Jan. 28, 1969 B. STEELE 3,424,226

LOST WAX CASTING METHOD

Filed Dec. 16, 1966 Sheet 1 of 3

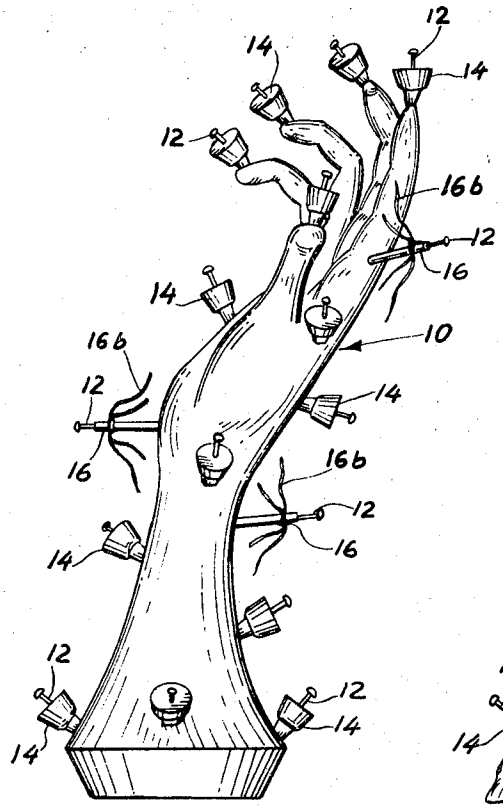


Fig. 1

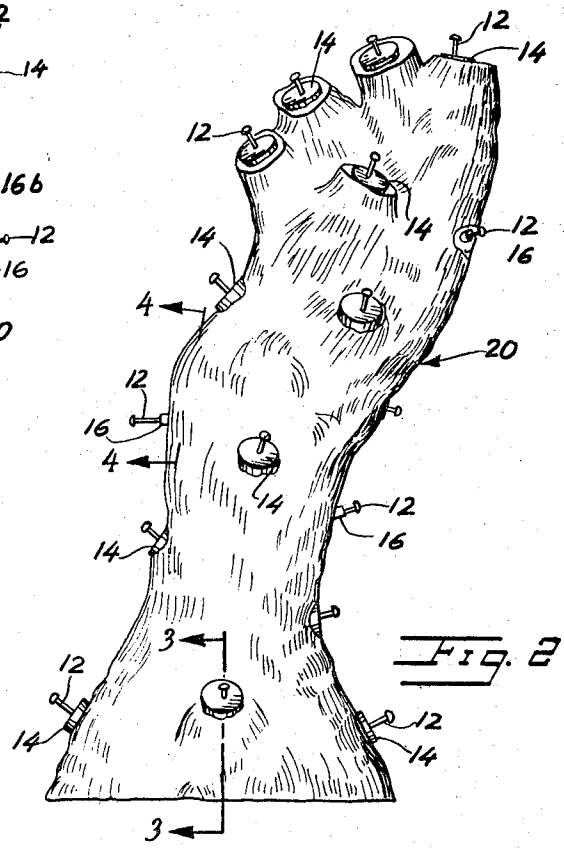


Fig. 2

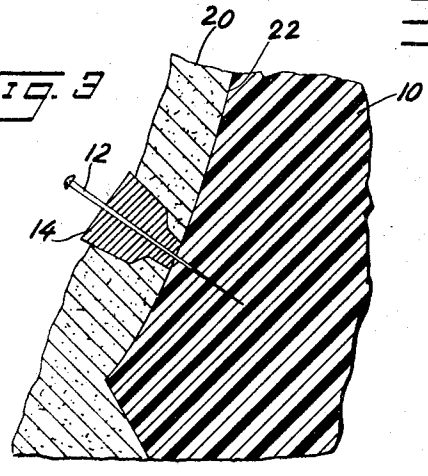


Fig. 3

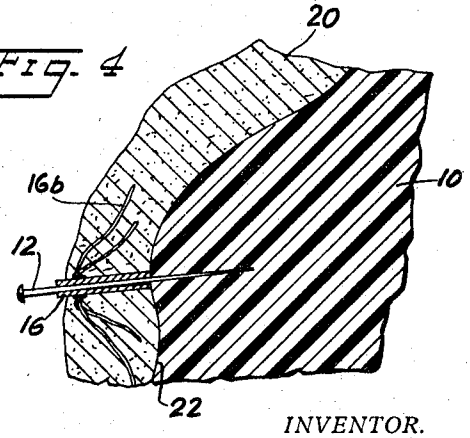


Fig. 4

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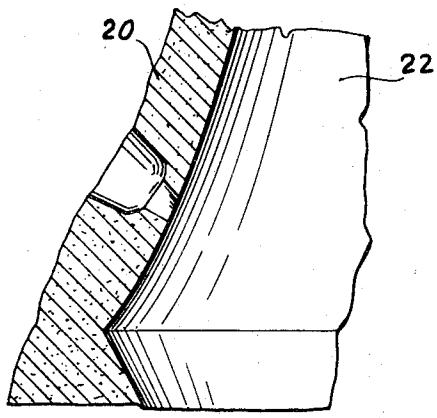


Fig. 3A

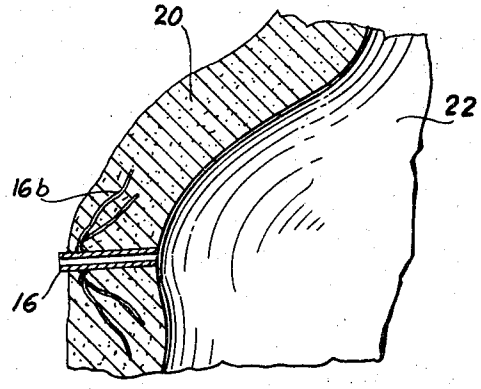


Fig. 4A

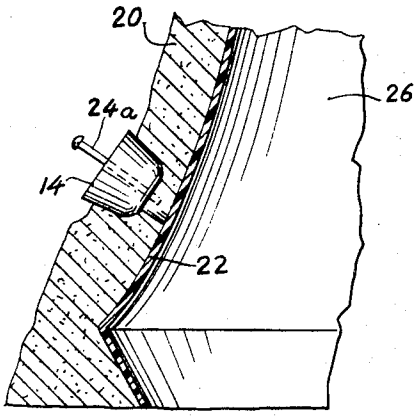


Fig. 5

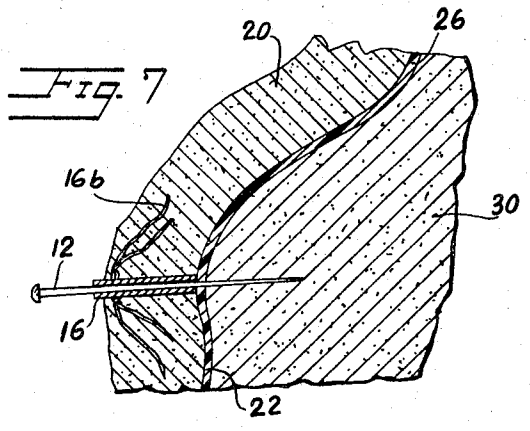


Fig. 7

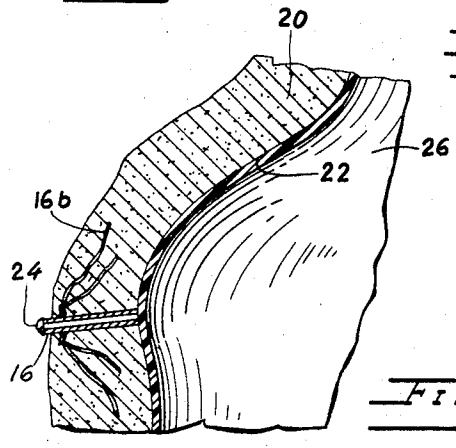


Fig. 6

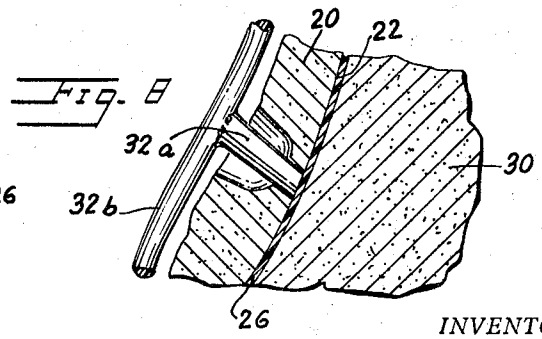


Fig. 8

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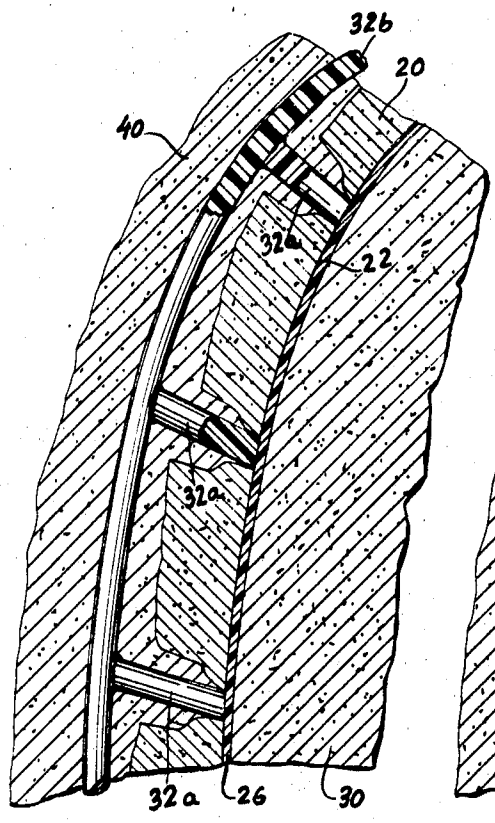


Fig. 9

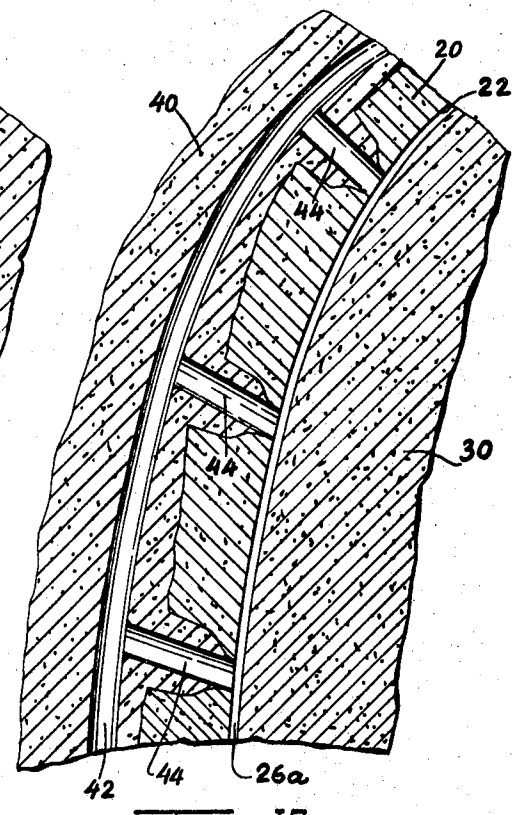


Fig. 10

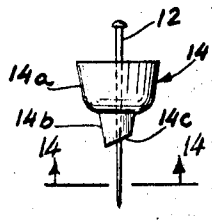


Fig. 11

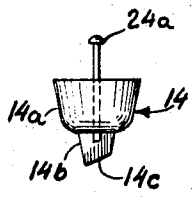


Fig. 12

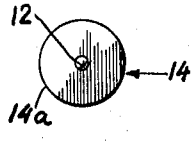


Fig. 13

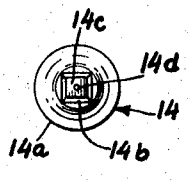


Fig. 14

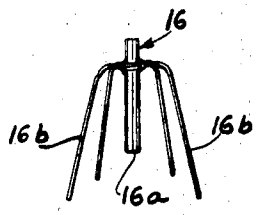


Fig. 15

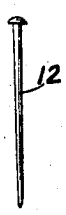


Fig. 16

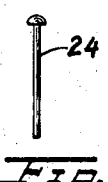


Fig. 17

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3,424,226

LOST WAX CASTING METHOD

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Filed Dec. 16, 1966, Ser. No. 602,262
U.S. Cl. 164—28 6 Claims
Int. Cl. B22c 9/04, 9/02; B28b 7/34

The present invention relates to a novel lost wax method for making hollow metal castings from models of wax, clay, plaster, stone or other such material.

The lost wax process is, basically, a process whereby a removable duplicative material, namely wax, within a mold is replaced with metal of a permanent nature having the same configuration as the removable duplicative material. While application may be had to works of art—duplicating an original sculpture—the process of the present invention provides castings of such great accuracy and faithfulness to the original or model that industrial applications wherein close tolerances must be maintained are contemplated.

The method taught herein is adaptable, as will hereinafter be shown, to various types of casting such as wherein (a) the original is of a destructible nature and need not be preserved and (b) the original is of a non-destructible nature and must be preserved. Examples of these categories may be (a) the original is made of wax which may be melted down, plastic which may be removed by a solvent, etc., or (b) the original is a material such as clay, stone or plaster which is not to be destroyed. In connection with this latter category, the method is applicable to originals of large size and scale. Hereinafter the original to be duplicated will be termed the model regardless of which category is involved.

In the drawing:

FIGURE 1 is a side view of a model showing core support pins, plug jackets and pin sleeves in place thereon.

FIGURE 2 is a side view of the primary investment which has been formed around the model of FIGURE 1.

FIGURE 3 is a fragmentary partial cross-sectional view taken across line 3—3 of FIGURE 2 showing a core support pin with plug jacket in place.

FIGURE 3A is the fragmentary cross-sectional view of the primary investment of FIGURE 3 with the core support pin, plug jacket and model removed therefrom.

FIGURE 4 is a fragmentary partial cross-sectional view taken across line 4—4 of FIGURE 2 showing a core support pin and a pin sleeve in place.

FIGURE 4A is the fragmentary cross-sectional view of the primary investment of FIGURE 4 with the core support pin and model removed therefrom.

FIGURE 5 is the fragmentary cross-sectional view of the primary investment of FIGURE 3 showing the wax shell and plug jacket in place.

FIGURE 6 is the fragmentary cross-sectional view of the primary investment of FIGURE 4 showing the wax shell, pin sleeve and dummy pin in place.

FIGURE 7 is the fragmentary cross-sectional view of the primary investment of FIGURE 4 showing the wax shell pin sleeve, core support pin and core in place.

FIGURE 8 is a portion of the fragmentary cross-sectional view of the primary investment of FIGURE 3 showing the wax shell, core and wax rods in place.

FIGURE 9 is a fragmentary partial cross-sectional view of the primary investment, secondary investment, wax shell, wax rods and core according to the present invention.

FIGURE 10 is the fragmentary view of FIGURE 9 after removal of the wax shell and wax in the gates and sprue.

FIGURE 11 is a side view of a plug jacket with a core support pin in place.

FIGURE 12 is a side view of a plug jacket with a pin molded in place.

FIGURE 13 is a top view of a plug jacket with a pin in place.

FIGURE 14 is a bottom view as taken across line 14—14 of FIGURE 11.

FIGURE 15 is a side view of a pin sleeve.

FIGURE 16 is a side view of a core support pin.

FIGURE 17 is a side view of a dummy pin.

Referring to the drawing, a model **10** may be made of any suitable material such as wax, clay, plaster, wood, stone or the like. At each of a number of various locations about the surface of model **10** is placed a core support pin **12**, a view of which may be seen in FIGURE 16. Each core support pin **12** has a relatively thin, elongated tapered shank terminating in a relatively sharp point permitting such pin **12** to be pushed into model **10** with relative ease. If model **10** is made of an impenetrable material, such as plaster or stone, into which core support pins **12** cannot be pushed, it may be necessary to drill holes therein to receive core support pins **12**.

Each of the several core support pins **12** inserted partly into model **10** carries either a plug jacket **14** or a pin sleeve **16**. Each plug jacket **14**, which may be formed of any suitable material such as plastic, rubber or metal, has a body portion **14***a* of circular cross-section, the diameter of which becomes smaller as body portion **14***a* tapers to meet a relatively smaller end portion **14***b* having a square cross-section and ending in a bottom surface **14***c*. Bottom surface **14***c* of each plug jacket **14** is placed in contact with model **10** and may be shaped so as to follow the contour of model **10** at the area of contact. A central hole **14***d* is provided for insertion of a pin. Each pin sleeve **16** has a central tube **16***a* which may be made, for example, of copper alloy tubing, and several outwardly extending wire stabilizers **16***b*.

There is now formed about model **10** the primary investment **20**. The inner surface **22** of primary investment **20** is made to contact and to follow faithfully the contour of model **10**. Inner surface **22** forms the molding surface which determines the final shape and contour of the ultimate casting. Primary investment **20** is formed to a sufficient thickness at least to cover the major portion of each of the plug jackets **14** and pin sleeves **16**.

When primary investment **20** is completely formed and set, all core support pins **12** and some plug jackets are withdrawn and model **10** is completely removed from primary investment **20**. While normally removal of model **10** involves destruction thereof, for example, melting or burning out a wax model, there is described hereinbelow a method of forming a primary investment without injury or destruction of the model. In all cases the primary investment should be preserved.

All plug jacket and pin sleeve holes in primary investment **20**, with the exception of such holes to be used for air displacement, are now filled. Each pin sleeve **16** not to be used for air displacement is filled with a dummy pin **24**. Each hole in primary investment **20** formed by removal of a plug jacket **14** and to be used for air displacement may be filled by reinserting a plug jacket which has no central hole **14***d*, or by placing other similar filler material in such hole after coating the surrounding surfaces thereof with a releasing agent to permit subsequent removal of the filler material. Dummy pins **24** are similar to core support pins **12** except that the former have blunt ends and are of the same lengths as the particular pin sleeve tube **16***a* into which they may be placed.

Primary investment **20** may be inverted and is completely filled with molten wax or other such depositable and removable material. Unfilled holes in primary investment **20** permit the escape of trapped air and such holes are plugged as soon as air therein has been displaced and the molten wax begins filling such holes. The molten wax is permitted to solidify to the extent of forming a wax

shell **26** of desired thickness adjacent to and completely covering inner surface **22**, whereupon the remaining wax, still molten, is poured out of or otherwise removed from primary investment **20**. The thickness of wax shell **26** determines the wall thickness of the final casting.

Dummy pins **24** are removed and core support pins **12** are inserted into pin sleeve tubes **16***a*. Other filler material, if used, is removed. All core support pins **12** pierce through wax shell **26**. Some of such core support pins **12** are removed to provide air displacement passages through wax shell **26** and primary investment **20**.

Investment material is placed inside primary investment **20** and wax shell **26** where it solidifies to form core **30**. Air displacement holes are plugged with core support pins **12** as soon as all air has been displaced by the investment material. Core support pins **12** extend from primary investment **20** through wax shell **26** into core **30**. FIGURE 7 shows the primary investment **20** and core **30** separated by wax shell **26** configuration which exists at this step of the instant process.

Selected plug jackets **14** are removed from primary investment **20** exposing wax shell **26** at such places. Wax rods **32***a* are placed in the holes thus formed in primary investment **20** and are attached, as by fusing, to wax shell **26**. Wax rods **32***a* are cylinders of wax which are somewhat longer than the thickness of primary investment **20**. Wax rods **32***b* are similar in material and diameter to wax rods **32***a*, but are of sufficient length to permit said wax rods **32***b* to be placed in approximately parallel relation to inner surface **22** and for each of such wax rods **32***b* to connect with several wax rods **32***a* and to extend upwardly and downwardly to a point above and to a point below the secondary investment to be described. Wax rods **32***a* and **32***b* are fused, welded or otherwise joined together at each point of mutual contact.

A refractory material, known as investment material, is placed about the entire outer surface of primary investment **20**, is inserted into all holes which are formed by removal of the remaining plug jackets **14** not selected as in the preceding paragraph and is inserted about wax rods **32***a* in all such other formed holes. This investment material entirely covers all remaining core support pins **12** and wax rods **32***a* and **32***b* except for the uppermost and lowermost portions of the latter rods **32***b* which are left exposed; upon drying and setting, the material forms secondary investment **40**. Secondary investment **40** is accordingly provided with a system of interconnecting wax channels formed by wax rods **32***a* and **32***b* which exit to meet at a point above and at a point below secondary investment **40**.

The entire unit, now consisting of secondary investment **40**, primary investment **20**, wax shell **26**, core **30**, wax rods **32***a* and **32***b* and various core support pins **12** in pin sleeves **16** is heated to melt out all wax therein, the wax flowing out of the exposed point below secondary investment **40**. The result is the formation of sprues **42**, gates **44** and a void or space **26***a* between core **30** and inner surface **22** formerly occupied by wax shell **26**. Sprues **42** and gates **44** form interconnecting passageways in secondary investment **40** which provide communication between space **26***a* and the outside, the passageways meeting at the outside surface of secondary investment **40** at the top and again at the bottom thereof. Core **30** is maintained securely in place relative to primary investment **20** by core support pins **12** which, having pierced through wax shell **26**, are firmly embedded in core **30** on the one hand and secondary investment **40** on the other hand. After the wax has been melted out, the passageway opening at the bottom of secondary investment **40** is closed. The entire unit, which is called a mold, is now complete and is continuous.

Molten metal, or any other suitable material, is now poured into the complete mold and enters space **26***a* via sprues **42** and gates **44**. Upon solidification of the metal, all investments—primary, secondary and core—are removed, leaving the final casting which is a duplicate, albeit hollow, of model **10**. Metal which filled sprues **42** and gates **44** is removed as by cutting it away from the final casting. Core support pins **12** are withdrawn from the final casting and the remaining holes are, if necessary, filled.

In the event it is necessary to preserve model **10**, primary investment **20** can be made in keyed sections as follows. The surface of model **10** is subdivided and pin sleeves **16**, with a core support pin **12**, are placed in each division, the core support pins **12** penetrating model **10**. Pre-drilled holes may be necessary for this purpose. Wax rods **32***a* are attached to model **10**. Plug jackets **14** are unnecessary for the keyed sections method in that the wax rods form the requisite holes in primary investment **20**. Investment material is then placed against model **10** covering a given division. When dried and set the investment material becomes one section of what will be primary investment **20**.

The section is removed from model **10** after first withdrawing core support pins **12** and the procedure is repeated for each of the other divisions on the surface of model **10**. Sections of primary investment **20** may be keyed in any conventional manner, as by particular shape, by numbering or by other identifying means, so as to permit rapid and accurate assembly of the sections to form a complete primary investment **20**. Sections may be welded to each other by use of investment material as a welding material, or any suitable adhesive or joining method may be utilized. Once fully assembled, primary investment **20** may be used in the manner specified above for a continuous primary investment.

The sectioned primary investment method of the paragraph last preceding may also be utilized if the model is of such large size, or has a particular shape or configuration, that a one-piece primary investment is not utilizable or is utilizable only with difficulty.

While the foregoing is illustrative of preferred embodiments of the present invention, it is to be understood that other embodiments and modifications thereof may be provided within the broad spirit of the invention and the broad scope of the claims.

What is claimed is:

1. The process of casting a duplicate from a model, comprising the steps of:

(a) forming a primary investment, containing formed holes, about the model;

(b) separating the model from the primary investment;

(c) forming a shell of a removable duplicative material in the primary investment;

(d) forming a core in said shell and primary investment;

(e) placing removable rods in the formed holes in the primary investment and connecting said rods to said shell;

(f) forming a secondary investment about said primary investment, said secondary investment having interconnecting passageways formed therein;

(g) removing said shell and said rods from said core, primary investment and secondary investment; and

(h) casting the duplicate between the primary investment and core.

2. The process of casting a duplicate from a model in accordance with claim **1**, additionally comprising the step of:

(a) securing the core in position relative to the primary investment.

3. The process of casting a duplicate from a model in accordance with claim **1**, additionally comprising the step of:

(a) pinning the core to the primary investment to prevent relative movement therebetween.

4. The process of casting a duplicate from a model in accordance with claim **1**, additionally comprising the step of:

(a) pinning the core to the primary investment to prevent relative movement therebetween by embed-

ding pins in the secondary investment, said pins passing through and being supported by the primary investment by means of pin sleeves secured therein, and extending into said core.

5. The process of casting a duplicate from a model in accordance with claim 1, additionally comprising the step of:

(a) forming holes in the primary investment by means of removable plug jackets.

6. The process of casting a duplicate from a model in accordance with claim 1, wherein forming the primary investment comprises the steps of:

(a) forming investment material in individual keyed sections about the model; and

(b) assembling the keyed sections after removal from the model to form the primary investment.

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U.S. Cl. X.R.

164—361; 249—85