

Sept. 15, 1970

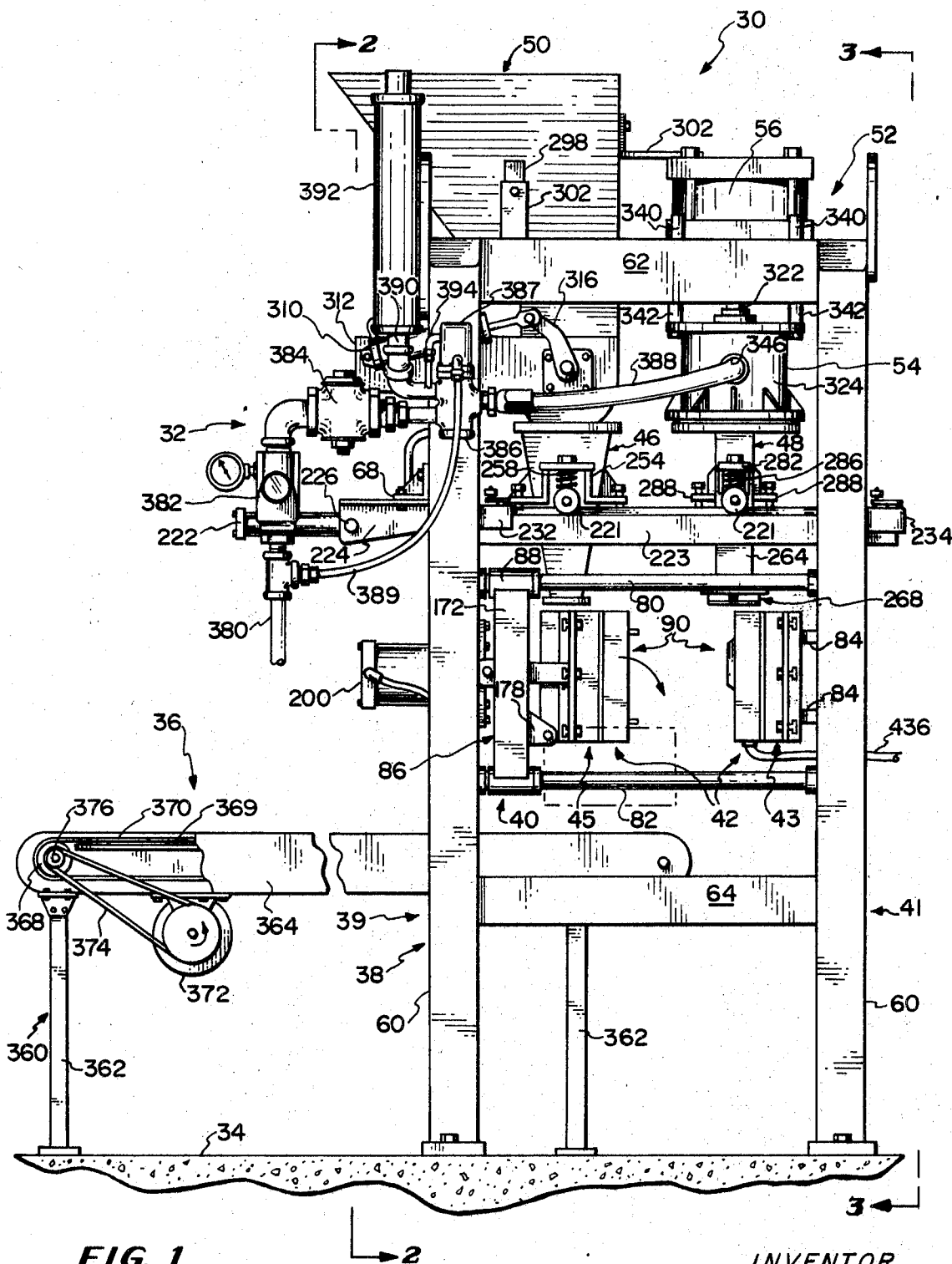
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3,528,481

CORE MAKING MACHINE WITH HARDENING GAS MANIFOLD

Filed Oct. 17, 1968

9 Sheets-Sheet 1



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CORE MAKING MACHINE WITH HARDENING GAS MANIFOLD

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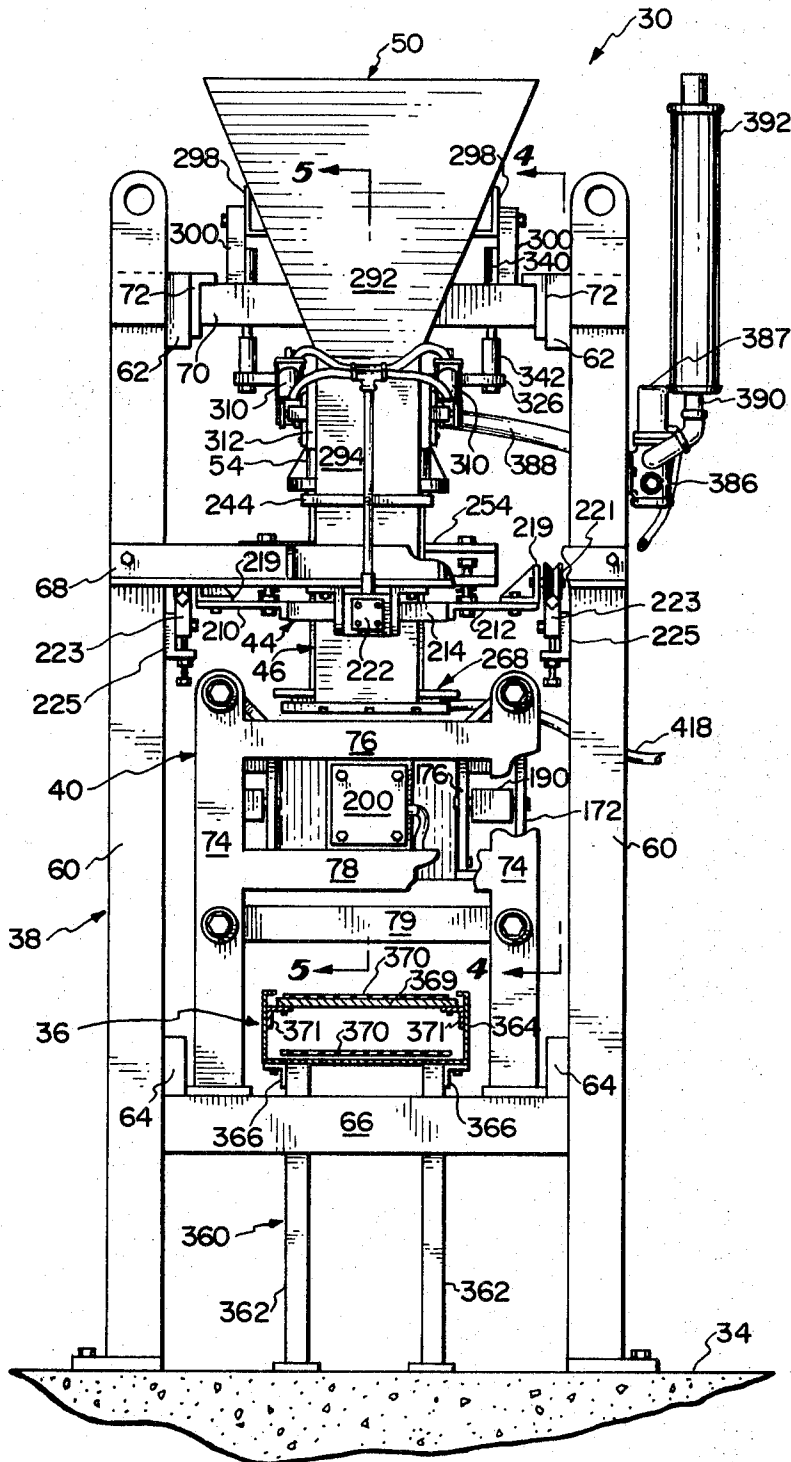


FIG. 2

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CORE MAKING MACHINE WITH HARDENING GAS MANIFOLD

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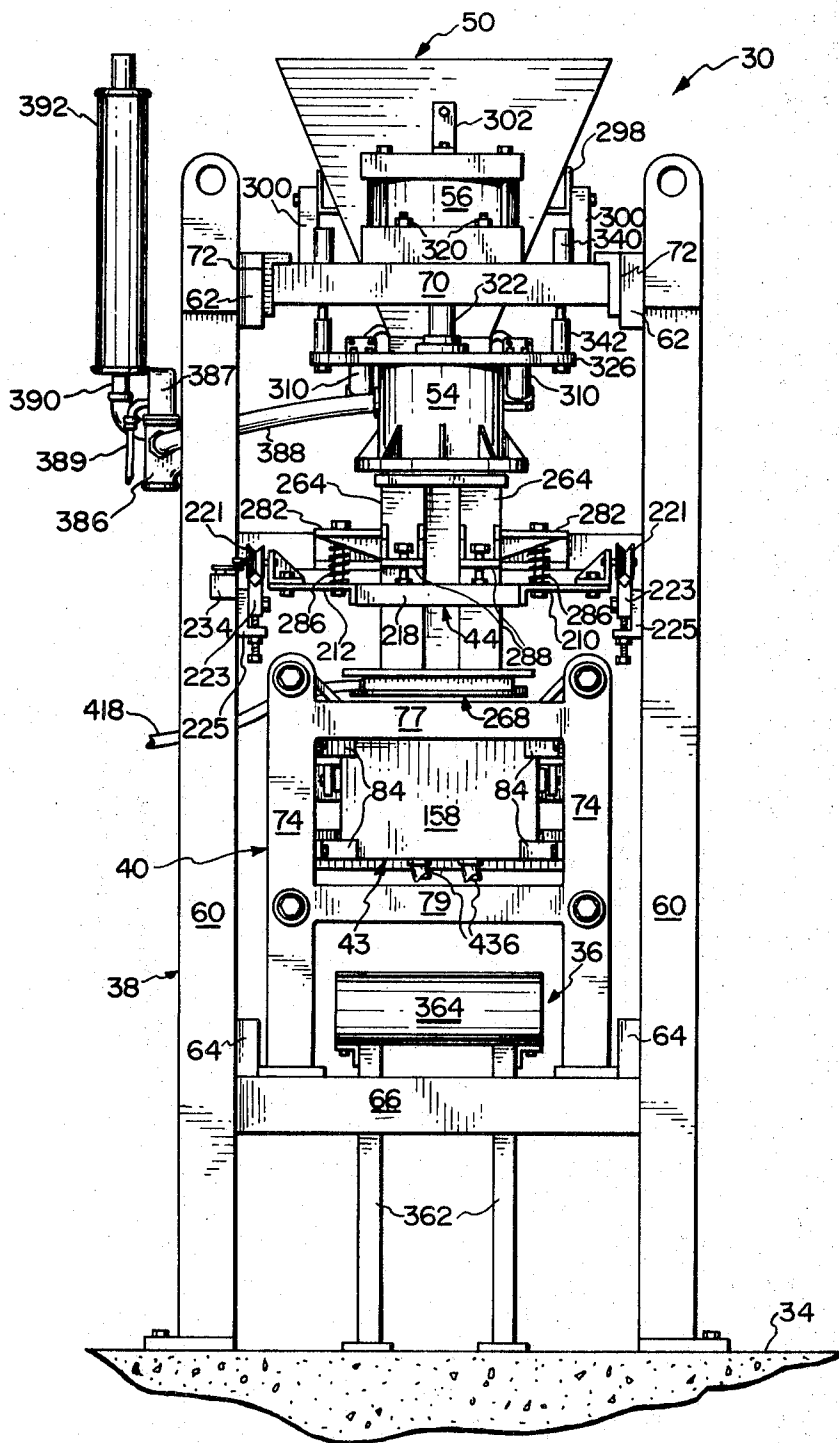


FIG. 3

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CORE MAKING MACHINE WITH HARDENING GAS MANIFOLD

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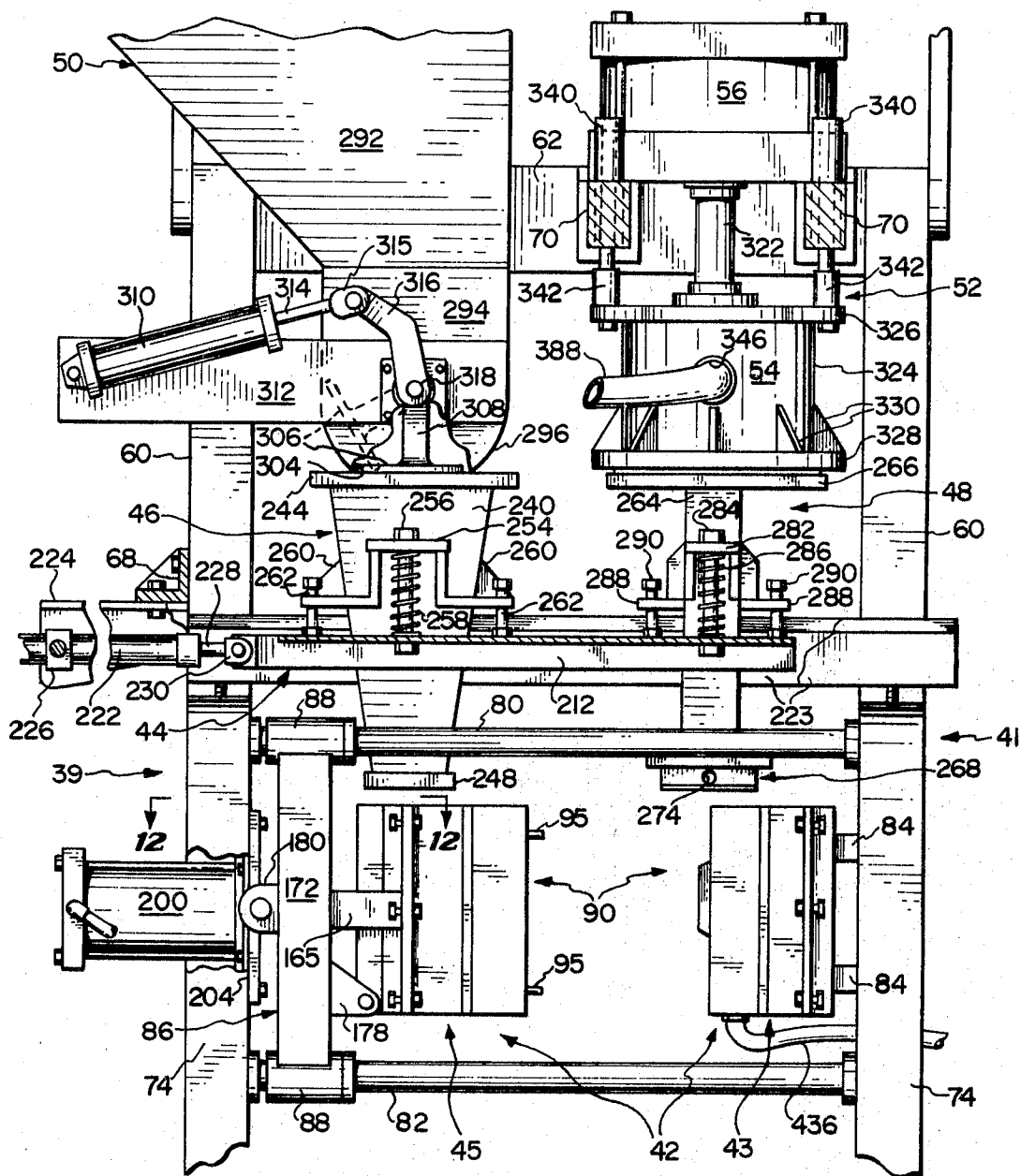


FIG. 4

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CORE MAKING MACHINE WITH HARDENING GAS MANIFOLD

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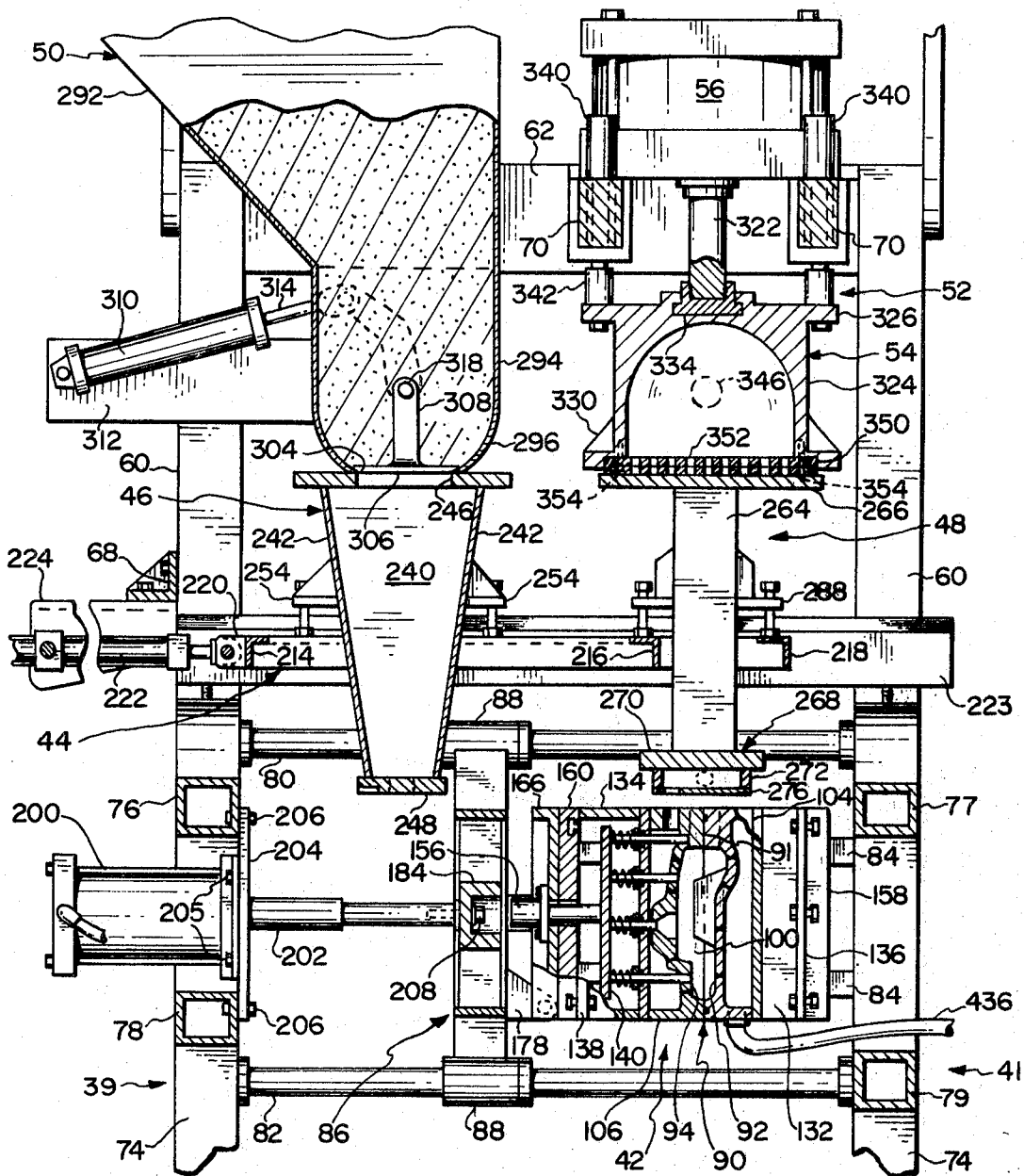


FIG. 5

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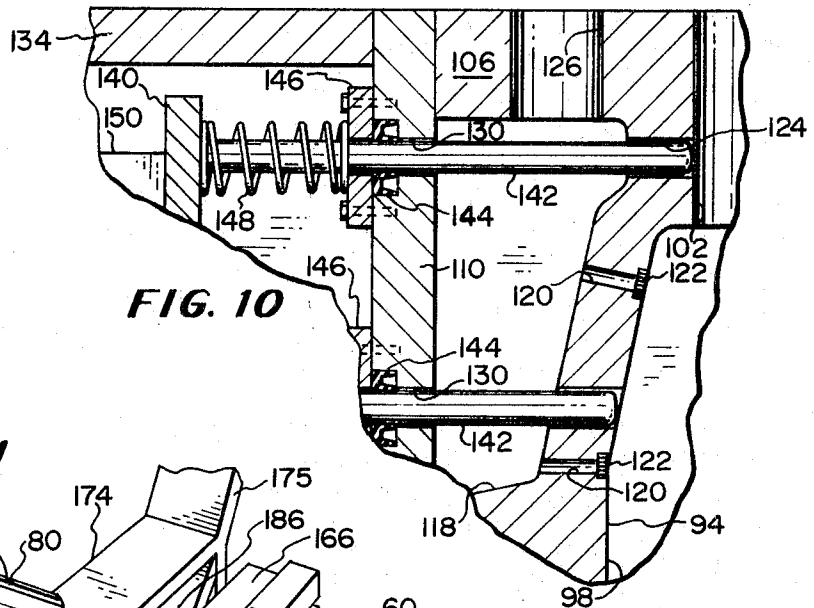


FIG. 10

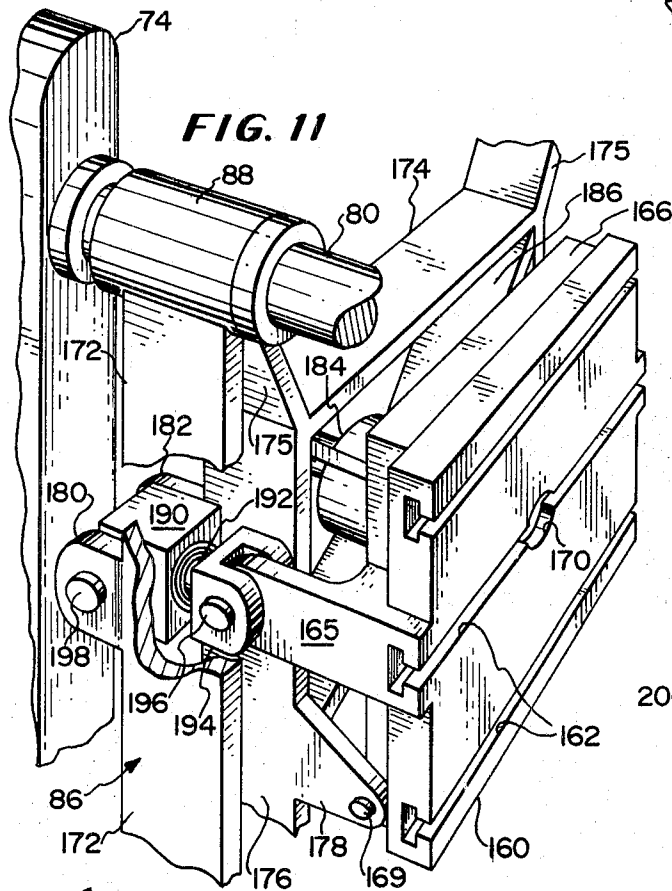


FIG. 11

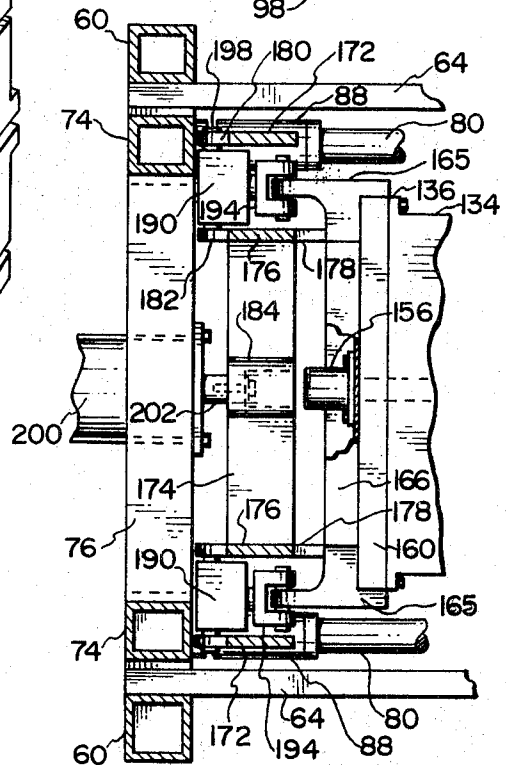


FIG. 12

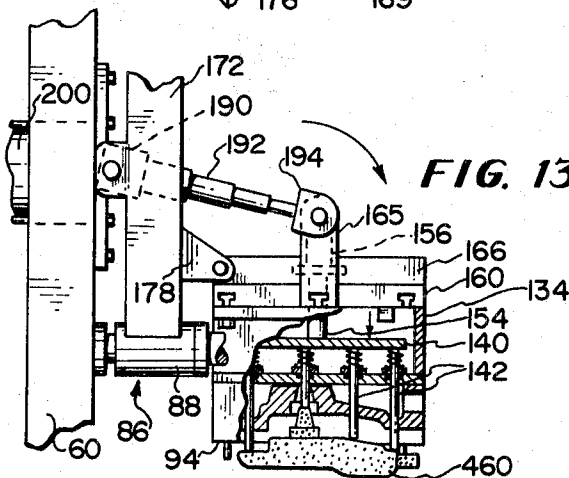


FIG. 13

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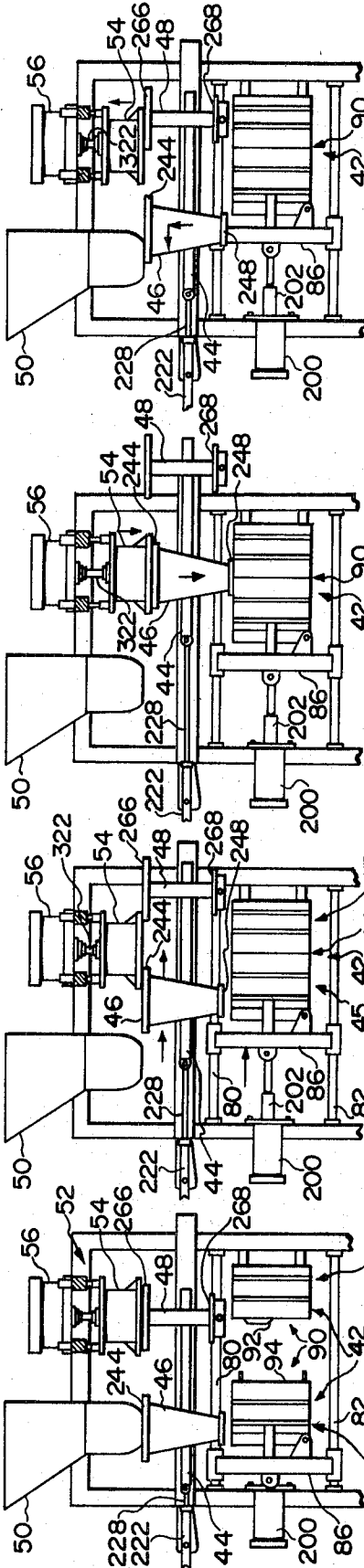


FIG. 17

FIG. 16

FIG. 15

FIG. 14

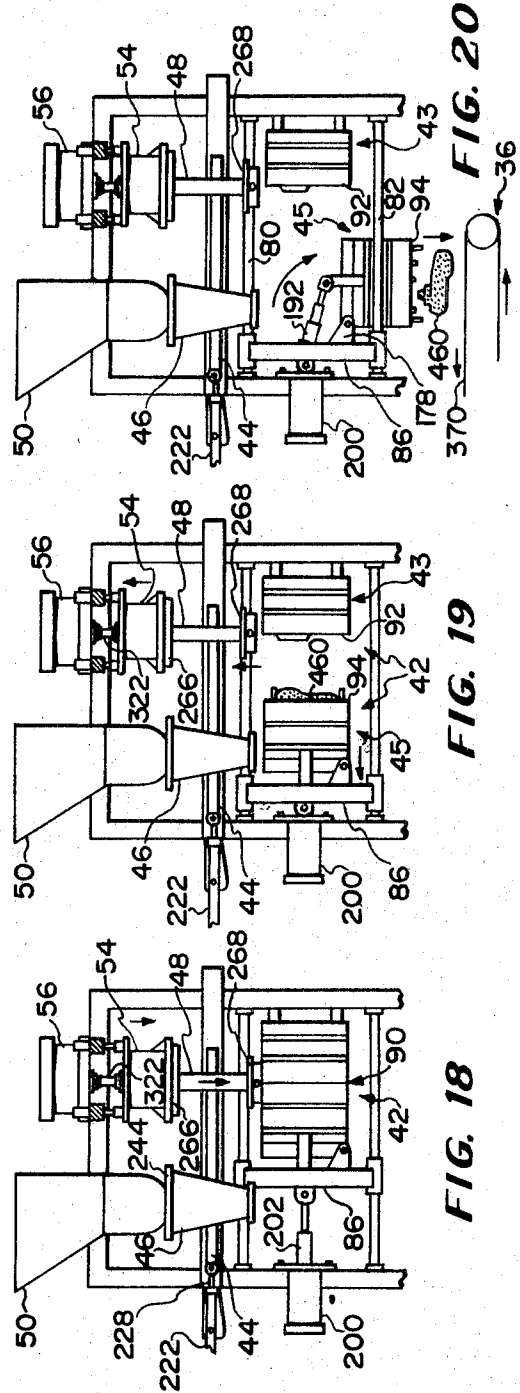


FIG. 18

FIG. 19

FIG. 20

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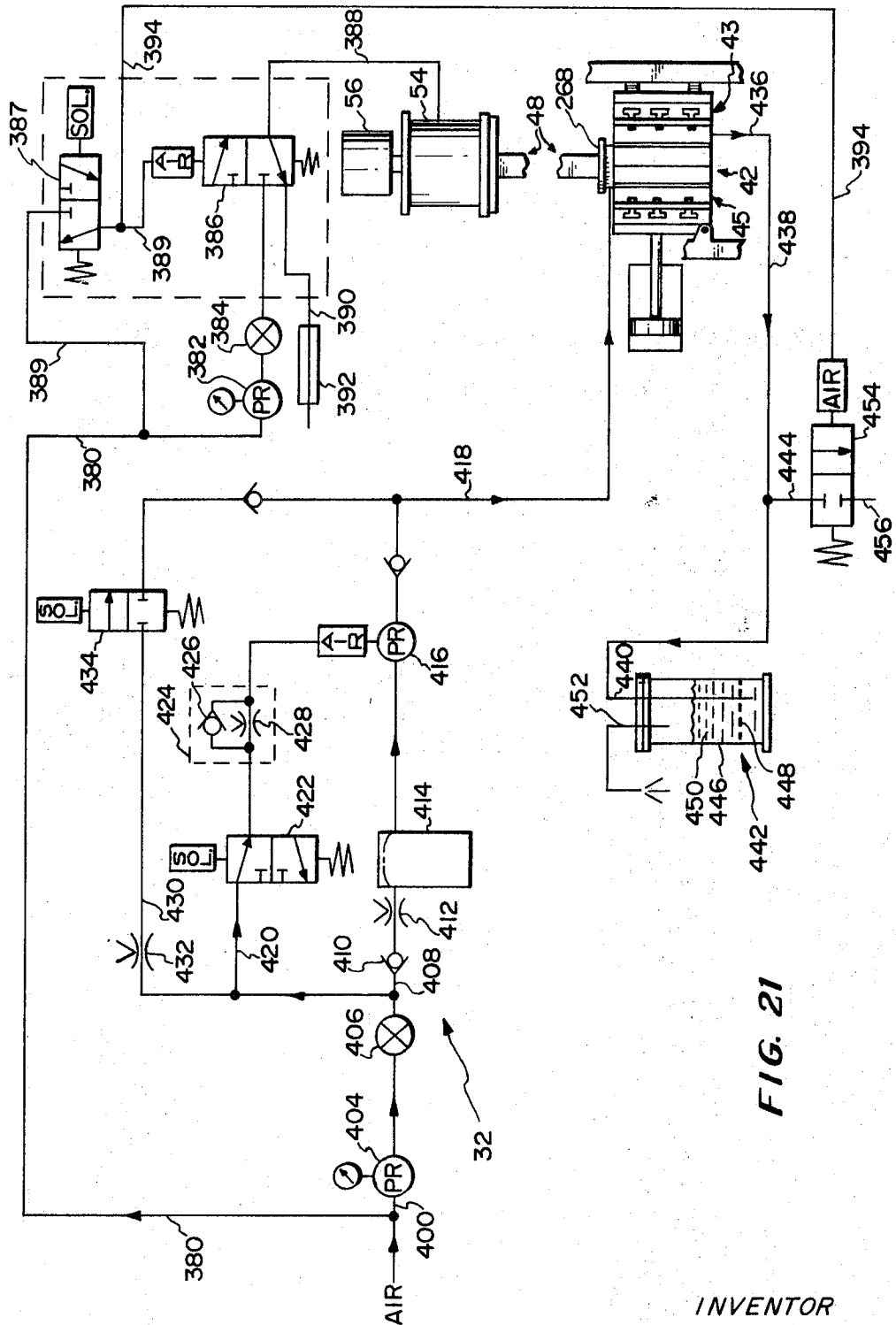
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CORE MAKING MACHINE WITH HARDENING GAS MANIFOLD

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9 Sheets-Sheet 9



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3,528,481

CORE MAKING MACHINE WITH HARDENING GAS MANIFOLD

Robert S. Lund, Elmhurst, Ill., assignor to Pettibone Corporation, Chicago, Ill., a corporation of Delaware
Continuation-in-part of application Ser. No. 737,162, June 14, 1968. This application Oct. 17, 1968, Ser. No. 768,465

Int. Cl. B22c 13/12, 9/12

U.S. Cl. 164—183

10 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for making foundry sand articles such as sand cores includes a mold box having horizontally separable box sections defining a mold cavity therebetween, a blow head mounted in spaced superposed relation to the mold box for vertical reciprocal movement, means for reciprocating the blow head, a sand hopper mounted in spaced relation above the mold box in lateral alignment with the blow head, carriage means mounted for horizontal reciprocal movement between the blow head and the hopper thereabove and the mold box therebelow, a sand magazine mounted on the carriage means for horizontal movement therewith and for vertical reciprocal movement relative thereto, a gas manifold mounted on the carriage means for horizontal movement therewith and for vertical reciprocal movement relative thereto, and means for reciprocating the carriage means to dispose the magazine and the manifold alternately between the blow head and the mold box, and to dispose the magazine adjacent the hopper when the manifold is disposed between the blow head and the mold box, whereby the blow head reciprocating means is operable to move the blow head towards the mold box alternately in engagement with the magazine and the manifold for moving them to positions adjacent the mold box for filling and gassing the mold cavity respectively.

RELATED APPLICATION

This is a continuation-in-part of application Ser. No. 737,162 Filed June 14, 1968.

BACKGROUND OF THE INVENTION

This invention relates to apparatus for making foundry sand articles, particularly sand cores. More particularly, the invention relates to apparatus for making sand articles by a "cold box" process, wherein sand containing a hardenable binder is blown into a mold box to form a molded article therein, and a gaseous hardening agent for the binder is blown into the mold box to thereby harden the molded article without necessity for the application of heat.

The manufacture of shell cores and molds from sand coated with a hardenable binder is a well-developed art. Thus, for example, an automatic core-making machine for making cores by a "hot box" process is disclosed in U.S. Pat. No. 3,096,547 granted to William A. Hunter and the present inventor. The hot box process employs sand coated with a thermosetting resinous binder, and molded articles are hardened in mold boxes by the application of heat.

While the hot box processes have achieved widespread success, certain disadvantages are inherent in the processes. Thus, production rates and variations in core thickness are limited by heat transfer rates. The molded articles are subject to thermal stresses. Mold boxes must be constructed of heavy cast iron, so as to retain heat and avoid warping. Operations are conducted with open gas flames at high temperatures.

Cold box processes also have been provided wherein molded sand articles containing a hardenable binder were hardened or cured by contact with a gaseous hardening agent. For example, one such process employed sodium silicate as the binder and carbon dioxide as the hardening agent. The characteristics of the early cold box sand articles were less desirable, and consequently, articles made by hot box processes have been preferred.

More recently, developments in resinous binders have resulted in the introduction commercially of binder materials which may be hardened by a gaseous hardening agent in a cold box process to produce very desirable foundry sand articles. The sand articles may be produced without the disadvantages of the hot box processes. Inasmuch as heat transfer is not a factor, the hardening or cure time is substantially less than in a hot box process, and the sand articles can have widely varying thicknesses. Thermal stress is not present in the sand articles. The mold boxes may be constructed of diverse materials.

The aforementioned patent describes a vertical in-line apparatus and method for making sand articles by a hot box process, wherein a mold box having separable upper core and lower drag sections is employed, and the box sections are mounted for relative vertical movement between them. My above-identified application, Ser. No. 737,162, discloses an illustrative embodiment of similar structure for making sand articles by a cold box process. Such apparatus is especially desirable for the manufacture of relatively large sand articles. Another type of apparatus previously employed in the hot box process for the manufacture of small articles, such as pin cores and fitting cores, employs a mold box having separable box sections mounted for relative horizontal movement between them. The present invention more specifically relates to apparatus of the latter type.

SUMMARY OF THE INVENTION

The present invention provides a new and improved apparatus of the horizontally separable mold box type for making foundry sand articles by a cold box process. More particularly, the apparatus may be utilized for the manufacture of sand articles by a process wherein foundry sand containing a hardenable binder is contacted with a gaseous hardening agent for the binder either according to the early processes or utilizing the more recent developments in binder materials.

The apparatus of the invention includes a mold box having separable box sections defining a mold cavity therebetween and having a sand filling opening and gas passageways to the cavity, means mounting the box sections for relative horizontal reciprocal movement between them, a blow head mounted in spaced superposed relation to the mold box for vertical reciprocal movement, means for reciprocating the blow head, carriage means mounted for horizontal reciprocal movement between the blow head and the mold box, a sand magazine mounted on the carriage means for horizontal movement therewith, means mounting the magazine for vertical reciprocal movement, a gas manifold mounted on the carriage means for horizontal movement therewith, means mounting the manifold for vertical reciprocal movement, and means for reciprocating the carriage means to dispose the magazine and the manifold alternately between the blow head and the mold box, whereby the blow head reciprocating means is operable to move the blow head towards the mold box alternately in engagement with the magazine and the manifold for moving them to positions adjacent the mold box for filling and gassing the mold cavity respectively. Preferably, a sand hopper is mounted above the carriage means and arranged for filling the magazine

when the manifold is disposed between the blow head and the mold box.

The apparatus more preferably includes gas manifold chambers adjacent the mold box sections in communication with the mold cavity, one of the chambers having an opening registering with an opening provided in the gas manifold when the manifold is adjacent the mold box for conducting gas therebetween. Stripper pins are associated with one of the chambers and its adjacent box section for movement therethrough. It is further preferred to pivotally mount the last-named chamber, its adjacent box section, and the stripper pins for rotation to a downwardly facing position of the box section for ejection of a molded article therefrom.

Employing the apparatus of the invention, foundry sand articles are manufactured at a high rate of production, accurately, with minimum molding materials, and with few rejects. The apparatus is compact and operates efficiently in fully automatic continuous production, and equipment, space and labor requirements are minimized.

BRIEF DESCRIPTION OF THE DRAWING

The attached drawings illustrate a preferred embodiment of the invention, without limitation thereto. In the drawings, like elements are identified by like reference symbols in each of the views, and:

FIG. 1 is a side elevational view of apparatus for making foundry sand articles according to the invention, with parts broken away, illustrating the apparatus as it appears at the start of a cycle of operation and, similarly, at the end of the cycle;

FIG. 2 is a vertical sectional and front end elevational view thereof, with parts broken away, taken substantially on lines 2—2 of FIG. 1;

FIG. 3 is an elevational view of the rear end thereof, taken substantially on line 3—3 of FIG. 1;

FIG. 4 is an enlarged vertical sectional view thereof, with parts broken away, taken substantially on line 4—4 of FIG. 2;

FIG. 5 is an enlarged vertical sectional view thereof, with parts broken away, taken substantially on line 5—5 of FIG. 2, illustrating the mold box thereof in closed position;

FIG. 6 is a further enlarged elevational and partly sectional view of the mold box and associated structure, and a portion of a sand magazine thereof, illustrating the sand filling operation;

FIG. 7 is a horizontal sectional view of a blow plate on the sand magazine, taken substantially on line 7—7 of FIG. 6;

FIG. 8 is a vertical sectional and elevational view of the mold box and associated structure, and a gas manifold thereof, illustrating the gassing operation;

FIG. 9 is a horizontal sectional view of the gas manifold, taken substantially on line 9—9 of FIG. 8;

FIG. 10 is a further enlarged fragmentary vertical sectional view of the structure illustrated in FIG. 8;

FIG. 11 is an enlarged fragmentary perspective view with parts broken away of mounting structure for a movable section of the mold box;

FIG. 12 is an enlarged horizontal sectional view of the movable box section mounting structure, with parts broken away, taken substantially on line 12—12 of FIG. 4;

FIG. 13 is a fragmentary elevational and partly sectional view of the movable box section and its mounting structure, similar to the view of FIG. 4 but with the structure in ejection positions thereof;

FIGS. 14—20 are schematic fragmentary side elevational and sectional views of the apparatus, illustrating successive positions of the parts from the beginning to the end of a cycle of operation; and

FIG. 21 is a diagrammatic representation of equipment for supplying air and gaseous hardening agent to machine instrumentalities and exhausting the same therefrom.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, particularly FIGS. 1—5 and 21, a preferred embodiment of apparatus for making foundry sand articles according to the invention includes a core-making machine 30 and air and gas supply equipment generally designated by the number 32, the latter being shown in part in FIG. 1 and illustrated diagrammatically in FIG. 21. The apparatus is mounted on a foundry floor 34 or other supporting surface. The apparatus is employed in combination with a belt conveyor 36, which is also mounted on the foundry floor.

GENERAL ORGANIZATION OF THE MACHINE

The core-making machine 30 includes in its general organization a main frame 38 having front and rear ends 39 and 41, and a sub-frame 40 mounted on the main frame, each being of generally rectangular configuration. The conveyor 36 extends from within the main frame; generally below the sub-frame, to any desired external location.

A mold assembly 42 is mounted on the sub-frame 40. The assembly is composed of separable mold units, including a stationary or fixed unit 43 and a horizontally reciprocally movable and rotatable unit 45. One or more sand articles are molded and hardened or cured in the mold assembly when the assembly is closed with the units brought together, as shown in FIG. 5. The movable unit 45 is separated from the stationary unit 43 and is rotated to a downwardly facing position for ejecting the sand article or articles onto the conveyor 36 therebeneath, as shown in FIG. 1.

A rectangular carriage 44 is mounted on the main frame 38 for horizontal reciprocal movement in spaced relation above the sub-frame 40. The carriage is movable between a front or outer position, illustrated in FIGS. 1, 4, 5, 14 and 18—20, and a rear or inner position, illustrated in FIG. 16. A sand magazine 46 and a gas manifold assembly 48 are mounted on the carriage in spaced apart relation and in lateral alignment therealong. The magazine is mounted adjacent the front end and the manifold assembly is mounted adjacent the rear end of the carriage. The magazine and the manifold assembly are horizontally movable with the carriage, and each is independently vertically movable thereon, to and from the mold assembly 42.

A sand hopper 50 and a blow head and cylinder assembly 52 are mounted on the main frame 38 in spaced apart relation and in lateral alignment, above the carriage 44 and the sand magazine 46 and gas manifold assembly 48 thereon. The blow head and cylinder assembly 52 includes a blow head 54 and a superposed double-acting air cylinder 56. The hopper is mounted adjacent the front end 39 of the main frame. The blow head and cylinder assembly is mounted adjacent the rear end 41 of the main frame in vertical alignment with the mold assembly 42 when the latter is in its closed position. The spacing of the hopper and the blow head and cylinder assembly correspond to the spacing of the sand magazine and the gas manifold assembly, for bringing the latter into engagement with the former.

In the rearward disposition of the carriage 44, illustrated in FIG. 16, the gas manifold assembly 46 is in an out of the way position, and the sand magazine 46 is in vertical registry with and adjacent the blow head and cylinder assembly 52. The blow head cylinder 56 is operable to move the blow head 54 towards the mold assembly 42 in engagement with the magazine for moving the magazine to a position adjacent the mold assembly, for supplying molding sand to the assembly.

With the carriage 44 in its forward disposition, as illustrated in FIG. 18, the sand magazine 46 is in vertical registry with and adjacent the sand hopper 50, for filling the magazine from the hopper. The gas manifold assembly 48 is in vertical registry with and adjacent the blow

head 54. The blow head cylinder 56 is operable to move the blow head towards the mold assembly 42 in engagement with the manifold assembly 48 for moving the latter to a position adjacent the mold assembly, for conducting gas under pressure between the manifold assembly and the mold assembly.

As described in greater detail hereinafter, the movable mold unit 45 of the mold assembly 42 is moved cooperatively with the carriage 44 and the blow head 54 for sand filling, gassing, and sand article ejecting operations.

THE MACHINE STRUCTURE

Referring to FIGS. 1-5 the main frame 38 includes four uprights or corner posts 60. The uprights are connected by upper and lower side cross bars 62 and 64, by lower end cross bars 66, and by an intermediate end cross bar 68. Spaced parallel blow head cylinder mounting cross bars 70 extend between the upper side cross bars 62 and are secured to thrust brackets 72 fixed to the side cross bars.

The sub-frame 40 includes four legs 74 mounted on the lower end cross bars 66. The legs are joined at opposite ends of the sub-frame by upper cross bars 76 and 77, and lower cross bars 78 and 79, at the respective ends. The legs are joined on the sides of the frame by parallel horizontal upper slide rods 80 and lower slide rods 82. The mold assembly 42 is mounted on the sub-frame between the slide rods for movement of the movable unit 45 on the rods to and from the stationary unit 43. The movable unit is mounted on a traveling frame 86 having bushings 88 slidable on the slide rods. The stationary unit is mounted on a pair of legs 74 by mounting brackets 84 (FIG. 3).

As seen most clearly in FIG. 8, the mold assembly 42 includes a mold box 90 having separable mating stationary and movable rectangular box sections 92 and 94, respectively, which come in contact at a vertical parting line or plane 91. A compression gasket 93 is mounted in the face of the stationary box section adjacent its periphery, for sealing the mold box. Guide pins 95 (see also FIG. 4) extend from the movable box section into recesses in the stationary box section. The box sections have respective cavities or recesses 96 and 98 which together form a mold cavity 100. Similar mating recesses in the box sections form two filling openings 102 extending from the top of the mold box to the mold cavity 100.

Rectangular hollow bodies 104 and 106 are formed integrally with respective mold box sections 92 and 94, and extend outwardly therefrom. End closure plates 108 and 110 are secured to the bodies 104 and 106, and together with the mold box sections 92 and 94 they form gas manifold chambers 112 and 114 having manifold cavities 116 and 118. As seen particularly on reference to FIG. 10, small gas or vent openings 120 are provided in the mold box sections for communication between the mold cavity 100 and the manifold cavities 116 and 118. The openings are closed by sand blocking screens 122 at the surfaces of the mold cavity.

The movable box section 94 is also provided with cylindrical stripper pin openings 124 extending between the mold cavity and the manifold cavity 118. Three aligned gas supply openings 126 are provided in the movable hollow body 106 at the top of the mold box, and two gas exhaust openings 128 are provided in the stationary hollow body 104 at the bottom of the mold box, in communication with respective manifold cavities 118 and 116. Stripper pin openings 130 are provided in the closure plate 110 of the movable gas manifold chamber, in alignment with the stripper pin openings 124 in the movable mold box section 94.

Rectangular spacer frames 132 and 134 are secured to the manifold chambers 112 and 114, as by bolts 135 extending through the frames and into the hollow bodies 104 and 106. The spacer frames are provided with integral vertical mounting flanges 136 and 138 (FIG. 6). The spacer frame 134 of the movable unit 45 also serves

as a housing for a stripper plate 140 bearing stripper pins 142. The stripper pins extend through the aligned pin openings 130 and 124 in the closure plate 110 and the box section 94. As seen in FIG. 10, the box section pin openings 124 are dimensioned to provide a slight clearance around the stripper pins, to establish additional gaseous communication between the mold cavity 100 and the manifold cavity 118.

Resilient gland seals 144 seal the openings 130 in the closure plate 110 around the stripper pins 142, and the seals are secured by retaining disks 146 fastened to the closure plate. The stripper plate is urged outwardly by compression springs 148 mounted on the stripper pins between the plate and the retaining disks. Gauge blocks 150 limit the outward movement of the stripper plate and locate the inner ends of the stripper pins with their surfaces substantially flush with the wall of the movable box section cavity 98.

The mold box section, the manifold chamber, and the spacer frame of each of the mold units 43 and 45 constitute a separate sub-unit which is interchangeable with other such sub-units for producing molded articles of various sizes and configurations, as described. Such sub-units are detachably mounted on stationary and movable rectangular platens 158 and 160. The platens are provided with mounting T-slots 162 for receiving nut and bolt fastenings 164 inserted through suitable openings in the mounting flanges 136 and 138 on the spacer frames. The gauge blocks 150 for the stripper plate 140 may be mounted on the movable platen 160, or on the stripper plate.

The stationary platen 158 is secured to the mounting brackets 84 for supporting the stationary mold unit 43. The movable platen 160 is secured to a flanged mounting plate 166, as by screws 167, and the two are mounted on the travelling frame 86 for supporting the movable mold unit 45. For this purpose, integral rockers arms 165 extend from the centers of opposite sides of the platen beyond the mounting plate (see FIGS. 11 and 12). Trunnions 169 are secured on opposite sides of the mounting plate adjacent the lower end thereof.

A single acting stripper air cylinder 156 is secured to the mounting plate 166, and piston rod 154 extends therefrom through an opening 168 in the plate and a registering opening 170 in the platen 160. The outer end of the piston rod is secured to the center of the stripper plate 140. The cylinder is operable to extend the piston rod and the stripper plate therewith, to insert the stripper pins 142 into the movable box section cavity 98 for stripping and ejecting a molded article therefrom.

Referring to FIGS. 11 and 12, the traveling frame 86 includes vertical side bars 172 and a spider 174 having ribs 175, both being secured to the bushings 88, as by welding. The spider includes vertical side bars 176 spaced inwardly from the frame side bars 172. The spider side bars have integral mounting brackets 178 projecting rearwardly therefrom. The frame and spider side bars have respective integral ears 180 and 182 projecting forwardly therefrom, above the brackets 178. A cup shaped hub 184 is secured centrally of the spider by diagonal bars 186.

The movable mold unit 45 is pivotally mounted on the spider 174 by means of the trunnions 169 on the platen mounting plate 166 which are journaled in corresponding openings in the spider mounting brackets 178. The unit is rotated about the trunnion axis by means of two double acting rocking air cylinders 190. The cylinders are mounted between the ears 180 and 182 at the sides of the traveling frame, by means of trunnions 198 on the cylinders which are journaled in corresponding openings in the ears. Telescoping piston rods 192 extend from the cylinders and are connected to the rocker arms 165 by clevises 194 each having a pivot pin 196 extending therethrough and through a rocker arm. The cylin-

ders extend the piston rods to rotate the mold unit 45 through an angle of 90°, between horizontal and vertically downward facing positions, the latter as illustrated in FIG. 13.

As seen in FIG. 5, a double acting mold box air cylinder 200 having a telescoping piston rod 202 is mounted on a plate 204 by screws 205, in turn secured by screws 206 to the cross bars 76 and 78 at the front end of the sub-frame 40. The piston rod is connected to the spider 174 by a screw 208 inserted through the hub 184 into the end of the rod. The cylinder operates to extend and retract the piston rod for horizontally reciprocally moving the movable mold unit 45 to and from the stationary mold unit 43.

Referring to FIGS. 1-5, the carriage 44 includes parallel angle bars 210 and 212 forming the sides of the carriage, and parallel front, intermediate and rear angle cross bars 214, 216 and 218 secured to the side bars. Two spaced-apart wheel mounting brackets 219 are mounted on each of the side bars 210 and 212, and a wheel 221 is rotatably mounted on each bracket. The wheels travel on longitudinally extending horizontal rails 223, which are vertically adjustably mounted on brackets 225 secured to the insides of the frame uprights 60. The carriage thus is supported on the rails for horizontal reciprocal movement.

A boss 220 is provided on the front cross bar 214 of the carriage and extends forwardly therefrom. A double acting carriage air cylinder 222 is mounted on a pair of brackets 224 in turn secured to the intermediate cross bar 68 of the main frame. The cylinder is swivelly supported on the brackets by means of trunnion members 226 thereon which are journaled in openings in the brackets. A piston rod 228 extends from the cylinder and is connected to the carriage boss 220 by a clevis and pin 230. Front and rear limit switches 232 and 234 are mounted on the uprights 60 adjacent the carriage for engagement therewith. The cylinder and piston operate to move the carriage between its front and rear positions, as determined by the limit switches.

The sand magazine 46 is funnel-shaped, having parallel frusto-conical side walls 240 and convergent rectangular end walls 242. The magazine is surmounted by a top plate 244 having a central charging opening 246 therein. A blow plate 248 forms the bottom of the magazine, and it is provided with two centrally disposed blow holes 250 (see FIG. 7) and three spaced vent grooves 252 along the bottom front edge of the plate.

A mounting yoke 254 is secured to each of the side walls 240 of the sand magazine and to gussets 260 thereon, as by welding. A headed vertical guide rod 256 extends through a central opening in each yoke and is secured in an aligned opening in each of the side bars 210 and 212. The rod is inserted through a magazine supporting coil spring 258 interposed between each yoke and the corresponding side bar. The yoke ends are slidable on guide bolts 262 inserted therethrough and threaded into the side bars 210 and 212. In this manner, the sand magazine 46 is resiliently supported on the carriage 44 for vertical reciprocal movement thereon.

The gas manifold assembly 48 includes two vertical support columns 264 surmounted by a horizontal thrust plate 266 secured thereto. A rectangular gas manifold 268 extends horizontally across the bottom of the support columns and is secured thereto. As seen most clearly in FIGS. 8 and 9, the manifold includes a top plate 270, a rectangular side frame 272 having a gas supply opening 274 in one wall thereof, and a bottom plate 276 which define a manifold cavity 280. An annular compression gasket 281 is mounted in the bottom plate adjacent its periphery. Three aligned spaced gas discharge openings 278 are formed in the bottom plate, inwardly of the gasket.

As seen in FIGS. 3 and 4, a manifold support bracket 282 is secured to the outer side of each support column

264. A headed guide rod 284 is inserted through the bracket and secured to a side bar 210 or 212. The rod is inserted through a manifold supporting coil spring 286 interposed between the bracket and the side bar. Guide brackets 288 are secured to the front and rear sides of the support columns 264. Guide bolts 290 are inserted through openings in the brackets and threaded into the intermediate and rear angle cross bars 216 and 218 of the carriage (see FIG. 5). In this manner, the gas manifold assembly 48 is resiliently supported for vertical reciprocal movement on the carriage 44.

Referring to FIGS. 1-5, the sand hopper 50 includes a funnel-shaped upper section 292 and a generally rectangular lower section 294 having a rounded lower end 296. The hopper is supported by angle bars 298 secured to opposite sides of the upper section 292, and brackets 300 connected to the angle bars and secured to the upper side cross bars 62 of the main frame. An angle bracket 302 (FIG. 1) is secured to the rear side of the upper section 292 and to the blow head cylinder 56, to provide additional support.

A discharge opening 304 is provided in the bottom of the lower section 294 of the sand hopper. The opening is opened and closed by a gate 306 mounted in the hopper and having arms 308. The gate is operated by two air cylinders 310 pivotally mounted on mounting bars 312 secured to opposite sides of the lower section 294. A piston rod 314 extends from each cylinder and is pivotally connected by a clevis 315 to a crank 316 secured to a crank shaft 318 connected to one arm 308 of the gate. The gate is movable by operation of the cylinders from the closed position illustrated in full lines in FIG. 4 to an open position illustrated in broken lines.

The blow head cylinder 56 is secured on the cylinder mounting cross bars 70 by bolts 320 (FIG. 3). As seen in FIG. 5, piston rod 322 having a threaded end extends downwardly between the cross bars and is connected to the blow head 54. The blow head includes a cast casing 324 having upper and lower horizontal flanges 326 and 328, the latter being reinforced by gussets 330. A transverse T-slot or keyway 332 is formed in the top of the casing, and a connecting bar 334 having a threaded opening 336 is inserted in the slot. The piston rod is threaded into the opening for supporting the blow head. Guide rods 338 are secured to the upper blow head flange 326 and extend upwardly in bushings 340 mounted in the cross bars 70. The rods extend through spacer sleeves 342, interposed between the upper flange and the cross bars.

A dome-shaped cavity 344 is formed in the casing 324, and an air supply opening 346 extends through the casing wall to the cavity. The lower end of the casing is open to the cavity, and an annular recess 348 is formed in the flange 328 thereat. An elastomeric sealing ring 350 is mounted in the recess, and a distributor plate or grid 352 is mounted within the sealing ring. The distributor plate is secured to the bottom of the casing by fastening screws 354.

Referring particularly to FIGS. 4-9, the sand magazine 46 is adapted to be disposed adjacent the hopper 50 on its upper side for filling the magazine. The magazine top plate 244 is adjacent to the bottom 296 of the hopper when the carriage 44 is in its forward position. The discharge opening 304 of the hopper registers with the charging opening 246 of the magazine, and the magazine is filled when the gate 306 is opened. The consistency of the sand-resin mix in the illustrative embodiment is such as to prevent sand from escaping through the blow holes 250 in the blow plate 248.

The sand magazine is adapted to be disposed adjacent the blow head 54 and the mold box 90 on its upper and lower sides, respectively, in communication with the filling openings 102 in the mold box for filling the mold cavity 100. In the rear position of the carriage 44, the magazine top plate 244 is adjacent the distributor plate

352 of the blow head. When the blow head cylinder 56 is operated to move the blow head towards the mold box, as illustrated in FIG. 16, the magazine is thereby disposed adjacent the mold box. The openings in the distributor plate 352 register with the charging opening 246 in the sand magazine. The blow holes 250 in the magazine blow plate 248 register with the filling openings 102 in the mold box. The vent grooves 252 in the magazine blow plate register with the gas supply openings 126 in the gas manifold chamber 114. The mold cavity 100 then may be filled with molding sand to form a molded article therein by supplying air under pressure to the blow head cavity 344 through the supply opening 346.

The gas manifold 268 is adapted to be disposed adjacent the mold box 90 on its lower side and in communication with the mold cavity 100. The gas manifold assembly 48 is interposed between the blow head 54 and the mold box when the carriage 44 is in its forward position. The thrust plate 266 is adjacent the blow head distributor plate 352. When the blow head is moved towards the mold box, as illustrated in FIG. 18, the gas manifold is thereby disposed adjacent the mold box. The manifold sealingly engages the mold box with the manifold discharge openings 278 registering with the gas supply openings 126 in the gas manifold chamber 114. The manifold bottom plate 276 covers and closes the sand fillings 102 in the mold box. Gas under pressure introduced through the manifold supply opening 274 then may be conducted to the manifold chamber cavity 118 and from there to the mold cavity 100 for gassing and thereby hardening or curing the molded article therein. Alternatively, gas may be introduced through the exhaust openings 128 in the gas manifold chamber 112, and exhausted through the gas supply openings 126 in the manifold chamber 114 and through the gas manifold 268.

The belt conveyor 36 employed with the core making machine 30 includes a stand 360 having legs 362 and a housing 364 secured to the legs by brackets 366. Rollers 368 are mounted at opposite ends of the housing, and an endless conveyor belt 370 is trained over the rollers. The belt is supported between the rollers by a pan 369 supported on the housing by brackets 371. The conveyor belt is driven by a motor and pulley assembly 372 mounted on the housing and coupled by a drive belt 374 with a pulley 376 drivingly connected to the outer roller 368, which is in driving engagement with the conveyor belt. The conveyor is inserted into the main frame 38, so that it extends beneath the mold box 90 for receiving articles ejected therefrom and conveying them from the machine to a desired external location.

THE AIR AND GAS SUPPLY EQUIPMENT

Referring particularly to FIGS. 1 and 21, the air and gas supply equipment 32 includes equipment for supplying air under pressure to the blow head 54, including an air line 380 connected to an air pressure source, not shown. The air line is connected to a pressure regulating valve or regulator 382, a shut off valve 384, and a three-way pilot-operated blow valve 386. Operation of the blow valve is controlled by a pilot solenoid valve 387 in a pilot air line 389 to the blow valve. The blow valve is connected to a hose 388 joined to the blow head casing 324 at the air supply opening 346. An exhaust line 390 having a muffler 392 therein is also connected to the three-way valve. A branch line 394 is connected to the pilot air line 389, downstream of the pilot solenoid valve 387, for a purpose subsequently described. The blow valve 386 is operated to alternately admit air to the blow head 54 for the sand filling operation, and exhaust air therefrom.

The air and gas supply equipment also includes separately counted equipment for supplying a mixture of air and gaseous hardening agent to the mold box 90, and for exhausting the mixture, as illustrated diagrammatically in FIG. 21. A main air line 400 is connected to the air pressure source and to a pressure regulating valve or

regulator 404 and a shut-off valve 406. A gas generator line 408 is connected to the main air line 400. A check valve 410, an adjustable flow control valve 412, a gas generator 414, and a pilot-operated manifold pressure regulating valve or regulator 416 are connected in the gas generator line. A gas supply line 418 is connected to the gas generator line 408 and to the gas manifold 268 at its supply opening 274.

The gas generator 414 is a conventional air line lubricator, and it contains a vaporizable liquid hardening agent for the sand binder. In an illustrative embodiment, the hardening agent is a catalytic or reactive agent, which causes the synthetic resinous sand binder to harden or cure rapidly. The hardening agent is vaporized into the air stream in the gas generator, and conducted to the gas manifold 268 and thence to the mold cavity 100.

A pilot air line 420 is connected to the main line 400. A pilot solenoid valve 422 and a flow control valve 424 are connected in the pilot air line, and the line is connected to the manifold pressure regulator 416 in a conventional manner for controlling the operation of the regulator. The flow control valve 424 includes a check valve 426 and an adjustable flow regulating orifice 428. As pressure builds up in the pilot air line, the manifold pressure regulator 416 controls the gas flow therethrough to provide progressively increasing pressure on the downstream side thereof, i.e., in the gas supply line 418 leading to the gas manifold 268.

A generator bypass line 430 is also connected to the main air line 400, and an adjustable flow regulating orifice 432 and a bypass solenoid valve 434 are connected therein. The bypass line serves to supply air directly to the gas manifold 268, for purging the system.

Exhaust hoses 436 are connected to the gas manifold chamber 112 at the exhaust openings 128 therein (see FIG. 8), and the hoses are connected to an exhaust line 438. The exhaust line is connected to the inlet pipe 440 of a scrubber 442. A branch line 444 is connected to the exhaust line 438, for bypassing the scrubber.

The scrubber 442 includes a closed cylindrical tank 446 provided with a foraminous header 448 in its lower portion and partly filled with a liquid 450 for removing noxious or hazardous hardening agent from the exhaust gases removed from the mold box 90. The inlet pipe 440 extends into the liquid below the header, for bubbling the gases through the liquid. The gases freed of hardening agent are vented to the atmosphere through a vent pipe 452 at the top of the scrubber.

The branch line 444 is connected to a pilot-operated scrubber bypass solenoid valve 454, and an exhaust fitting 456 is connected to the valve. The valve is connected to the blow valve pilot air line 389 by the branch line 394 therefrom, for exhausting air directly to the atmosphere during the sand filling operation.

OPERATION

The components of the machine 30 are in the positions illustrated in FIGS. 1, 4, and 14 at the beginning and end of each cycle of operation. In the first operating step, the mold box 90 is closed and the sand magazine 46 is positioned adjacent thereto, preparatory to filling the mold cavity 100 with resin-coated sand. The sequence of movement is illustrated in FIGS. 15 and 16.

In this step, the mold box cylinder 200 is operated to extend its piston rod 202 and move the traveling frame 86 and the mold unit 45 thereon horizontally, until the movable mold box section 94 engages the stationary mold box section 92 to form the mold cavity 100. The carriage cylinder 222 is also operated to extend its position rod 228 and move the carriage 44 to its rear position, wherein the sand magazine 46 is disposed beneath the blow head 54 and above the mold box 90.

The blow head cylinder 56 next is operated to extend its piston rod 322 and move the blow head 54 towards the mold box, thereby engaging the top plate 244 of the sand magazine 46 and moving the magazine towards the

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mold box against the tension of the magazine supporting springs 258 (see FIG. 4). As illustrated in FIG. 6, the blow plate 248 of the sand magazine is moved into engagement with the top of the mold box. The blow holes 250 in the blow plate register with the filling openings 102 in the mold box, and the vent grooves 252 in the blow plate register with the gas supply openings 126 in the manifold chamber 114.

The blow valve 386 is operated by operation of its pilot valve 387 to admit air to the blow head cavity 344. Air flows from the cavity through the distributor plate 352 into the sand magazine 46, and blows the sand therein into the mold cavity 100, filling the cavity. Air is exhausted from the mold cavity through the gas or vent openings 120 and the stripper pin openings 124 around the stripper pins 142 therein (FIGS. 6, 8 and 10). The air is conducted to the manifold chamber cavities 116 and 118. The air in the cavity 118 escapes to the atmosphere through the gas supply openings 126 and the blow plate vent grooves 252. The air in the cavity 116 escapes through the exhaust openings 128 and the exhaust hoses 436, and is vented to the atmosphere through the exhaust fitting 436 (FIG. 21) connected to the scrubber bypass solenoid valve 454, operated by air from the blow valve pilot line 389. After filling the mold cavity, the blow valve is restored to its exhaust position, shown in FIG. 21. A porous molded article or core 460 is formed in the mold box cavity 100 in this manner. The article is, however, not hardened or cured.

The blow head cylinder 56 next is operated to raise its piston rod 322 and the blow head 54. The sand magazine 46 relieved of the pressure of the blow head is thereupon restored to its original elevated position on the carriage 44 by the magazine springs 258, and moved away from the mold box. As illustrated in FIGS. 17 and 18, the carriage 44 then is reciprocated to its front position, bringing the sand magazine into alignment with the sand hopper 50. The hopper cylinders 310 (FIG. 4) then are operated to open the gate 306 and refill the magazine.

The movement of the carriage 44 brings the gas manifold assembly 48 into position between the blow head 54 and the mold box 90. As illustrated in FIG. 18, the blow head cylinder 56 next is operated to move the blow head 54 downwardly against the thrust plate 266 on the manifold assembly, and move the manifold 268 into sealing engagement with the mold box 90, as shown in FIG. 8. The discharge openings 278 of the manifold register with the gas supply openings 126 in the manifold chamber 114, and the bottom plate 276 of the manifold closes the filling openings 102.

The gas supply equipment next is placed in the condition illustrated in FIG. 21, for supplying air containing gaseous hardening agent to the gas manifold 268. At this time, the pilot solenoid valve 422 for the manifold pressure regulator 416 admits air to the flow control valve 424, supplying air at progressively increasing pressure to the regulator and thereby progressively opening the regulator. Air is conducted through the gas generator 414, forming a gaseous mixture of air and hardening agent, which is conducted through the gas supply line 418 to the gas manifold 268 and from there to the mold cavity 100 at progressively increasing pressure.

Air containing gaseous hardening agent is conducted to the mold cavity 100 through passageways provided by the supply openings 126 in the manifold chamber 114, and the gas openings 120 and the stripper pin openings 124 in the movable mold box section 94. The gas openings and the stripper pin openings are distributed throughout the mold box section so as to distribute the gas containing hardening agent throughout the molded article 460 in the cavity. The gas readily penetrates the porous article.

In order to provide rapid hardening, the gas is supplied at substantial pressure, e.g., about 40 pounds per square inch gauge. It has been found that when the gas is admitted at relatively high pressure initially, the velocities

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through the openings are such as to erode the unhardened molded article 460 at the points of introduction of the gas. It has been found further that when the gas is blown into the mold box at progressively increasing pressure, the molded article hardens adjacent the points of introduction of the gas sufficiently to prevent substantial erosion of the molded article at such points. Thus, the article hardens rapidly and sufficiently to withstand the relatively low initial gas pressures, and hardening increases progressively with the progressive increase in gas pressure to withstand the increasing gas velocities and produce accurately molded articles at a high hardening rate.

The exhaust gas containing residual hardening agent leaves the mold cavity through the gas openings 120 in the stationary mold box section 92, and is collected in the manifold cavity 116. The exhaust gas flows through the exhaust openings 128 and the exhaust hoses 436 to the scrubber inlet pipe 440 (FIG. 21). The exhaust gas bubbled through the liquid 450 in the scrubber tank 446, removing residual hardening agent, and the resulting air freed of hardening agent is vented to the atmosphere through the vent pipe 452.

Following a predetermined hardening period, the pilot valve 422 for the manifold pressure regulator 416 is placed in its exhaust position, to close the regulator. The generator bypass valve 434 is opened to admit air to the gas supply line 418. The system is purged by conducting air through the manifold 268, the manifold chambers 112 and 114 the mold box 90, and the scrubber 442, for a predetermined period of time, in the same manner as in the gassing operation. The generator bypass valve 434 then is closed, and the gas supply equipment is rendered inactive until the next cycle of operation.

The gas manifold 268, the mold box sections 92 and 94, and the gas manifold chambers 112 and 114 are tightly sealed while gaseous hardening agent is blown into and exhausted from the mold box. Thus, the compression gasket 281 on the gas manifold forms a tight seal with the mold box. The compression gasket 93 on the mold box section 92 provides a tight seal between the mold box sections. The gland seals 144 in the end closure plate 110 prevent escape of gas around the stripper pins 142.

In the illustrative embodiment, about one-half to one second elapses between the time that gaseous hardening agent is admitted to the gas supply line 418 from the manifold pressure regulator 416 to attainment of full pressure. Complete hardening and purging each require as little as about two seconds. It will be seen, therefore, that production is greatly accelerated employing the invention.

As noted above, the air containing gaseous hardening agent could as well be introduced through the exhaust openings 128 in the manifold chamber 112, and exhausted through the supply openings 126 in the manifold chamber 114, with suitable changes in the connections to the gas manifold 268 and the exhaust hoses 436. While the illustrative gassing structure and method are preferred, the gaseous hardening agent may be introduced in other ways. For example, the hardening agent might be introduced directly to the mold cavity 100, through the filling openings 102, and exhausted through the gas openings 120 and the stripper pin openings 124. In such case, exhaust hoses may be connected to both of the gas manifold chambers 112 and 114. Similarly, other gassing arrangements may be made.

Following gassing and purging, and as illustrated in FIG. 19, the blow head cylinder 56 next is operated to raise the blow head 54. The gas manifold assembly 48 relieved of the pressure of the blow head is thereupon restored to its original elevated position on the carriage 44 by the manifold springs 286, and moved away from the mold box 90 (see FIG. 4).

Also as illustrated in FIG. 19, the mold box cylinder 200 then is operated to retract its piston rod 202 and separate the mold box sections 92 and 94. The mold box is designed to cause the molded article 460 to adhere to the movable box section 94. Following retraction, and

as illustrated in FIGS. 13 and 20, the rocking cylinders 190 are operated to extend their piston rods 192 and rock the movable mold unit 45 about its trunnions 169. The movable mold box section 94 and the molded article 460 thereon are brought into downwardly facing position a short distance above the belt 370 of the conveyor 36. The stripper cylinder 156 then is operated to extend its piston rod 154 and move the stripper plate 140 inwardly towards the mold box section against the tension of the stripper springs 148. Movement of the stripper plate causes the stripper pins 142 to extend into the box section cavity 98, and strip and eject the molded article 460 therefrom and onto the conveyor belt.

Following stripping, the stripper cylinder 156 is operated to retract the stripper plate 140, which seats on the gauge blocks 150 to locate the outer ends of the stripper pins flush with the box section cavity 98, ready for the next filling operation. The rocking cylinders 190 are operated to restore the movable mold unit 45 to its original position, with its mold box section 94 facing the stationary mold box section 92. The apparatus then is in the condition illustrated in FIGS. 1, 4, and 14, ready for a new cycle of operation. The apparatus may be operated continuously and automatically in this manner, employing conventional electrical and pneumatic timing and control instrumentalities.

The apparatus of the invention may be employed for manufacturing foundry sand articles by various cold box processes. The illustrative embodiment is well adapted for the use of sand containing a hardenable resinous binder, and a gaseous hardening agent of a noxious or hazardous nature requiring confinement of the gases. Exemplary commercially available resinous binders include a mixture of equal weight proportions of "Isocure I" and "Isocure II" (ADM Company), employed in a binder proportion up to about 2% by weight of the sand. An amine hardening or curing agent, in particular, triethylamine is employed with such binder. In this case, the liquid in the gas generator 414 is triethylamine, and the liquid 450 in the scrubber tank 446 is an aqueous acid such as phosphoric acid.

In foundry practice, various mold box designs are employed, together with suitable sand blow plate, manifold bottom plate, and stripping pin arrangements. It is also contemplated that the stationary mold box section 92 may be provided with stripper pins, similarly to the movable mold box section 94, if desired. Alternatively, the stationary mold box section 92 and the mold unit 43 in which the box section is incorporated may be mounted for pivotal movement and employed to retain the sand article 460 and eject the article onto the conveyor belt, rather than the movable mold unit 45, which then may be limited in its movement to horizontal reciprocal movement for opening and closing the mold. The illustrative embodiment is, however, preferred, as it lends itself more readily to the use of auxiliary equipment, such as mandrels which may be inserted into and withdrawn from mold boxes of other designs from below. The invention is adaptable to a variety of such requirements, and the structure shown and described is merely illustrative.

Employing the invention, the various advantages of the cold box process are achieved and additional advantages are obtained, as described above. Production rates are high, typically four to five complete cycles a minute. The apparatus is compact, efficient, and reliable, and is well adapted for continuous automatic production of sand articles in a variety of sizes and shapes.

While a preferred embodiment of the invention has been described and illustrated, it will be apparent to those skilled in the art that various changes and modifications in the apparatus may be made within the spirit and scope of the invention. It is intended that all such changes and modifications be included within the scope of the appended claims.

Having thus described the invention what I claim as new and desire to secure by Letters Patent is:

1. Apparatus for making foundry sand articles which comprises:

a mold box having separable box sections defining a mold cavity therebetween and having a sand filling opening and gas passageways to said cavity, means mounting said box sections for relative horizontal reciprocal movement between them,

a blow head mounted in spaced superposed relation to said mold box for vertical reciprocal movement, means for vertically reciprocating said blow head,

carriage means mounted for horizontal reciprocal movement between said blow head and said mold box, a sand magazine mounted on said carriage means for horizontal movement therewith and adapted to be disposed adjacent said blow head and said mold box on its upper and lower sides respectively and in communication with said filling opening for filling said mold cavity,

means mounting said magazine on said carriage means for vertical reciprocal movement relative thereto,

a gas manifold mounted on said carriage means for horizontal movement therewith and adapted to be disposed adjacent said mold box on its lower side and in communication with said gas passageways for conducting gas under pressure between the manifold and said mold cavity,

means mounting said manifold on said carriage means for vertical reciprocal movement relative thereto, and means for horizontally reciprocating said carriage means to dispose said magazine and said manifold alternately between said blow head and said mold box, whereby said blow head vertical reciprocating means is operable to move said blow head towards said mold box alternately in engagement with said magazine and said manifold for moving them to said positions adjacent the mold box.

2. Apparatus as defined in claim 1 including resilient means for moving said magazine and said manifold away from said mold box upon movement of said blow head away from the mold box.

3. Apparatus as defined in claim 1 including a sand hopper mounted above said carriage means and arranged for filling said magazine when said manifold is disposed between said blow head and said mold box.

4. Apparatus as defined in claim 1 including gas manifold chambers adjacent said box sections in communication with said mold cavity, one of said chambers having an opening registering with an opening provided in said manifold when the manifold is adjacent said mold box for conducting gas therebetween.

5. Apparatus as defined in claim 4 wherein said manifold includes means for closing said filling opening when adjacent said mold box.

6. Apparatus as defined in claim 4 including stripper pins associated with one of said chambers and its adjacent box section for movement therethrough.

7. Apparatus as defined in claim 6 including means pivotally mounting said last-named chamber and adjacent box section and said stripper pins for rotation to a downwardly facing position of the box section for ejection of a molded article therefrom.

8. Apparatus for making foundry sand articles which comprises:

a mold box having separable box sections defining a mold cavity therebetween and having a sand filling opening and gas passageways to said cavity,

means mounting one of said box sections for horizontal reciprocal movements relative to the remaining box section,

means for horizontally reciprocating said one box section,

a blow head mounted in spaced superposed relation to said mold box for vertical reciprocal movement,

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means for vertically reciprocating said blow head,
a sand hopper mounted in spaced relation above said
mold box and in lateral alignment with said blow
head,

carriage means mounted for horizontal reciprocal move-
ment between said blow head and said hopper there-
above and said mold box therebelow,

a sand magazine mounted on said carriage means for
horizontal movement therewith and for vertical reci-
procal movement relative thereto, said magazine be-
ing adapted to be disposed alternately adjacent said
hopper on its upper side for filling the magazine, and
adjacent said blow head and said mold box on its
upper and lower sides respectively in communication
with said filling opening for filling said mold cavity,
means resiliently supporting said magazine on said car-
riage means,

a gas manifold mounted on said carriage means for hor-
izontal movement therewith and for vertical recipro-
cal movement relative thereto, said manifold being
adapted to be disposed adjacent said mold box on its
lower side and in communication with said gas pas-
sageways for conducting gas under pressure between
the manifold and said mold cavity,

means resiliently supporting said manifold on said car-
riage means, and

means for horizontally reciprocating said carriage
means to dispose said magazine and said manifold al-
ternately between said blow head and said mold box,
and to dispose said magazine adjacent said hopper
when the manifold is disposed between the blow head
and the mold box,

whereby said blow head vertically reciprocating means
is operable to move said blow head towards said
mold box alternately in engagement with said maga-

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zine and said manifold for moving them to said posi-
tions adjacent the mold box.

9. Apparatus as defined in claim 8 including:

stripper pins associated with one of said box sections for
reciprocal movement therethrough,

means for reciprocating said stripper pins,

means pivotally mounting said last-named box section
and said stripper pins for rotation to a downwardly
facing position of the box section for ejection of a
molded article therefrom, and

means for reciprocally rotating said last-named box sec-
tion and said stripper pins.

10. Apparatus as defined in claim 9 including gas mani-
fold chambers adjacent said box sections in communica-
tion with said mold cavity, the chamber adjacent said
last-named box section being rotatable therewith, said
stripper pins also being associated with said last-named
chamber for movement therethrough, and one of said
chambers having an opening registering with an opening
provided in said manifold when the manifold is adjacent
said mold box for conducting gas therebetween.

References Cited

UNITED STATES PATENTS

3,059,294	10/1962	Dunn et al.	164—16 X
3,060,534	10/1962	Enzenbacher	164—16
3,089,205	5/1963	Ellms	164—183
3,096,547	7/1963	Hunter et al.	164—200 X
3,247,545	4/1966	Sullivan	18—5
3,398,781	8/1968	Bevis	164—228

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