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W. E. McCULLOUGH ET AL

2,265,243

METHOD OF FORMING COMPOSITE METAL STRUCTURES

Filed July 8, 1940

FIG.1

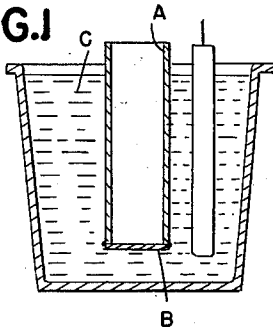


FIG.2.

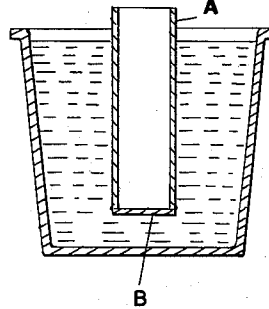


FIG.5.

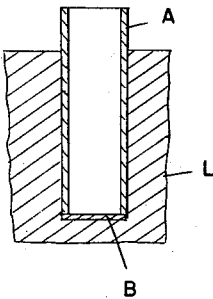


FIG.6.

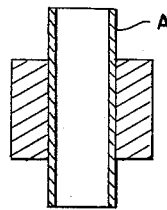


FIG.3.

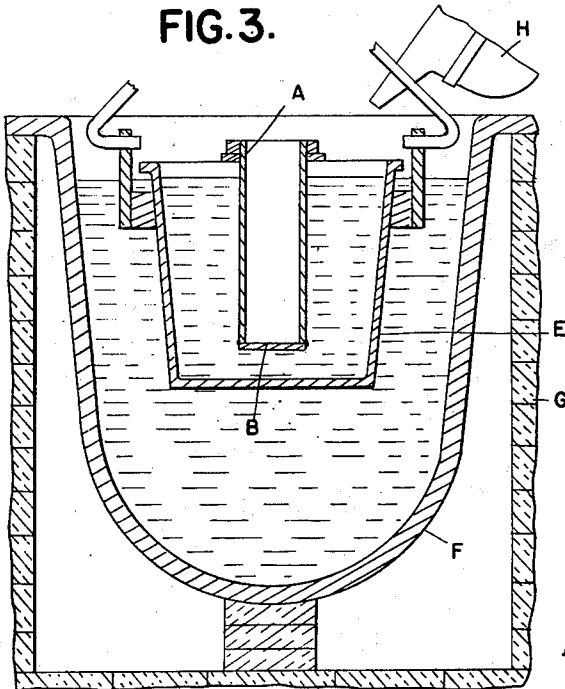
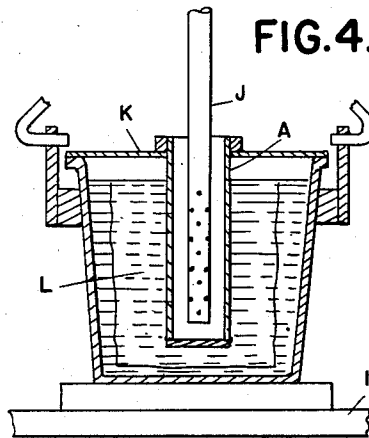


FIG.4.



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METHOD OF FORMING COMPOSITE METAL STRUCTURES

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7 Claims. (Cl. 22-204)

The invention relates generally to composite structures formed of metals of different specific gravity and thermal conductivity. More particularly, the invention relates to heat dissipating structures, such as finned cylinders for air cooled internal combustion engines used in aircraft. In the present state of the art, various methods have been employed for forming the heat dissipating fins of engine cylinders. In one method these fins have been machined from a thick walled cylinder blank so as to be integral with the finished wall of the cylinder. Another method is to form the finished cylinder wall and the fins of separate members and usually of different materials, these being united by pressing or shrinking the one about the other. The first method is wasteful of material and high in machining cost, as well as forming a product of excessive weight. The second method has the objection that the fins are not integral with the cylinder wall, which reduces thermal conductivity therebetween, and also forms an insecure attachment.

It is the object of the invention to obtain a composite structure and method of forming the same in which two metals of different physical characteristics are integrated with each other. One of these metals, such for instance as steel, is of relatively high specific gravity and low in thermal conductivity, while the other metal, such for instance as aluminum, magnesium, or alloys thereof, is relatively low in specific gravity and high in thermal conductivity. Thus, in the construction of a finned cylinder for air cooled internal combustion engines, the cylinder may be formed of steel and the fins of the lighter metal. The invention, therefore, consists in the composite structure and method of forming the same as hereinafter set forth.

In the drawing:

Figure 1 is a diagrammatic view illustrating the cleaning of the cylinder;

Figure 2 is a similar view showing the hot galvanizing of the cylinder;

Figure 3 is a cross section through the apparatus for surrounding the cylinder with molten aluminum;

Figure 4 is a similar view illustrating the chilling step;

Figure 5 is a cross section through the blank as removed from the molten bath;

Figure 6 is a similar view of the completed blank.

Generally described, our improved method comprises the amalgamation or welding of a

molten metal to the surface of another metal having a higher melting point and the subsequent freezing of the former to the latter. As specifically illustrated, the composite structure is a finned cylinder which is formed by the following procedure. The cylinder blank A, preferably formed of steel, is closed at one end as for instance by a sheet metal member B welded thereto so as to form a liquid seal. This cylinder is first thoroughly cleansed on its outer surface which may be conveniently accomplished by what is known as the "Tainton" process, the cylinder being immersed in a molten bath C of caustic soda, and an electric current passed therethrough, the cylinder constituting the anode. After cleansing, the cylinder is hot galvanized by dipping in a bath of molten zinc or zinc alloy having a temperature of from 800° F. to 850° F. As the melting point of zinc is about 700° F., the superheating thereof facilitates the forming of a welding reaction between the zinc and the steel.

The cylinder is next suspended within a pot E containing a highly heated fluxing material. Preferably, this pot is heated by immersion in a fused salt bath contained in a larger pot F in the furnace G. The fluxing material within the pot E may be the same as that in the pot F, this being preferably a mixture of sodium chloride 73%, and sodium fluoride 27%, having a melting point of approximately 1250° F. The bath within the pot F is raised to a temperature from 1420° F. to 1500° F., after which the pot E is lowered therein and filled with the fused salt and the cylinder A is suspended therein. When the cylinder attains the temperature of the fused salt, molten metal is poured into the pot E, as for instance from a ladle H. This will displace the flux and surround the cylinder. The pot E is next removed from the bath and placed on a suitable support, such as the table I, after which the cylinder is rapidly cooled to a temperature where the molten metal will freeze thereupon. Preferably, this cooling is effected by the insertion of a perforated spray nozzle J within the cylinder and forcing a spray of water and compressed air therethrough. The molten metal within the pot may be protected from the spray by cover members K surrounding the cylinder and the spray continued for a sufficient period of time to freeze about the cylinder a wall of metal of the desired thickness. The pot E is of a diameter considerably in excess of the diameter of the composite structure so as to maintain a surrounding body of molten metal as long as

the freezing process continues. The spray pipe J is then removed, after which the cylinder A together with the surrounding ingot L frozen thereon, is lifted out of the pot and subjected to further cooling, preferably by the reinsertion of the spray nozzle. The purpose of this further cooling is to rapidly reduce the temperature of the metal, thereby securing greater density therein. The lower portion of the ingot L and the bottom B are then cut away to form a structure as shown in Figure 6. This may be subsequently machined to finish the cylinder and to cut the fins.

Where the ingot is formed of an aluminum alloy, this is preferably of a composition of silicon 11% to 13%, nickel 2% to 3%, copper .5% to 1.5% and the balance of aluminum. There may be, however, a small amount of iron, such as .2% as an impurity. Such an aluminum alloy has a lower coefficient of thermal expansion than other common aluminum alloys, which is desirable inasmuch as steel and ferrous alloys have a coefficient of thermal expansion considerably lower than aluminum base alloys. It is not, however, essential to use this particular alloy, as other alloys of aluminum or magnesium may be found suitable for the purpose.

The precoating of the cylinder with zinc facilitates the bonding of the aluminum alloy to the steel by forming an alloy with each of these metals. If desired, instead of using pure zinc as a bonding material, an alloy of zinc with 5% to 20% of silver may be used, the silver imparting ductility and lessening the likelihood of cracking between the ingot and the cylinder.

In the composite structure as described, the ingot of aluminum or other alloy is effectively bonded to the steel cylinder so as to secure high thermal conductivity therebetween, as well as forming a strong connection.

What we claim as our invention is:

1. In a method of forming heat exchange structures, the steps of placing an annular cylinder blank in contact with superheated molten metal of lower specific gravity and having a lower melting point and higher coefficient of thermal conductivity, and rapidly chilling the former solely through the inner surface thereof to freeze thereupon and integrate therewith an ingot of the latter.

2. In a method of forming composite structures, the steps of placing an annular cylinder blank with one of its surfaces in contact with superheated molten metal of lower specific gravity and having a lower melting point and higher coefficient of thermal conductivity, maintaining contact to effect an alloying of the metals, and in

then rapidly chilling the former through the surface thereof opposite that in contact with the molten metal to freeze thereupon an ingot of the latter.

3. In a method of forming finned cylinders, the steps of coating the external surface of an annular cylinder blank with a bonding metal, casting a ring of aluminum alloy about said cylinder the molten metal being highly superheated to integrate the same with the bonding material, and rapidly chilling solely from the interior of the cylinder radially outward to produce a progressive solidification of the metal of the ring and the complete bonding of the same to the cylinder.

4. In a method of forming finned cylinders, the steps of closing one end of an annular cylinder blank, hot galvanizing the outer surface of said cylinder, placing the cylinder in a surrounding pot containing fluxing material and raised to a temperature of over 1400° F., pouring a molten aluminum alloy at approximately the same temperature into said pot to displace the flux, and rapidly chilling solely from the interior of the cylinder to cause progressive solidification of the aluminum alloy in a radially outward direction.

5. In a method of forming composite metal structures, the steps of immersing a member formed of a metal having a relatively high melting point in a bath of superheated molten metal having a lower melting point, rapidly chilling the former to progressively freeze thereupon an ingot of the latter, and completing said freezing of the ingot to the desired dimensions while it is still surrounded by a volume of molten metal.

6. In a method of forming composite metal structures, the steps of immersing a member formed of a metal having a relatively high melting point in a bath of superheated molten metal having a lower melting point, rapidly chilling the former to freeze thereupon and therearound an ingot of the latter, of progressively increasing thickness completing said freezing of the ingot to the desired dimensions while it is still surrounded by a volume of molten metal and then withdrawing from the bath.

7. In a method of forming heat exchange structures, the steps of contacting the outer surface of an annular cylinder blank with superheated molten metal having a lower melting point and higher coefficient of thermal conductivity, and rapidly chilling the former solely through the inner surface thereof to freeze therearound and integrate therewith an ingot of the latter metal.

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