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T. OPERHALL ET AL

3,063,113

DISPOSABLE PATTERN WITH LOWER MELTING EXTERNAL COATING

Filed Dec. 10, 1959

FIG. 1

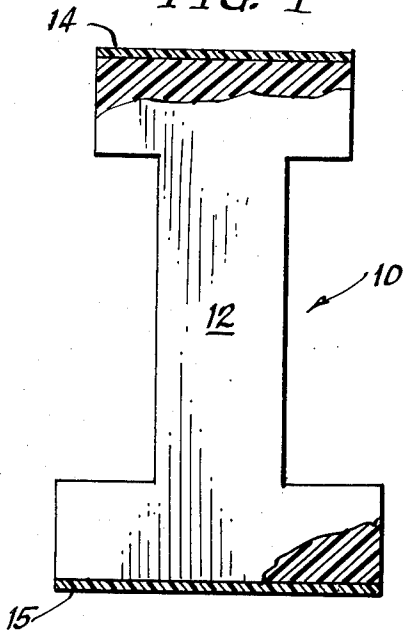


FIG. 2

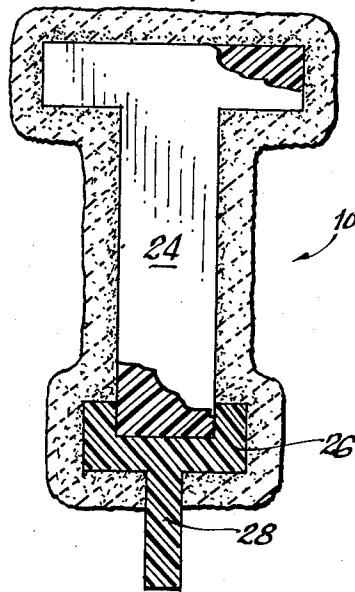


FIG. 3

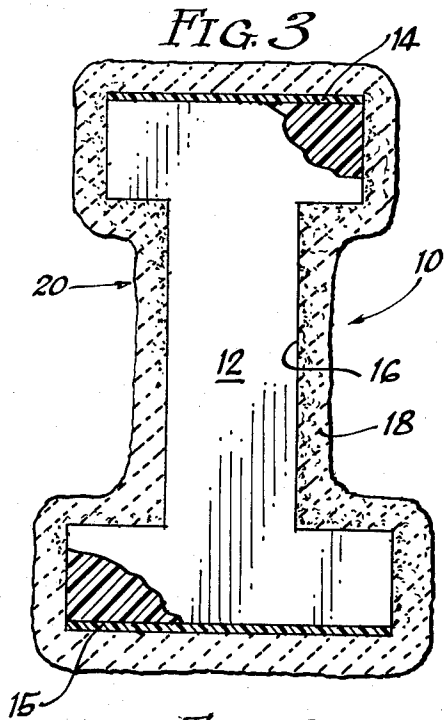


FIG. 4

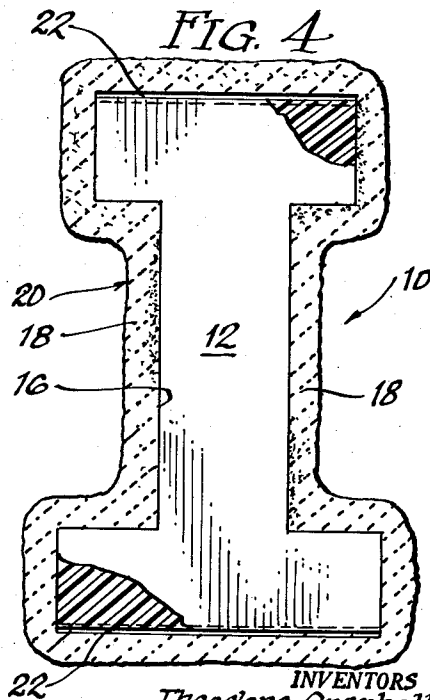


FIG. 3

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1

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**DISPOSABLE PATTERN WITH LOWER
MELTING EXTERNAL COATING**

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12 Claims. (Cl. 22—158)

This invention relates to the art of metal casting using molds which are formed about a pattern fabricated of an expendable material whereby the pattern can be disposed of after the mold has been formed to leave a cavity into which the molten metal may be poured to produce the metal casting, and it relates more particularly to new and improved expendable patterns and method for the manufacture of same.

To the present, two types of processes are generally used for producing precision metal objects from expendable patterns. These processes are investment casting and ceramic shell metal casting.

In the ceramic shell metal casting process, a ceramic shell is built up about the expendable pattern by first coating the pattern with a wet slip generally referred to as a dip coat composition which may be formulated of colloidal silica, finely divided particles of zircon and the like suspended in an aqueous medium with a binder as represented by the formulations in Patents Nos. 2,441,695, 2,806,270, and 2,790,219.

After the excess dip coat has been drained from the surface of the pattern, the wetted surface is covered by a stucco of ceramic particles such as alundum of from 50 to about 80 mesh. After the stucco has been applied, the combined coatings are air dried and a number of similar dip coats and stucco coats are applied with intervening air drying cycles until a shell of sufficient thickness and strength has been built up on the surface of the pattern. In actual practice, the particle size of the stucco increases from the inner coating to the outer coating for the purpose of interlocking one coat with another in building up the composite layers.

In the investment casting process, the pattern with the built-up layers of dip coat and stucco is invested within a matrix of ceramic material for support. For investment, the composite pattern and shell is mounted within a metal flask which is then filled with a composition formulated of a ceramic and inorganic binder, such as a silicate which slowly sets to form a rigid matrix about the shell to support the shell when the metal is poured therein. After the investment material has set, the composite structure is advanced through a furnace where it is heated for from 12 to 24 hours from room temperature to a temperature of about 1800–2200° F. During the heating cycle, the pattern material is removed either by being reduced to a molten state for flow from the mold or by burning when heated to the temperature of combustion, or both. In many investment casting processes, long term, low temperature melt out cycles are used in an effort to prevent mold cracking.

The end product is a mold formed of an outer metal shell, the investment as a matrix, and an inner lining of the built-up layers formed of the material in the dip coat and stucco. The heated mold is carried from the furnace for mounting upon the metal-pouring furnace wherein the metal to be cast is melted and poured into the heated mold in measured amounts to fill the mold.

More recently, many of the deficiencies of the investment process have been overcome by a process herein-after referred to as the "monoshell process" wherein the expense and weight of the investment have been eliminated and the time for removing the pattern and matur-

2

ing the mold has been greatly reduced, thereby to conserve on the weight of the mold and the cost of the materials. The monoshell process also permits inspection of the mold prior to metal casting as distinguished from the inability to inspect in the investment casting process, thereby to enable an increase in yield of acceptable castings from about 60 to 70% in the conventional investment casting process to better than 90% in the monoshell process.

In the monoshell process, the steps of building up the shell by alternate dip and stucco coats are essentially the same as those in the investment casting process except that, instead of investing the shell, the shell is given a final coat of a dip coat composition containing a eutectic material having a lower maturing temperature than the ceramic materials in the stucco or dip coat, as represented by feldspar, so that, when the composite structure is subsequently heated to a high temperature for pattern removal and maturing the mold, the eutectic material in the outer portions of the shell can flow inwardly into the mold to seal fissures and cracks that otherwise form. The eutectic material appears also to function as an auxiliary binder which operates to integrate the mold into a composite structure having sufficient strength to permit handling in the normal casting process without the necessity of investing the mold for support.

For a fuller description of the monoshell process and the materials employed therein, reference may be made to the copending application of Theodore Operhall et al., Serial No. 708,628, filed January 13, 1958, which has issued in U.S. Patent No. 2,961,751, and entitled "Metal Casting Process and Elements and Compositions Used in Same." For purposes of description, the disclosure of said application is incorporated herein by reference.

Where it is attempted to produce large precision parts by lost wax casting processes, special problems are encountered. Most of these problems stem from the inadequacies of the materials used to form the expendable patterns.

The substances most often employed in the fabrication of expendable patterns are low melting point waxes. Experience has shown patterns of these waxes may be readily removed from molds with a minimum of difficulty insofar as mold spoilage is concerned. When used to form large patterns, low melting waxes are deficient from several standpoints. They tend to deform either during the fabrication of the patterns and during the normal handling operations required to form the molds.

In the case of ceramic shell casting where a number of coats of ceramic must be placed around the patterns, large wax patterns sometimes are not sufficiently strong to stand the unsupported weight of the ceramic and will deform and break the ceramic shell prior to the pattern removal step in the casting cycle.

One attempt to overcome the deficiencies of using low melting point waxes as pattern materials resided in the use of structurally strong plastics. Plastics have the advantage of being structurally strong, are not easily deformed and are readily formed into a variety of complex shapes. They also are easily fabricated into clusters by the expediency of using cements as solvents. In the preparation of patterns of substantial dimension, the pattern can be fabricated of separate sections of plastics which can be joined together to form a composite pattern of adequate strength. This is an important characteristic which greatly favors the use of plastics in pattern manufacture.

Plastic patterns, however, suffer from one major deficiency. They are incapable of being removed by heat without violent expansion taking place within the mold cavity. This unfortunate property of plastic patterns renders them unsuitable for most lost wax casting processes. They are particularly unsuited for ceramic shell

processes where the features of structural strength and attendant freedom from deformation when large patterns are necessitated would be most welcome. Structurally strong pattern materials, other than plastics, also are subject to the deficiencies mentioned regarding the plastic patterns.

It would be a valuable contribution to the precision metal casting art if an expendable pattern were available which was structurally strong, was not subject to deformation and yet could be removed from ceramic molds without causing mold damage.

Thus, it is an object of this invention to produce and to provide a method for producing expendable patterns of the type described embodying means to nullify the effects of expansion taking place before the material of which the patterns are formed is reduced to a flowable state to relieve pressure on the ceramic shell formed about the pattern.

It is another object of this invention to produce and to provide a method for producing improved patterns of a heat expendable material for use in mold formation in the manner described with a higher yield of good molds from which a higher yield of acceptable metal castings can be produced.

A further object is to produce high-strength patterns of thermoplastic material which are free of the expansion problems heretofore confronting the use of such materials as patterns in the formation of ceramic molds.

Still another object is to provide patterns which may be of large physical dimensions yet will not deform under normal conditions of handling and use.

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 drawings, in which—

FIGURE 1 is a schematic sectional view of a fragmentary portion of a pattern embodying the features of this invention;

FIGURE 2 is another schematic sectional view of a fragmentary portion of a pattern embodying the features of this invention;

FIGURE 3 is a schematic sectional view of a fragmentary portion of a mold prepared with a pattern of the type shown in FIGURE 1, and

FIGURE 4 is a schematic sectional view, similar to that of FIGURE 2, showing the relationship between elements in an intermediate stage of the heating cycle to remove the pattern from the mold.

It has been found that the problems of the type heretofore described in the use of patterns formed of a material subject to expansions at temperatures below the melting point or decomposition point of the material can be overcome, in accordance with the practice of this invention, when the patterns are fabricated of a combination which makes use of such material as the base of the pattern and a thin coating over at least a portion thereof of another material having a melting point below the temperature at which significant changes in dimension due to expansion take place in the base material. Thus, the material forming the thin coating on the surface of the pattern will be reduced to a flowable state prior to the expansion of the base material such that the material forming the coating will flow from the pattern and leave sufficient space between the pattern and the shell into which the base material, forming the major portion of the pattern, can expand without exerting any pressure on the ceramic mold until such time as the base material itself is heated to a temperature sufficient to cause its elimination from the mold. These patterns are most advantageously employed in producing ceramic shell molds although they are also useful in the production of investment casting molds.

It will be significant that the thickness of the coating of the lower melting point material need be no greater than the amount of expansion calculated to take place through the cross-section of the pattern formed of the

base material. Such thickness could be considered as the minimum since thicker sections of coating of the lower melting point material may be employed, but it is undesirable to make use of layers of excessive thickness since advantages in the form of strength, dimensional stability and surface detail cannot otherwise be maximized.

It has been found that the desired advantages and improvements can be secured when only portions of the base material forming the pattern are coated with the surface layer of lower melting point material. Under such circumstances, it is preferred to provide the surface coating in areas which may be referred to as non-critical areas, i.e., in areas which are not subject to close dimensional tolerance, areas which do not require high finish in "as cast" condition but which will subsequently be processed through additional finishing steps, such as machining, grinding and the like, and on surfaces of the greatest length since the expansion most often occurs in a linear direction and is cumulative. It has been found that improvements in yield of good molds can be secure when as little as 10% of the mold surface includes the lower melting point material, but it is preferred to make use of a mold having a greater proportion of its surface formed of the lower melting point material and preferably its entire surface.

In another embodiment of the invention, the pattern can be composed of both the lower and higher melting point materials which form separate sections of the pattern. When this technique is used, the low melting point material is preferably positioned near spruing or gating so that it is quickly removed from the mold cavity to provide an expansion space.

In the preparation of the pattern, the portion of the pattern formed of the plastic or base material is dimensioned to take into consideration the thickness of the surface coating of the lower melting point material so that the composite structure will embody the dimensional characteristics of the completed pattern. In other words, the portion of the pattern formed of the base material is dimensioned to correspond to the full pattern less the thickness of the coating so that, together, the base material and the coating will form a completed pattern having the tolerances required for mold construction.

Thus the base material of which the pattern is formed may be formulated of a plastic or of a higher melting point wax composition, or of a material such as a metal or compound which is capable of being disposed of at elevated temperature, as by burning out, flowing out as a melt, gasification, or thermal decomposition.

When, as in the preferred practice of this invention, the pattern is fabricated of a synthetic thermoplastic resinous material as the base material, such material may be selected of a large group of thermoplastic resins well known to the investment casting art. Typical plastics for use as the base material include polystyrene, polyvinyl chloride, polyvinylidene chloride, vinyl chloride-vinyl acetate copolymer, polymethylmethacrylate and polyalkyl acrylates and copolymers thereof with acrylonitrile, styrene, vinyl chloride, vinylidene chloride and the like. Of these plastics, polystyrene is the most desirable due to its availability, cost, ease of fabrication and strength.

The lower melting point materials used to form the coating on the base material of the pattern may be selected from such materials as low melting point paraffin waxes which are commonly derived from petroleum hydrocarbons and from natural waxes such as carnauba wax and beeswax and the like, and mixtures thereof. Also useful are such low melting point solids as hydrogenated vegetable oils and saturated fatty acids having sufficient molecular weight to be solid at ambient temperature. Thus, for example, hydrogenated high molecular weight fish oils, stearic acid and hydrogenated beef tallow might be suitable as coatings on the surfaces of the base material to form a completed pattern.

5

Also useful, although somewhat less desirable than the foregoing materials, are the high molecular weight polyethylene glycols, polypropylene glycols and other polyhydric alcohol polymers marketed under the trade name of Carbowax. In addition to the use of organic substances of the type described, other substances such as low melting metals and alloys may be employed without departing from the spirit of the invention.

The coating should be embodied onto the pattern to form a surface meeting the close tolerance requirements and it would be desirable to place the coating on the pattern in such a manner that such tolerances can be preserved. Thus, in the case of materials as represented by waxes having a low melting point, the base material would be fabricated in one mold dimensioned to correspond to the dimensional tolerance of the product less the thickness of the applied coating. The coating of lower melting point material, if of sufficient thickness, could be incorporated onto the surfaces of the base material by arrangement of the molded base pattern in a second mold corresponding to the full pattern after which the lower melting point material would be introduced substantially completely to fill the space about the base pattern in the mold. As an alternative, portions of the base pattern in non-critical areas could be coated with the lower melting point material as by a conventional coating process, such as dip coating, brush coating, spray coating, flow coating or the like, using control of the composition and solids for adjustment of the thickness of the coating applied.

Where the surfaces to be coated are not of complex curvature or are not excessively under cut, a coating of controlled thickness could be incorporated by a system wherein the lower melting point material is supplied as a preformed sheet or film or such sheet could be formed thereof on a device, such as a microtome, and then applied to a section of the surface of the pattern, preferably after it has been warmed sufficiently to allow the surface of the wax to adhere thereto. In the instance of making use of low melting point metals and alloys, the process of sputtering or vacuum electro-deposition could be used to place films of controlled thickness over the surfaces of the base pattern.

The thickness of the coating will be dependent, as previously described, upon the thermal expansion characteristics of the base pattern through the various cross-sections. Routine experimentation can be employed to determine the thicknesses required for use with particular materials and particular cross-sections thereof. As a general rule, it may be said that the coating should be of sufficient thickness to leave, upon removal, an opening into which the base material can expand without contacting the ceramic shell until removal of the base material begins to take place.

Referring now to the drawing, FIGURE 1 the completed pattern 10 is shown as being formed of a base section 12 forming the major portion of the pattern with a portion of its surface coated with thin layers 14 and 15 to complete the pattern. The base section 12 is formed of a heat disposable material, such as polystyrene, polymethylmethacrylate, and the like which may have a melting point of about 300-450° F. The coatings 14 and 15 may be formulated of a wax composition having a melting point in the order of about 180-250° F.

FIGURE 3 illustrates the composite pattern with successive layers of dip coats and stucco coats built up onto the surfaces of the pattern with the inner layers of stucco having a smaller mesh size than the outer layers to provide a smoother surface for better finish of the mold surface 16 against which the molten metal is to be cast. For a more detailed description of the build-up of the mold 18 about the pattern 10, reference may be made to the copending application of Operhall et al., Ser. No. 708,628, now Patent No. 2,961,751, describing the "Mono-Shell" process.

6

FIGURE 4 illustrates the relationship between the mold parts after the composite mold 20 of FIGURE 3 has been exposed to high temperatures such as temperatures within the range of 1800-2700° F. in a heating chamber for the purpose of maturing the ceramic shell and removing the disposable pattern. The illustration represents the elements in an initial stage of the heating cycle wherein the pattern 10 has been heated to a temperature above the melting point temperature for the wax coating 14 and 15 but below the melting point temperature for the material forming the base pattern 12. As illustrated, the coating 14 and 15 of lower melting point material has been reduced to a molten state to enable flow from the mold to leave a small space 22 between the base pattern 12 and the inner surfaces of the ceramic shell 18, defining the mold cavity, and into which the base pattern has partially expanded due to temperature rise. The drawing in FIGURE 3 is exaggerated to illustrate the expansion characteristics of the base pattern from the broken line to the solid line in FIGURE 4.

FIGURE 2 shows another embodiment of the invention. The pattern 10 is composed of two sections 24 and 26. Section 24 is formed of a high melting point substance such as polystyrene whereas section 26 is fabricated of a low melting point heat disposable material such as wax. Section 26 also contains a gate 28 which may be affixed to sprueing to form a pattern cluster. The dotted lines show the portion of the pattern that would be invested or coated to form a ceramic shell.

As the materials continue to heat up within the furnace, the temperature of the base pattern will soon exceed the melting point temperature of the material of which it is formed or else the composition temperature thereof thereby completely to eliminate the base pattern from the mold cavity. Thereafter, heating is continued to mature the ceramic material after which the mold is removed from the furnace. When used to form ceramic shells, the pattern removal temperatures should be quite high, viz., 1000° F. or more to quickly remove the low melting point portion of the pattern.

Under these conditions, the mold can be inspected to make certain that good castings can be produced therefrom. The mold can be transferred from the heating furnace to the melting casting stand for introduction of measured quantities of molten metal therein. Instead, as is sometimes preferred in the "Mono-Shell" process, the heated mold can be allowed to air cool for subsequent inspection and for subsequent use in a metal casting process. Prior to such subsequent use, the mold would be reheated for metal pouring. In the interim, an additional layer of the eutectic material constituting the final ceramic coating in the "Mono-Shell" process can be applied for reduction to a fused state during the reheating step whereby a mold having improved characteristics will be presented to the casting step.

It will be apparent from the foregoing that there is provided a new and improved concept in pattern manufacture whereby difficulties heretofore encountered in the use of patterns of disposable material in preparation of ceramic molds are substantially completely obviated to the end that mold cracking and deterioration can be reduced by as much as fifty percent.

In addition to preventing mold breakage, the inventive concepts permit the melting out operation or pattern removal to be conducted at temperatures below those which have previously been specified. This feature permits ceramic shell molding processes of the type described to be utilized in foundries in which equipment for extremely high temperature melt-out is not available. By the use of the described concepts, it becomes possible to make use of plastic patterns of various dimension including extremely large patterns which were heretofore impractical to use in metal casting processes. The invention is particularly important in allowing large size patterns to be produced without deformation occurring.

It will be understood that changes may be made in the details of construction, materials and operation without departing from the spirit of the invention, especially as defined in the following claims.

We claim:

1. The method of producing a pattern of heat disposable material for enclosure within a ceramic shell from which the pattern is to be removed to define a mold cavity into which molten metal is to be introduced in a metal casting process comprising forming a base pattern dimensioned to correspond to the dimensional characteristics of the completed pattern less the thickness of a coating to be formed on a substantial portion thereon, and then applying a coating to said deficient portions of the base pattern of a material having a melting point below the melting point temperature of the material of the base pattern and dimensioned to make up the difference between the base pattern and the completed pattern whereby the composite corresponds to a completed pattern of the desired dimensional tolerances.

2. The method as claimed in claim 1 in which the coating is formed of a material having a melting point below the temperature at which noticeable expansion occurs in the material of the base pattern.

3. The method as claimed in claim 1 in which the coating is dimensioned to have a minimum thickness corresponding to the amount of expansion in the base pattern at the temperature at which the material of the base pattern is removed.

4. The method as claimed in claim 1 in which the coating is dimensioned to have a minimum thickness corresponding to the expansion in the base pattern at the melting point temperature of the material of which the base pattern is formed.

5. The method as claimed in claim 1 in which the coating covers less than the entire surface of the base pattern but more than 10 percent thereof.

6. The method as claimed in claim 1 in which the base pattern is formed of polystyrene and the coating is formed of a lower melting point wax.

7. The method as claimed in claim 1 in which the base pattern is formed of polymethylmethacrylate and the coating is formed of a lower melting point wax.

8. The method as claimed in claim 1 in which the base pattern is formed of a higher melting point wax and the coating is formed of a lower melting point wax.

9. A pattern suitable for producing ceramic molds for metal casting which comprises a base pattern and a coating on a substantial portion of the surface of the base pattern formed of a composition having a melting point lower than the temperature for disposal of the base pattern and wherein the combined coating and base pattern of which the mold is formed constitute the mold pattern of the desired dimension.

10. A pattern as claimed in claim 9 wherein the coating is formed of a lower melting point wax.

11. A pattern as claimed in claim 9 in which the base pattern is formed of polystyrene.

12. A pattern as claimed in claim 9 in which the coating is dimensioned to have a minimum thickness corresponding to the expansion of the base pattern at the temperature for its removal.

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Dedication

3,063,113.—*Theodore Operhall*, Whitehall, and *Emery E. Kuhary*, North Muskegon, Mich. DISPOSABLE PATTERN WITH LOWER MELTING EXTERNAL COATING. Patent dated Nov. 13, 1962. Dedication filed June 3, 1977, by the assignee, *Howmet Corporation*. Hereby dedicates to the Public the remaining term of said patent.
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