July 7, 1959 J. I. MORAN ET AL 2,893,079

SHELL MOLD MACHINE AND METHOD

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FIG. 1

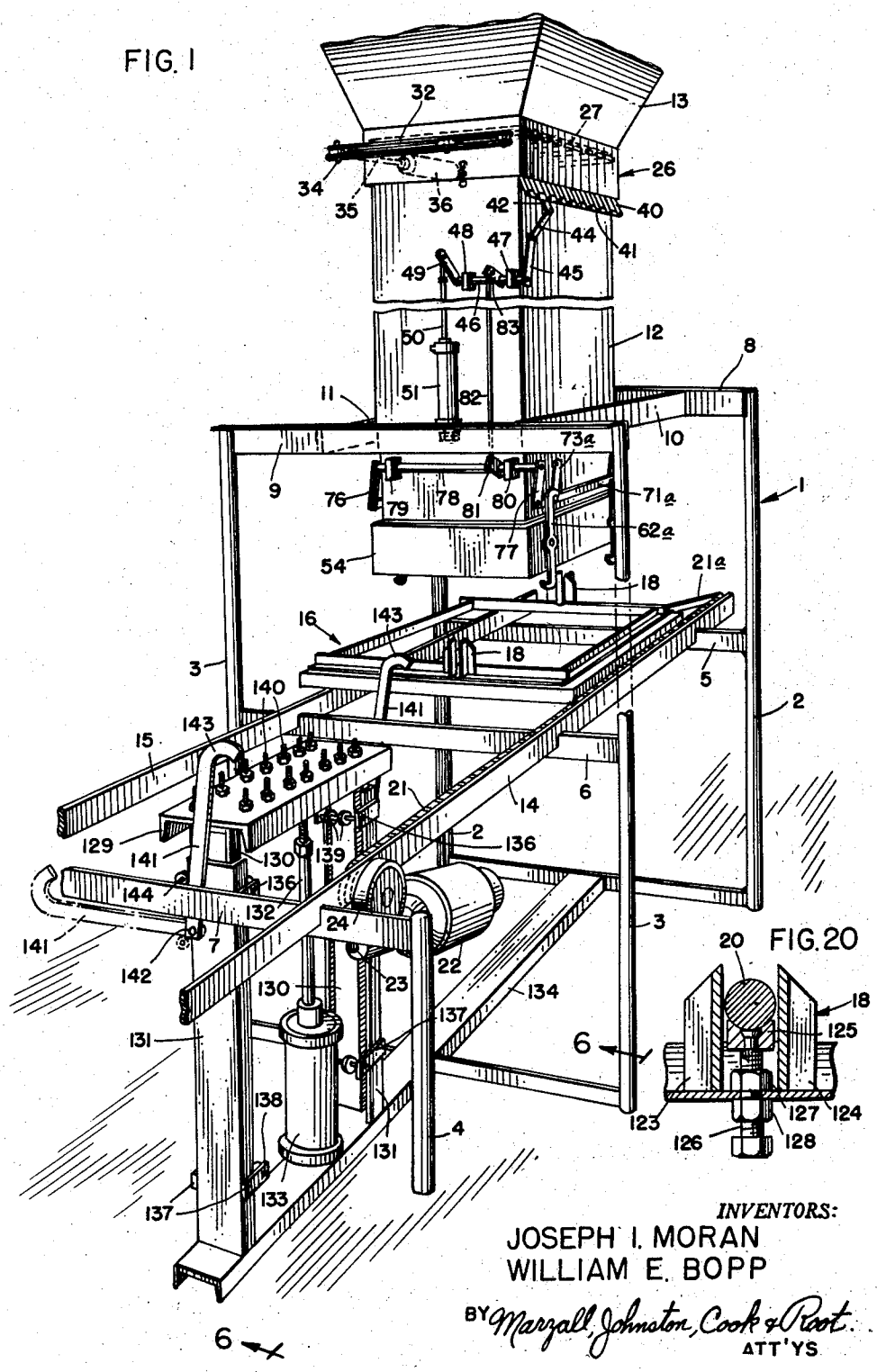


FIG. 20

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FIG. 3

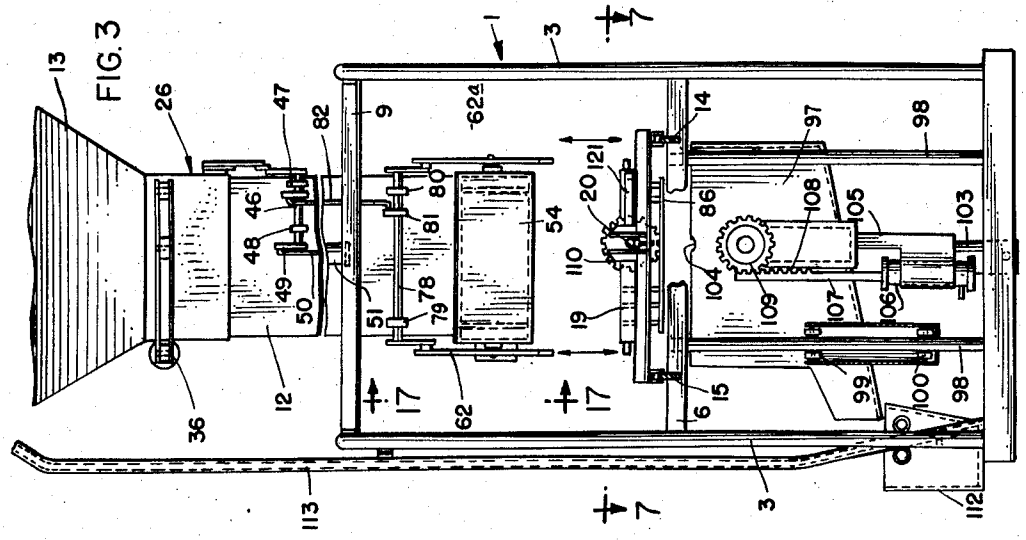
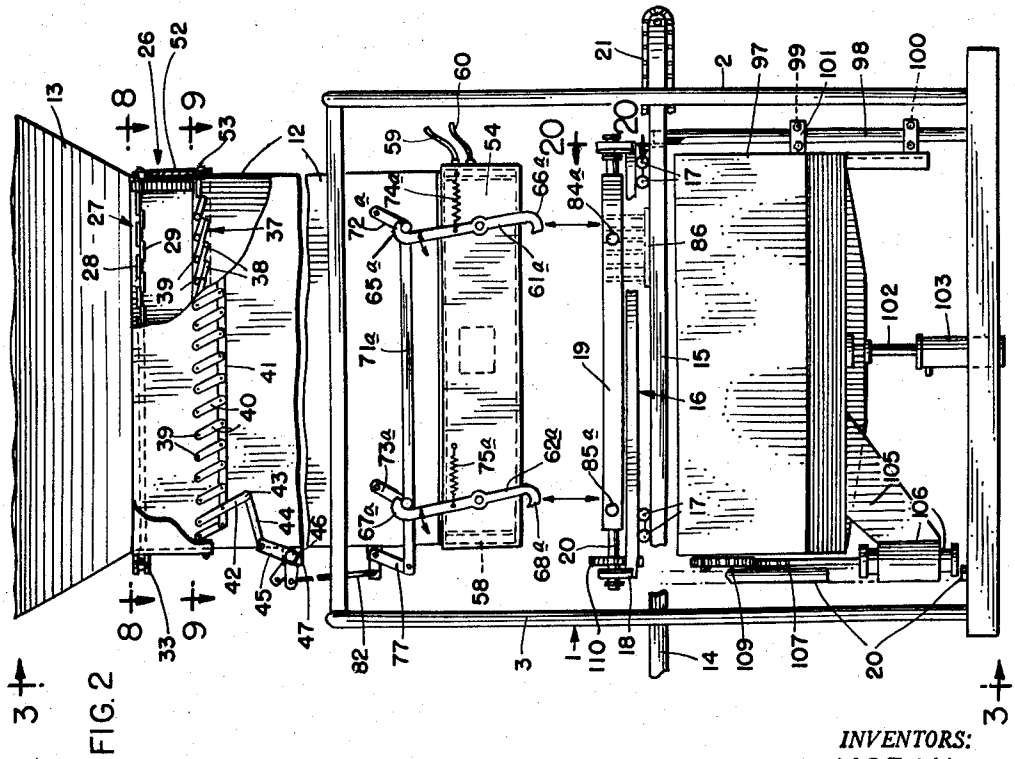


FIG. 2



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FIG. 5

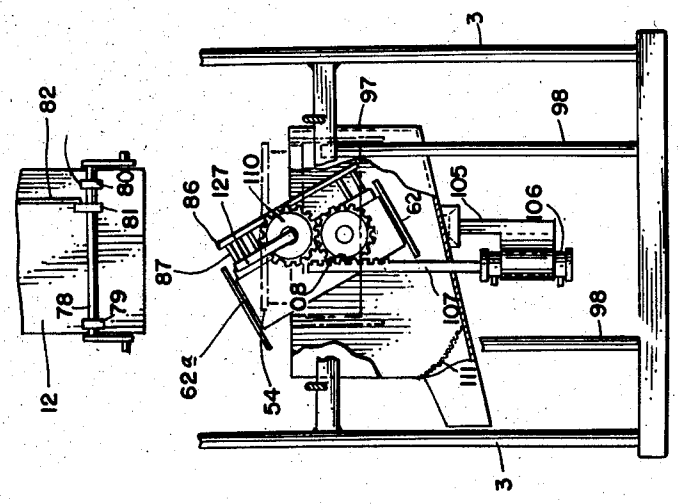
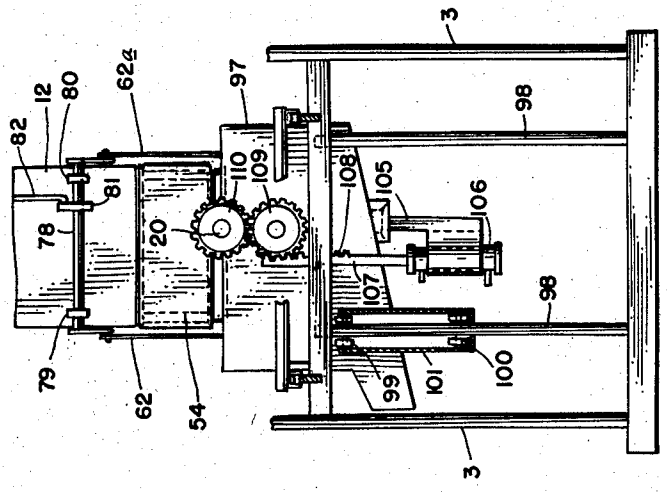


FIG. 4



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SHELL MOLD MACHINE AND METHOD

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FIG. 6

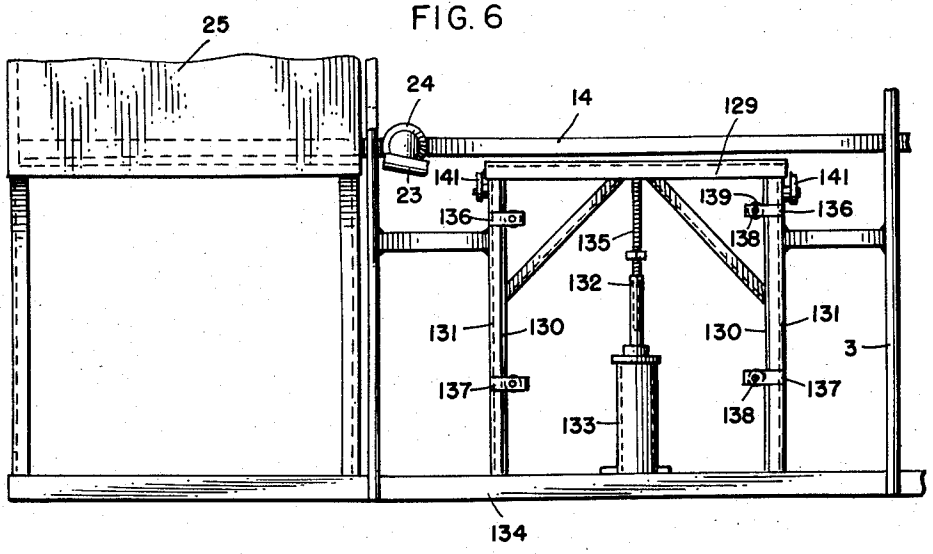
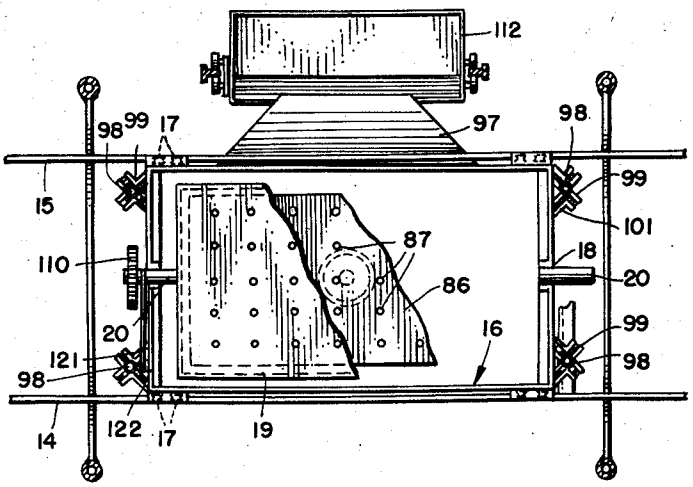


FIG. 7



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SHELL MOLD MACHINE AND METHOD

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FIG. 8

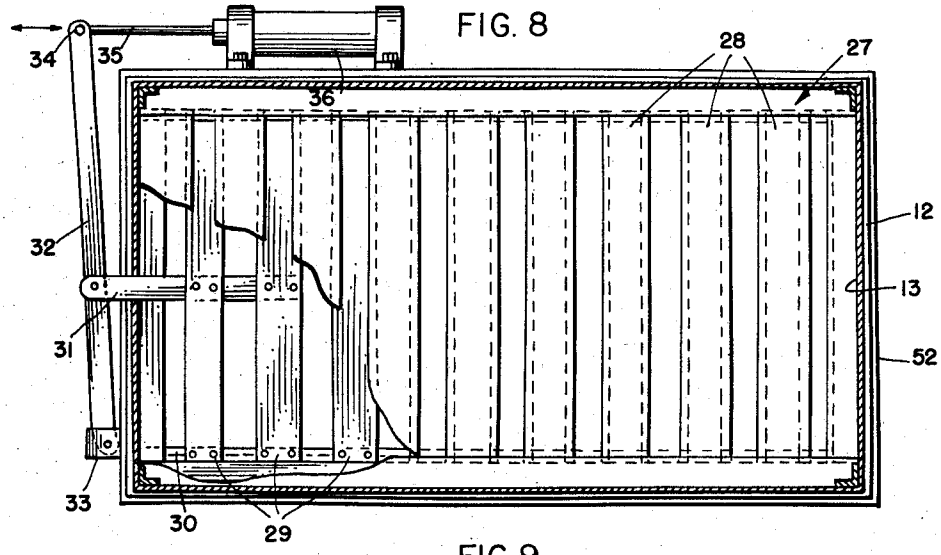


FIG. 9

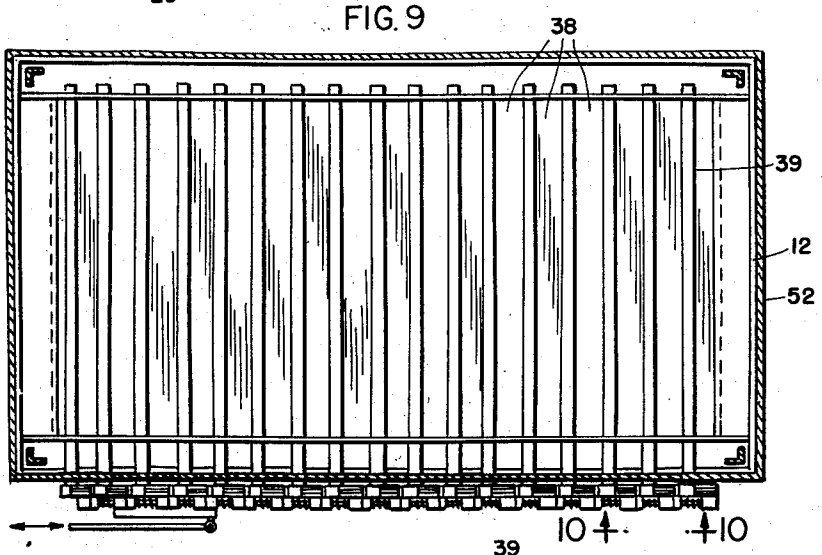
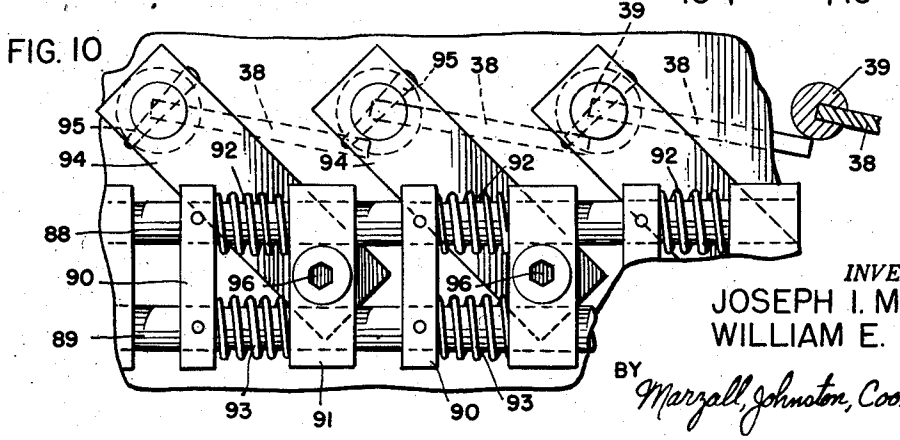


FIG. 10



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FIG. 11

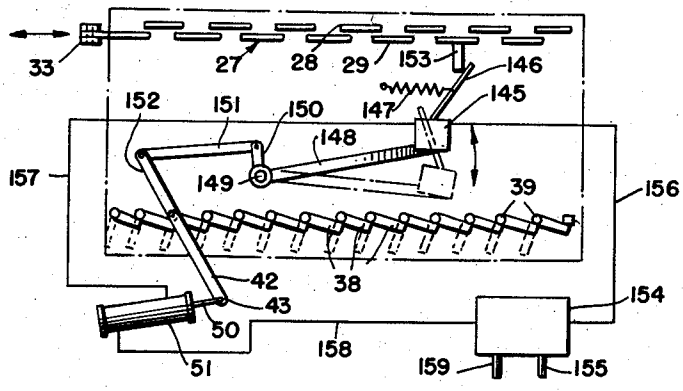


FIG. 12

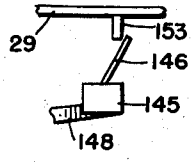


FIG. 13

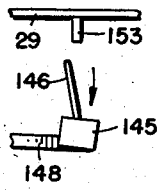


FIG. 14

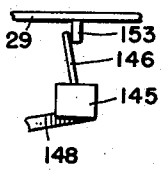


FIG. 15

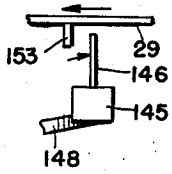


FIG. 16

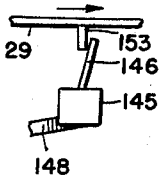


FIG. 17

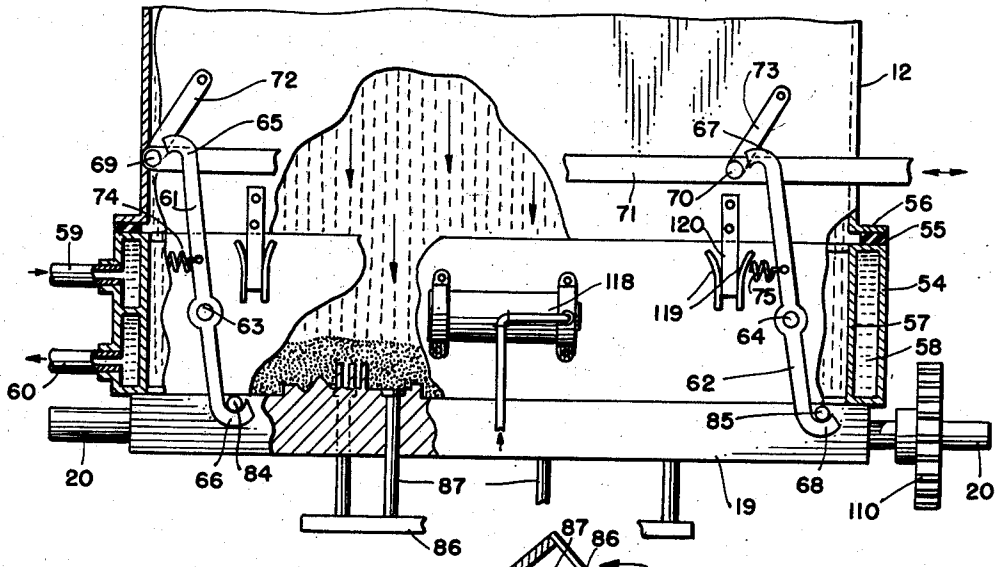


FIG. 18

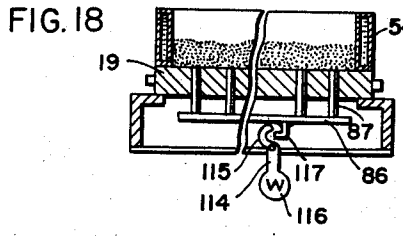
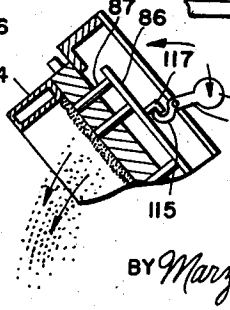


FIG. 19



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SHELL MOLD MACHINE AND METHOD

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Application January 21, 1955, Serial No. 483,387

7 Claims. (Cl. 22—35)

This invention relates in general to the art of making shell molds and is directed more specifically to a novel machine and method for making shell molds, whereby intricate and complicated castings may be made, which has not been possible heretofore with present known machines and methods.

In recent years the use of shell molds has been on the increase with the advent of machines capable of making the molds at an increased rate of speed. As is well known, the general process of making shell molds consists in the provision of a pattern which is heated in an oven and thereafter applying to said pattern a quantity of molding sand mixed with a relatively small percentage of a suitable resin. The heat of the pattern fuses the resin and sand after which the excess sand mix is removed and the remainder is baked. The relatively thin shell mold is then stripped from the pattern for use.

One of the difficulties which has been encountered in the past with shell molding machines and methods is that intricate and complicated molds could not be made. The machines and process have been satisfactory for ordinary molds which are relatively shallow. When an attempt has been made to provide a shell mold from a pattern having relatively deep or narrow voids therein, there was a tendency for the heat of the pattern to fuse the sand and resin before it reached the bottom of the void.

This difficulty has been particularly noticeable in making molds for casting cylinder heads or any other article where elongated fins or other irregular projections are necessary.

Another disadvantage in the use of machines and methods heretofore known is that the thickness of the shell mold as well as the density thereof has not always been uniform. The desirability of a shell mold having a uniform density and thickness throughout is obvious but it cannot be attained where the sand mix is deposited onto the pattern progressively from one side thereof to the other, as occurs in machines where hoppers are affixed to the pattern and the two are rolled over or revolve together.

The present invention, therefore, is designed as a machine and method for making shell molds which overcome all of the disadvantages and difficulties above mentioned.

It is, therefore, the principal object of the invention to provide a machine for producing shell molds which is capable of producing molds having intricate and complicated shapes and forms which have been impossible to produce heretofore, either in the ordinary sand mold devices or in other shell mold machines.

Another important object is to provide a shell mold machine which is adapted to produce molds of higher quality and improved structure and appearance.

A further object of the invention is to provide an improved machine for making shell molds wherein a constant charge of the sand and resin mix is always deposited uniformly over the entire area of the pattern at one

time, thereby insuring uniform thickness and density of the mold.

Still another object of the invention is to provide improved machines for uniformly depositing a charge of constant volume onto the pattern in a shell mold machine wherein a predetermined quantity of the sand mix charge is transferred from an upper hopper into a chamber therebelow and then from said chamber onto the pattern.

A still further object is to provide in a shell mold machine a charging chamber into which a predetermined charge of a sand and resin mix is deposited wherein a plurality of shutter devices in the bottom of the chamber are operable simultaneously to drop another charge downwardly onto the pattern therebelow throughout a sufficient distance to insure that the sand mix will reach to all parts of the voids on the pattern as well as to insure a uniform thickness of the entire mold.

Still another object is to provide a shell mold machine wherein the excess mixture of sand and resin is dumped from the pattern into a lower hopper from which it is later returned into the top part of an upper hopper, thereby providing a sufficient time lag before the same sand and resin are re-used to insure that no hot or partially cured resin is thereafter deposited onto the pattern.

Another object is to provide in a shell mold machine a lower hopper having a screen associated therewith into which the excess sand mix may be dumped from the pattern, thereby preventing any partially cured resin from entering the lower hopper from which it is transferred later to an upper hopper.

A further object of the invention is to provide water-cooled jacket means capable of being secured to the pattern during the time that the sand mix charge is being deposited onto the pattern, thereby isolating the pattern heat from the jacket and hopper assembly and eliminating a build-up of the sand mix on the jacket.

A still further and specific object of the invention is to provide means for vibrating the pattern and jacket during the time that the sand mix charge is being deposited thereon to additionally insure that the charge will reach the bottom of the deepest recess or voids in the pattern.

Another object is to provide a charging chamber immediately below the upper hopper in a shell mold machine into which a predetermined charge of sand mix is deposited prior to the making of each mold, thereby insuring uniformity in the molds because of a constant volume of charge being dropped throughout the same distance each time onto the pattern.

A further object of the invention is to provide a novel operating means for the shutters above and below the charging chamber to prevent the opening of the shutters in the bottom of the charging chamber until the other shutters at the top of the chamber have opened and closed, thereby insuring the presence of a charge in the chamber when the lower shutters are opened.

Still another object is to provide new and improved means for dumping the excess charge of the sand mix from the pattern, whereby it becomes unnecessary for the main hopper to be secured to the pattern during the dumping procedure.

Still another and more specific object is to provide a novel means for preventing movement of the stripper pins of the pattern during the dumping of the excess charge therefrom.

Another object is to provide a novel method or process for making shell molds whereby molds can be produced having shapes and contours not heretofore possible in previously known methods.

A further object is to provide an improved method of

producing shell molds whereby a constant charge of the sand and resin mix is dropped vertically downwardly through a predetermined distance onto the pattern, thereby enabling the charge of sand mix to reach remote points in the voids of complicated and intricate patterns which could not be reached by other methods heretofore known, thereby enabling more complex castings to be produced from the shell molds made according to this method.

Other objects and advantages of the invention will become apparent upon reading the following description taken in conjunction with the accompanying drawings, in which

Fig. 1 is a perspective view of a shell mold machine embodying certain features of the present invention with certain parts removed for the sake of clarity;

Fig. 2 is a front elevational view of that part of the machine embodying the present invention;

Fig. 3 is a vertical end elevational view of that part of the machine embodying the present invention and taken along the plane of line 3—3 of Fig. 2;

Fig. 4 is a view similar to Fig. 3 with certain of the parts omitted but showing the lower hopper and pattern elevated and in position to be secured to the jacket;

Fig. 5 is a view similar to Fig. 4 but showing the lower hopper, pattern and jacket in an intermediate position and rotated for dumping the excess sand mix;

Fig. 6 is a fragmentary front elevational view taken along the plane of line 6—6 of Fig. 1;

Fig. 7 is a horizontal sectional view taken along the plane of line 7—7 of Fig. 3 showing the pattern in plan and partially broken away to show the stripper fingers;

Fig. 8 is an enlarged horizontal sectional view taken along the plane of line 8—8 of Fig. 2 with parts broken away for the sake of clarity and showing the upper shutters;

Fig. 9 is an enlarged horizontal sectional view taken along the plane of line 9—9 of Fig. 2 and showing the lower shutter construction;

Fig. 10 is a further enlarged fragmentary elevational view showing a detail of the lower shutters and taken along the plane of line 10—10 of Fig. 9;

Fig. 11 is a schematic illustration of the upper and lower shutters of the charging chamber and the means for operating them, including the valve arrangement for preventing the opening of the lower shutters until the upper shutters have been closed;

Figs. 12 to 16, inclusive, are diagrammatic illustrations showing the sequence of operations of the valve and upper shutters;

Fig. 17 is an enlarged rear elevational view of the pattern, jacket and lower part of the upper hopper extension with certain parts broken away and shown in section for the sake of clarity, and taken along the plane of line 17—17 of Fig. 3;

Fig. 18 is a vertical transverse sectional view through the pattern assembly illustrating the devices for rendering the stripper pins inoperative during the dumping process;

Fig. 19 is a fragmentary view similar to Fig. 18 but showing the operation of the stripper pin retaining means when the pattern is in dumping position, and

Fig. 20 is an enlarged fragmentary sectional view of a detail of construction taken along the plane of line 20—20 of Fig. 2.

Referring now more particularly to the drawings and especially to Fig. 1, the machine consists of a suitable framework generally indicated at 1. The construction and arrangement of the framework is not an important consideration and may be varied to suit particular needs. As illustrated, however, the frame 1 consists of a plurality of spaced uprights 2, 3 and 4. The uprights 2 have an intermediate cross member 5 connected therebetween and the uprights 3 and 4 likewise have similar cross members 6 and 7 between each pair. Suitable supporting members are provided at the bottom so that the framework may be supported on a floor.

In addition to the intermediate cross members, the uprights 2 support a cross member 8 between the upper ends thereof and the uprights 3 support a similar cross member 9 between their upper ends. Additional supporting members 10 and 11 are secured to and span the distance between the cross members 8 and 9 and support an elongated enclosed extension 12 formed as a part of an upper hopper 13.

The hopper 13 is adapted to contain a quantity of a sand and resin mix for use in making the shell molds of the present invention.

A pair of tracks 14 and 15 extend longitudinally and horizontally through the framework 1 and are supported by the cross members 5, 6 and 7. A carriage generally indicated at 16 is mounted for movement along the tracks 14 and 15 and for this purpose suitable roller members 17 (Fig. 2) are fixed thereto. The carriage 16 is also provided at opposite ends thereof with suitably constructed journals 18 for the purpose of receiving and supporting a pattern. The pattern 19 is shown as supported on the carriage 16 in Figs. 2, 3 and 7.

The pattern 19 is provided with a shaft 20 at each end thereof adapted to be received by the journals 18 and it will be immediately apparent that this arrangement constitutes an important feature of the present invention. The arrangement not only permits the pattern 19 to be rotated when excess sand mix is dumped therefrom as will be more fully poined out hereinafter, but also permits easy removal of the pattern and replacement thereof by a different pattern without dismantling any part of the machine and without disturbing the carriage on which it is supported. Thus, patterns can be quickly and easily interchanged for making different molds of various contours.

Movement of the carriage 16 and the pattern 19 thereon along the tracks 14 and 15 may be accomplished in any suitable and well known manner, but in the present instance there is illustrated a chain drive 21 suitably secured to an arm 21*a* at one end of the carriage 16. Likewise, any suitable form of drive means may be utilized for moving the chain, such as a motor 22 driving a worm 23 in mesh with a worm gear 24. The shaft of the worm gear 24 may have a suitable sprocket mounted thereon engaging the chain 21 so that rotation thereof will cause movement of the carriage 16 along the tracks 14 and 15.

In machines for making shell molds it is necessary to have an oven which is utilized not only for insuring heating the pattern but also for baking the mold after the sand mix has been deposited thereon. Such an oven is illustrated generally in Fig. 6 by the numeral 25 and it is evident that the carriage 16 may be moved to a position on tracks 14 and 15 within the oven 25 because of the extended arm 21*a* connected between the chain 21 and the carriage 16. This arrangement permits the carriage to be moved into the oven without the necessity of having the chain drive also enter the oven.

A charging chamber generally shown at 26 in Figs. 1, 2 and 3 is arranged immediately below the hopper 13 and at the upper end of the enclosed extension 12. The charging chamber 26 forms an important feature of the present invention and constitutes one of the main considerations in obtaining an improved mold having a uniform thickness and density. Also, the charging chamber 26 in combination with the downwardly extending enclosure 12 is an arrangement which is primarily responsible for being able to produce molds from patterns having exceptionally deep and narrow voids or recesses therein.

The arrangement is such that the sand mix is admitted to the charging chamber in sufficient quantities to fill the chamber. Thus, the charge is always uniform. Furthermore, the arrangement is such that when the bottom of

the charging chamber is opened, the entire charge will drop vertically downwardly onto the pattern therebelow so that the charge is not only applied uniformly to the pattern, but also with sufficient force that the sand mix is able to reach all parts of the pattern before bridging takes place due to the build-up of the sand and resin across narrow openings.

In order to accomplish this result, there is provided a plurality of shutter members generally shown at **27** in Figs. 2 and 8. These shutters are positioned immediately below the hopper **13** and at the upper end of the charging chamber **26**. The shutter construction includes a plurality of flat horizontally spaced bars **28** and another plurality of like flat bars **29** immediately therebelow. The bars or shutter members **29** normally close the space between the upper shutter members **28** thereby forming a support for the sand and resin mix in the hopper **13**.

In the illustrated embodiment of the invention the lower shutters **29** are secured at their ends to a frame **30** which is movable laterally of the hopper. Thus, when the shutters **29** are moved to a position below the shutters **28** the sand mix will be permitted to be dropped downwardly between the shutters and onto the charging chamber. When the chamber is filled with the charge, the lower shutters **29** are returned to their normal closed position to prevent any more sand mix from entering the chamber during the time that the charge is being deposited onto the pattern.

While any suitable mechanism may be arranged for actuating the shutter arrangement **27**, there has been illustrated in Fig. 8 a preferred arrangement. A bar **31** is secured to several of the shutters **29** and extends outwardly beyond the sides of the hopper and has its outer end pivotally connected to an arm **32**. One end of the arm **32** is pivotally mounted on a bracket **33** and the other end thereof is pivoted at **34** to the outer end of a piston rod **35**. The piston rod **35** is secured in any usual and well known manner to a piston movable within a cylinder **36** mounted on one side of the hopper or its extension **12**. The piston may be moved by fluid means, either air or hydraulic fluid. When the fluid is admitted to the cylinder on one side of the piston the rod **35**, arm **32** and bar **31** will move outwardly and carry the group of shutters **29** to open position. After the charging chamber has a sufficient quantity of sand mix deposited therein, fluid is then admitted to the opposite side of the piston to return the shutters **29** to their closed position.

The bottom of the charging chamber **26** is indicated generally by the numeral **37** and consists of a plurality of shutter members **38** which are pivotally mounted by being secured to elongated rods **39** journaled for rotation at each end thereof. These shutter members are illustrated in Figs. 2, 9 and 10. Fig. 2 illustrates one form of mechanism for actuating the shutters while Figs. 9 and 10 illustrate a modified operating device. In Fig. 2 there is illustrated a plurality of angularly disposed arms **40** also secured at their upper ends to the rods **39**. The lower ends of the arms **40** are pivotally secured to an operating bar **41**. Thus, when the bar **41** is shifted toward the left from its position shown in Fig. 2, the arms **40** will be rotated, causing the rods **39** to rotate and the shutters **38** to open.

The mechanism utilized for operating the bar **41** to open and close the shutters **38** includes an operating arm **42** also mounted on one of the rods **39** and pivoted to the bar **41** but having an extension below the bar **41**, the end **43** of which is pivoted to one end of a link **44**. The other end of link **44** is pivoted to an arm **45** secured to a rock shaft **46** mounted for rotating or rocking movement in supports **47** and **48** (Fig. 1). The opposite end of the shaft **46** has secured thereto an arm **49** pivotally connected to the outer end of a piston rod **50**. This rod has a piston at its inner end (not shown) within a cylinder **51** suitably mounted on the framework of the machine.

It is thus evident that when fluid is admitted to the upper part of the cylinder **51** to cause the piston therein and piston rod **50** to move downwardly, the rock shaft **46** will rotate in a counter-clockwise direction as viewed in Fig. 2. Counter-clockwise rotation of shaft **46** will cause bar **41** to move toward the left through the linkage arrangement **45**, **44** and **42**, thus causing all of the shutters **38** to open simultaneously. Admission of fluid to cylinder **51** below the piston therein will cause a reverse movement to take place, thereby moving the shutters **38** to closed position. The charging chamber, then, will comprise the space between the upper shutters **27** and lower shutters **38** so that the amount of sand mix deposited therein from the hopper **13** will be constant for each cycle of the machine and for every mold. Due to the fact that the lower shutters **38** are of the vane type, all of which open and close simultaneously, the entire charge of the sand mix will be dropped downwardly upon the opening of the shutters **38** in substantially an extended loose mass as distinguished from the charging operations of presently known machines which dump the sand mix onto the pattern progressively from one side thereof to the other and through a much shorter distance. The sand mix is dropped vertically downwardly through the enclosed extension **12** from the charging chamber onto the pattern, thereby insuring not only an even deposit and a uniform thickness of mold, but also insuring that the sand mix will reach to all parts of narrow cavities or voids in the pattern.

The nature of the sand mix is such that it will not drop downwardly as one solid mass when the lower shutters are opened but will drop progressively in a somewhat loose aerated mass. The lower shutters have been designd as to the number and width thereof and as to their speed of opening so that the proper drop of the charge will be obtained. If the shutters are opened too slowly, the sand will begin to fall toward one side of the pattern and thus may cause a build-up of a greater amount of sand on one side than on the other. It is inevitable regardless of the speed with which the shutters are operated, that the initial sand drop will be toward one side of the pattern. The shutters, however, are opened at a sufficient speed so that this fall of sand at one side will be quickly compensated for by the time the shutters reach completely open position. It will be observed by viewing Fig. 11, for example, that when the shutters are completely open they will have moved past the vertical position by a distance of substantially 10 or 12 degrees, as illustrated by the dotted line position thereof. When this position of the shutters is reached, the falling sand will then be directed somewhat toward the opposite side of the pattern so that before the complete charge of sand has left the charging chamber there will be an even distribution of the entire charge over the pattern.

If there were relatively few shutters, then a greater amount of sand would be deposited on one side than on the other side of the pattern. If the number of shutters were to be increased considerably, then the open area would be relatively small and would have a tendency to hold back the sand rather than allow it to drop. Thus, the number of shutters for a given area is critical within limits and the angular position of the shutters when they are fully opened is also critical to achieve the result of a substantially uniform drop of the sand charge.

It may be desirable to control the amount of the charge depending upon the pattern from which the mold is being made. Another important feature of the invention involves the design of the apparatus which permits the size of the charging chamber to be varied. As illustrated, for example, in Fig. 2, the charging chamber includes a jacket portion **52** which surrounds the upper part of the enclosed extension **12** and telescopes thereover. The upper shutters **27** and their frame are secured in fixed

position to the upper part of the extension 12. The lower shutters 38 and their frame are mounted on the jacket 52 which is secured in place on the extension 12 by any suitable means such as the retaining bolts 53. To vary the charge it is merely necessary to raise or lower the jacket 52 which increases or decreases the vertical distance between the upper and lower shutters and thereby increases or decreases the volume of sand mix which the charging chamber is capable of holding.

A further important feature is the provision of a water-cooled jacket normally mounted on the lower part of the hopper extension 12 but which may be detached therefrom and secured to the pattern plate during the time that the sand mix is being deposited onto the pattern as well as during the dumping of the excess sand mix therefrom. This jacket is indicated by the numeral 54 and may be seen in Figs. 1, 2, 3, 4, 5, and 17. The latter figure illustrates the jacket 54 in somewhat greater detail.

This jacket 54 is mounted immediately below the enclosed extension 12 and bears upwardly against the rubber gasket 55 secured to the underside of an outwardly extending flange 56 around the lower edge of the extension 12. The jacket 54 is provided with an inner wall 57 spaced from the outer wall to provide a passage 58 around the entire jacket for the purpose of receiving cooling water which may be circulated therethrough. An inlet 59 and an outlet 60 are provided at one end of the jacket 54 whereby water may be continuously circulated through the passage 58. As may become more apparent hereinafter, when this water-cooled jacket is mounted upon the pattern plate 19 during the time that the sand mix is being deposited thereon from the charging chamber, it will effectively prevent heat from the pattern from being transmitted to the jacket which otherwise would cause the sand mix to fuse around the sides of the pattern plate and thus build up around the edges.

An arrangement has been designed which permits the jacket 54 to be mounted on or suspended from the extension 12 and to be released therefrom and secured to the pattern plate during the depositing of the sand mix and during the subsequent step of dumping the excess sand from the pattern. This arrangement may be clearly understood from viewing particularly Figs. 1, 2 and 17. Locking members 61 and 62 at one side of the jacket 54 and similar locking members 61*a* and 62*a* at the opposite side of the jacket are pivotally mounted on the jacket intermediate their ends by pivot pins 63 and 64 at one side and 63*a* and 64*a* at the opposite side, respectively. Locking member 61 is provided with hooked upper and lower ends 65 and 66 extending in opposite directions. Locking member 62 is similarly provided with upper and lower hooked ends 67 and 68 also oppositely disposed. Studs or pins 69 and 70 extend outwardly from a longitudinally movable bar 71 and are adapted to be received by the upper hooked portions 65 and 67, respectively, thereby supporting the jacket 54 therefrom. The opposite side of the jacket is similarly arranged where the upper hooked ends 65*a* and 67*a* of the respective locking members extend over similar studs or pins on the longitudinally movable bar 71*a*. The jacket is thus supported on opposite sides and suspended from the lower end of the enclosed extension 12.

The bar 71 is, in turn, suspended from the pivotally mounted links 72 and 73 while the bar 71*a* at the opposite side is likewise suspended from the pivoted links 72*a* and 73*a*. Coiled tension springs 74 and 75 at one side of the machine and 74*a* and 75*a* at the opposite side, associated with the locking members, each has one end thereof connected to the jacket and has the other end thereof connected to the respective locking members 61, 62, 61*a*, and 62*a*. The springs normally urge the locking members toward locking position in contact with the pins on the bars 71 and 71*a*.

When the pattern plate is in position and has been moved upwardly to the jacket 54, the same mechanism used for operating the lower shutters 38 and depositing the sand mix on the pattern also operates the bars 71 and 71*a* to release the locking members 61, 62, 61*a* and 62*a* from the lower end of the extension 12 and locks them onto the pattern plate, as will appear more fully hereinafter.

This operating mechanism may be seen more clearly in Fig. 1 where it will be noted that the movable bars 71 and 71*a* are provided at one end thereof with arms 76 and 77 respectively. These arms are pivoted to the bars at their lower ends and are secured at their upper ends to a rock shaft 78 supported for rotating movement in journals 79 and 80. An arm 81 is also secured to the rock shaft 78 and is connected at its outer end to a link 82 which extends upwardly and is connected to another arm 83 fixed to the shaft 46.

Thus, when the shaft 46 is rotated due to the operation of the piston rod 50 in cylinder 51, there will be imparted a similar rocking movement to the shaft 78 which will transmit a longitudinal movement to the bars 71 and 71*a* through arms 76 and 77. These bars will be moved toward the left as viewed in Fig. 17 or toward the right as viewed in Fig. 2, thereby to release the upper ends of the locking members from the pins on the respective bars.

The pattern plate 19 is provided at one side thereof with outwardly extending pins 84 and 85 and at the opposite side thereof with similar pins 84*a* and 85*a*. When the pattern plate 19 is elevated, by means to be more fully described hereinafter, from the position thereof shown in Fig. 2 to the position shown in Figs. 4 and 17, it will contact the lower side of the jacket 54. The pins on the pattern are positioned thereon so that when the pattern is elevated they will clear the lower hooked ends of the locking members. When the lower shutters are operated the bars 71 and 71*a* will be moved to the position shown in Fig. 17 where the pins 69 and 70 thereon are free of the upper hooked ends of the locking members. The tension springs 74, 75, 74*a* and 75*a* will move the respective locking members to which they are connected to the position of Fig. 17 where the lower hooked ends thereof are in engagement with the pins on the pattern plate 19. Thus the jacket 54 will be released from the extension 12 and will thereafter move downwardly with the pattern.

From the foregoing it will be clear that the pattern plate 19 is elevated to a position in contact with the jacket 54 and when the lower shutters 38 are opened to deposit the sand mix onto the pattern, the jacket 54 will be released from the extension 12 and secured to the pattern plate. At this point in the operation of the machine the sand mix will have been deposited on the pattern, as indicated in Fig. 17.

A stripper plate 86 is movably mounted on the pattern plate 19 and is located therebelow and is provided with a plurality of stripper pins 87 as may be needed, depending upon the pattern being used. Thus, a stripper plate is made a part of each pattern so that when a pattern is removed from the carriage 16 and replaced by another pattern, the latter patern will have its own stripper plate with the stripper pins properly positioned thereon. This plate is free to move during the stripping operation which causes the plate to move upwardly and strip the mold from the pattern.

Fig. 10 illustrates a modified and preferred mechanism for operating the lower shutters 38. The arrangement shown in Fig. 2 and described above is satisfactory but the preferred form has the advantage of being able to insure operation of the shutters even though a large piece of foreign matter or other solid material may become lodged at one edge of one of the shutters during the closing operation. When this occurs, the one shutter may be permitted to remain slightly open in contact with the piece of solid material while the other shutters may continue to move to closed position.

To accomplish this result a pair of longitudinally mov-

able tension bars 88 and 89 are utilized in the place of the operating bar 41 as shown in Fig. 2. A plurality of spaced operating members 90 have openings therethrough for the reception of the tension bars 88 and 89 and are rigidly secured thereto. Thus, when the tension bars are moved, the operating bars 90 will move with them.

Associated with each bar 90 and spaced therefrom is a bearing member 91 also having openings therethrough for the reception of the tension bars 88 and 89. These bearing members 91, however, are mounted on the tension bars for free sliding movement with respect thereto.

Coiled compression springs 92 and 93 surround the tension bars 88 and 89, respectively, and are located between each operating bar 90 and bearing member 91. An operating arm 94 is associated with each bearing member 91 and with each of the rotatably mounted rods 39. Each arm 94 is substantially U-shaped so as to straddle the tension bars and bearing members and each receives at its upper end a rod 39 to which it is secured such as by means of the pins 95. The lower end of each arm 94 is secured to a sliding bearing member 91 by a bolt 96.

In the operation of this preferred mechanism for the lower shutters, the operating mechanism described above and illustrated in Figs. 1 and 2 may be utilized for shifting the tension bars 88 and 89 toward the left from their position shown in Fig. 10. When the tension bars move toward the left they will slide through the bearing members 91 but will carry with them the operating bars 90 to a position where each bar 90 is in contact with the bearing member 91 at the left thereof, as viewed in Fig. 10. Continued movement of the tension bars 88 and 89 and the operating bars 90 will thereupon move the bearing members 91 toward the left which will carry with them the operating arms 94 rotating them in a clockwise direction. When this occurs, the rods 39 will rotate and will carry with them the shutters 38 moving them to open position.

Upon the return movement of the tension bars 88 and 89 toward the right for closing the shutters, there will be a lost motion during the time that the operating bars 90 are compressing the springs 92 and 93. When a sufficient compression has been reached, further movement of the bars 90 will cause movement in the same direction of the bearing members 91, thereupon rotating the operating arms 94 in a counter-clockwise direction to close the shutters 38.

If during this closing movement of the shutters some obstruction, such as a piece of fused sand or other solid material should become lodged between adjacent shutters, the full hydraulic pressure is not concentrated on that shutter, but will be taken up by the springs. The closing movement of that one shutter will be stopped but the hydraulic pressure acting upon the springs 92 and 93 will cause the remaining shutters to complete their closing movement. The rotating vane type shutter without this feature has the disadvantage that if one is held open, all of them remain open and the pressure on the shutters themselves causes them to become twisted and bent on the rotating shaft.

A lower hopper 97 is positioned within the main frame and immediately below the carriage 16 when in the position shown in the various figures. This lower hopper is mounted for vertical reciprocating movement on a plurality of guide rods 98. There is a guide rod 98 at each corner of the hopper 97 and the hopper is guided in its vertical movement by a plurality of suitably arranged upper and lower spaced roller members 99 and 100. These roller members are supported on the hopper by suitable bracket members 101.

The bottom of the hopper 97 slopes downwardly toward the rear of the machine as may be seen clearly in Figs. 3, 4 and 5 and is mounted upon the upper end of a vertically reciprocable piston rod 102 having a piston at its lower end within a cylinder 103. The device is fluid operated so that when fluid is admitted to the bottom of cylinder 103 the piston rod 102 will be elevated carrying with it the lower hopper 97. The upper edge of the hopper is of a size to pass through the carriage 16 and is provided at the opposite ends thereof with arcuate recesses 104. These recesses 104 are in alignment with the shafts 20 at opposite ends of the pattern plate 19 so that as the hopper is moved upwardly from the position thereof shown in Figs. 2 and 3, it will pick up the pattern plate and stripper plate 86 connected therewith and elevate the entire assembly to the position shown in Fig. 4 where the pattern plate 19 is against the underside of the jacket 54. In this position the lower shutters 38 are opened to deposit the same onto the pattern at which time the jacket is disengaged from the enclosed extension 12 and becomes engaged with the pattern plate 19 as above set forth.

From the position of the parts shown in Fig. 4 the assembly of jacket 54, pattern plate 19, stripper plates 86, and hopper 97, is lowered to an intermediate position as shown in Fig. 5. The assembly is moved downwardly a distance sufficient for the pattern plate and jacket to be rotated to dump the excess sand mix therefrom and into the hopper and to provide sufficient clearance below the lower end of the enclosed extension 12.

The mechanism for rotating the assembly and dumping the sand mix therefrom includes a bracket or supporting arm 105 extending outwardly from the bottom of the hopper 97 at one end thereof (Fig. 2). This supporting arm 105 supports a fluid cylinder 106 which operates a piston rod 107 having a plurality of teeth 108 thereon thus forming a rack. The teeth 108 engage a pinion 109 mounted on the end of the hopper 97 so that when fluid enters the cylinder 106 at the bottom thereof to elevate the piston rod 107 it will cause a clockwise rotation of the pinion 109, as viewed in Figs. 3, 4 and 5.

It will be noted that one of the end shafts 20 of the pattern plate 19 is also provided with a gear 110 which is adapted to become engaged with the pinion 109 when the lower hopper 97 is elevated to the position shown in Fig. 4.

After the sand mix has been deposited onto the patterm, fluid is caused to flow into the upper end of cylinder 103 to lower the hopper 97, pattern plate 19 and jacket 54 to the position shown in Fig. 5. When the assembly reaches this position, fluid then actuates the piston rod or rack 107 to move it upwardly causing pinion 109 to rotate in a clockwise direction. This then rotates gear 110 in a counter-clockwise direction and carries with it the pattern plate 19, stripper plate 86 and jacket 54. The excess sand mix which has not adhered to the pattern is thereupon dumped into the lower hopper 97 and is passed through a screen 111. This will screen out any particles which may have been fused due to the heat of the pattern but which did not adhere. The remainder of the sand mix then passes outwardly from the hopper 97 and into a skip bucket 112 mounted on the vertically postioned tracks 113 (Fig. 3). This excess sand mix is then carried upwardly in the bucket 112 on the tracks 113 by any suitable drive mechanism (not shown) and is dumped into the top of the upper hopper 13.

The advantage of this arrangement is that the temperature of the sand mix having been raised after being deposited onto the pattern and within the jacket, will be given an opportunity to decrease and to return to its normal temperature before again being placed into the charging chamber.

Since it is customary to have the stripper plate and pins separate from the pattern plate, it is one of the novel features of the present invention that the stripper plate 86 is mounted directly upon and in association with the pattern plate 19. Since, however, the plate and pins are free to move in a direction to strip the mold from the pattern, it is necessary to provide suitable means for preventing such movement during the time that the excess sand mix is being dumped from the pattern and

jacket 54 into the lower hopper. Figs. 18 and 19 illustrate a device for accomplishing this result by holding the stripper plate 86 in a retracted position during the roll-over of the pattern plate. This device consists of a weighted lever 114 which is pivotally mounted on a frame adjacent the stripper plate and is provided with a hook 115 at its upper end. The lower end 116 thereof is weighted so that the entire lever arm will be caused to rotate about its pivotal point freely when the pattern is rolled over to dumping position. A weighted lever 114 is provided at each end of the stripper plate 86 and is adapted to cooperate with an angle member 117 also at each end of the stripper plate and extending downwardly from the underside thereof.

From the position of the parts as shown in Fig. 18 the roll-over mechanism causes the pattern and its associated parts to rotate about the axes of the pattern shafts 20 in a counter-clockwise direction to the position shown in Fig. 19. At the proper point during the roll-over of the pattern but before the stripper plate 86 has a tendency to move against the mold because of gravity, the weighted lever arms 114 will be actuated by the weighted ends thereof and will move the hooked ends 115 into engagement with the angle members 117, as shown in Fig. 19. The excess sand mix is thus dumped from the pattern plate while the stripper plate is held against movement toward the mold.

As stated hereinabove, one of the advantages in having an arrangement where the drop of the sand charge is vertical throughout a relatively great distance is the uniformity of the sand deposited on the pattern and the ability of the sand to reach deep recesses in the pattern. To assist in this action and to aid in increasing the density of the sand mix as may be required by the pattern design, there is also provided a suitable form of vibrating mechanism 118 mounted on the side of the jacket 54 (Fig. 17). This vibrator is commercially available and is preferably air operated and therefore needs no detailed description. It is sufficient to state here that such a vibrator has been found to be extremely useful when combined with the jacket 54 and when it is brought into use at the time the pattern is in contact therewith and during the charging operation. As the sand is dropped onto the pattern, the vibrators are brought into action and impart a sufficient vibration to the sand and pattern to cause the density of the sand mix to be increased, thereby making a stronger and better mold. The vibration, of course, also aids the sand drop itself to insure that the sand will reach the bottom of the deepest recess.

Another detail of the jacket and pattern assembly is the guide means to insure the return of the jacket to proper position against the lower end of the enclosed extension 12. Any suitable guide means may be used, such means being illustrated in Fig. 17 as including the spaced guide tracks 119 mounted on the jacket 54 and the guide bar 120 mounted on the lower end of extension 12 and projecting downwardly therefrom. There may be as many of these guide means as may be necessary to insure that when the jacket 54 is returned to its uppermost position, it will be located properly with respect to the locking mechanism.

Inasmuch as the pattern plate 19 is mounted slightly off center so that one side thereof will be heavier than the other to insure that the pattern plate will remain level at all times while it is receiving the sand mix, there is provided a stop arm 121 fixed to one of the shafts 20 (Figs. 3 and 7) which is adapted to rest upon a stop member 122 mounted on the carriage 16.

The arrangement is such that the pattern is caused to rotate about its own axis during the dumping of the excess sand mix therefrom and when it is returned to its normal horizontal position, the stop arm 121 will come against the stop 122.

Another detail of the mounting for the pattern plate resides in the adjustable trunnions at each end of the carriage upon which the two shafts 20 of the pattern plate are supported. A detailed illustration of one form which these adjustable trunnions 18 may take is shown in Fig. 20. Each trunnion comprises the spaced vertical legs 123 and 124 within which a supporting member 125 is adjustably mounted. The upper surface of the support 125 is arcuately concave to support the shaft 20. A bolt 126 has one end thereof extending upwardly between the legs 123 and 124 and has the support 125 mounted thereon. Thus, as the bolt 126 is raised or lowered due to its threaded connection with the end channel of the carriage frame, the end of the pattern plate associated therewith will likewise be raised and lowered. The bolt then may be held in any adjusted position by means of the lock nuts 127 and 128. This arrangement aids materially in enabling the pattern plate to be positioned horizontally at all times while it is at rest in the carriage.

After the excess sand mix has been dumped into the lower hopper and the assembly of jacket 54, pattern plate 19 and stripper plate 86 has been returned to the horizontal position thereof, fluid is again admitted into the bottom of cylinder 103 to elevate the lower hopper 97 and the aforementioned assembly back to the position shown in Fig. 4. At this point in the cycle of the machine the lower shutters 38 are then closed by a reverse operation of the mechanism which caused them to open which will also move the bars 71 and 71*a* back to their normal position to release the jacket 54 from the pattern plate and again mount it upon the lower end of the extension 12.

The lower hopper 97 is then lowered back to its normal position below the carriage 16, thereupon returning the pattern plate and stripper plate to the carriage where it is supported in trunnions 18 as hereinabove described.

The carriage and pattern plate with the mold thereon are then returned to the oven 25 (Fig. 6) for the curing operation. To do this, the motor 22 operates the gear 24 to move the upper run of chain 21 toward the oven. Since the carriage 16 is secured to the chain through the arm 21*a*, it will be carried to a position within the oven. After the curing of the mold has been completed, the carriage, pattern plate with the mold thereon, and stripper plate are removed from the oven and moved to the stripping station. This station is illustrated at the righthand side of Fig. 6 as well as in Fig. 1.

At the stripping station there is provided a stripping table 129 which extends longitudinally between the tracks 14 and 15 and which is supported at each end thereof by telescoping support members of any suitable design. In the present instance and for purposes of illustration, there is shown in Fig. 1 a pair of spaced supporting members for the stripping table 129, each of which includes an inner channel member 130 with its open side facing outwardly, and an outer channel member 131 with its open side facing inwardly. The inner and outer channel members are thus placed one within the other so as to telescope.

Between these telescoping supporting members the stripping table 129 is secured to the upper end of a piston rod 132 vertically reciprocable within a cylinder 133 mounted below the stripping table upon the floor below the frame or upon a rigid channel member 134.

The piston rod 132 is preferably internally threaded to receive a threaded rod 135 whereby the effective length of the piston rod 132 may be varied to suit conditions which will depend somewhat upon the size of the pattern from which the mold is being stripped.

Each inner channel 130 is guided in its reciprocating movement by suitable guide means which have been illustrated herein as including upper and lower brackets 136 and 137 mounted on each of the outer channel members 131. Each bracket member supports a rod 138 extending across the inner closed side of the inner

channel 130 upon which may be mounted a pair of rollers 139 in rolling contact with the inner channel 130.

Thus, as the stripping table 129 is raised and lowered upon the introduction of fluid into the cylinder 133, it is guided in these movements by the telescoping support members at each end thereof.

The stripping table 129 is preferably provided with a plurality of vertically adjustable pins 140 adapted to come against the lower side of the stripper plate 86 during the stripping of the mold from the pattern. The reason for making these pins 140 adjustable is that the stripper plate 86 and possibly the pattern may tend to become somewhat warped after considerable use due to continually heating and cooling. It is important during the stripping operation that all parts of the stripper plate be caused to move upwardly at the same moment. The pins 140 may be adjusted so that even if the plate may be somewhat warped or one side is higher than the other, all of the pins 140 will strike the plate at the same time when properly adjusted.

It is necessary to provide suitable means to hold the pattern firmly in the carriage trunnions during the stripping operation because of the pressure developed by the stripping action. Various specific forms of hold-down mechanism suitable for use in the present machine may occur to those skilled in the art and one form of such a device is shown herein for purposes of illustration. Referring to Fig. 1, it will be noted that a pair of elongated hooked members 141 are pivotally mounted at each end of the stripping table 129, one on each of the supporting members 131. One end of each hooked member 141 is rotatably mounted on the supports by means of a pivot pin 142 and the upper or outer end of each member is in the form of a hook 143. The normal position of each hooked member 141 during the cycle of the machine is substantially horizontal, as indicated by the dotted line position thereof in Fig. 1.

A roller member 144 suitably mounted on each of the inner telescoping channel members 130 is positioned adjacent one edge of each hooked member 141. Each roller 144 is movable with the channel member 130 on which it is mounted so that as the stripping table 129 moves upwardly, each roller 144 will also move upwardly from the dotted line position thereof shown in Fig. 1 to the full line position thereof. Thus, the roller 144 at each end of the stripping table will rotate its associated hooked member 141 upwardly during the first approximately one inch or so of travel of the stripping table.

The hooked ends 143 of the members 141 will thus be moved into position above the shafts 20 at each end of the pattern plate 19 and will hold the pattern plate down in the trunnions 18 against the pressure of the stripping table 129 as it moves upwardly against the stripper plate 86. Continued movement upwardly of the stripping table will thereupon elevate the stripper plate 86 and stripper pins 87 to strip the mold from the pattern. The mold may then be removed by hand after which the operator may blow off the pattern and spray it with a stripper agent if necessary. The appropriate application of fluid to the cylinder 133 will lower the stripping table 129 and its associated parts back to their normal position at which time the hooked members 141 will return to their horizontal position to enable the carriage and pattern to move along the tracks 14 and 15. At this point the machine is then ready to be recycled and produce another mold.

Referring now particularly to Figs. 11 through 16 inclusive, there is diagrammatically illustrated the fluid system for operating the lower shutters 38 and the association thereof with the upper shutters 27 whereby the lower shutters are prevented from opening until the upper shutters have opened and then closed. This arrangement insures that the lower shutters cannot be opened unless there is a charge of sand mix in the charging chamber.

In the arrangement illustrated diagrammatically in Fig. 11, there is shown a valve member 145 which is a check valve normally permitting the flow of fluid toward the right therethrough, as viewed in Fig. 11. An arm 146 associated with valve 145 is operable to hold the check valve 145 open when moved toward the right, as viewed in Fig. 11, and to permit it to close when the arm is moved toward the left. The normal position of arm 146 is toward the left and it is urged to that position by a suitable tension spring 147.

Valve 145 is mounted on an arm 148 which is mounted for rotation on a rotatable pin or rock shaft 149. Another arm 150 is mounted on the rock shaft 149 to which is pivotally secured a link 151. The opposite end of this link is pivoted to one end of an arm 152 which may be either an extension of the arm 42 or may itself be directly secured to one of the rods 39 on which the shutters 38 are mounted.

When fluid is admitted to cylinder 51 to rotate arm 42 in a clockwise direction it will be evident that the linkage arrangement consisting of the links 152, 151 and 150 will operate to rotate shaft 149 in a clockwise direction, thus moving the valve 145 and its arm 146 downwardly to the dotted line position shown in Fig. 11.

When this occurs, the spring 147 will operate to pull the arm 146 toward the left permitting the check valve to close. An operating bracket or arm 153 is mounted on one of the lower shutter members 29 of the upper shutter assembly 27 and extends downwardly thereof to hold valve arm 146 toward the right and maintain the check valve open at the proper time during the cycling of the machine.

The position of the parts shown in Fig. 11 is the position thereof when a charge of sand mix has been deposited in the charging chamber. When the pattern plate has been elevated against the underside of the water-cooled jacket, the parts are in readiness for the sand mix to be deposited onto the pattern from the charging chamber. To do this, a manual 4-way valve 154 may be operated to permit fluid to flow from the intake side thereof shown at 155 through a suitable conduit 156 and through the check valve 145 which is being held in open position by the arm 146 in contact with the arm 153. The fluid flows through the valve and another suitable conduit 157 to the cylinder 51, thereupon causing the piston rod 50 thereof to move inwardly and open the shutters 38 in the manner described above. The opening of the shutters will thereupon cause the valve 145 to drop downwardly as shown in Fig. 11. The fluid at the opposite end of cylinder 51 is exhausted therefrom through a suitable conduit 158 and the exhaust 159 of the valve 154. The sand mix is then dumped from the charging chamber onto the pattern.

Fig. 12 illustrates the check valve 145 and its associated parts in the same position as illustrated in Fig. 11 where the valve is held open for the passage of fluid therethrough to the cylinder 51. As soon as the piston rod 50 operates to open the shutters 38, the check valve 145 will be moved downwardly to the position shown in Fig. 13. It will be noted that in this position the valve arm 146 will be below the operating arm 153 and the spring 147 will have moved the valve arm to permit the check valve to be closed. In this position of the parts fluid can no longer flow through the valve 145 to the cylinder 51 but fluid will be able to flow from the cylinder 51 in the opposite direction through valve 145 and back to the exhaust.

After the sand has been deposited on the pattern the machine then continues its cycle to the point where the excess sand mix is dumped from the pattern and the jacket has been again secured to the lower end of the extension 12. At this point the 4-way valve 154 is operated to cause fluid to flow in the opposite direction through conduit 158 to cylinder 51 to move piston rod 50 outwardly and close the shutters 38. The fluid in the cylinder will return through conduit 157 and check valve 145 back to the exhaust 159. When the shutters are closed, the jacket 54 will be released from the pattern plate and at the same

time valve **145** will be returned to its upper position illustrated in Fig. 14.

It will be noted here that the valve arm **146** is now on the lefthand side of the operating arm **153** and the check valve is still in its normally closed position.

If an operator should forget to operate the upper shutters to place a charge of sand mix in the charging chamber, it will be impossible for him to open the lower shutters because valve **145** is closed and fluid cannot flow therethrough from the 4-way valve **154** to the cylinder **51**. Unless the lower shutters can be opened, the water-cooled jacket cannot be released from its normal mounting and be attached to the pattern plate. Thus, if an operator should attempt to actuate valve **154** and finds that the lower shutters cannot be opened, he will know immediately that there is no charge of sand mix in the charging chamber.

The operator will then actuate a suitable valve to admit fluid to the cylinder **36** to open the upper shutters and permit a charge of sand mix to enter the charging chamber. When this occurs, the lower set **29** of the upper shutters **27** will move toward the left and carry with them the operating arm **153** from the position thereof shown in Fig. 14 to its position shown in Fig. 15. After the charging chamber has received its charge and the upper shutters are moved to closed position, the operating arm **153** will be returned toward the right to the position thereof shown in Fig. 16. As stated above, in this position of the parts the valve arm **146** will have opened the check valve so that fluid can flow therethrough to the cylinder **51** which will cause the lower shutters to open.

This arrangement is particularly advantageous in preventing an operator from cycling the machine through a dry run. As long as there is sand in the upper hopper, the machine cannot pass through that portion of its cycle where the water-cooled jacket is attached to the pattern plate and consequently the operator of the machine will immediately become aware of the fact that there is no sand mix on the pattern.

Operation

The foregoing description of the various parts of the machine has been given in detail and the operation of these various parts will now be correlated to illustrate a typical cycling of the machine.

In the beginning a suitable pattern plate having the proper stripper plate secured thereto will be placed upon the carriage **16** so that the trunnions **18** thereof will receive the shafts **20**. An obvious advantage of this arrangement is the fact that the patterns can be quickly and easily changed. The pattern is then leveled and the motor **22** is started which will carry the carriage and pattern plate along the tracks **14** and **15** to the oven **25** where the pattern is heated.

After the pattern has reached the proper temperature the carriage and pattern will be moved by the chain **21** across the stripping station to the investment chamber.

Fluid is then admitted to the cylinder **103** (Figs. 2 and 3), whereupon the lower hopper **97** will be elevated. The lower hopper will pass upwardly through the carriage **16** and will pick up the pattern plate **19** by contacting the shafts **20** thereof. This assembly of parts will then continue to rise to the position thereof shown in Fig. 4 where the pattern plate is pressed upwardly against the underside of the water-cooled jacket **54**.

At this time or at an earlier time fluid will be admitted to the cylinder **36** (Fig. 8) to open the upper shutters and permit a charge of sand mix to be deposited in the charging chamber. The upper shutters are then closed by a reverse flow of fluid through cylinder **36** whereupon the valve **145** will have been moved to open position shown in Fig. 11 enabling the lower shutters **38** to be opened.

When the lower shutters **38** are opened by the operation of the fluid passing through valve **145** and into cylinder **51** the charge of sand mix will be dropped downwardly onto the pattern plate at which time the jacket may also be caused to vibrate, if desired, which, in turn, vibrates the pattern causing a dense pack. Simultaneously with the opening of the lower shutters **38**, the locking members **61**, **62**, **61***a*, and **62***a* will be released from the respective operating bars **71** and **71***a* and the lower hooked ends thereof will attach themselves to the pins on the pattern plate (Fig. 17).

When the sand mix is deposited onto the hot pattern the heat will fuse the sand mix while at the same time the water-cooled feature of the jacket will isolate the pattern heat from the jacket and hopper assembly, eliminating a build-up of the sand mix on the jacket.

The assembly of lower hopper, pattern plate and jacket, will then be lowered substantially to the position shown in Fig. 5 where the roll-over step is carried out for dumping the excess sand mix into the lower hopper. The securing of the jacket to the pattern holds the complete charge of sand over the pattern to the instant of dumping and also permits the roll-over of the pattern on its own axis. This arrangement has the advantage of reducing the effects of inertia on the small plastic shell and permits of a light construction which facilitates the speed of operation.

When the excess sand mix is dumped into the lower hopper it is screened for removing any coagulated or encrusted sand while the remainder of the sand mix passes through the screen to the skip bucket which returns the sand to the upper part of the upper hopper.

During the roll-over step the counter-weighted locking members will be actuated by gravity to hold the stripper pins in retracted position, thereby eliminating the necessity of using springs.

After the dumping of the excess sand mix, the parts are returned to horizontal position and are again elevated to the position thereof shown in Fig. 4. The lower shutters are then closed which not only returns the check valve **145** to its position shown in Fig. 14, but also releases the water-cooled jacket from the pattern and again attaches it to the lower end of the enclosed extension **12**. The lower hopper with the pattern plate and mold thereon is then returned to its lowermost position and leaves the pattern plate on the carriage. The carriage and pattern plate are then returned to the oven where the mold is cured. After the curing operation the carriage, pattern and mold are removed from the oven through the operation of the chain drive and are indexed at the stripping station. The stripping table **129** is then raised by admission of fluid to the cylinder **133** where the adjustable bolts **140** come into contact with the stripper plate **86**. At the same time the hooked members **141** or other suitable hold-down means are brought into position to hold the pattern down while the stripper pins **87** continue to move upwardly and strip the mold from the pattern. The machine is then in readiness for recycling after the pattern is blown off and a stripper agent has been sprayed onto the pattern.

From the foregoing description it will be evident that the machine embodies many novel and advantageous features for producing shell molds rapidly. The molds produced by the machine embodying the present invention are more uniform and have greater strength than those which have been produced heretofore by other machines and methods. Furthermore, the invention is capable of producing molds from complex and intricate patterns and particularly patterns having unusually deep and narrow cavities which have been unable to be produced heretofore with any degree of success.

Changes may be made in the form, construction and arrangement of parts from those disclosed herein without in any way departing from the spirit of the invention or sacrificing any of the attendant advantages thereof, provided, however, that such changes fall within the scope of the claims appended hereto.

The invention is hereby claimed as follows:

1. In a machine for producing shell molds, a frame, an upper hopper on said frame adapted to contain a quantity of a sand mix for use in making the molds, an elongated enclosure extending downwardly from said hopper and having an opening in the lower end thereof, a chamber in the upper part of said enclosure, means for depositing a predetermined charge of sand mix into said chamber from said hopper, a carriage below said enclosure adapted to support a pattern thereon, a lower hopper below said carriage, means for elevating said lower hopper and pattern to the open lower end of said enclosure, means for dropping downwardly the entire sand mix charge in said chamber onto the pattern, and means to dump the excess sand mix from said pattern into said lower hopper.

2. In a machine for producing shell molds, a frame, an upper hopper on said frame adapted to contain a quantity of sand mix for use in making the molds, an elongated enclosure extending downwardly from said hopper and having an opening in the lower end thereof, a chamber in the upper part of said enclosure, means for depositing a predetermined charge of sand mix into said chamber from said hopper, a jacket surrounding the lower end of said enclosure and removably mounted thereon, a carriage below said enclosure adapted to support a pattern thereon, means for elevating the pattern to said jacket, means for dropping downwardly the entire sand mix charge in said chamber onto the pattern mechanical means for automatically removing said jacket from said enclosure and mounting it on the pattern, means for dumping the excess sand mix from said pattern, and means for again mounting said jacket on said enclosure after the dumping operation.

3. In a machine for producing shell molds, a frame, an upper hopper on said frame adapted to contain a quantity of sand mix for use in making the molds, an elongated enclosure extending downwardly from said hopper, a jacket removably mounted on the lower end of said enclosure, a carriage below said enclosure adapted to support a pattern thereon, means for elevating the pattern to said jacket, means to deposit a charge of sand mix onto said pattern while in elevated position, mechanical means for automatically releasing said jacket from said enclosure and mounting it on the pattern, and means for rotating the pattern and jacket to dump the excess sand mix therefrom, said third named means being operable also to release said jacket from the pattern and remount it on said enclosure.

4. In a machine for producing shell molds, a frame, an upper hopper on said frame adapted to contain a quantity of sand mix for use in making the molds, an elongated enclosure extending downwardly from said hopper, a jacket removably mounted on the lower end of said enclosure, a carriage below said enclosure adapted to support a pattern thereon, means for elevating the pattern to said jacket, means to deposit a charge of sand mix onto said pattern while in elevated position, means for cooling said jacket, mechanical means for automatically releasing said jacket from said enclosure and mounting it on the pattern, and means for rotating the pattern and jacket to dump the excess sand mix therefrom, said fourth named means being operable also to release said jacket from the pattern and remount it on said enclosure.

5. In a machine for producing shell molds, a frame, an upper hopper on said frame adapted to contain a quantity of sand mix for use in making the molds, movable closure means forming the bottom of said hopper to support the sand mix therein, a second movable closure means spaced downwardly from said first closure means, a chamber between said first and second closure means into which a charge of sand mix may be deposited from said hopper upon movement of said first closure means to open position, said second closure means including a plurality of rotatably mounted vanes, means operable to open said vanes to permit the charge of sand mix in said chamber to drop downwardly onto a pattern therebelow and thereafter to close said vanes, and yieldable means associated with said last named means operable to permit any vane having an obstruction in the path of movement thereof to remain partially open while the remaining vanes continue to move to closed position.

6. In a machine for producing shell molds, a frame, an upper hopper on said frame adapted to contain a quantity of sand mix for use in making the molds, movable closure means forming the bottom of said hopper to support the sand mix therein, a second movable closure means spaced downwardly from said first closure means, a chamber between said closure means, an elongated enclosure extending downwardly from said hopper, a jacket removably mounted on said enclosure, a carriage below said enclosure adapted to support a pattern thereon, means for opening said first closure means thereby to deposit a charge of sand mix from said hopper into said chamber, means to elevate the pattern into contact with said jacket, means to open said second closure means thereby to drop the charge of sand mix onto said pattern, said last named means being operable also to release said jacket from said enclosure and secure it to the pattern and means operable to dump the excess sand mix from said jacket and pattern while they are secured together.

7. In a machine for producing shell molds, a frame, an upper hopper on said frame adapted to contain a quantity of sand mix for use in making the molds, movable closure means forming the bottom of said hopper to support the sand mix therein, a second movable closure means spaced downwardly from said first closure means and forming a chamber therebetween, a carriage below said chamber adapted to have a pattern mounted thereon, fluid actuated means to open and then close said first closure means to permit a charge of the sand mix to drop downwardly from said hopper to said chamber and onto said second closure means during the time that said first closure means is open, fluid actuated means to open said second closure means and permit the sand mix in said chamber to drop downwardly onto the pattern therebelow, valve means movable with said second closure means and operatively connected to said second mentioned fluid actuated means for preventing operation of said second closure means until after said first closure means has been opened and then closed, said valve means including a control member thereon for opening and closing said valve means, said control members being normally disposed in position to close said valve means and thereby prevent actuation of said second fluid actuated means, and means on said first closure means and engageable with said control member at the close of a reciprocation of said first closure means from closed position to open position and back to closed position to thereby move said control member to position to open said valve means and permit said second fluid means to be actuated to open said second closure means.

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