One form of mold forming apparatus includes a carriage mounting a flask, the carriage being movable horizontally between a mold forming position and a position adjacent a mold discharging station. In the mold forming position, the flask and a lower pattern plate form a mold chamber into which sand is deposited. The flask and lower pattern plate are then moved vertically to compress the sand against an upper pattern plate. After the mold is formed, the flask and lower pattern plate are returned to their initial position. The lower pattern plate is then lowered away from the flask and the flask is rotated ninety degrees. The carriage is then moved to the discharge station and a pusher element discharges the mold from the flask onto a support. In another form, a pair of horizontally movable carriages mount vertically movable flasks. Respective lower cope and drag pattern plates and the flasks are movable vertically upwardly to compress the sand and form molds. When returned, and the lower pattern plates are moved away from the flasks, the flasks are rotated ninety degrees. The flask carrying carriages are then moved toward the discharge station to butt the molds and thereby form the mold cavity and for discharge of the molds onto a support.

6 Claims, 10 Drawing Figures
The present invention relates to mold forming apparatus and particularly relates to apparatus for and methods of forming molds for flaskless molding.

In flaskless molding it has been the practice to use molding chambers known as flasks in which sand is molded for the purpose of casting various metal products. For proper casting techniques it is necessary for the casting to remain within the flask and sand mold in order to cool without the surface hardening of the casting which would occur if the casting was prematurely exposed in a semi-molten condition. Because of this required residence time it is necessary in continuous casting operations to have a large number of flasks in order to carry out the molding, casting and cooling operation. This arrangement involves considerable expense in capital equipment without improving the quality of the casting formed during the casting operation.

In an effort has been made to develop flaskless molding techniques and some work has been done on a blow-squeeze technique in order to eliminate the need for a large number of flasks. In principle, the blow-squeeze technique involves the use of a single flask for forming a sand mold. The single flask is positioned upright at the molding station and pattern plates are positioned in the front and rear end walls of the flask. The flask is filled by blowing sand through the top wall of the flask into the flask cavity. The sand is then squeezed horizontally and after removal of the front pattern plate the mold is pushed out of the flask onto a receiving conveyor. It is necessary to blow sand into the mold because gravity filling is not feasible when the pattern plates are vertically arranged at the front and rear end walls of the flask.

In the practice of this molding technique a number of problems have been encountered which relate primarily to the inherent limitation in blowing sand for purposes of filling the flask. The blown sand has a blasting effect on the pattern plates which tend to wear rapidly and have a lower pattern plate life. The abrasive wearing of the pattern plates also effects the dimensional accuracy of the casting.

The blowing of the sand into the mold tends to disturb the balance of the sand mix so that the sand fines and other additives collect at the surface (primarily in the vent area) of the mold and it is more difficult for gas to penetrate the mold which causes various type casting defects. Moreover the bonding of the sand in the mold is harder to achieve because fines are disturbed during the blowing operation.

It has also been determined that sand cannot be effectively blown beyond two cubic feet and consequently there is a practical limit to the size of molds which can be formed by the blow-squeeze technique.

There are further limitations on this technique because of the power requirements involved in the generation of compressed air. In addition, it has been found necessary to locate vents in the pattern plates to achieve the required packing of sand around the contours of the pattern plate. The vents are located on a trial and error basis which adds considerably to the expense of forming pattern plates.

The foregoing difficulties have been overcome to a very significant extent by the molding machine described in copending application, Ser. No. 687,750 filed Dec. 4, 1967 and now abandoned of common assignee herewith wherein a vertical filling and squeezing of the sand between vertically spaced pattern plates enclosing the ends of a molding flask is effected. After mold formation, the flask, as disclosed in that application, is tilted and lined such that the mold can be pushed horizontally out of the flask onto a receiving conveyor for metal pouring operations.

In one form of the present invention, there is provided a machine frame having a carriage movable horizontally between a mold forming position and a position adjacent a mold discharge station. The carriage pivotally carries a flask which is, in turn, movable vertically between a lower sand receiving position and an upper sand compressing position. In the lower position, a lower pattern plate carried by a fluid actuated cylinder closes the lower end of the flask to form a mold chamber. A chute is disposed above the mold chamber on the machine frame for depositing sand into the mold chamber. An upper pattern plate is carried by a carriage mounted on the frame and is movable into the vertical registry over the flask after the sand has been deposited into the mold chamber. The cylinder carrying the lower pattern plate then moves both the flask and lower pattern plate upwardly to compress the sand in the mold chamber against the upper pattern plate. After the mold is formed, the flask and lower pattern plate are lowered to their initial positions and the lower pattern plate is then lowered away from the underside of the flask, the sand mold being retained in the flask by frictional action. The flask is then rotated about ninety degrees and the carriage is moved horizontally to the mold discharge station. At the discharge station, a pusher element engages the mold and pushes through the flask to discharge the mold onto a support surface. The carriage then returns to the initial mold forming position and the mold forming operation is repeated.

In another form hereof, cope and drag mold portions are simultaneously formed. To accomplish this, a pair of carriages each mounting a flask are disposed in mold forming positions below respective sand chutes. Lower pattern plates are carried by fluid actuated cylinders and, when the mold chambers are filled with sand, the lower pattern plates and flasks are moveable vertically into sand compressing positions with upper backing plates closing off the upper ends of the flasks and providing the reaction force. After the mold is formed, the flasks and lower pattern plates are lowered and the lower pattern plates are then lowered away from the underside of the flasks. Each flask is then rotated about ninety degrees in opposite directions and the carriages are moved horizontally to the discharge station whereat the flasks are aligned one with the other with their respective mold cavities in lateral registry each with the other. At the discharge station, a pusher element engages the molds and pushes through the flasks to discharge the molds onto the support surface. The carriages are then returned to their initial mold forming positions whereupon formation of additional cope and drag mold portions can be affected.

Accordingly, it is a primary object of the present invention to provide an improved mold forming apparatus for flaskless molding.
It is another object of the present invention to provide an improved mold forming apparatus for flaskless molding which is simple in construction, economical to manufacture, and simple and efficient in use.

It is still another object of the present invention to provide an improved mold forming apparatus for flaskless molding wherein the flasks are filled vertically with sand and compressed in a vertical direction, then swung to a horizontal position and thereupon moved to a discharge station for discharging the mold from the flask onto a support surface.

It is a related object of the present invention to provide improved methods and apparatus for forming cope and drag mold portions.

These and further objects and advantages of the present invention will become more apparent upon reference to the following specification, appended claims and drawings wherein:

FIG. 1 is an end elevational view of an improved mold forming apparatus constructed in accordance with the present invention;

FIG. 2 is a view similar to FIG. 1 illustrating the molding chamber in a raised position for compressing the sand therein;

FIG. 3 is a fragmentary side elevational view of the mold forming apparatus illustrated in FIG. 1 with the flask containing the mold rotated ninety degrees;

FIG. 4 is a view similar to FIG. 3 illustrating the flask at the discharge station with a pusher element discharging the mold from the flask;

FIG. 5 is a side elevational view of another form of an improved mold forming apparatus constructed in accordance with the present invention;

FIG. 6 is an end elevational view thereof;

FIGS. 7–8 are views similar to FIG. 5 illustrating further operational sequences of the mold forming apparatus hereof; and

FIGS. 9–10 are side elevational views of the mold forming apparatus illustrated in FIG. 5 with parts in cross section and illustrating the operational sequence for discharging the molds.

Referring now to the drawings, particularly to FIGS. 1 and 2, there is illustrated a generally C-shaped frame 10 supporting the mold forming apparatus hereof generally indicated 12. Frame 10 includes upper and lower legs 14 and 16 respectively, the upper leg 14 including a sand chute 18 disposed over mold forming apparatus 12. Sand chute 18 lies in communication with suitable batching equipment, not shown, whereby sand can be dispensed through chute 18 for disposition in a mold forming chamber to be described. Frame 10 also carries a pair of laterally spaced tracks 20 along the underside of upper leg 14, tracks 20 mounting rollers 22.

A carriage 24 is carried on rollers 22 for movement between the positions thereof illustrated in FIGS. 1 and 2 by means of a fluid actuated, preferably hydraulic, cylinder 26 mounted on frame 10. Carriage 24 mounts a backing support plate 28 which, in turn and in this form of the invention, mounts a downwardly facing upper pattern plate 30. Accordingly, upper pattern plate 30 is movable from a position spaced horizontally from mold forming apparatus 18 into a position in vertical registry thereover for reasons to be described.

Mold forming apparatus 18 includes a carriage 32 carried on suitable guide rails 34 upstanding from lower leg 16 of frame 10 for horizontal movement between a mold forming position and a position adjacent a discharge station, indicated generally at 36 in FIGS. 3 and 4. A pair of fluid actuated, preferably hydraulic cylinders 38 are suitably fixed to frame 10 with the piston rods 40 thereof being fixed to carriage 32. Carriage 32 preferably comprises a pair of side rails 44 and a cross rail 46 extending between side rails 44. A pair of laterally spaced upright trunnion supports 48 are carried on side rails 44 with each support 48 having an elongated vertically extending slot 50 adjacent its upper end. Trunnions 52 ride in slots 50 and are fixed to the sides 54 of a flask generally indicated at 56. As illustrated in FIG. 1, flask 56 has open opposite ends and has a plurality of pins 58 depending along its lower edges for reasons to be described.

A conventional rotary mechanism 60 is provided on carriage 32 for rotating flask 56 from a horizontal disposition, illustrated in FIG. 1, to a vertical disposition, illustrated in FIG. 3. Tilting mechanism may comprise a power operated cylinder, not shown, coupled to trunnions 52 for rotating flask 54. Alternatively, the flask could be tilted manually by a handwheel and gearing arrangement not shown.

A lower pattern plate 70 is carried on the upper end of a piston rod 72, the fluid actuated cylinder 74 therefore being supported by the lower leg 16 of frame 10. The piston rod 72, in an intermediate position thereof, locates lower pattern plate 70 in position to close off the lower open end of flask 56 and to define therewith a molding chamber 80. It will be appreciated that the pattern plate 70 carries locating holes for receiving the locating pins 58 on flask 56, whereby the pattern plate is properly located relative to the flask.

Discharge station 36 includes a frame 82 having a central opening and a plurality of locating holes on the side thereof facing flask 56. Discharge station 36 also includes a horizontal support surface 84 on which the molds formed by molding apparatus 18 can be deposited.

In use, sand is disposed through chute 18 into the molding chamber 80 defined by flask 56 and lower pattern plate 70. Cylinder 26 is then actuated to move carriage 24 and hence upper plate 30 into the mold forming position in vertical registry over flask 56. Cylinder 74 is then actuated to conjointly elevate lower pattern plate 70 and flask 56 such that upper plate 30 is received within flask 56. Further extension of piston 72 compresses the sand in molding chamber 80 to form the mold. After the mold is formed, the flask 56, lower pattern plate 70 and the mold are lowered to the position illustrated in FIG. 1. Lower pattern plate 70 is then lowered away from the underside of flask 56 by further retraction of piston 72. The sand mold is retained within flask 56 due to its frictional engagement with the sides of the flask. Thereafter, the tilt mechanism 60 is actuated to rotate the flask and the mold therein from a generally horizontal position to the vertically disposed position illustrated in FIG. 3. Cylinders 38 are then actuated to move carriage 32 horizontally from the mold forming position toward the discharge station with the aligning pins 58 carried on flask 56 being received in the locating holes 83 at the discharge station. When the flask is thus aligned with the discharge frame 82 and hence support surface 84, as seen in FIG. 4, a pusher
head 86 actuated by a fluid cylinder 88 carried on carriage 32 extends into and through flask 56 to push mold M into support surface 84 at discharge station 36. The mold pattern provided by upper pattern plate 30 is thus aligned with the mold pattern formed by the lower pattern plate of a previously formed mold to form the metal receiving cavity C. After the mold has been discharged, pusher head 86 is retracted and carriage 32 is retracted to the mold forming position. The tilt mechanism is then actuated to rotate flask 56 to the horizontal position and it will be appreciated that during the previously described flask tilting and carriage moving operations the upper pattern plate has been retracted to its out of way position as illustrated in FIG. 1. Thus the new mold can be formed by repeating the above described process.

Referring to the embodiment hereof illustrated in FIGS. 5–10, there is disclosed apparatus for forming cope and drag mold portions which apparatus is similar to that previously described. In this form, there is provided a substantially C-shaped frame 100 having upper and lower legs 102 and 104 respectively with sand chutes 106 and 108 disposed in upper leg 102. A carriage 110 is carried on rollers 112, rollers 112 being supported on guide rails 114 below upper leg 102. A pair of backing plates 116 and 118 are carried on carriage 110 and, it will be appreciated that a fluid actuated cylinder is provided 111 as seen in FIG. 6 for moving carriage 110 between positions locating backing plates 116 and 118 offset from molding apparatus 120 and positions in vertical registry above the moldling apparatus 120 and 122. Lower leg 104 of frame 100 mounts a pair of spaced guide rails 124 on which a pair of carriages 126 and 128 are mounted for sliding movement between the mold forming positions illustrated in FIGS. 5–8 and mold discharge positions illustrated in FIGS. 9 and 10. Carriages 126 and 128 are moved by respective cylinders 130 and 132. Each of the carriages carries a pair of spaced upstanding supports 134 and 136 each having a vertically extending slot 138. Tunnions 140 are carried in the slots and the trunnions 140 on carriage 134 pivotally mount flask 142 while the trunnions 140 associated with the carriage 120 pivotally mount flask 144. Conventional rotary mechanisms 143 (such as Rotac) are provided to tilt each of the flasks 142 and 144 between the horizontally disposed positions as seen in FIG. 5 and the vertically disposed positions as seen in FIGS. 9 and 10.

Below each of the mold positions is mounted a fluid actuated cylinder 150, the pistons of which carry lower pattern plates 152 and 154. Pattern plate 152 includes locating holes for receiving the location pins 156 carried along the lower edges of flask 142. Lower pattern plate 154 carries a plurality of locating pins for engagement in locating openings carried along the lower edges of flask 144. A discharge station 160 is provided and includes a horizontally disposed surface 162 for receiving the molds formed in flasks 142 and 144. Carriage 126 also carries a cylinder 166 on which is mounted a pusher head 168 for discharging the molds from the flask in a manner to be described.

In utilizing this form of the present invention, the pistons of cylinders 150 are actuated such that the lower pattern plates 152 and 154 engage and close off the open lower ends of flask 142 and 144 to form mold chambers therewith. Sand is then disposed into the mold chamber through chutes 106 and 108. Thereafter, carriage 110 is moved along frame 100 to locate backing plates 116 and 118 in registry above the respective flasks 142 and 144. Actuation of cylinders 150 then elevates flasks 142 and 144 and lower pattern plates such that the backing plates 116 and 118 are received within and close off the upper ends of the respective flasks 142 and 144, the sand being compressed in the molding chambers to form the mold. After the mold has been formed, the pistons of cylinders 150 are retracted such that the flasks, pattern plates and molds obtain the positions illustrated in FIG. 8. The lower pattern plates having been lowered away from the flasks 142 and 144 with the molds therein being retained by frictional engagement with the interior or side walls of the flasks. The tilt mechanisms 143 are then actuated to rotate flasks 142 and 144 in opposite directions such that the flasks are aligned vertically and the openings through the flasks and containing the molds lie in horizontal registry one with the other. Locating pins 156 are also aligned in horizontal registry with the locating openings on flask 144. With the flasks disposed vertically, cylinders 130 and 132 are actuated to move carriages 126 and 128 horizontally toward the discharge station with the locating pins 156 on flask 142 being disposed in the openings in flask 144. Preferably, pins and locating openings are provided about the upper side of flask 144 and the discharge station respectively such that flask 144 and hence flask 142 can be aligned with the discharge station when moved thereto. It will be appreciated that the mold cavities provided by the lower pattern plates in the molds lie in open registry one with the other and form the mold cavities for receiving the metal. To discharge the molds from the flasks, the cylinder 166 is actuated and pusher head 168 engages the molds and pushes through the flasks 142 and 144 with the mold in flask 142 being pushed from flask 142 through flask 144 onto the support surface. Upon retraction of head 168 and repositioning of carriages 126 and 128 to the mold forming positions illustrated in FIG. 5, it will be appreciated that the molding apparatus is in readiness to form another mold.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. Molding apparatus comprising a frame, a pair of generally horizontally disposed plates, at least one of said plates including a pattern plate, a flask disposed between said plates forming a mold chamber therewith and carried by said frame for generally horizontal movement, means for depositing mold forming material into said mold chamber, means for moving at least one of said plates toward the other of said plates to compress the mold forming material therebetween to form at least a portion of a mold, means for spacing
said plates from said flask, means for swinging said flask from a generally horizontal position to a generally vertical position, a mold support surface spaced from said flask, means for moving said flask to a position adjacent the mold support station, and means including an element movable into said flask, when in said vertical position, to discharge the mold portion onto said support surface.

2. Apparatus according to claim 1 comprising a second pair of generally horizontally disposed plates, at least one of said second pair of plates including a pattern plate, a second flask disposed between said second plates forming a second mold chamber therewith and mounted on said frame for generally horizontal movement, means for depositing mold forming material into said second mold chamber, means for swinging said second plates toward the other of said second plates to compress the mold forming material therebetween to form at least a portion of a mold, means for spacing said second plates from said second flask, means for swinging said second flask from a generally horizontal position to a generally vertical position, means for moving said second flask to a position adjacent said mold support station, said flask moving means locating said flasks in horizontal registry one with the other at said mold support surface, said element being movable into said flasks, when in said vertical position, to discharge the mold portions from said flasks onto said support surface.

3. Apparatus according to claim 2 including means for aligning said first and second flasks one with the other and means for aligning said flasks with said mold support surface.

4. Mold forming apparatus comprising a lower pattern plate, an upper plate, a flask disposed above said lower pattern plate and forming a mold chamber therewith, means carrying said flask and said lower pattern plate for conjoint movement in a generally vertical direction between first and second positions, means for depositing mold forming material into said mold chamber when said lower pattern plate and said flask lie in said first position, means for moving said lower pattern plate and said flask from said first position into said second position to compress the mold forming material between said lower pattern plate and said upper plate to form at least a portion of a mold, means for moving said lower pattern plate away from said flask, a generally horizontally disposed support, means for swinging said flask from said horizontal orientation into a vertical orientation, and discharging means including an element movable through said flask to discharge the mold portion onto said support.

5. Mold forming apparatus comprising a lower pattern plate, an upper plate, a flask disposed above said lower pattern plate and forming a mold chamber therewith, means carrying said flask and said lower pattern plate for conjoint movement in a generally vertical direction between first and second positions, means for depositing mold forming material into said mold chamber when said lower pattern plate and said flask lie in said first position, means for moving said lower pattern plate and said flask from said first position into said second position to compress the mold forming material between said lower pattern plate and said upper plate to form at least a portion of a mold, means for moving said lower pattern plate away from said flask, a discharge station having a support surface, said station being spaced from said flask when the latter lies in said first position, said flask being disposed in a substantially horizontal orientation in said first position, means for swinging said flask from said horizontal orientation into a vertical orientation, means for moving said flask from said first position to a position adjacent said discharge station, said discharging means including an element movable into said flask to displace the mold position therefrom for deposition on said support surface.

6. Mold forming apparatus comprising a lower pattern plate, an upper plate, a flask disposed above said lower pattern plate and forming a mold chamber therewith, means carrying said flask and said lower pattern plate for conjoint movement in a generally vertical direction between first and second positions, means for depositing mold forming material into said mold chamber when said lower pattern plate and said flask lie in said first position, means for moving said lower pattern plate and said flask from said first position into said second position to compress the mold forming material between said lower pattern plate and said upper plate to form at least a portion of a mold, means for discharging the mold portion from said flask, a second lower pattern plate, a second upper plate, a second flask disposed above said second lower pattern plate and forming a second mold chamber therewith, means carrying said second flask and said second lower pattern plate for conjoint movement in a generally vertical direction between first and second positions, means for depositing mold forming material into said second mold chamber when said second lower pattern plate and said second flask lie in said first position, means for moving said second lower pattern plate and said second flask from said first position into said second position to compress the mold forming material between said second lower pattern plate and said upper plate to form at least a portion of a mold, means for moving said second lower pattern plate away from said second flask, a generally horizontally disposed support, means for swinging said second flask from said horizontal orientation into a vertical orientation, and discharging means including an element movable through said second flask to discharge the mold portion onto said support.

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