Feb. 14, 1967 E. M. REARWIN ETAL 3,303,535

SAND MOLD PATTERNS FORMED OF POROUS OR PERMEABLE METAL

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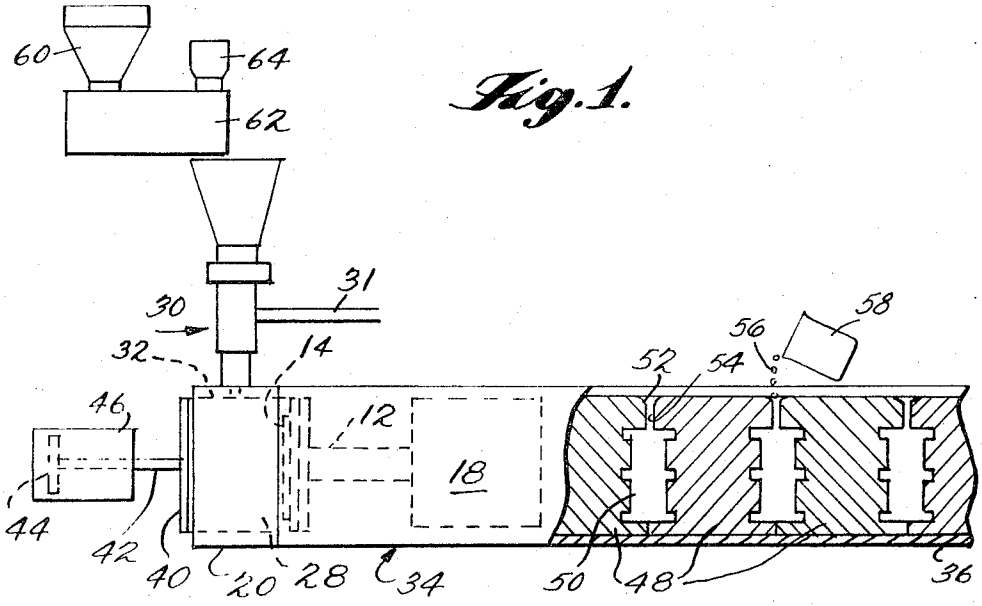

Fig. 1.

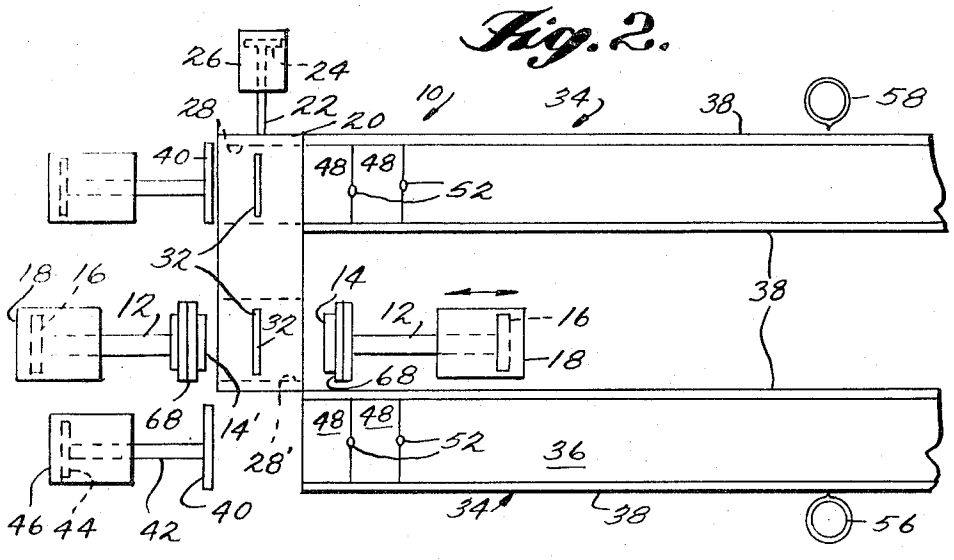

Fig. 2.

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Fig. 3.

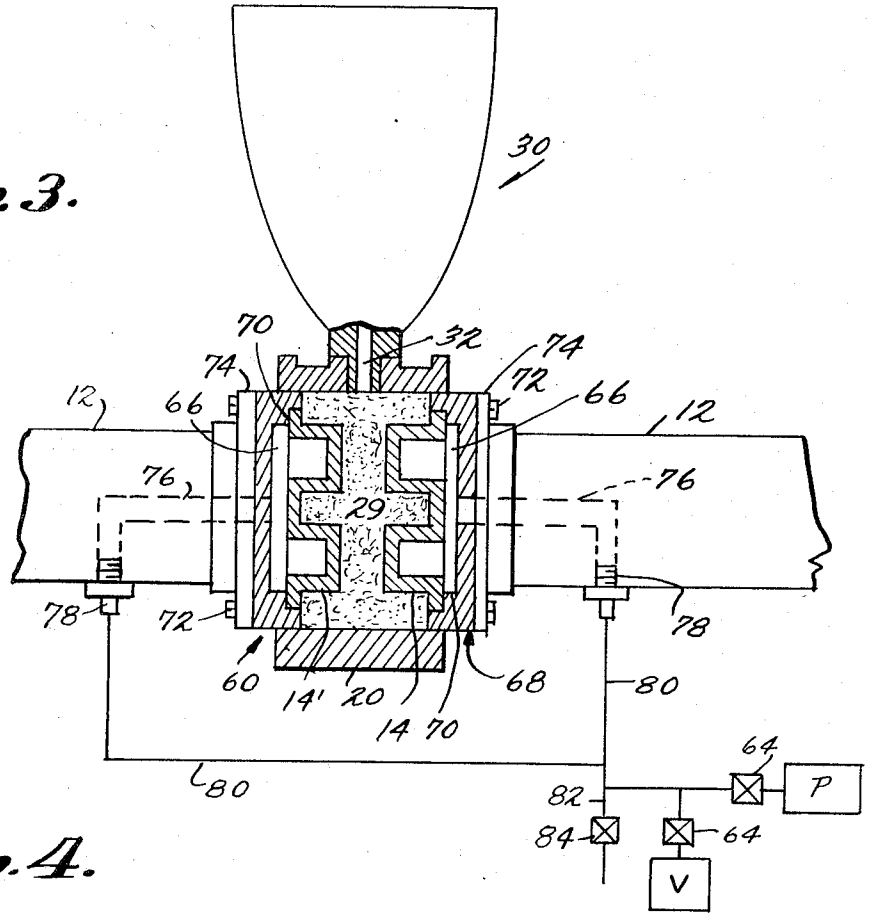
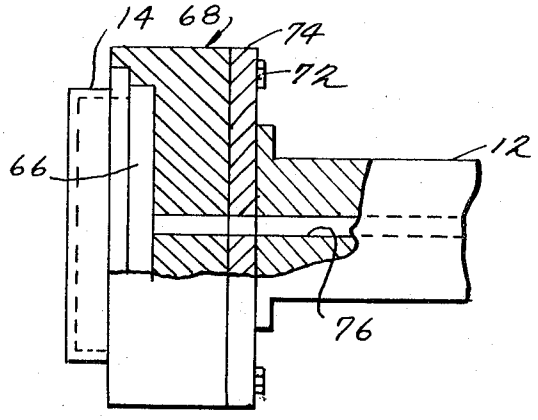


Fig. 4.



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SAND MOLD PATTERNS FORMED OF POROUS OR PERMEABLE METAL

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This invention relates to the manufacture of molds or cores, hereinafter referred to as molds, from mixtures of sand or the like for use in casting operations, and in particular it relates to improvements in the construction and use of pattern plates which are employed to shape the sand mixture.

It is conventional practice to form molds from sand mixtures by compacting the mixture within a frame or flask and in contact with a solid pattern, the contours of which form a complementary cavity in the sand. The patterns are generally constructed of metal but they also may be constructed of wood, gypsum or other material having sufficient hardness and strength. A variety of techniques are employed, depending on the nature of the mixture, the desired strength of the mold and the type of metal to be cast. One often-employed technique involves the blowing of a sand-air mixture into the flask to distribute the sand uniformly therein and then pressing the loosely packed sand with the pattern which is mounted so as to be movable with respect to the flask. The pattern is then withdrawn and the compacted sand block is removed from the flask for use with or without other blocks as a mold. In more sophisticated mold-making machines, such as that described in the patent to Wallwork No. 2,871,527, issued February 3, 1959, the sand blocks are fabricated automatically and continuously so that casting of parts may be carried out continuously.

A problem which often exists in separating a pattern from the pressed sand block is the disruption of the sand at the instant the pattern face is pulled away from the mold impression in the sand. It appears that this difficulty arises because molding sand, when compacted, becomes quite dense and relatively impermeable to gas so that a vacuum is sometimes formed between the sand and the pattern when the two are pulled apart. It has been suggested in the past that small holes drilled through the pattern or through the flask wall or through both will aid in the separation of the pattern from the sand, particularly if compressed air is applied to the holes. While this procedure facilitates separation of pattern from the sand, the holes in the pattern present a disadvantage in that they produce surface mars in the sand which are later transmitted to the casting.

According to the present invention patterns for molding sand or other particulate material are constructed of porous material and are so arranged with respect to the other parts of the mold-forming apparatus that gas can be rapidly and uniformly delivered to all, or at least a substantial portion of the contact area between sand and pattern. By this arrangement, separation of the pattern from its sand block may be rapidly and effectively accomplished without the need for distinct holes in the pattern. In addition, the arrangement provides an excellent, uniform escape route for blowing air so that the usual vents in the flask or pattern may be dispensed with.

The porous patterns of the present invention also permit certain operations which cannot be carried out satisfactorily with conventional solid patterns, even those provided with conventional vent holes. For example, the uniform percolation of carbon dioxide through the sand mixture, as suggested by the Wallwork patent, can be readily carried out. In addition, the moisture content of the sand can be rapidly adjusted and made uniform throughout the sand by passing air or other gas of desired humidity or saturated steam through the pattern. Similarly, the temperature of the mold can be rapidly and uniformly adjusted by passing a gas of the desired temperature through the pattern. For some purposes it is desirable to heat only the pattern and this can be achieved by gasing the pattern before it contacts the sand mixture.

While the invention is applicable to any sand pressing operation it will be appreciated that particular advantages are realized when the porous pattern arrangement is incorporated in an automatic, continuously operating machine, such as that illustrated in the drawings, wherein the steps of the process are conventionally time-controlled and follow closely one after another.

It is a primary object of the present invention to provide an improved pattern for use in compacting mixtures of sand or the like into a mold or core, said improved pattern being uniformly porous over at least a portion thereof so that gases may be rapidly and uniformly delivered and withdrawn through the porous portion.

It is a further object to provide a mold-making machine of the continuously-operating automatic type with a porous pattern whereby separation of the pattern from the compressed sand block may be rapidly effected so as to permit the automatic sequence of mold-forming steps to be carried out rapidly and smoothly.

It is another object of the invention to provide a method and apparatus for rapidly and uniformly delivering or removing gases from a sand mixture or the like which is formed into a mold or core of a desired shape by being pressed into contact with a pattern.

It is another object to provide a method and apparatus for compacting sand molds or cores against a pattern in which provision is made for rapidly and uniformly contacting with a gas the surface of the compacted sand which is in contact with the pattern.

These and other objects and advantages will become apparent from the following detailed description of a mold-making machine taken in conjunction with the drawings in which:

FIGURE 1 is a schematic side elevational view, partly broken away, of a machine for making sand molds;

FIGURE 2 is a top plan view of the machine of FIGURE 1 with some of the parts removed;

FIGURE 3 is a fragmentary vertical sectional view of part of the machine of FIGURE 1 on an enlarged scale; and

FIGURE 4 is a fragmentary top plan view, partly broken away, of part of the machine of FIGURE 1.

Referring to FIGURES 1 and 2, there is shown schematically a mold-making machine **10** of the type fully disclosed in the aforesaid Wallwork Patent No. 2,871,527 with the exception that the present machine **10** is provided with porous patterns embodying the principles of the present invention.

The machine **10** includes a pair of opposed hydraulic rams **12**, each carrying a porous pattern **14**, **14'** at the end nearest the other ram **12**. The other end of each ram **12** connects with a piston **16** contained within a fixed hy-

draulic cylinder 18 so that the patterns 14 may be moved toward and away from each other. Between the patterns is a flask or frame 20 mounted for reciprocal movement in a horizontal plane in a direction normal to the direction of movement of the rams 12. A ram 22 connected at one end to the frame 20 and at its other end to a piston 24 within a fixed cylinder 26 effects reciprocal movement of the frame 20.

The frame 20 is a generally rectangular element having two horizontally spaced openings 28, 28' therethrough, each of which is sized to receive the patterns 14, 14' when the rams 12 are extended. Thus, each opening 28, 28' is capable of forming a chamber into which a sand mixture 29 (FIGURE 3) may be introduced and subsequently pressed by further extending the rams 12. In the type of machine illustrated, a conventional sand blowing head 30 having a compressed air line 31 is mounted above the frame 20 between the patterns 14, 14' and is adapted to be lowered into engagement with the top of the frame 20. The discharge of the sand blower 30 is thereby placed in communication with one of two blowing slots 32 each of which extends through the top of the frame 20 and communicates with one of the openings 28, 28'.

After a sand mix has been blown into one of the openings 28, 28' and compressed between the patterns 14, 14', the rams 12 are retracted so as to separate the patterns from the sand block 29 and from the frame 20. One of the important advantages of the present invention is that the porous patterns 14, 14' prevent the formation of a vacuum between the sand and the pattern face and thereby permit rapid separation of the patterns without damage to the sand block. The ram 22 is then operated to move the frame 20 transversely of the patterns 14, 14' so as to place the other of the openings 28, 28' between the patterns 14, 14'.

Spaced from opposite sides of one of the rams 12 and extending parallel thereto are a pair of upwardly facing fixed channel members 34, each having a bottom wall 36 and a pair of upstanding side walls 38 which form a channel of the same dimensions as the openings 28, 28' in the frame 20. The ends of the members 34 are disposed immediately adjacent the path of travel of the frame 20 and are so spaced apart that upon movement of the frame 20 the opening 28 is alignable with one of the members 34 and the opening 28' is alignable with the other member 34.

Opposite the end of each of the channel members 34 and on the other side of the frame 20 is an ejector plate 40 sized to fit within one of the openings 28, 28' in the frame 20. Each ejector plate 40 is connected to a piston rod 42 and a piston 44 contained within a fixed cylinder 46 so as to be reciprocal in the same direction as the patterns 14, 14'. Upon extension of the appropriate piston rod 42 one of the ejector plates 40 will push the compacted sand from one of the openings 28, 28' in the form of a block 48 which has a pattern imprint on each of two opposite faces thereof. Each block 48 is pushed onto its respective channel members 34 and into engagement with the next preceding block from the same opening in the frame. As a result, a mold cavity 50 is formed between each two adjacent blocks 48, one half of each cavity 50 being defined by the imprint in one face of one block. As will be understood by those familiar with the art, the patterns 14, 14' and/or their support structures are provided with configurations for forming suitable sprues 52 and gates 54 at the top of each mold cavity 50 so that molten metal 56 can be poured into the cavities from ladles 58.

Sand for forming the blocks 48 is supplied to the blowing head 30 in any convenient manner as by means of a sand hopper 60 and mixer 62. A second hopper 64 also feeds into the mixer for delivering binding agents for the sand if desired.

The various movable elements of the machine 10 are controlled to operate automatically in sequence. No description of a control system is given inasmuch as such systems are conventional in the art and form no part of the present invention.

According to the invention and referring to FIGURES 3 and 4, the patterns 14, 14' are constructed of porous material so that gas may pass readily therethrough. As pointed out above, one of the principal advantages of the porous construction is that vacuum between parts of the pattern faces and the sand 29 is either prevented from forming during the pressing step or readily relieved if it does form.

The porous material from which the patterns are constructed is not critical, it being necessary only that the patterns have sufficient strength to form the desired impression in the sand and have sufficient permeability to permit the flow of gas therethrough for rapidly releasing the pattern from the compacted sand. Of course, the pressing temperatuers to be used, the nature of the sand mixture and the desired smoothness of the impression to be formed will also influence the choice of pattern material. It has been found that sintered metal stock of the type conventionally used to make bushings or filters has the required strength and porosity for most applications, and in addition, they may be easily cleaned by forcing suitable cleaning solutions through their pores. Patterns constructed of sintered, tin-coated powders of brass and bronze have given good results.

Almost any inert particulate material may be used, cohesion of the particles being achieved by any necessary combination of heat, pressure and binder material. In some instances, uniformly graded sand in admixture with a thermosetting resin can be used, but patterns formed in this manner are usually too brittle for most applications. It will be appreciated that some uses of the patterns require a more open free-flowing structure to pass fluids readily while others demand smaller pores and a tighter structure for better surface finish on the sand and higher static pressure drop. Patterns of the desired porosity can be obtained by proper selection of the particle size of the particulate material and the pressure and temperature employed in making the patterns. If desired, the porosity of a given metal pattern may be increased by passing acid therethrough to dissolve some of the metal.

In order that the porosity of the patterns 14, 14' may be effective it is highly desirable that a chamber or cavity be provided adjacent and substantially coextensive with the side of each pattern which faces away from the sand mixture 29. The purpose of this arrangement is to assure generally uniform fluid pressure over the backs of the patterns so that generally uniform flow of fluid through the patterns over its entire surface will be achieved. In the embodiment illustrated such a chamber 66 is provided by setting each pattern 14, 14' into a rigid frame 68 which consists of a thick metal plate having a cavity in one face thereof adapted to engage and support only the edges of the respective pattern. As shown, the cavity in each frame 68 has an inwardly extending, peripheral shoulder 70 which engages the periphery of the respective pattern so that the fluid chamber 66 is defined by the inner wall of the frame 68 and the rear surface of the respective pattern. The patterns 14, 14' are secured in the frames 68 in any suitable manner.

Each frame 68 is secured to the end of one of the rams 12 as by means of bolts 72 which pass through a platen 74 forming part of the ram. Fluid communication between each chamber 66 and the exterior of the machine is provided by means of a passage 76 extending through the back of the frame 68, the platen 74 and the ram 12. At a convenient location on the rams the passages 76 communicate with fittings 78 which are connected by means of flexible lines 80 to a system for venting or pressurizing the chambers 66. As shown, the system includes a pipe 82 having an end open to the atmosphere, a vacuum source V and a gas pressure source P and valves 84 for completing whichever connection is de-

sired. The source P may be simply a compressed air source or it may also include a heater for the air and a steam source.

It will be understood that the manner in which the fluid chambers **66** are connected to various fluid sources is not critical and that any suitable mechanical arrangement may be employed for the purpose. It will be understood also that the fluid chambers **66** may be formed in other ways than that illustrated, it being necessary only to provide free flow of fluid over a substantial portion of the surfaces of the patterns **14**, **14'**. In the case of large or intricately shaped patterns it may be desirable to provide several small chambers separated from each other by reinforcing partitions.

The operation of the machine **10** has been described in general terms along with the description of its components. Starting with the components in the positions shown in FIGURE 2, the two rams **12** are extended from their fixed cylinders **18** to positions at which the pattern support frames **68** enter part way into the opening **28'** in the movable flask **20** and thereby form a closed molding chamber. The sand-blowing head **30** is then lowered to place its discharge opening in communication with the respective blowing slot **32** and molding sand **29** is blown by means of compressed air into the molding chamber. Simultaneously, the fluid chambers **66** behind the porous patterns **14**, **14'** are either vented to atmosphere through pipe **82** or connected to the vacuum source V in order to allow the blowing air to escape from the molding chamber by passing through the patterns **14**, **14'**.

After the sand-blowing operation, the rams **12** are further extended from their fixed cylinders **18** in order to compress the sand **29** into a more or less self-supporting block having a pattern impression in each of two opposite sides. In desired, various heating, moisturizing or drying steps may be carried out on the sand **29** before, during or after the pressing operation by connecting the fluid chambers **66** to the appropriate source of pressurized treating fluid. In a similar manner the patterns alone may be pre-heated or otherwise pretreated prior to the sand-blowing step.

Upon completion of the pressing step the rams **12** are retracted in order to separate the patterns **14**, **14'** from the pressed sand block. The primary advantage of the invention is realized at this time by supplying compressed air to the fluid chambers **66** behind the patterns **14**, **14'** so as to assure rapid, effective separation of the patterns from the sand without disturbing the latter.

The movable frame **20** is then moved into alignment with one of the tracks **34** by extending the piston rod **22** from its fixed cylinder **26**. The sand block **48** carried within the opening **28'** in the frame **20** is then pushed out onto the track **34** by means of the ejector plate **40**. At this time the opening **28** in the flask **20** is in alignment with the patterns **14**, **14'** and the blowing and molding steps are repeated. Upon subsequent retraction of the piston rod **22** the frame is returned to its FIGURE 1 position whereupon the block of sand in the opening **28** is ejected onto the other track **34**. Casting of molten metal from the ladles **56** into the mold cavities **50** between adjacent sand blocks **48** on each track **34** may then be performed.

While the patterns **14**, **14'** are preferably constructed wholly of porous material, as illustrated in the drawing, it may be desirable in some cases to construct only a portion or portions of the patterns of porous material. For example, it might be found that removal of a particular pattern shape tends to disrupt the sand only in one or more distinct areas. Under these conditions it may be desirable to use porous material only for those areas, as by constructing a conventional metal pattern, drilling out the necessary portions and replacing the drilled out portions with sintered inserts which have been formed into the necessary shapes.

From the above description, it will be apparent that the present invention assures that rapid and effective separation of a pattern from compacted sand is effected without the use of conventional vent holes which produce surface blemishes on the mold cavity. As pointed out before, this is of particular advantage in a continuous, automatic mold-forming process where each pattern separation step, like the other steps, must be performed within a constant, predetermined length of time. In processes which combine mold production and casting in a continuously operating system, such as that described here and in the aforesaid Wallwork patent, the present invention assures that the complete process will not be adversely affected by difficulties associated with the separation step. While a specific embodiment of the invention has been described and illustrated it will be apparent that modifications thereof may be made within the scope of the invention and it is not intended that the details of the embodiment be limiting except as they appear in the appended claims.

What is claimed is:

1. In an apparatus for shaping a mixture of sand or the like into a relatively self-supporting body by compressing the sand in contact with a rigid pattern: flask means and at least one rigid pattern defining together a sand retaining chamber; said pattern being contoured to impress a complementary contour in the sand and having a substantial portion constructed of porous, gas-permeable material having a large number of small diameter passageways therethrough, said portion extending from the front surface of said pattern which contacts the sand to the rear surface of said porous portion; a pattern support plate carrying said pattern, said plate having a cavity therein facing the rear surface of said pattern and defining therewith a second chamber which is coextensive with said porous portion, said plate having an aperture therein for introducing or withdrawing fluid from said second chamber whereby flow of fluid may be effected through said porous portion in either direction, said pattern support plate being movably mounted relaitve to said flask means whereby said flask means may be opened and closed.

2. Apparatus as in claim **1** wherein said cavity has a peripheral shoulder engaging and supporting the peripheral edge of said pattern.

3. Apparatus as in claim **1** wherein said porous portion is sintered metal.

4. Apparatus as in claim **1** wherein the pattern is constructed wholly of porous material.

5. In an apparatus for rapidly and continuously producing sand molds for use in casting operations, said apparatus including a flask having an opening therethrough, means for closing the ends of said opening so as to form a mold-forming cavity in which a sand mixture may be compressed, said closing means comprising at least one pattern means which is movable toward the other end of said opening so as to compress the sand mixture into a block, and means for removing the sand block from said opening, the improved construction for the pattern means which comprises: a pattern plate having a substantial portion constructed of porous, gas-permeable material having a large number of small diameter passageways therethrough, said portion extending from the front surface of said pattern plate which contacts the sand mixture to the rear surface of said pattern plate, and conduit means communicating with the rear surface of said porous portion for passing fluid through said porous portion, said conduit means including structure defining a chamber disposed rearwardly of said pattern plate, the rear surface of said porous portion forming at least part of a wall of said chamber, another wall of said chamber having an aperture therein for introducing or withdrawing fluid from said chamber.

6. Apparatus as in claim **5** wherein said porous portion is sintered metal.

7. Apparatus as in claim **5** wherein the pattern is constructed wholly of porous material.

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