May 18, 1948. R. C. FEAGIN ET AL 2,441,695

CASTING MOLD

Filed May 31, 1944

Fig. 1.

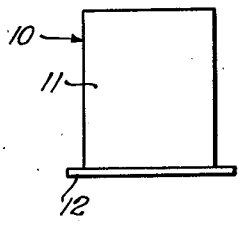


Fig. 2.

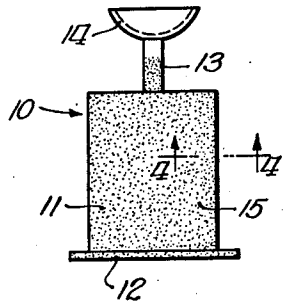


Fig. 3.

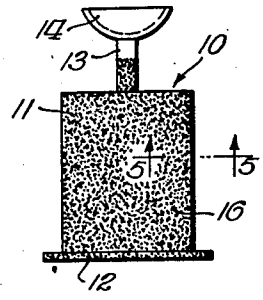


Fig. 4.

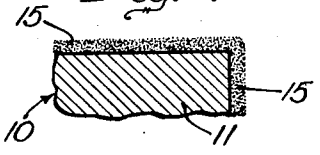


Fig. 5.

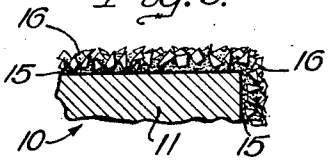


Fig. 6.

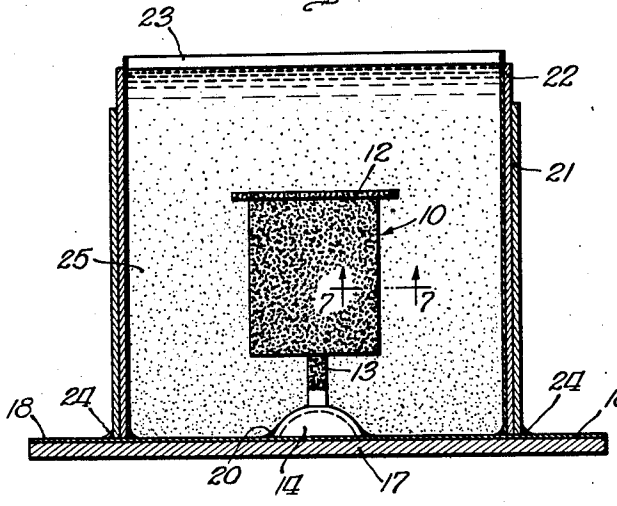


Fig. 7.

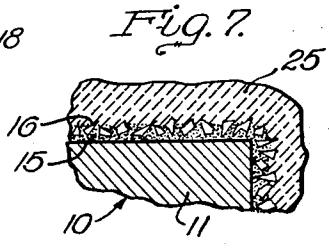


Fig. 8.

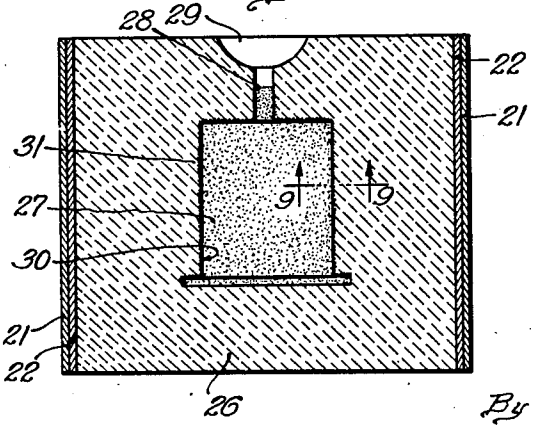
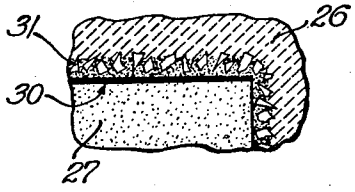


Fig. 9.



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UNITED STATES PATENT OFFICE

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CASTING MOLD

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Application May 31, 1944, Serial No. 538,166

7 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.

While the particular embodiment of the invention which we 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 having a high degree of surface smoothness; also relatively great strength and substantial resistance to water.

Another object of the invention is to provide in conjunction with this improved coating a layer of material preferably coextensive with such coating, and of a character effectively to bond or anchor the coating to the refractory mold body; this bonding or anchoring material preventing separation of the coating from the body of the mold and cracking and breaking of the coating (with resulting defects in the casting), particularly when the mold is heated to a high temperature preliminary to casting and in pouring the molten material, such as a high fusing metal or alloy, into the mold.

Another object of the invention is to provide improvements of the character set forth which will render possible precision casting of articles which have extreme hardness and are difficult to finish, whereby such articles are cast consistently with a high degree of surface smoothness and detail, and require little, if any, finishing of the articles after the casting operation.

Another object of the invention is to provide an improved method of applying the coating material to the low fusing destructible pattern from which the coating and bonding or anchoring material are transferred to the mold body.

Another object of the invention is to provide an improved refractory mold having its casting surface coated with the improved coating material and having the coating bonded to the mold body in accordance with the present invention.

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

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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 smooth casting surface on the mold body;

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

Figure 4 is a fragmentary microscopic section taken on the line 4—4 of Figure 2;

Figure 5 is a fragmentary microscopic section taken on the line 5—5 of Figure 3;

Figure 6 is a more or less schematic sectional view showing one illustrative manner in which the refractory mold is formed about the pattern;

Figure 7 is a fragmentary microscopic section taken on the line 7—7 of Figure 6;

Figure 8 is a sectional view through the completed refractory mold after eliminating the pattern; and

Figure 9 is a fragmentary microscopic section taken on the line 9—9 of Figure 8.

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 the copending application of Albert W. Merrick, Serial No. 422,421, filed December 10, 1941, now Patent 2,381,459, 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 of the other destructible materials well known in the art. 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, we attach to such pattern a sprue element 13 having, at its outer end, a pouring basin forming part 14. The element 13 and part 14 are formed of low fusing material, preferably 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. We prefer to use, as the refractory material, silica, finely ground, for example, to approximately 200 mesh or finer. The use of a finely ground refractory material produces a smooth coating which results in a casting having a high degree of surface smoothness and possessing the maximum of detail present in the pattern itself. Other refractory materials, such as fused quartz, fused alumina, zircon, zirconia, mullite, fused magnesia, and the like may be employed.

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 is preferably 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. The presence of a small amount of acid is indicated as highly desirable. The acid content may be varied from 0% to approximately 25% of the liquid content of the refractory mix which forms the primary investment 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—we preferably add ammonium alginate to the refractory mix. The percentage of this constituent can be varied widely, depending upon the particular characteristics desired in the primary investment coating. We contemplate varying the content of ammonium alginate from approximately 1.0% to approximately 10.0% of the total weight of the mix. This material serves as a low temperature film-forming binder, and gives the coating composition the advantageous characteristics above set forth. Similar materials can 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 "Wetanol" (sulfatate, a hydrocarbon sulfonate), and "Aerosol" OT (sodium dioctyl sulfo-cuccinate), "Tergitol" (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" (mixture of alliphatic esters)—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% Wetanol	cc..	7.5
Potter's Flint	lbs..	2.3

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

Water	cc..	290
Glycerine	cc..	45
Water glass	cc..	180
6% ammonium alginate solution	cc..	15
Octyl alcohol	cc..	0.3
7.5% Wetanol solution	cc..	7.5
Potter's Flint	lbs..	2.4

Another composition 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
Octyl alcohol	cc..	0.3
7.5% Wetanol	cc..	7.5
Potter's Flint	lbs..	2.3

Referring, for example, to the first-mentioned typical coating composition, this composition 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. We do not, however, 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, we 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 situable 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 (preferably silica) in coarse particle form, grade from approximately 50 to 100 mesh. Other refractory materials, such as those referred to in describing the composition of the coating 15, may, of course, be employed. 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 flowing thereof along the surface of the pattern, for example from the high points of the pattern.

We have found it desirable, under certain circumstances, to provide a heavier primary coating for producing certain types of castings. This can be accomplished 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 particles 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.

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 6, whereas the completed refractory mold is indicated at 26 in Figure 8. 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 material used in forming the body of the mold 26 may be, in general, any suitable refractory filler and a suitable binder. The refractory filler may be in comminuted form, silica or any of the other refractory materials well known in the art. In general, in such materials the bulk of the refractory filler is usually present in the form of coarse or large particles of a particle size larger than the particle size of the refractory particles 16 applied to the pattern in the "sanding" operation. The use of coarse refractory particles in the secondary investment material for forming the mold body provides desirable porosity in the mold for the escape of air and gases in the casting operation, as well understood in the art.

While any suitable binder may be employed in the secondary investment material 25, we preferably use an investment having a tetra-ethyl silicate binder, or the investment material disclosed and claimed in the copending application of Paul F. Collins, Serial No. 450,619, filed July 11, 1942, now Patent 2,380,945, issued August 7, 1945. Any of the other binders known in the art, or suitable for refractory mold materials, may, of course, be employed. The binder for the primary coating material is preferably the same, or selected to match the binder for the secondary investment material, although, this may vary within the scope of the present invention.

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 the smooth, strong, and water-resistant coating 15, and the coarse refractory material 16 securely bonding the coating to the refractory mold material. 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. The resulting bonding or anchoring of the coating to the body of the refractory mold 26 prevents, as already pointed out, separation of the coating from the body of the mold, and cracking and breaking of the coating (with resulting defects in the casting), particularly when the mold is heated to a high temperature preliminary to casting and in pouring the molten material, such as a high fusing metal or alloy, into the mold.

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.

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

We claim:

1. A refractory mold comprising a body of comminuted refractory material having a casting surface covered with a coating comprising a comminuted refractory material of relatively fine

particle size and a layer of comminuted refractory material of particle size coarser than the particle size of the refractory material of said coating and finer than the particle size of the refractory material of the mold body, said last mentioned layer of refractory material being substantially coextensive with said coating and interposed between the coating and the mold body to anchor the coating to the mold body.

2. A refractory mold comprising a body of comminuted refractory material having a casting surface covered with a coating comprising a comminuted refractory material of relatively fine particle size and a binding agent, and a layer of comminuted refractory material of particle size coarser than the particle size of the refractory material of said coating and finer than the partiele size of the refractory material of the mold body, said last mentioned layer of refractory material being substantially coextensive with said coating and interposed between the coating and the mold body to bond and anchor the coating to the mold body.

3. A refractory mold comprising a body of comminuted refractory material having a casting surface covered with a coating comprising a comminuted refractory material of relatively fine particle size, a binding agent and a film-forming constituent, and a layer of comminuted refractory material of particle size coarser than the particle size of the refractory material of said coating and finer than the particle size of the refractory material of the mold body, said last mentioned layer of refractory material being substantially coextensive with said coating and interposed between the coating and the mold body to bond and anchor the coating to the mold body.

4. A refractory mold comprising a body of comminuted refractory material having a casting surface covered with a coating comprising a comminuted refractory material of relatively fine particle size, a binding agent and a water-soluble alginate acting as a film-forming constituent, and a layer of comminuted refractory material of particle size coarser than the particle size of the refractory material of said coating and finer than the particle size of the refractory material of the mold body, said last mentioned layer of refractory material being substantially coextensive with said coating and interposed between the coating and the mold body to bond and anchor the coating to the mold body.

5. The method of fabricating a mold having a refractory mold body provided with a smooth casting surface, which comprises, dipping a fusible pattern into a fluid mixture of finely divided refractory material and a binding material, withdrawing said pattern from said mixture whereby it will be provided with a coating thereof, applying to said coating while it is at least

partially wet a refractory material having a particle size larger than the particle size of the finely divided refractory material in said coating, drying the coating with said last mentioned refractory material thereon, and investing said coated pattern in a settable investment composition comprising a refractory material of larger particle size than that of said refractory material applied to said coating.

6. The method of fabricating a mold having a refractory mold body provided with a smooth casting surface, which comprises, coating a fusible pattern with a fluid mixture of finely divided refractory material, a binding material and a film forming constituent, partially drying said coating, dusting said partially dried coating with a refractory material having a particle size coarser than that of said finely divided refractory material, drying said coated and dusted pattern, and investing said pattern so coated, dusted and dried, in a settable investment composition containing a refractory material of larger particle size than that of said refractory material used for dusting.

7. The method of fabricating a mold having a refractory mold body provided with a casting surface which comprises coating a fusible pattern with a mixture of finely divided refractory material and a binding material, applying to said coating while it is still at least partially wet a refractory material having a particle size larger than the particle size of the finely divided refractory material in said coating, drying the coating with said last mentioned refractory material thereon, and investing said coated pattern in a settable investment composition comprising a refractory material of larger particle size than that of said refractory material applied to said coating.

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