ABSTRACT

A horizontal stack molding machine having a reciprocating pouring conveyor and an aligned non-powered cooling conveyor, a fixed pattern, a traversing pivot carriage including a projecting open ended flask with a movable pattern therein, a jolt and squeeze ram mechanism in the carriage supporting the movable pattern; a sand blow reservoir for blowing sand into the flask through sealed ports when the flask is clamped against the fixed pattern, the jolt and squeeze mechanism moving the movable pattern toward the fixed pattern to form a chamber of predetermined depth prior to blow and then, following blow, moving further to form a sand cake of predetermined hardness; the flask and movable pattern are then retracted as a unit to draw the cake from the fixed pattern, the carriage then traversing to align the cake with the conveyors, the flask and movable pattern then extending as a unit to index the pouring conveyor and the entire stack a predetermined distance; the pouring conveyor and flask are then retracted together with the pouring conveyor sliding beneath the stacked molds, the movable pattern however maintaining its position to remove the cake from the flask onto the pouring conveyor and when the cake is out of the flask, the movable pattern retracts to draw such pattern from the cake, the flask then retracting and the carriage traversing toward the fixed pattern to form another cake.

31 Claims, 18 Drawing Figures
This invention relates generally as indicated to a horizontal stack molding machine and more particularly to a foundry molding machine for producing a horizontal stack of foundry sand cakes having uniform hardness or density and yet the desired porosity required to make quality castings.

Sand molds or cakes which are too hard or dense may not make quality castings because of the inability of air properly to escape. This may result in blows or bubbles in the casting. In horizontal stack molding machines of the type seen in U.S. Pat. Nos. 3,008,199 and 2,871,527, it has generally been considered necessary to produce the cakes of as high hardness as possible because of the tendency of the cakes to crush or be damaged due to stresses encountered as the stack is moved horizontally. Accordingly molds of less hardness and greater permeability which can still withstand the stress of horizontal stack movement are desirable.

It is accordingly a principal object of the present invention to provide a horizontal stack molding machine which will produce sand cakes of the desired hardness and permeability to produce quality castings.

Another important object is the provision of a horizontal stack molding machine incorporating a jolt mechanism to obtain the desired mold hardness.

A further important object of the present invention is to provide such machine incorporating an indexing pouring conveyor which slides beneath a relatively short portion of the horizontal stack.

Another object is the provision of such machine having a unique traversing carriage and which does not require lengthy and expensive alignment devices.

A further object is the provision of such machine which will present the sand cake in a convenient position for automatic or manual coring.

Still another object is the provision of such machine wherein the chamber depth and thus the mold depth can readily be controlled by the operator.

Other objects and advantages of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described, the following description and the annexed drawings setting forth in detail an illustrative embodiment of the invention, this being indicative, however, of but one of the various ways in which the principles of the invention may be employed.

In said annexed drawings:

FIG. 1 is a side elevation partially broken away of a machine in accordance with the present invention;

FIG. 2 is a fragmentary enlarged vertical section through the pouring conveyor taken substantially on the line 2—2 of FIG. 1;

FIG. 3 is a slightly further enlarged fragmentary vertical section taken substantially on the line 3—3 of FIG. 1;

FIG. 4 is an enlarged vertical section taken substantially on the line 4—4 of FIG. 1;

FIG. 5 is an enlarged fragmentary side elevation of the machine illustrating the details of the sand reservoir and traversing carriage;

FIG. 6 is a vertical section of the traversing carriage taken substantially on the line 6—6 of FIG. 5;

FIG. 7 is an enlarged fragmentary vertical section taken through the center of the traversing carriage;

FIG. 8 is a horizontal section of the traversing carriage on a somewhat reduced scale as seen from the line 8—8 in FIG. 7;

FIG. 9 is a top plan view of the traversing carriage pivot mechanism;

FIG. 10 is a front elevation, partially broken away, of the control mechanism for controlling the chamber depth during blow; and

FIGS. 11 through 18 are schematic illustrations of the machine showing the sequence of operations.

THE MACHINE — GENERAL ARRANGEMENT

Referring first to FIG. 1, the horizontal stack molding machine is indicated generally at 10 and includes a heavy-duty rectangular frame 11 providing lateral access windows 12. At one end of the frame 11 there is provided a window 13 through which extends pouring conveyor 14 and the horizontally stacked sand cakes 15 therein. The sand cakes are supported on the pouring conveyor by means of elongated slide rails 17 and the entire conveyor is mounted for short distance reciprocation as hereinafter described. The pouring conveyor 14 is aligned with and feed connected to cooling conveyor 18.

The cooling conveyor comprises a belt 19 trained about idler end sheaves 20 and 21 on frame 22. The horizontal top flight of the belt is supported on a plurality of closely spaced relatively small idlers 23. The bottom flight of the belt extends about idler 24, tensioning sheave 25, and idlers 26 and 27. The cooling conveyor 18 is not powered but is moved only by the horizontal force on the sand cakes 15 supported thereon, this force being obtained by the machine 10 as hereinafter described. The pouring conveyor is, however, provided with an index drive piston-cylinder assembly 28 for driving the sheave 20 to unload the same at the conclusion of operation. Since it is impossible to provide a drive for the cooling conveyor which will provide a constant torque, no drive is provided during operation of the machine. The sand cakes 15 drop as indicated at 29 from the cooling conveyor to a sand shake-out for separation of the sand and casting. Depending upon the time required for cooling, intermediate cooling conveyor sections may be omitted or provided.

The machine 10 includes a sand hopper 31 adapted to receive sand by conveyor from a suitable muller or sand conditioner. The hopper is positioned on a butterfly valve 32 mounted on top of sand blow reservoir 33. The flattened funnel bottom 34 of such reservoir extends between U-shape frame plates 35 seen in better detail in FIG. 5. The bight portion of such plates support therebetween a pattern stool 36 for a fixed pattern plate 37. Top and bottom traversing rods 39 and 40 extend between the traverse frame members 41 and 42 at the discharge end of the machine as seen more clearly in FIG. 2 and transverse frame members 43 and 44 extending between the frame plates 35 as seen more clearly in FIG. 5.

Such traversing rods serve a dual function, i.e. that of guide rods and piston rods for movement of pivot traversing carriage 46. As seen perhaps more clearly in some of the schematics such as FIG. 11, each traversing rod is provided with a piston as seen at 47 and 48, each piston being enclosed by a traversing cylinder as seen at 49 and 50, respectively. The carriage 46 is pivotally
connected to the traversing cylinders as indicated generally at 52 and 53 and as seen in greater detail in FIGS. 7 and 8. The carriage 46 includes a forwardly projecting housing 55 in which is mounted an open ended slip flask 56. A movable pattern plate 57 is adapted to telescope within the frame as seen more clearly in FIG. 7 and some of the schematics.

The housing 55 is provided with laterally extending plates 58 and 59 as seen in FIG. 8 which are provided with guide bushings to receive alignment pins 60 projecting from the pattern stool 36. Such guide bushings also engage alignment pins 61 mounted on frame 62.

As seen more clearly in FIG. 4 the frame 62 provides a window 64 which is the entrance to the pouring conveyor. The frame 62 is connected to a similar frame 65 by the longitudinally extending structural members 66 of rectangular sectional configuration and at the bottom corners by structural members 67 of circular sectional configuration. The tops of the frame members 67 are even with or slightly below the plane of the cake supporting plate 68 so that the operator may push defective cakes laterally from the machine through the windows 69 provided between the frame members 62 and 65. The plate 68 extends only for the extent of the windows 69 and beyond that the cakes 15 move along the slide rails 17.

The top of the frame 11 may include electrical cabinets as seen at 71. Adjacent the electrical cabinets there is provided a large air reservoir 72 seen in FIG. 5 together with the butterfly valve operating mechanism shown generally at 73. Hydraulic power may be provided from a power unit in the cabinet 74 at the end of the machine. The operator’s control panel is provided at 75 near the inspection window 69.

THE POURING CONVEYOR

Referring now additionally to FIGS. 2 and 3 it will be seen that the pouring conveyor 14 includes a main frame 80 which is supported for short distance reciprocation by four roll stands 81, 82, 83 and 84. Each roll stand includes an upstanding plate 85 inwardly from which projects a pair of bottom support rollers 86 and a top roller 87. The plate 85 is also provided with a window between such top and bottom rolls through which projects the periphery of roll 88 journalled between brackets on a vertical axis. Thus each stand includes four rollers, each roller engaging the top, bottom or outer surface of respective rolls 90, 91, 92 or 93 secured to the lateral edges of the depending frame structures 94 secured to the main pouring conveyor frame 80.

The pouring conveyor frame 80 includes two longitudinally extending side structural members 95 and 96 of the sectional configuration seen more clearly in FIG. 2 which laterally confine the sand cakes to the proper path on the pouring conveyor. Sand shields 97 extend from the frame members 95 and 96 opposing the roll stands to protect the same from falling sand. The side frame members 95 and 96, as well as the sub-frame 80, are secured to the frame 65 adjacent the windows 69 so that the entire structure from the alignment pins 61 to the ends of the rails 17 adjacent the cooling conveyor are mounted for reciprocation on the roll stands.

The roll stands 81 and 82 are mounted on a sub-stand 98 which extends transversely beneath the pouring conveyor. However, the roll stands 83 and 84 are mounted on brackets 99 and 100 extending from the end of the frame 11. A pneumatic piston-cylinder assembly 101 is mounted between such stands and the rod thereof is connected to arm 102 secured to the pouring conveyor frame 80. Movement of the pouring conveyor is obtained between the piston-cylinder assembly 101 and the action of the traversing mechanism as hereinafter described.

A set of bridge rails 104 as seen in FIGS. 1 and 2 is interposed between the slide rails 17 of the pouring conveyor. Such bridge rolls are mounted on bracket 105 and provide an effective bridge between the end of the pouring conveyor 14 and the entrance to the cooling conveyor 18.

TRaversing MEchanism

The traversing mechanism may be divided into two categories. The first can be considered the traversing cylinders or slide which simply reciprocate. The second would be the turret or pivot carrie 46 which not only reciprocates with the slide but automatically turns end for end during each stroke.

The slide is illustrated perhaps more clearly in FIGS. 4, 6, and 7 as well as in some of the schematics. Referring initially to FIGS. 4 and 6, it will be seen that the traversing cylinders 49 and 50 include laterally extending projections 110 and 111 to which U-shape frame 112 is connected by the suitable fasteners indicated at 113. Accordingly the traversing cylinders are rigidly interconnected at one end by the U-shaped frame 112 and at the opposite end by the pivot connections 52 and 53 to the turret or pivot carriage 46 as seen in FIGS. 5 and 7, for example.

Each traversing cylinder is provided at each end with a bushing 115 held in place by cylinder cap 116 which also secures wiper 117. The end of each cylinder is provided with a transversely extending semi-circular projection 118 accommodating on the interior thereof bushing 119 which is held in place by cap 120 secured by the fasteners 121 seen in FIG. 8. The bushing 119 accommodates the enlarged portion of pivot pin 122. The pin 122 projects from the main housing 123 of the pivot carriage 46 and thrust washers are provided between the pivoting and non-pivoting surfaces as indicated at 124. The pin 125 forming the pivot connection 53 between the pivot carriage and the bottom traversing cylinder 50 is axially aligned with the pin 122. Suitable sand seals are provided for the thrust washers and bushings as indicated.

The pivot carriage 46 is illustrated more clearly in FIGS. 5, 6, 7 and 8. Referring first to FIG. 8, it will be seen that the main housing 123 includes lateral projections 130 and 131 to which are secured cylinder rods 132 and 133. The other ends of the rods are secured to the lateral projections 58 and 59 at the forward end of the pivot carriage. Each rod is provided with a split piston indicated generally at 134. Such pistons are within the squeeze cylinders 135 and 136. The construction of the squeeze piston-cylinder assemblies are identical to that of the traversing piston-cylinder assemblies, at least so far as diameters of cylinders and piston rods are concerned, both being hydraulically operated.

Each cylinder is provided with an inward projection indicated at 138 and 139 which is firmly secured to outwardly extending projections 140 and 141 on squeeze carriage cylinder 142. The squeeze carriage cylinder 142 supports the squeeze ram 143 for movement within
the main housing 123. The squeeze ram is of the rectangular configuration of the interior of the slip flask 56 and is adapted to telescope within the flask. The pattern plate 57, to which the movable pattern is adapted to be secured, is mounted on stol 144 and a bolster 145 is provided between the plate and stol. Locating pins 146 extending into bushings 147 in the ram 143 assist in locating the tooling with respect to the ram.

The ram includes a cylindrical extension 150 telescoped within the cylinder 142. A jolt ram or hammer 151 telescopes within the extension 150 and is provided with bushings 152 and 153 permitting the same readily to slide on center rod 154 which is connected to the ram 143. The rod 154 extends through bushing 155 and is annular plate 156 closing the end of cylinder 142. A relatively stiff spring 157 extends between washer 158 and the washer-nut assembly 159 on the end of the rod 154. Such spring tends to inhibit shock loads which would be imparted to the hydraulic system. The end wall 166 forms a plenum chamber 160 and the pressure in such plenum is maintained from about 6 to about 25 p.s.i. Air for the jolt operation is supplied through passage 161. When pressurized, the ram 151 is driven against the plenum until the pressure exhausts through port 162 whereupon the ram rebounds to strike the squeeze ram 143. Additional guide rods 163 are provided as seen in FIGS. 6 and 8 connected to the ram 143.

The ram 143 is provided with a peripheral wear plate indicated at 165 and a seal ring assembly 166 secured to the housing 55 by the fasteners 167 includes an inflatable seal 168. The seal will normally be inflated during the blow filling of the chamber 170. Sand is blown into the chamber from the reservoir through nozzle assembly 171 which may include a urethane liner 172 to reduce wear. The top front edge of the housing 55 is provided with a shelf 173 to prevent loose sand from falling over the face of a formed sand cake and the front peripheral edge of the flask 56 is provided with a deformable seal 174.

THE PIVOT MECHANISM

Referring now to FIGS. 5, 6, 7 and 9, it will be seen that there is mounted on the traversing cylinder 50 a linear cam 176 having the profile configuration seen in FIG. 9. The cam includes a symmetrical throw 177, the center of which is directly opposite the pivot pin 125. A roller cam follower 178 is mounted in dependent fashion at the corner of bell crank 179. A guide roller 180 is mounted on the top of the short arm 181 of the bell crank. The roller 180 rides in slot 182 on the underside of the main housing 123 of the pivot carriage 46. The proximal end of the bell crank 179 is mounted on pivot shaft 183 which is in turn secured to arm 184 pivotally connected to air spring 185 at 186. Thus from the pivot 186 to the rollers 178 and 180 there is a rigid linkage system, the air spring urging the roller 178 against the surface of cam 176.

When the roller 178 is against the straight surface 187 on either side of the throw 177, the roller 180 will be aligned with the pivot pin 125. As the traversing cylinder 50 moves to the left as seen in FIG. 9, the throw or cam portion of the linear cam will move the roller 180 about the pivot pin 125 180° as it moves therepast. By stopping the traversing cylinder with the roller 178 at the high point in the cam, the pivot carriage will have traversed 90° about the pivot 125. Reference may be had to the copending application of Robert G. Shields entitled “Foundry Molding Machine”, filed Feb. 26, 1969, Ser. No. 802,510, illustrating in greater detail a similar pivot mechanism in a vertically moving carriage. It will also be appreciated that other mechanisms may be employed for obtaining the pivot of the carriage as, for example, that seen in Ellms U.S. Pat. No. 3,089,205, entitled “Mold and Core Blowing Machine”.

THE BLOW RESERVOIR

Referring now to FIG. 5, it will be seen that the blow reservoir 33 is mounted in the upper portion of the frame 11 and comprises a generally vertically extending cylinder in which is mounted a vertically extending screen 190 having vertical slits therein. Air is admitted behind such screen through blow valve 191 permitting air under pressure to enter the reservoir from the tank 72. A pair of exhaust valves 192 exhaust the pressure from the reservoir following the blow operation. To control the top of the reservoir there is provided the butterfly valve assembly 32 which includes a circular valve member 193 pivoted at 194 by the operation of piston-cylinder assembly 195, the rod of which is pivotally connected at 196 to valve operating arm 197 keyed to the pivot 194 of the valve member. When the valve member is in the closed position shown, an annular elastomeric seal 198 is inflated to provide an effective sand and air seal around the peripheral edge of the valve member. Pressure for the seal 198 may be provided through a diverter port from the blow valve 191. The blow valve will not be opened until the valve member 193 is in its closed position shown. In the vertical position of the valve member, sand is free to drop from the hopper 31 into the reservoir.

The funnel bottom 34 of the blow hopper includes a wear lining 199 such as the aforementioned urethane. The bottom or nozzle of the hopper at 200 has a configuration similar to the ports 171 seen in FIG. 8 and includes a peripheral inflatable seal 201. The seal of course ensures a proper sealing engagement between the bottom of the nozzle 201 and the top of the port 171 seen in FIG. 8.

CYCLE AND MOLD DEPTH CONTROLS

There are two similar controls for the machine, one may be termed the carriage limit position control while the other selects the mold depth and thus provides a direct operator control of the density or permeability of the mold. Only the chamber depth control is illustrated in detail in FIG. 10. The control comprises an array of reed switches in a control box 210. Such box may be mounted on bracket 211 secured to the main housing 123 of the pivot carriage as seen in FIG. 6. The reed switches indicated generally at 212 are positioned apart a predetermined distance as, for example, one-half inch. Reading from left to right in the group of adjacent reed switches, such reed switches may obtain a mold depth of from sixteen to eight and one-half inches. The switch indicated at 213 may be employed during pattern change to indicate that the movable pattern has been positioned full forward for access.

The operator selects which of the limit switches 213 will be employed in the circuit by operating initially range selector switch 214 to select a sub-range as indicated by the four surrounding selector switches 215, 216, 217 and 218. As indicated, the selected depth is
fifteen and one-half inches which means that the second switch from the left in the group of switches 212 will be the only switch in such group which will function during the cycle of the machine. In operation, the squeeze ram will move to the fifteen and one-half setting prior to blow and in this manner the operator can control the permeability and hardness of the mold.

Referring to FIG. 6, it will be seen that the other control is in the form of reed switch enclosure 224 housing similarly arranged reeds which are actuated by the traversing magnetic actuator 125 mounted on bracket 226 extending from the traversing cylinder 49. As seen in schematic FIG. 11 the reed switch enclosure is mounted on the underside of the upper portion of the frame.

The control unit illustrated is, of course, simply an indication of the linear position of the traversing cylinder at any one point during the cycle of the machine. Such control 224, 225 may indicate, among other functions, the end of the stroke in either direction. The control may also indicate coring positions where the pivot carriage would stop to permit automatic or manual coring, and it may also indicate blow-offs or spray operations in connection with the patterns.

OPERATION

Referring now more particularly to the schematics of FIGS. 11–18 and initially to FIG. 11, it will be seen that the machine is in a position clamped up to blow. The traversing slide or carriage has been indexed full forward by the traversing piston-cylinder assemblies and th pivot carriage 46 is clamped against pattern plate 37 on which is mounted fixed pattern 230. The movable pattern 231 is mounted on pattern plate 57 supported by the ram of the pivot carriage 46. In the position seen in FIG. 11, the sand blow reservoir 33 has been filled by conveyor 233, the conveyor being controlled by sand probe 234. After such filling, the butterfly valve 193 is in its closed position as seen. The seals 168 and 201 are inflated. The depth of the mold chamber 170 has been controlled from the selected reed switch from the control of FIG. 10 and the blow operation is now ready to commence. The blow valve 191 is opened and air from tank 72 enters the blow reservoir forcing the sand into the chamber 170.

After the sand is blown into the cavity 170, the seals 201 and 168 are deflated and air is exhausted from the reservoir through the exhaust valves 192. The jolt-squeeze operation now begins with the squeeze piston-cylinder assemblies moving the jolt ram 143 toward the fixed pattern 230. The jolt ram 151 will be in operation only during the squeeze. The depth of the sand cake 15 being formed as seen in FIG. 12 is determined by sand characteristics, blow pressure, squeeze pressure, and chamber depth during blow. The latter three parameters are readily set by the operator to obtain a cake 15 of the desired hardness and permeability.

Following the formation of the cake as seen in FIG. 12, the ram 143 is hydraulically locked with respect to the flask to maintain that position of the movable pattern 231 with respect to the cake throughout the traverse. In FIG. 12, the slow draw is about to begin following the completion of the jolt and squeeze.

Referring now to FIG. 13, the traversing piston-cylinder assemblies have retracted slowly slightly to draw the cake 15 from the fixed patter 230. As seen in FIG. 13, the rapid traverse is about to begin and at this point in the cycle the butterfly valve 193 will open to permit recharging of the reservoir 33.

Such recharging has commenced as seen in FIG. 14. During the rapid traverse, the traversing cylinder assemblies 49 and 50 will move the pivot carriage 46 to the left as seen in FIG. 14 and the cam and follower mechanism of FIG. 9 will cause the carriage 46 to pivot about its vertical pivot axis so that the sand cake 15 is facing the operator. During initial traverse, the pivot carriage moves linearly drawing the flask from the fixed pattern 230 for the slow draw and moving the guide bushings off of the alignment pins 60. At the position seen in FIG. 14 the slide may be stopped to permit automatic or manual coring of the exposed face of the cake 15. However, it will be appreciated that coring may take place in the opposite face of the cake after it has been deposited at the entrance to the pouring conveyor. Completion of the traverse continues the pivot of the carriage 46 until it is facing in the opposite direction and further continued traverse moves the carriage into contact with the entrance to the pouring conveyor. The guide bushings on the pivot carriage will receive the alignment pins 61 and continued movement of the slide will cause contact between the face of the pivot carriage and the frame 62 through contact buttons 240 seen in FIG. 4. Such contact is initially achieved as seen in FIG. 15 and yet the traversing carriage continues moving to the left as seen in FIG. 16 pushing the pouring conveyor and the sand cakes thereon to the left until stop 241 on the pouring conveyor engages stop 242 on the machine frame. The entire stack is thus indexed one cake. The stops, although not illustrated as such, may be adjustable. During such continued movement of the traversing carriage, the rod end of pneumatic piston-cylinder assembly will exhaust as the piston thereof moves forward.

Following contact between the stops 241 and 242, pneumatic piston-cylinder assemblies 243 and 244 mounted on the frame 62 as seen more clearly in FIG. 4 are retracted elevating cake contact pads 245 and 246, respectively, which function, in the extended position of the piston-cylinder assemblies, to secure the initial cake in the horizontal stack with respect to the pouring conveyor.

When such hold-down piston-cylinder assemblies are retracted as seen in FIG. 17, air pressure is applied to the rod end of the piston-cylinder assembly 101 to move the pouring conveyor 14 to the right beneath the stack of cakes 15 thereon. During this movement of conveyor 14 to the right, a valve of the machine is actuated so that there is an open passage from the left side of pistons 47 and 48 contained in cylinders 49 and 50, respectively, to the left side, as seen in FIG. 17 of piston 134 contained in cylinder 135 and a similar piston contained in cylinder 136. With this passage open, a movement of pivot carriage 46 to the right will force oil from cylinders 49 and 50 and into cylinders 135 and 136; and since cylinders 49, 50, 135 and 136 are of the same diameter, and their piston rods are identical in diameter, the net effect will be that ram 143 will stay stationary in space, or with respect to frame 11, otherwise a slight rightward movement of ram 143 due to compressibility of the oil. A small oil cylinder can be provided which will be attached to conveyor 14 so that movement of conveyor 14 will cause a small amount of
oil to be added to the volume to the left of the aforementioned pistons, and this combined with an appropriate relief valve, will ensure that the cake from which the flask is being drawn will be held with a predetermined pressure against the stack of cakes.

In this manner the pouring conveyor 14 is maintained in contact with the face of the pivot carriage 46 as the latter is retracted with respect to the ram 143. This draws the flask from the cake while simultaneously sliding the entrance to the pouring conveyor beneath the cake. Reed switch 248 in the control 210 may be employed to signal that the cake is in position on the entrance to the pouring conveyor initiating the retraction of the ram 143 slowly to draw the movable pattern from the cake after the hold-down piston-cylinder assemblies 243 and 244 have been extended. At this time the valve 193 is closing, the blow reservoir having been filled by the conveyor 233 to the level permitted by the probe 234.

After the slow draw of the movable pattern 231 from the cake 15 rapid traverse takes place with the traversing slide and pivot carriage returning to the position of FIG. 11. The entire cycle may take approximately 13.5 seconds and while the cake is being formed and the carriage is traversing, the molds formed by the horizontally stacked cakes 15 may be poured from ladle 250 as indicated in FIGS. 11 and 14.

With the present invention it is preferred to have a pouring conveyor less than fourteen feet in length and the coefficient of friction of the pouring conveyor can be calculated to be approximately 0.45. The cooling conveyor coefficient of friction may be substantially less and on the order of 0.04.

The relationship of green compression strength of the sand cakes versus conveyor length can be expressed in three equations, and they are:

\[ S_{c1} = N_f f_i v^2 \]

\[ S_{c2} = N_f f_i \]

\[ S_{c3} = N_f f_i f_s k_1 \]

where:

- \( S_{c1} \) = Green compression stress of the sand at the entrance to the pouring conveyor to slide the sand cakes or molds with respect to the pouring conveyor, as in the illustrated embodiment.
- \( S_{c2} \) = Green compressive stress of the sand at the entrance to the cooling conveyor to move the sand mold along the cooling conveyor.
- \( S_{c3} \) = The green compressive stress at the entrance to the pouring conveyor necessary to slide the molds over a fixed pouring conveyor and a moving cooling conveyor as such that illustrated.
- \( f_i \) = Coefficient of friction between sand cakes and pouring conveyor.
- \( f_s \) = Coefficient of friction of cooling conveyor.
- \( N \) = Factor of safety which includes the area of mold in compression (from 40 to 60 percent) and variations in mold hardness, green compressive strength, and mold handling (from 1.8 to 2.45).
- \( k_1 \) = Density of sand.

Equations 1 and 2 state the relationship of green compression strength (as determined by standard tests) versus conveyor length for the pouring and cooling conveyors illustrated. However, in some cases, it may be advantageous to fix the pouring conveyor and then equation 3 applies.

The application of these equations will reduce the length of the pouring conveyor to about 12 feet or less. This results in the following advantages:

1. Enable foundries to use their standard foundry sand without expensive special additives to increase green compressive strength.
2. Allow foundries to produce softer molds which will increase permeability and reduce blows.
3. Reduce or eliminate the crushing of sand cakes; thus, increasing reliability.
4. Eliminate the necessity of powering and synchronizing the cooling conveyor with the pouring conveyor or molding machine.

It can now be seen that there is provided a simplified and yet high speed foundry molding machine for producing a horizontal stack of molds. With this machine it is possible to produce molds having less hardness and more permeability thereby avoiding blows or bubbles in the casting. It will be appreciated that the principles of this invention may apply to a machine wherein the pivot carriage revolves around a horizontal pivot so that the sand cake will be facing upwardly in an intermediate position for coring.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A horizontal stack foundry molding machine comprising a carriage including a projecting flask, a linear pouring conveyor ram means telescoping within such flask to ram a sand cake therein, means to turn said carriage end-for-end, and means to deposit such cake on said pouring conveyor by relative telescoping movement of said ram means and flask to form with other thus produced molds such horizontal stack.
2. A machine as set forth in claim 1 wherein said ram means supports a first pattern.
3. A machine as set forth in claim 2 including means to support a second pattern, said flask contacting said second pattern in one position of said carriage.
4. A machine as set forth in claim 2 including jolt means mounted in said means ram.
5. A machine as set forth in claim 3 including alignment means operative to align said flask with said second pattern and said pouring conveyor.
6. A machine as set forth in claim 3 including means to blow sand within such flask when in contact with said second pattern.
7. A machine as set forth in claim 6 including means to control the position of said first pattern with respect to said second pattern prior to the blowing of said within such flask.
8. A machine as set forth in claim 1 including means supporting said pouring conveyor for horizontal reciprocating movement.
9. A horizontal stack molding machine comprising a carriage including a projecting flask, means to ram a sand cake in such flask, means to turn said carriage end-for-end, means to deposit such cake on a pouring conveyor, and means supporting said pouring conveyor for horizontal reciprocating movement, said pouring conveyor being moved in one direction by said carriage and in the opposite direction by a piston-cylinder assembly.
10. A machine as set forth in claim 9 including means to move said pouring conveyor and flask in unison.
11. A machine as set forth in claim 10 including a squeeze ram on said carriage thus to hold said cake as the flask is withdrawn and the pouring conveyor is slid thereunder.

12. A horizontal stack foundry molding machine comprising a carriage including a projecting flask, a linear pouring conveyor, means to ram a sand cake in such flask, means to turn said carriage end-for-end, means to deposit such cake on said pouring conveyor to form with other thus produced molds such horizontal stack, and guide rods extending end-to-end of the machine supporting said carriage for reciprocating movement.

13. A horizontal stack molding machine comprising a carriage including a projecting flask, means to ram a sand cake in such flask, means to turn said carriage end-for-end, and means to deposit such cake on a pouring conveyor; guide rods extending end-to-end of the machine supporting said carriage for reciprocating movement, pistons and cylinders on said guide rods, the cylinders being interconnected, a pivot carriage supported on said cylinders housing said projecting flask, and cam means to turn said pivot carriage end-for-end in response to movement of said cylinders along said guide rods.

14. A machine as set forth in claim 13 including two such guide rods and cylinders thereon vertically spaced with said pivot carriage being pivotally connected therewithout about a vertical axis.

15. A machine as set forth in claim 12 including a squeeze ram on said pivot carriage adapted to support a pattern movable within said flask, said squeeze ram being operated by a pair of fixed pistons and movable cylinders.

16. A machine as set forth in claim 8 including a cooling conveyor aligned with said pouring conveyor, said cooling conveyor comprising a belt supported on a plurality of idler rolls and being moved normally only by the movement of the stack thereof.

17. In combination, a molding machine for producing sand cakes, a pouring conveyor, and an aligned cooling conveyor, said conveyors being adapted to support a horizontal stack of cakes, said pouring conveyor including a cake supporting surface, means mounting said surface for short distance horizontal reciprocation, a traversing carriage in said molding machine having an open-ended flask in which such sand cakes are produced, and means to index said carriage from a cake forming position to a position in contact with the entrance to the pouring conveyor, further indexing of the carriage extending said pouring conveyor.

18. A stack type foundry molding machine comprising a carriage, a projecting open-ended flask supported on said carriage, a ram on said carriage adapted to support a first pattern, a second pattern, a pouring conveyor, means to index said carriage between a first position wherein such second pattern closes the projecting end of such flask and a second position wherein the projecting end of such flask contacts said pouring conveyor, said pouring conveyor being mounted for reciprocating movement, and means to return said pouring conveyor after being indexed by such flask.

19. A machine as set forth in claim 18 including means to ram a sand cake in such flask in such first position.

20. A machine as set forth in claim 18 wherein said means to index said carriage includes pivot means to turn such flask end-for-end.

21. A machine as set forth in claim 18 including alignment means adjacent such second pattern and at the entrance to said pouring conveyor properly to align such flask in both said positions.

22. A stack type foundry molding machine comprising a carriage, a projecting open-ended flask supported on said carriage, a ram on said carriage adapted to support a first pattern, a second pattern, a pouring conveyor, means to index said carriage between a first position wherein such second pattern closes the projecting end of such flask and a second position wherein the projecting end of such flask contacts said pouring conveyor, said pouring conveyor being mounted for reciprocating movement, and means to return said pouring conveyor in contact with such flask as such flask withdraws with respect to said ram to deposit a sand cake on the entrance of said pouring conveyor.

23. A stack type foundry molding machine comprising a carriage, a projecting open-ended flask supported on said carriage, a ram on said carriage adapted to support a first pattern, a second pattern, a pouring conveyor, and means to index said carriage between a first position wherein such second pattern closes the projecting end of such flask and a second position wherein the projecting end of such flask contacts said pouring conveyor, said means to index said carriage including means to move such flask further toward said pouring conveyor following contact to index said pouring conveyor, said carriage comprising a pair of traversing piston-cylinder assemblies, said ram and such projecting open-ended flask being pivotally supported between the cylinders thereof.

24. A machine as set forth in claim 18 including means to blow sand within such flask in such first position.

25. A machine as set forth in claim 18 including means to fill such flask with sand in such first position, and means to move said ram and thus such first pattern toward the second pattern after such flask has been filled with sand to ram a sand cake therein.

26. A machine as set forth in claim 18 including jolt means in said ram operative to facilitate the compaction of sand in such flask to form a sand cake.

27. A machine as set forth in claim 18 wherein said carriage includes a slide and a turret, and means responsive to movement of said slide to pivot said turret.

28. A horizontal stack foundry molding machine comprising a pivot carriage, a projecting open-ended flask supported on said pivot carriage, a ram on said carriage adapted to support a first pattern for moving such pattern through the proximal end of the flask, a traversing carriage supporting said pivot carriage and operative in one position to place the distal end of such flask, adjacent a second pattern to form a mold box, means to fill such box with sand, means operative relatively to move such patterns to form a sand cake in such flask, means to index said traversing carriage to another position wherein said ram and flask are moved relatively to each other to add such cake to a horizontal stack, and separate alignment means at said one posi-
tion and said another position cooperating with alignment means on such flask properly to align such flask in both such positions.

29. A machine as set forth in claim 27 including means responsive to the indexing of said traversing carriage to pivot said pivot carriage and thus such flask.

30. A machine as set forth in claim 29 wherein said last mentioned means comprises a cam on said traversing carriage and a follower connected to said pivot carriage to pivot the latter end-for-end.

31. A horizontal stack molding machine comprising a flask, a movable ram in said flask operative to form a sand mold therein, a pouring conveyor, means to move said flask into contact with said pouring conveyor to index said conveyor and the molds thereon, and means to return said conveyor and retract said flask simultaneously while holding said ram stationary to deposit such mold on said conveyor against the horizontal stack.

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