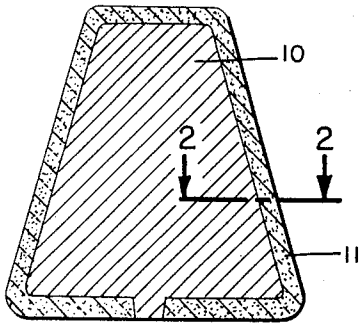
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THERMALLY INSULATED SHELL MOLD AND METHOD FOR MAKING SAME

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FIG. 1



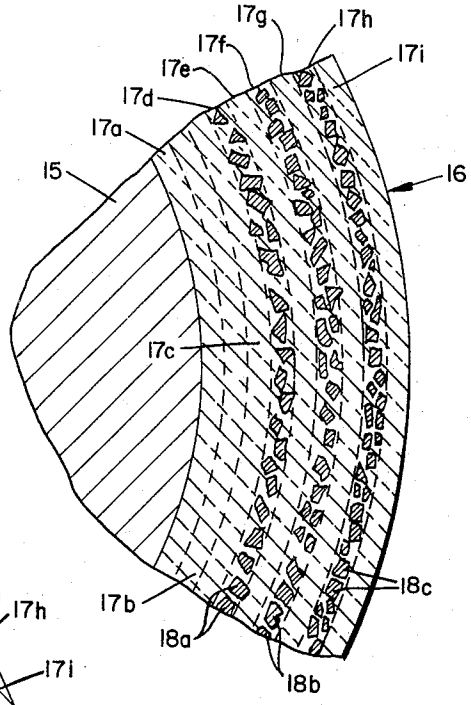


FIG. 4

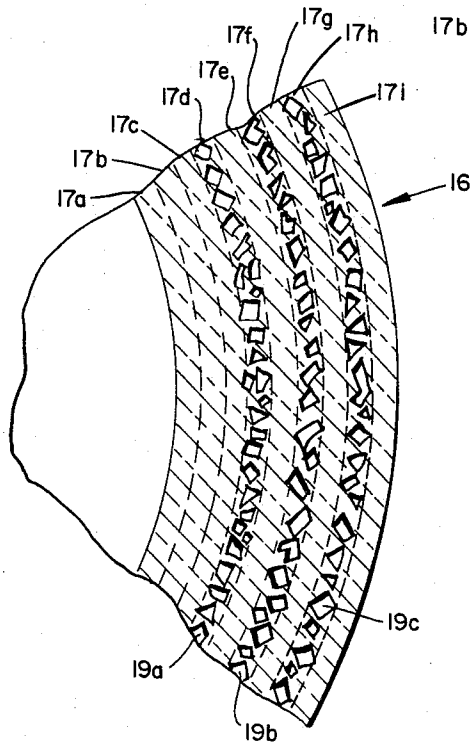


FIG. 5

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FIG. 2

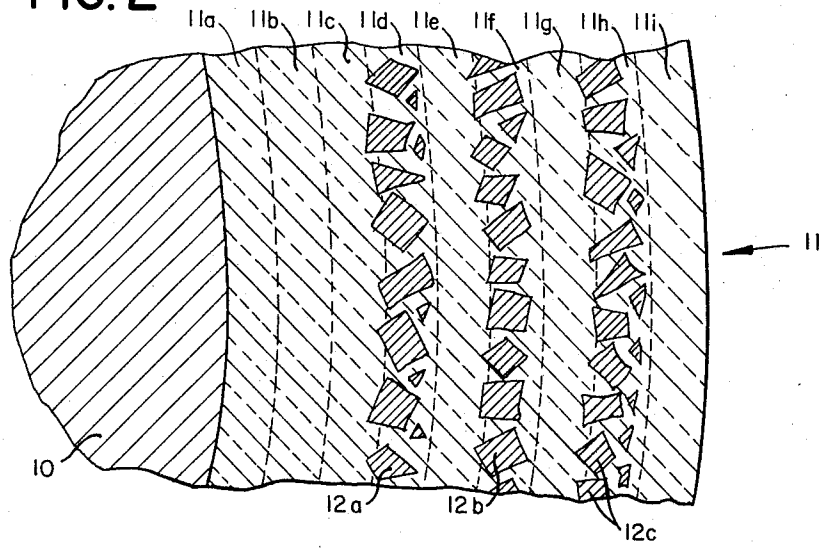
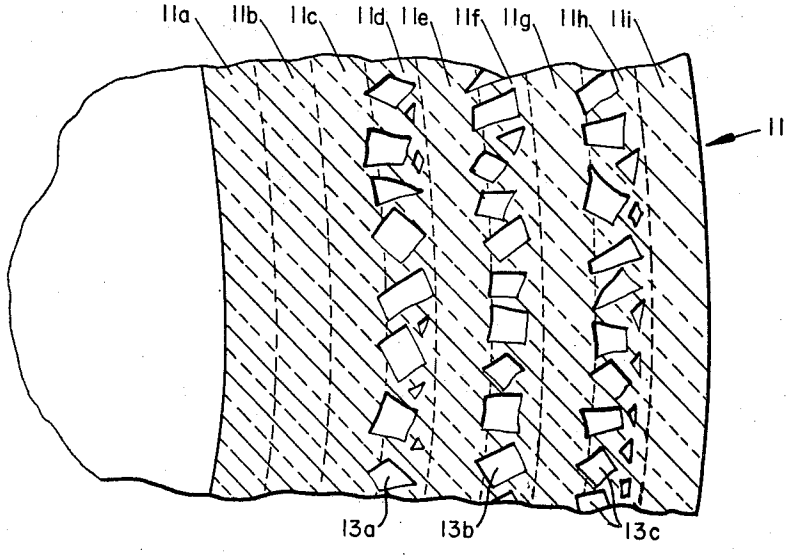


FIG. 3



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THERMALLY INSULATED SHELL MOLD AND METHOD FOR MAKING SAME

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17 Claims. (Cl. 164—34)

This invention relates to thermally insulated refractory shell molds and, more particularly, to a shell mold, and its method of manufacture, characterized by a multiplicity of voids within its wall which reduce the cooling rate of the mold and the casting therewithin.

In the manufacture of accurate metal castings, it is customary to make a pattern of the desired casting in wax or a similar fusible material and then to form a refractory mold by dip-coating the pattern a number of times in a liquid suspension of a finely divided refractory which hardens in layers on the pattern. When a refractory shell has thus been built up, it is only necessary to eliminate the pattern from within it in order to form an accurate mold of the article to be cast. At the time the mold is to be used in a casting operation, the practice is to pre-heat it to casting temperature so that the molten metal can best fill the mold cavity without solidifying prematurely.

To avoid defects in a casting such as shrinkage and the formation of voids, the cast metal must feed into and fill out all sections of the mold cavity. This cannot be achieved if some portions of the casting solidify too fast, and therefore the cooling rate of the casting must be controlled. For this reason, it has been the custom in the precision casting industry to encase the outside of the mold in a dry backup material or an asbestos wrapping which serves as a thermal insulator to lessen the cooling rate of the shell.

A primary object of the present invention is to eliminate the necessity for external insulation of this sort by undertaking unique measures during the manufacture of the shell mold to form a cellular wall structure of substantially reduced thermal conductivity.

Broadly stated, the method of the invention is applicable to the conventional manufacture of a refractory mold wherein a multi-layered shell is formed by successively coating and hardening slurries comprising a binder and a fine refractory on a pattern and thereafter eliminating the pattern. In accordance with the method, an even distribution of a particulate thermally decomposable material is embedded in at least one of the slurry coats subsequent to the first before it is hardened. The shell is subsequently heated above the decomposition temperature of the material to eliminate the material and leave voids distributed throughout the shell wall. The thermally insulated refractory shell mold produced by this method comprises the usual plurality of layers of bonded refractory material. It is characterized by the fact that at least one layer excluding the inner layer defines at least part of the multiplicity of voids which reduce the cooling rate of the mold. At least the inner layer is free of such voids.

When a refractory mold is manufactured in accordance with the invention, its thermal insulating means is incorporated in situ within the cellular wall of the shell itself. The multiplicity of voids reduces outward heat flow from the inner casting surface of the mold to the point where it becomes unnecessary to undertake separate steps toward insulating the mold, such as surrounding it with a dry

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backup material or a wrapping of asbestos. The mold itself is thus capable of maintaining its desired temperature between the time it leaves the pre-heat furnace and is filled with the molten metal in the casting process.

Even very thin sections filled out satisfactorily during casting since no quick chilling occurs as the molten metal is fed into the mold cavity. Also and due to the insulating effect of the mold made in accordance with the invention, rapid cooling of the metal in the mold is prevented and a sound casting free of shrinkage and from defects is produced. All of this is accomplished without additional external insulation for the mold because the voids in its wall are sufficient for reducing the cooling rate both of the mold and of the casting therewithin.

Preferred embodiments of the method and product of the invention are described hereinbelow with reference to the accompanying drawing, wherein

FIG. 1 is a simplified illustration of a refractory shell mold built up on a pattern;

FIG. 2 is an enlarged section taken along the line 2—2 of FIG. 1 illustrating a shell formed on the pattern in accordance with one embodiment of the invention;

FIG. 3 is a similar section of the FIG. 2 shell when it is ready for casting;

FIG. 4 is a similar section of a shell formed on a pattern in accordance with another embodiment of the invention; and

FIG. 5 is a similar section of the shell of FIG. 4 when it is ready for casting.

Referring first to FIGS. 1 to 3, an accurate pattern **10** of the article to be cast is first made by any common procedure, preferably using a fusible material such as wax, a thermoplastic composition, or the like. In forming a shell mold **11** about the pattern **10**, a number of coats of a refractory composition are applied to the pattern. The process known as dip-coating is a particularly satisfactory technique for applying the coats, involving the steps of immersing the pattern in a vessel containing an adequate depth of the coating composition and then lifting it out and holding it out for a brief time over the vessel while the excess composition drains off.

The composition used for each dip-coating is a slurry of controlled viscosity comprising, among other things, a liquid suspension of finely divided refractory particles and a binder. The finely divided refractory may be zirconium silicate, zirconium oxide, aluminum oxide, silica, or other well known materials usually having a particle size at least about 80% minus 270-mesh. Typical slurries in which the refractory material is suspended may have a binder of hydrolyzed ethyl silicate or isopropyl silicate, in which case hardening would be carried out by gelling the slurry dip-coat, perhaps in an atmosphere of ammonia gas or in air or by means of chemical gelling agents. Alternatively, the slurries may comprise a suspension of the refractory material in an aqueous sol containing colloidally dispersed silica, in which case hardening is usually achieved as a result of evaporation of water from the sol vehicle so that the colloidal constituents of the sol coagulate and bond the finely divided refractory particles together.

As suggested by the dotted lines in FIGS. 2 and 3, the mold **11** developed on the pattern **10** is actually formed of a plurality of layers resulting from the respective dip-coating operations, nine such layers **11***a* to **11***i* aggregating from about one-eighth to one-half of an inch

thickness are shown in this embodiment. Since the slurry used to form the first layer **11***a* defines the inner or casting furnace of the finished mold, it should have an especially smooth surface. The refractory material suspended in the slurry of the first dip-coating step should therefore be particularly fine, for example, about 90% minus 325-mesh. The usual practice is to "sand" each coating by sprinkling it while still wet with a relatively coarse refractory, such as fused alumina or grog fine enough to pass a 60-mesh screen but not over about 20% minus 200-mesh. These coarser particles embed themselves in the coating and provide a rough surface to which the next succeeding coating can easily become bonded. Such sanding is preferably carried out in the practice of this invention, though it is modified to some extent in the second embodiment described hereinafter. No attempt has been made to illustrate these inter-layer refractory particles in the drawing.

In accordance with the invention, an even distribution of a particulate thermally decomposable material is embedded in at least one of the slurry coats subsequent to the first before it is hardened. The organic particulate material may be plastic, wood chips, cork, sawdust, corn chips, or any other material which decomposes substantially completely at temperatures below the pre-heat temperature to which the mold is subjected before casting, for example, about 1800° F. In the embodiment of FIGS. 2 and 3, wood chips are used as the organic particulate material. These are particles of chipped wood of fairly regular size, more or less cubicle and up to about one-fourth of an inch or so on a side. Wood chips do not have an apparent overall fineness substantially different from coarse sawdust but they are more regular in size. It should also be noted that wood chips are a commercial product which is readily available.

After the layers **11***a* and **11***b* have each been applied by dip-coating and then sanded and hardened, the third layer **11***c* is applied and while it is still wet it is sprinkled with an even distribution of wood chips **12***a*. The wood chips **12***a* embed themselves partially into the surface of the layer **11***c* and are retained on it when the layer is hardened. In most cases it is contemplated that the wood chips **12***a* will be the sole particulate material applied to the layer **11***c* but it is not excluded that a certain amount of the refractory sanding material may be applied with them if desired. After the layer **11***c* is hardened with the wood chips **12***a* attached to it, the layer **11***d* is applied over the wood chips to cover them and embed them within the shell. Once the layer **11***d* has been hardened and sanded in the usual manner, the layer **11***e* is applied, sprinkled with more wood chips **12***b* and hardened. This is repeated with the layers **11***f* and **11***h* covering the layers **12***b* and **12***c* respectively of wood chips, while the outer layer **11***i* is of a conventional nature free of wood chips.

When the last layer **11***i* has been hardened, the mold containing the pattern is ready for the next operation which is elimination of the pattern material. This may be done by inverting the mold so that its sprue is directed downwardly and heating it above the fushion temperature of the pattern **10** so that the pattern material melts and drains off. Various techniques are known for eliminating the pattern and the particular choice is of no special significance in the practice of this invention.

At this stage of the process when the pattern has been eliminated, the shell stands alone in its green state comprising nine bonded layers of refractory material with the inner two and outermost layers being of a conventional nature and the alternate adjoining layers **11***c*–**11***d*, **11***e*–**11***b* and **11***g*–**11***h* defining between them respective layers **12***a*, **12***b* and **12***c* of evenly distributed wood chip particles. In accordance with the invention, the shell is to be heated above the decomposition temperature of the thermally decomposable material (i.e., the wood chips) to eliminate the material and leave voids distributed throughout the shell wall. The heating may be a step unto itself, but it is often preferred to leave the wood chips within the wall of the green mold until the time comes to pre-heat the mold to casting temperature. This is done by introducing the mold into a hot oven where it is heated in the usual manner to about 1800° F., at which temperature all traces of wood chips in the wall of the mold undergo combustion. As a result, a multiplicity of evenly distributed air-filled voids **13***a*, **13***b* and **13***c* are left defined between the alternate adjoining layers **11***c*–**11***d*, **11***e*–**11***f* and **11***g*–**11***h*, the remainder of the layers being free of such voids. When the mold **11** is removed from the pre-heating oven, its inner casting surface defined by the first layer **11***a* cools very slowly compared to that of a conventional mold because the multiplicity of voids within the portions of the shell wall closer to its exterior serve as effective insulating means substantially retarding outward heat transfer. Because the casting surface of the mold remains at a satisfactory casting temperature for a greatly protracted period, no difficulty is involved in carrying out the casting process without chilling the molten metal as it fills the mold cavity. Even very thin sections can therefore be cast with precision, and there is no danger that the mold will be inadequately or improperly filled with the molten metal or that X-ray shrinkage will be exhibited in the completed casting. All this is made possible solely because of the multiplicity of voids defined in the shell wall and there is no need to encase the mold in a dry backup material or an asbestos wrapping as the practice has been heretofore.

Turning now to the embodiment of the invention with which FIGS. 4 and 5 are concerned, a pattern **15** is given a series of slurry dip-coats to form a mold **16** comprising layers **17***a* to **17***i*, all steps being the same as those described in the previous embodiment but for the exceptions noted below. Instead of sprinkling or dusting certain of the layers with a particulate thermally decomposable material, the material is dispersed prior to dip-coating throughout the slurries used for the alternate layers **17***d*, **17***f* and **17***h*. The slurries used for these three dip-coats have the particulate thermally decomposable material mixed directly within them along with the finely divided refractory and the binder so that the decomposable material is automatically embedded as shown at **18***a*, **18***b* and **18***c* in the respective dip-coats as they are applied. Wood chips are not as desirable for this embodiment of the invention as in the embodiment discussed previously because they can have an adverse effect on the viscosity of the slurries. Sawdust serves well for admixture directly into the slurries as do corn chips, cork, and certain thermally decomposable plastics.

Each of the layers **17***a* to **17***i* may be sanded with a relatively coarse refractory material in the conventional manner, including the layers **17***d*, **17***f* and **17***h* which contain the decomposable particles. When the mold **16** containing the pattern **15** is completed, there is an even distribution of the various decomposable particles **18***a*, **18***b* and **18***c* with substantially every one of the particles embedded wholly within one of the respective dip-coat layers **17***d*, **17***f* and **17***h*. The pattern **15** is eliminated as before and the mold **16** is heated to a temperature above the decomposition temperature of the decomposable particles preferably at the time the mold is pre-heated for casting. As shown in FIG. 5, this burns out the particles and leaves the alternate layers **17***d*, **17***f* and **17***h* each defining a multiplicity of evenly distributed air-filled voids **19***a*, **19***b* and **19***c* respectively which reduce the cooling rate of the mold. The inner three layers **17***a*, **17***b* and **17***c*, the outermost layer **17***i*, and the remaining layers **17***e* and **17***g* are free of such voids. Prior to and during casting, the insulating effect of these voids prevents chilling of the molten metal to the same extent as in the previous embodiment.

We claim:

1. In the manufacture of a refractory mold wherein

a multi-layered shell is formed by successively coating and hardening slurries comprising a binder and a fine refractory on a pattern and thereafter eliminating the pattern, a method of thermally insulating the shell which comprises

(a) embedding an even distribution of a particulate thermally decomposable material in at least one of the slurry coats subsequent to the first before it is hardened, and

(b) subsequently heating the shell above the decomposition temperature of the material to eliminate the material and leave voids distributed throughout alternate layers of the shell wall.

2. In the manufacture of a refractory mold wherein a multi-layered shell is formed by successively dip-coating and hardening slurries comprising a binder and a fine refractory on a fusible pattern at least seven times and thereafter eliminating the pattern, a method of thermally insulating the shell which comprises

(a) embedding an even distribution of a particulate thermally decomposable material in alternate dip-coats subsequent to the first two and excluding the last before each is hardened, and

(b) heating the shell after the pattern is eliminated above the decomposition temperature of the material to eliminate the material and leave air-filled voids distributed in alternate layers throughout the shell wall.

3. A method according to claim **2** wherein the organic particulate material is either plastic, wood chips, cork, sawdust or corn chips.

4. In the manufacture of a refractory mold wherein a multi-layered shell is formed by successively coating and hardening slurries comprising a binder and a fine refractory on a pattern and thereafter eliminating the pattern, a method of thermally insulating the shell which comprises

(a) distributing a particulate thermally decomposable material over the surface of at least one of the slurry coats subsequent to the first before it is hardened, and

(b) subsequently heating the shell above the decomposition temperature of the material to eliminate the material and leave voids distributed throughout the shell wall.

5. In the manufacture of a refractory mold wherein a multi-layered shell is formed by successively dip-coating and hardening slurries comprising a binder and a fine refractory on a fusible pattern at least seven times and thereafter eliminating the pattern, a method of thermally insulating the shell which comprises

(a) distributing an organic particulate thermally decomposable material over the surface of alternate slurry dip-coats subsequent to at least the first two and excluding the last before each is hardened, and

(b) heating the shell after the pattern is eliminated above the decomposition temperature of the material to eliminate the material and leave air-filled voids distributed in alternate layers throughout the shell wall.

6. A method according to claim **5** wherein the organic particulate thermally decomposable material is wood chips.

7. A method according to claim **5** wherein the organic particulate material is either plastic, wood chips, cork, sawdust or corn chips.

8. In the manufacture of a refractory mold wherein a multi-layered shell is formed by successively coating and hardening slurries comprising a binder and a fine refractory on a pattern and thereafter eliminating the pattern, a method of thermally insulating the shell which comprises

(a) dispersing a particulate thermally decomposable material throughout the slurries used for at least one of the coats subsequent to the first so that the material is embedded and evenly distributed in that coat before it is hardened, and

(b) subsequently heating the shell above the decomposition temperature of the material to eliminate the material and leave voids distributed throughout alternate layers of the shell wall.

9. In the manufacture of a refractory mold wherein a multi-layered shell is formed by successively dip-coating and hardening slurries comprising a binder and a fine refractory on a fusible pattern at least seven times and thereafter eliminating the pattern, a method of thermally insulating the shell which comprises

(a) dispersing an organic particulate thermally decomposable material throughout the slurries used for alternate dip-coats subsequent to at least the first three and excluding the last so that the material is embedded and evenly distributed in those alternate dip-coats before each is hardened, and

(b) heating the shell after the pattern is eliminated above the decomposition temperature of the material to eliminate the material and leave air-filled voids distributed in alternate layers throughout the shell wall.

10. A method according to claim **9** wherein the organic particulate material is either plastic, cork, sawdust or corn chips.

11. In a thermally insulated refractory shell mold comprising a plurality of layers of bonded refractory material, the improvement which comprises

(a) one or more alternate layers excluding the inner layer defining at least part of a multiplicity of voids which reduce the cooling rate of the mold,

(b) at least the inner layer being free of such voids.

12. In a thermally insulated refractory shell mold comprising at least seven layers of bonded refractory materail, the improvement which comprises

(a) a plurality of alternate layers excluding the inner layer defining at least part of a multiplicity of evenly distributed air-filled voids which reduce the cooling rate of the mold,

(b) the remainder of the layers being free of such voids.

13. A shell mold according to claim **12** wherein substantially every void is defined by respective adjoining layers.

14. A shell mold according to claim **12** wherein substantially every void is defined within one of the respective layers.

15. In a thermally insulated refractory shell mold comprising at least seven layers of bonded refractory material, the improvement which comprises

(a) a plurality of alternate adjoining layers, excluding at least the inner two layers, defining between them a multiplicity of evenly distributed air-filled voids which reduce the cooling rate of the mold.

(b) the remainder of the layers being free of such voids.

16. In a thermally insulated refractory shell mold comprising at least seven layers of bonded refractory material, the improvement which comprises

(a) a plurality of alternate layers, excluding at least the inner three layers and the outermost layer, each defining a multiplicity of evenly distributed air-filled voids which reduce the cooling rate of the mold,

(b) the remainder of the layers being free of such voids.

17. In the manufacture of a refractory mold wherein a multi-layered shell is formed by successively coating and hardening slurries comprising a binder and a fine refractory on a pattern and thereafter eliminating the pattern, a method of providing a multiplicity of voids through the shell which comprises:

(a) distributing a particulate thermally decomposable material over the surface of at least one of the

slurry coats subsequent to the first before it is hardened, and

(b) subsequently heating the shell above the decomposition temperature of the material to eliminate the material and leave voids distributed throughout the shell wall.

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