

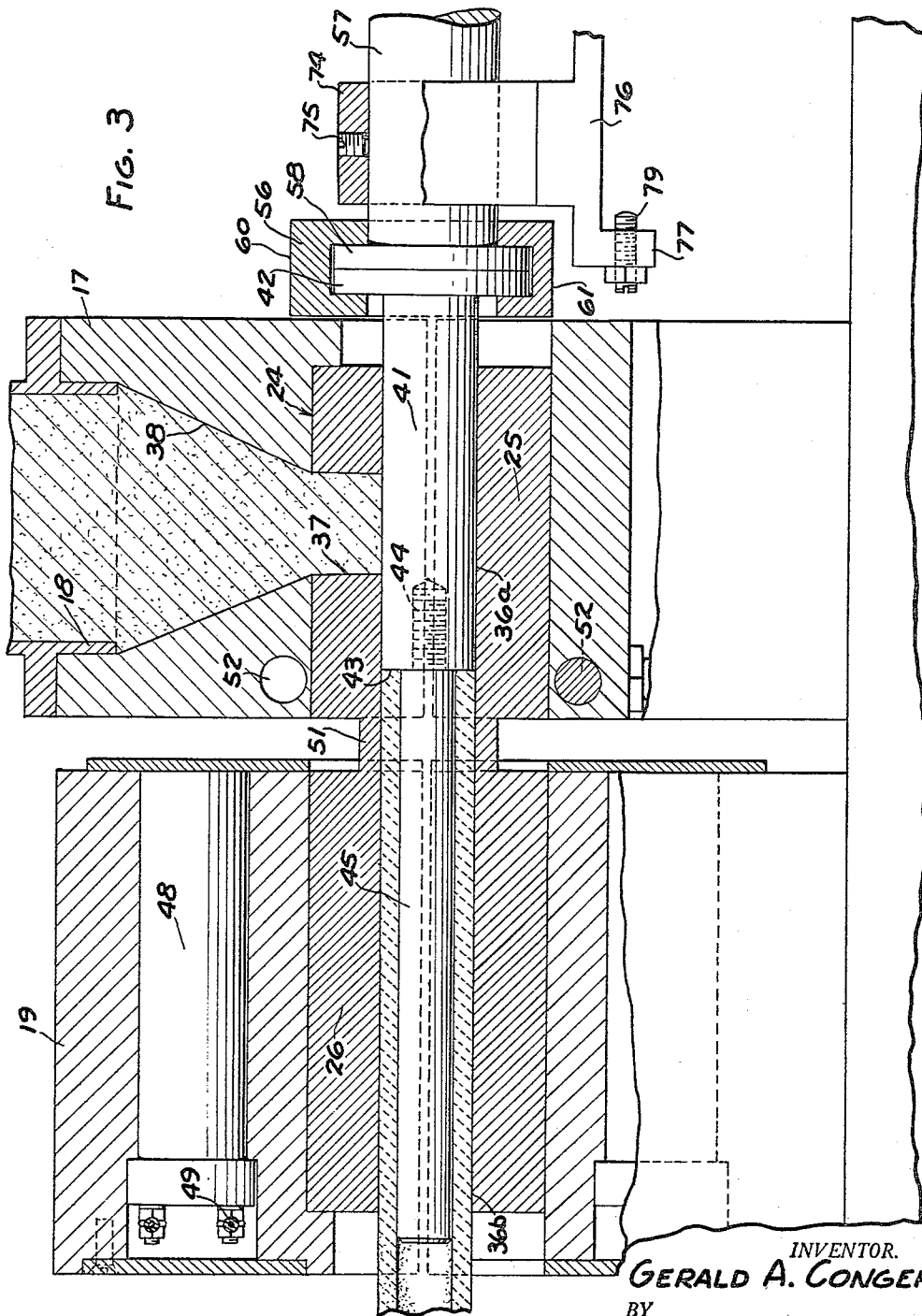
June 11, 1963

G. A. CONGER
METHOD AND APPARATUS FOR CONTINUOUSLY FORMING
FOUNDRY MOLDS, CORE AND THE LIKE

3,092,878

Filed Aug. 24, 1960

4 Sheets-Sheet 2



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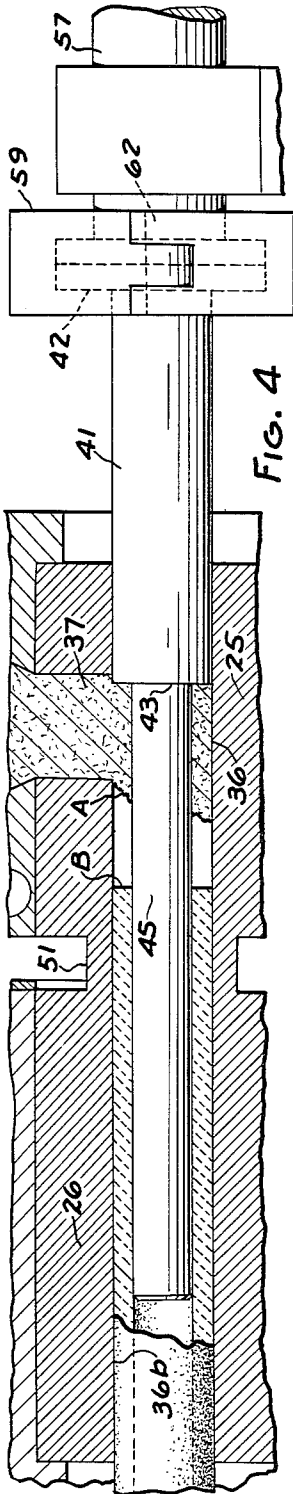


FIG. 4

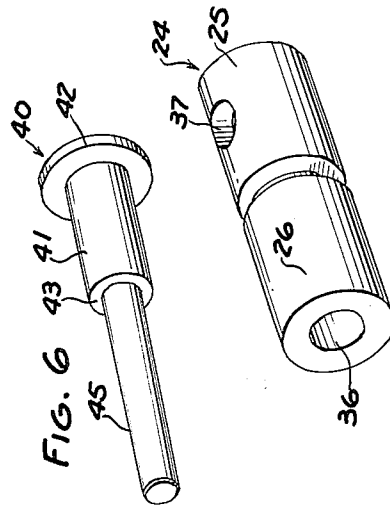


FIG. 6

FIG. 7

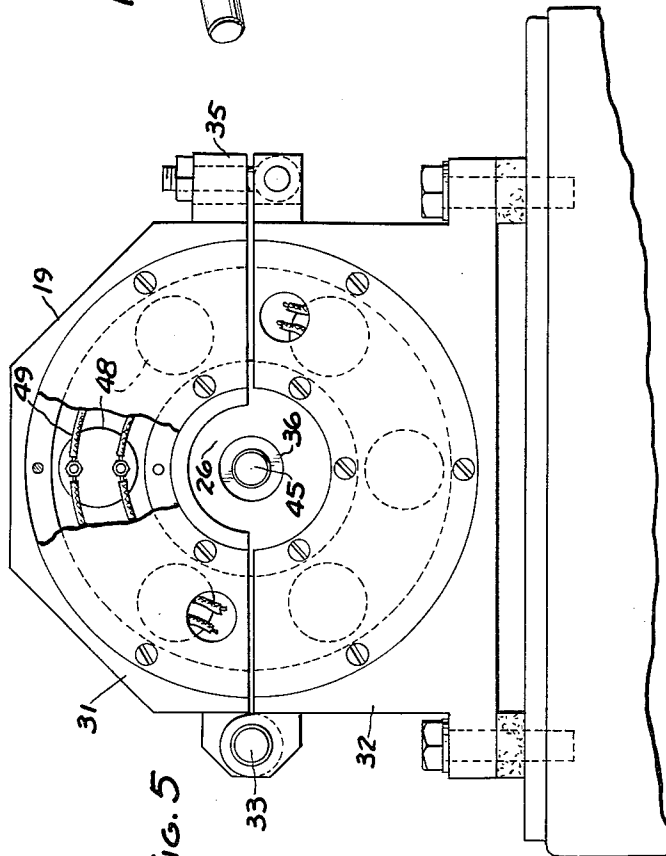


FIG. 5

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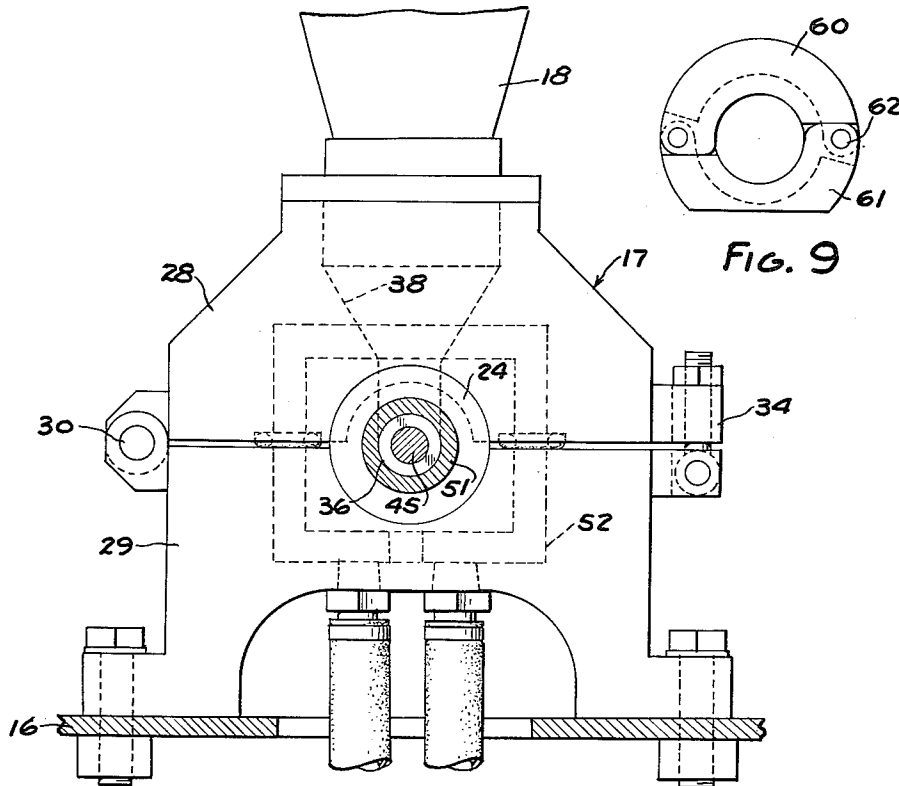


FIG. 8

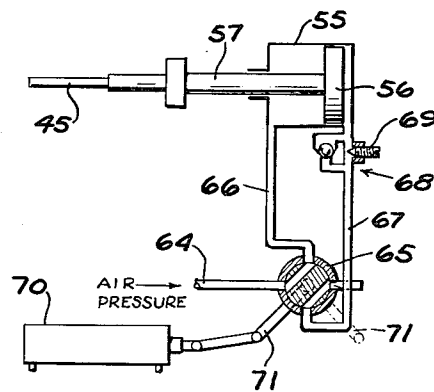


FIG. 10

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3,092,878

METHOD AND APPARATUS FOR CONTINUOUSLY FORMING FOUNDRY MOLDS, CORES AND THE LIKE

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10 Claims. (Cl. 22—11)

This application is a continuation-in-part of my co-pending application Serial No. 772,083, filed November 5, 1958, and entitled "Method and Apparatus for Continuously Forming Foundry Molds, Cores and the Like," now abandoned.

This invention is concerned with forming foundry mold and core shapes or the like in continuous lengths which can be cut to desired shorter lengths to provide individual articles.

The invention specifically lies in the coated sand art wherein foundry mold and core shapes are made from free flowing sand in which the sand particles have been coated with a thermo-setting resin or binder. Conventionally, the cores or molds, even though of relatively small diameter and of regular shape, have been made by packing the coated sand in individual patterns and then subjecting the sand to heat while still in the patterns to cure the binder. This process is relatively slow, requires a considerable amount of equipment, and is relatively costly. In one attempt to improve on this process, the coated sand has been forced through a die by a screw but this proved unsatisfactory because the sand twists under the action of the screw as it passes through the die and consequently the sand cannot be cured while in the die with any reasonable expectation of obtaining a reliable bond between the sand particles.

An object of this invention is to provide a simple, economical method and apparatus with which it is feasible to form foundry mold and core shapes in continuous lengths from coated sand.

The invention is carried out in general by advancing the coated sand intermittently through a die passageway by the action of a rectilinearly reciprocating ram. A portion of the die passageway is heated for curing the sand. Since the sand progresses through the die passageway with substantially rectilinear movement and without any substantial twisting, a reliable bond is obtained between the sand particles. Where hollow shapes are to be made, a mandrel is secured to the ram so that it projects into the die passageway and the sand is formed around the mandrel.

One form of the invention is illustrated in the accompanying drawings.

FIG. 1 is a partly diagrammatic side elevation illustrating apparatus according to the invention.

FIG. 2 is a generally perspective view of a shaped article which may be formed by means of the present invention.

FIG. 3 is an enlarged fragmentary partly diagrammatic side elevation with parts shown in section to illustrate structure according to this invention.

FIG. 4 is a partly diagrammatic fragmentary view generally similar to FIG. 3 but illustrating parts in a different relative position.

FIG. 5 is a partly diagrammatic end elevation of the apparatus.

FIG. 6 is a perspective view illustrating a ram and mandrel unit separate from the other parts.

FIG. 7 is a perspective view illustrating the die unit separate from the other parts.

FIG. 8 is a generally sectional view taken on line 8—8 of FIG. 1.

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FIG. 9 is a generally elevational view of an attachment for fastening the ram unit to a motor unit.

FIG. 10 is a diagrammatic representation of pneumatic equipment for actuating the ram.

The apparatus 15 shown in FIG. 1 includes a base 16 upon which is mounted a support 17 for a coated sand hopper 18. A heater housing 19 and a fluid pressure motor 20 such as a pneumatic motor are also supported on base 16. A control panel for the apparatus is represented at 21. A die unit 24 has one end portion 25 supported in the housing provided by hopper support 17 and another end portion 26 supported within heater housing 19. Housing 17 has upper and lower sections 28 and 29 hinged together as at 30 (FIG. 8) and heater housing 19 similarly has upper and lower sections 31 and 32 hinged together as at 33 (FIG. 5) to facilitate removal, replacement or maintenance of die unit 24 or other internal parts. Housing sections 28 and 29 are clamped shut by a swiveled bolt and lug arrangement 34 and the heater housing sections are similarly clamped shut by a swivel bolt and lug arrangement 35.

A longitudinal passageway 36 extends entirely through die unit 24 and opens at both ends of the die unit. A port 37 opens transversely through a side wall of portion 25 of the die unit contained in hopper support 17. This port is in registry with a passageway or chute 38 in the hopper support which receives coated sand from hopper 18 (FIG. 3).

A ram and mandrel unit 40 includes a cylindrical portion 41 terminating at one end in an adapter disc or flange 42 and terminating at its other end in a transverse shoulder 43 which is preferably perpendicularly disposed as shown. Fastened to ram portion 41 by such means as a threaded connection 44 (FIG. 3) is an elongate mandrel portion 45 projecting away from ram face 43. Ram portion 41 fits slidably within the portion 36a of passageway 36 lying within the feed end 25 of die unit 24. Mandrel 45 projects into the heated end 26 of the die unit with the exterior surface of the mandrel spaced inwardly of the wall of portion 36b of the passageway lying within heater housing 19.

The heater housing contains a number of electric heaters 48 circumferentially arranged around the die unit and furnished with current through conduits 49. Die unit 24 has relatively thick walls at its end portions 25 and 26 and has an intermediate thin walled portion 51 which extends between heater housing 19 and hopper support 17 to restrict heat transfer away from heated die portion 26 for a purpose to be described. Housing 17 contains conduits 52 for coolant to insure that portions of the die unit adjacent the heated portion will remain cool.

Ram and mandrel unit 40 is advanced and retracted in a rectilinear direction within passageway 36 by pneumatic motor 20 which includes a cylinder 55, a piston 56, a piston rod 57 having an end flange 58 connected to flange 42 on the ram and mandrel unit through an adapter 59. Adapter 59 comprises a pair of semi-circular elements 60 and 61 internally recessed as best shown in FIG. 3 for receiving flanges 42 and 58. Sections 60 and 61 have portions which are pinned together as at 62.

Cylinder 55 is furnished with air under pressure through a supply line 64, a four-way valve 65, and conduits 66 and 67, the latter conduit being provided with a check valve 68 and an adjustable screw type metering valve 69. Valve 65 is operated by such means as a solenoid 70 and interposed linkage 71. A collar 74 is adjustably fixed on piston rod 57 by a set screw 75 and has a depending member 76 carrying spaced apart lugs 77 and 78 with threadedly adjustable strikers 79 and 80 for tripping a lever 81 which operates a double throw switch 82 for actuating solenoid 70.

The coated sand comprises a body of sand which has been mixed with a relatively quick setting resin or binder so that the sand particles are coated with the resin. A phenol-formaldehyde resin is satisfactory, examples of which are commercially available as BRR5655, produced by Union Carbide Plastics Company, division of Union Carbide Corp., and 19207 Durez, product of Durez Plastics Division, Hooker Chemical Company, of Tonawanda, New York.

In operation it may be assumed that hopper 18 has been supplied with a quantity of coated sand. Ram and mandrel unit 40 has been retracted to the position shown in FIG. 4 so that port 37 is open. End portion 26 of the die unit has been heated by heater 48. Sand from hopper 18 gravitates through chute 38 and also port 37 into the portion of passageway 36 underlying the port. The sand flows around mandrel 45 and may flow somewhat forwardly into the passageway as represented at A (FIG. 4). A suitable control such as a starting switch button S is operated to actuate solenoid 70 for operating valve 65 to admit air under pressure from supply conduit 65 into air line 67 for advancing piston 56 and ram mandrel unit 40. When the ram mandrel unit advances, ram face 43 forces a quantity of sand from beneath port 37 into passageway 36 toward heated portion 26 of the die unit. The ram face advances approximately to the position illustrated in FIG. 3.

When the ram reaches the forward end of its stroke, striker 80 trips lever switch 81 to operate switch 82 and establish a circuit for actuating solenoid 70 to operate valve 65 so that air under pressure is introduced through air line 66 into cylinder 55 for retracting piston 56 and the ram. Air is exhausted from the cylinder through air line 67 and the rate of retraction of the piston is regulated by adjusting screw 69 to regulate the size of the exhaust orifice. When piston 56 reaches the end of its retraction stroke ram face 43 has been retracted again to the FIG. 4 position wherein port 37 is open. At this point striker 79 trips switch lever 81 in the opposite direction for again actuating solenoid 70 to shift valve 65 for admitting air under pressure through air line 67 to advance piston 56 and the ram mandrel unit. The cycle is then repeated.

Reciprocating movement of ram face 43 intermittently forces a quantity of sand from the region of port 37 toward the heated end 26 of the die unit. This action also intermittently advances the sand through the heated portion of the die passageway. At first there may be little or no resistance to this movement but frictional resistance builds up as a greater quantity of sand is forced forwardly by the ram and as the thermosetting bonding material in the sand begins to cure. When this happens, sand in the heated portion 26 tends to adhere to the walls of the passageway so that its resistance to movement is increased and the compacting action of the ram is also increased. Ultimately, resistance increases to such an extent that the sand is firmly packed before entering the heated region 26 and reaches a generally form-retaining condition at a location generally indicated at B.

However, the sand at this point does not have permanent form-retaining properties and if the restraint of the die passageway or mandrel were removed, the sand at this location would again fall into a heap of discrete sand particles. The sand does not attain a permanent set or form-retaining condition until the binder cures at least partially in the heated portion of the passageway.

Where a hollow article is being formed as in the present illustration, mandrel 45 provides internal support for the sand and the sand is molded between the mandrel surface and passageway wall under the packing action of the ram.

The amount of heat to which the sand is subjected is predetermined so that when the sand emerges from the downstream end of the heated die, the binder has been cured and the article emerges from the die in a continuous

length L which may be severed at desired locations to provide individual molds or cores of desired lengths. One such individual article is the tubular molded shape illustrated in FIG. 2 which has round cylindrical inner and outer walls. However, the external or internal wall shapes may be varied as desired. For example, either the internal or external wall or both could have a polygonal contour instead of a round one. The internal and external wall contours need not be similar. Moreover, the internal and external surfaces need not be concentric. It is only necessary that the mandrel surface, die passageway wall and direction of movement of the ram and mandrel be substantially parallel to the axis of the die passageway. Solid articles of various cross sectional shapes can be formed as well as hollow articles by merely eliminating mandrel 45 and changing the contour of passageway 36 downstream of port 37.

Thin walled portion 51 of the die unit restricts heat transfer into the free end 25 of the die unit to minimize the possibility of the sand being prematurely heated and cured. Coolant in ducts 52 also serves to keep sand in die portion 25 cool for the same purpose. The first portions of length L which emerge from the apparatus after it has been set into operation may be faulty since a certain length of time may be required for proper packing to build up within the apparatus. It has been found in practice that the amount of faulty material seldom exceeds in length the length of the passageway from port 37 to the downstream end of the die unit. Taken in consideration with the total amount of the product produced in an average run, the amount of this faulty material is insignificant.

The total amount of heat to which the sand is subjected may be regulated either by changing the temperature of heaters 48 as by means of a control 85 or by regulating the cyclic rate of the ram. The latter is accomplished by adjusting meter valve 69 to regulate the retraction stroke time of piston 56 or by adjusting striker screws 79, 80 for regulating the length of stroke of the piston and ram. In practice a ram stroke of about one and one-half times the diameter of passageway 36 has been found desirable. In different sizes and types of apparatus, the length of the heated portion 26 of the die unit may also be changed for changing the amount of heat entering the sand.

Different combinations of die units and ram-mandrel units may be installed in the apparatus by unfastening screw clamps 34 and 35, swinging the upper sections 28 and 31 of housing 17 and heater housing to open position, and detaching adapter sections 60 and 61 by removal of one or both pins 62. To install a new die unit and ram-mandrel unit, the parts are merely placed in position, adapter 51 is coupled, and the housing sections are swung to place and clamped shut. The structure thus makes replacement of parts and maintenance thereof very simple and rapid.

It is to be noted that passageway 36 extends in a generally rectilinear direction and that the ram and mandrel are moved also in a generally rectilinear direction with respect to the die unit. Consequently, the sand forced through the die passageway by the ram moves substantially without any twisting movement and is moved along a straight line. This enables an effective, reliable, uniform bond to form between the sand particles when the thermo-setting bonding material cures. In practice it has been found that the heated portion 36b of the die passageway must have a length which is about at least four times the diameter of the passageway to obtain best results. With this approximate ratio, the amount of packing is adequate and the temperatures required to cure the binder are not excessive since the sand is heated for an adequate time interval to utilize relatively low temperatures. It has been found desirable in practice to subject the sand to curing heat for about twenty to twenty-five seconds.

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Where used, mandrel 45 must extend forwardly into heated portion 36b of the die passageway at least to the region where the binder has cured adequately to permanently secure the sand in its ultimate shape. The mandrel may extend to or slightly beyond the downstream end of the die in the forward position of the ram (FIG. 3). However, the mandrel may not extend any great distance beyond the die because the cooling sand which has left against the mandrel, thereby interfering with reciprocation of the mandrel. In most cases, the end of the mandrel should never project more than a fraction of an inch beyond the heated die. In short, the mandrel must have a length such that it reaches the curing location of the binder but such that it will not extend to a location where there is any substantial thermo-contracting of the cured shape.

The intermittent advancing movement of the ram and the body of sand in the heated die passageway 36b prevents the sand from sticking to the heated die walls to such an extent as to impede proper operation of the apparatus. Since the curing of the sand progresses inwardly, there is less tendency of the sand to stick to mandrel 45 than to the walls of the heated die. Consequently, the mandrel can be intermittently retracted without retracting the body of sand in the die and the intermittent retracting movement prevents the mandrel from sticking unduly to the interior of the body of sand. The cyclic action of the apparatus can thus continue smoothly for an indefinite period.

I claim:

1. The method of forming foundry mold or core shapes which comprises, providing a body of coated foundry sand in which the sand particles are coated with a thermo-setting binder, intermittently introducing a generally predetermined quantity of the sand into a die having a mandrel disposed along a longitudinal axis of the die and with the die and the mandrel defining a cross-sectional shape substantially the same as that of a shape to be formed therein, intermittently applying substantially rectilinear force to the sand in the die and thereby intermittently advancing the sand through the die, by means of said die confining the intermittently moving sand in directions transverse to its direction of movement and thereby causing the sand to pack in the die as a result of resistance to relative movement of the sand and die and assume substantially the cross dimensions of said die, then, without otherwise treating the exterior surface of the packed sand, continuing to apply said force to intermittently advance the packed sand in said die through a zone at least about four times as long as said cross dimension of said die, subjecting the packed sand in said zone to heat, said heat being sufficient to cure said thermo-setting binder to bond the sand particles together in a permanent shape, continuing to apply said force to advance the shape out of said die while confining the mandrel so that it does not project more than about one inch downstream of the heated zone, and without substantially changing the cross dimensions of said shape severing the shape to predetermined lengths after it has emerged from the die.

2. The method of forming foundry mold or core shapes which comprises, providing a body of coated foundry sand in which the sand particles are coated with a thermo-setting binder, intermittently introducing a generally predetermined quantity of the sand into a die including a mandrel with the die having a cross-sectional shape substantially the same as that of a shape to be formed therein, while leaving wall portions defining the die substantially stationary relative to each other, intermittently applying substantially rectilinear force to the sand in the die and thereby intermittently advancing the sand through the die, by means of said die confining the intermittently moving sand in directions transverse to its direction of movement and thereby causing the sand to pack in the die as a result

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of resistance to relative movement of the sand and die and assume substantially the cross dimensions of said die, then, without otherwise treating the exterior surface of the packed sand, continuing to apply said force to intermittently advance the packed sand in said die through a zone at least about four times as long as said cross dimension of said die, controlling the application of said force so that the packed sand is advanced through said zone at a predetermined rate, applying heat to the packed sand in said zone, coordinating the application of said heat with the rate of advancement of the packed sand through said zone so that said heat cures said thermo-setting binder while the sand is in said zone, whereby to bond the sand particles together in a permanent shape, continuing to apply said force to advance the shape out of said die the mandrel being positioned so that it does not project more than about one inch downstream of the heated zone when the shape is advanced out of said die, and without substantially changing the cross dimensions of said shape severing the shape to predetermined lengths after it has emerged from the die.

3. The method of forming foundry mold or core shapes which comprises, providing a body of coated foundry sand in which the sand particles are coated with a thermo-setting binder, providing a die passageway whose cross dimensions are substantially the same as those of a shape to be formed and having an axis and side walls which are substantially parallel to said axis, intermittently introducing a generally predetermined quantity of sand into said passageway over a mandrel, while leaving the wall portions defining said die substantially stationary relative to each other intermittently applying force to the sand in the passageway and thereby intermittently advancing the sand substantially axially through the passageway, by means of the side walls of said passageway confining the intermittently moving sand in substantially all directions perpendicular to the axis of the passageway, and thereby causing the sand to pack in the passageway as a result of resistance to relative movement of the sand and passageway walls and assume substantially the cross dimensions of said passageway, then, without otherwise treating the exterior surface of the packed sand, continuing to apply said force to intermittently advance the packed sand in said passageway through a zone at least about four times as long as said cross dimension of the passageway, heating the portion of said die walls defining said zone and thereby applying heat to the packed sand in said zone, controlling the application of said heat so that it cures said thermo-setting binder while the packed sand is in said zone, whereby to bond the sand particles together in a permanent shape, continuing to apply said force to advance the shape out of said die passageway, and without substantially changing the cross dimensions of said shape, the mandrel being positioned so that it does not project more than about one inch downstream of the heated zone when the shaft is advanced out of said die, and then severing the shape to predetermined lengths after it has emerged from the die passageway.

4. The method of forming foundry mold or core shapes which comprises, providing a body of coated foundry sand in which the sand particles are coated with a thermo-setting binder, providing a die having a passageway whose cross dimensions are substantially the same as those of a shape to be formed and having a longitudinal axis and side walls substantially parallel to said axis, providing a mandrel in said passageway whose exterior surface portions are spaced from the passageway walls and are substantially parallel to the passageway axis, intermittently introducing a generally predetermined quantity of the sand into the die passageway, while leaving the wall portions of said die substantially stationary relative to each other intermittently applying force to the sand in the passageway and thereby intermittently advancing the sand substantially axially through the passageway, confining the sand between the exterior surfaces of the mandrel

and said side walls of the passageway and thereby causing the sand to pack between the passageway walls and mandrel as a result of resistance to movement of sand in the passageway and assume substantially the dimensions of said passageway, then, without otherwise treating the exterior surface of the packed sand, continuing to apply said force to intermittently advance the packed sand in said passageway through a zone at least about four times as long as said cross dimension of said passageway, subjecting the packed sand in said zone to heat, controlling said heat so that the thermo-setting binder cures in said zone whereby to bond the sand particles together in a permanent shape, continuing to apply said force to advance the shape out of the die passageway and over the end of said mandrel, and then without substantially changing the cross dimensions of said shape and while confining the mandrel so that it does not project more than one inch downstream of the heated zone when the shape is advanced out of said die severing the shape to predetermined lengths.

5. The method defined in claim 4 and including the additional steps of reciprocally advancing and retracting said mandrel synchronous with intermittent application of said force, and controlling the movement of said mandrel so that in its farthest point of advance it projects at least to the region of said zone wherein said sand becomes form-retaining under the action of the curing binder but stops short of the region of substantial thermal contraction after said shape has emerged from said die passageway.

6. Apparatus for continually forming foundry mold or core shapes comprising, means forming a die having a passageway of predetermined cross dimension, a longitudinal axis and side walls substantially parallel to said axis, means operable to introduce intermittently into said passageway a predetermined quantity of foundry sand whose particles are coated with a thermo-setting binder, the sand being disposed peripherally of a mandrel disposed in said passageway and which mandrel does not project more than about one inch downstream of an outlet end of said passageway, means operable to advance the sand intermittently through said passageway in a substantially axial rectilinear direction, said passageway having such a length that resistance between the sand and passageway walls causes the sand to pack within said passageway, means operable to heat a portion of said die so that a portion of the length of said passageway forms a heating zone within which the thermo-setting resin is cured as the packed sand passes therethrough, said heating zone having a length at least about four times said cross dimension of said die passageway, said die and heating zone having downstream ends which are substantially coterminous.

7. Apparatus for continuously forming foundry mold or core shapes comprising, means forming a die having a passageway with a longitudinal axis and side walls substantially parallel to said axis, means forming a mandrel which is reciprocable within said passageway in a direction substantially parallel to said axis, means operable to introduce intermittently into said passageway a predetermined quantity of foundry sand whose particles are coated with a thermo-setting binder, means operable to intermittently advance the sand through said passageway in a substantially axial direction, said passageway and mandrel having a length such that the sand packs between the mandrel exterior and the side walls of said passageway as a result of resistance to passage of the sand through the passageway, the length of said passageway being about at least four times the diameter of said passageway, means operable to heat a portion of said die so that a portion of the length of said passageway forms a heating zone within which the thermo-setting binder is cured, means operable to reciprocate said mandrel in said passageway in synchronism with intermittent advance-

ment of the sand through the passageway, said mandrel having a length such that at its farthest point of advance, it projects at least to the region in said heating zone where the packed sand becomes form-retaining, the length of said mandrel being limited so that at its farthest point of advance the end of said mandrel is positioned no more than one inch downstream of said heating zone.

8. Apparatus for continuously forming foundry mold or core shapes comprising, means forming a die having a passageway of predetermined diameter with a longitudinal axis and side walls substantially parallel to said axis, means forming a mandrel reciprocable within said passageway in a direction substantially parallel to said axis, said mandrel having an exterior surface which is substantially parallel to said axis, means operable to intermittently introduce into said passageway a predetermined quantity of foundry sand whose particles are coated with a thermo-setting binder, means operable to intermittently advance the sand through said passageway in a substantially rectilinear axial direction, said passageway and mandrel having such a length that the sand becomes packed between the mandrel exterior and the side walls of the passageway as a result of resistance to movement of the sand through said passageway the length of said passageway being about at least four times the diameter of said passageway, means operable to heat a portion of said die so that a portion of the length of said passageway forms a heating zone in which said thermo-setting binder becomes cured, means operable to advance and retract said mandrel in said passageway in synchronism with intermittent advancement of said sand through said passageway, said mandrel having a length such that at its farthest point of advance it projects into said heating zone at least to the region where said sand becomes form-retaining as a result of curing of the binder, the length of said mandrel being limited so that at its farthest point of advance it is positioned no more than one inch downstream of said heating zone.

9. The combination defined in claim 6 said mandrel being reciprocable within said passageway substantially parallel to said axis in synchronism with intermittent advancement of the sand, the length of said mandrel being limited so that at its farthest point of advance, the downstream end of said mandrel is positioned no more than one inch downstream of said heating zone, as previously defined.

10. The method of forming foundry mold or core shapes which comprises, providing a body of coated foundry sand in which the sand particles are coated with a thermo-setting binder, intermittently introducing a generally predetermined quantity of sand into a die passageway over a mandrel intermittently applying substantially rectilinear force to the sand in the die passageway and thereby intermittently advancing the sand through the die passageway, by means of said die passageway confining the intermittently moving sand in directions transverse to its direction of movement and thereby causing the sand to pack in the die passageway as a result of resistance to relative movement of the sand and die passageway, continuing to apply said force to intermittently advance the packed sand in said die passageway through a portion of said die passageway forming a heating zone at least about four times as long as the cross dimension of said die passageway, subjecting the packed sand in said zone to heat, said heat being sufficient to cure said thermo-setting binder to bond the sand particles together in a permanent shape, substantially simultaneously advancing the shape out of said heating zone and die passageway while limiting movement of the mandrel so that at its farthest point of advance the end of the mandrel is positioned no more than one inch downstream of the heated zone, and severing the shape to predetermined lengths after it has emerged from said die passageway.

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