is in its lowermost or minimum position. The pressure will vary with the size and shape of the aluminous metal body as well as the composition of the alloy. Usually, pressures within the range of 15,000 to 50,000 p.s.i. are adequate. It is necessary, in any case, that provisions be made to permit the lateral or radial flow of the aluminous metal in all directions from the aluminous metal blank over the surface of the dissimilar metal component in contact with the blank. If the composite article has upwardly or downwardly extending wall portions either completely or partially covered with aluminous metal, then provision must be made for flowing the metal over those walls. The aluminous metal blank must undergo a reduction in thickness of at least 10% to obtain the requisite metal flow and tenacity of bond. Ordinarily, a reduction in thickness of the aluminous metal component of 10 to 50% is sufficient to produce the necessary flow of metal but greater reductions can be made, if desired. During the pressing operation the dissimilar metal cladding is maintained in a smooth condition and the pressure of the aluminous metal against it prevents any buckling or malformation. In addition, the pressure serves to close any surface pores or voids as well as those at the edges and back or non-bonded surface of the aluminous metal component.

It will be appreciated that effective flow of the aluminous metal cannot be obtained if the layer is too thin. It has been found that the layer must be of at least 0.1" in thickness in the final product to secure the advantages of bonding by metal flow and also provide a rigid structure. Where the aluminous metal component has a thickness close to the minimum, the dissimilar metal component should also be relatively thin, preferably near the minimum thickness.

The deformation of the aluminous metal and the bonding to the dissimilar metal can be ordinarily effected by a single stroke of the press which simplifies and shortens the fabrication operation. However, if the assembly is maintained at the proper temperature the pressing may be accomplished in several steps instead of one.

The composite bonded article is removed from the confined space upon completion of the bonding operation and allowed to cool to room temperature. No additional pressing or heating is required to perfect the bond. The product of the process has a smooth, uniform firmly bonded dissimilar metal cladding on a heavy or thick aluminous metal base. It has been possible by means of this process to provide a dissimilar metal cladding on a surface of such items as die castings which have offered so much difficulty in the past to being plated or coated with another metal.

It is to be understood that there may be some openings or depressions in the clad surface as required by design of the article. Such openings or depressions may be initially provided in the aluminous metal blank and dissimilar metal sheet or they may be made after the shaping and bonding operation. Also, it is to be understood that some depressions may be intentionally produced during the pressing operation by the die in contact with the dissimilar metal. However, such depressions should not be of magnitude which obstructs the flow of the aluminous metal. An example of discontinuities which do not affect bonding are the holes or grooves in the sole plate of a steam iron for emission of steam.

It should also be understood that in making some articles, such as pans, it may be desirable to provide an excess of metal at the edge which can either be removed or rolled to form a bead and thus give the article a finished edge.

One embodiment of my invention which exemplifies its advantages is to be found in the stainless steel cladding of aluminous metal flat iron sole plates. For this purpose a No. 302 (18-8 type) stainless steel sheet blank 0.013 inch in thickness was cut to the required outline of the final sole plate. One surface of the blank was then scratch brushed whereby all surface oxide is removed.

The aluminous metal blank used in forming the sole plate consisted of a permanent mold casting of an aluminum base alloy composed of aluminum, 10% copper, 4% silicon, and 0.3% magnesium. The casting was made with the heating elements embedded therein. The plate portion of the blank was 0.500 inch in thickness and of slightly shorter length and width than the stainless steel sheet, whereby a margin of about 0.25 inch was provided between the edge of the casting and the edge of the stainless steel sheet blank. The surface to be bonded to the stainless steel was lightly ground.

The prepared surfaces of the two components were then placed in contact with each other in a suitable die in a hydraulic press, heated to 870° F. in the die, and finally pressed under a pressure of 18,000 to 21,000 p.s.i. with a reduction in thickness of the aluminous metal component amounting to 25% which resulted in filling the entire die cavity. On removal from the die and cooling to room temperature the stainless steel cladding was found to be uniformly and firmly bonded to the aluminous metal base, and the base revealed no pores on the non-bonded surfaces.

The foregoing components, the dies for effecting compression and the final product are illustrated in the accompanying drawings. The stainless steel sheet blank 10 to be used in making a stainless steel clad aluminum alloy sole plate and which is cut to the size required in the final product is shown in Fig. 1. The cast aluminous metal plate 12 to be bonded to the stainless steel blank 10 shown in Fig. 2 is provided with a raised channel portion 14 which encloses the electrical heating element 16. To form the composite sole plate the aluminous metal plate 12 is placed in the lower die 18 of a press with the bottom surface of the plate up and the stainless steel blank 10 laid thereon with the previously prepared surface against the aluminous metal. This arrangement in plan view is seen in Fig. 3 and in cross section in Fig. 4. In the latter figure it will be noted that the raised channel portion 14 of the plate rests in a complementary channel groove in the die 18 and the whole assembly is below the top surface 22 of the die. The die cavity is of greater lateral dimension than the plate whereby a space 20 exists between the plate 12 and the lateral wall of the die. A portion of that wall is vertical to permit downward movement of the sheet blank 10, the distance it moves during the pressing operation being denoted as 30. A very small but yet adequate clearance should be provided between the edges of the stainless steel sheet and the vertical die wall to allow free downward movement of the sheet without scraping or galling the die wall. On the other hand, the clearance should not be great enough to permit the aluminous metal to squeeze out around the edges of the sheet.

Pressing of the assembled components is effected by downward movement of the upper die 24, said die being guided by vertical surface 26 and a corresponding surface in the die cavity in die block 18. The upper die 24 descends until the top surface 22 of die 18 meets the stop surface 28 of die 24. The product of the pressing and bonding operation is shown in Fig. 5, the compressed plate 32 with heating element 16 in channel 14. The plate 32 has been spread laterally to the edge of the stainless steel sheet cladding 10.

To effect bonding the assembled metal components are heated to a temperature above 700° F. but below the temperature of incipient fusion of the aluminous metal either in the die by means not shown, for example by gas or by an induction coil or prior to placement in the die. Upon attaining the desired temperature, if the heating is done in the die, the upper die 24 is moved downwardly to the lowermost position. If the components are at temperature when assembled in the die, the pressing can be performed immediately. During the pressing operation the stainless steel sheet blank 10 moves downwardly over the vertical distance 30 and the space 20 becomes filled as the aluminous metal flows laterally. The aluminous metal blank is, of course, reduced in thickness by the amount represented by the distance 30. The flow of metal is such that it moves outwardly in all directions to the edge of the stainless steel component 10 thus producing some movement of aluminous metal over the entire surface of the stainless steel sheet.

Another example of cladding aluminous metal with a thin sheet of stainless steel is found in the production of a composite pan as shown in Figs. 6 and 7. The stainless steel component in this case consisted of a preformed circular shell 36 having a flat bottom and flared side wall. The shell was composed of No. 302 stainless steel and had a thickness of 0.010 inch.

The aluminous metal blank 34 employed consisted of a circular permanent mold casting 0.97 inch in thickness and of a smaller diameter than the flat bottom surface of the stainless steel shell. The aluminous metal was an aluminum base alloy containing 5% of silicon and the balance substantially all aluminum.

The outer surface of the stainless steel shell was scratch brushed while one surface of the aluminous metal blank was lightly ground to remove any undesirable surface impurities.

To form the composite pan, the aluminous metal blank 34 was positioned in the cavity of the lower die block 38 with the prepared surface of the blank facing upwardly. The side walls 46 of the die cavity flared outwardly and were complementary to the tapered surface 48 on the upper male die 40. The stainless steel shell was placed on the aluminous metal blank and the upper die lowered to press the shell against the blank. In this position both blank and shell were heated to a temperature of 900° F. by heating elements within the die blocks. Upon attaining the desired temperature the upper die was pressed downwardly under a pressure of 18,000 to 21,000 p.s.i. so that the aluminous metal spread outwardly into space 50 and upwardly between the outer surface of the shell and the tapered wall 46 of the lower die cavity. The upper die moved down until stop surface 42 came in contact with the top surface 44 of the lower die block. The downward pressure reduced the thickness of the aluminous metal blank to 0.100", which amounted to a 90% decrease in thickness and produced a layer of substantially uniform thickness over the entire outer surface of the article.

A sound tenacious bond was developed between the two metal components over the entire interfacial area. The flared wall portions of the pan were firmly joined together, the movement of the aluminous metal over the stainless steel within the confined space between the dies being sufficient to establish a tenacious joint. It is considered that a pressure was exerted on the components normal to the die wall surface and that this in addition to the metal flow produced the firm bond. The finished composite product is shown in Fig. 7 where the compressed and extended aluminous metal 52 covers the entire outer surface of the shell 36.

The pan illustrated in Fig. 8 was made by shortening the flared walls 36 and allowing the aluminous metal to flow past the top edge and form top portion 53. This excess metal can be removed or shaped to form a finished edge on the pan.

In the modification shown in Figs. 9 and 10 only the bottom portion of the composite pan is covered by the aluminous metal. The pan is produced in substantially the same manner as described above. An aluminous metal blank 34 and a stainless steel shell 36 are heated between two die blocks 38 and 40 and compressed with a 35% reduction in thickness of the aluminous metal component. To confine the metal flow to the bottom portion of the shell, the lower die cavity must be shaped so that the flared surface 46 comes in contact with the stainless steel shell and the lower portion 54 of the wall forms an angle or merges with the upper portion 46 whereby when they are in a closed position the aluminous metal cannot pass beyond the angle. Ordinarily, it is desirable to feather the edge of the aluminous metal component at 58 as shown in Fig. 10. The stainless steel shell 36 is bare above the feathered edge but the bottom is covered by the aluminous metal layer 56.

It will be appreciated that by applying pressure over the entire surface of the hot aluminous metal component and simultaneously causing that metal to flow over the heated dissimilar metal a bond can be established between the two components. Furthermore, it is unnecessary that the metal flow be only in a horizontal direction, but it can move upwardly or downwardly at any angle providing enough pressure is applied.

This application is a continuation-in-part of my co-pending application Serial No. 492,277, filed March 4, 1955, now abandoned.

Having thus described my invention and one embodiment thereof, I claim:

1. The method of cladding a relatively large surface area of a relatively thick aluminous metal body with a relatively thin integral layer of a dissimilar metal having a melting point above that of aluminum selected from the group consisting of iron, copper, nickel, titanium and zirconium and alloys wherein these metals predominate which comprises providing said dissimilar metal in the form of a sheet blank of the same lateral dimensions as required for the final composite article, cleaning that surface of the blank which is to be bonded to the aluminous metal to remove any oxide or other contaminating substances, providing a pre-shaped aluminous metal body of greater thickness than the aluminous metal portion of the final composite article and of smaller lateral dimensions than said dissimilar metal sheet blank, said aluminous metal body also having a smooth relatively large surface area to be bonded to the dissimilar metal, heating said dissimilar metal sheet blank and said aluminous metal body to a temperature between 700° F. and the temperature of incipient fusion of the aluminous metal, said heating being done under protective conditions which minimize the formation of oxide on the two metal surfaces to be bonded, pressing together said dissimilar metal sheet blank and said aluminous metal body in a confined space while the metal components are within the aforesaid temperature range, the cleansed dissimilar metal surface being in contact with said smooth surface of said aluminous metal body, and said aluminous metal body being positioned with respect to the dissimilar metal sheet blank such that the edges of the blank extend beyond the lateral edges of the aluminous metal body whereby a margin of the dissimilar metal sheet is provided around the entire periphery of the aluminous metal body, the pressure being simultaneously applied to said assembled dissimilar metal and aluminous metal components over the entire area to be bonded, the pressure being sufficient to cause the aluminous metal to flow laterally in all directions over said dissimilar metal sheet blank toward the edges thereof and to cause a reduction in thickness of said aluminous body of at least 10% whereby the dissimilar metal sheet becomes firmly and uniformly bonded to said aluminous metal body, and finally cooling the bonded article to room temperature.

2. The method according to claim 1 wherein the thin integral layer is 0.010 to 0.050 inch in thickness.

3. The method of producing a pan-like composite article of aluminous metal and a dissimilar metal selected from the group consisting of iron, copper, nickel, titanium and zirconium and alloys wherein these metals predominate, said article having a base and walls extending upwardly from the periphery of the base, said method comprising providing said dissimilar metal in the form of a pan-shaped blank of substantially the size and shape of the final composite article, cleaning that surface of the dissimilar metal blank which is to be bonded to the aluminous metal to remove any oxide or other contaminating substances, providing a pre-shaped aluminous metal body of greater thickness than the aluminous metal portion of the final composite article and of smaller lateral dimensions than the base of said pan, heating said dissimilar metal pan-shaped blank and said aluminous metal body to a temperature between 700° F. and the temperature of incipient fusion of the aluminous metal, said heating being done under protective conditions which minimize the formation of oxide on the two metal surfaces to be bonded, pressing together said dissimilar metal pan blank and said aluminous metal body in a confined space while they are within the aforesaid temperature range, the cleansed bottom surface of the dissimilar metal blank facing the aluminous metal body, and said aluminous metal body being positioned with respect to said bottom pan surface such that its periphery is beyond the lateral edges of the aluminous metal body whereby a margin of dissimilar metal is provided around the entire periphery of the aluminous metal body, the pressure being applied over the entire surface of the initial aluminous metal body and that portion which spreads out from the initial body and over any part of the upwardly extending walls of the pan-shaped blank, the pressure being sufficient to cause the metal to flow outwardly to the periphery of the pan bottom and upwardly over at least a portion of the side walls of the pan with a resultant reduction in thickness of the aluminous metal blank of at least 10% whereby the dissimilar metal pan component becomes firmly and uniformly bonded to the aluminous metal component, and finally cooling the composite article to room temperature.

4. The method of claim 3 wherein the aluminous metal is applied and bonded to only substantially the bottom of the dissimilar metal pan.

5. The method of cladding a relatively large surface area of a relatively thick rigid aluminous metal body with a stainless steel sheet which comprises providing a stainless steel sheet blank of the same lateral dimensions as the cladding on the final composite article, cleaning that surface of the blank which is to be bonded to the aluminous metal to remove any oxide or other contaminating substances, providing a pre-shaped aluminous metal body of greater thickness than the aluminous metal portion of the final composite article and of smaller lateral dimensions than the stainless steel blank, said aluminous metal body also having a smooth relatively large surface area to be bonded to the stainless steel, heating said stainless steel blank and said aluminous metal body to a temperature between 700° F. and the temperature of incipient fusion of the aluminous metal, said heating being done under protective conditions which minimize the formation of oxide on the two metal surfaces to be bonded, pressing together said stainless steel blank and aluminous metal body in a confined space while the metal components are within the aforesaid temperature range, the cleansed stainless steel surface being in contact with said smooth surface of said aluminous metal body, and said aluminous metal body being positioned with respect to the stainless steel blank such that the edges of the blank extend beyond the lateral edges of the aluminous metal body whereby a substantially uniform margin of stainless steel is provided around the entire periphery of the aluminous metal body, the pressure being simultaneously applied to said assembled

stainless steel and aluminous metal components over the entire area to be bonded, the pressure being sufficient to cause the aluminous metal to flow laterally in all directions over said stainless steel blank and to the edge thereof and to cause a reduction in thickness of said aluminous metal body of between 10 and 50% whereby the stainless steel becomes firmly and uniformly bonded to said aluminous metal body, and finally cooling the bonded article to room temperature.

6. The method of cladding a relatively large surface area of a relatively thick rigid aluminous metal body with a stainless steel sheet which comprises providing a stainless steel sheet blank of the same lateral dimensions as the cladding on the final composite article, cleaning that surface of the blank which is to be bonded to the aluminous metal to remove any oxide or other contaminating substances, providing a pre-shaped aluminous metal body of greater thickness than the aluminous metal portion of the final composite article and of smaller lateral dimensions than the stainless steel blank, said aluminous metal body also having a smooth relatively large surface area to be bonded to the stainless steel, positioning said body in an open sided die with said smooth surface toward the open side, the lateral edge of said body being spaced from the lateral wall of the die such that the space is filled when the aluminous metal body is reduced in thickness during the subsequent pressing step, superimposing said stainless steel blank on said smooth aluminous metal surface with the cleansed surface of said blank against the smooth aluminous metal surface, said stainless steel blank also being so positioned that the edges extend beyond the periphery of the aluminous body, raising the temperature of said assembled metal components to a temperature between 700° F. and the temperature of incipient fusion of said aluminous metal, immediately applying pressure to said assembled components over the entire area to be bonded from the open side of said die, said pressure being sufficient to reduce the thickness of the aluminous metal body from 10 to 50% and cause said metal to flow laterally to the die walls and over the marginal portion of the stainless steel blank initially extending beyond the periphery of the aluminous metal body whereby said stainless steel sheet becomes firmly and uniformly bonded to said aluminous metal body, and finally cooling the bonded article to room temperature.

7. The method of cladding a relatively large surface area of a relatively thick rigid aluminous metal body with a stainless steel sheet which comprises providing a stainless steel sheet blank of the same lateral dimensions as the cladding on the final composite article, cleaning that surface of the blank which is to be bonded to the aluminous metal body to remove any oxide or other contaminating substances, providing a pre-shaped aluminous metal body of greater thickness than the aluminous metal portion of the final composite article and of smaller lateral dimensions than the stainless steel blank, said aluminous metal body also having a smooth relatively large surface area to be bonded to the stainless steel, heating said stainless steel blank and said aluminous metal body to a temperature between 700° F. and the temperature of incipient fusion of the aluminous metal, said heating being done under protective conditions which minimize the formation of oxide on the two metal surfaces to be bonded, positioning said hot aluminous metal body in an open sided die with said smooth surface toward the open side, the lateral edge of said body being spaced from the lateral wall of the die such that the space is filled when the aluminous metal body is reduced in thickness during the subsequent pressing step, laying said stainless steel blank on said smooth aluminous metal surface with the cleansed surface of said blank against the smooth aluminous metal surface, said stainless steel blank also being so positioned that the edges extend beyond the periphery of the aluminous metal body, im-

mediately pressing said assembled blank and aluminous metal body over the entire area to be bonded from the open side of the die, said pressure being sufficient to reduce the thickness of the aluminous metal body from 10 to 50% and cause said metal to flow laterally to the die walls and over the marginal portion of the stainless steel blank initially extending beyond the periphery of the aluminous metal body whereby said stainless steel sheet becomes firmly and uniformly bonded to said aluminous metal body, and finally cooling the bonded article to room temperature.

8. The method of cladding a relatively large surface area of a relatively thick rigid aluminous metal body with a stainless steel sheet which comprises providing a stainless steel sheet blank 0.010 to 0.050 inch in thickness and of the same lateral dimensions as the cladding on the final composite article, abrading that surface of the blank which is to be bonded to the aluminous metal, providing a pre-shaped aluminous metal body at least 0.25 inch in thickness and of smaller lateral dimensions than the stainless steel blank, said aluminous metal body also having a smooth relatively large surface area to be bonded to the stainless steel, heating said stainless steel blank and aluminous metal body to a temperature between 700 and 950° F., said heating being done under protective conditions which minimize the formation of oxide on the two metal surfaces to be bonded, pressing together said stainless steel blank and aluminous metal body in a die while the metal components are within the aforesaid temperature range, the cleansed stainless steel surface being in contact with said smooth surface of said aluminous metal body and said body being positioned with respect to the stainless steel blank such that the edges of the blank extend beyond the lateral edges of the aluminous metal body whereby a substantially uniform margin of stainless steel is provided around the entire periphery of the aluminous metal body, the pressure being simultaneously applied to said assembled aluminous metal body and stainless steel components over the entire area to be bonded, the pressure being sufficient to cause the aluminous metal to flow laterally over said stainless steel blank and to the edge thereof and to cause a reduction in thickness of said aluminous metal body of between 10 and 50% whereby the stainless steel becomes firmly and uniformly bonded to said aluminous metal body, and finally cooling the bonded article to room temperature.

9. The method of cladding the bottom surface of an aluminous metal flat iron sole plate with a stainless steel sheet which comprises providing a stainless steel sheet blank of the contour and dimensions of the final sole plate, abrading that side of said blank which is to be bonded to the sole plate, providing an aluminous metal sole plate of greater thickness and smaller lateral dimensions than the aluminous metal component of the final product, said lateral dimensions also being smaller than those of the stainless steel blank, said sole plate having a smooth bottom surface, positioning said sole plate in an open sided die with the bottom of said plate toward the open side and the edges of said plate spaced from the lateral wall of the die such that the reduction in thickness of the plate during the subsequent pressing operation will cause a lateral flow of the aluminous metal and a filling of said space, superimposing said stainless steel blank on said sole plate with the abraded surface against the plate, said stainless steel blank also being so positioned that the edges extend substantially uniformly beyond the periphery of the aluminous plate around the entire plate, raising the temperature of said assembled plate and blank to a temperature between 700 and 950° F., immediately applying pressure to said heated stainless steel blank and aluminous metal sole plate over the entire area to be bonded from the open side of said die, said pressure being sufficient to reduce the thickness of the aluminous metal sole plate from 10 to 50% and cause said metal to flow laterally to the die walls and over that

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portion of the stainless steel blank initially extending beyond the periphery of the aluminous metal sole plate whereby said stainless steel sheet becomes firmly and uniformly bonded to said aluminous metal sole plate, and finally cooling the clad sole plate to room temperature.

10. The method of cladding at least one surface of a relatively thick plate-like cast aluminous metal body with a stainless steel sheet which comprises providing a stainless steel sheet blank of the same lateral dimensions as the cladding on the final composite article, cleaning that surface of the blank which is to be bonded to the aluminous metal to remove any oxide or any other contaminating substances, providing a plate-like aluminous metal casting of greater thickness than the aluminous metal portion of the final composite article and of smaller lateral dimensions than the stainless steel blank, said aluminous metal casting having a smooth relatively large surface area to be bonded to the stainless steel, heating said stainless steel blank and said aluminous metal casting to a temperature between 700° F. and the temperature of the incipient fusion of the aluminous metal, said heating being done under protective conditions which minimize the formation of oxide on the two metal surfaces to be bonded, pressing together said stainless steel blank and aluminous metal casting, in a confined space while the metal components are within the aforesaid temperature

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range, the cleansed stainless steel surface being in contact with said smooth surface of said aluminous metal casting, said casting being positioned with respect to the stainless steel blank such that the edges of the blank extend beyond the lateral edges of the casting whereby a substantially uniform margin of stainless steel is provided around the entire periphery of the casting, the pressure being simultaneously applied to said assembled stainless steel and aluminous metal components over the entire area to be bonded, the pressure being sufficient to cause the aluminous metal to flow laterally in all directions over same stainless steel blank and to the edge thereof and to cause a reduction in thickness of said aluminous metal casting of between 10 and 50% whereby the stainless steel becomes firmly and uniformly bonded to said casting, and finally cooling the bonded article to room temperature.

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