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METHOD OF COATING METALS

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Fig. 1

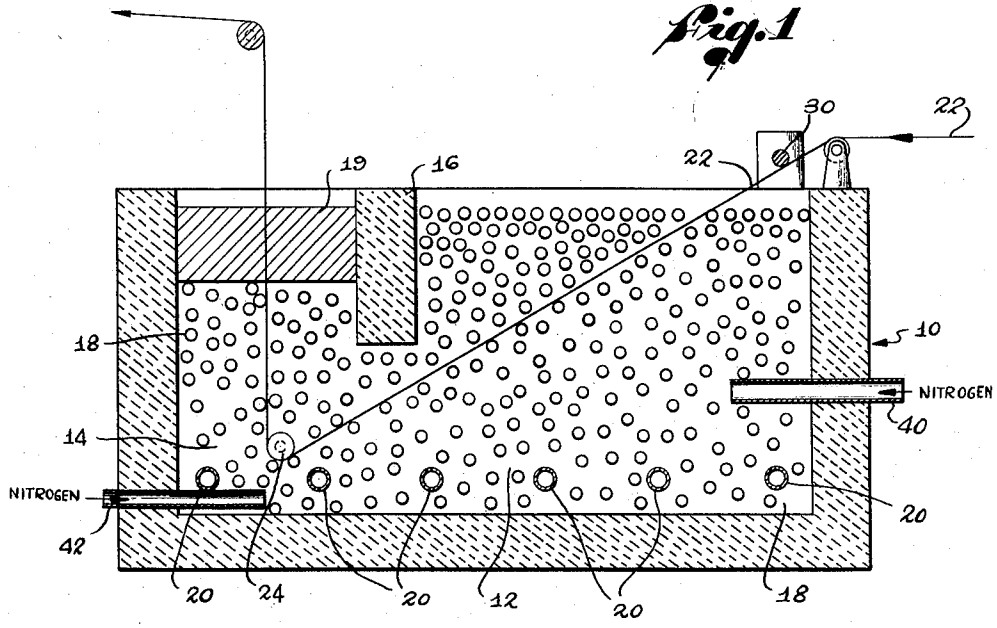
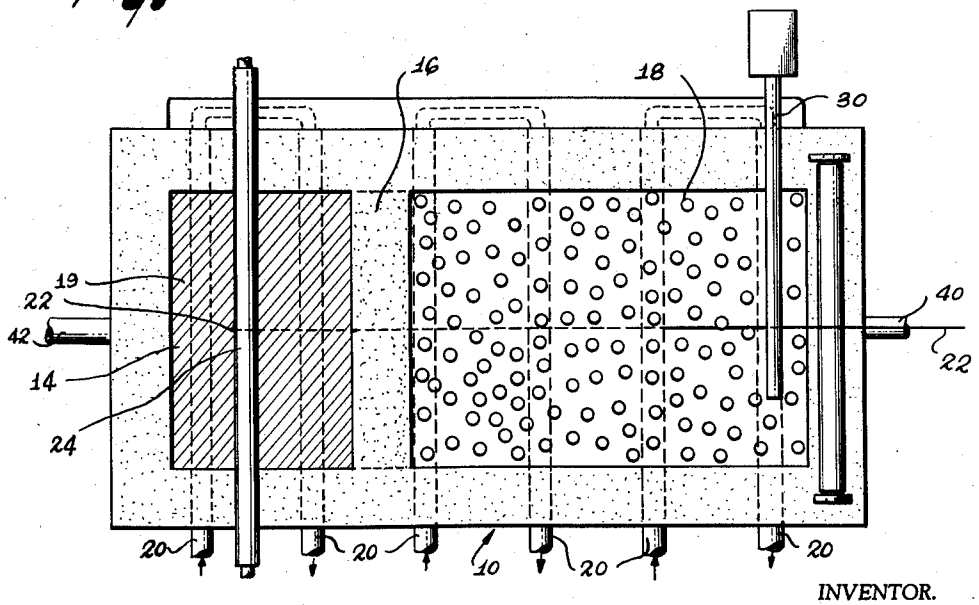


Fig. 2



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METHOD OF COATING METALS

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This invention relates generally to a method and means for coating metal objects with dissimilar materials and more particularly relates to an improved hot-dip method of coating metals with aluminum, magnesium, their respective alloys, mixtures of aluminum with other substances, mixtures of magnesium with other substances, and relates also to a method for coating metals with non-metals such as plastic compounds.

In prior hot-dip aluminizing processes for coating metals, it has been customary to utilize molten salt baths to both heat and clean the metal prior to the actual coating step. On certain types of hot-dip aluminizing processes, wherein the aluminum is in direct contact with the molten salt, the heat is conducted from the molten salt to heat the aluminum thereby avoiding placement of the heating coils or rods in the aluminum melt itself. In this type of conduction-heating process, the molten salt bath thus has several different functions and advantages.

One disadvantage, however, is that upon cooling the salt bath, after a coating run, the salt in the crucible solidifies and renders the cleaning of the salt crucible or replacement of the salt extremely difficult. Similarly, on start-up of a coating run, a large amount of heat (the latent heat of fusion), must first be added to change the state of the salt from solid to liquid. In general then, the necessity of freezing and remelting of the molten salt constitutes its chief drawback.

In view of the foregoing facts, the major object of the present invention is to provide, in coating processes of the type described, an improved method of hot-dip coating of metals which is simpler and more economical than hitherto known.

It is another object of the present invention to provide, in coating processes of the type described, an improved method of conductive heating of the coating metal or other non-metal substances.

A further object of the present invention is to provide a process for the coating of base metal objects wherein improved preheating of the base metal to the proper coating temperature, just prior to the coating, is obtained.

Still another object of the present invention is to provide a process for the coating of metals with a coating metal such as aluminum and aluminum alloys, the coating metal being in direct physical contact with a solid heating medium which is both capable of transferring heat to the aluminum to melt the same and to maintain it in a molten state by direct conduction to the aluminum.

A further object of the present invention is to provide a process for the coating of metals wherein the coating metal is made molten by direct heat transfer contact from heating media, the heating media being in the form of a packed bed of finely divided solids.

These and other objects of the invention will become more clearly understood by referring to the following detailed description and to the accompanying drawings, in which:

Figure 1 is an axial longitudinal cross-section of a

crucible or furnace embodying one form of the invention; and

Figure 2 is a plan view of the furnace of Figure 1.

Referring now to Figures 1 and 2, a refractory crucible or furnace **10** is employed in my process, and preferably is divided into two lower interconnecting compartments **12** and **14** by means of a refractory baffle **16**. The compartments **12** and **14** each contain a multiplicity of very finely divided, highly heat-resistant solid particles which preferably have an apparent density, in the packed bed form, above the density of the coating metal used. The terms granular or particulate, as used both in the claims and specification, includes all forms of finely divided pieced solid materials in the form of fibers, powders, flakes, grains, pellets, tiny spheres and the like, and any other geometric shape. For example, if substantially pure aluminum is the coating metal, the apparent density of the packed bed of finely divided particulate refractory solids may be above 2.7. Manganese oxide, zirconium oxide, or alumina (aluminum oxide) are examples of suitable packed bed materials for use in an aluminizing process. These materials preferably, but not necessarily, have an average size of 0.01 inch or smaller.

It also appears that a packed bed of solids which has an apparent density lighter than that of the aluminum, or other coating metal, can "support" the coating metal because of the surface tension of the coating metal when molten. The surface tension effects prevent the coating metal from penetrating into the interstices of the granular solids. Examples of suitable granular solids having a lighter apparent density than the coating metals used herein are silica, granular, powdered, or fibrous carbon, coke, and charcoal.

The packed bed of particulate solids **18** is heated to temperatures substantially above the melting point of the coating metal whereby to render the coating metal molten by conduction of heat from the packed bed **18** to the coating metal. The heating of the packed bed **18** is conducted in any suitable manner, such as by passing hot gases through a bank of tubes **20** connected to a source of gas (not shown), mounted within the packed bed **18**.

If substantially pure aluminum or an alloy thereof is the coating metal, the packed bed **18** is heated to a temperature preferably between 50–400° F. higher than the coating metal melting point. In most instances, the packed bed temperatures thus lie within the range of 1100–1600° F.

The metal to be coated may be continuous in nature, as wire, strip or sheet, or discrete non-continuous objects, such as individual castings or the like. In Figures 1 and 2, a continuous base metal, such as wire **22**, is shown, by way of example. The base metal **22** is usually first chemically pickled to eliminate oxides, dirt, grease, etc. from the surface thereof and then enters compartment **12**; the base metal then passes through the hot packed bed **18** and around a roller **24** and moves upwardly in the coating compartment **14** through the remainder of the packed bed **18** into the overlying layer of coating metal **19**. The coated wire **22** then is withdrawn from the coating metal layer **19** to other process steps, such as cooling or quenching.

The base metal **22** is preferably heated to the temperature of the packed bed **18** or at least, to the approximate melting point temperature of the coating metal by the time it is ready for the actual coating. In order to facilitate the heat transfer to the metal **22** to be coated, the metal is vibrated in any suitable manner, e.g., mechanically or electro-mechanically. A schematic representation of a mechanically vibrating rod **30** is shown which strikes the metal **22** just prior to its entry into the crucible **10**.

Also, in order to increase the heat transfer character-

istics of the packed bed, it has been found that when an inert gas, such as compressed nitrogen or carbon dioxide, is introduced into the packed bed, as for example along the conduits 40, 42 at such a rate as to fluidize, partially fluidize, or agitate the packed bed in the region of the path of movement of the wire 22, it will substantially increase the rate of heat transfer to the wire 22 or metal to be coated and therefore increase the rate of throughput of the metal 22.

It is also advantageous to fluidize the packed bed 18 in a pulsating discontinuous or intermittent fashion.

Thus, it will be seen that relative motion between the metal 22 and the packed bed 18 is utilized throughout the travel of the metal 22 through the bed 18 and may be employed for only a portion of its travel through the bed, if deemed advisable. It is to be emphasized that the relative motion is to be set up in the region of the path of the metal 22 to increase the rate of heat transfer and prevent channeling of heat introduced into the packed bed 18.

It is also found that a substantial amount of heat is transferred to the metal 22 by radiation, and therefore, the particulate surface actually contacting the metal 22 need not be continuous for good heat transfer.

It may be necessary to prevent oxidation of the aluminum or other coating metal by air-sealing the aluminum; finely ground particles which are lighter than the coating metal are advantageously employed for this purpose, a thin layer of these particles being placed on the exposed aluminum or other coating metal surface. For example, a thin layer of silica, coke or carbon particles or granules may be used. The coke or carbon is especially useful in that it combines with oxygen in the vicinity of the coating metal 19 to form carbon monoxide and carbon dioxide. A hood (not shown) placed over the coating section 14 of the crucible 10 then becomes necessary. Further, any possible oxidation of the metal 22 being coated is minimized by means of an extremely close packing of the packed bed 18.

The coating metals that are used in conjunction with this process are primarily aluminum and magnesium, although other more conventional coating metals may also be employed. Also, mixtures of a coating metal with other substances, such as fluxing materials, ceramic materials and the like, may be employed. Further, non-metals may be coated by means of the above-described process, it being necessary to retain the coating non-metal in its molten or liquid state by means of the heated solids bed. Suitable non-metals are, by way of example, phenol-formaldehyde resins, acrylic resins, and urea-formaldehyde resins and other plastic compounds.

Metals that are suitable for being coated by means of my process include titanium, iron, vanadium, chromium, manganese, cobalt, nickel and copper, and alloys thereof.

It should be noted that while the preferred embodiment herein described comprises a coating metal supported by a heated packed bed, it is also within the scope of my invention to alter the relative positioning of the coating metal and the packed bed, provided they remain in direct contact with each other. Thus, a heated packed bed comprising for example silica or carbon granular solids (these having apparent densities less than that of aluminum and magnesium) can be supported by the coating metal and the base metal passed first into the heated bed, thence through the coating metal, and withdrawn through the packed bed.

While several embodiments of my invention have been described in detail, I do not intend to be limited thereby, but only by the appended claims.

I claim:

1. A method of coating a base metal with a molten coating substance which includes the steps of: placing a coating substance on at least a portion of the surface of a packed bed of finely divided heat-resistant granular solids, said coating substance floating on said packed bed; heating said packed bed to a temperature at least equal to the melting point of said coating substance, said coating substance being melted by heat transferred from said packed bed to said overlying coating metal; passing said metal to be coated into and through said heated packed bed to thereby cause said base metal to be heated; and passing said heated metal from said bed of granular solids directly, without any intervening oxidation, into said molten coating substance to be thereby coated.

2. The process of claim 1 wherein said coating substance is selected from the group consisting of aluminum, aluminum alloys, magnesium, magnesium alloys, aluminum mixtures, magnesium mixtures, and plastic resins.

3. The process of claim 1 wherein said base metal is selected from the group consisting of titanium, vanadium, chromium, manganese, iron, cobalt, nickel and copper and their alloys.

4. The process of claim 1 wherein said granular solids are selected from the group consisting of manganese oxide, aluminum oxide, zirconium oxide, silica and carbon.

5. The process of claim 1 wherein said granular solids have a lower apparent density than said coating substance.

6. The process of claim 1 wherein said granular solids have a higher apparent density than said coating substance.

7. The process of claim 1 wherein said base metal is chemically pickled to eliminate oxides, dirt, and grease just prior to its passage through said heated packed bed.

8. The method of claim 1 wherein heat is transmitted, primarily by conduction, from said packed bed to said molten coating substance.

9. A method of coating a base metal with a molten coating metal which includes the steps of: thermally contacting a coating metal with at least a portion of a packed bed of finely divided heat-resistant granular solids, said packed bed being of higher apparent density than said coating metal, said coating metal being supported by said packed bed; heating said packed bed to a temperature at least equal to the melting point of said coating metal, said coating metal being melted by heat transferred from said packed bed to said overlying coating metal; passing said metal to be coated into and through said heated packed bed to thereby cause said base metal to be heated to a temperature approximately equal to the temperature of said packed bed; imparting relative motion between said packed bed and said base metal for at least a portion of its travel through said packed bed; and passing said heated metal from said bed of granular solids directly, without any intervening oxidation, into said molten coating metal to be thereby coated.

10. The process of claim 9 wherein said relative motion is obtained by vibrating said base metal upon its entry into said packed bed.

11. The process of claim 10 wherein the fluidizing means comprises compressed inert gas.

12. The process of claim 9 wherein said relative motion is obtained by agitating at least a portion of the granular solids in said packed bed in the region of the path of said base metal.

13. The process of claim 9 wherein said relative motion is obtained by fluidizing at least a portion of the granular solids in said packed bed in the region of the path of said base metal.

14. The process of claim 9 wherein said base metal is a continuous piece of material.

15. The process of claim 9 wherein the exposed surface of said coating metal is air-sealed with a multiplicity of granular heat resistant solids.

16. A method of coating a base metal with a molten coating metal which includes the steps of: placing a coating metal on at least a portion of the surface of a

packed bed of finely divided heat-resistant granular solids, said coating metal floating on said packed bed; heating said packed bed to a temperature at least equal to the melting point of said coating metal, said coating metal being melted by heat transferred from said packed bed to said overlying coating metal; passing said metal to be coated into and through said heated packed bed to thereby cause said base metal to be heated to a temperature at least approximately equal to the melting point of said coating metal; and passing said heated metal from said bed of granular solids directly, without any intervening oxidation, into said molten coating metal to be thereby coated.

17. A method of coating a base metal with a molten coating substance, selected from the group consisting of aluminum, aluminum alloys, magnesium, magnesium alloys, aluminum mixtures, magnesium mixtures, and plastic resins, which includes the steps of: thermally contacting a coating substance with at least a portion of the surface of a packed bed of finely divided heat-resistant granular solids, said coating substance overlying said packed bed, and sealing said packed bed from air; heating said packed bed to a temperature at least equal to the melting point of said coating substance; passing said metal to be coated into and through said heated packed bed, the temperature of said base metal, upon exit from said heated bed, being at least equal to the melting point of said coating substance; and passing said heated metal from said bed of granular solids, without any intervening oxidation, into said molten coating substance to be thereby coated.

18. A method of coating a base metal with a molten coating metal which includes the steps of: maintaining a coating metal, in heat transfer relationship, with at least a portion of a packed bed of finely divided heat resistant granular solids, said packed bed having an apparent density less than that of the said coating metal, said coating metal overlying said packed bed, and being maintained in said overlying relationship at least, in part, by its surface tension; heating said packed bed to a temperature at least equal to the melting point of said coating metal; passing said metal to be coated into and through said heated packed bed to thereby cause said base metal to be heated; and passing said heated metal from said bed of granular solids, without intervening oxidation, into said molten coating metal to be thereby coated.

19. A method of coating a base metal with a molten coating substance selected from the group consisting of aluminum, aluminum alloys, magnesium, magnesium alloys, aluminum mixtures, magnesium mixtures, and plastic resins, which comprises: maintaining said coating substance, in overlying heat-transfer relationship with, and at least partially supported by a packed bed of finely divided heat-resistant granular solids; heating said packed bed to a temperature at least equal to the melting point of said coating substance; passing said metal to be coated into and through said heated packed bed, said base metal having a temperature, upon exit from said base metal, approximately equal to the temperature of said packed bed; and passing said heated metal from said bed of granular solids, without intervening oxidation, into said molten coating substance to be thereby coated.

20. The method of coating a base metal with a molten coating metal which includes the steps of: maintaining a coating metal, in heat transfer relationship, with at least a portion of a packed bed of heat resistant granular solids, said coating metal overlying said packed bed; heating said packed bed to a temperature at least equal to the melting point of said coating metal; passing said metal to be coated into and through said heated and packed bed to thereby cause said base metal to be heated to a temperature approximately equal to the temperature

of said packed bed; imparting relative motion between said packed bed and said base metal for at least a portion of its travel through said packed bed; and passing said heated metal from said bed of granular solids, without any intervening oxidation, into said molten coating metal to be thereby coated.

21. A method of claim 20 wherein said relative motion is obtained by fluidizing at least a portion of the granular solids in said packed bed in the region of the path of said base metal.

22. A method of coating a base metal with a molten coating substance, selected from the group consisting of aluminum, aluminum alloys, magnesium, magnesium alloys, aluminum mixtures, magnesium mixtures, and plastic resins, which includes the steps of: thermally contacting a coating substance with at least a portion of the surface of a packed bed of finely divided heat-resistant granular solids, said solids being selected from the group consisting of manganese oxide, aluminum oxide, zirconium oxide, silica, and carbon, said coating substance overlying said packed bed; heating said packed bed to a temperature at least equal to the melting point of said coating substance; passing said metal to be coated into and through said heated packed bed, the temperature of said base metal, upon exit from said heated bed, being at least equal to the melting point of said coating substance; and passing said heated metal from said bed of granular solids, without any intervening oxidation, into said molten coating substance to be thereby coated.

23. A method of coating a base metal with a molten coating substance, selected from the group consisting of aluminum, aluminum alloys, magnesium, magnesium alloys, aluminum mixtures, magnesium mixtures, and plastic resins, which includes the steps of: thermally contacting a coating substance with at least a portion of the surface of a packed bed of finely divided heat-resistant granular solids, said packed bed having a lower apparent density than said coating substance, said coating substance overlying said packed bed; heating said packed bed to a temperature at least equal to the melting point of said coating substance; passing said metal to be coated into and through said heated packed bed, the temperature of said base metal, upon exit from said heated bed, being at least equal to the melting point of said coating substance; and passing said heated metal from said bed of granular solids, without any intervening oxidation, into said molten coating substance to be thereby coated.

24. A method of coating a base metal with a molten coating substance, selected from the group consisting of aluminum, aluminum alloys, magnesium, magnesium alloys, aluminum mixtures, magnesium mixtures, and plastic resins, which includes the steps of: thermally contacting a coating substance with at least a portion of the surface of a packed bed of finely divided heat-resistant granular solids, said packed bed having a higher apparent density than said coating substance, said coating substance overlying said packed bed; heating said packed bed to a temperature at least equal to the melting point of said coating substance; passing said metal to be coated into and through said heated packed bed, the temperature of said base metal, upon exit from said heated bed, being at least equal to the melting point of said coating substance; and passing said heated metal from said bed of granular solids, without any intervening oxidation, into said molten coating substance to be thereby coated.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,935,420 May 3, 1960

Herbert E. Linden

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 29, for "heated" read -- hot base --.

Signed and sealed this 25th day of October 1960.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents