United States Patent

Van Deberg et al.

[15] **3,688,830**

[45] **Sept. 5, 1972**

[54] METHOD OF MAKING MOLDS

[72] Inventors: **Walter H. Van Deberg,** Berkley, Mich.; **Earl A. Thompson, deceased,** late of Bloomfield Hills, Mich.; **Elizabeth F. Thompson, executrix,** Bloomfield Hills, Mich.; **Paul Franseth, executor,** Grosse Pointe, Mich.; **Michael M. Wild, executor,** Royal Oak, Mich.

[73] Assignee: **Earl A. Thompson Manufacturing Co.,** Ferndale, Mich.

[22] Filed: **Aug. 28, 1969**

[21] Appl. No.: **853,984**

[52] **U.S. Cl.**.....**164/22,** 164/201

[51] **Int. Cl.**.....**B22c 15/22**

[58] **Field of Search**.....164/14, 15, 19, 20, 21, 22, 164/23, 24, 33, 37, 40, 165, 200, 201, 202; 222/193, 195; 306/53

[56] **References Cited**

UNITED STATES PATENTS

3,470,938	10/1969	Miller et al.	164/19 X
3,540,520	10/1970	Abraham et al.	164/201
3,192,580	7/1965	Lubalin	164/14
3,001,829	9/1961	De Saint-Martin	302/53
3,121,593	2/1964	McIlvaine	222/193 X
3,149,884	9/1964	Jones	302/53
3,269,428	8/1966	Stockel et al.	222/195 X
3,360,301	12/1967	Donaho	302/53

FOREIGN PATENTS OR APPLICATIONS

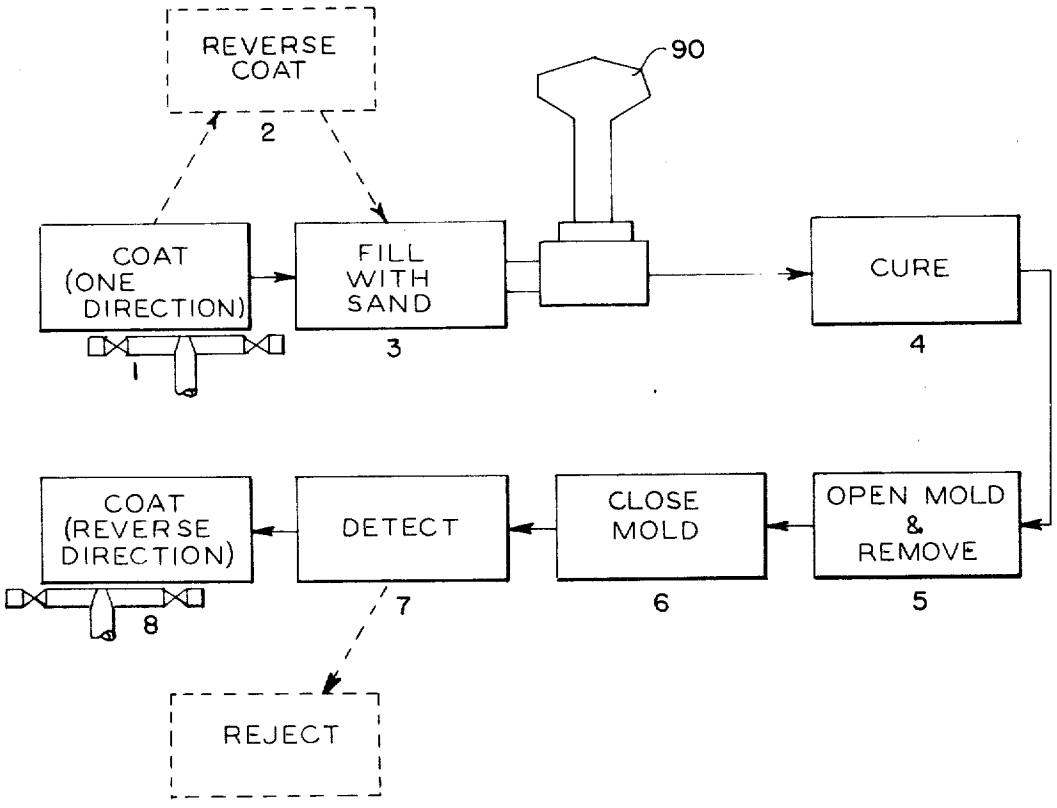
513,378	8/1929	Germany	164/200

Primary Examiner—J. Spencer Overholser
Assistant Examiner—John E. Roethel
Attorney—Theodore L. Chisholm

[57] **ABSTRACT**

A series of expendable shell molds is formed in a permanent pattern having a series of connected mold cavities. A passage extends from outside the pattern into each end of the series. A suspension of parting agent is blown by gas or superheated steam into the cavities through one of the passages while the other is vented through an orifice of controlled size to maintain the desired pressure. To coat evenly the parting agent may then be blown in the opposite direction through the cavities. Thereafter molding sand is blown into the pattern through one or both of the passages. Imperfect closing of the separatable pattern is detected by blowing air into a third passage which ends at the parting plane. The air is supplied from a constant pressure source through an orifice of predetermined size and the pressure is measured on the downstream side of the orifice. A blow box connected to a sand hopper is pivoted to be swung toward and away from the pattern. A sand valve and a vent valve cooperate to dump sand from the hopper rapidly into the blow box. Gas under pressure is distributed throughout the sand from below to fluidize the sand and simultaneously force is applied above the sand to flow the mass into the pattern.

6 Claims, 14 Drawing Figures



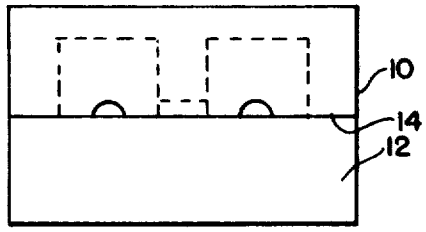


FIG. 1

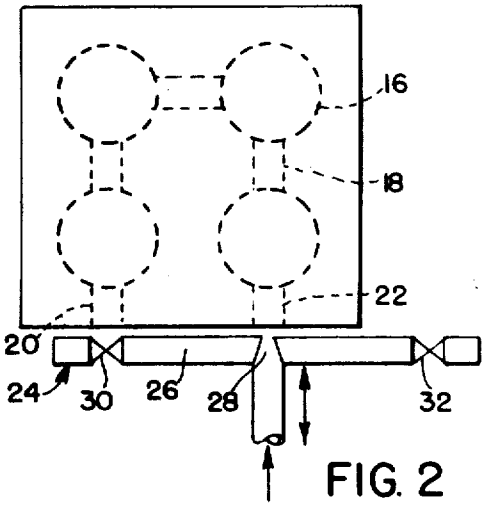


FIG. 2

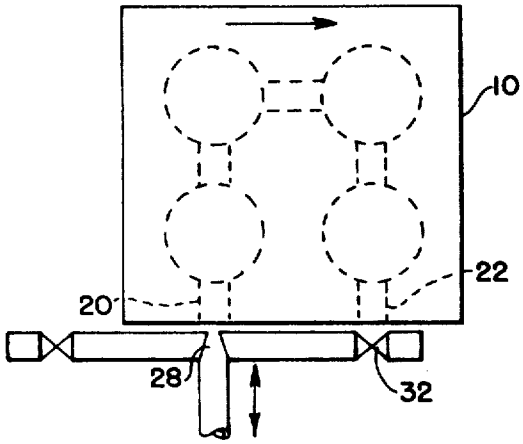


FIG. 3

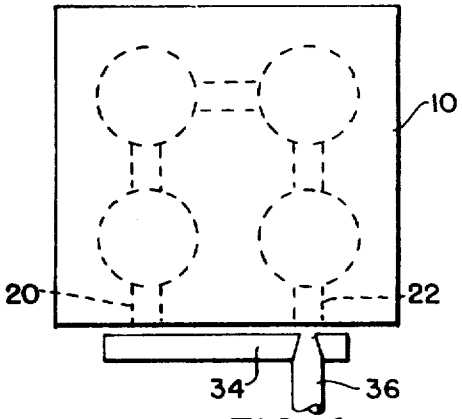


FIG. 4

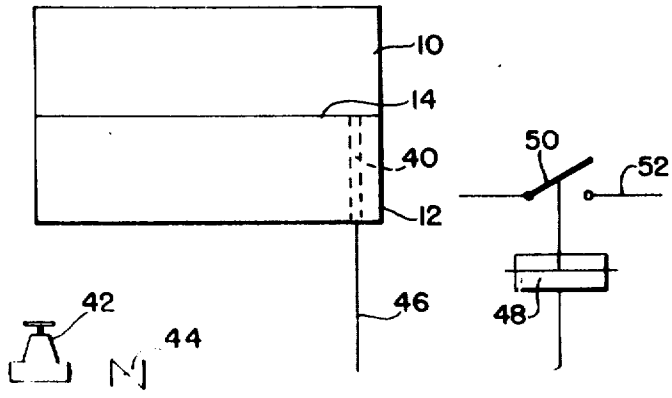


FIG. 5

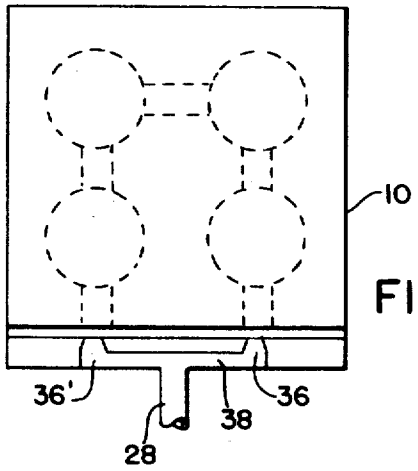

10
36'
36
38
28

FIG. 6

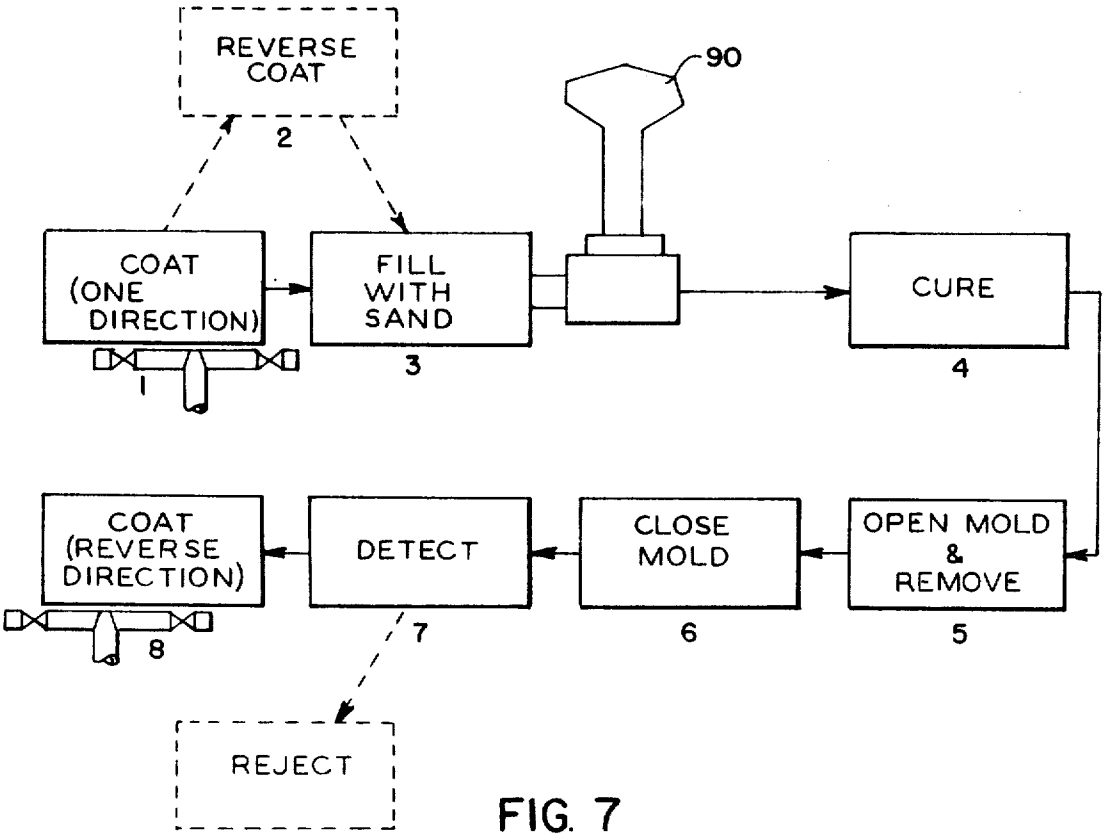

REVERSE COAT
2
90
COAT (ONE DIRECTION)
1
FILL WITH SAND
3
CURE
4
COAT (REVERSE DIRECTION)
8
DETECT
7
CLOSE MOLD
6
OPEN MOLD & REMOVE
5
REJECT

FIG. 7

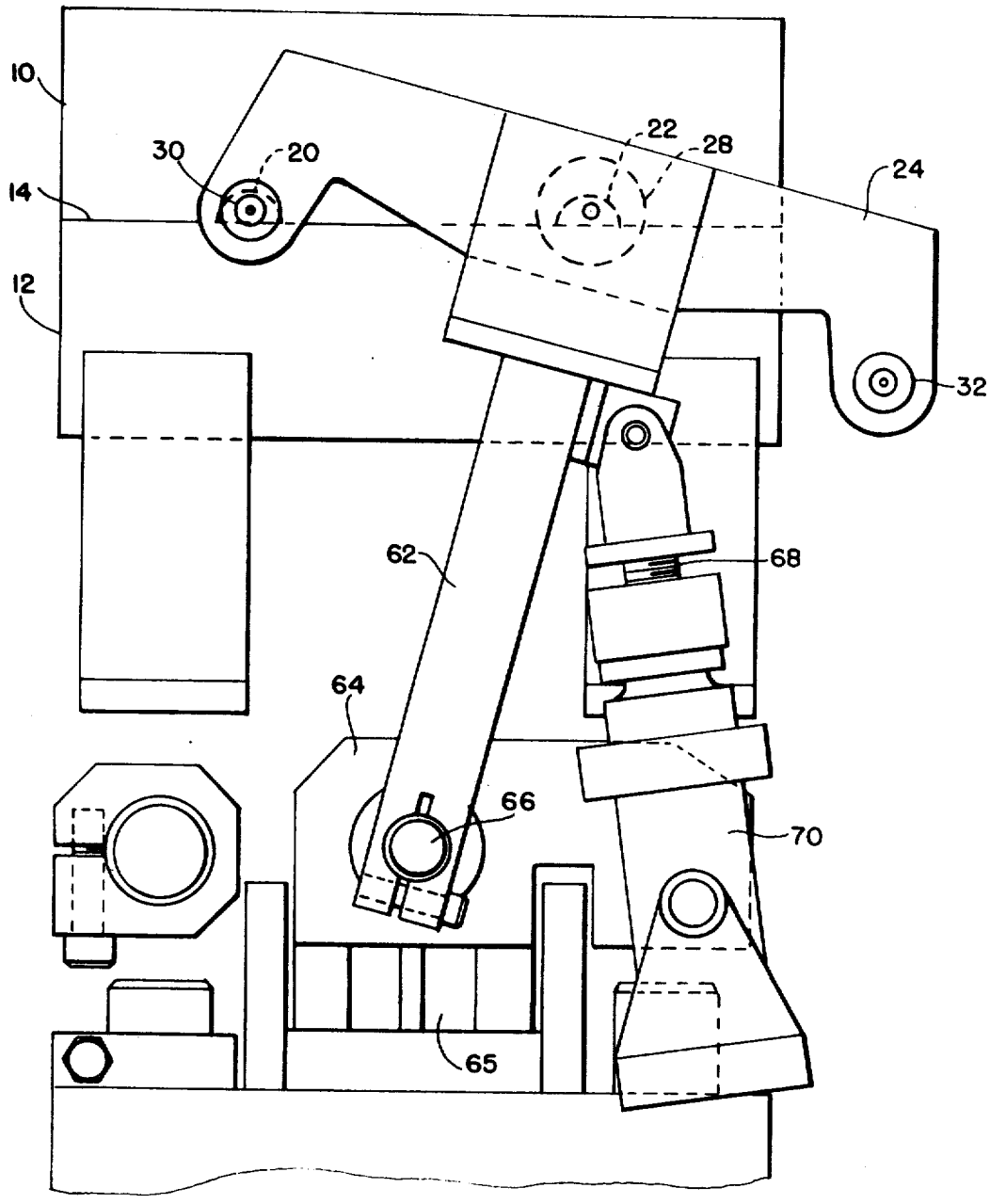


FIG. 8

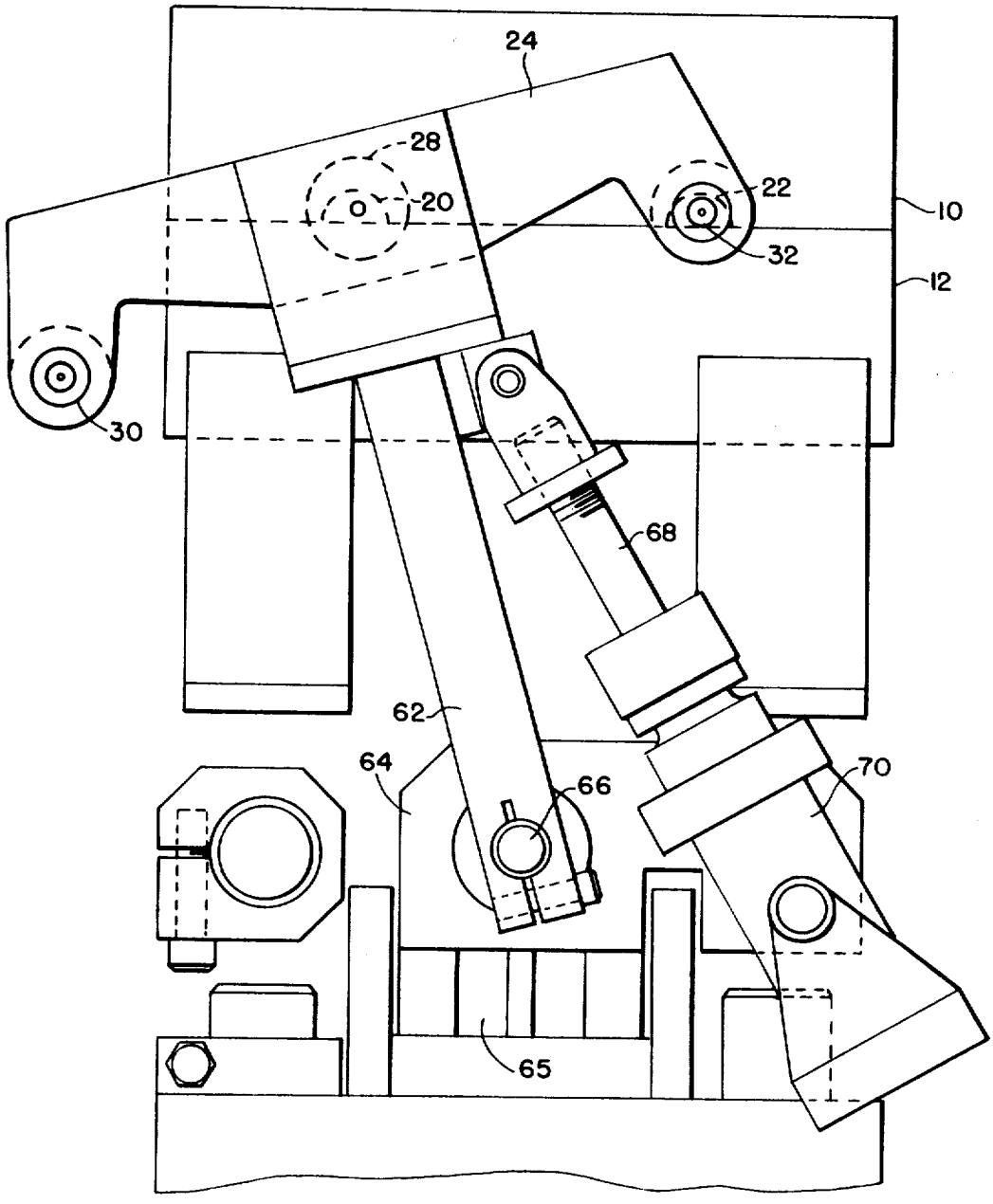


FIG. 9

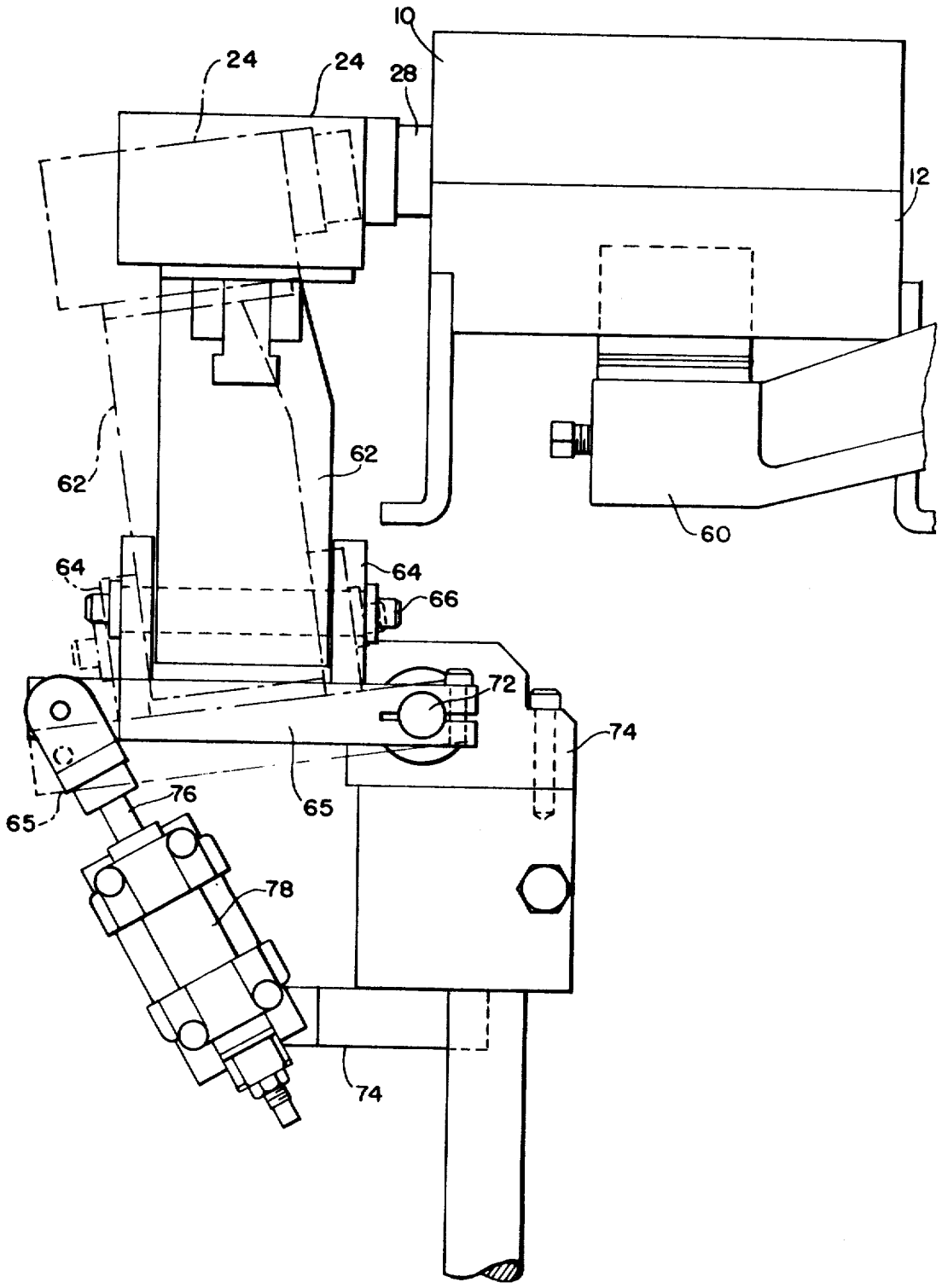


FIG. 10

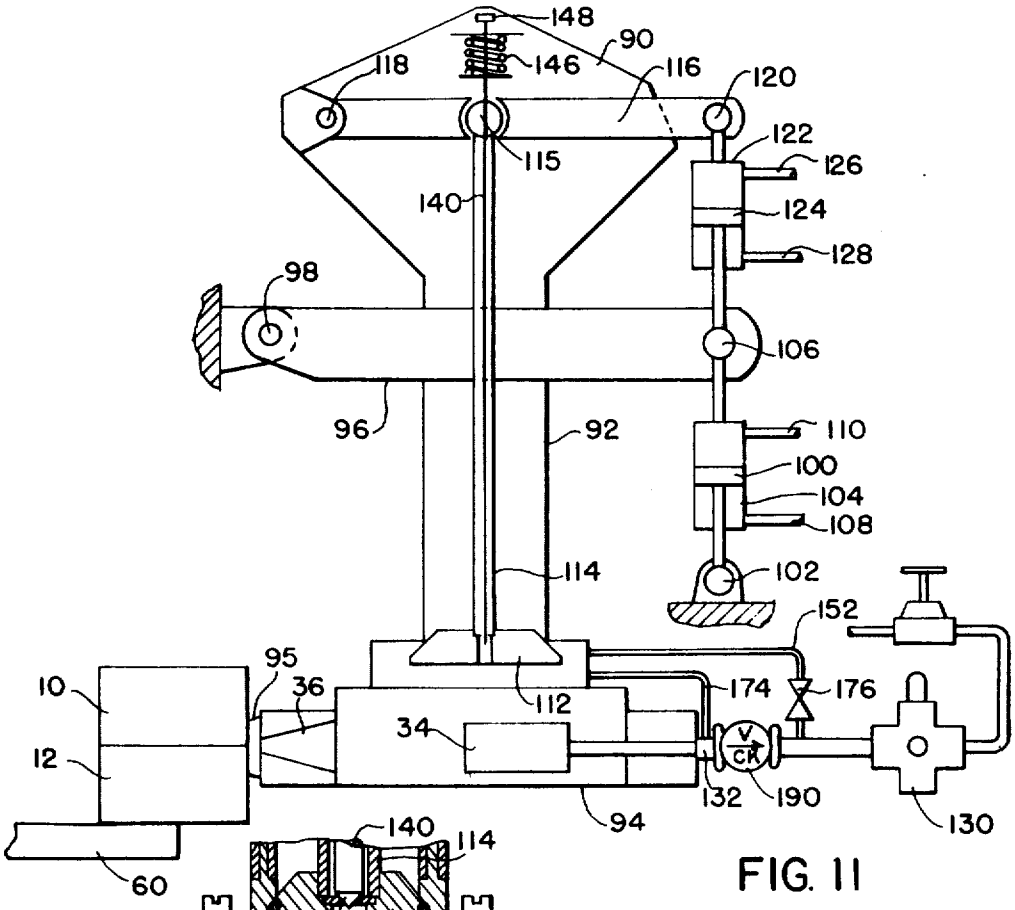


FIG. 11

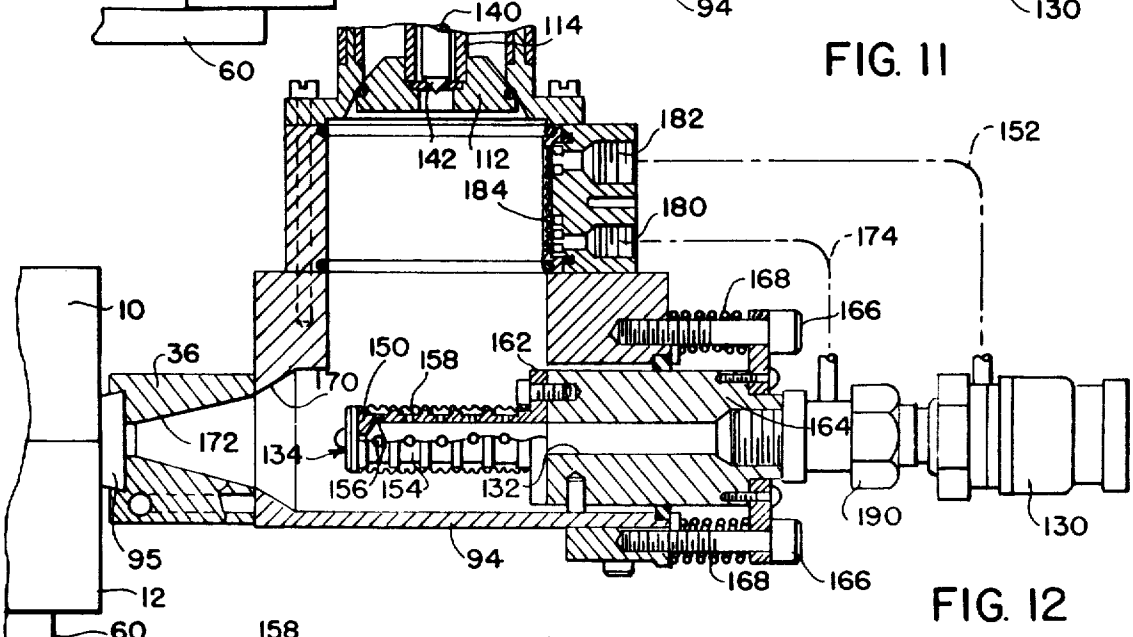


FIG. 12

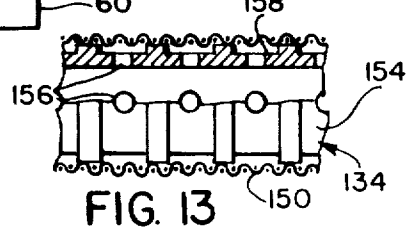


FIG. 13

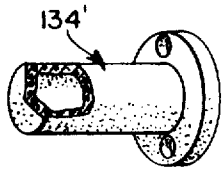


FIG. 14

METHOD OF MAKING MOLDS

This invention relates to the making of molds, for example shell molds for making ferrous metal castings. The invention is concerned with improvements in both the application of parting agent to permanent patterns and with the delivery of mold-forming material into the pattern cavity.

In order to help separate the finished shell mold from the pattern, the walls of the cavity which determine and shape the mold are coated with a parting agent such as a silicon oil which may be applied before each mold is formed. In customary processes the parting agent is sprayed on the exposed cavity surfaces of an open pattern with an air suspension or mist of the parting agent. But the parting agent also coats the surfaces of separation of the pattern. This retains particles of dust or fine sand which may dislodge from the finished molds. Such particles may prevent the subsequent precise mating of the mold halves and prevent precise closing of the pattern. To avoid this I propose to spray the parting agent through a passage into a pattern which is first accurately mated and precisely closed.

With molds with complicated cavity shapes or with a long series of cavities it is sometimes difficult to coat the surfaces evenly, and the last cavity in the series may not receive enough. Sometimes several molds are made successively from the same cavity between successive applications of parting agent and when this is done uneven distribution of the parting agent becomes very important because removal of molds may completely remove parting agent from the last cavity while the first cavity may have enough.

One of the objects of the invention is to increase the reliability and evenness of coating with parting agent.

Another object is to prevent application of parting agent to the parting surfaces of the pattern.

Another object is to provide an improved method for detecting minute separation of parts of a mold which is nominally and apparently closed but actually held slightly open by small obstacles such as grains of molding sand adhering to the surfaces of separation.

Another object is to prevent excessive build-up of parting agent in one part of the pattern.

In the making of large numbers of small inexpensive expendable shell molds it is important that the mold making apparatus operate rapidly, accurately and economically to make precisely formed molds. One of the important requirements of this operation is to transfer small quantities of sand rapidly and intermittently from a sand storage place to a blow box and the rapid and precise filling of the mold cavity from the blow box. Accordingly, another object of the invention is to provide an improved, economical, efficient and rapid device for transferring measured amounts of sand from a storage place into a mold cavity and packing the sand in the cavity to form a precise mold.

Another object of the invention is to provide an improved method and means for maintaining, during the blowing operation, a body of sand having fluid characteristics so that the sand will flow accurately into the mold cavity and be firmly packed to provide a precise mold.

Another object is to provide an apparatus which can readily be moved against the pattern and away from the pattern to permit the coating of the pattern with a parting agent between intervals of blowing the sand into the mold.

These and other objects of the invention will be understood from the following description and from the accompanying drawings which disclose, for illustration only and not by way of limitation, one way of practicing the invention and one form of apparatus for carrying out the process.

FIG. 1 is a diagrammatic side elevation of a pattern for forming molds in accordance with this invention.

FIG. 2 is a diagrammatic plan of the pattern shown in FIG. 1 showing one form of blow-vent nozzle for coating the mold cavity with parting agent.

FIG. 3 is a view corresponding to FIG. 2 showing the blow-vent nozzle in a different position to perform another coating step.

FIG. 4 is a view corresponding to FIG. 2 showing schematically one form of nozzle for blowing molding sand into the pattern cavity.

FIG. 5 is a diagrammatic illustration of one form of device for detecting an inaccurately closed pattern.

FIG. 6 corresponds to FIG. 4 but shows a modified form of the sand nozzle.

FIG. 7 is a flow diagram illustrating successive steps in the making of a mold in accordance with my invention.

FIG. 8 is a partial structural elevation corresponding to FIG. 1 showing one form of apparatus for carrying out this invention with the blow-bent nozzle in the position indicated by FIG. 2.

FIG. 9 is an elevation like FIG. 8 showing the blow-vent nozzle in a position corresponding to FIG. 3.

FIG. 10 is a partially schematic elevation taken from the right of FIG. 8 and 9 showing the movement of the blow-vent nozzle toward and away from the pattern.

FIG. 11 is a schematic elevation of another form of device for blowing sand into the pattern.

FIG. 12 is an enlarged structural section in the plane of the paper showing the lower portion of the sand blowing device illustrated in FIG. 11.

FIG. 13 is an enlarged elevation partly in section of the sand fluidizing nozzle shown in FIG. 12.

FIG. 14 is a perspective partly broken away of a modified form of fluidizing nozzle.

DEFINITIONS

As used here pressure gas means any gas under pressure, including, without limitation air and superheated steam.

Sand means any granular mold-forming material adapted to be packed into a cavity and cured to form a mold. One example, without limitation, is silicon sand, the grains of which have been coated with a curable binder.

Referring in detail to the drawings, 10 and 12 are the top and bottom halves of a permanent metal pattern which mate along a plane of separation indicated by the line 14. The pattern has a series of cavities 16 connected by passages 18 as shown in dotted lines. The bottom half 12 has, at the parting plane, grooves forming passages 20 and 22 from outside the pattern into the series of cavities, there being one passage connecting each end of the series of cavities with the atmosphere as shown in FIG. 2.

A gas suspension of parting agent is sprayed into one of the passages 20 or 22 while venting the other passage 22 or 20. The spray can pass through the entire pattern and coat the walls of each of the four cavities. We spray

with a blow-vent nozzle 24 including a bar 26 carrying spray nozzle 28 and having spaced calibrated orifices 30 and 32 through the bar. When the bar is in position shown in FIG. 2 and with the bar clamped against the side of the pattern, a suspension of parting agent is sprayed through the nozzle 28 into the passage 22, the passage 20 being vented to the atmosphere through the calibrated orifice 30. The size of the exit orifices 30 and 32 is so related to the size of the nozzle 28, to the blowing pressure and to the size of the passages that the suspension is somewhat retarded in being vented to the atmosphere to encourage even coating. After the parting agent has been so applied, and either before or after the removal of a finished mold from the pattern, the pattern can be sprayed in the reverse direction as shown in FIG. 3 in which the blow-vent nozzle has been moved so that the nozzle 28 sprays into the pattern passage 20 and the passage 22 is vented through the orifice 32.

The reverse blowing of parting agent has various advantages. As parting agent is sprayed into one passage (e.g., 22) it tends to coat the early part of the passage through the pattern (including the cavities) more heavily than the later part of the passage near the exit 20. Not only does reverse blowing promote even coating, but this even coating tends to prevent excessive build-up of parting agent during the repetition of the process in making a large number of molds. Repeated removal of cured molds progressively removes or consumes the parting agent. If the parting agent were sprayed always from the same end, and sufficient agent were maintained at the other end, an undesirable quantity would build up near the apply end.

The invention includes spraying alternately from opposite ends of the pattern successively even when a single spray in one direction is enough to coat the pattern between making one mold and making the next. Thus in FIG. 7 at station 1 the mold cavity may always be sprayed through passage 22 but may be sprayed, for example, every other time a mold is made, or every fourth time. At station 8 the mold cavity may be sprayed only through passage 20, but may be sprayed only in the intervals between spraying at station 1. This tends to even the consumption of the parting agent, even if every application, while sufficient, is not uniform.

Since the parting agent is applied only when the mold halves are accurately mated and since the passages and cavities of the pattern are exposed to the atmosphere through a vent which controls the pressure in the cavities and prevents the development of an excessive pressure, no parting agent reaches the surfaces of separation of the pattern.

The gas used for blowing the parting agent may be superheated steam. This appears to reduce the viscosity of some parting agents and to distribute them evenly. Also it tends to prevent cooling of the mold between curing operations which would otherwise occur with compressed air.

When the parting agent has been satisfactorily applied to the pattern, whether in a single stage as illustrated in FIG. 2, or two successive stages as illustrated in FIGS. 2 and 3 together, the pattern is ready to be filled with sand. Referring to FIG. 4, we pack the cavities by blowing sand into one of the passages, for example, 22, while closing or blocking the other passage 20. This provides a single dead-end passage for delivering an air suspension of treated sand into the pattern. It will be understood that the pattern is provided with small air vents, as is known in the art, to permit the escape of the air from the suspension of sand grains while preventing the escape of the sand and thus effect packing. Such vents occur around ejection pins which have a carefully determined clearance between the pins and the holes in which they are mounted. This is customary molding practice and being well known is not illustrated here.

It is important to prevent flow of sand and air out of one of the passages 20 or 22 when blowing the sand into the pattern. To this end we provide a sand blow nozzle as shown in FIG. 4, in which a bar 34 carries the nozzle 36 and is elongated to cover the passage 20 while the nozzle 36 is opposite the passage 22. When the bar is clamped against the pattern this effectively closes the passage 20.

One very good way of preventing flow out of the passage 20 while blowing sand into the passage 22 is to blow sand into the mold cavity through both passages at the same time, for example with a twin sand blow nozzle as illustrated in FIG. 6. Sand is blown simultaneously into both passages 20 and 22 through two sand nozzles 36' and 36' in a manifold 38.

The process of making molds includes the following steps: close pattern, apply parting agent, blow sand, cure mold, open pattern and remove finished mold, close pattern, apply parting agent if necessary, blow sand, and repeat.

It sometimes happens that when the pattern is open dust adheres to the parting surfaces. This is particularly apt to happen when the pattern is open for removing a finished mold. While the mold is formed of a closely packed, adhered and cured body of sand grains, it is possible for very fine sand grains to dust off and get on the parting surfaces of the pattern. Sometimes these are too small to be noticed but they prevent the precise closing of the pattern and this prevents the making of accurate molds. This opening may be so small as not to be apparent to the operator or the pattern may be so covered with shields or other parts of the machine that it is difficult for the operator to see the mold.

In order to detect when a mold is held slightly open while nominally and apparently closed a passage 40 is provided through one of the pattern halves to the surface of separation as shown in FIG. 5. When testing the pattern for separation we blow into this passage air from a source of regulated constant pressure through a fixed orifice of definite size and I measure the pressure between the orifice and the surface of separation. This may be done by apparatus shown in the United States patent of one of us, Walter H. Van Deberg, U.S. Pat. No. 3,029,629, Apr. 27, 1962, and in the application of said Van Deberg, executed of even date herewith, titled SEPARATION 179 DETECTOR, the disclosures of which are incorporated herein by reference.

Referring to FIG. 5, air is supplied from a pressure regulator 42 through a calibrated orifice 44 to a test line 46 from which it is delivered into the passage 40 through a pressure tight connection. Pressure in the line 40 is measured by any suitable sensor 48, which may be a flexible diaphragm clamped between two halves of a chamber and carrying a rod which, when

there is high pressure in line **46**, holds open a switch **50** in an electric circuit. An open switch indicates that the pattern is closed. When the switch **50** closes, indicating an open pattern, the electric circuit **52** may make a visual or audible signal or may reject the pattern so that the parting agent may not be applied or so that sand will not be blown in. I use the term reject to include anything which prevents use of the pattern, for example physically removing the pattern from proximity to the blow-vent nozzle or from proximity to the sand blow nozzle, or activating mechanism to cause the pattern to pass by the nozzles while preventing operation of the nozzles.

The invention includes mounting a series of patterns on a transfer device such as a rotary indexing table **60**, for example like that shown at **10** in the U.S. Re. Pat. No. 26,218 to Earl A. Thompson, June 6, 1967, the disclosure of which is incorporated by reference herein. The table is intermittently rotated, to present each mold successively to a series of stations in which the operations diagrammatically indicated in FIG. 7 may be performed.

At station **1** the mold may be coated with parting agent sprayed in one direction as indicated in FIG. 2. At optional station **2** the pattern may be sprayed with parting agent in the reverse direction as indicated in FIG. 3. Alternatively the pattern may pass by station **2** depending on whether or not a reverse coating is required. At station **3** the pattern may be filled with sand either as indicated in FIG. **4** or as in FIG. **6**. At station **4**, which may include prolonged exposure in a heater, the mold is cured in any well known manner. At station **5** the pattern is opened and the finished mold removed. At station **6** the mold is closed. At station **7** the mold is tested for precise closing as indicated in FIG. **5**. If the mold is not closed it is rejected in any one of the ways indicated above. At station **8**, if the mold is not rejected it is coated with parting agent again, if this is necessary, and this may be done either in a single stage illustrated in FIG. **2** or in two stages as illustrated in FIG. **3**. Then the cycle is repeated as described above.

In one form of machine for practicing the invention patterns **10–12** are attached at intervals around the circumference of the table **60** corresponding to the positions of the fixtures **114** of the reissue patent. The table is rotated step by step as disclosed therein, stopping with a pattern at each station. Blow-vent nozzles **24** and sand blow nozzles **36** are placed at the various stations, corresponding to stations **14** in the reissue patent, to perform the operations described above whenever the table is at rest.

The parts **24**, and **36** may be constructed as shown in FIGS. **10–14**. As seen in FIGS. **8** and **9**, arm **62** carries the blow-vent nozzle **24** and is pivoted between the arms **64** of a pivoted yoke **65** by a shaft **66**. The rod can be rocked in the yoke to move the blow-vent nozzle between its FIG. **8** (or FIG. **2**) position and its FIG. **9** (or FIG. **3**) position by a piston rod **68** sliding in a double-acting cylinder **70** pivoted to the yoke. The piston rod may be activated by suitable hydraulic apparatus like that shown in the reissue patent by having the cylinder form part of a hydraulic link such as a, c or e in FIG. **5** of that patent.

The pivoted yoke **65** is clamped to a shaft **72** (FIG. **10**) journaled in a fixed support **74** so that the entire structure including blow-vent nozzle **24**, arm **62**, yoke **65**, and cylinder **70** can be rocked selectively to clamp the blow-vent nozzle against the pattern, as in full lines in FIG. **10**, or move away from the pattern (dotted lines in FIG. **10**) to let the table be moved. This rocking is done by a piston rod **76** pivoted to the yoke **65** (FIG. **10**) and sliding in a double-acting hydraulic cylinder **78** pivoted to the support **72**. The cylinder may be actuated as shown in the Reissue patent. In the position of FIG. **8** the central nozzle **28** discharges into the first passage **22** in the pattern and the passage **20** is vented through the control orifice **30**. The nozzle **28** is supplied with a suspension of parting agent by any suitable connection, not shown, connected to a timed control valve, not shown. In the position of FIG. **9** the nozzle **28** discharges into the passage **20** of the pattern while the control orifice or vent orifice **32** vents the passage **22**.

FIGS. **11** and **12** show diagrammatically and structurally one form of device for blowing sand into the patterns. A sand hopper **90** including a discharge tube **92** is attached to the upper side of a sand blow box **94** which carries and communicates with a sand blow nozzle **36** which may have a seal **95** which can be pressed against the pattern **10–12**. The hopper and blow box together form a rigid structure which is rigidly supported on a bar **96** pivoted to a fixed support at **98** so that the bar can be swung up and down by a rod and piston **100** pivoted at **102** to a fixed support and sliding in a double acting hydraulic cylinder **104** pivoted at **106** to the bar **96** and supplied by a hydraulic lines **108** and **110**. When there is higher pressure in the line **110** then in the line **44** the link formed by the cylinder and piston rod is lengthened to raise the right end of the rod **96** to tilt the sand hopper to move the blow box away from the pattern **10–12**, in order to permit the table **60** to be indexed or to permit another form of device such as a parting agent blower to be pressed against the pattern.

Sand contained in the hopper **90** can drop into the blow box when a sand valve **112** opens downward at the bottom of the tube **92**. The valve is pivoted to a link **116** pivoted at its left end to the hopper at **118** and pivoted at its right end at **120** to a double acting hydraulic cylinder **122** having a piston and rod **124** pivoted to the bar **96** at **106** and supplied by hydraulic lines **126** and **128**. The valve **112** may be supported by a tube **114** pivoted at **115** in the link **116**. When there is higher hydraulic pressure in the line **126** this tends to lengthen the link formed by the cylinder, piston and rod, and this holds the valve closed. When there is higher pressure in the line **128** the valve is dropped to admit sand to the blow box. Opposite ends of the cylinder **122** may be pressurized to open or close the valve by a hydraulic link corresponding to the link **314*a*** in the Reissue patent referred to.

It is contemplated that at each opening of the valve **112** a quantity of sand approximately equal to that required to fill the mold cavity will be dropped into the blow box. The maximum quantity of sand in the blow box at this time will be about 25 percent more than required to fill the mold and will substantially fill the blow box, although it may be slightly less than the capacity of the blow box.

It is desirable that this charge of sand be delivered from the hopper to the blow box as rapidly as possible and since this may occur under the action of gravity it may be necessary to vent the blow box as sand is being dumped into it. For this purpose we provide a vent valve in the sand valve connected to the atmosphere. This is the conical end **142** of a rod **140** cooperating with a valve seat secured to the end of the tube **114**. The rod **140** is grounded at the top of the hopper to a spring **146** so that as the sand valve **112** descends in opening, the rod **114** follows it for a short distance until stopped by a flange **148**. Further movement of the sand valve **112** opens the vent valve **142**.

One form of actual structure of the blow box is shown in FIG. **12**.

With the blow box **94** held against the pattern **10–12** by the cylinder **104** the valve **112** is momentarily opened to deposit the desired quantity of sand. Then the valve **112** is closed and air under pressure is admitted by a valve **130** to the interior of the blow box to blow sand into the pattern until the cavity is tightly packed with sand, leaving some sand remaining in the blow box. Thereafter the valve **130** is closed, the blow box is vented to relieve pressure therein through vent line **152** and the entire apparatus is swung away from the pattern **10–12** to allow table **60** to be rotated.

Two conditions are important in blowing sand satisfactorily into the pattern. The sand should be in a condition approximating that of a fluid and there should be a moving force on the top surface of the sand.

The first is achieved by blowing air under pressure into the body of the sand below its top surface and distributing this air throughout the sand to produce an air-sand mixture which has fluid characteristics analogous to the properties of quick sand. This fluid condition is achieved by the air nozzle **134** in FIGS. **12** and **13**. This is a hollow tube **154** having an interior passage which is an extension of the passage **132** and which is connected through radial passages **156** with exterior grooves **158** inside a screen **160** which surrounds the tube. The nozzle **134** has a flange **162** by which it is attached to an adjustable plug **164** through which the passage **132** is formed. The plug can be adjusted in and out by screws **166** and springs **168**.

Alternatively the nozzle **134'** shown in FIG. **14** can be formed as a hollow cylinder of porous sintered metal analogous to the metal used for porous self-lubricating bearings.

Preferably the nozzle extends substantially across the width of the blow box and is aligned with the blow nozzle **36** and extends close to a tapered opening **170** which matches the tapered opening **172** of the interior of the blow nozzle **36**.

It is important to maintain the proper ratio of volume of sand to air flow through the nozzle **134**. The air admitted through the nozzle **134** fluidizes the entire body of sand in the blow box. The force which flows the sand into the pattern may be the force of air pressure on top of the sand in the blow box, plus the force of fluidizing air, the air being admitted through the passages **132** and **174**, whenever the valve **130** is open. The pressure on top of the sand should be equal to or preferably greater than the pressure of the air within the body of the sand in order to achieve satisfactory flow of sand and to prevent the air from the nozzle **134** causing a sand storm in the space above the sand above the blow box. The pressure above the sand will be the pressure of the air supply while the pressure within the sand will be somewhat less due to the resistance to flow through the nozzle **134** and through the sand itself. The required balance between air pressure on top of the sand and fluidity can be determined by proper adjustment of the plug **164** in or out and by proper proportion of the passages **156** and **158** and screen **160** (or alternatively the porousity of the nozzle **134'**). A choke may be placed in the passage **132**.

As will be seen from FIG. **11**, whenever the valve **130** is turned on air pressure is supplied to the nozzle **134**, to the supply line **174** and to the vent line **152**. The supply to the vent line is insignificant because of the line **174**. It is important to vent the space above the chamber whenever the air supply is cut off as has been explained and it is important that this space be vented slowly in order to prevent even temporarily a higher pressure in the body of the sand than above it. To this end the vent line **152** has a choke **176** to reduce the pressure slowly above the sand.

FIG. **12** shows the air supply and vent connection to the space above the sand and the blow box. The wall of the blow box is provided with an opening **180** for connection to the line **174** and an opening **182** containing the suitable choke **176** for connection to the vent line **152**. A screen **184** may be placed over these openings.

When the air supply is interrupted it is possible to have a higher pressure in the blow box than in the passage **132**. This tends to force fine sand or dust from the sand and into the passage **132**. This could eventually work into the system and interfere with the proper operation of the valve **130**. To prevent this a check valve **190** is placed in the supply line between the valve **130** and the nozzle **134**, as close to the nozzle as practical and at any rate between the nozzle and the connection of the vent line **152**.

In an alternative arrangement the pressure from air above the sand in the blow box can be dispensed with and the sand flowed into the pattern centrifugally. With such an arrangement the vent line and the fluidizing line would be used and the entire structure would be revolved rapidly about an axis to the right of the blow box as seen in FIG. **12**. Preferably also the L-shaped blow box illustrated would be changed to a straight cylindrical structure arranged radially between the axis of rotation and the patterns **10–12**. The entire structure would be rotated or revolved at any suitable speed to provide the necessary force on the inter-face between the sand and the space in the box which force would be equal to or greater than the force exerted by the air pressure in the sand.

The table **60** is intermittently rotated. When the table is at rest the blow nozzles and sand nozzles are pressed against the patterns, then the appropriate blowing operations are performed, the air supply is shut off and the blow-vent nozzle and sand nozzles are swung away from the patterns. Then the table is advanced to the next position of rest. All of these movements are in timed coordination and can be effected by the actuation and control apparatus disclosed in said Reissue patent. Each of the movements and each opening and closing of a valve to supply parting agent or sand may

be performed by the appropriate cylinders shown herein or other cylinders, not shown, to operate the valves, all of which cylinders are connected to hydraulic links such as *a*, *c*, *e*, *g*, *h* disclosed in said Reissue patent. These are arranged to perform in order the steps illustrated in FIG. 7.

We claim as our invention

1. The method of making a mold in a pattern having a cavity and a pair of passages from outside the pattern into the cavity, which includes blowing a suspension of parting agent through one of the passages and into the cavity, then preventing flow from the pattern out of one of the passages while blowing a gaseous suspension of mold-forming material through the other passage and while permitting escape from the pattern of the gas of the last named suspension to pack the cavity with mold-forming material.

2. The method of making a mold in a pattern having a cavity for forming a mold and having a pair of passages from outside the pattern into the cavity, which includes flowing a gaseous suspension of parting agent through one of the passages and into the cavity to coat the wall of the cavity with parting agent, then flowing a gaseous suspension of mold-forming material through both passages while permitting escape through the pattern of the gas of the last named suspension to pack the cavity with mold-forming material.

3. The method of making a mold which includes using a pattern having a cavity for forming a mold and having a pair of passages from outside the pattern into the cavity, which includes flowing a gaseous suspension of parting agent in one direction through to one of the passages and into the cavity, then flowing a gaseous suspension of parting agent in the opposite direction through the other passage and into the cavity, then preventing flow from the pattern out of one of the passages while flowing a gaseous suspension of mold-forming material through the remaining passage and while permitting escape through the pattern of the gas of the last named suspension to pack the cavity with mold-forming material.

4. The method of making a plurality of molds in a pattern having a series of connected cavities for forming a plurality of molds and having a first passage from outside the pattern into one end of the series of cavities and having a second passage from outside the pattern into the other end of the series of cavities, which includes flowing a gaseous suspension of parting agent through one of the passages and into the series of cavities then preventing flowing from the cavities out of one of the passages while flowing a gaseous suspension of mold-forming material through the other passage and while permitting escape through the cavities of the gas of the last named suspension to pack the series of cavities with mold forming material.

5. The method of making molds in a pattern having a passage through the pattern including a cavity for forming a mold, which method includes blowing a suspension of parting agent in one direction into the passage to coat the cavity, filling the cavity with mold-forming material and forming a mold, removing the mold, blowing a suspension of parting agent in the opposite direction through the cavity to coat the mold and again making a mold in the cavity.

6. The method of making a mold in a closed pattern having a cavity and a passage from outside the pattern into the cavity, which method includes blowing a suspension of parting agent in superheated steam into the passage and into the cavity, then blowing a gaseous suspension of mold-forming material through the passage while permitting escape from the pattern of the gas of the last named suspension to pack the cavity with mold-forming material.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,688,830 Dated September 5, 1972

Inventor(s) WALTER H. VAN DEBERG ET AL

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover sheet [73] the name of the assignee should read -- F. Jos. Lamb Company, Warren Michigan, a corporation of Michigan. --

Signed and sealed this 15th day of May 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.