

Feb. 25, 1969

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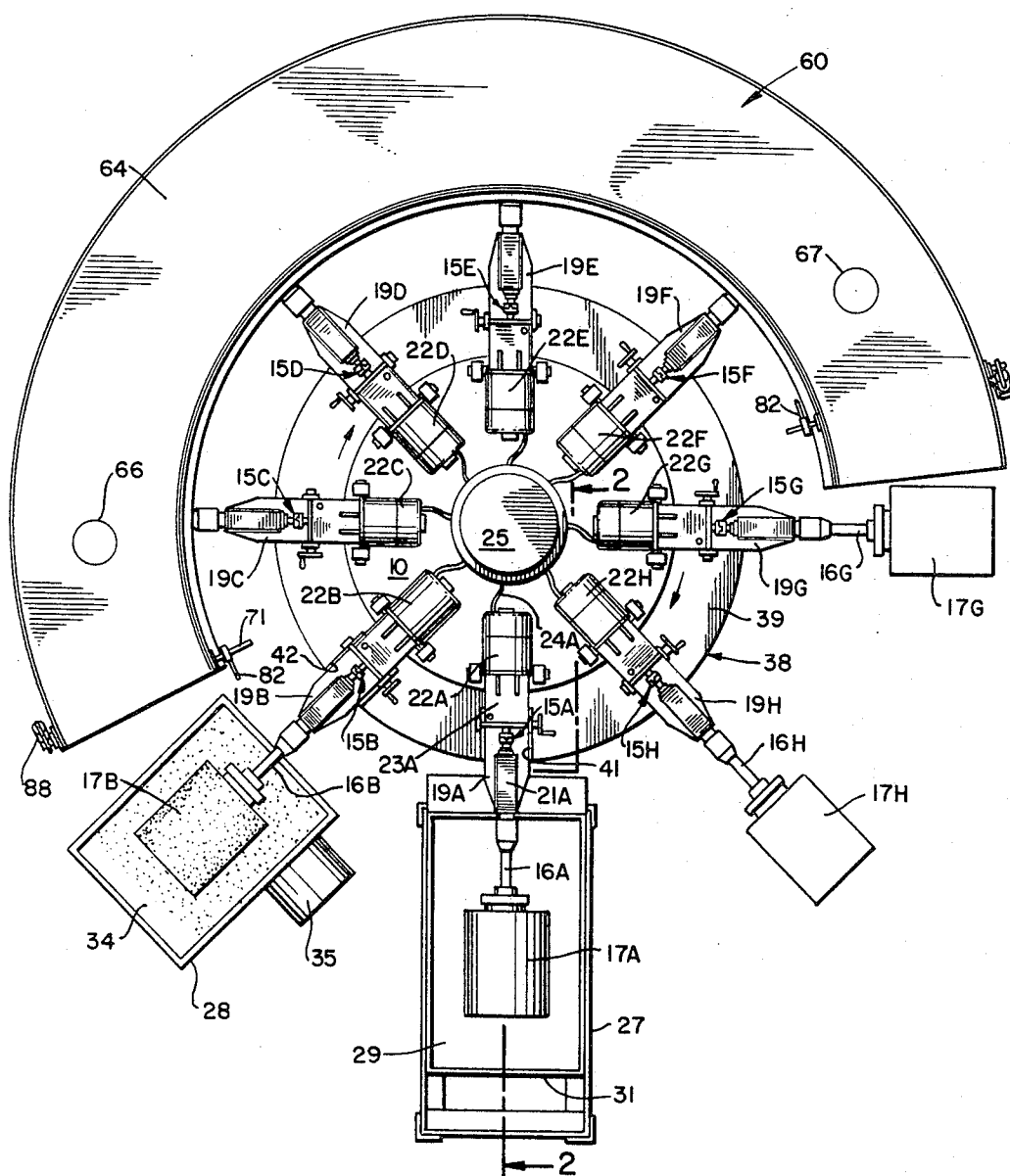
3,429,358

METHOD FOR MANUFACTURE OF REFRACTORY SHELL MOLDS

Original Filed Sept. 21, 1964

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FIG. 1



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FIG. 3

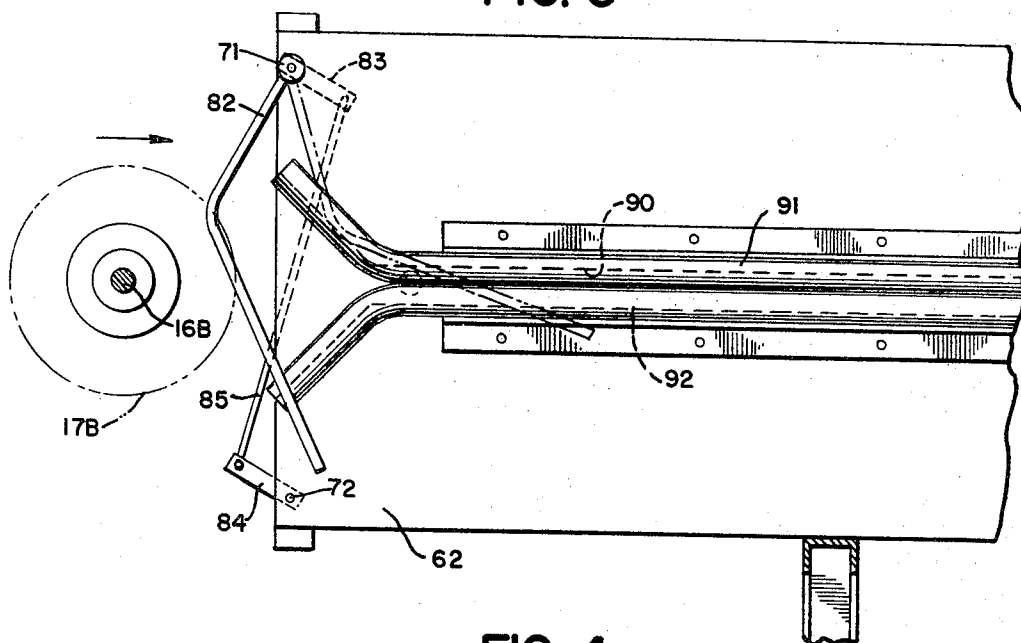
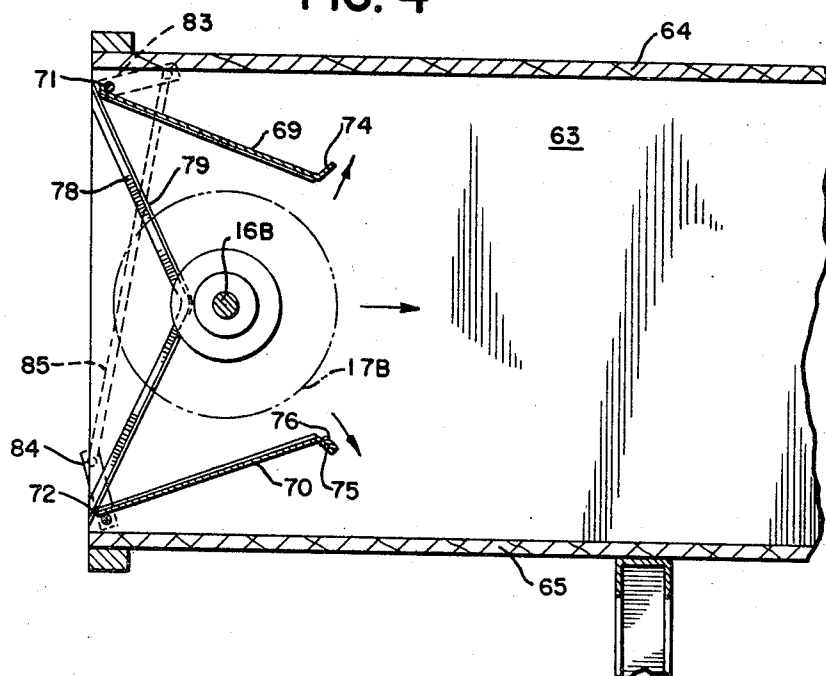


FIG. 4



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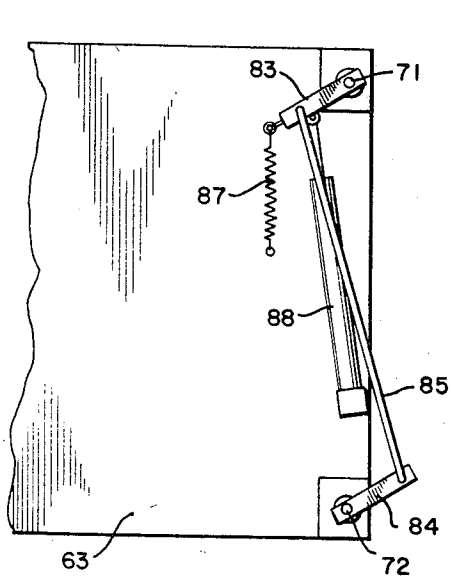


FIG. 5

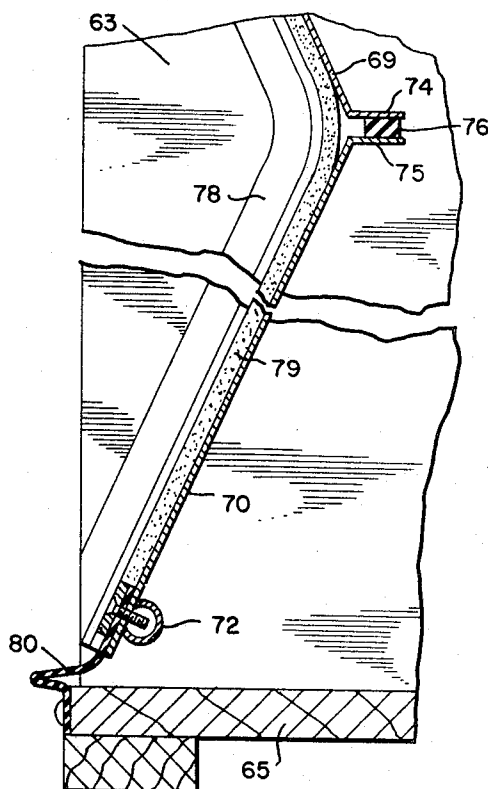


FIG. 6

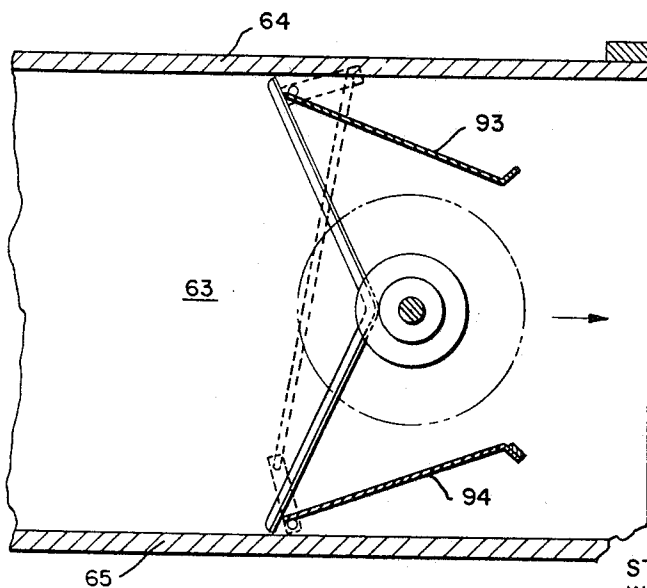


FIG. 7

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METHOD FOR MANUFACTURE OF REFRACTORY SHELL MOLDS

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Original application Sept. 21, 1964, Ser. No. 397,858, now Patent No. 3,278,998, dated Oct. 18, 1966, Divided and this application May 19, 1966, Ser. No. 565,367

U.S. Cl. 164-26

3 Claims

Int. Cl. B22c 3/00, 1/02; B05c 3/103

ABSTRACT OF THE DISCLOSURE

This disclosure relates to a method for developing a sanded and hardened refractory slurry coating on a pattern which method includes the steps of a continuously and slowly rotating spindle-mounted pattern at a substantially constant speed, swinging the pattern downwardly into a slurry at an angle below the horizontal to cover the pattern with an excess of slurry, raising the pattern above the horizontal as rotation continues to produce a more uniform coating, performing a similar coating step with sanding material and gelling the sanding slurry coating in a gaseous atmosphere.

This is a division of application Ser. No. 397,858, filed Sept. 21, 1964 issued as Patent No. 3,278,998, Oct. 18, 1966.

This invention relates to the manufacture of multi-layered refractory shell molds and, more particularly, to apparatus and a method for developing successive sanded and hardened refractory slurry coatings on a plurality of patterns.

Molds for accurate metal castings are customarily made by shaping a pattern of the desired casting in wax or other fusible material and then developing a refractory shell by dip-coating the pattern a number of times in a liquid suspension containing a finely divided refractory which hardens in layers on the pattern. An accurate shell mold of the article to be cast is provided by eliminating the pattern from within the multi-layered shell.

A primary purpose of the present invention is to provide a machine for forming successive refractory molds in an automatic series of steps, at a relatively high rate of production. Also the invention contemplates an improved method embodied in the series of steps which achieves the optimum multi-layered shell structure on the pattern. If a pattern is dipped into the refractory slurry in a vertical motion there is a tendency to entrap air in pockets on many pattern shapes and no matter how the pattern may be turned about to spread the coating it is quite difficult to eliminate such air pockets. Also, if the pattern is left hanging vertically to drain the dip-coating there is a tendency for the coating to spread unevenly to the lower portion of the pattern and produce a layer of varying thickness even if the pattern is rotated as it drains. This may be partially corrected in some instances by spinning the pattern in the manner of a centrifuge as the excess slurry is drained off, but even then a satisfactory coating does not result with most pattern shapes. Through experimentation it has been discovered that the most uniform dip-coating free of all air pockets is obtained by swinging the pattern down into the slurry at a 20° to 50° angle (preferably 30°) while rotating it at a slow rate, and then raising the pattern to approximately the same angle above the horizontal while the slow rotation continues to drain the excess dip coat. The present invention is directed to this method and to a fully automatic machine for carrying out the process in a rapid and controlled manner.

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Broadly stated, the refractory mold forming machine of the invention is designed for automatically developing successive sanded and hardened refractory slurry coatings on patterns. It comprises a rotatable mount and indexing means for turning the mount through a series of angularly spaced hold positions. An individually rotatable spindle is provided on the mount for each pattern and it has a translatable outer end portion adapted to hold the associated pattern projecting from the mount. Drive means are provided for the spindle, and dip tanks for containing the refractory slurry and a sanding material respectively are located adjacent the mount where the spindle stops at respective hold positions of the mount. Displacement means are included for translating the outer end portion of the spindle when it is adjacent the dip tanks to dip the pattern thereon into and out of the refractory slurry and sanding material successively and form a sanded slurry coating on the pattern.

By means of this apparatus the improved method of forming the slurry coating in accordance with the invention can be carried out in the process of developing successive sanded and hardened refractory slurry coatings on a pattern. The method includes the steps of continuously rotating the pattern and swinging it downwardly toward the surface of a quantity of the slurry so that it enters the slurry at an angle between 20° and 50° below the horizontal and is covered with an excess of the slurry. The rotating pattern is then swung upwardly from the quantity of the slurry to a position between 20° and 50° above the horizontal and is maintained in that position while the excess slurry drains therefrom to leave a uniform slurry coating on the pattern. The angles above and below the horizontal to which the rotating pattern is swung are each substantially 30° in preferred embodiment of the method. Also, it is preferable to rotate the pattern slowly at between 5 and 25 r.p.m., which is considerably below the spinning rate of centrifuge techniques employed heretofore.

A preferred embodiment of the invention is described hereinbelow with reference to the accompanying drawings, wherein

FIG. 1 is a plan view of the overall apparatus;

FIG. 2 is a fragmentary enlarged section taken along the line 2-2 of FIG. 1 showing the pattern in its lower and upper positions with respect to the refractory slurry dip tank;

FIG. 3 is an enlarged fragmentary elevation of the entry end of a gas-filled gelling chamber through which each sanded and coated pattern may be passed;

FIG. 4 is an enlarged fragmentary section of the entry end of the chamber showing its doors in open position;

FIG. 5 is an enlarged fragmentary elevation of the means for closing the entry doors of the chamber;

FIG. 6 is an enlarged fragmentary section partly broken away showing the construction of the entry doors of the chamber; and

FIG. 7 is an enlarged fragmentary section showing the exit doors of the chamber as the pattern passes there-through.

The materials used for practicing the invention are a plurality of patterns, a refractory slurry and a quantity of sanding material. Each pattern may be of wax or similar fusible material. The refractory slurry is a liquid including finely divided refractory particles and a binder. Typical slurries may have a refractory of zirconium silicate, zirconium oxide, aluminum oxide or silica having a particle size of about 80% minus 270 mesh. The binder may be hydrolyzed ethyl silicate or isopropyl silicate which gels in an atmosphere of ammonia gas, or it may be an aqueous sol containing colloiddally displaced silica which hardens by evaporation of its water content so that the colloidal constituents coagulate and bond the refractory particles to-

gether. The apparatus of the embodiment described below is designed for gelling a binder in an ammonia atmosphere, but it is adaptable to air-hardening a binder such as colloidal silica simply by eliminating the ammonia chamber.

Referring first to FIGS. 1 and 2, the apparatus includes a circular mounting plate 10 disposed for rotation in a horizontal plane about the vertical axis of a standard indexing unit 11 driven by an indexing motor within the housing of the unit. The motor-driven indexing unit 11 is adapted to turn the mounting plate 10 through a series (in this embodiment, eight) angularly spaced hold or dwell positions. It is supported on a frame 13.

Eight corresponding spindles 15A through 15H are located on the mounting plate 10 about respective axes disposed radially with respect to the mounting plate axis at eight uniform angular intervals corresponding to the angular spacing between the hold positions of the mounting plate. The spindles 15A through 15H include respective end portions 16A through 16H projecting radially from the mounting plate 10 nominally parallel thereto. Respective patterns 17A through 17H are removably attached by any suitable means to the end portions 16A through 16H of the respective spindles 15A through 15H.

As shown in detail in FIG. 2, the respective spindles include supports 19A through 19H, each of which is pivotally attached by a respective clevis and pin assembly (20A in FIG. 2) to the mounting plate 10 to permit the associated spindle end portion to swing upwardly and downwardly out of its nominal position. Opposite their clevis and pin assemblies the respective supports 19A through 19H are provided with roller support as described hereinafter. The various spindles are individually rotatably mounted in bearings (21A in FIG. 2), and drive motors 22A through 22H on the respective supports 19A through 19H are provided for continuously rotating the associated spindles and the patterns held thereby. A variable drive unit (23A in FIG. 2) is included between each spindle and its drive motor for adjustment of its rate of rotation. Power is supplied to each of the motors 22A through 22H by conductors (24A in FIG. 2) to which current is transmitted by a conventional brush and ring assembly centrally disposed on top of the indexing unit 11 within a housing 25.

A pair of open dip tanks 27 and 28 are fixed adjacent the mounting plate 10 where adjacent pairs of the spindles 15A through 15H stop at successive hold positions of the mounting plate 10. Rotation of the mounting plate 10 is in a clockwise direction as shown in FIG. 1 and therefore the first dip tank encountered by one of the spindles is the tank 27. It contains a quantity of the refractory slurry 29 and its outer side 31 and bottom 32 are angled as shown in FIG. 2. Suitable flow control means are provided in association with the dip tank 27 to insure a constant level of the slurry 29 as the successive coating operations are carried out, but it forms no part of the invention and is not shown in the drawings. The dip tank 28 is encountered next by one of the spindles and it contains a quantity of the sanding material 34. Again, means not shown in the drawing are provided for maintaining the level of sanding material 34 in the dip tank 28, and the bed is fluidized by a blower 34 in a conventional manner with an updraft of air to permit each coated pattern to be immersed easily within the sanding material without disturbing the coating.

In FIGS. 1 and 2, displacement means indicated generally at 37 are provided for pivoting the successive supports 19A through 19H when they stop adjacent the dip tank 27 during hold positions of the mounting plate 10. A horizontal track ring 38 is fixed with respect to the frame 13 concentric with the mounting plate 10 to remain fixed during the indexing operation. On the periphery 39 the track ring 38 provides a surface upon which respective roller carriages (39A in FIG. 2), pivotally linked to the individual supports 19A through 19H, roll as the mounting plate 10 indexes. As shown in FIG. 1, a cutout 41 is formed in the periphery 39 of the track ring 38

directly opposite the slurry dip tank 27, and a similar cutout 42 is formed in the periphery 39 of the track ring 38 directly opposite the sanding material dip tank 28.

When the roller carriage associated with one of the supports, for example the roller carriage 39A associated with the support 19A, reaches the cutout 41 opposite the slurry dip tank 27, it rolls onto a lift plate 44 which at that time is fitted within the cutout 41 co-planar with the periphery 39 of the track ring. The lift plate 44 is supported on a vertical strut 45 which in turn is movable on a rod 46 attached to the frame 13. Annular slides 47 surround the rod 46 and support the strut 45 in its upright position. When the roller carriage 39A of the support 19A rests on the lift plate 44, vertical movement of the strut 45 on the rod 46 permits the support 19A to be moved downwardly to the solid line position shown in FIG. 2 and upwardly to the dotted line position shown therein. This displacement of the lift plate 44 is accomplished by double-acting hydraulic cylinders 49 and 50 pivotally mounted in-line with one another between a bracket 52 on the frame 13 and a roller 53 engageable with the underside of the lift plate 44. Suitable hydraulic lines 55 and 56 associated with the respective cylinders 49 and 50 are connected to a hydraulic pump 58 mounted on the frame 13.

The foregoing is a description of the displacement means 37 associated with the cutout 41 opposite the slurry dip tank 27. In order to move the successive supports 19A through 19H upwardly and downwardly in an angular motion when they index in turn to the sanding material dip tank 28, separate displacement means are provided in association with the cutout 42 opposite the sanding material dip tank 28. This second displacement means is identical to the displacement means 37 in all respects both in structure and function and, therefore, it need not be described in detail.

When the slurry coating applied to the various patterns are of the previously mentioned type which must be gelled in an atmosphere of ammonia gas, an arcuate chamber 60 for containing the ammonia gas extends concentrically around the greater part of the mounting plate 10 between the dip tanks 27 and 28. The chamber 60 appears in plan in FIG. 1 and in greater detail in FIGS. 3 to 7. It consists of an open ended housing of rectangular cross section formed of inner and outer side walls 62 and 63 respectively and top and bottom walls 64 and 65 respectively. These wall members may be made of plywood. Suitable input and output conduit means 66 and 67 are included for charging ammonia gas into the chamber 60. At each of its opposite ends, some form of ventilation hood or the like may be associated with the chamber 60 to evacuate any escaped ammonia gas from the vicinity, but for clarity they are not shown in the drawings.

Referring to FIGS. 3 to 6, entry door means at the end of the chamber adjacent the sanding material dip tank 28 are shown which are adapted to open before and close behind each successive pattern as it is carried into the chamber 60. The entry door means itself comprises upper and lower aluminum door plates 69 and 70 hinged about respective axles 71 and 72 horizontally disposed adjacent the top and bottom walls 64 and 65 of the chamber. Flanges 74 and 75 are formed at the outer edges of the door plates 69 and 70 respectively and the flange 75 has a resilient sealing strip 76 cemented to it to prevent escape of gas from between the adjoining edges of the plates 69 and 70 when they are closed as shown in FIG. 6. Further sealing means is provided by a seat 78 on the inside of the outer side wall 63 of the chamber fitted with a resilient sealing strip 79 which engages the lateral edges of the door plates 69 and 70 when they are closed as shown in FIG. 6. A similar lateral sealing assembly of a seat and sealing strip is provided on the inside of the opposite inner side wall 62 but it does not appear in the drawings. The horizontal edges of the door plates 69

and 70 adjacent the respective axles 71 and 72 are sealed by flexible webs 80 connecting them with the top and bottom walls 64 and 65 of the chamber. One such web 80 interconnecting the lower edge of the lower door plate 70 with the bottom wall 65 of the chamber 60 is shown in FIG. 6.

Both door plates 69 and 70 are opened by a single curved control arm 82 shown in FIG. 3 which is rigidly attached to the end of the upper axle 71 on the exterior of the chamber 60 adjacent the inner side wall 62. Respective lever arms 83 and 84 are attached to the opposite ends of the axles 71 and 72 on the outside of the chamber adjacent the outer side wall 63 and they are linked by a rod 85. When one of the patterns, 17B as shown in FIG. 3, approaches the closed door plates 69 and 70 at the entry end of the chamber 60, the outer end portion 16B of its spindle 15B engages the curved control arm 82 and rotates it in a counterclockwise direction as shown in FIG. 3. By means of the lever arms 83 and 84 and their link 85, this rotation of the control arm 82 swings the upper and lower door plates 69 and 70 inwardly as shown in FIG. 4 to open the interior of the chamber 60 so that the pattern 17B may move into it.

In FIG. 3 the spindle end portion 16B is shown in the dot-dash lines to have displaced the control arm 82 to a considerable extent, and when it clears the end of the control arm 82 the pattern 17B is entirely within the chamber and the door plates 69 and 70 are free to close. This closure of the door plates is effected by means of a tension spring 87 fixed at one end to the outside of the outer side wall 63 and at its other end to the lever arm 83 so that the spring 87 pulls the door plates 69 and 70 back to their closed position. The impact of closure is reduced by a dampening cylinder 88 also connected between the outer side wall 63 and the lever arm 83.

To permit the spindle end portion 16B and those following it to carry the associated pattern 17B throughout the length of the chamber 60, a slot 90 is formed horizontally along the center of the inner side wall 62 of the chamber. The spindle end portion 16B projects through this slot and moves along it as it indexes around the inside of the arcuate chamber 60. To prevent escape of the ammonia gas from the interior of the chamber 60 through this slot, a pair of extended resiliently engaged displaceable sealing members 91 and 92, preferably in the form of rubber hoses, are attached along the edges of the slot 90 to cover the slot except where the successive spindle end portions displace them apart to project into the chamber. At the entry end of the chamber, the end portions of the sealing members 91 and 92 are spread apart to allow the spindles to slide between them, as shown in FIG. 3.

At the exit end of the chamber shown in FIG. 7, door plates 93 and 94 are provided in association with sealing and opening-closing means identical to those at the entry end of the chamber described hereinbefore with reference to FIGS. 3 to 6. Thus, the exit door plates 93 and 94 open before and close behind each successive pattern as it is carried out of the chamber 60 in precisely the same manner in which it enters the chamber.

In the following description of the operation of the apparatus and the method it embodies, it is to be understood that suitable electrical and hydraulic control systems are provided to commence, time, carry out and stop the various functions of the machine, and correlate them with one another, in accordance with known design concepts. First, eight patterns 17A through 17H are attached to the spindles 15A through 15H and the refractory slurry 29 and the fluidized sanding material 34 are provided in the respective dip tanks 27 and 28. By means of the slide ring and brush assemblies within the housing 25, power is transmitted to each of the drive motors 22A through 22H so that they rotate the spindles and respective patterns continuously at between 5 and 25 r.p.m. and preferably at about 12 r.p.m. The indexing unit 11 is operated

to turn the mounting plate 10 in a series of one-eighth turns with a hold of 30 to 40 seconds between each incremental turn. When the support 18A rolls on its roller carriage 39A onto the lift plate 44 opposite the slurry dip tank 27 as shown in FIG. 1, the displacement means 37 is actuated so that its upper cylinder 49 retracts and lowers the lift plate 44 to the position shown in solid lines in FIG. 2. This causes the support 19A to pivot about its clevis assembly 20A and swing the spindle 15A downwardly so that the rotating pattern 17A on its outer end portion 16A enters the slurry 29 at an angle of between 20° and 50°, and preferably 30°, below the horizontal.

As the pattern 17A slowly rotates in the slurry 29 as shown in FIG. 2, an excess coating of the slurry is developed over all parts of the pattern. Thereafter, both the lower and upper cylinders 49 and 50 of the displacement means 37 are actuated to their extending positions so that the excessively coated pattern 17A is lifted past its nominal position parallel to the mounting plate 10 on up to the elevated position shown in dotted lines in FIG. 2 between 20° and 50°, and preferably 30°, above the horizontal. As the pattern turns in this elevated position, the excess slurry drains from it down into the dip tank 27 and a uniform slurry coating is left on the pattern entirely free of air pockets. When this has been done, the lower cylinder 50 of the displacement means 37 is retracted to lower the lift plate 44 to its initial position within the slot 41 co-planar with the periphery 39 of the track ring 38 and the spindle 15A is thus brought back to its nominal horizontal position.

This cycle of dipping, dwelling, raising, draining and returning lasts about 30 to 40 seconds and upon its completion the indexing unit 11 moves the mounting plate 10 an eighth of a turn to roll the support 19A from the lift plate 44 and along the periphery 39 of the track ring 38 to the lift plate in the cutout 42 of the similar displacement means directly opposite the sanding material dip tank 28. When the support 19A is in this position the next support 19H is opposite the slurry dip tank and its cycle is carried out to form a dip coating on the pattern 17H. While this occurs, the displacement means associated with the sanding material dip tank 28 is operated to lower the rotating coated pattern 17A into the fluidized sanding material 34 to form a complete coating of the sanding material over the previously applied slurry coat. The sanding cycle is carried out by this displacement means just as the coating cycle had been carried out by the displacement means 37, including the elevation of the sanded and coated pattern 17A to an angle from 20° to 50° (and preferably 30°) above the horizontal at the end of the cycle in order to remove excess sanding material from recesses in the pattern.

When the coated pattern 17A has been sanded and the next pattern 17H has been coated, the indexing unit 11 turns the mounting plate 10 through another eighth of a turn to bring the next pattern 17G into coating position and displace the coated pattern 17A into sanding position. As this is done, the sanded and coated pattern 17A approaches and enters the entry end of the ammonia chamber 60. The end portion 16A of the spindle 15A engages the curved control arm 82 to open the door plates 69 and 70, and after the sanded and coated pattern 17A is within the chamber 60 the door plates 69 and 70 close behind it, all as described hereinbefore. The spindle end portion 16A at this point has passed between the opposed extended resilient sealing members 91 and 92 and slides between them without allowing ammonia to escape from the chamber 60.

The indexing continues in increments of one eighth of a turn as each pattern is successively coated and sanded and then carried into the ammonia chamber 60. As the pattern 17A moves incrementally through the ammonia chamber 60 in this manner, its slurry coating beneath the sanding material is gelled so that when it passes from the exit end of the chamber 60, with the door plates 93 and

94 opening before it and closing behind it, the sanded slurry coating is hardened and the pattern 17A is ready for the application of another coat of the slurry. This is accomplished simply by recycling the pattern 17A through another complete revolution of the mounting plate 10 and the process is repeated until the desired number of sanded and coated layers has been formed. For a typical refractory mold, nine such coated and sanded layers of the slurry may be applied and gelled in this fashion. When shells of the desired thickness are developed on all of the patterns 17A through 17H, the operator begins to remove them from their respective spindles 16A through 16H starting with the one which had been first dipped in the slurry at the beginning of the operation, which in this example is the pattern 17A. This removal of the completed shells and patterns from the spindles may be done successively at the station immediately preceding the slurry dip tank 27, which is the position of the pattern 17H as it appears in FIG. 1. The rotation of each spindle may be individually stopped to permit removal of its associated shell and pattern and a new uncoated pattern may be mounted in place immediately so that the production cycle can continue without interruption.

We claim:

1. In a process of developing successive sanded and hardened refractory slurry coatings on a pattern, a method of forming coatings which comprises
 - (a) continuously and slowly rotating the pattern,
 - (b) swinging the rotating pattern downwardly toward the surface of a quantity of the slurry so that it enters the slurry at an angle of between 20° and 50° below the horizontal and is covered with an excess of the slurry,
 - (c) swinging the rotating pattern upwardly from the quantity of the slurry to a position between 20° and 50° above the horizontal,

- (d) maintaining the rotating pattern in said position and continuing the rotation at a slow speed while the excess slurry drains therefrom to leave a uniform slurry coating on the pattern,
 - (e) moving the pattern adjacent a quantity of a sanding material,
 - (f) swinging the rotating pattern downwardly to facilitate engagement of the slurry coating with the sanding material,
 - (g) swinging the rotating pattern upwardly to a position between 20° and 50° above the horizontal,
 - (h) maintaining the rotating pattern in said position while excess sanding material falls from the rotating pattern, and
 - (i) moving the pattern to a gaseous treatment station for treating the slurry sand coating to gell the coating.
2. The method according to claim 1 wherein the angles above and below the horizontal to which the rotating pattern is swung are each substantially 30°.
 3. The method according to claim 1 wherein the pattern is continuously rotated at between 5 and 25 r.p.m.

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U.S. Cl. X.R.

18—24; 118—416, 426