

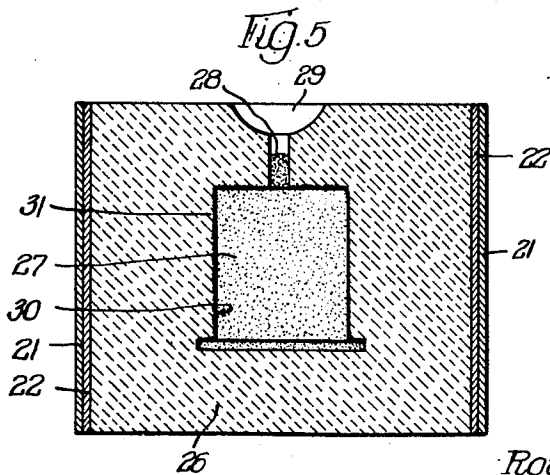
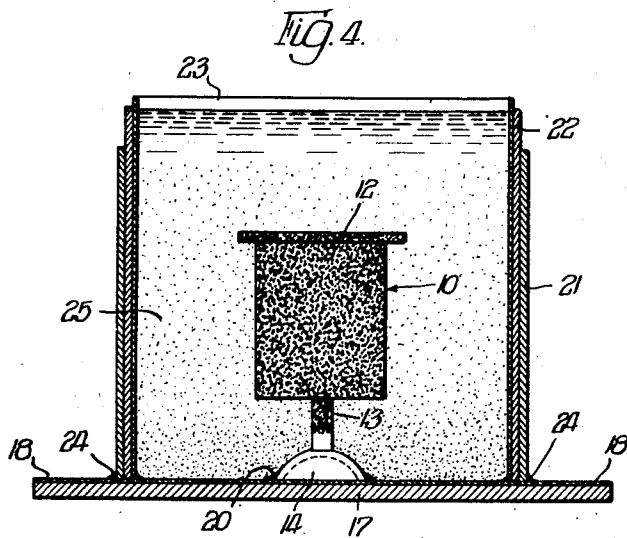
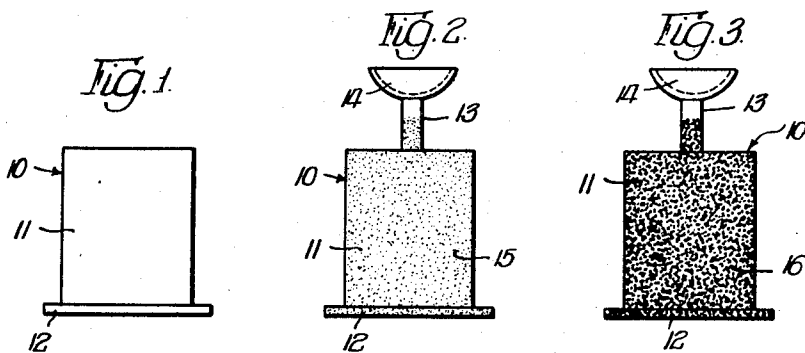
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CASTING MOLD

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2,491,096

CASTING MOLD

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5 Claims. (Cl. 22-189)

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This invention relates, in general, to the art of casting, and has particular relation to improvements in the coating of the casting surfaces of refractory molds.

The present invention may be characterized as an improvement in coatings for the casting surfaces of refractory molds of the general character of the coatings disclosed and claimed in the copending application of Roy C. Feagin and Eric H. Zahn, Serial No. 538,166, filed May 31, 1944 (now United States Patent No. 2,441,695, patented May 18, 1948) and, more particularly, as an improvement in the dipcoat composition of the above application.

While the particular embodiment of the invention which I shall describe hereinafter in connection with the drawing has to do with the coating of the casting surfaces of refractory molds for casting articles of high fusing metals and alloys, it is to be understood that the invention is not limited to the character or use of the mold except to the extent that such limitations are expressly included in the appended claims.

One of the main objects of the present invention is to provide, for the casting surfaces of refractory molds, an improved coating which has a high degree of refractoriness and a high degree of hardness.

Another object of the invention is to provide a coating having this high degree of refractoriness and high degree of hardness and which will eliminate or reduce the tendency to form oxide or slag coatings on relatively high melting alloys or metals such as stainless steel, Stellite, the cobalt-chromium-molybdenum alloys disclosed in Charles H. Prange patents Reissue No. 20,877, reissued October 4, 1938, No. 2,135,600, patented November 8, 1938, and No. 2,180,549, patented November 21, 1939, and Albert W. Merrick Patent No. 2,381,459, patented August 7, 1945, or other high melting alloys containing chromium.

Another object of the invention is to provide a coating having a high degree of refractoriness and high degree of hardness combined with a high degree of surface smoothness; also relatively great strength and substantial resistance to water.

Another object of the invention is to provide a coating against which a relatively high melting metal or alloy is adapted to be cast and of a character to produce a casting with a glossy, oxide-free surface; more particularly, a refractory coating composition of a character to form

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a eutectic which will eliminate or reduce the presence of oxide on the casting.

Another object of the invention is to provide an improved combination of the improved coating of the present invention with an all silica mold body; also with a mold body comprising a refractory from the group consisting of zircon and zirconium oxide.

Further objects and advantages of the invention will become apparent from the following detailed description, taken in connection with the accompanying drawing in which:

Figure 1 is a schematic view showing in simplified form a pattern of an article to be cast;

Figure 2 is a view similar to Figure 1; showing the pattern provided with a sprue element, and also showing applied to the pattern the coating for forming the casting surface on the mold body;

Figure 3 is a view similar to Figure 2, showing applied to the coated pattern a material for bonding or anchoring the coating to the mold body;

Figure 4 is a more or less schematic sectional view showing one illustrative manner in which the refractory mold is formed about the pattern; and

Figure 5 is a sectional view through the completed refractory mold after eliminating the pattern.

Referring to the drawing, the reference character 10 designates a pattern of an article to be cast. While this pattern 10 is shown as comprising a cylindrical body 11 having a base flange 12, it is to be understood that the shape of the pattern will vary according to the article to be cast and that the pattern shown in the drawing is of simplified form for purposes of illustration. It may be shaped, for example, for use in casting turbine buckets of the character disclosed and claimed in Albert W. Merrick Patent No. 2,381,459, issued August 7, 1945, or it may be shaped for use in making dental castings or in casting other articles, as suitable and desired.

The pattern 10 is preferably formed of low fusing material, such as wax, or of any other vaporizable of fusible or combustible or destructible material. The pattern may be cast under force or pressure in known manner so as to reproduce accurately the desired article as to dimensions and configuration, and as to all fine detail.

Having produced the pattern 10 of Figure 1, a sprue element 13 is attached to such pattern. The sprue element 13 has, at its outer end, a

pouring-basin-forming part 14. The element 13 and part 14 are formed of a vaporizable or fusible or combustible or destructible material corresponding with the material of the pattern 10.

The pattern 10 of Figure 2, with the sprue 13 and its basin-forming part 14 attached thereto, is then coated with the coating material which is to form the casting surface of the refractory mold. This coating material, in its preferred form, is prepared by mixing a suitable quantity of comminuted refractory material with a binding agent and a film forming material which will harden by air-drying. The comminuted refractory material of the coating is finely ground, for example, to approximately minus 150 mesh, or finer; i. e., in certain embodiments of the invention, to approximately minus 325 mesh.

According to the present invention, the refractory portion of the coating consists of at least two different refractories of a character and combined in such proportions as to produce a lower fusing point than either of the refractories alone, whereby to reduce the tendency to form oxide and scale coatings on high melting alloy or metal castings. These refractory portions of the coatings—particular examples of which will hereinafter appear—also produce coatings which have a high degree of refractoriness and a high degree of hardness combined with the relatively little or less tendency to form oxide and scale coatings on relatively high melting alloys or metals, for example, such as stainless steel, Stellite, the cobalt-chromium-molybdenum alloys previously mentioned, or other high melting alloys containing chromium. These refractory portions of the coatings have these properties combined with a high degree of surface smoothness; also relatively great strength and substantial resistance to water; and will provide the maximum of detail present in the pattern itself.

In order to produce a coating which will be flexible to the desired extent, glycerin is preferably employed in the refractory mix for forming the primary investment coating. Due to its hygroscopic character it prevents rapid drying of the coating, and, subsequently, the cracking and peeling of the coating from the pattern. The best range of this constituent is from approximately 0% to approximately 20% of the liquid content of the mix.

Sodium silicate or water glass is preferably added to the mix as the binding agent for the refractory constituent of the coating. This binding agent is preferably employed in quantity sufficient to add strength to the refractory mix, both in the dried stage and in the fired stage, preparatory to receiving the molten metal or alloy. While it is not highly desirable to use an excessive amount of sodium silicate in the coating, this substance should constitute at least approximately 10%, and preferably from approximately 10% to approximately 40% of the liquid constituent. Binders other than sodium silicate may be used in the refractory mix for forming the primary investment coating, as will hereinafter appear.

Hydrochloric acid may be added to the mix as the setting or gelling agent for the binder. It reacts with the sodium silicate to form a hydrous silicic acid gel. Other acids may be used, such as sulphuric, phosphoric, lactic and the like. Where acid is used it may be varied from 0% to approximately 25% of the liquid content of the refractory mix which forms the primary invest-

ment coating. A higher acid content is preferably avoided since it may produce instantaneous gelling, resulting in a lumpy mix within the refractory composition, thereby producing an unsatisfactory coating.

For the purpose of providing an additional binding effect which renders the coating stronger and more resistant to water—also, somewhat harder—ammonium alginate may be added to the refractory mix.

The percentage of this constituent can be varied widely, depending upon the particular characteristics desired in the primary investment coating. I contemplate varying the content of ammonium alginate from approximately 1% to approximately 10% of the total weight of the mix. Where this material is employed it serves as a low temperature film-forming binder and gives the coating composition certain of its advantageous characteristics as set forth in the patent of Roy C. Feagin and Eric H. Zahn, previously identified. Similar materials may be used which fall in the class comprising algin, sodium alginate, and other water soluble alginates. The algin and alginates form a hard, tough film on drying from solution. Solutions of these materials may be gelled by the addition of acids, salts, and organic solvents.

For the purpose of assuring a smooth coating of the pattern with the refractory mix, a wetting agent—such as sulfate—a hydrocarbon sulfonate and OT (sodium dioctyl sulfo-succinate) sulphate of higher alcohols or the like—is preferably used in the mix. The range of such substance may vary from approximately .01% to approximately 1.0% of total weight. Excessive use of the wetting agent may form bubbles in the coating composition, resulting in rough castings, and therefore should be avoided.

In order to minimize bubble formation in the mixture and in the coating on the pattern, a defoaming agent is preferably employed in the mix. Octyl alcohol is a suitable defoaming agent, but other defoaming agents—such as "Fomax"—may be used. The percentage of this ingredient may vary from approximately .01% to approximately 0.10%.

One typical composition embodying the present invention and suitable as the refractory coating mix is as follows:

Water	cc	290
Glycerin	cc	45
Water glass	cc	90
Hydrochloric acid (4.42% by weight)	cc	65
6% ammonium alginate solution	cc	15
Octyl alcohol	cc	0.3
7.5% wetting agent	cc	7.5
Zircon (approximately—325 mesh)	lbs	1.5
Fused alumina (approximately 450 mesh)	lbs	1.5

This composition has less tendency to form oxide or slag coatings on relatively high melting alloys or metals, such as stainless steel, Stellite, the cobalt-chromium-molybdenum alloys previously mentioned, or other high melting alloys containing chromium. There is very slight reaction between these alloys and the refractory mold surfaces. Very little of the refractory adheres to the casting, thereby enabling the casting to be finished with a minimum of machine work and finishing operations.

The coating composition as exemplified by the foregoing example may be termed the primary investment coating. After the constituents are combined and thoroughly mixed, the pattern 10 is

completely coated with this material, as shown, for example, at 15 in Figure 2 of the drawing. The coating of the pattern is preferably accomplished by dipping the pattern in the coating solution. This is quicker than spraying the coating on the pattern. Dipping also assures more uniform and smooth coating of all surfaces of the pattern. The advantages of the dipping method of applying the coating are fully covered in the previously identified patent of Roy C. Feagin and Eric H. Zahn.

I have found that satisfactory coatings can be produced using no acid or alginate in the coating compositions, and therefore I do not intend to be limited to the use of an acid or alginate in the coating composition.

I do not, at least within certain aspects of the present invention, intend to be limited to this particular method of applying the coating 15 to the pattern. Where the dipping method of applying the coating is not expressly included in the claims, I intend to cover the primary investment coating per se, regardless of whether it is applied by dipping, spraying, stuccoing, painting it on the pattern, or in other suitable manner.

After the pattern 10 has been thoroughly coated with the primary investment material 15 and while the coating 15 is still wet, the surface is thoroughly covered, for example, by sprinkling it with refractory material in relatively coarse particle form. Silica graded from approximately 50 mesh to approximately 100 mesh may be used, as described in the previously mentioned patent of Roy C. Feagin and Eric H. Zahn. Other refractory materials, such as those described in the above application and as will hereinafter appear, may, of course, be employed for covering the coated surface of the pattern.

The layer of coarse refractory particles covering the coating 15 is shown at 16. The sprinkling of the wet pattern with the coarse refractory particles is termed "sanding." After the wet pattern has been thoroughly "sanded," the excess coarse refractory particles are shaken off and the dipped and "sanded" pattern is allowed to dry. The coarse refractory particles 16, as applied to the surface of the coating 15, penetrate the coating 15 to varying depths, and are thus effectively bonded in place.

After air-setting of the dipped and "sanded" pattern, the primary coating consists of a roughened exterior surface brought about by the bonding and drying of the coarse refractory particles on its surface. This roughened surface interlocks with the secondary investment composition forming the body of the mold effectively to bond or anchor the coating in place. Moreover, the "sanding" operation assists in fixing the coating 15 in place by preventing a drainage or flow thereof along the surface of the pattern, for example, from the high points of the pattern.

Where a heavier primary coating is desired, it can be provided on a commercial scale by dipping and "sanding" the destructible pattern as above described, permitting the dipped and "sanded" pattern to air-dry, and subsequently repeating the operation of dipping and "sanding" to build up the thickness of the primary coating to the desired degree.

The application of the outer coating 16 of coarse refractory particles also tends to prevent cracking or crazing of the primary investment as it sets or dries, the layer of the primary investment remaining in contact with the pattern being appreciably thinner than when it is initially applied, due to the flow thereof between the par-

ticles of the outer coarse layer 16. This also has the advantage of tending to eliminate or reduce any difference in expansion of the primary investment relative to the investment material constituting the body of the mold.

Further examples of refractory portions for use with the coating or dipcoat composition 15, in lieu of the refractory portion of such coating as previously described, are as follows:

	Per cent
I. Alundum, crystalline (approximately—600 mesh)-----	25
Zirconia, electrically fused (approximately—325 mesh)-----	75
II. Alundum (approximately—600 mesh)	10
Flint (approximately—200 mesh)-----	90
Sanded with 100–150 mesh zircon	
III. Alundum (approximately—600 mesh)	25
Flint (approximately—200 mesh)-----	75
Sanded with 100–120 mesh crystalline Alundum	
IV. Magnesia, electrically fused (approximately—220 mesh)-----	75
Zircon (approximately—325 mesh)---	25
Sanded with 100–120 mesh Alundum	
V. Alundum (approximately—600 mesh)	15
Flint (approximately—200 mesh)-----	85
VI. Alundum (approximately—600 mesh)	10
Zirconia (approximately—325 mesh)---	25
Flint (approximately—200 mesh)-----	65
VII. Alundum (approximately—600 mesh)	10
Flint (approximately—200 mesh)-----	25
Zirconia (approximately—325 mesh)---	65
VIII. Zirconia (approximately—200 mesh)---	100
Sanded with 100–120 mesh Alundum	
IX. Flint (approximately—200 mesh)-----	50
Zircon (approximately—325 mesh)---	50
X. Zirconia (approximately—325 mesh)---	50
Flint (approximately—200 mesh)-----	50

I find that with Example I of coating refractory, sanded with approximately 100 mesh sand, perfect detail is obtained with very little oxide formation; that Example II, sanded as indicated, provides excellent detail and glossy areas; that Example III, sanded as indicated, provides a glossy surface and no oxide; that with Example IV of coating refractory, sanded with approximately 100–120 mesh Alundum, good detail is obtained with but slight oxide formation; that Example V provides an excellent surface and no oxide; that with Examples VI and VII of coating refractories, sanded with approximately 100 mesh sand, excellent castings are obtained without oxide formation; and that with Examples VIII, IX, and X, sanded with approximately 100 mesh sand, excellent castings are obtained with but very slight oxide formation.

Further examples of refractory portions for use with the coating or dipcoat composition 15 in lieu of the refractory portions of these coatings as previously described are as follows:

	Per cent
XI. Zirconium oxide-----	78
Magnesium oxide (calcined)-----	22
XII. Titanium oxide-----	10
Flint -----	90

The fusing point of Example XI is approximately 1550° C. The fusing point of Example XII is approximately 1540° C. These figures are based on equilibrium diagrams in the book "Refractories," by F. H. Norton.

The dipcoats above described form a relatively low fusing coating because of solid reaction at

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high temperature. With a mixture such as flint and alumina, for example, a lower melting eutectic formation is provided. This eliminates, or materially reduces, the oxide on the casting.

Usually at higher temperatures there is present in these mixtures a liquid phase. The same is true of the following compositions:

	Per cent
XIII. Alundum -----	20
Flint -----	80
XIV. Alundum -----	10
Zirconium oxide -----	25
Flint -----	65

It seems that the slight fusion of these coatings upon contact with the hot metal causes a reaction with the metal oxide and fuses with it. This might account for the adherence of the oxide to the coating and not to the casting, thereby producing a glossy, oxide-free casting. There also appears to be an inhibiting action toward oxide formation by the use of these refractory mixtures. The fusion points will be somewhat lowered by the use of sodium silicate bond. I do not, of course, intend to be limited to the theory set forth, but reserve the right to revise or correct the same as may become necessary.

After the pattern is coated and "sanded" and the coating has dried, a suitable mold of refractory material is formed about the pattern, including the sprue 13 thereof, which sprue is allowed to extend through the wall of the refractory mold so as to permit the escape of the material of the pattern and to form an ingate for the fluid metal. The refractory mold may be formed about the pattern in any known or suitable manner. This procedure, therefore, will not be described in detail except to state that the secondary investment material for forming the body of the mold is indicated at 25 in Figure 4, whereas the completed refractory mold is indicated at 26 in Figure 5. The plate 17 is shown as having a coating of wax or other suitable material at 18 to which the basin-forming element 14 is waxed or otherwise suitably secured at 20. The investment sleeve 21, preferably of heat resistant alloy, is shown as having an asbestos liner 22 and an inner paper liner 23, and as waxed to coating 18, at 24.

The secondary investment material for forming the body of the mold 26 may, for example, be the silica investment having a tetra-ethyl silicate binder according to Arthur B. Ray Patent No. 2,027,932, issued January 14, 1936, or it may be the investment material disclosed and claimed in Paul F. Collins Patent No. 2,380,945, issued August 7, 1945, or any other suitable secondary investment material may be used.

I further contemplate, for use as a secondary investment 25 for forming the body 26 of the mold, a composition of zircon cement from approximately 25% to approximately 35%, ground calcined fire clay or "P" grog approximately 50%, and sand (approximately 100 mesh) from approximately 15% to approximately 25%; also a composition of zircon cement approximately 25%, banding sand (approximately 60 mesh) approximately 50%, and sand (approximately 100 mesh) approximately 25%; also a composition of zircon cement approximately 25%, silica (approximately 80 mesh) approximately 15%, sand (approximately 100 mesh) approximately 15%, silica (approximately 60 mesh) approximately 20%, and ground calcined fire clay or "P" grog approximately 25%; also a composition of zircon cement approximately 35%,

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sand (approximately 100 mesh) approximately 15%, and ground grog (marketed by Seaboard Refractories Company) approximately 50%; and a composition of zircon cement approximately 35%, silica (approximately 80 mesh) approximately 10%, and grog (approximately—20 mesh), marketed by Brooklyn Fire Brick Company, approximately 55%.

The general procedure with the last mentioned form of secondary investment is to mix the cement or refractory mixture with a definite quantity of water and pour it into the mold with some vibration during the pouring, and then allow the mold to set. The setting time may be regulated from three minutes up. The advantages of a material of this type are apparent. It is extremely simple, no binder is required, and the molds do not require any packing on the vibrator. The refractory mixture sets like plaster, but does not decompose like plaster when heated up at a temperature suitable for casting high fusing alloys. The investment is not expensive, nor is it inflammable. Consequently, there is no fire hazard.

When the refractory mold 26 has solidified or set sufficiently, it is subjected to heat at a temperature about or slightly above the fusing point of the material of the pattern, this material, when melted, escaping through the opening 28 formed by the sprue 13. This leaves the casting cavity 27 with a smooth, glossy coating having the properties set forth. In forming the mold 26 about the pattern, the wet investment material 25 flows into and fills the interstices in the rough outer surface of the coating, thereby anchoring the coating to the body of the refractory mold 26.

Upon completion of the mold 26, metal having the desired properties for the finished casting is poured or otherwise introduced into the mold cavity 27. The resulting casting, which may have extreme hardness and be difficult to machine, has a high degree of surface smoothness and detail, and requires little, if any, finishing of the article after the casting operation. After the casting has been made, the refractory mold 26 may be broken to permit removal of the casting.

I do not intend to be limited to the precise details or to the precise embodiments of the invention shown and described, as variations in the details and other embodiments are contemplated within the scope of the appended claims.

I claim:

1. A refractory mold having a body composed of a refractory and a binder, and a casting surface for said mold body comprising a binder and a refractory portion more finely ground than the refractory of the mold body, the relatively finely ground refractory portion of said casting surface consisting essentially of at least two different refractories of a character and combined in such proportions as to produce a lower fusing point than either of the refractories alone whereby to reduce the tendency to form oxide and scale coatings on high melting alloy or metal castings.

2. A refractory mold according to claim 1 wherein the two or more different refractories of the casting surface consist essentially of silica and alumina.

3. A refractory mold according to claim 1 wherein the two or more different refractories of the casting surface consist essentially of flint and alumina.

4. A refractory mold according to claim 1 wherein the two or more different refractories of

the casting surface consist essentially of silica, alumina and zircon.

5. A refractory mold according to claim 1 wherein two or more different refractories of the casting surface consist essentially of silica, alumina and zirconium oxide.

ROY C. FEAGIN.

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