

Feb. 6, 1945.

R. J. MILLER

2,368,718

METHOD OF MAKING MOLDS HAVING ACCOMMODATION CORES

Filed Nov. 27, 1942

3 Sheets-Sheet 1

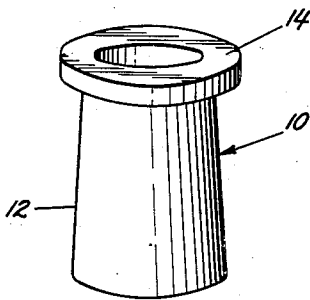


FIG. 1.

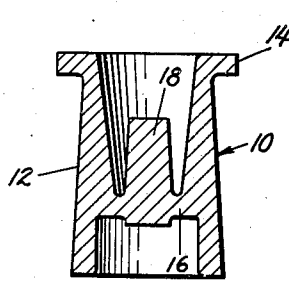


FIG. 2.

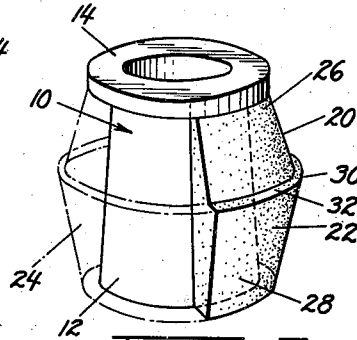


FIG. 3.

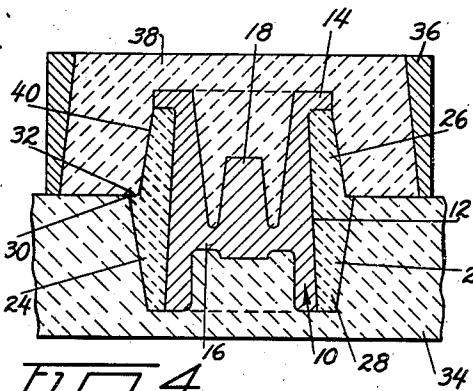


FIG. 4.

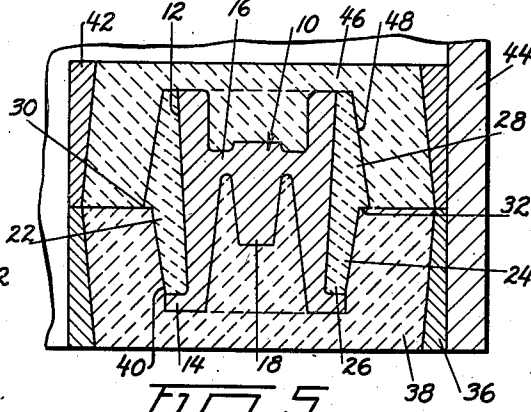


FIG. 5.

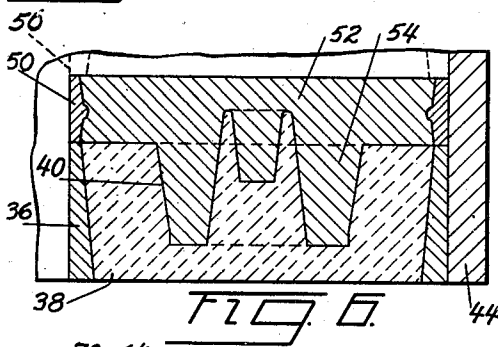


FIG. 6.

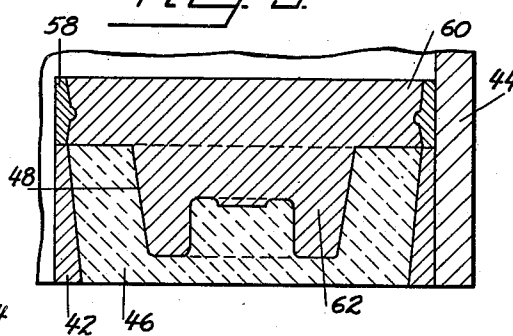


FIG. 7.

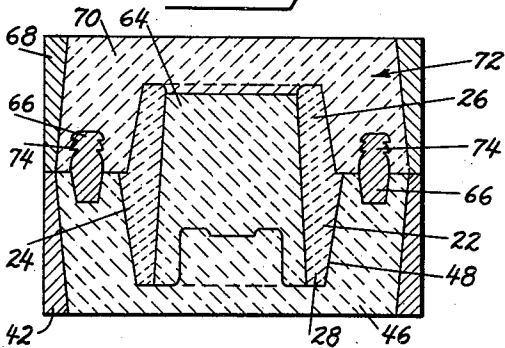


FIG. 8.

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3 Sheets-Sheet 2

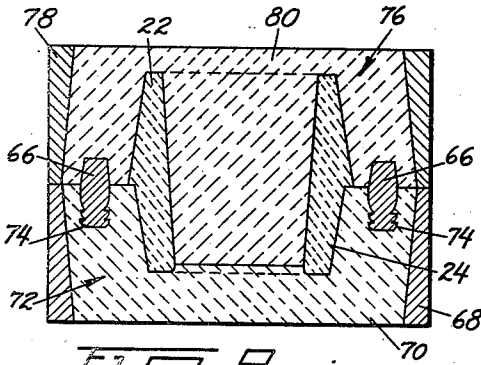


FIG. 9.

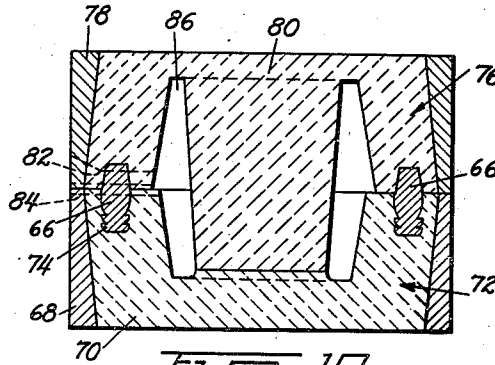


FIG. 10.

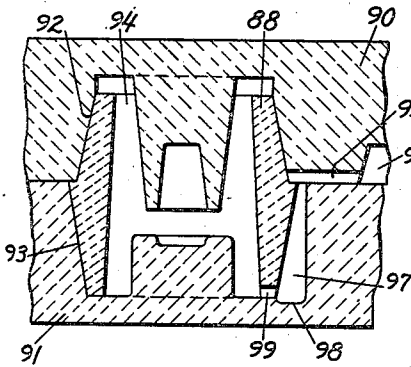


FIG. 11.

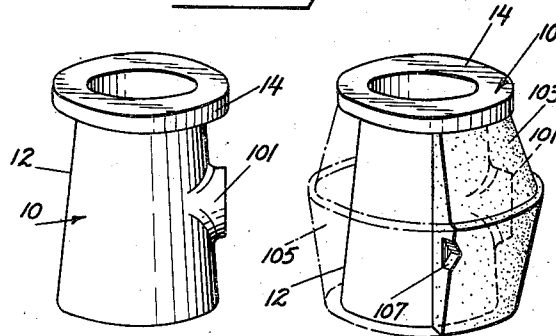


FIG. 12.

FIG. 13.

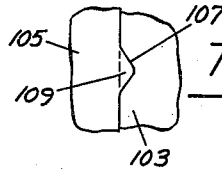


FIG. 14.

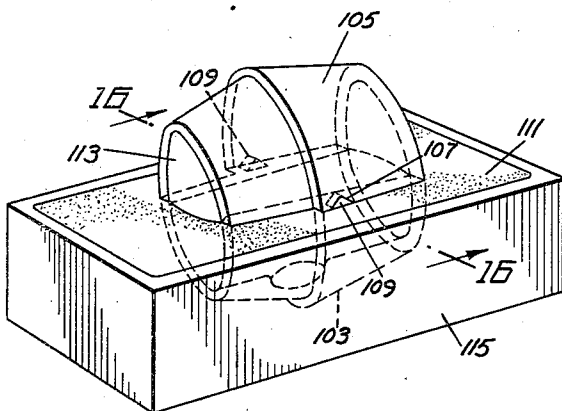


FIG. 15.

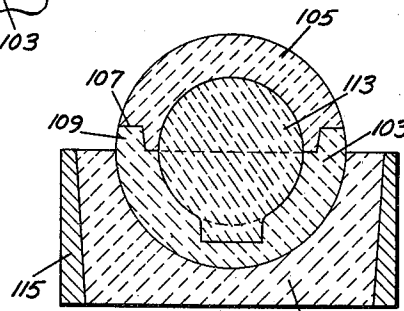


FIG. 16.

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METHOD OF MAKING MOLDS HAVING ACCOMMODATION CORES

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3 Sheets-Sheet 3

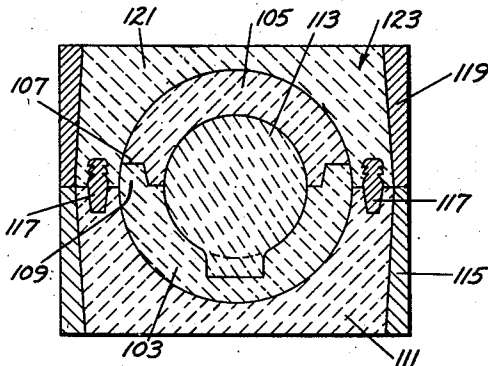


FIG. 17.

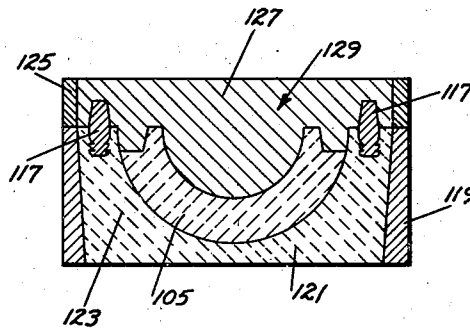


FIG. 18.

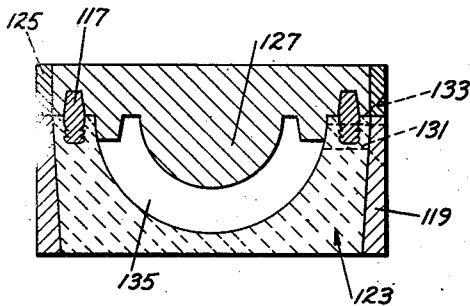


FIG. 19.

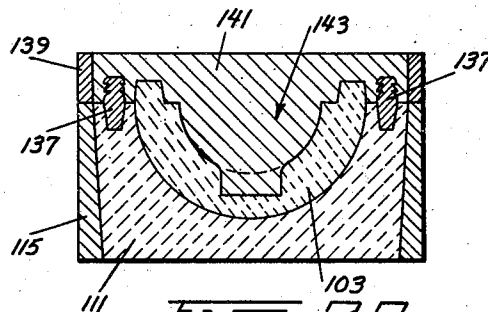


FIG. 20.

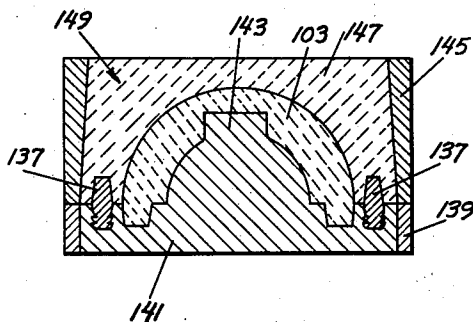


FIG. 21.

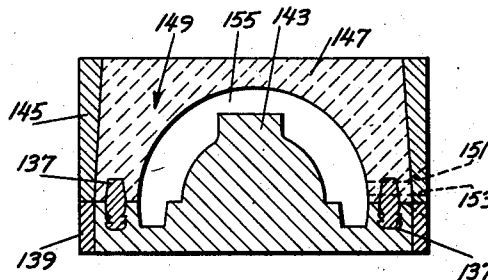


FIG. 22.

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UNITED STATES PATENT OFFICE

2,368,718

METHOD OF MAKING MOLDS HAVING
ACCOMMODATION CORES

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Application November 27, 1942, Serial No. 467,088

7 Claims. (Cl. 22—193)

This invention relates to the art of casting, and more particularly to the use of cores formed by a reproductive process for forming mold cavities of articles having irregular contours where back draft would be encountered in the formation of mold cavities in the methods heretofore employed. These core members may be of the transition type to extend a parting line throughout the usable mold-forming substance in both the cope and drag sections of a mold.

In certain types of casting equipment now being used commercially, such for example as the Capaco process as disclosed in Patent No. 2,201,037, issued May 14, 1940, molds of accurate external dimensions are formed from separate die patterns. Each die pattern consists of a pattern or a group of patterns positioned in a flask. Where a plurality of patterns are used in a single flask, each pattern member is carried on a base of accurate external dimensions to accurately locate the pattern in the flask to assure proper alignment of the mold cavities of the cooperating mold members formed from the separate die patterns.

In this and other types of casting equipment being used commercially, it is impossible to form mold cavities of articles having irregular surfaces where back draft would be encountered. As pointed out in my copending application Serial No. 459,106 filed September 21, 1942, it is impossible in the Capaco process to extend a parting beyond the usable mold-forming substance of one mold plus the majority of the depth of a single pattern base member.

My copending application Serial No. 459,106 discloses a method whereby a parting line may be extended throughout the usable mold-forming substance of both the cope and the drag sections of the flask by the use of transition cores. By the method disclosed in said application it is difficult to accommodate articles having contoured surfaces where a substantial amount of back draft would be encountered.

This invention is directed primarily to the use of accommodation cores to permit the formation of mold cavities of articles having contoured surfaces embodying back draft. The accommodation cores may be in the form of transition cores to extend a parting throughout the usable mold-forming substance in both the cope and drag sections of a mold.

An object of this invention resides in the development of an improved method whereby articles having contoured surfaces embodying back draft may be readily formed by a casting operation.

A further object of the invention is to provide an improved method of making cooperating core and mold members embodying a casting cavity of an article having a contoured surface embodying back draft.

Another object resides in the use of removable accommodation cores to form casting cavity surface embodying back draft.

A further object of the invention is to provide an improved method of making core boxes by a reproductive method for forming accommodation cores to compensate for back draft in the article to be cast.

Still another object resides in the formation of cooperating core box and pattern members of an article embodying back draft by applying to the surface of a pattern of the article to be formed a parting material to eliminate back draft and forming pattern members of the combined pattern member and the parting material by a reproductive method, and forming core boxes from the parting material by a reproductive method.

Another object of the invention is to provide transition accommodation cores to permit the casting of articles having back draft and to extend a parting throughout the entire usable mold-forming substance of the cope and drag sections of a mold.

A further object resides in the use of a plurality of interlocked core members to form a portion of the surface of a casting cavity of an article having contoured surfaces or projections in the form of bosses, etc., whereby back draft would be encountered.

Another object of the invention is to form a plurality of core boxes by a reproductive method from segments of interlocked parting material applied to a pattern surface to eliminate back draft and to accommodate irregularities in the surface of the article to be formed.

Other objects and advantages of this invention will be apparent from the following detailed description considered in connection with the accompanying drawings, submitted for purposes of illustration only, and not intended to define the scope of the invention, reference being had for that purpose to the subjoined claims.

In the drawings wherein similar reference characters refer to similar parts throughout the several views:

Fig. 1 is a perspective view of a master pattern of an article having back draft to be formed by a casting operation.

Fig. 2 is a longitudinal sectional view of the pattern illustrated in Fig. 1.

Fig. 3 is a perspective view illustrating the first step in the practice of this invention wherein separable parting material is applied to the surface of the master pattern to eliminate back draft and to form an accommodation core-forming member.

Fig. 4 is a sectional view illustrating the steps of embedding the master pattern and accommodation core-forming member in parting material and applying a moldable substance to the exposed surfaces thereof to form a female impression in a frame.

Fig. 5 is a view similar to Fig. 4 showing the pattern and accommodation core-forming members inverted and positioned in the female impression formed in the step illustrated in Fig. 4 with the parting material removed and illustrating the formation of a female impression of the exposed pattern member and accommodation core-forming member in a frame aligned with the frame surrounding the female impression formed in the step illustrated in Fig. 4.

Fig. 6 is a sectional view illustrating the formation of a production pattern member of the pattern and accommodation core members from the female impression formed in the step illustrated in Fig. 4.

Fig. 7 is a view similar to Fig. 6 illustrating the formation of a production pattern from the female impression of the pattern and accommodation core members formed in the step illustrated in Fig. 5.

Fig. 8 is a sectional view illustrating the step of forming the first half of the accommodation core box member from the core-forming member positioned in the female impression formed in the step illustrated in Fig. 5 with additional parting material added to fill the space formerly occupied by the master pattern and to eliminate back draft.

Fig. 9 is also a sectional view illustrating the formation of the second half of the accommodation core-box member from the first half of the accommodation core-box member, the parting material applied in the step illustrated in Fig. 8 being removed.

Fig. 10 is a sectional view illustrating the core-box members assembled to form the accommodation core member.

Fig. 11 is an assembled view showing the accommodation core member in place in drag and cope mold members formed from the production pattern equipment illustrated in Figs. 6 and 7 and showing the method of feeding molten alloy or metal to the mold cavity.

Fig. 12 is a perspective view similar to Fig. 1 showing a modified form of the invention wherein the article to be formed is provided with a boss projecting from one side wherein back draft in a plurality of directions would be encountered.

Fig. 13 is a perspective view illustrating the formation of an accommodation core-forming segment to eliminate back draft in a plurality of directions encountered in the surfaces of the master pattern and the extending boss carried thereby.

Fig. 14 is a fragmentary sectional view illustrating one suitable form of locating means between the accommodation core-forming segments.

Fig. 15 is a perspective view illustrating the master pattern and accommodation core-forming segments embedded in parting material preparatory to forming core-box members for making the accommodation core segments.

Fig. 16 is a sectional view taken substantially on the line 16—16 of Fig. 15 looking in the direction of the arrows preparatory to forming core-box members for making the accommodation.

Fig. 17 is a sectional view illustrating the formation of the first half of a core-box member for forming one of the accommodation core segments.

Fig. 18 is a sectional view illustrating the formation of the other half of the core box for making one of the accommodation core segments.

Fig. 19 is a sectional view illustrating the core-box members in assembled position with the pouring and venting means in place for forming one of the accommodation core segments.

Fig. 20 is a sectional view illustrating the step of forming the first half of a core box for making another of the accommodation core segments to eliminate back draft in a plurality of directions.

Fig. 21 is a sectional view illustrating the formation of the second half of this core-box member.

Fig. 22 is a sectional view illustrating the core-box members assembled with the pouring and venting means in place in operative position to form the segment of the accommodation core segment.

Before explaining in detail the present invention it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Referring now to the drawings, Figs. 1 and 2 are illustrative of a pattern of any article 10 having back draft which may be formed by a casting operation. The article 10 may, for example, be a cone-shaped member having an upwardly tapering outer surface 12 terminating in a radially-extended flange 14 at its upper or smaller end. The article 10 may be cored internally as illustrated in Fig. 2, and an inwardly-extended web 16 may support an axially-extending hub 18.

By the methods heretofore employed in the casting art, it would be extremely difficult, if not impossible, to cast this type of article, since it would be necessary to extend the parting longitudinally of the article 10, and hanging cores would be required to form the hub 18 and web 16.

These difficulties may be readily eliminated by the use of an accommodation core-forming member surrounding the pattern of the article 10 to eliminate back draft. The core box for forming the accommodation core may be conveniently and accurately formed by a reproductive process from the surfaces of any suitable parting material applied to the pattern to provide an accommodation core-forming member to eliminate back draft.

As illustrated in Fig. 3, suitable parting material 20 is applied to the tapered outer surface 12 of the pattern of the article 10 to eliminate back draft between the tapered surface and the flange 14. The material 20 may be any substance suitable for making partings, such as molding clay, plaster, wax, paraffin, an alloy of the Wood's metal group, or the Cerro alloys consisting for example of 42% tin and 58% bismuth.

The parting material 20 should closely adhere to the surface of the pattern of the article 10 to form an accurate female impression of the

surface of the pattern. If desired, a thin layer of parting material may be sprayed onto the surface of the pattern to faithfully reproduce the surface of the pattern, and the remainder of the area of the accommodation core-forming members may be applied to this sprayed layer.

The parting material 20 is preferably split longitudinally to form two accommodation core-forming segments 22 and 24 capable of being separated to remove them from the pattern of the article 10. The outer surfaces of the core-forming segments 22 and 24 are shaped to eliminate back draft on the surface of the pattern and to provide upper and lower sections 26 and 28 respectively tapering in opposite directions from a point 30 positioned approximately midway of the length of the pattern of the article 10. If desired, an inwardly-extended flange 32 may be formed on the core-forming segments 22 and 24 at the point 30 to more definitely locate the positioning of the accommodation core in the cope and drag sections of the mold at the time castings are formed.

Referring now to Fig. 4 it will be observed that the pattern of the article 10 with the accommodation core-forming members 22 and 24 in place is embedded in any suitable parting material 34. The parting material 34 may be similar to the parting material 20 of which the accommodation core-forming members 22 and 24 are formed, and it may be applied to the lower section 28 of the accommodation core-forming segments 22 and 24 in any convenient manner.

A frame 36 preferably having smooth, accurately-dimensioned outer edges is positioned on the parting material 34 to surround the upper section 26 of the accommodation core-forming members 22 and 24 and the pattern of the article 10.

Any suitable moldable substance 38 is introduced into the space within the frame 36 to form a female impression 40 of the exposed surfaces of the pattern 10 and the upper section 26 of the accommodation core-forming members 22 and 24. The substance 38 may be virtually any material capable of flowing and solidifying to form within the frame 36 the female impression 40 of the core-forming and pattern members. Suitable materials for this purpose are the various Wood's or type metals, white metal, plaster, plastics either of the thermosetting or thermoplastic types, and the so-called Cerro alloys consisting for example of 42% tin and 58% bismuth. The cerro alloys possess the characteristics of flowing and hardening with substantially no change of volume. When these alloys are employed the female impression 40 accurately conforms to the shape and contour of the core-forming and pattern members. In the event that the substance employed does not possess the characteristics of maintaining substantially constant volume upon change of state, suitable allowance should be made to compensate the variation of volume.

After solidification of the moldable substance 38, the entire assembly may be inverted and the parting material 34 removed. Another frame 42 preferably having smooth, accurately-dimensioned outer edges is superimposed on the frame 36 and is accurately aligned therewith by means of a right angle 44 adapted to engage the side walls of the frames 36 and 42.

A moldable substance 46 is introduced into the space within the frame 42 to form a female impression 48 of the exposed surfaces of the pattern

of the article 10 and the lower section 28 of the accommodation core-forming members 22 and 24. The substance 46 may, like the substance 38, be any material capable of being applied and solidifying to form the female impression 48 of the pattern and core-forming members.

The substance 46 may be the same type of material as the substance 38, suitable precautions being taken to guard against fusion with the solidified substance 38. Where the substances 38 and 46 are alloys applied in the molten state, the block of the solidified substance 38 acts to chill the molten substance 46 to prevent fusion of the blocks having the female impressions 40 and 48 of spaced portions of the pattern and accommodation core-forming members. Where substances other than alloys are used, suitable parting materials may be employed.

The blocks formed by solidification of the substances 38 and 46 are retained in their associated frames 36 and 42 respectively by the frictional contact of the outer surfaces of the blocks and the inner surfaces of the frames. It will be apparent that if desired, an inwardly-extending bead may be carried by the frames to engage and securely hold the blocks in place. After solidification of the substance 46, the frames 36 and 42 having the female impressions 40 and 48 respectively therein may be separated from the pattern and accommodation core-forming members.

Where the pattern equipment is to be used in the so-called Capaco process of molding, the female impressions 40 and 48 may be used as illustrated in Figs. 6 and 7 to form production pattern equipment of the pattern and accommodation core-forming members. A production pattern frame 50, preferably of the same external dimensions as the frame 36, is superimposed on the frame 36 and is accurately aligned therewith by means of the right angle 44 as illustrated in Fig. 6.

Any suitable pattern-forming moldable material 52 is introduced into the space within the frame 50 to form thereon a production pattern 54 accurately conforming to the contour of the female impression 40 of the pattern and accommodation core-forming members. If desired, a riser frame 56 may be superimposed on the production pattern frame 50, as more fully disclosed in my copending application Serial No. 454,831, filed August 14, 1942.

Where the production pattern equipment is to be mounted in a flask to form a die pattern as in the Capaco process of molding, the pattern frame 50 is formed to accurate external dimensions conforming to the required dimension of the pattern equipment under consideration. It will be apparent that the pattern frame can be of any desired shape and dimensions to adopt the production pattern equipment for use in any type of molding process.

A production pattern frame 58 may be superimposed on the frame 42, and moldable material 60 applied to form on the frame 58, a production pattern 62 accurately conforming to the contour of the female impression 48 in the substance 46.

The pattern-forming substance 52 and 60 may be any suitable material capable of accurately conforming to the contour of the female impressions 40 and 48 respectively. A desirable material for this purpose is cerrobaze, an alloy possessing the characteristic of flowing at approximately 350° F. and solidifying with negligible shrinkage. Other suitable materials are other cerro alloys, white metal, Wood's or type metal,

aluminum, various alloys of brass, bronze, etc., and plastics either of the thermoplastic or thermosetting types. Suitable allowances should be made to compensate variations of volume of the substances 52 and 60 upon change of state from liquid to solid in the event that said substances do not possess the characteristic of substantially constant volume upon change from liquid to solid states.

The accommodation core-forming members 22 and 24 may be removed from the pattern of the article 10 and used in the formation of a core box for making an accommodation core to be used with molds formed from the production patterns 54 and 62 to form a casting cavity conforming with the contour of the pattern of the article 10.

The members 22 and 24 of the accommodation core former may be positioned in the female impression 48 of the substance 46 in the frame 42 as illustrated in Fig. 8. Suitable parting material 64 may be introduced into the space within the members 22 and 24 of the accommodation core former to fill the space occupied by the pattern and to eliminate back draft in the core-forming members 22 and 24.

Locator means such for example as the dowel pins 66 may be positioned in the substance 46 outside the female impression 48 of the pattern and accommodation core-forming members. A frame 68 may be superimposed on the frame 42 and a moldable substance 70 applied to form the first half 72 of the core box. The moldable substance 70 may be any suitable material such as those discussed above for the making of the female impressions or for the making of the production patterns. The core box half 72 embodies the contour of the upper section 26 of the core-forming members 22 and 24, the contour of the parting material 64, and the contour of the exposed upper surface of the substance 46 having the female impression 48 therein.

As illustrated in Fig. 8 the upper ends of the dowel or locator pins 66 have contoured portions 74 to engage within the moldable substance 70 to lock the dowels to the first half 72 of the core box.

After the substance 70 has solidified, the entire assembly may be inverted and the frame 42 with the female impression 48 in the substance 46 removed. The dowel or locator members 66 remain in the substance 70. The parting material 64 may also be removed from the inside of the accommodation core-forming members 22 and 24.

The second half 76 of the core box may be formed from the first core box half 72 and the accommodation core-forming members 22 and 24, as illustrated in Fig. 9. Another frame 78 may be superimposed on the frame 68 and any suitable substance 80 introduced into the space within the frame 78 to provide the second half 76 of the core box with a surface conforming with the remainder of the contour of the accommodation core-forming members 22 and 24 previously covered by the female impression 48 and the parting material 64.

The substance 80 surrounds the exposed portions of the dowel pins 66 to form dowel impressions to locate the second half 76 of the core box with reference to the first half 72. If desired, the frames 68 and 78 of the first and second halves of the core box members 72 and 76 may be located by means of the right-angle frame 44. The use of the dowel pins 66 is more con-

venient because the core-box members 72 and 76 must be assembled and disassembled each time an accommodation core member is formed.

After the substance 80 has solidified, the second half 76 of the core box may be removed from the first half 72 and the accommodation core-forming members 22 and 24 removed. Suitable riser and feeder apertures 82 and 84 may be extended through the walls of the first and second halves of the core box to permit the introduction of a suitable core-forming substance into the accommodation core cavity 86, as illustrated in Fig. 10.

Where the pattern and core-forming members are used in processes such as the Capaco process of plaster molding a gypsum compound having suitable strengthening ingredients is introduced into the accommodation core cavity 86 through the feeder 82 of the core box to form an accommodation core 88. When the core has attained a predetermined set, it is removed from the core box and is subjected to a drying process to dispel virtually all of its moisture and to provide a relatively porous core having a highly calendered surface.

The production patterns 54 and 62 formed in the step illustrated in Figs. 6 and 7 are mounted in flasks to form die patterns. A gypsum compound similar to that of which the accommodation core 88 was formed may be applied to the die patterns having the production patterns 54 and 62 to form cope and drag molds 90 and 91 having female impressions 92 and 93 respectively of the pattern of the article 10 and the accommodation core 88.

The accommodation core 88 may be positioned in the mold impressions 92 and 93 in the cope and drag sections of the mold to provide a casting cavity 94 accurately conforming to the contour of the pattern of the article 10.

The casting cavity 94 may be supplied with molten alloy or metal by means of a suitable feeder passage 95 communicating with a gate impression 96 formed in the cope or drag sections of the mold. The feeder passage 95 communicates with a downwardly-extending passageway 97 terminating in a surge pool 98. The surge pool 98 communicates with the casting cavity 94 through a restricted feeder 99 positioned at the bottom thereof. The impressions of the feeder passageways may be formed in the mold and accommodation core members by means of suitable pattern members applied to the production pattern and core-box members before the accommodation core 88 and the cope and drag mold members 90 and 91 are formed.

It will be noted that molten alloy or metal is introduced into the mold cavity 94 at the bottom. No turbulence is caused during the filling of the mold and the envelope formed on the surface of the molten alloy or metal during the pouring operation is progressively expanded and is not ruptured. Entrained air and gases formed during the pouring operation are dispelled through the relatively porous walls of the accommodation core and mold members surrounding the casting cavity 94.

It will be apparent that the pattern and accommodation core-box members may be used to form molds and accommodation core members for use in any type of molding operation, and the complete mold assembly, including the accommodation core member, may be employed to make wax patterns for use in the so-called "Lost wax" method of casting. If desired, the produc-

tion patterns 54 and 62 may be used in the Capaco process to form patterns in the harder and more durable alloys, such as Beryllium brass, etc.

This invention is not limited to the formation of accommodation cores to eliminate back draft in a single direction, since a plurality of accommodation core members may be formed to eliminate back draft in several directions. The accommodation core member may be divided into a plurality of smaller segments, each segment being capable of relieving back draft in a portion only of the surface of the pattern. Core boxes for forming each accommodation core segment may be formed by the reproductive process directly from the accommodation core-forming segment. The accommodation core-forming members may be provided with registering means to locate each segment accurately relative to the other segments employed to form the complete accommodation core member.

Figs. 12 to 22 illustrate the formation of two separate accommodation core-forming segments, one of which embodies back draft in two directions. It will of course be apparent that any desired number of segments may be employed to eliminate back draft. An accommodation core member formed of a plurality of segments is necessary where back draft in a plurality of directions is encountered, because it would be impossible to open a single core box embodying double back draft after the formation of the accommodation core member.

As illustrated in Fig. 12, a radially-extended boss 101 projects outwardly from the conically-shaped surface 12 of the pattern 10. Because of the radially-extended flange 14 the conically-shaped surface 12 embodies back draft in one direction, and the boss 101 extending therefrom embodies back draft in another direction.

As illustrated in Fig. 13, an accommodation core-forming member having longitudinally-extending separable elements 103 and 105 is formed on the pattern 10. Cooperating registering means 107 and 109 are formed between the accommodation core-forming segments 103 and 105 respectively as more clearly illustrated in Figs. 13 and 14 to accurately locate the segments of the accommodation core-forming member relative to each other.

The pattern 10 with the accommodation core-forming members 103 and 105 in place thereon may be used in the manner illustrated in Figs. 4 to 7 to form production pattern equipment of the pattern and accommodation core-forming members.

Core boxes for making cooperating accommodation core segments conforming to the shape and contour of the core-forming members 103 and 105 may be formed as illustrated in Figs. 15 to 22 inclusive.

The core-forming segments 103 and 105 may be separated from the pattern 10, reassembled by means of the registering means 107 and 109, and embedded in parting material 111 as illustrated in Figs. 15 and 16. The parting material 111 should be extended to cover the core-forming segment 103, and additional parting material 113 may be employed to fill the space between the segments 103 and 105 formerly occupied by the pattern 10 and to eliminate back draft. The parting material 111 is preferably positioned in a frame 115 to insure more accurate results in the formation of the core-box members.

As illustrated in Fig. 17, dowel or locator pins

117 are positioned in the parting material 111 outside the contour of the accommodation core-forming member 103. A frame 119 is superimposed on the frame 115, and moldable substance 121 similar to the moldable substance 70 and 80 illustrated in Figs. 8 and 9 is introduced into the space within the frame 119 to form a female impression of the exposed surface of the core-forming segment 105 and the parting material 111 and 113. The substance 121 engages the exposed ends of the dowel pins 117 to securely lock them to the first half 123 of the core-box member for making the core segment conforming to the shape of the accommodation core-forming member 105.

Upon solidification of the substance 121 the entire assembly may be inverted, the frame 115 with the parting material 111 removed, and the accommodation core-forming member 103 and parting material 113 also removed. A frame 125 is superimposed on the frame 119, and a moldable substance 127 is applied to form the second half 129 of this core-box member.

After the substance 127 solidifies the core box may be opened and the accommodation core-forming segment 105 removed. Suitable feeding and venting openings 131 and 133 may be extended into the accommodation core-forming cavity 135 formed between the first and second halves 123 and 127 respectively of the core box. The core box may then be used in the manner previously indicated to form accommodation core segments accurately conforming to the shape and contour of the accommodation core-forming segment 105.

The core box for making accommodation core segments embodying the shape and contour of the segment 103 may be formed by the reproductive method from the core-forming segment 103. Additional dowel or locator pins 137 may be positioned in the openings in the parting material 111 formerly occupied by the dowel pins 117. A frame 139 may be superimposed on the frame 115 and suitable core box-forming moldable substance 141 introduced into the space within the frame 139 to form the first half 143 of the core-box member for forming accommodation core segments conforming to the shape and contour of the core-forming member 103.

After the substance 141 solidifies, the assembly may be inverted and the frame 115 with the parting material 111 removed. As disclosed in Fig. 21 a frame 145 may be superimposed on the frame 139 and core box-forming moldable substance 147 introduced to form the second half 149 of the core box for forming accommodation cores embodying the contour of the accommodation core-forming member 103.

The accommodation core-forming member 103 may be removed from the core box and suitable feeding and venting passageways 151 and 153 extended through the core-box member to communicate with the accommodation core cavity 155 conforming to the contour of the accommodation core-forming member 103.

Accommodation core segments conforming to the shape and contour of the accommodation core-forming segments 103 and 105 may be formed in the core boxes. These segments may be located by their cooperating registering means and positioned in the mold cavities 92 and 93 of the cope and drag mold members illustrated in Fig. 11 to provide a casting cavity embodying the contour of the pattern 10 and the boss 101 projecting therefrom as illustrated in Fig. 13.

I claim:

1. The method of forming accommodation core boxes comprising applying to a pattern of an article embodying back draft a moldable substance capable of conforming to the contour of the pattern, shaping the external surfaces of the moldable substance to eliminate back draft and provide accommodation core-forming members, forming cope and drag patterns of the pattern member and core-forming members, removing the core-forming members from the pattern member, assembling the core-forming members and applying parting material to eliminate back draft, forming a first half of a core-box member by a reproductive process from the core-forming members and parting material, inverting the assembly and removing the parting material, and forming a second half of the core-box member by a reproductive process from the core-forming members and first half of the core box.

2. The method of forming cooperative pattern and core-box members for casting an article having back draft comprising applying to a pattern of the article to be formed a moldable substance to eliminate back draft and provide separable core-forming members, forming female impressions of the pattern and core-forming members, forming production patterns from the female impressions, separating the core-forming members from the pattern, assembling the core-forming members in one of the female impressions and applying parting material to the core-forming members to eliminate back draft, forming a half core-box member by a reproductive process from the core-forming members, removing the female impression and parting material, forming the other half of the core-box member from the core-forming members, removing the female impression and parting material, forming the other half of the core-box member from the core-forming members, removing the core-forming members from the core box, and providing a feeding opening communicating with the accommodation core cavity.

3. The method of making cooperating pattern and core-box members to form a casting cavity embodying back draft comprising applying to a pattern of the article to be formed a moldable substance capable of assuming the contour of the pattern, contouring the external surfaces of the moldable substance to eliminate back draft and provide accommodation core-forming members, forming production pattern members of the assembled pattern and core-forming members, separating the core-forming members from the pattern, reassembling the core-forming members with the pattern removed, applying parting material to the core forming members to fill the space occupied by the pattern and to eliminate back draft and forming core boxes by a reproductive process from the core-forming members and parting material.

4. The method of forming core boxes for making accommodation cores for casting an article having back draft comprising applying to a pattern of said article a moldable substance capable of conforming to the contour of the pattern, shaping the external surfaces of the moldable substance to eliminate back draft and provide accommodation core-forming members, separat-

ing the core-forming members from the pattern member, applying parting material to the core-forming members to eliminate back draft, forming a first half of a core box member by a reproductive process from the core-forming members and parting material, removing the parting material, and forming a second half of the core box member by a reproductive process from the core-forming members and first half of the core box.

5. The method of forming core boxes to make accommodation cores to eliminate back draft in a plurality of directions comprising applying to a pattern a moldable substance capable of conforming to the shape of the pattern, contouring the exposed surfaces of the moldable substance to eliminate back draft, separating the moldable substance into a plurality of segments to provide a plurality of accommodation core-forming segments, separating the core-forming segments from the pattern, reassembling the core-forming segments with the pattern removed, applying parting material to fill the space occupied by the pattern and to eliminate back draft, forming core box portions from the core-forming segments and parting material by a casting operation, removing the parting material and casting the remainder of the core box members from the core-forming segments and said initially formed core box portions.

6. The method of forming cooperating mold and accommodation core members for casting an article having back draft comprising applying to a pattern of the article to be formed a moldable substance to eliminate back draft and provide separable core-forming members, forming impressions of spaced portions of the pattern and core-forming members, forming production patterns from said impressions, separating the core-forming members from the pattern, applying parting material to the core-forming members to eliminate back draft, forming portions of core box members by a reproductive process from the core-forming members and parting material, removing the parting material, forming the remainder of the core box members from the core-forming members and said portions of the core box members, and forming cooperating mold and accommodation core members from said pattern and core box members.

7. The method of forming cooperating pattern and core box members to eliminate back draft in a plurality of directions comprising applying moldable substance to a pattern, shaping the external surfaces of the moldable substance to eliminate back draft and to provide a plurality of spaced interlocked core-forming members, forming pattern members of the pattern and core-forming members by a reproductive process, separating the core-forming members from the pattern, applying parting material to each segment to fill the space occupied by the pattern, forming a core box portion from each core-forming segment and its applied parting material by a reproductive process, removing the parting material, and forming the remainder of the core box for each core segment by a reproductive process from the core-forming member and the previously formed core box portion.

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