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Horton

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[45] **May 28, 1974**

[54] **METHOD FOR FORMING CERAMIC SHELL MOLDS**

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[21] Appl. No.: **360,796**

Related U.S. Application Data

[62] Division of Ser. No. 172,035, Aug. 16, 1971, abandoned.

[52] **U.S. Cl.** **164/25**

[51] **Int. Cl.** **B22c 9/04**

[58] **Field of Search** 164/23, 24, 25, 26, 165, 164/166; 118/426

[56] **References Cited**

UNITED STATES PATENTS

R26,495	12/1968	Watts et al.	164/26
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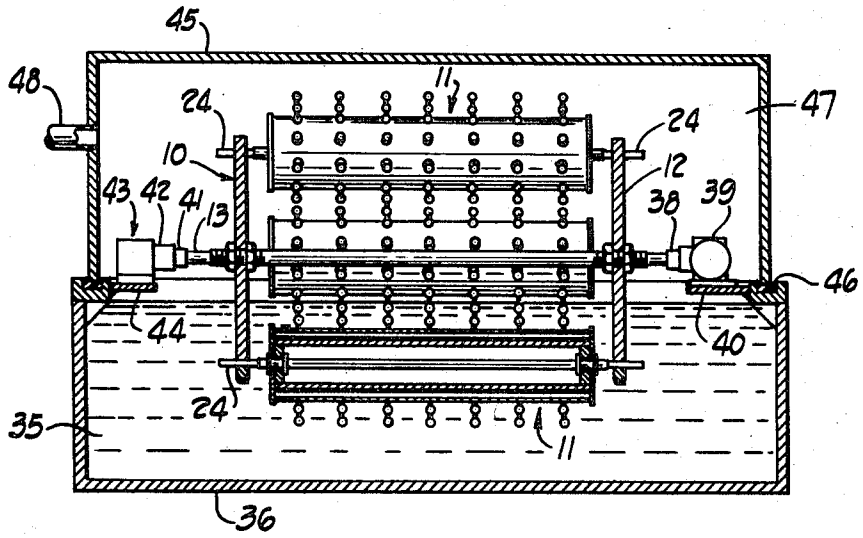
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Primary Examiner—J. Spencer Overholser
Assistant Examiner—John E. Roethel
Attorney, Agent, or Firm—Watts, Hoffmann, Fisher & Heinke Co.

[57] **ABSTRACT**

A method is provided for simultaneously coating a plurality of pattern set-ups with refractory material in a single operation during the production of ceramic shell molds. An array of circumferentially spaced pattern set-ups is mounted for rotation about a horizontal axis so that each set-up is moved about the axis between a raised position and a lowered position in which the set-up is at least partially immersed in refractory material. In one preferred embodiment of the invention provision is made for rotating each set-up about its longitudinal axis during the coating operation.

8 Claims, 6 Drawing Figures



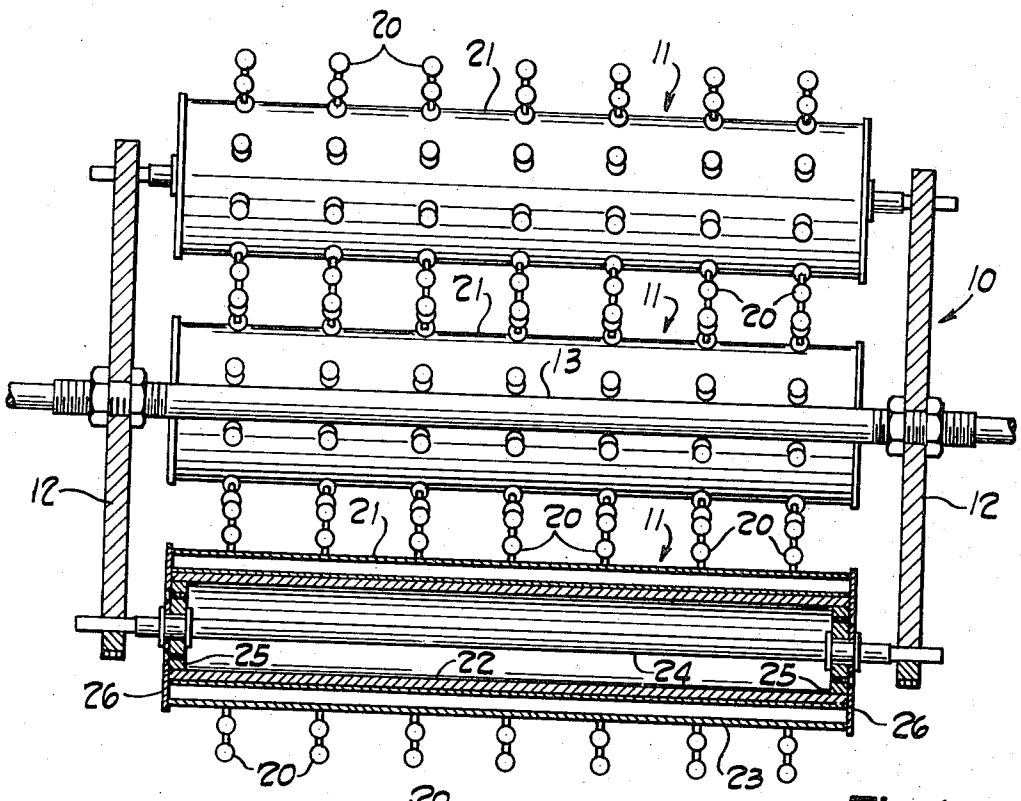


Fig. 1

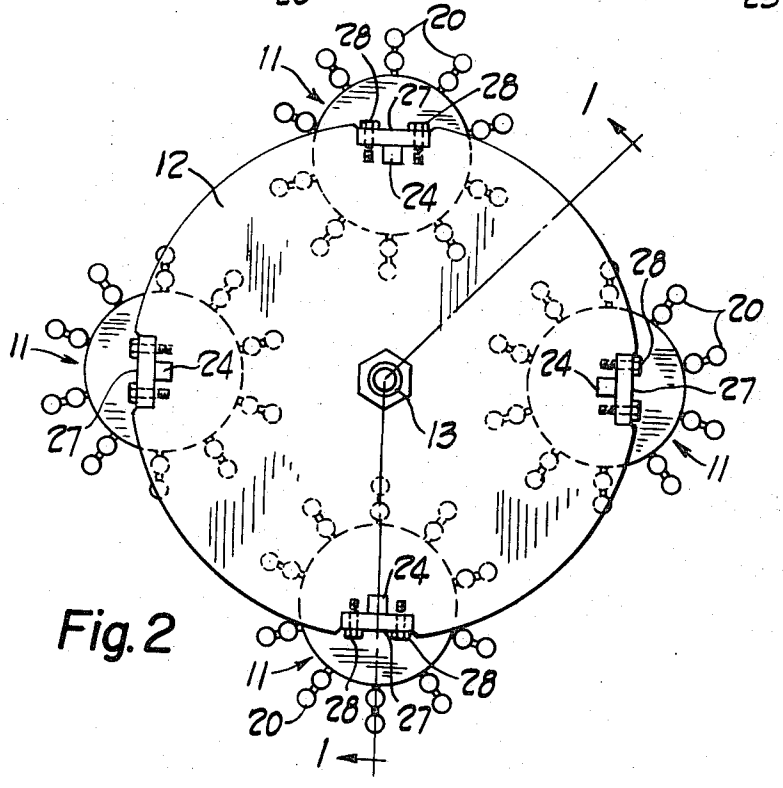


Fig. 2

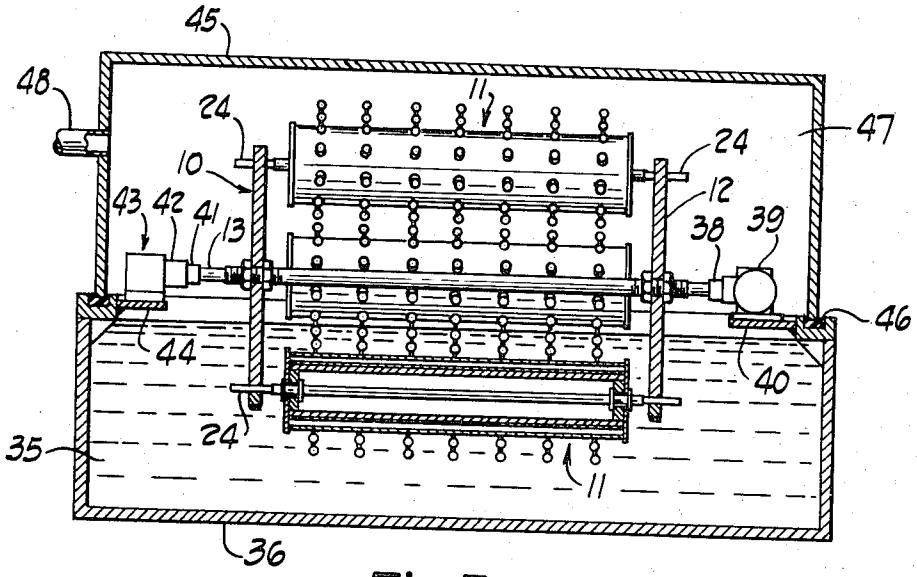

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48
24
11
47
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41
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46
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35
24
11
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Fig. 3

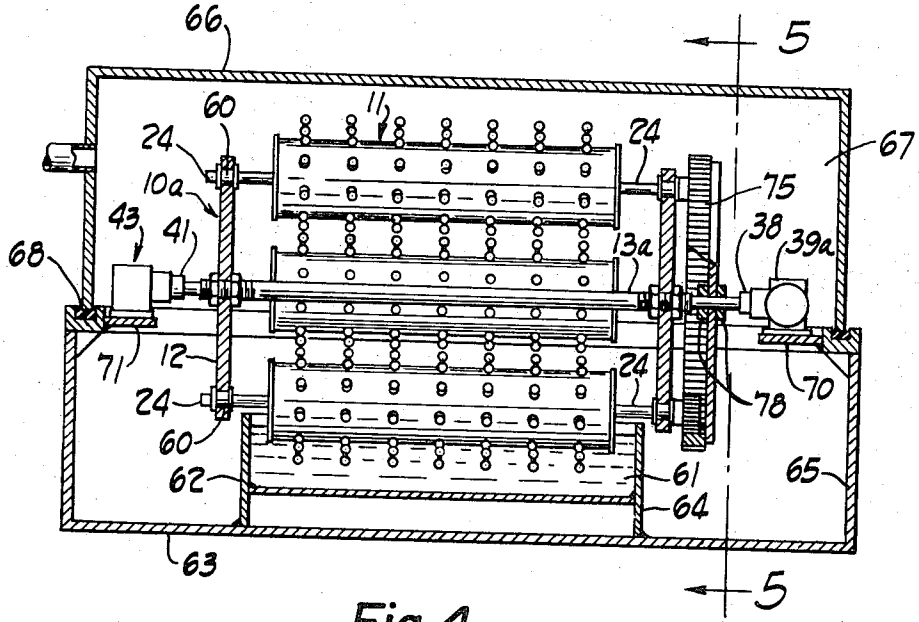

66
5
60
11
24
24
67
10a
75
43
41
38
39a
68
13a
71
12
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63
5

Fig. 4

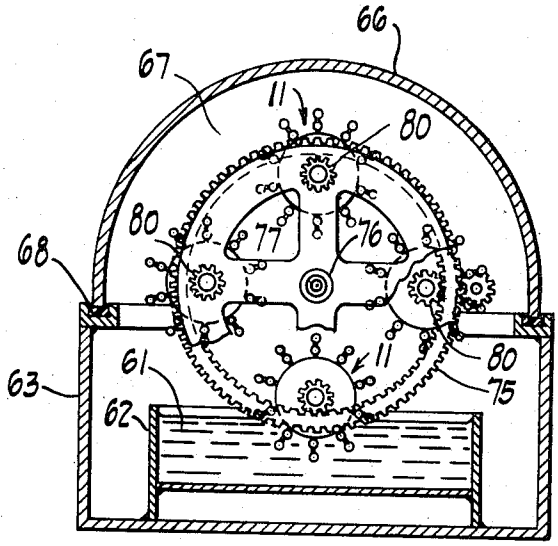

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62

Fig. 5

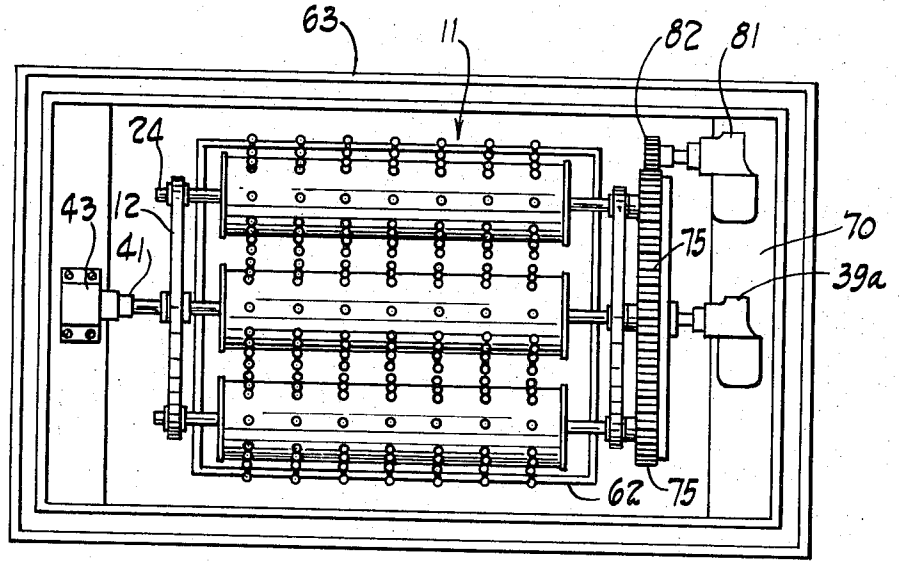

63
11
82
81
24
43
12
41
75
70
39a
62
75

Fig. 6

METHOD FOR FORMING CERAMIC SHELL MOLDS

CROSS-REFERENCE TO RELATED APPLICATION

This application is a division of application Ser. No. 172,035 filed Aug. 16, 1971, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates generally to the art of investment casting, and more specifically to ceramic shell molding techniques of precision casting wherein shell molds suitable for casting metal are prepared by building up layers of refractory material around disposable patterns which are subsequently removed from the mold.

As is known to those familiar with the art of investment casting, ceramic shell molds are prepared using patterns which are replicas of the parts to be cast in metal and which are formed of an expendable material. These patterns are attached to a sprue member to form what is known as a "set-up." The formation of a shell mold around the set-up is accomplished by dipping it into a refractory slurry of controlled viscosity followed by directional draining to coat the patterns uniformly. After draining excess slurry from the set-up, the slurry coating is sanded or stuccoed while wet with coarser refractory particles, such as by dipping the set-up into an air-fluidized bed of dry refractory material. The result is a coat of ceramic material having refractory particles embedded in the surface. This coat is hardened, usually by air drying at room conditions. After the first coat is sufficiently hard and dry, the steps of dipping, draining, stuccoing and drying are repeated until a refractory shell having a sufficient thickness to resist the stresses occurring in subsequent operations has been built up around the set-up. The usual shell thickness is from one-eighth inch to about one-half inch, although thicker or thinner shells may be formed for special situations. The set-up including the disposable patterns is then removed from the shell mold and the mold prepared for the casting operation.

In order to obtain a satisfactory shell mold for casting metal, it is necessary to form dense, void-free coatings around the set-up. This requires the set-up to be carefully rotated so that the slurry will flow over and coat all areas of the set-up uniformly. A satisfactory coating is particularly difficult to obtain when the workpiece patterns have relatively complex shapes, including holes, slots, narrow passageways, surface detail and the like. The viscosity of the slurry is often such that it will not easily flow into and cover the complex portions of the patterns. There is also a tendency for air to be trapped in restricted areas of the patterns and/or in previously applied coatings so as to weaken the shell mold and produce voids which may result in the castings being scrapped. Further, when the set-up consists of a large number of closely spaced patterns, there is a tendency for a substantial amount of the slurry to be retained between the patterns so as to form relatively thick wall portions in these areas. The thick wall portions are difficult to dry properly and may crack when heated, such as during the pattern removal operations and/or when the molds are fired prior to casting.

An important advance in the art of ceramic shell molding is described in U.S. Pat. No. RE. 26,495, issued Dec. 3, 1968 to Claude H. Watts et al. As disclosed in that patent, the pattern set-up is horizontally positioned for rotation about its longitudinal axis so that rows of patterns on the set-up can be moved into and out of a slurry bath by rotating the set-up. The rotation of the set-up on its horizontal axis has been found to produce excellent coating results and to avoid the problems discussed above. As the set-up is rotated to move the rows of patterns into and out of the slurry, the angular positions of the patterns are continuously changed. As a result, the slurry can run over all portions of the patterns and fill all of the pattern cavities and other difficult-to-fill areas so as to produce a uniform coating. By rotating the pattern set-up on its horizontal axis following the coating operation, it is also possible to obtain improved directional draining of excess slurry and to prevent the slurry from being trapped between closely spaced patterns so as to form thick, difficult-to-dry wall areas.

SUMMARY OF THE INVENTION

An object of the present invention is to provide method for simultaneously applying slurry coatings to a plurality of pattern set-ups in a single operation so as to obtain the several advantages described in the above-referenced U.S. Pat. No. RE 26,495.

In accordance with the preferred embodiments of the present invention, a plurality of pattern set-ups are supported by a fixture which is mounted for rotation about an axis transverse to the vertical height of a slurry tank. The set-ups are supported at locations disposed about the axis of rotation of the fixture and are spaced radially from the axis. When the fixture is rotated, each pattern set-up is revolved about the axis of the fixture between a lowered position in which the set-up is at least partially immersed in the slurry and a raised position. In one preferred embodiment, provision is made for rotating each of the pattern set-ups about its longitudinal axis during the coating operation. A cover or hood may be associated with the tank to form a vacuum chamber in which the fixture is disposed so that the slurry and the set-ups can be subjected to vacuum conditions when the set-ups are being rotated and coated with slurry.

A primary advantage obtained by the invention is that it makes it possible to produce relatively small diameter set-ups in a practical and economical manner. This is of particular benefit to investment foundries whose operations are limited by the capacity of their melting furnaces and other equipment and which do not require the sophisticated mold making apparatus of the size used by larger foundries. The new method and apparatus for simultaneously coating a plurality of set-ups in a single operation reduce the costs of making shell molds and are especially suitable for the production of small diameter molds compatible to the operations of small foundries.

Other objects, advantages and a fuller understanding of the invention will be had from the following detailed description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view taken on the line 1—1 of FIG. 2 and shows an assembly of pattern set-ups supported by a fixture in accordance with this invention;

FIG. 2 is an end elevational view of the assembly shown in FIG. 1;

FIG. 3 is a vertical elevation, partially in cross-section, showing the assembly of FIG. 1 mounted for a coating operation according to one embodiment of this invention;

FIG. 4 is a vertical elevation, partially in cross-section, showing the assembly of FIG. 1 mounted for a coating operation according to another embodiment of this invention;

FIG. 5 is a cross-sectional view taken on the line 5—5 of FIG. 4; and

FIG. 6 is a top plan view with portions eliminated of the arrangement shown in FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings and to FIGS. 1 and 2 in particular, there is shown a fixture **10** which supports a plurality of pattern set-ups **11**. The fixture **10** is comprised of a pair of disks **12** which are suitably secured to a rod **13** in axially spaced locations.

Each of the set-ups **11** is of a typical construction including a plurality of workpiece patterns **20** which project from the outside wall of a sprue member **21**. In accordance with conventional practice, the workpiece patterns **20**, which are replicas of the parts to be cast and include the necessary gates and risers, are formed of an expendable material, such as wax, a synthetic resin, or a wax and resin composition.

The sprue members **21** are generally cylindrical. As shown, each such sprue member may be comprised of a tube **22** made of cardboard or other relatively stiff material, and a corrugated cardboard sleeve **23** which surrounds the tube **22**. The sleeve **23** is axially corrugated in its inner surface while the other surface of the sleeve is smooth. The smooth outer cylindrical wall of the sleeve **23** is provided with a thin coating of wax or the like to which the patterns **20** are attached. A rod **24** extends longitudinally through each set-up **11** and the ends of the tube **22** are closed by disks **25** which are secured to the rod **24** by any suitable means. Each set-up is completed by annular plates **26** which are secured to the disks **25**. The plates **26** project circumferentially beyond the sleeve **23** a sufficient distance to prevent the shell forming material from being built up around the ends of the set-up.

It is to be understood that the described construction of the sprue members **21** can be varied and that the illustrated structure is not limiting of the invention. For example, the body of each sprue member may be formed by an injection molded wax tube. According to another conventional practice, the sprue members may comprise metal tubes coated with wax.

In accordance with the present invention, the set-ups **11** are supported in circumferentially spaced locations around the outer peripheries of the disks **12**. The longitudinal axes of the set-ups defined by the rods **24** are radially spaced from and are preferably parallel to the axis of the fixture **10** defined by the rod **13**. As shown in FIG. **2**, the ends of the rods **24** are received in slots or notches formed in the disks **12** and are held in place by keepers **27**. The keepers **27** are removably fastened to the disks **12** in any suitable manner, as by screws **28**, in order to permit the set-ups **11** to be mounted on and removed from the fixture **10**.

FIG. **3** illustrates one preferred manner of coating the set-ups **11** with refractory slurry. As shown, a refractory slurry bath **35** is provided in a tank **36**. The fixture **10** is mounted above the bottom of the tank **36** for rotation about a horizontal axis defined by the rod **13**. One end of the horizontally extending rod **13** is engaged in a rotatable drive cup or shaft socket **38**. A motor **39** is mounted on a plate **40** at one end of the tank **36** and has its output shaft in driving connection with the cup or shaft socket **38** for rotating the fixture **10**. The other end of the rod **13** is received within a spring-biased, axially movable socket **41** which is rotatably journaled within a sleeve **42** of a mounting assembly **43**. The mounting assembly **43** is supported by a plate **44** connected to the tank **36**.

The fixture **10** is mounted for rotation by first inserting one end of the fixture rod **13** in the socket **41** which is then pressed inwardly relative to the sleeve **42** to permit the other end of the fixture rod **13** to be inserted in the drive cup **38**. When the spring-biased socket **41** is released, the socket is urged outwardly of the sleeve **42** so that the fixture **10** is firmly supported for rotation by the motor **39**.

In accordance with conventional practices, a suitable refractory slurry used for coating the pattern set-ups **11** consists essentially of a suspension of fine refractory powder, such as zircon (zirconium silicate) and fused silica, in a binder solution comprised mainly of colloidal silica sol and small amounts of an organic film former, a wetting agent, and a defoaming agent. The refractory powder usually is minus 100 mesh.

In forming the slurry coatings around the pattern set-ups **11**, the fixture **12** is rotated relatively slowly by the motor **39**, for example, about 5 rpm, so that each set-up is lowered into the slurry **35** at one side of the tank **36** and is raised out of the slurry at the other side of the tank. The rotative movement of the fixture constantly changes the angular positions or attitudes of the various patterns **20**. This constant changing of the attitudes of the various patterns is advantageous, since the excess slurry is caused to run over the patterns as they are rotated out of the bath and around the rod **13**, thereby resulting in uniform pattern coverage.

It is usually desirable to apply at least the initial slurry coatings under a vacuum in order to remove occluded air in the slurry and to prevent formation of air bubbles on the surfaces of the patterns. Such a procedure is particularly advantageous with patterns having intricate surface detail and difficult-to-fill areas, such as small recesses and cavities, which tend to trap air during rotation of the fixture.

As shown in FIG. **3**, a removable cover **45** is provided for the tank **36**. The cover **45** is engageable with a tank seal member **46** to form a vacuum chamber **47** in which the fixture **10** and the set-ups **11** are disposed. A fitting **48** is mounted through an end of the cover **45** and is adapted to be connected by a vacuum line (not shown) to a suitable vacuum pump or the like. When the cover **45** has been moved to the closed position against the seal **46**, a vacuum is drawn in the chamber **47** to remove any air bubbles from the slurry **35**, and the fixture **10** is rotated while the slurry is under the vacuum. It will be understood that the vacuum treatment of the slurry may be effected either during each such coating operation or during only selected applications of the slurry to the set-ups. In some instances, the use of a vacuum treatment can be eliminated entirely.

Subsequent to the described coating operation the coated set-ups **11** are stuccoed with coarse refractory materials, such as by rotating the fixture **10** to move the coated set-ups **11** through an air-fluidized bed of refractory materials. The stuccoed coatings are then allowed to harden, as by forced air drying. Additional slurry coatings may be applied in the same manner, stuccoed and allowed to harden until a ceramic shell of the desired thickness has been produced around each pattern set-up.

FIGS. **4, 5** and **6** illustrate another preferred arrangement and procedure for coating the pattern set-ups **11** with refractory slurry. According to this embodiment of the invention, the pattern set-ups **11** are supported by a fixture **10a** in substantially the same manner as described above in connection with FIGS. **1** and **2** except that the set-ups are mounted for rotation about their longitudinal axes. The ends of the set-up rods **24** are journaled in sleeves **60.** The sleeves **60** are mounted in the notches formed in the plates **12***a* around their outer peripheries and are held in place by keepers (not shown) similar to the keepers **27** described above.

As shown in FIGS. **4, 5** and **6,** a refractory slurry bath **61** is provided in a tank **62.** The tank **62** is mounted in a housing **63** so that at least one end wall **64** of the tank is spaced inwardly from the adjacent end wall **65** of the housing. A cover **66** cooperates with the housing **63** to form a vacuum chamber **67** over the slurry bath **61.** In its closed position, the edges of the cover are engaged against a seal ring **68.**

The fixture **10***a* is supported for rotation about a horizontal axis in the same manner as described above in connection with FIG. **3.** One end of the fixture rod **13***a* is engaged in a drive cup or shaft socket **38** which is driven by a motor **39***a* supported on a plate **70.** The other end of the rod **13***a* is engaged in a spring-biased, axially movable cup or socket **41** of a mounting assembly **43** which is supported on a plate **71.**

Provision is made for rotating each of the pattern set-ups **11** about its longitudinal axis as the fixture **10***a* is rotated about the horizontal axis defined by the rod **13***a*. A ring-type gear **75** having teeth in its inner and outer peripheries is freely rotatable on the fixture rod **13a** between the tank end wall **64** and the end wall **65** of the housing **63.** As shown in FIG. **5,** the gear **75** has a central hub portion **76** which receives the rod **13***a* and radially extending spider arms **77.** The hub portion **76** is mounted between removable members **78** which are fixed to the rod **13***a* so that the gear **75** is free to rotate relative to the rod while being restrained against axial movement. Pinions **80** are secured to the ends of the set-up rods **24** and engage the inner teeth of the gear **75** so that rotation of the gear is effective to rotate each of the individual set-ups **11.** The gear **75** is rotated by a motor **81** mounted on the plate **70.** A pinion **82** is fixed to the drive shaft of the motor **81** and engages the outer teeth of the gear **75.**

In a preferred manner of operation, the fixture **10***a* is rotated by the motor **39***a* to cause the set-ups **11** to revolve about the rod **13***a*, whereby each of the set-ups is moved between an upper position above the rod **13***a* and a lower position in which the set-up is at least partially immersed in the slurry. As shown in FIGS. **4** and **5,** only the lower portion of each set-up is immersed in the slurry when the set-up is in the lowered position. The motor **39***a* is preferably operated intermittently to rotate the fixture **10***a* step-wise, whereby each set-up is held in the lowered position for a predetermined length of time. The motor **81** may be operated to continuously rotate the set-ups about their longitudinal axes during the coating operation. By rotating the set-ups about their longitudinal axes at the same time they are revolved about the rod **13***a*, excess slurry is drained from the set-ups to prevent the formation of thick wall portions between the closely spaced patterns. If desired, the coating operation may be carried out under a vacuum in the manner described above in connection with FIG. **3.**

Many modifications and variations of the invention will be apparent to those skilled in the art in the light of the foregoing detailed disclosure. Therefore, it is to be understood that, within the scope of the appended claims, the invention can be practiced otherwise than as specifically shown and described.

What is claimed is:

1. In the production of investment casting molds by building up refractory layers around pattern set-ups, a method of applying refractory material to a plurality of pattern set-ups in a single operation comprising the steps of mounting an array of several pattern set-ups for rotation as a group about an axis transverse to the vertical, the pattern set-ups being spaced radially from said axis and arranged about it with their ends lying in planes transverse to said axis so that when the array is rotated each pattern set-up is moved about said axis between a lowered position and a raised position, rotating the array and moving each set-up to change the angular positions of its outer peripheral proportions, and applying fluent refractory material to the set-ups in the array, whereby the material is caused to uniformly cover the outer peripheral portions of the set-ups as their angular positions are changed.

2. In the production of investment casting molds by building up refractory layers around pattern set-ups, a method of applying refractory material to a plurality of pattern set-ups in a single operation comprising the steps of mounting an array of several pattern set-ups for rotation as a group about an axis transversed to the vertical height of a tank containing fluent refractory material, the pattern set-ups being spaced radially from said axis and arranged about it with their ends lying in planes transverse to said axis so that when the array is rotated each pattern set-up is moved about said axis between a lowered position in which it is at least partially immersed in the refractory material and a raised position in which the set-up is above the refractory material and rotating the array of pattern set-ups through the refractory material while moving each set-up to change the angular positions of its outer peripheral portions so that they are uniformly covered by the refractory material.

3. A method as claimed in claim **2** wherein said refractory material is a slurry, and including the step of placing the slurry under vacuum during rotation of the array.

4. A method as claimed in claim **2** in which at least some of said set-ups of said array are individually rotated about their longitudinal axes.

5. A method as claimed in claim **4** including the step of periodically interrupting rotation of said array when at least some of said set-ups are in said lowered position.

6. A method as claimed in claim 1 wherein the set-ups are held against rotation about their own axes as the array is rotated.

7. A method as claimed in claim 1 wherein the set-ups are individually rotated about their own axes as the array is rotated.

8. A method of making refractory molds by building up refractory layers around pattern set-ups, said method being characterized by the procedure of handling several pattern set-ups as a group during formation of the refractory layers around the set-ups in the group and including the steps of:

a. grouping a plurality of pattern set-ups in an array so that the set-ups are circumferentially spaced from each other about an axis and so that the ends of the set-ups lie in planes transverse to said axis,

b. processing the array of several pattern set-ups through a coating operation in which refractory slurry is applied to each set-up in a single operation,

c. processing said array of several pattern set-ups through a stuccoing operation in which refractory particles are applied to the coated set-ups of the array in a single operation,

d. hardening the stuccoed coatings around the set-ups,

e. repeating the coating and stuccoing operations to build up refractory layers around each set-up in the array, and

f. removing the set-ups from the array after refractory layers of the desired thickness have been formed,

g. at least one of said operations being carried out by the steps of:

i. mounting the array of set-ups for rotation about said axis with said axis being transverse to the vertical height of a tank containing fluent refractory material and so that when the array is rotated each pattern set-up is moved about said axis between the lowered position in which it is at least partially immersed in the refractory material and a raised position in which the set-up is above the refractory material,

ii. rotating the array of pattern set-ups through the refractory material while moving each set-up to change the angular positions of its outer peripheral portions so that they are uniformly covered by the refractory material.

* * * * *