

Aug. 5, 1958

W. S. HACKETT ET AL

2,845,669

METHOD OF CASTING IN SHELL MOLDS

Filed Oct. 12, 1953

2 Sheets-Sheet 1

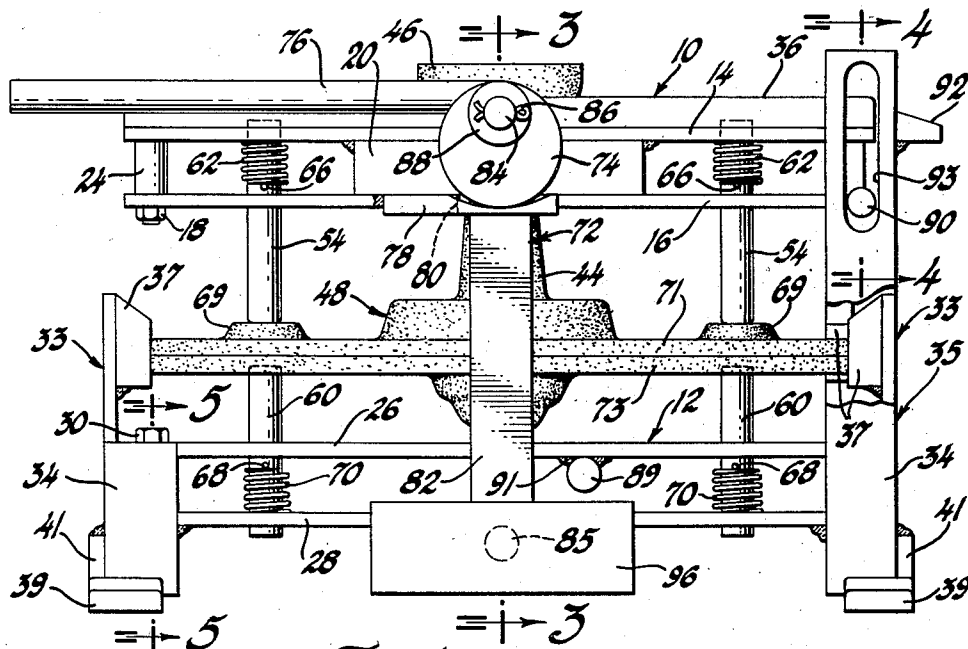


Fig. 1

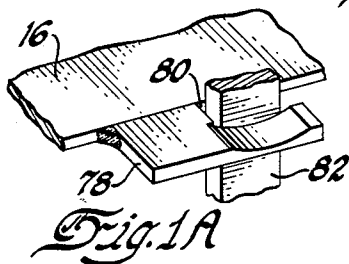


Fig. 1A

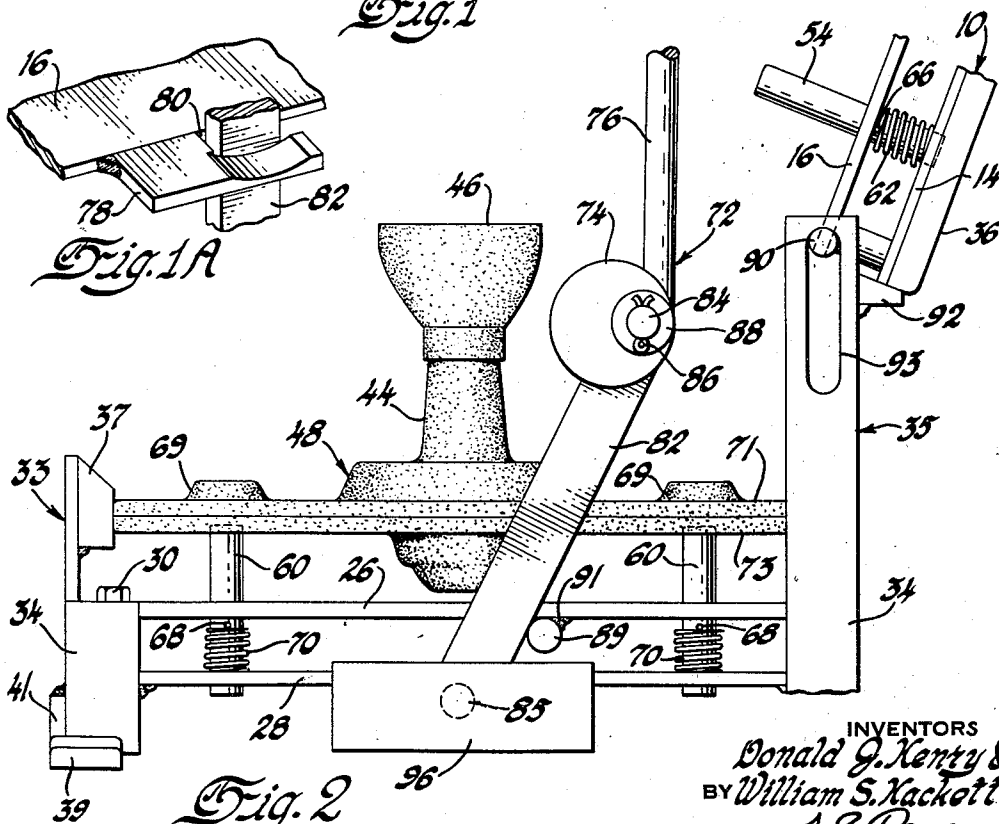


Fig. 2

INVENTORS
Donald J. Kenty &
BY William S. Hackett
J. E. Ross
ATTORNEY

Aug. 5, 1958

W. S. HACKETT ET AL

2,845,669

METHOD OF CASTING IN SHELL MOLDS

Filed Oct. 12, 1953

2 Sheets-Sheet 2

INVENTORS
Donald J. Kenty &
BY *William S. Hackett*
J. E. Ross
ATTORNEY

1

2,845,669

METHOD OF CASTING IN SHELL MOLDS

William S. Hackett, Saginaw, and Donald J. Henry, Detroit, Mich., assignors to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Application October 12, 1953, Serial No. 385,510

2 Claims. (Cl. 22—200)

This invention relates to metal casting operations using shell molds and particularly to an apparatus for supporting or backing up shell-type sand-resin molds during pouring of the molten metal.

Recently developed techniques in foundry practice employ thin-walled dispensable molds and cores composed of sand and plastic binders. These procedures, generally referred to as "shell molding" processes, are particularly suited for the production of precision castings in a wide variety of metals.

Essentially the shell molding process consists of using thermosetting plastic or resin as a binder for the sand grains to form rigid molds having high gas permeability, good surface smoothness and dimensional stability. The molding material, which is generally a dry mixture of a major proportion of silica sand and a minor proportion of plastic binder, is used in powdered form with no water being added. Phenol formaldehyde, phenol-furfural and melamine formaldehyde are typical examples of the type of thermosetting binders preferably used. It is desirable that the sand employed be free of metal oxides, clay, moisture and organic matter.

These sand-resin molds are prepared by allowing the dry mixture of sand and resin powder to come into contact with a hot metal pattern for a short period of time. A layer of the mix adheres to the metal surfaces due to the heating of the resin which entraps the sand with which it is intimately mixed, thereby accurately reproducing pattern details. Metal patterns must be employed because they are subjected to elevated temperatures. Pattern temperatures in the range between 250° F. and 450° F. are typical, but temperatures up to 800° F. may be advantageously employed under particular conditions. The half patterns, gate and runner are usually all permanently fixed on metal plates. The pattern temperatures and the length of time the molding material is allowed to remain in contact with the hot pattern surfaces determine the resulting thickness of the mold. Mold build-up times ranging from a few seconds to approximately one minute are appropriate for various applications.

After this short time interval, the excess dry sand and resin are removed, and the closely adhering sand-resin layer is preferably cured by heating to a temperature within the range of approximately 300° F. to 1500° F. for a short period of time, usually from a few seconds to five minutes, while in contact with the metal pattern. This baking operation results in the conversion of the resinous material to a hard insoluble binder which securely bonds the sand grains together. After the removal of the pattern and the mold from the curing oven, the mold is stripped from the pattern.

The formed molds are, in effect, thin shells which possess sufficient strength and stiffness to make them suitable for many casting operations if these shells are properly reinforced or backed up while the molten metal is being poured. However, if inadequate backing means is provided, these thin shell molds, because of inadequate rigidity, frequently tend to bulge, crack or otherwise become

2

distorted by the pressure of the molten metal during or immediately after pouring. Not only does such a mold distortion prevent casting to very close dimensional tolerances, but it may also result in excessive finning at the mold parting line.

Shell molds contain a relatively large amount of thermosetting resin binder, this binder normally constituting between 4% and 20% by weight of the molding material. Hence, upon contact of the molten metal with the cured shell molds, a considerable volume of volatiles is given off; and if these gases are not properly vented, distortion of the resultant castings or occlusion of gases therein results. It is therefore necessary that the mold-backing means not only rigidly support the molds, but also that this means provide for adequate venting of the formed mold gases.

The back-up bedding materials heretofore used, such as steel shot or sand, which meet this permeability requirement, frequently fail to adequately support these molds with the result that close dimensional tolerances in the mold cavity are not maintained. In most instances uneven pressure on the molds results from the use of this type of backing. Moreover, the mechanical handling of such bulky bedding material is a slow, cumbersome and expensive procedure.

Accordingly, a principal object of the present invention is to provide an apparatus for supporting assembled shell molds so as to eliminate the use of the aforementioned unsatisfactory types of backing means and the resultant casting difficulties. A further object of this invention is to provide a process for reinforcing shell molds during metal pouring operations so as to facilitate the casting procedure and thereby proportionately reduce casting expenses.

These and other objects are attained in accordance with this invention by the use of an apparatus having a pair of relatively movable plates each of which supports a plurality of mold-contacting pins or springs adapted to engage the back surfaces of shell molds to reinforce the latter and maintain them in position during pouring of the molten casting metal. These mold-contacting pins are resiliently mounted on the plates, such as by the use of compression springs, thereby permitting automatic adjustment of the mold supporting means to irregularities which may exist on the back surface of the mold. Moreover, this supporting mechanism is so designed as to permit the mold gases formed during pouring operations to readily escape into the atmosphere.

The resultant castings have very smooth as-cast surfaces, thereby considerably reducing the number of machining operations necessary in the production of precision parts. Furthermore, precision castings formed by the use of this shell mold supporting apparatus are almost completely devoid of fins because of the firm, even pressure applied to the back surfaces of the mold by the springs or spring-mounted mold-contacting pins. Although it is possible to cast certain parts by means of mold-contacting pins or projections which are not resiliently mounted, this latter type of procedure is not feasible for many casting operations because of the difficulty in providing the back of shell molds with sufficiently uniform surfaces to permit the molds to be taken directly from a mold-forming machine, baked in a curing oven, and placed in the back-up device. The resiliently mounted mold-contacting pins preferably used in accordance with the present invention obviate this difficulty and permit shell molds having relatively regular back surfaces to be rapidly, conveniently and inexpensively supported during pouring of the casting metal.

It will be understood that the term "mold," as used herein, is applied in its generic sense to mean a casting form which includes both molds and cores, this inven-

tion in no manner being limited to the former. Similarly, unless otherwise indicated, the word "pattern" is used herein as including both mold patterns and core boxes.

Other objects and advantages of the present invention will more fully appear from the following description of a preferred embodiment of the invention shown in the accompanying drawings, in which:

Figure 1 is an elevational end view of a shell mold clamping fixture embodying the present invention, the retractible mold-supporting pins being shown in their mold engaging position;

Figure 1a is a fragmentary perspective view showing the relationship between the clamping or camming mechanism and the upper plate of the apparatus shown in Figure 1;

Figure 2 is a fragmentary elevational end view showing the upper half of the shell mold clamping fixture in its open or disengaged position;

Figure 3 is a sectional side view along the line 3—3 of Figure 1;

Figure 4 is a fragmentary sectional view generally along the line 4—4 of Figure 1;

Figure 5 is a fragmentary sectional view generally along the line 5—5 of Figure 1;

Figure 6 is a fragmentary sectional view showing a modification of the resiliently mounted mold-engaging pins and the associated mounting parts shown in Figures 1, 2 and 3; and

Figure 7 is another modification of a spring-type mold-engaging means which may be employed in the apparatus shown in Figures 1, 2 and 3.

Referring more particularly to the drawings, Figure 1 shows a shell mold supporting apparatus or fixture embodying the invention and including a top plate assembly, indicated generally by 10, and a bottom plate assembly, indicated generally by 12. The assembly 10 includes an upper plate 14 and a lower plate 16, which are spatially separated vertically and rigidly retained in relative position by means of bolt and nut assemblies 18 and spacer brackets or plate supports 20, as best shown in Figure 3. Upper and lower spacer sleeves 22 and 24, respectively, are also used around the bolts to aid in maintaining the walls of the assembly 10 in proper spaced relationship and to lend structural rigidity to this assembly. Members 14, 16, 20, 22 and 24 are preferably formed of steel or cast iron.

The bottom plate assembly is of rather similar construction and includes an upper plate 26 and a lower plate 28 which are likewise spaced vertically and rigidly retained in proper position by means of bolt and nut assemblies 30 cooperating with spacer struts or sleeves 32. In the embodiment shown in the drawings, the corners and longer sides of the bottom plate assembly are provided with guide bars 33 and 35 to which are attached mold guide blocks 37 which function to properly align the shell and mold and maintain it in position laterally. The vertically extending L-shaped corner channel portions 34 of the guide bars serve as legs and may also be used to assist in retaining the upper and lower plates of the assembly 12 in proper relative position. An elongated slide plate 39 is shown as provided at each side of the apparatus. One of these plates is welded or otherwise suitably secured to the bottom edges of the channels 34 and one of the crossbars 41, while the other of these plates is attached to the bottom end of the guide bars 35 and the other crossbar.

A top panel or cover 36, which is preferably formed of sheet steel or similar material, is affixed to the upper surface of plate 14 and spatially separated therefrom by means of the nut and bolt assemblies 18 and the cover spacer sleeves 22. As shown in Figure 3, plates 14 and 16 are provided with generally central apertures 38 and 40, respectively, the cover 36 having a central portion which extends through these apertures and whose downturned inner edges terminate adjacent the aperture-de-

fining edges of the plate 16. These edges may be welded or otherwise secured together, if desired. Thus, the apertures in plates 14 and 16 and in cover 36 form a vertically extending sprue post hole or opening 42 through which the sprue portion 44 and pouring basin 46 of a shell mold, indicated generally at 48, may project, as will hereinafter be more fully explained.

The plates 14 and 16 of the top assembly 10 are provided with a plurality of small vertically aligned openings 50 and 52, respectively, through which reciprocable mold-engaging pins or rods 54 extend. Likewise, the plates 26 and 28 of the bottom plate assembly have generally aligned small openings 56 and 58, respectively, in which similar mold-supporting pins 60 are positioned. It is normally preferable to locate the upper pins 54 and the lower pins 60 in approximate alignment in order to maintain the supported shell mold under uniform pressure without introducing stresses in the mold, although it is usually not necessary to have them exactly coaxial.

In accordance with the present invention, spring means cooperates with each reciprocable pin to yieldingly force these pins into mold-contacting position. Thus, the upper mold-engaging pins 54 are shown as provided with coil springs 62 of the compression type whose upper ends contact and are retained in position by the lower surface of plate 14. Downward movement of the lower end of the springs is restricted by small laterally extending cotter pins or pegs 66, the lower ends of the springs contacting the upper surfaces of these pegs. The lateral extension of pegs 66 is greater than the diameter of the openings 52 in the plate 16 and prevents the pins 54 from slipping out of the top plate assembly when no shell mold is in position within the apparatus to exert upward pressure on the pins or when the upper half 10 of the fixture is in its open position, as shown in Figure 2. Likewise, the diameter of each coil spring at its upper end is larger than the openings 50 in plate 14 to prevent the springs from being forced upwardly through these openings. Thus the reciprocable pins 54 and the coil springs 62, which are preferably always compressed to a limited extent, are securely retained in position between the plate 14 and the plate 16.

In a similar manner, the lower mold-engaging pins 60 are provided with laterally extending cotter pins or pegs 68 which limit the upward movement of coil springs 70 and pins 60. The lateral extension of these springs and pegs is sufficient to prevent either the pegs or the springs from slipping through the openings 56 and 58 in the plates 26 and 28, respectively.

It will be appreciated, of course, that a considerably greater number of resiliently mounted mold-contacting pins may advantageously be employed to properly support the mold in many applications, but for purposes of explanation only a few such pins are shown as used in the modification of the invention described herein. In general, however, it is desirable to provide mold-contacting pins which support the mold at its mold print and print projection portions, indicated generally at 69.

Clamps, indicated generally by 72, are provided on either end of the shell mold back-up fixture and may be of any type suitable for retaining the top plate assembly and bottom plate assembly in proper mold-supporting position. When the shell mold 48 is clamped between these assemblies, the resiliently mounted pins 54 contact the top or back surface of the upper shell mold half 71 while the lower spring-biased pins 60 similarly engage the bottom or back surface of the lower half 73 of the shell mold. The movable pins thereby apply even pressure to these shell mold halves and maintain the assembled mold in proper position. The resiliency of the coil springs 62 and 70 permits these pins to adapt themselves to irregularities in the back surfaces of the shell molds and to slight changes in the contour of the molds without exerting undue pressure on the mold surfaces while at the same time, always being retained in mold-contacting posi-

tion. Of course, where the mold contour is very irregular, pins of varying lengths may be used, thus applying pressure equally at all mold-contacting points. This can be easily accomplished since the back-up apparatus is normally designed to support a particular shell mold form.

In the modification of the invention shown in the drawings, each of the clamps 72 includes a cam 74 having rigidly connected thereto an arm or handle 76 which functions as a lever to rotate the cam against a cam-engaging plate or clamp guide 78 projecting laterally from plate 16. Of course, the cam-engaging plates may be either affixed or formed integral with the plate 16. When the cam arms 76 are pivoted clockwise, as viewed from the right end of the apparatus (Figure 1), the cam is rotated out of contact with the cam-engaging plates 78. As shown in Figure 1a, the cam-engaging plates are of L-shaped construction, thereby each defining with the plate 16 a slot 80 in which a clamp strap or clamp bar 82 may be positioned. Each of these clamp bars is pivotally secured at its upper end to one of the cams and cam arms 76 by means of a pin or rod 84, this arrangement being seen best in Figure 3. The inner ends of the clamp handle pins 84 are shown as welded to the clamp bars, while their outer ends are provided with cotter pins 86 to retain the cams and attached cam arms in position. The lower end of each clamp bar 82 is likewise pivotally secured by means of a rod 85 and cotter pin 87, the former being welded or otherwise appropriately secured to the lower plate 28 of assembly 12. Washers 88 are preferably provided adjacent the cotter pins in each instance. An L-shaped end bumper 96 is shown as welded to a bumper support 98 adjacent each rod 85.

A stop 89 is welded, as shown at 91, or otherwise suitably attached to either end of the plate 26 to limit the maximum amount of pivoting of the clamp bar 82 in a clockwise direction, as viewed in Figures 1 and 2. Likewise, a stop 92 is affixed to each of the larger vertically extending guide bars 35 near the upper end thereof. The upper plate assembly thus can be rested on the stops 92 while the mold and casting are being removed from the apparatus.

Hence, it will be seen that when the cam 74 is rotated out of contact with the cam plate 78, the clamp bar 82 may be pivoted out of the slot 80 between the cam-engaging plate or extension 78 and the plate 16. This bar and the pivotally attached cam and cam arm should be moved sufficiently far to the right, as viewed in Figures 1 and 2, to permit the cam-engaging extension 78 to clear these parts when the top plate assembly 10 is raised and rotated out of mold-engaging position after the molten metal has been poured and the casting has solidified.

This rotation of the top plate assembly 10 is accomplished by means of transversely projecting pins or dowels 90 which are secured to the end edges of plate 16 (Figure 4). In the embodiment of the invention shown in the drawings, these dowels are slidably positioned in vertically extending guide slots 93 formed in the longer pair of corner guide bars 35 near the upper ends thereof and function as hinges for the top plate assembly. With this arrangement the top plate assembly is maintained in proper vertical alignment relative to the bottom plate and yet is both pivotable and vertically reciprocable relative thereto. Alternatively, of course, the whole top assembly 10 may be disengageably affixed to the bottom plate assembly 12 and may be designed to be removed entirely from it. The embodiment of the invention shown is preferred, however, because of the expeditious manner in which the plate assemblies are aligned.

In the modification shown in Figure 6, a retractable lower mold-engaging pin 60a is mounted on a lower supporting plate 28a by means of upper and lower cotter pins 100 and washers 102. The pin 60a is slidably positioned in and supported by a sleeve or liner 104, which is tightly fitted within the opening 106 in plate 28a. Ex-

cept for the fact that the upper end of the compression spring 62a abuts a washer rather than a small pin 68, this construction is generally similar to the one described above.

A somewhat different arrangement of a retractable or resilient mold-supporting member is shown in Figure 7. Here a pin 108 is rigidly mounted within the opening 106 in plate 28a by means of a threaded bolt portion 110 and a nut 112. A coil spring 114 of the compression type is secured to the upper end of pin 108 by a cotter pin 116. Hence, in this construction the spring, rather than a pin, functions as the retractable mold-supporting member. With these latter two arrangements only one pin supporting plate, such as plate 28a, is necessary rather than the two shown in Figures 1 through 5.

When the above-described apparatus is used to support shell molds during pouring of molten casting metal, it is desirable that the springs 62, 70, 62a and 114 be formed of a material which possesses resistance to softening or taking a "set" at temperatures up to approximately 900° F. Upon pouring, the supported shell molds normally flame to a considerable extent, the flames extending particularly to the upper portion of the apparatus. Hence, the springs which are exposed to this intense heat, should retain their physical properties at red heat temperature, i. e., at or above about 900° F. Springs which are formed of high speed steel should therefore be employed in preference to oil-tempered springs or stainless steel springs. High speed steel springs normally possess resistance to tempering at temperatures up to about 1050° F. Examples of high speed steels which may be used as spring material are the high tungsten content steels containing approximately 18% tungsten, 4% chromium and 1% to 2% vanadium and the high molybdenum steels containing about 9% molybdenum, 4% chromium, 1.5% tungsten and 1.5% vanadium, as well as certain high cobalt content steels.

The mold-supporting apparatus described above operates in the following manner when used during the actual casting process. After the shell mold halves 71 and 73 have been removed from the curing oven, their smooth casting-defining faces are placed into contact with each other, and the formed mold assembly is positioned on the upper ends of the bottom mold-engaging pins 60. The top plate assembly is then pivoted counterclockwise (Figures 1 and 2) and lowered, as hereinbefore described, until the upper mold-engaging pins 54 contact the upper or back surface of the top shell mold half 71. Next the lever or cam arms 76 and clamp bars 82 are rotated counterclockwise, as viewed from the end of the apparatus shown in Figures 1 and 2, until the latter are in position within the slots 80. Further counterclockwise movement of the cam arms 76 results in engagement of the cam-engaging plates 78 by the edges of cams 74 farthest from the pins 84. This camming action results in depressing the top plate assembly 10 until the upper mold-engaging pins 54 exert sufficient pressure on the mold to slightly depress the lower mold-engaging pins 60 and compress springs 62 and 70. When the apparatus is in this position, the mold halves are securely clamped together by the retracted spring-supported pins and are ready to receive the molten casting metal. At the same time, the pressure exerted on the mold is insufficient to cause fracture or distortion of the mold halves.

Upon pouring the liquid metal through the sprue 44 and into the mold cavity in the usual manner, the hot metal, on contacting the shell mold, burns the plastic binder of the mold to essentially carbon. The gases which are generated readily escape through the highly permeable sand-resin shell and are vented from the mold through the open sides in the mold-supporting apparatus.

After the casting has been permitted to solidify, the cam arms 76 are rotated clockwise, relieving the pressure between the cams 74 and the cam-engaging plates 78.

The clamp bars 82 are thus pivoted out of slots 80 to permit the top plate assembly to be rotated out of contact with the shell mold. Of course, the pressure is thereby removed from the outer surfaces of the mold and the spring-mounted pins 54 and 60 return to their normal positions. The top plate assembly then may be rested on stops 92, as shown in Figure 2, and the solidified casting and adhering shell mold halves readily removed from the bottom plate assembly 12 by metal tongs or other appropriate means, thus completing the operating cycle. As a result of the breakdown of the thermosetting resin binder in the mold, as hereinbefore described, the shake-out is readily accomplished, and the casting is ready for use or subsequent finishing operations.

Of course, it will be understood that, although in the modification shown in the drawings and described herein, the shell mold supporting apparatus is arranged so that the shell mold is horizontally positioned, this general construction is also adaptable for vertical positioning of the mold. With this latter arrangement the pouring basin 46 would extend upwardly through an opening in an end or side wall of the apparatus between plates 16 and 26. With such a construction, of course, further provision would necessarily have to be made for vertically supporting the shell mold immediately prior to clamping between the pins 54 and 60. This could be accomplished by having an aligning member support the lower edges of the assembled shell mold while, if desired, other members could temporarily hold the mold against the ends of pins 60.

It also will be understood that the shell mold supporting apparatus described above could also be designed so that one shell mold half is retained in position against the lower ends of the upper mold-engaging pins 54, while the other shell mold half is retained against the upper ends of the lower mold-engaging pins 60 preparatory to lowering of the top plate assembly. Once this assembly is lowered into position, thereby bringing the mold halves into contact, the apparatus would function in a manner similar to that described above. However, in view of the fact that the shell mold halves are normally provided with mating mold prints and print projections, the modification shown is preferred since it provides for perfect alignment of the mold halves and eliminates any possibility of even slight mis-alignment caused by attrition of mold prints due to relative movement of the mold halves upon closure of the top and bottom plate assemblies.

Inasmuch as shell molds, if properly supported in the above-described manner during pouring of the molten casting metal, faithfully reproduce pattern details and maintain good dimensional tolerance, they can be used to provide cast metal parts with extremely thin section which can be cast to almost the precise dimensions ultimately desired. The resultant castings have smooth and clean surfaces, true dimensions, and a minimum of fin at the mold parting line. These desirable qualities result from the unusual surface smoothness and excellent permeability of shell molds and their rigidity when clamped together as hereinbefore described during metal pouring operations.

The surfaces of these castings are also free of residual

mold material, thereby generally eliminating the necessity of shot blasting. Hence the use of such properly supported shell molds permits the production of sound precision castings in a variety of metals over a wide range of casting temperatures.

Various modifications in the arrangement and details of the embodiment of the invention described and shown herein will be apparent to those skilled in the art and are contemplated as within the scope of the present invention as defined in the following claims.

We claim:

1. A process for forming a precision casting by use of a shell mold, said process comprising assembling a pair of shell mold halves to receive molten casting metal, positioning a side of the resultant assembled shell mold against the ends of a series of spring-biased mold-engaging pins which are slidably mounted within apertures in a supporting plate, moving a second series of spring-biased mold-engaging pins into contact with the side of the mold opposite said first series of pins, clamping said first and second series of spring-biased pins into firm engagement with the shell mold so as to partially retract said pins, pouring molten casting metal into said shell mold, permitting the casting metal to solidify, thereafter moving said second series of spring-biased pins out of engagement with said mold, and subsequently removing the shell mold and solidified casting from the ends of said first series of spring-biased pins.

2. A process for forming a casting by means of a shell mold, said process comprising assembling a pair of shell mold halves in abutting position to form an interjacent casting-defining cavity, positioning a side of the resultant assembled shell mold against the ends of a series of spring-biased mold-engaging pins which are mounted on a supporting plate and are slidable in a direction generally normal thereto, moving a second series of spring-biased mold-engaging pins which are slidably mounted on a second supporting plate into contact with the side of the assembled shell mold opposite said first series of pins, clamping said first and second series of spring-biased pins into firm engagement with the shell mold so as to partially retract said pins, pouring molten casting metal into said casting-defining cavity while said shell mold is clamped by said pins, permitting the casting metal to solidify, thereafter moving one of said series of spring-biased pins out of engagement with said mold, and subsequently moving the shell mold and solidified casting out of contact with the other of said series of spring-biased pins.

References Cited in the file of this patent

UNITED STATES PATENTS

55	Re. 13,097	Molder	Mar. 22, 1910
	498,406	Rhodes	May 30, 1893
	2,192,133	Hagemeyer	Feb. 27, 1940
	2,659,945	Valyi	Nov. 24, 1953
	2,728,122	McLeer	Dec. 27, 1955
60	2,736,936	Grueneberg	Mar. 6, 1956

OTHER REFERENCES

Am. Foundryman, Aug. 1952, pages 42-46.