

Jan. 10, 1967

N. G. LIRONES
METHOD OF PREPARING AN INVESTMENT MOLD
FOR USE IN PRECISION CASTING
Filed Aug. 23, 1965

3,296,666

FIG. 1

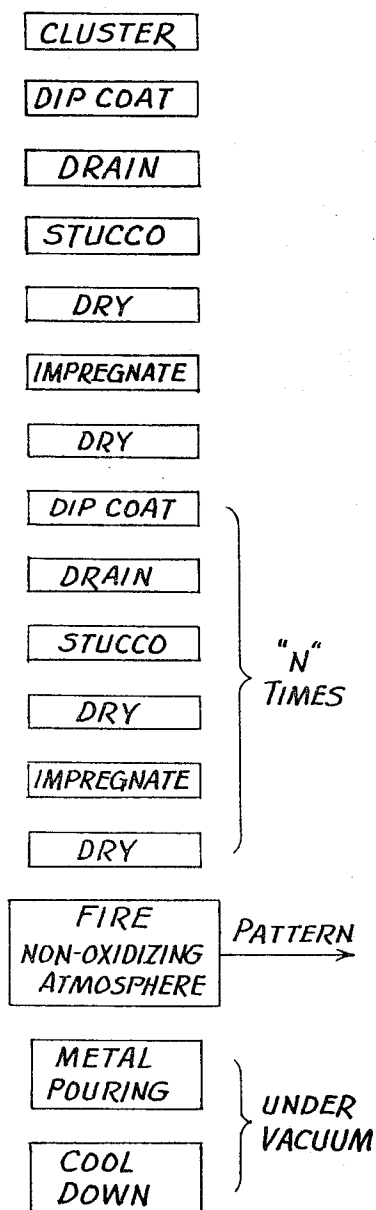


FIG. 2

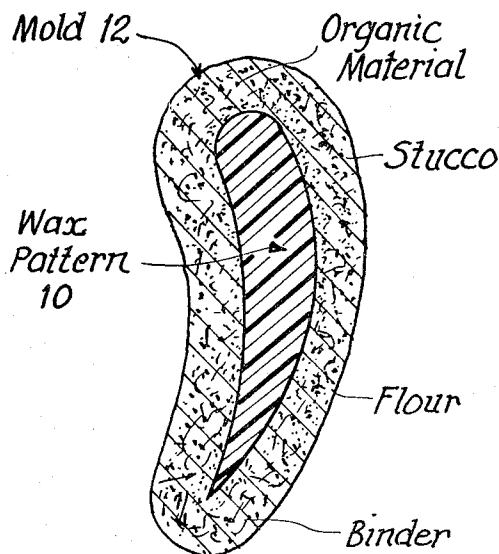
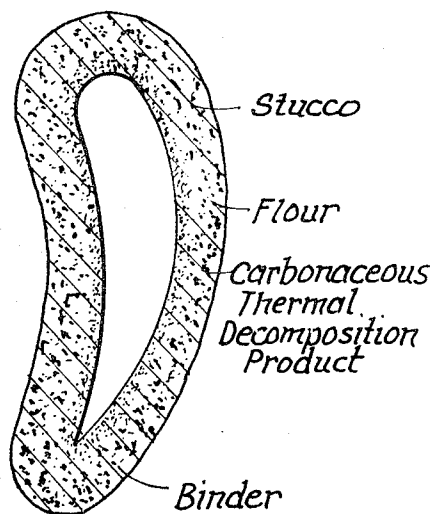


FIG. 3



INVENTOR
Nick G. Lirones
by McDougall, Hersh & Scott
Attys

1

3,296,666

METHOD OF PREPARING AN INVESTMENT MOLD FOR USE IN PRECISION CASTING

Nick G. Lirones, North Muskegon, Mich., assignor to Howmet Corporation, a corporation of Delaware
Filed Aug. 23, 1965, Ser. No. 481,728
11 Claims. (Cl. 22—196)

This application is a continuation-in-part of my copending application Serial No. 441,814, filed March 22, 1965, and entitled "Mold and Method of Fabrication," now Patent No. 3,256,574.

This invention relates to the preparation of molds in which shaped products can be cast of metal such as beryllium, titanium, zirconium, hafnium, molybdenum, tungsten, uranium and the like refractory metals, reactive heavy metals, and metals of the Group IVb of the periodic system.

The invention will be described with reference to the preparation and use of a mold formed about a heat or otherwise disposable pattern by repeatedly wetting with a dip coat composition and stuccoing to build up a monolithic structure from which the pattern is subsequently removed to leave a corresponding mold cavity into which the metal in a molten state can be directly cast to produce a metal product having a shape corresponding to the cavity left by the removed pattern. It will be understood that the concepts of this invention will have application also to molds formed by investment of the monolithic structure into a ceramic body for support, in accordance with conventional investment casting procedures, but it is preferred to make use of the monolithic mold without such investment when sufficient strength can be embodied in the walls of the monolithic mold to enable the molten metal to be poured directly into the mold without support.

It is an object of this invention to produce and to provide a method for producing new and improved molds for use in the casting of various materials and it is a related object to provide a new and improved molding process employing the same and compositions for use in the preparation of same.

More specifically, it is an object of this invention to produce a mold which is of sufficient high strength and stability to enable molten metals to be poured directly therein; in which reactive and refractory or other high melting point metals can be cast; in which metals can be formed in a manner to minimize oxidation thereby to enable use of the process and materials in the forming of shapes that have heretofore been difficult to produce, and it is a related object to provide a new and improved molding process which can be easily carried out for the casting of materials which have heretofore been difficult to mold and in which the molded product can be easily and efficiently separated from the mold.

These and other objects and advantages of this invention will hereinafter appear and, for purposes of illustration, but not of limitation, an embodiment of the invention is shown in the accompanying drawing in which—

FIG. 1 is a flow diagram of the process embodying the product of this invention;

FIG. 2 is a schematic sectional view through a mold formed about a heat disposable pattern, in accordance with the practice of this invention; and

2

FIG. 3 is a schematic sectional view through the final mold.

In the aforementioned copending application, description is made of a mold and method for the manufacture of same, in which at least the inner portions of the mold, immediately surrounding the mold cavity, is formed essentially of graphite materials by application of a series of coatings including a dip coat composition alternating with a stucco coat in which the dip coat composition is formulated of colloidal graphite binder and graphite flour and the stucco is a graphite stucco, and in which the remainder of the mold walls are formed of the same materials applied in the same way to build up a wall of the desired thickness or in which the remainder of about one half or more of the mold wall thickness is formulated of inorganic or ceramic materials, including a dip coat composition of colloidal silica and ceramic flour and ceramic stucco, applied in alternate layers. The concept of the aforementioned patent application comprises the impregnation of the mold after pattern removal and firing to incorporate an organic material, such as an organic resinous material that is thermally decomposable when heated to elevated temperature in a non-oxidizing atmosphere to deposit a carbonaceous thermal decomposition product in situ in the heated mold to produce a mold in which metal of the types described can be cast to produce shaped products.

In order to incorporate a sufficient amount of thermally decomposable organic resinous material into the mold walls, it has been found desirable to carry out a number of impregnations with the resinous material with intermediate heating of the entire system to effect the desired thermal decomposition after each impregnation. This is a laborious and time consuming procedure which, while it is effective to produce a suitable mold in which the molten reactive or refractory metals can be cast, markedly increases the mold cost and the products produced therefrom.

It has now been found that a more effective amount of the thermally decomposable organic material, preferably an organic resinous material, can be incorporated into the mold wall in a more desirable distribution through the cross section of the mold wall, when the thermally decomposable organic material is introduced during the build up of the cross section of the mold walls about the heat disposable pattern and before the pattern has been removed from the mold.

For this purpose, impregnation to introduce the thermally decomposable organic resinous material or other organic material is achieved during the build up of the mold wall and preferably after the application of the dip and stucco coatings and subsequent drying. The impregnation of the mold with the decomposable organic material can be made after each stuccoing and drying step or after selected ones of the stuccoing and drying steps, preferably after the first few dip coat and stucco applications, to achieve the desired distribution and concentration of organic resinous material in the mold walls.

Having described the basic concepts of the invention, description will now be made of the compositions employed in the practice of the invention and the method of fabrication of the new and improved mold.

In the following description, the terms "pattern" and "cluster" will be used interchangeably to refer to the wax or plastic pattern 10 or a cluster formed of a multi-

3

plicity of such individual patterns. Instead of wax, the patterns can be formed of other materials which can be removed by heat, solvent, chemical reaction or the like. It will be understood that changes may be made in the details of formulation, materials and methods employed without departing from the spirit of the invention.

EXAMPLE 1

Preparation of wax pattern and cluster

The pattern 10 is formed of conventional materials disposable by heat or chemicals, as in the well known investment casting processes. In the illustrated modification, the pattern is molded under pressure in suitable metal molds by injection of molten wax to fill the mold and set the pattern. Instead, the pattern can be formed of a thermoplastic, synthetic resinous material or combinations of such plastics and wax.

If the mold is to be formed about more than one pattern, the plurality of patterns are connected by runners for communication with a pouring spout to form a completed cluster. Where, as in the instant process, the cluster is to be repeatedly dipped into a slurry, it is desirable to provide a hanger rod for carrying the cluster and for suspending the cluster for drying and the like.

EXAMPLE 2

Dip coat composition

2.77 percent by weight solids of colloidal graphite (22% solids in aqueous medium)
37.8 percent by weight solids of graphite flour (less than 200 mesh)
0.174 percent by weight emulsifying agent (gum tragacanth)
0.003 percent by weight anionic wetting agent (sodium heptadecyl sulphate)
Remainder water

As the colloidal graphite, it is preferred to make use of colloidal particles of graphite of less than 1 micron. For the purpose of reducing cost, use can be made of a combination of such colloidal graphite mixed with up to 50 percent by weight and preferably up to only 30 percent by weight of semi-colloidal graphite having a particle size of between 1-20 microns.

The amount of colloidal graphite in the dip coat composition may vary but it is desirable to make use of an amount greater than 0.5 percent by weight but less than 10 percent by weight and preferably an amount within the range of 1 to 3.0 percent by weight. The amount of graphite flour can vary between 15-45 percent by weight of the dip coat composition and it is preferred to make use of an amount within the range of 20-30 percent by weight of the dip coat composition.

In the dip coat compositions represented by the above formulation, the emulsifying agents and the anionic wetting agents are preferred but not essential. Instead of gum tragacanth, use can be made of other hydrophilic colloids such as the gums, gelatins, alginates and the like, wherein, when used, such emulsifying agents are employed in an amount within the range of 0.01 to 0.5 percent by weight. Instead of the sodium heptadecyl sulphate wetting agent, other anionic surface active agents may be employed such as the alkyl sulphates and the alkyl aryl sulfonates and their salts. When employed, the amount of such surface active agent may range from 0.01 to 0.5 percent by weight of the composition. The dip coat composition will have a pH within the range of 8.8 to 9.4.

The solids content, insofar as the colloidal or semi-colloidal graphite and graphite flour is concerned, can be varied quite widely, it being necessary only to formulate for a viscosity that can be handled to coat the pattern and to make use of colloidal or semi-colloidal graphite in an amount sufficient to achieve the desired bonding action.

4

For this purpose, it is deemed sufficient if the latter is present in an amount to make up more than 1.5 percent by weight of the graphite solids of the dip coat composition and it is usually undesirable and uneconomical to make use of an amount of colloidal or semi-colloidal graphite greater than 10 percent by weight of the graphite in the dip coat composition. It will be understood, however, that the essentially 100% graphite making up the solids in the dip coat composition can be achieved by the use of colloidal or colloidal and semi-colloidal graphite alone.

Application of the dip coat composition

The wax pattern or cluster is first inspected to remove dirt, flakes and other objects which may be adhered to the surfaces of the wax patterns and which, if allowed to remain, would impair the preparation of a good mold and lead to an imperfect casting. The cleaned cluster is immersed into the dip coat composition, while being stirred, to cover all of the surfaces of the cluster with the exception of the lip of the pouring spout. To promote the elimination of air pockets, it is desirable to rotate the cluster while immersing in the dip coat composition. Instead of immersing the pattern in the stirred slurry of the dip coat composition for coverage of the surfaces of the pattern, the dip coat composition can be applied to achieve the desired coverage by spraying the dip coat composition onto the surfaces of the pattern. By this latter spraying technique the coating weight of the dip coat composition can be increased or decreased, as desired, by comparison with the amount of coating retained on the surfaces by immersion.

When fully coated, the pattern or cluster is suspended to drain excess dip coat composition. During drainage, the cluster can be inspected to detect air pockets which can be eliminated by addressing a stream of air onto the uncoated portions and thereafter allowing the slurry of the dip coat composition to flow onto the uncovered areas. While the cluster is being drained, it should be held in different planes designed to achieve uniform coating on all surfaces. In general, drainage should be completed within a few minutes but, in any event, in less time than would allow the coating to dry whereby the surface would not retain stucco in the desired uniform arrangement.

EXAMPLE 3

Stuccoing

After the cluster has been allowed to drain for a short time and while the surface is still wet with the dip coat composition, the surface is stuccoed with particles of graphite having the following particle size distribution:

Tyler screen size:	Percent retained on screen
65	62
100	29
150	7
200	1
Pan	1

The graphite will hereinafter be referred to as having a particle size of more than 150 mesh but less than 35 mesh. The particles of graphite are caused to flow over the surface of the pattern until the wet surface is substantially completely covered.

Application of stucco coat

After the uniformity of coating has been achieved with the dip coat composition, the stucco is sprinkled onto the wet surface while constantly changing the position of the cluster substantially uniformly to cover the dip coating with a layer of stucco, while at the same time minimizing flow of the dip coat composition whereby non-uniformities might otherwise develop. In practice, the graphite particles are rained down from above through a screening member which is constantly fed from a vibratory

5

conveyor. The particles of graphite adhere to the wet coating and become partially embedded therein to become integrated with the coating formed on the wax patterns. Instead of raining the graphite particles onto the wet surface, the particles of graphite can be formed into a fluidized bed into which the wet pattern is immersed.

If the dip coat composition is adjusted to enable gellation to take place within a very short period of time, the stuccoed cluster need not be set aside for drying. However, it is preferred to slow the gellation of the dip coat so that sufficient leeway is available for the desired drainage and stucco application. Thus it is desirable to provide for an air dry for a time ranging from 10-25 minutes. It will be understood that the drying time may be extended indefinitely beyond the times described without harm to the structure. If desired, drying of the combined coatings can be accelerated in a humidity controlled air circulating chamber heated to a temperature up to about 100° F.

The particle size of the graphite stucco is not critical since the particle size of the graphite can be varied over a fairly wide range. However, for best practice of this invention, it is preferred to make use of graphite having a particle size greater than 150 mesh and less than 20 mesh.

EXAMPLE 4

Impregnation

Impregnating composition D:

1 part by weight phenol-formaldehyde (Catalin #136—Catalin Corporation)

1-10 parts by weight isopropyl alcohol

Impregnating composition B:

1 part by weight water soluble phenol-formaldehyde resin (Catalin #8944)

1-10 parts by weight water

Impregnating composition C:

95-99 parts by weight liquid furfuryl alcohol resin (Durex #16470—Durex Plastic Division, Hooker Chemical Company)

1-5 parts by weight accelerator

100 parts by weight Durex #17932

100 parts by weight solvent-acetone, methyl ethyl ketone, toluol or butyl alcohol

Impregnating composition D:

Liquid polyacrylic resin (Armstrong T-321—Armstrong Corp.)

The impregnating composition is applied to the layer of dip coat composition and stucco after drying. Impregnation can be effected by immersion of the coated cluster into a bath of impregnating composition or application can be made by a flow coat process, spray coating or brush coating for impregnation of the dried layer of the dip coat and stucco with the organic resinous material. The impregnating cluster is then dried to remove the diluent from the impregnating composition.

Instead of the illustrated phenol-formaldehyde resin, furfuryl resin or polyacrylic resin, use can be made of impregnating compositions formulated of others of the natural or synthetic organic resinous materials in corresponding dilutions or of other high molecular weight organic materials such as proteins, albumens, carbohydrates, starches and the like, which, upon firing at elevated temperatures in excess of 600° F., and preferably in excess of 800° F., in a non-oxidizing atmosphere, reduce to form into a stable carbonaceous reduction reaction product in the interstices between the graphite particles of the graphite flour, colloidal graphite and graphite stucco.

The operations are repeated, that is the cluster is again wet with the dip coat composition, covered with fine particles of graphite stucco, dried and then again impregnated with the compositions A, B, C or D and dried to build up a second composite impregnated layer. In the pre-

6

ferred practice of this invention, it is desirable, though not essential, to precede the immersion of the coated cluster in the dip coat composition with a pre-wetting step in which the prewetting composition employs substantially the same formulation as the dip coat composition with the exception that a lower viscosity is employed, as occasioned by the formulation to include additional amounts of water sufficient to reduce the total solids to about 25-75% of the solids in the dip coat composition. Thus the coated pattern is first submerged in the prewet composition more completely to penetrate and wet out the coated surface followed almost immediately by submer-
 10 sion in the dip coat composition after which the steps of drainage, stuccoing with the fine particles of graphite, and drying are carried out. Thus the layers become better integrated one with the other to produce a strong and composite structure.

The steps of prewetting, if used, dip coating, stuccoing with the dry particles of graphite, impregnating and drying can be repeated several times until a mold 12 of the desired thickness and strength has been built up about the disposable pattern or cluster.

While a mold of higher strength will be secured if the graphite particles of the type having a mesh size within the range of more than 150 but less than 20 are used throughout to build up the mold, it is preferred to make use of particles of graphite of larger dimension for use as the stucco after the second coat and preferably after the fifth coat. For such outer layers or coatings, graphite having the following particle size distribution may be employed:

Tyler screen size:	Percent retained	
	on screen	
8	-----	1
10	-----	14
20	-----	65
35	-----	18
65	-----	1
Pan	-----	1

The foregoing will hereinafter be referred to as having a particle size greater than 35 mesh but less than 8 mesh.

As previously pointed out, it is not essential to impregnate the previously applied layers after each application of the dip coat composition and stucco. For most uses, it is sufficient if the impregnation step is employed only after the first few applications of dip coat and stucco thereby to concentrate the thermally decomposable organic material in the inner portions of the mold walls immediately surrounding the mold cavity. By this technique, a higher concentration of organic material can be provided in the area where the organic decomposable product is most desirable.

When the thermally decomposable organic material is embodied in the mold walls in the manner described, the carbonaceous material formed upon thermal decompositions in the non-oxidizing or reducing atmosphere is of a character which permits construction of the mold walls entirely of conventional ceramic materials, such as by the use of a dip coat composition formulated of non-organic or ceramic materials and a ceramic stucco where it makes possible the construction of the mold walls wherein the inner portions of up to half the thickness of the mold wall is formed of graphitic materials in the manner previously described while the remainder is formed of inorganic or ceramic materials.

The following will illustrate dip coat compositions and stucco formulated of inorganic or ceramic materials which can be applied and processed in construction of the mold walls about the cluster in the same manner as described for the graphite materials in the previous Examples 1 to 3.

EXAMPLE 5

Dip coat composition

Colloidal silica (30% grade) -----cc--	8000
Zircon (99% through 325 maximum) -----lbs--	165
Water -----cc--	6150
Sodium fluoride -----grams--	110

The dip coat composition is applied in the conventional manner previously described for the dip coat of colloidal graphite and graphite flour.

EXAMPLE 6

Stucco

The stucco which may be applied in the ceramic portions of the mold can comprise Alundum (100% through 50 maximum with less than 3% through 100 maximum).

The stucco is applied in the same manner as the graphite stucco.

For a more detailed description of the build up of all or portions of the mold wall with ceramic materials and for components which may be substituted for the colloidal silica and zircon in the dip coat composition or Alundum in the stucco, reference may be made to the previously issued patent of Operhall et al. No. 2,961,751.

A mold 12 having a wall thickness of $\frac{1}{4}$ to $\frac{1}{2}$ inch is usually sufficient for the casting of products of normal weight or dimension by molten metal casting, although molds of greater or lesser wall thickness can be fabricated depending upon the weight or size of the casting that is being poured. The normal wall thickness can be achieved with compositions of the type described in from 5 to 10 cycles of dip coating, stuccoing, drying, impregnating and drying.

After drying, the composite structure is dewaxed or the disposable pattern is removed by inverting the mold and by heating to a temperature above the melting point of the material or materials of which the pattern is formed and preferably to a temperature above 400° F., but below the temperature at which the organic impregnated material will be burned out of the mold. Dewaxing can be carried out by other processes such as hot sand dewaxing wherein the inverted mold is surrounded with sand preheated to a temperature within the range of 400°–800° F. or in which the hot sand is poured over the mold, or by steam dewaxing wherein the composite structure is housed in an autoclave or else steam at high pressure is introduced into the mold. For a more detailed description thereof, reference may be made to the aforementioned copending application or to the others of my copending application Ser. No. 441,827, filed March 22, 1965, and Ser. No. 449,294, filed April 19, 1965.

Removal of the pattern can be carried out as a separate operation in the manner described, but it is preferred to combine the pattern removal step with the subsequent step of curing the mold wherein the mold with the pattern or after the pattern has been removed by one or the other of the aforementioned processes, is introduced into a zone heated to a temperature above 800° F. and preferably to a temperature within the range of 1000° to 2300° F. while the atmosphere in the zone is maintained as an inert, or non-oxidizing, or reducing atmosphere, as by the use of an inert gas, such as argon, nitrogen, carbon monoxide and the like. Under such conditions, the mold is cured and the organic impregnating material is thermally decomposed to a stable form of carbon or carbonaceous decomposition product which effectively coats the adjacent graphitic or ceramic materials with a protective coating that blocks reaction between the graphitic or ceramic materials and the hot molten metal poured into the cavity of the mold. The desired cure of the mold and thermo breakdown of the organic material can usually be achieved at a temperature within the range described in from 15 to 30 minutes, but there is no harm in heating for a longer period of time to insure complete stabilization of the materials making up the mold.

It has been found that the carbonaceous decomposition product formed is of the type which either swells or operates otherwise substantially to fill the interstices in the mold since the resulting mold is less pervious to the penetration of molten metal poured into the mold cavity while still providing microporous openings which enable the mold to breathe thereby to block reaction between the molten metal and the materials of which the mold is formed, while at the same time providing a uniform smooth surface at the inner face of the mold for the production of a molded product which conforms more exactly to the original shape of the mold cavity and with less surface imperfections. Thus, there is produced an acceptable product of such metals which have heretofore been incapable of being processed in molds to produce shaped products.

It is believed that the stabilized thermal decomposition product formed of the organic impregnated material is capable also of functioning as a binder in the cured product since a mold of the desired strength results with mold walls of thinner cross section or form compositions wherein the binder component in the dip coat composition is substantially eliminated or materially reduced.

Molten metal can be poured directly into the mold cavity for the fabrication of molded products since the mold possesses sufficient strength and has sufficient mass integrity to enable the molten metal to be poured into the mold without external support. While mold preheating is not essential, it is desirable to preheat the mold prior to metal pouring. If the mold is preheated to a temperature above 800° F., it is desirable to effect such preheat either under vacuum conditions or in an inert or a non-oxidizing atmosphere of the type previously described, otherwise the graphite and the carbonaceous product will burn out of the mold. Since the described refractory metals, reactive heavy metals or metals of Group IVb have a melting point far in excess of 800° F., it is desirable to achieve metal pouring by vacuum casting techniques wherein the mold is enclosed within a vacuum chamber that communicates with a melting furnace whereby a vacuum can be drawn to evacuate the chamber and the mold prior to metal pouring. The mold and metal cast therein are preferably maintained under vacuum conditions until the poured metal has solidified or the mold has cooled to a temperature below 800° F. Thereafter, the assembly can be removed from the vacuum chamber for further processing.

To assist in filling the mold, centrifugal casting techniques can be employed in combination with metal pouring. By way of specific illustration, description will be made of the use of a mold in embodying the features of this invention in the preparation of a cast metal product of titanium, it being understood that others of the refractory metals, heavy reactive metals or metals of Group IVb and alloys thereof may be similarly cast.

In practice, the mold is housed within a vacuum chamber located beneath a melting furnace and a vacuum is drawn on the mold and then the molten titanium is poured under vacuum into the mold, with or without preheating the mold, by inverting the melting furnace. When preheating is employed, it is desirable to preheat the mold while under vacuum conditions in which the mold may be preheated to a temperature up to 800° F., although preheating to higher temperatures is preferred.

The poured metal is allowed to cool in the mold while in the vacuum chamber or while under a protective inert or non-oxidizing atmosphere to a temperature below that at which oxidation of the carbonaceous material can take place before removal of the cast metal product from the protective atmosphere of the mold. The cast metal product can be removed by conventional techniques, such as impacting and shaping to disintegrate the mold and free the casting.

For a more detailed description in the use of a mold of the type described for metal casting or for the cast-

ing of glass or ceramic compositions, reference may be made to the aforementioned copending applications.

As used herein, the term "ceramic flour" and the term "ceramic stucco" are intended to include flour and stucco formed of ceramic materials such as silica, fused glass, fused quartz, zirconium silicates, beryl ores, thoria, zirconite, kyanite, mullite, and sillaminit, and oxides of the type previously described including zircon and aluminum.

It will be understood that the concepts of this invention reside not only in the mold but in the manufacture thereof, and the use thereof. It will be understood that changes may be made in the details of formulation, processes of fabrication and construction of the mold without departing from the spirit of the invention, especially as defined in the following claims.

I claim:

1. In the method of producing a mold for use in casting shaped products of metals selected of the group consisting of refractory metals, reactive heavy metals and metals of Group IVb of the periodic system, the steps of wetting the surfaces of a heat disposable pattern corresponding to the shape of the product to be molded with a dip coat composition containing a binder component and a finely divided flour, applying a stucco in the form of solid particles to the surfaces of the pattern while wet with the dip coat composition whereby a layer of stucco is retained on the wet surfaces, drying the applied coating, impregnating the dried coating with a fluid composition containing an organic material which is easily thermally decomposed in a non-oxidizing atmosphere to a stable form of a carbonaceous decomposition product when heated to decomposition temperature, repeating the applications of the dip coat composition, stucco and drying followed by impregnation for a number of cycles to form a composite layer of the dip coat, solid and stucco impregnated with the organic material, treating the composite to effect removal of the pattern and providing a mold having a mold cavity shaped to correspond to the pattern that has been removed, heating the mold to a temperature in excess of 800° F. in a non-oxidizing atmosphere to cure the mold and thermally to decompose the organic material in situ in the mold walls to a carbonaceous decomposition product.

2. The method as claim in claim 1 in which the step of impregnation with the organic material is conducted after only the first cycles in forming the composite layer about the mold pattern.

3. The method as claimed in claim 1 in which the step

of impregnating with the organic material is carried out after each stuccoing step.

4. The method as claimed in claim 1 which includes the step of drying after each impregnation.

5. The method as claimed in claim 1 in which the organic material is a resinous material selected from the group consisting of phenol formaldehyde resin, cresol formaldehyde resin, resorcinol formaldehyde resin, furfuryl alcohol resin, furfuryl aldehyde resin, and an acrylic resin.

6. The method as claimed in claim 1 in which the organic material is selected from the group consisting of a synthetic resinous material, a natural resin, gum, a protein, a carbohydrate, and an albumen.

7. The method as claimed in claim 1 in which the treatment for pattern removal and for heating to cure the mold and decompose the organic material is achieved in a single heating step.

8. The method as claimed in claim 1 in which the mold is heated to a temperature within the range of 1000-2300° F.

9. The method as claimed in claim 1 in which the dip coat composition applied during at least the first few cycles is formulated to contain as solids a graphite flour and colloidal graphite and in which the stucco is a graphite stucco.

10. The method as claimed in claim 9 in which the dip coat composition containing the graphite flour and colloidal graphite and the graphite stucco is applied throughout the cross-section of the mold wall.

11. The method as claimed in claim 1 in which the dip coat composition is formulated to contain as solids a ceramic flour and an inorganic binder and in which the stucco is selected from the group consisting of a ceramic and inorganic material.

References Cited by the Examiner

UNITED STATES PATENTS

2,862,826	12/1958	Hohn et al.	22—193
2,886,869	5/1959	Webb et al.	22—196

FOREIGN PATENTS

1,004,388	11/1951	France.
1,217,412	12/1959	France.

J. SPENCER OVERHOLSER, *Primary Examiner*.

MARCUS U. LYONS, E. MAR, *Assistant Examiners*.