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MOLD COATING

Walter A. Dean, Lakewood, Ohio, assignor to Aluminum Company of America, Pittsburgh, Pa., a corporation of Pennsylvania

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This invention relates to methods of coating, and coatings for surfaces of mold cavities into which molten light metal, such as aluminum and aluminum alloys and magnesium and magnesium alloys, is to be cast. Such surfaces are usually composed of mold wall, cores and chills cooperating to form and define a cavity in the mold. While generally applicable to any mold, the invention has particular reference to molds of the permanent or semi-permanent type in which at least a portion of the mold cavity surface is composed of a relatively permanent material such as steel, cast iron or other metal. The invention is particularly useful in the casting of magnesium and alloys thereof and is specifically directed to the problems arising when that molten metal, or alloys containing substantial amounts thereof, contacts coatings provided on the surfaces of the mold cavity.

Coatings are usually applied to the walls of a mold cavity, prior to casting molten metal therein, to prevent a sudden chilling of that portion of the metal which contacts the surfaces of the mold cavity, to prevent reaction between mold material and molten metal, to prevent cavity wall erosion and sticking of the metal casting to the mold wall, and to serve other purposes, all of which are well known in the foundry art. For successful operation the coating should have the required thermal characteristics, should provide a surface from which a casting of smooth clean surface may be obtained, should promote ready and exact filling of the mold cavity by the molten metal and should be resistant to the erosive or abrasive action of the incoming metal, as well as capable of preserving its physical integrity under the varying thermal conditions to which it is necessarily subjected during repeated casting operations. It is desirable that a balance of all of these qualities be obtained with the end in view of producing a sound satisfactory casting without constant expensive interruption of the casting process to renew the coating on the casting cavity.

This invention is directed to that general object, its specific object being to provide coated molds, methods of casting and coatings which will meet the peculiar problems which occur in the casting of light metals and alloys. In achieving these objects, as hereinafter described, the invention provides coatings, methods of coating and coated molds which are particularly suited to the casting of magnesium and those alloys of magnesium which contain that metal in such amount as to lend to the alloy the well known reactive characteristics of that metal.

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The coatings of this invention are comprised of two general elements—binder and insulator or body material. The coatings are applied to the mold cavity surfaces by means of a carrier, liquid in character, which is usually water, although other liquids may be used. The proportions or concentration of this carrier with respect to the coating will depend upon the operator's needs and the manner in which the coating is to be applied, for instance, by spraying, brushing or the like. The insulator or body material may be one or more of many inorganic materials which are used to perform this function in mold coatings. Their specific selection may depend upon several factors, including the temperatures involved, the thermal characteristics required, the nature of the desired surface of the casting to be produced (smooth or rough) and, with regard to obtaining optimum coating quality and performance under particular molding conditions, the binder employed. As is later specifically noted, colloidal graphite, furnace slag and vermiculite are particular insulators which are adapted to achieve optimum benefits and specific results in the practice of this invention, but other inorganic materials such as, for instance, other forms of graphite, magnesium oxide, diatomaceous silica, asbestos, soapstone, china clays, and the like, may also be used toward the obtainment of the general objects above stated. Any one or several of these and other insulators may be used in one coating. The proportion of insulator to binder in the final coating is governed by considerations specific and immediate to the foundry conditions faced by the operator, and selection of specific proportions is governed by the intricacy and size of the mold cavity, the particular light metal or alloy being handled, the relative binding quality of the binder, the bulk and covering power of the insulator, the thickness of coating desired and other well known factors. In any event, absolute proportions are a matter of simple and routine selection.

The binder promotes adherence of the particles of the insulator or body material to the mold wall and forms a matrix which gives continuity to the coating and may also serve to protect the insulator particles against erosion or attack of the molten metal. Binders previously used for this purpose have not been entirely satisfactory in the casting of magnesium and its alloys. The problem has been to provide a binder which is not subject to attack by that highly reactive metal and which would also bind the insulator particles to the mold in the form of a continuous coating. Binders, such as sodium silicate, which have previously been used for this purpose have often been found to be inadequate, particularly as regards resistance to attack by the molten metal at elevated temperatures. The result has been that the coatings failed within a relatively short time, thus necessitating frequent interruption of the casting process in order to renew the coating.

According to my invention I provide a binder of soluble stable phosphate which not only withstands the action of the molten metal to a remarkable degree, but also fulfills the other functions which are necessary to the provision of a relatively hard, adherent and continuous coating upon the mold cavity surfaces. By "soluble stable phosphate" is meant phosphates which are, initially, substantially soluble as such in the carrier and which do not melt or cease to exist as phosphate at the temperatures reached during the casting operations. Of such soluble stable phosphates the phosphates of those alkali metals of atomic weight between 20 and 40 are preferred, the preferred results being obtained with sodium phosphate.

A mold coating compounded in accordance with this invention will therefore comprise a binder of soluble phosphate, preferably sodium phosphate, and insulator or body material. Such a coating is particularly adapted to the casting of magnesium and those alloys which contain that reactive metal in such amounts as to cause similar reactive characteristics in the alloy. The coating is substantially inert to the molten metal, as compared with previously used coatings, is hard and is relatively stable in the sense that it does not easily crack or spall under the conditions of casting. While the inorganic insulator or body material used in these coatings may be chosen from the wide range of such materials available in order to meet the particular conditions of casting such as, for example, the thermal conditions, the type of coating surface desired, the complexity of the mold cavity and the particular light metal or alloy being cast, I have found that the inert insulators vermiculite, furnace slag and colloidal graphite act with the soluble phosphate binder to produce superior coatings which are particularly adapted to the casting of magnesium and its alloys. When these insulators are present in the coating, other insulators, an excellent example of which is the diatomaceous silica known as Silocel, may advantageously be added to further vary the characteristics of the coating.

A desirable property of the soluble stable phosphate-bound coatings which are the subject of this invention is their relative permanence under the conditions met in casting in permanent molds. In large modern foundries permanent mold casting is a relatively continuous operation in which costs depend, to a substantial extent, upon lack of interruption of the casting routine. The molds used are, through one or several production days, permanent, and a continuous supply of molten metal to such molds is merely a matter of arrangement. Given good foundry conditions the casting routine can therefore proceed uninterrupted provided that the coating on the mold cavity surfaces does not fail and thus necessitate interruption of foundry procedure in order that it may be renewed. Mold cavity coatings for the casting of light metals and alloys thereof, including the superior coatings compounded in accordance with the principles of this invention, do not achieve a permanence of the same character as that of the molds to which they are applied, and this is particularly true in the casting of magnesium and its alloys.

To further increase the longevity of a mold coating I provide the mold coating with a superficial layer of soluble phosphate, preferably sodium phosphate. This layer is applied to the surface of the mold coating in any convenient manner as by spraying and when dried forms a hard surface which adds to the effective life of the mold coating without materially altering its functional characteristics. If sprayed while the mold surfaces are at elevated temperature, as is often the practice in applying mold coatings, drying will be substantially instantaneous. When applied to any mold coating, including the soluble phosphate-bound coatings which are the subject of this invention, as well as the coatings which they are designed to replace, this facing or layer of soluble stable phosphate serves to minimize reaction between molten magnesium or its alloys and the coating. In applying this superficial layer of soluble phosphate, neither the manner of application nor the concentration of the phosphate in the solution is a critical factor. The concentration employed will govern the number of applications necessary to produce a superficial layer of a given thickness. A solution of 20 per cent by weight of sodium phosphate

$$(Na_3PO_4.12H_2O)$$

has given good results when applied by a spray. The desirable result is a well-dried continuous superficial hard layer of soluble stable phosphate imposed on the mold coating.

Where the mold cavity is, at least in part, defined by a non-permanent material, such as a sand core, no problem of permanence arises since the cavity is, to that extent, destroyed after each casting operation. However, the value of the superficial layer in decreasing the reaction of the molten metal on the core coating and in preventing erosion during casting is sufficiently great as to justify its use in many cases.

As examples of mold coating compounded in accordance with the principles of this invention and particularly useful in the casting of magnesium and of alloys containing that metal may be cited the following:

Coating A

Sodium phosphate	grams	25
Vermiculite	do	40

Carrier, 100 cubic centimeters of water.

Coating B

Sodium phosphate	grams	25
Blast furnace slag	do	25

Carrier, 100 cubic centimeters of water.

Coating C

Sodium phosphate ____ grams __ 25
Aquadag, 100 cubic centimeters (colloidal graphite in water suspension, the water likewise acting as the carrier).

The relative proportions of binder and insulator in these particular coatings are adjusted for use in the casting of a magnesium base alloy in a permanent mold of relatively intricate cavity shape. Such specific proportions form no part of this invention and may be varied by the operator to meet specific conditions. Usually the soluble stable phosphate is preferably present in amounts not less than about 25 per cent by weight of the total weight of binder and insulator, but percentages expressed by weight are not necessarily significant since some insulators, such as Silocel, asbestos and others, have a very low weight per unit volume. Simple trial will indicate the amount of soluble phosphate necessary to bind the insulator to the mold and to produce the desirable continuity and thickness of coating. These coatings may be used as such, but in the preferred embodiment of the invention they are provided with the superficial layer of soluble phosphate above described.

The mold coatings herein described may be applied directly to the surfaces of the mold cavity. In some instances it may be desirable to first wash the mold cavity surfaces with a preliminary wash or coating to obtain a surface to which the mold coating will more readily adhere. The use of such preliminary washes or base coatings is well known. Their use is, of course, no part of this invention, and since they are completely covered by the mold coating applied thereon, they do not contact the molten metal poured into the mold cavity. Other similar steps such as are normally used in foundry practice may be undertaken in connection with the practice of the present invention.

Following is a specific example of the practice of the invention herein described in its preferred form:

The mold used was made of cast iron. Steel cores were used. The molten metal cast into this mold was a magnesium base alloy containing about 90 per cent of magnesium. The metal-receiving surfaces of the mold cavity were first treated with a base wash to promote adherence of the mold coating. The mold cavity surfaces thus prepared were then coated with a mold coating composed of

	Grams
Finely divided vermiculite	200
Sodium phosphate ($Na_3PO_4.12H_2O$)	125

this coating being applied in a carrier consisting of one half liter of water. The coating thus formed was sprayed with an aqueous solution of soluble phosphate (100 grams of $Na_3PO_4.12H_2O$ in 250 cubic centimeters of water) to form the superficial protective layer above described. Castings were then poured until the coating thus formed on the mold cavity surface failed. Failure as noted by discoloration of the casting or the coating or by spalling or cracking of the coating did not take place until 33 casts had been made as compared with a failure of previously used coatings after about 4 casts. Such a comparison in this particular instance is numerically indicative rather than absolute. In all cases, however, the coatings of the present invention have been observed to be superior to previously used coatings.

While certain preferred embodiments of the invention, and specific examples thereof, have been described, it will be understood that such are by way of example only and that the invention may be otherwise practiced within the scope of the appended claims. It will also be understood that the mold cavity "surfaces" referred to in the appended claims may be originally bare or originally provided with a preliminary or base coating.

I claim:

1. In the coating of mold cavities into which molten light metal is to be cast, the improvement consisting in providing on at least part of the mold cavity surfaces a coating comprising a binder of substantially soluble stable phosphate and inorganic insulator material and thereafter applying to the coating thus formed a superficial layer of substantially soluble stable phosphate.

2. In the coating of mold cavities into which molten light metal is to be cast, the improvement consisting in providing on at least part of the mold cavity surfaces a coating comprising a binder of substantially soluble stable phosphate and inorganic insulator material and thereafter applying to the coating thus formed a layer of a phosphate of an alkali metal of atomic weight between 20 and 40.

3. In the coating of mold cavities into which molten light metal is to be cast, the improvement consisting in providing on at least part of the mold cavity surfaces a coating comprising a binder of substantially soluble stable phosphate and inorganic insulator material and thereafter applying a solution of sodium phosphate to said coating to form thereon a superficial layer of said phosphate.

4. In the method of casting light metal into mold cavities at least a portion of the surfaces of which are provided with a coating containing a binder and inorganic insulator material, the improvement consisting in facing the coating with a layer of substantially soluble stable phosphate.

5. In the method of casting light metal into mold cavities at least a portion of the surfaces of which are provided with a coating containing a binder and inorganic insulator material, the improvement consisting in facing the coating with a layer of sodium phosphate.

6. In combination a mold cavity surface, a coating containing a binder and inorganic insulator material on said surface and a layer of substantially soluble stable phosphate on the surface of said coating.

7. In combination a mold cavity surface, a coating composed of substantially soluble stable phosphate and inorganic insulator material on said surface and a layer of sodium phosphate on the surface of said coating.

8. In the casting of magnesium and alloys thereof in permanent molds at least part of the mold cavity surfaces of which are provided with a coating containing a binder and inorganic insulator material, the improvement consisting in applying to the outer surface of said coating a layer of substantially soluble stable phosphate.

9. In the casting of magnesium and alloys thereof in permanent molds the mold cavity surfaces of which are provided, at least in part, with a coating containing a binder and inorganic insulator material, the improvement consisting in applying to the outer surface of said coating a layer of sodium phosphate.

WALTER A. DEAN.

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