May 12, 1970 R. H. BARRON 3,511,302

METHOD FOR PRODUCING A SHELL FACED MOLD

Filed Feb. 27, 1967

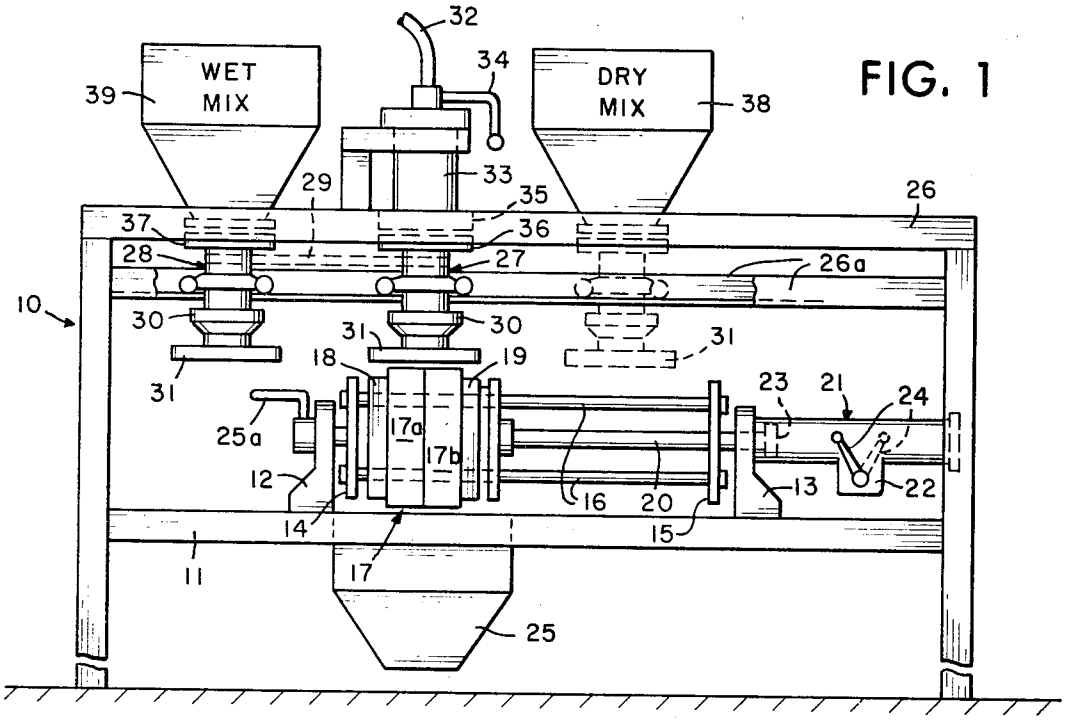


FIG. 1

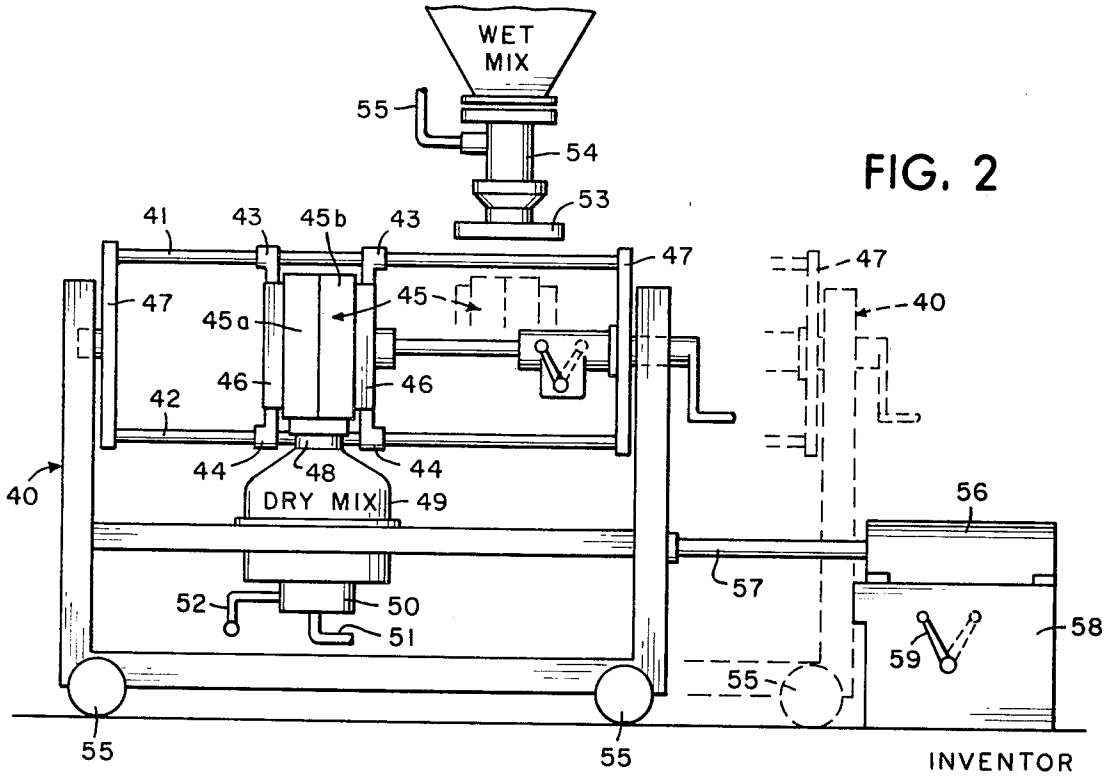


FIG. 2

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United States Patent Office 3,511,302
Patented May 12, 1970

3,511,302

METHOD FOR PRODUCING A SHELL FACED MOLD

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Filed Feb. 27, 1967, Ser. No. 618,772
Int. Cl. B22c 9/12
U.S. Cl. 164—24 6 Claims

ABSTRACT OF THE DISCLOSURE

The subject shell mold consists of applying dry molding sand the granules of which are coated with a resin binder to a heated pattern to render the sand capable of faithfully reproducing the shape of the pattern with as thin a facing layer of the binder treated sand as is possible so that the least amount of finer grades of sand are used to make a mold as thin as possible. The subject shell mold is the product or the result of a process in which the formation of the shell mold, before its removal, has applied thereto a wet backfill mixture of refractory media and an air-set binder as a backing to the shell to render it rigid for withdrawal from the pattern and strong enough to stand up during the pouring of molten metal and its solidification. Thereafter the mold is intended to break down so that the material may be easily separated from the solidified casting. The resulting shell mold is gas permeable and obtains high fidelity of pattern shape reproduction and dimensions.

The present invention relates primarily to the metal casting industry and is particularly directed to improvements in the process for forming shell face molds.

The improvement hereinafter to be set forth in greater detail has the advantages of greatly speeding up the molding process by introducing reductions in the cycles or steps usually associated with molding processes, permits people skilled in machine operation to successfully perform the molding process, effects substantial savings of material, and has sufficient flexibility to adapt the process for semi-automatic operation of shop machines and tools.

In the metal casting industry the shell molding process, as it is known heretofore, usually involves the coating of the pattern with a refractory (sand) material mixed with a thermosetting binder, and allowing material to remain on the pattern until it has hardened to a thickness in excess of ¼" so as to reproduce the shape of the pattern and have strength to be removed without damage. Thereafter the excess refractory with the thermosetting binder which has not reacted is removed, thereby leaving the remaining hardened material to form the "shell" which is then cured so that it will have sufficient strength for subsequent handling. The requirement in shell molding is to obtain rigidity of the shell so that it will withstand the mechanical and thermo stresses created by the impact and subsequent shrinkage and solidification of the molten metal.

It is desirable, however, to have molds formed of thin shells, of the order of something less than ¼". The benefits of thin shells is that they reduce substantially the use of the refractory material, allow the use of much finer grades of refractory sands to form the casting surface in the mold which would thereby have greater fidelity of shape and contour of the finished product, is gas permeable, has reduced gas evolution characteristics, and affords a significant reduction of time for the making of the shell molds.

The present invention is an improvement upon the prior shell molds and shell face molding processes as it

overcomes the disadvantages of the processes heretofore devised by eliminating the necessity for performing secondary curing operations, and effecting economies in the use of materials.

It is an object of the invention to simplify the shell face molding process so that a significantly faster cycle of shell mold manufacture can be obtained with reduction in the amount of raw materials necessary. It is a further object of the present invention to provide a shell mold and a process for forming the same with a backing material that will impart mechanical strength without significant increase in cost.

A preferred process hereinafter to be set forth in greater detail includes the steps of applying the shell facing media to a heated pattern for a time sufficient to permit the thermosetting action to create a thin shell coating on the pattern, removing the excess media while allowing the heated pattern to finish curing the thermosetting coating material in the media, and thereafter applying a low cost secondary media as a backfill to the hot shell facing which will impart mechanical strength to the shell facing so as to permit immediate removal thereof from the pattern, whereby to eliminate further processing. The preferred shell facing has the granules of the refractory or sand material individually coated with a thermosetting binder that has low gas evolution properties and will setup to a hardened condition with heat application. To the foregoing there is applied a backing material to lend mechanical strength to the thin shell face, the same being combined during the process of creating the shell facing so that the shell mold may be removed from the pattern as quickly as possible, whereby the pattern can be reused immediately to result in higher productivity per pattern.

Certain preferred forms of apparatus for practicing this invention are disclosed in the accompanying drawing, and reference will be had to the views of the drawing before proceeding with a more complete discussion of the methods involved.

In the drawings:

FIG. 1 is a schematic front elevational view of apparatus suitable for producing shell mold and cores by the improved shell face molding process; and

FIG. 2 is a schematic front elevational view of another form of apparatus useful herein.

Referring now to the apparatus shown schematically in FIG. 1, it is observed that there is a suitable frame structure **10** provided to support the various components now to be described. Within the frame **10** there is provided suitable horizontal platform **11** which is adapted to support spaced pivot stands **12** and **13**. The stand **12** carries a roll over-plate **14** and the stand **13** likewise carries a companion roll over-plate **15**. The roll over-plates are interconnected by means of slide rods **16**, the slide rods supporting the heated corebox **17**. The corebox **17** is made up of a cope section **17***a* and a drag section **17***b*. Each of the cope and drag sections is provided with a heat source **18** and **19**, respectively, the heat source being either gas or electric as may be desired. In the apparatus shown the cope section **17***a* of the corebox is intended to remain adjacent the bearing stand **12**, and the drag section **17***b* is intended to be horizontally movable along the slide rods **16** by means of the piston rod **20** of the air motor **21**. Air under pressure can be supplied by means of a control valve **22** to either side of the piston **23** (shown in dotted line) in the air motor cylinder to effect movement thereof. In the position shown a control lever **24** (in full line) applies pressure to piston **23** so as to close the drag section **17***b* on the cope section **17***a* to retain it in clamped relationship. When the control lever **24** is moved to the dotted line

position the drag section 17*b* is withdrawn for discharge of the shell mold.

The parts thus far described with respect to the corebox **17** are bodily rotatable on the bearings in the stands **12** and **13** so that the corebox may be rotated approximately 180° for the purpose of dumping the loose unheated material into a collection bin **25** supported in dependent relationship from the platform **11**. The roll over action may be performed manually by hand crank **25***a* or it can be performed by means of a suitable motor, the latter of which is believed unnecessary to illustrate.

The frame **10** is provided in its upper region with the horizontal supporting means **26** and **26***a*, the latter of which forms a track for the transversing movement of a pair of magazines **27** and **28**. These magazines may be independently movable along the supporting track means **26***a* or they may be interconnected by a suitable tie element **29** (shown in dotted outline only) so that the magazines move together. Each magazine is provided with an outlet head **30**, and each outlet head **30** has its blow plate **31**. In FIG. 1 there is shown an overhead source of air under pressure depicted by the conduit **32**. The conduit connects with the housing of a blow valve **33** under the control of a lever **34**, and air under pressure is delivered through the valve body **33** to the outlet plate **35** which is adapted to match with and seal on the inlet plate **36** for the magazine **27**, or with an inlet plate **37** for magazine **28**, depending on which magazine is aligned with plate **35**. Since the magazines **27** and **28** are adapted to be movable horizontally, it is necessary that there be suitable means for slight raising and lowering of the valve body **33** so that downward pressure may be exerted on each magazine to take up the clearance needed for horizontal motion and to press its blow plate **31** over the inlet opening (not shown) in the cope and drag sections of the corebox **17**.

The apparatus of FIG. 1 is provided with separate sources of core materials represented by a supply hopper **38** for dry material and a supply hopper **39** for wet or moist material. These hoppers are situated on opposite sides of the valve body **33** such that when the magazine **27** is moved to the dotted line position shown at the right of its full line position, the magazine **28** may be moved from its full line position rightwardly to assume a position now occupied by magazine **27** between the valve body **33** and the corebox **17**. Thus, the magazines **27** and **28** are alternately moved between the material supply hoppers and the corebox for delivering, at the proper time in the sequence of operations, the necessary coremaking material later to described.

Turning now to FIG. 2, it will be observed that a suitable frame structure **40** is provided with horizontal tracks **41** and **42** for receiving slides **43** and **44**, respectively. The slides **43** and **44** together support a corebox **45** having a cope section **45***a* and a drag section **45***b*. Each of the sections is provided with a source of heat associated with the hotbox section through suitable enclosures **46**. In this apparatus the corebox **45** is movable from its full line position to its dotted line position so that dry and moist core materials may be supplied thereto. In the full line position of the corebox **45** it is understood that the corebox has been turned or rotated upon the turning plates **47** supported in the frame **40** on suitable bearings so that its inlet is at the lower slide in clamped registration with the blow-plate **48** of a supply magazine **49** for dry material. The magazine is connected by suitable chamber **50** to a source of air under pressure at conduit **51**, and a suitable control **52** is provided to regulate the blowing of the dry material from the magazine upwardly into the corebox **45**. At the conclusion of the blowing operation when the shell facing has formed the air is shut off and the excess material will flow by gravity back into the magazine, thereby avoiding the necessity for rolling the corebox over to dump excess material as would be necessary in the apparatus of FIG. 1.

Still referring to the apparatus of FIG. 2, it can be seen that when the corebox **45** is moved rightwardly to the dotted line position it must be rolled over 180° so that the inlet which was at the lower side may be brought to the upper side and into alignment with the blow plate **53** of magazine **54** which supplies moist material to the corebox. A supply of air under pressure is brought by conduit **55** into the side of the magazine **54**, or at any suitable connection where at the proper time it can be released for blowing the moist material into the corebox **45**. Here again, the magazine **54** must be moved downwardly so that the blow plate **53** will be tightly clamped over the inlet to the corebox. Such moving means is well understood in the art and has not been shown herein.

As seen in FIG. 2, the frame **40** is in the form of a carriage movable on suitable wheels **55** along the floor. The carriage movement is under the control of an air motor **56** which is connected by piston rod **57** to the carriage. The motor **56** is mounted on a support **58** and is conveniently controlled by lever **59** movable between the positions shown.

In the present shell face molding process, whether utilizing the apparatus above described or its equivalent, it is pointed out that the step to be followed include applying a shell facing media to the heated pattern, allowing sufficient time for the action of the thermosetting binder to unite or harden the media into a wafer thin shell, removing the excess or unheated media in which no thermosetting action has occurred, allowing the media of the shell facing to cure, and finally applying secondary media which will insure rigidity of the wafer thin shell facing and allow immediate removal of the shell mold from the pattern within need for further processing prior to utilizing the shell mold for pouring of the casting metal.

In considering the present method of producing molds and cores it stands out that there are certain critical factors in putting such a process into use. A first factor is that the shell facing, even though wafer thin, must have the necessary strength to prevent its breakage upon removal from the pattern. Furthermore, it is believed that having formed a thin shell facing which is gas permeable, and provided a moist backfill, the moisture in the backfill is released through the shell facing upon opening the corebox and provides a sort of surface lubrication which aids in releasing the same from the pattern. A second factor is that the wafer thin shell must be strong enough to withstand the mechanical and thermo stresses imposed upon it by the impact of the molten metal and by the subsequent shrinkage and solidification of the molten metal. The present practice of shell molding has ignored these and other critical factors related to the above principal factors.

The present improvement has significant advantages over what has been called the Croning process. The present method for the first time permits reducing the thickness of the shell molds to ⅛ inch or less, which advantage is obtained partly by the application of a relatively low temperature for the pattern and rapid cycling of the facing media to the pattern and subsequent removal of the unhardened or excess material from the corebox cavity. The temperatures are of the order of 300°–450° F. and the cycle time involved is in the range of 5–10 seconds. Other significant advantages for the present invention are found in lessening the amounts of the more expensive facing media. The reduction in the amount of facing media results in greater permeability of the shell mold or core, and therefore a thinner shell facing with a lower amount of gas evolution when exposed to the elevated temperatures of the molten casting metal. With a wafer thin layer of the facing media the improved process is able to use less quantities of the more costly finer grain molding sands and a higher percentage of binder material without increasing the gas evolution problem

so that the surface finish and tolerances of the finished casting are significantly improved. Furthermore, the wafer thin shell facing media of the present improvement does not have the "peel back" tendencies which normally occur with thicker shells when the excess or unheated material is removed or dumped from the cavities.

The steps in the process hereinafter to be more particularly claimed include applying the shell facing media to the heated pattern, allowing sufficient time as measured in the matter of seconds for the action of the binder material to achieve the creation of a wafer thin shell, removing the excess or unheated media, keeping the shell facing in contact with the heated pattern to effect its cure, and in the latter period of the curing cycle applying secondary media consisting of low cost materials which will be hardened by heat from the pattern passed through the shell facing and back up and insure rigidity of the shell facing, thereby allowing immediate removal of the mold from the pattern while at the same time requiring no further processing other than air-drying as the finished mold is moved to the place where the casting metal is to be poured. There is thus provided a low cost, high permability refractory media coated with a binder that has low gas evolution and will air or chemically set up without heat application, and applying the combined mixture to the back side of the cured shell while the shell is still adhered to the pattern. It is a significant feature that the backfill material is effected by the heat of the shell face media so that it is very rapidly hardened, and this will permit removal of the mold or core from the pattern almost as fast as the machine operator can move. Since the backfill material remains in position it will continue to harden or set because of the continued dispersion of the heat from the shell facing.

The present invention has the additional benefit that by leaving the backfill material in position to mechanically strengthen the shell facing material, the backfill material will continue to withdraw heat from the shell facing and thereby produce a normalizing effect on the usual shrinkage stresses which may have built up during the curing cycle of the shell facing material itself. This normalizing of stresses improves the ability to remove the mold or core from the pattern within seconds.

The apparatus shown in either FIG. 1 or 2 is adapted to the foregoing process since the application of the dry mixture of shell facing media is supplied from the hopper **38** in FIG. 1 or the magazine **49** in FIG. 2, and the wet backfill media is supplied from the hopper **39** of FIG. 1 or the magazine **54** of FIG. 2. Adaptation of the method of mold manufacture is a relative simple matter of creating metal cope and drag patterns such as are mounted in the cope and drag sections **17***a* and **17***b* of FIG. 1. The patterns, as it is understood in this art, are separated on three sides by a metal border for the creation of a corebox pattern and the resulting mold must then be booked together or stacked cope against drag to receive the molten metal. Particular care must be exercised in providing venting of the patterns and coreboxes, since the usual extent of venting is not considered sufficient because without additional venting the backfill material will not penetrate and reach the remote cavities with the proper density to provide the necessary rigidity for the shell facing. In shell face moding the venting occurs through the shell face media and must do so without creating any distortion. In such instances bridge posts need to be added between two faces of the pattern in order to guarantee sufficient rigidity for removal from the pattern.

The present method has been successfully utilized to produce aluminum, brass and hard bronze casting. The conditions under which the method has been practiced include the use of shell-sand mixture in the dry mix conditions of AFS #95 to 100 grain fineness silica sand coated with at least 2% by weight high melt point resin. The dry mix is applied under air pressure by blowing into the corebox, and the excess dry mixture is dumped by gravity as in FIG. 2 or by inversion of the corebore as in FIG. 1. Prior to the application of the dry mix the pattern in the corebox is raised to a temperature of approximately 325° F. which is in the lower reach of the desired range of from 300 to 450° F. The dry mix is permitted to remain in contact with the pattern for approximately five seconds before the gravity dumping step occurs. The time, of course, determines the thickness of the shell facing, and five seconds produces shell facing thickness of approximately 1/16 in. The curing cycle for the shell facing media with the binder is approximately 15 seconds, which period of time is consumed in performing the gravity dumping step so that when the dumping step has been completed, as would be required in inverting the corebox of the apparatus of FIG. 1, the corebox is ready to receive the backfill mixture consisting of AFS #36 grain fineness silica sand coated with by weight either 1% acrylic resin or 1% furan resin or 1% waterglass. The moist backfill mixture is also injected by air pressure in a blowing operation. The total time necessary for the average pattern, following the steps of the process as outlined above, will be found to consume approximately 30 to 40 seconds. The low percentage of binders in the dry and moist mixtures and the cycle time for producing completed molds approach the minimum limitations for producing practical molds. The percentage of binder in the shell mixture and the thickness of the shell itself must be adjusted to the experience of the artisan in relation to the individual parts to be cast. It has been determined that a resin content of 12 percent by weight when used with 180 AFS grain fineness sand will produce optimum cast surface finish. It has also been determined that for maximum permeability in the backfill media AFS #30 grain fineness sand using 1–1½ percent by weight of binder will suffice. Throughout this disclosure whenever reference is made to "wafer thin shell" or "thin shell facing" it shall be taken to mean a lamina of hardened fine grain media and binder of a thickness not in excess of ¼ inch, and preferably of a thickness in the range of 1/16 to 3/16 inch.

It is evident now when the resin coated molding media is blown into the heated corebox the media next to the pattern quickly hardens and adheres to the mold. The corebox is then dumped of its unheated sand and a wafer thin layer of bonded media is left against the pattern. Next the resin coated backfill is blown into the cavity so that rigidity of the wafer thin shell facing is assured. The corebox is then opened and the mold ejected so that the cycle may be repeated. It is necessary to have low temperatures of the order of from 300° to 450° F., for successful production of thin shell facings. This increases feasibilty of using aluminum patterns rather than iron or brass to obtain considerable cost savings and it further reduces shrinkage factors in determining casting tolerance. Faster mold cycles are possible with the present method due to lower temperatures. This method permits full advantage of the shell mold technique (close tolerance and smooth surface) while utilizing only about one-third the usual amount of shell molding material.

While the invention has been described in connection with molds and apparatus for producing molds, it is understood that cores may also be made in the same way, and that molds and cores are intended to be included in the the claims without material limitations.

What is claimed is:

1. The method of producing rigid molds and cores having a thin shell facing for metal casting including providing a heated pattern, placing a first mixture of resin coated dry media of fine grain characteristic in contact with said heated pattern for a period of time to harden the resin coated media to conform the media to the surfaces of said pattern, removing all of the unhardened resin coated media immediately at the end of the hardening time to leave a fragile substantially nonselfsupporting shell facing on said pattern, curing the shell facing and while still in contact with the pattern placing a second

mixture of binder coated most media of relatively less fine grain characteristic than said first mixture in contact with the back of said shell facing, said second mixture substantially accelerating toward hardening in response to heat passing from said shell facing and forming a rigid backing for said shell facing, and removing the shell facing with its rigid backing from said pattern to complete the mold.

2. The method of claim 1 wherein the pattern is heated to a temperature within the range of 300° F. to 450° F., and the period of hardening time is of the order of 5 to 10 seconds for said first mixture to produce a shell facing of an average thickness of approximately one-eighth inch.

3. The method of claim 1 wherein the pattern is heated to a temperature within the range of 300° F. to 450° F., the first mixture is media coated with substantially 2% by weight of resin binder, all of the unhardened first mixture is removed after about 5 to 10 seconds, and said second mixture is allowed to remain to draw heat from said hardened first mixture.

4. The method of claim 1 wherein said first mixture includes a mix of AFS 60–180 grain fineness media coated with 2% to 12% by weight of resin binder, said second mixture includes a mix of AFS 36 grain fineness media coated with 1% by weight of binder, and the total time from application of said first mixture to said heated pattern to removal of said thin shell facing with its rigid backing is of the order of about 30 to 40 seconds to produce a shell facing having a thickness not to exceed about one-eighth inch.

5. The method of producing rigid thin shell face molds and cores for metal casting including filling the cavities of a heated corebox with a loose dry mixture of fine grain media and a thermosetting resin, permitting said first mixture to remain in contact with the heated surfaces of the corebox for a time not in excess of about 10 seconds to form a thin nonselfsupporting shell of hardened media and resin composition in contact with the surfaces of the corebox, removing all excess of said first mixture in loose nonhardened condition, again filling the cavities of the heated corebox with a moist mixture of relatively coarser grain media and a binder, maintaining the moist mixture

within the heated corebox cavities to draw heat from the hardened thin shell facing to set up said coarser media and binder and form a solid backfill reinforcement for the thin shell facing, and removing the thus reinforced thin shell facing from the corebox after a time of the order of 30 to 40 seconds.

6. The method of forming rigid molds and cores having a thin shell facing comprising the steps of heating a pattern containing corebox, providing adjacent the corebox a first supply of a dry mixture of fine grain molding media and thermosetting binder and a second supply of a moist mixture of a relatively coarse grain molding media and thermosetting binder, moving a quantity of the dry mixture between the first supply and the corebox to obtain a hardened shell coating thereof upon the pattern surfaces, removing all unhardened excess of the dry mixture to leave a wafer thin shell coating on the pattern, moving a quantity of the moist mixture between the second supply and the corebox to back up the hardened coating with the moist mixture, permitting the moist mixture to harden with heat from said heated pattern and render the shell coating rigid, and removing the thus rigidly reinforced wafer thin shell from the pattern.

References Cited

UNITED STATES PATENTS

2,748,435	6/1956	Hackett	164—23
2,837,798	6/1958	Bleuenstein	164—43 X
2,841,844	7/1958	Ensign et al.	164—24
2,861,307	11/1958	Froberger	164—43 X
2,976,588	3/1961	Amala et al.	164—24
3,247,556	4/1966	Buell et al.	164—43

FOREIGN PATENTS

976,345	10/1950	France.

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U.S. Cl. X.R.

164—43, 361