Oct. 1, 1957 J. C. SAWYER 2,807,845

SHELL MOLD AND METHOD OF MAKING SAME

Filed April 7, 1953 2 Sheets-Sheet 1

Fig. 1

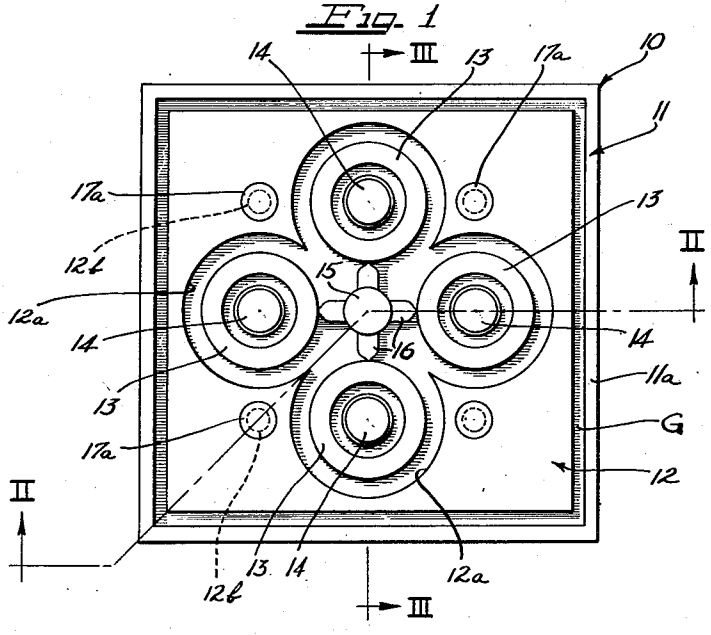


Fig. 2

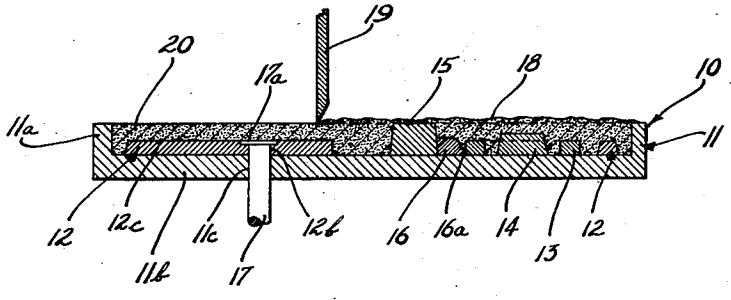
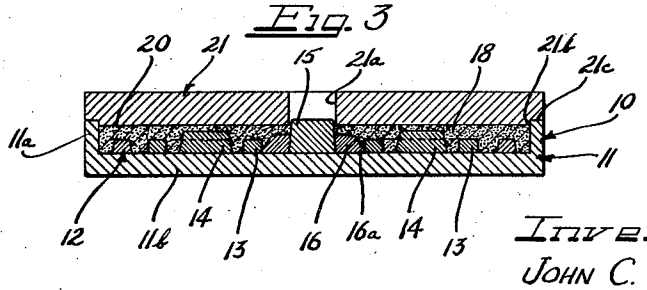


Fig. 3



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Fig. 4

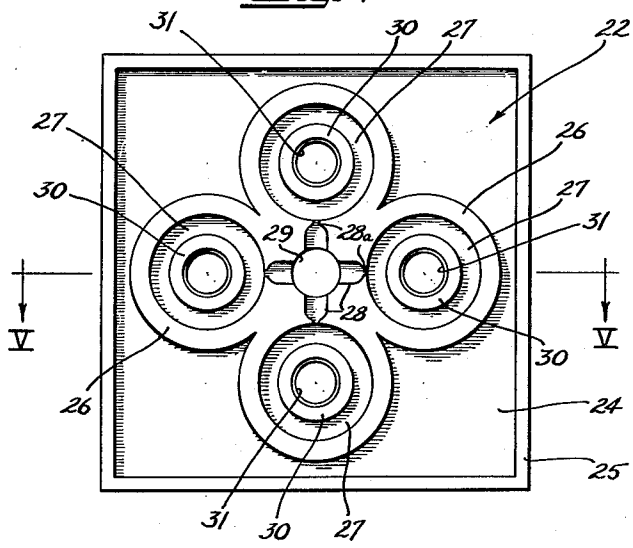


Fig. 5

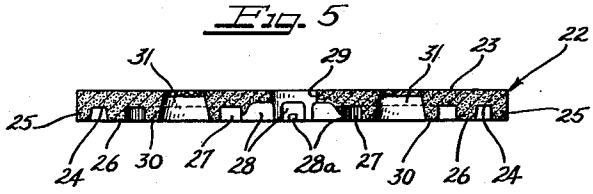
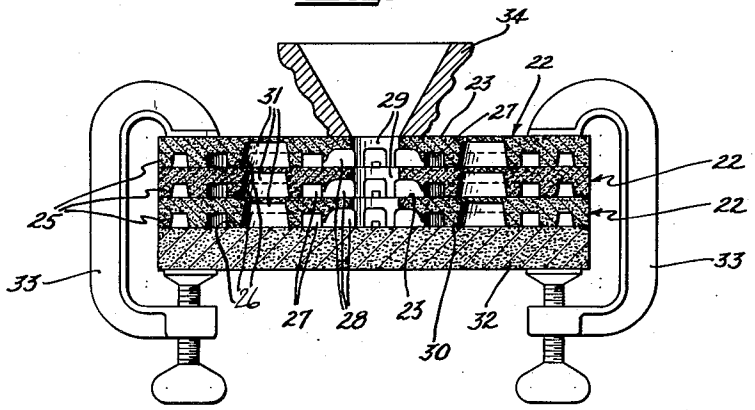


Fig. 6



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SHELL MOLD AND METHOD OF MAKING SAME

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6 Claims. (Cl. 22—130)

This invention relates to the production of molds. Specifically, this invention deals with molds composed of bonded sand such as are used in the so-called "shell mold" casting art.

Heretofore, "shell molds" have been prepared by depositing a mixture of thermosetting binder and sand on a heated pattern to soften the binder and bond the sand particles together thereby forming a continuous shell or coating over the pattern. The excess unbonded sand mixture on the pattern is then removed by inverting the assembly so as to allow the free sand particles to drop off of the coating. A relatively thin coating is thus formed having a rough outside face generally following the contour of the pattern. In this procedure, the thickness of the coating or shell is controlled by the degree of heat penetration from the pattern into the binder and sand mixture and is usually less than one quarter of an inch. If substantially thicker molds were attempted, they would not cure evenly in the subsequent heat treatment which is used to completely set the thermosetting binder. The relatively thin molds, after being completely cured, are conventionally held in face-to-face engagement and are backed up by steel shot or other suitable filling material which will follow the irregular outside face of the mold to give support thereto. The liquid metal to be cast is then poured into the mold cavity in the conventional manner.

Due to the necessity for freeing the outer face of the mold from the unset sand particles, the forming machines to produce these shell molds must be equipped with turning mechanisms so that the free excess sand on the pattern could drop off by gravity action.

The present invention now provides a shell mold with a smooth outside face which is useful in providing a mold cavity-closing face thereby accommodating the stacking together of a plurality of the molds to provide a succession of mold cavities each partially defined by an outside face of an adjacent mold.

Another feature of this present invention resides in the formation of a shell mold having a smooth, flat back face and a mold cavity of any desired depth without increasing the wall thickness of the shell beyond a desired thickness.

Another feature of the invention is to provide a mold pattern which has an insert plate surrounding its mold cavity-defining portion to decrease the thickness of the resulting mold in the areas of the mold surrounding the mold cavity.

Another important feature of this invention is to provide molds of flatter contour than heretofore possible, by curing the molds simultaneously from opposite faces.

A further feature of the invention resides in the provision of a shell mold which has the mold cavity-defining walls thereof surrounded by hollowed-out portions which portions in turn, are surrounded by a rigidifying maginal flange so that the molds can be easily stacked to provide safety reservoirs for molten metal in the event that a mold cavity-defining wall should break away.

Another important feature of the invention relates to

the provision of plate-like shell molds each having its own sprue and adapted to be stacked to coact with the next adjacent plate to produce the full sprue.

Another feature of the invention resides in the provision of a method of making shell molds which does not require inversion of the mold to remove excess sand from the back face of the mold.

It is then a very important object of this invention to provide plate-like shell molds adapted to be stacked for forming a series of mold cavities and not requiring the heretofore necessary backing material to support the shells.

Another object of this invention is to provide a shell mold having a marginal flange, ribs within the marginal flange defining the mold cavity, and hollow spaces between the flange and ribs forming reservoirs for molten metal in the event of breakthrough or leakage beyond the ribs.

Another important object of this invention is to provide a method of making molds from resin-impregnated particulate earth-like material such as silica or zircon sand, which involves the use of a pattern having a filter plate to create a hollow cavity beyond the mold cavity-defining wall.

A further object of this invention is to provide a resin-bonded sand plate mold with a central sprue adapted to register with the sprues in similar plate molds to produce a stack of molds fed from a single sprue.

Other and further objects and features of this invention will be apparent to those skilled in the art from the following detailed description of the annexed sheets of drawings which, by way of a preferred example, illustrate one embodiment of the invention.

On the drawings:

Figure 1 is a plan view of a pattern for forming a plate mold according to this invention.

Figure 2 is a vertical cross-sectional view with a part in elevation, taken along the line II—II of Figure 1 and showing the pattern filled with a thermosetting resin and sand mixture in particulate form.

Figure 3 is a vertical cross-sectional view taken along the line III—III of Figure 1 but illustrating the pattern filled with resin-impregnated sand and having a cover plate thereon to form a smooth top face for the mold.

Figure 4 is a plan view of the sand mold formed as illustrated in Figure 3.

Figure 5 is a vertical cross-sectional view taken along the line V—V of Figure 4.

Figure 6 is a vertical cross-sectional view, with parts in elevation, illustrating the manner in which the molds of Figures 4 and 5 are stacked and clamped together to provide a series of mold cavities filled from a common sprue.

As shown on the drawings:

The pattern **10** as illustrated in Figures 1 to 3 is for the purpose of forming resin-bonded sand molds in plate form and having four mold cavities of valve seat insert ring configurations fed from a central sprue. Valve seat insert rings for internal combustion engines are cast from expensive high-temperature and corrosion-resisting alloys that are difficult to grind and machine and the present invention forms castings in an almost finished state thereby minimizing the expensive heretofore necessary machining and grinding. It will be understood, of course, that the invention is not limited to the casting of any specific shape.

The illustrated pattern plate **10** includes a square box or container **11** with an upstanding peripheral wall **11***a* and a flat bottom wall **11***b*. A filler plate **12** is affixed to the bottom wall **11***b* to extend into equally spaced relation from the peripheral wall **11***a* for providing a gap G between the outer peripheral edge of the filler plate **12** and the inner face of the side wall **11***a* as shown in Figure 1,

This gap G should be of sufficient width to form therebetween a self-sustaining peripheral flange on the mold to be formed.

The filler plate **12** has a cloverleaf-shaped central cavity **12***a* with four lobes of fragmental circular contour. Push-out pin holes **12***b* with counterbores to provide for push-out pin heads are provided between the lobes of the cavity **12***a*. As shown in Figure 2, the plate **12** has a flat top **12***c* terminating at a level beneath the top edge of the side wall **11***a*.

Within the cloverleaf cavity **12***a* of the plate **12**, there are provided upstanding mold cavity-defining patterns integral with or attached to the bottom wall **11***b* of the pattern plate **11**. These patterns are spaced inwardly from the edges of the cavity **12***a* and comprise a circular ring **13** in each lobe of the cut-out portion terminating in a flat top at a level beneath the top edge of the side wall **11***a*, and a tapered plug **14** in spaced concentric relation within the ring **13** and projecting above the level of the ring **13** to terminate at a flat top beneath the top edge of the side wall **11***a*. A central tapered plug **15** is provided in the center of the space surrounded by the rings **13** and this central plug projects to a level that may be flush with the top edge of the side wall **11***a*. A separate runner and gate-forming pattern **16** extends from the plug **15** to each ring pattern **13** as shown in Figures 1, 2 and 3 and has an outer end portion converging both in width and in height to form a narrow and relatively thin connecting gate **16***a* against the outer face of the ring **13** at the bottom thereof.

Four ring-shaped mold cavities are formed by this arrangement, each defined by a ring **13**, and surrounded by concentric cavities created between the outer face of the ring pattern **13** and the adjoining edge wall of the cavity **12***a* of the plate **12** and by the space between the plug **14** and the inner face of the ring **13**. The plug **14**, of course, forms a blind cavity in the resulting mold.

As shown in Figures 2 and 3, the rings **13** have the same height as the plate **12** while the plugs **14** may extend to levels above the rings **13** and the central plug **15** is at a higher level than the plugs **14** or rings **13**. In addition, the runner-forming patterns **16** at the ends thereof adjacent the plug **15** may be at levels higher than the rings **13** but at levels lower than the edge of the side walls **11***a*.

The bottom wall **11***b* of the pattern box **11** has holes such as **11***c* therethrough in alignment with the holes **12***b* of the filler plate **12** to receive ejector pins such as **17** in slidable relation therethrough. The pins **17** have heads **17***a* fitting in the counterbores of the holes **12***b* of the plate **12**.

As shown in Figure 2, the pattern box **11** is filled with a mixture of sand and thermosetting resin binder **18** and the top of the sand mixture in the box is leveled by a scraper **19** to form a flat top face **20** substantially parallel with and no lower than the top edge of the side wall **11***a*. The resin and sand mixture **18** is in dry, pulverulent form and contains the resin-forming ingredients in intimate admixed relationship. A satisfactory sand mixture **18** may have the following composition:

	Percent by weight
Silica or zircon sand	92–98
Unset resin or resin-forming ingredients	8–2

the resin material preferably consisting of about 90% by weight phenolic resin in its A or B stage and about 10% by weight of formaldehyde-supplying material such as hexamethylenetetramine.

The sand mixture **18** is prepared by blending the ingredients thereof together until a homogeneous mixture is obtained.

After the scraper **19** forms the level top face **20**, a top plate **21** is pressed against the top face **20** of the sand as shown in Figure 3. This plate **21** has a central aperture **21***a* for freely receiving the top end of the plug **15**. The plate **21** has a pilot portion **21***b* fitting snugly within the

side wall **11***a* of the pattern box **11**. The shoulder **21***c* of the plate **21** surrounding the pilot portion **21***b* may rest on the top edge of the side wall **11***a*. The pilot portion **21***b* projects into the pattern box **11** a sufficient distance to firmly compact the sand mixture **18** and to form a smooth top face from the leveled-off top **20** of the sand without contacting the tops of the plugs **14**. The plate **21** may be removed but preferably should remain in place during curing of the binder.

The pattern box **11**, the filler plate **12**, the ring patterns **13**, the plugs **14**, and the plug **15**, are preferably of a good heat-conductive metal such as aluminum, steel, or the like, and are heated to temperatures sufficient to set the resin binder. If the plate **21** is to remain in place, it also should be made of similar good heat-conductive material. Resin curing temperatures of from 350–500° F. are satisfactory although any resin-setting temperature may be used depending upon the nature of the resin. The sand and resin mixture is deposited in the heated box **11** and covered with the heated plate **21**. After a heating period sufficient to convert the resin to the infusible stage, which period is generally only about 1 to 3 minutes, the ejector pins **17** are pushed to discharge a plate mold **22** from the pattern box.

The plate mold **22** as best shown in Figures 4 and 5 is a generally square plate with a flat top **23**, a flat bottom **24**, an upstanding peripheral wall **25** extending from around the flat bottom **24** and a four-lobed cloverleaf-shaped rib **26** defining a ring-shaped molding cavity **27** in each lobe thereof. Each molding cavity has a rectangular cross-section and is joined by gates **28** to a central pour hole or sprue **29** which extends completely through the pattern. A circular rim **30** defines the inner periphery of each molding cavity **27** and a tapered blind hole **31** is formed at the center of each rib **30**. The tapered sides for the holes **31** and the ribs **26** are provided for ease in removing the pattern from the mold.

As shown in Figures 4 and 5, the portion of each gate cavity **28** adjacent the molding cavity **27**, converges in width and in height for ease in removing the casting and to provide that the neck **28***a* is narrow to minimize machining at the point where the castings are broken away from the gates.

As shown in Figure 6, a plurality of molds **22** are vertically stacked and are supported by a bottom plate of resin-bonded sand **32** and are held in stacked relation by clamps **33**. It will be noted that the sprues **29** of each mold **22** are aligned to form a central sprue and a pouring funnel **34** registers with the top sprue **29**.

The bottom face **26** of the lowest mold **22** of the stack shown in Figure 6, rests on the flat top face of the bottom resin-bonded sand plate **32** while the bottom faces of the successive molds **22** rest on the top faces **23** of the next adjacent mold. The peripheral side walls **25** serve as retainers around the peripheries of the mold cavities **27** and in the event of breakthrough from a mold cavity **27**, these walls **25** are effective to prevent leakage of molten metal out of the assembly. In this manner, breakdown of a mold cavity in any mold plate will not interfere with the formation of good castings in the other cavities of the plates since the space into which the molten metal can flow in the broken mold, will be confined by the side wall. Furthermore, the peripheral side walls contribute to the rigidity desirable for stacking and clamping the individual molds in a composite assembly.

The blind holes **31** in the centers of the ring mold cavities **27** cooperate with the cavity surrounding the mold cavities and bounded by the side walls **25** to save resin and sand and to provide for uniform curing of the mold. In addition, these holes and this cavity provide for the formation of very permeable mold cavities **27** since each mold cavity **27** is surrounded by only a relatively thin wall.

It should be understood that any desired number of molds **22** can be stacked with the top face **23** of each mold providing a smooth bottom for the molding cavities in the next adjacent mold. It will also be understood that this invention provides for the formation of resin-bonded sand molds under pressure to produce the desired density and thereby create smoother surfaces than have heretofore been produced in shell molding. It will further be understood that the use of the filler pattern plate and the plugs for forming holes in the molds, not only result in material saving of mold-forming materials but also provide for the controlling of the wall thickness of the mold cavities thereby increasing the available permeability of the mold without increasing its bulk or weight. This procedure makes possible the provision of plate molds that can be stacked and have sufficient strength to withstand rough handling without, however, increasing thicknesses of the parts beyond those thicknesses that are desirable for shell molding. The control of the thicknesses of the various sections of the plate molds insures an even curing of the mold during the setting of the resin.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. A shell mold assembly for producing valve seat insert rings which comprises a stack of resin-bonded sand plates each having a flat face and an opposed active face with an upstanding peripheral side wall thereabout, said active face having raised ribs in the central portion thereof spaced inwardly from and surrounded by said upstanding side wall and defining a cloverleaf pattern, circular raised ribs in the central portion of each lobe of said cloverleaf and coacting therewith to define ring-shaped molding cavities, said plates having a hole in each circular rib whereby the molding cavities are defined by concentric ribs of controlled width, each plate having a central sprue therethrough and gate passages radiating therefrom to each molding cavity, means clamping said plates in superimposed stacked relation with the active face of one plate resting upon the flat face of the adjacent plate to coact therewith to define closed molding cavities surrounded by closed blind reservoirs between the molding cavities and the side walls, and said central sprues being aligned to provide a common sprue for the entire stack.

2. The method of making a shell mold of controlled density which comprises depositing a mixture of sand and binder in particulate form in a heated pattern box having an upstanding side wall, mold cavity-defining portions in spaced relation inside of said side wall and a filler plate spaced from said portions and said side wall for limiting the thickness of the portion of the mold surrounding the mold cavity to a thin wall rib, scraping the sand mixture flush with the top of the pattern box, pressing the sand mixture in the pattern box to compact the sand mixture to the desired density, heating the assembly to set the resin, and stripping the mold from the pattern box.

3. The method of making a shell mold which comprises depositing resin-impregnated sand onto a heated pattern plate, surrounding the mold cavity-forming portions of the plate with an insert plate spaced from said portions to limit the thickness of the cavity-defining walls, and baking the sand on the plate to produce a shell mold having mold cavity-defining walls of desired thickness.

4. A shell mold comprising a stack of resin-bonded sand plate molds, each plate mold having a flat face, an upstanding peripheral wall, and ribs within the confines of said wall and spaced therefrom, said ribs defining at least one molding cavity, a gate and a sprue, said peripheral wall and ribs of the plate molds in said stack being in mating contact with the flat faces of the adjacent plate molds, said sprues being in aligned communication in said stack, and means clamping the plate molds in said stack in mated-together relation to define a single sprue hole communicating through gates with a plurality of said molding cavities which are exteriorally surrounded by said ribs and peripheral walls, said peripheral walls being in spaced relation from the ribs surrounding the cavities to provide closed reservoirs receiving molten metal in the event of break-through of the metal from the molding cavities.

5. A sand mold assembly comprising a stack of resin-bonded sand mold plates, each plate having an upstanding peripheral wall, a smooth flat back face, and ribs defining the mold cavities, said ribs being spaced inwardly from said peripheral side wall, a sprue and a gate for supplying metal to said mold cavities, said sprue and gate being supported inwardly from said side wall, said ribs and side wall terminating in flush relation to provide a flat second face for the plate, means clamping said plates in stacked relation with the side walls and ribs of an upper plate in mated-together contact with the smooth flat back face of the adjacent lower plate whereby the adjacent lower plate coacts with the ribs to complete the mold cavities and coacts with the ribs and side walls to provide sealed reservoirs surrounding the mold cavities and adapted to receive molten metal in the event of break-through of the metal from the mold cavities.

6. A shell mold which comprises a resin-bonded sand plate having a flat back face, an upstanding peripheral wall, and an upstanding rib within the confines of the peripheral wall and spaced inwardly from said peripheral wall to define at least one molding cavity, said plate being adapted to be stacked with similar plates to provide the back face of one plate as a closure for the molding cavity of the next plate and as a closure for the space between the upstanding peripheral wall and the molding cavity of the next plate to form therewith a closed reservoir surrounding the molding cavity and adapted to receive molten metal from the molding cavity in the event of break-through of the metal from the cavity.

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