Oct. 27, 1942. S. M. STOODY ET AL 2,299,860

METHOD AND APPARATUS FOR CENTRIFUGALLY CASTING CORROSION RESISTANT ALLOYS

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FIG. 1.

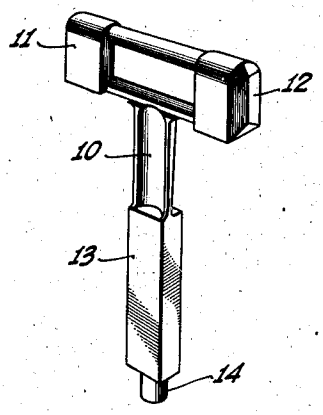
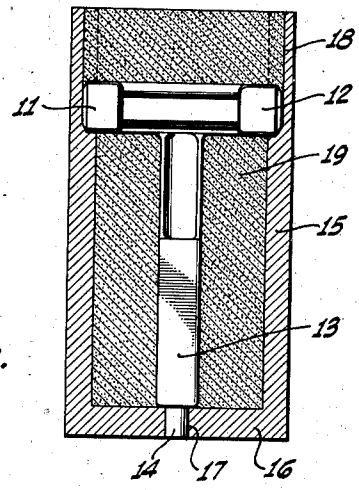


FIG. 2.



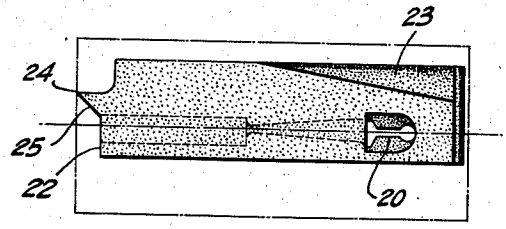


FIG. 5.

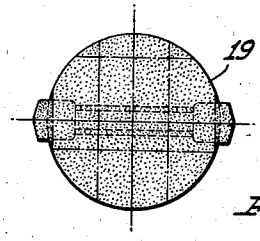


FIG. 3.

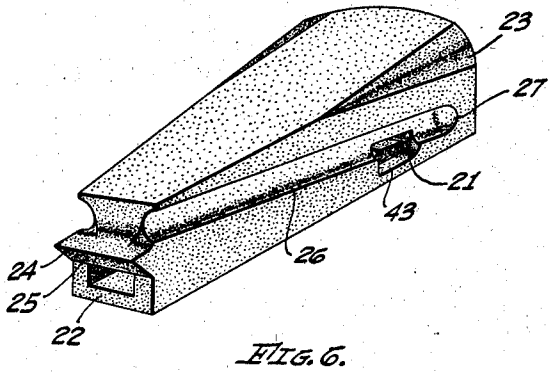


FIG. 6.

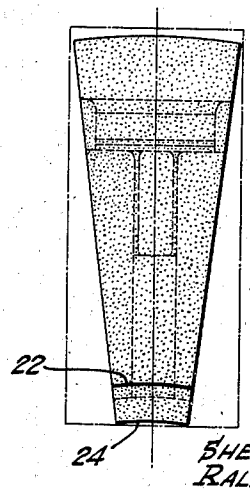


FIG. 4.

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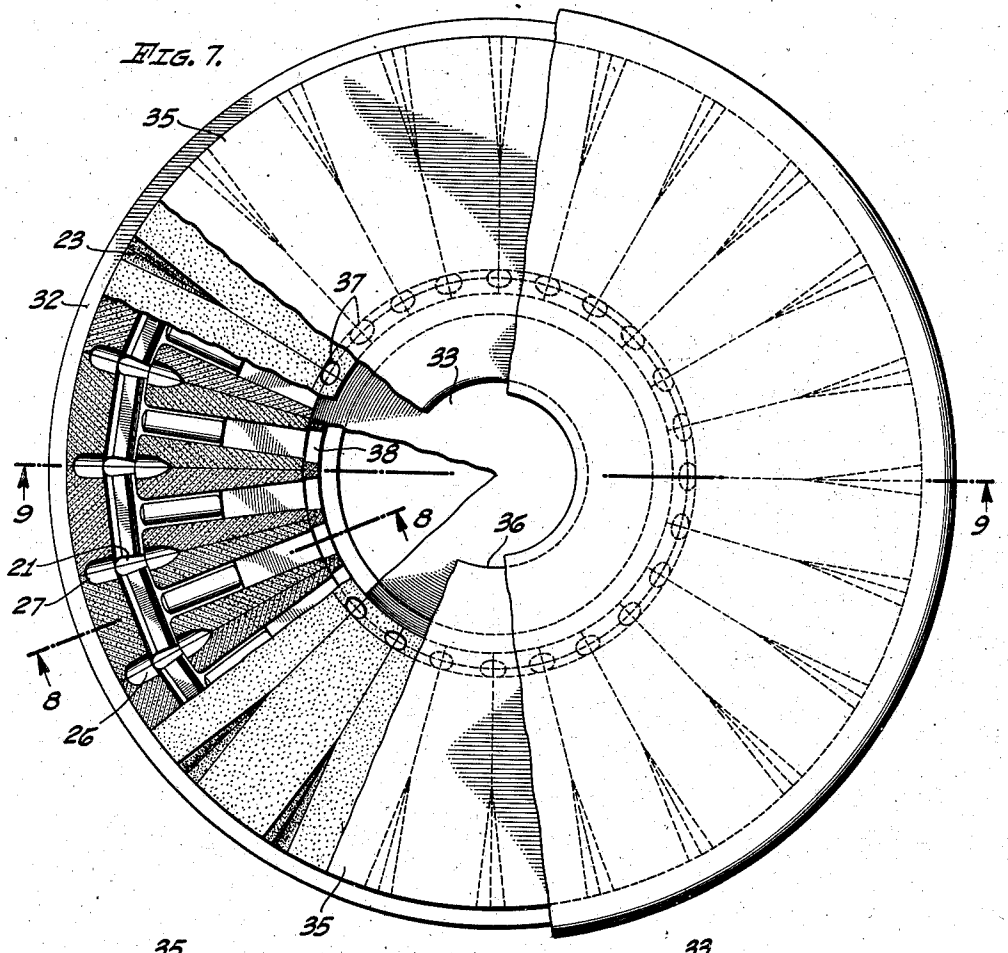
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FIG. 7.



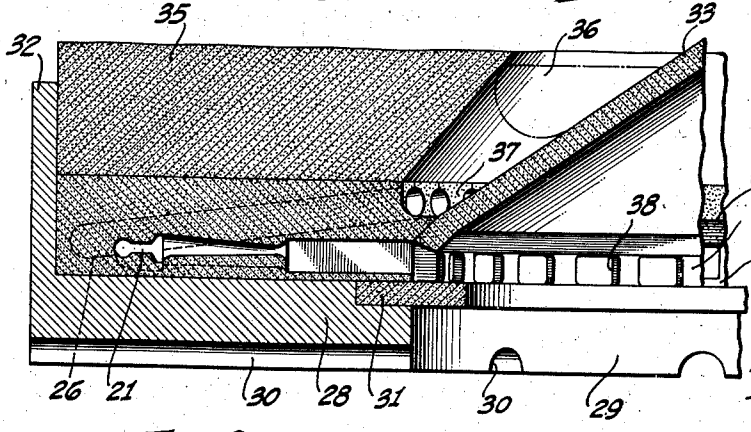


FIG. 8.

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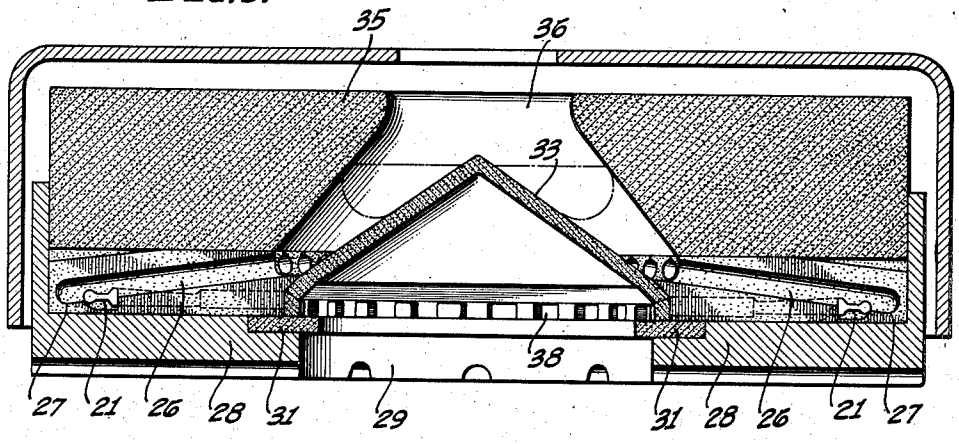
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METHOD AND APPARATUS FOR CENTRIFUGALLY CASTING CORROSION RESISTANT ALLOYS

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FIG. 9.



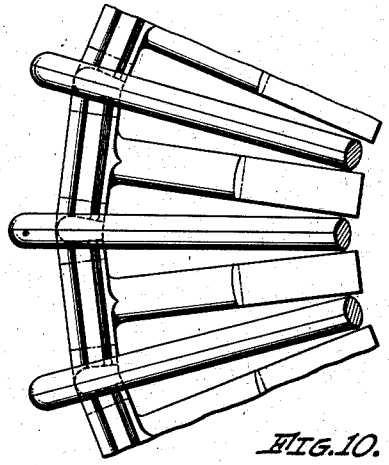


FIG. 10.

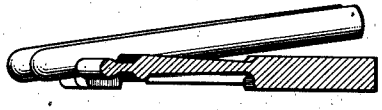


FIG. 11.

FIG. 12.



FIG. 14.

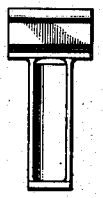


FIG. 13.

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METHOD AND APPARATUS FOR CENTRIFUGALLY CASTING CORROSION RESISTANT ALLOYS

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FIG. 15.

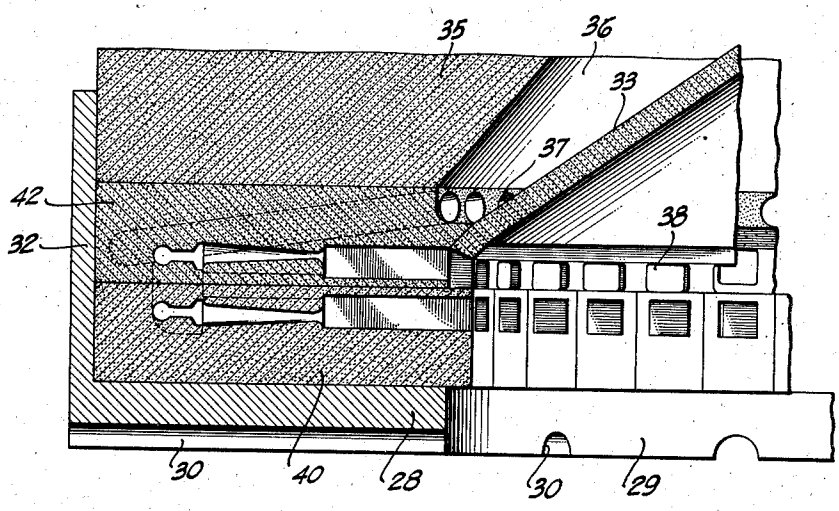
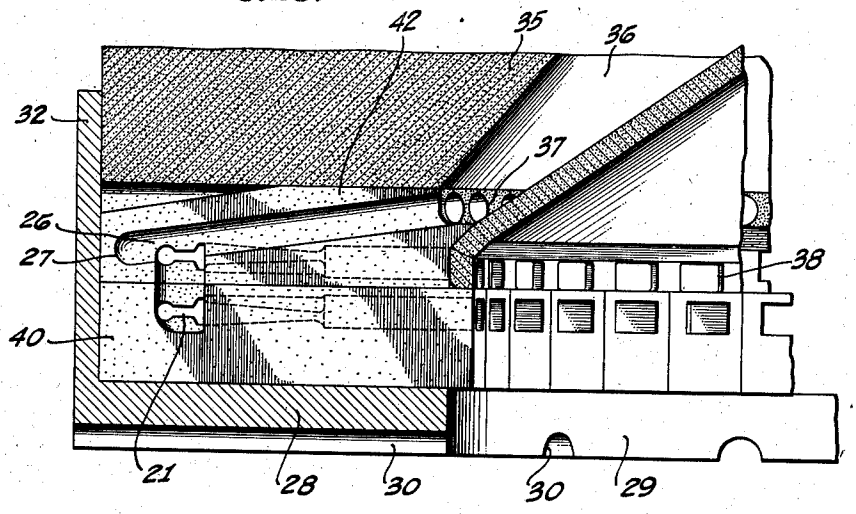


FIG. 16.



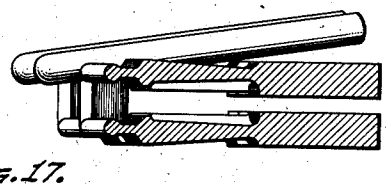


FIG. 17.

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Patented Oct. 27, 1942

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UNITED STATES PATENT OFFICE

2,299,860

METHOD AND APPARATUS FOR CENTRIFUGALLY CASTING CORROSION RESISTANT ALLOYS

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Application March 17, 1942, Serial No. 435,005

11 Claims. (Cl. 22—65)

This invention relates to a method and apparatus for making precision castings centrifugally of high melting point corrosion resistant alloys.

An object of the invention is to provide a new method and mold for making a multiplicity of castings centrifugally of relatively high melting point corrosion resistant alloys so that the castings will be so accurately formed that they will be identical requiring a minimum amount of machining or finishing operations.

Another object of the invention is to provide a method and apparatus for centrifugally casting metals and like substances wherein adequate provision is made to insure that only firm, clean, dense metal will be introduced into the mold cavity during the centrifugal casting operation, and to provide adequate vents and reservoirs for molten metal adjacent the mold cavity so that pipes that may form as the metal cools will not continue or extend into the metal of the casting.

While the invention may be employed wherever a multiplicity of identical and accurately formed castings is desired, it has been primarily designed for the production of the turbine blades of a supercharger used on aircraft. In such a construction the supercharger is driven by a turbine, the blades of which are subjected to the exhaust of the aircraft engine. These turbines when in operation are driven by the exhaust of the engine at a rotary speed of approximately 20,000 R. P. M. The blades being subjected to the direct exhaust gases which are not infrequently still flaming, are heated to a temperature of approximately 1200° F. They consequently must be resistant to the burning action of the exhaust gases and should be capable of sustaining a tensile stress of approximately 70,000 pounds per square inch.

Metals that are resistant to corrosion or the burning action of the exhaust gases from the engine and which possess this high tensile strength under high temperature are inherently hard and of a relatively high melting point, being poured usually at a temperature of approximately 3000° F. Because of their inherent hardness they are extremely difficult to machine. Consequently, it is of great importance to be able to accurately cast the turbine blades with such precision that the finish machine operations are reduced to a minimum. In other words, it is desired to reduce the machining operations to a mere cutting of the casting from its riser and the gates or entrances to the mold cavity. As the blades of the turbine are rotated at high speed and are subjected to high centrifugal forces it is manifest that the blades must be as nearly identical as possible for if the blades are not uniform the turbine will be unbalanced and the lack of balance becomes a materially destructive force under the high rotary speed. Inasmuch as the blades are formed of a metal that is inherently hard in order to secure corrosion resistance, it is difficult to machine the blades in order to correct any lack of balance. Consequently, the securing of precision castings that are identical is of great importance to the success of the present method and apparatus.

With the foregoing and other objects in view, which will be made manifest in the following detailed description and specifically pointed out in the appended claims, reference is had to the accompanying drawings for an illustrative embodiment of the invention, wherein:

Figure 1 is a perspective view of a diecast pattern that is employed to make and shape the mold cavity in the mold that forms a part of the apparatus embodying the present invention;

Fig. 2 is a sectional view of a flask illustrating the pattern shown in Fig. 1 as positioned therein and illustrating the mold as having been reamed up or tamped up in the flask about the pattern;

Fig. 3 is a top plan view of the mold illustrated as having been formed in Fig. 2 and illustrating in phantom lines the portions of the mold that are removed to produce one segment of the complete centrifugal mold;

Fig. 4 is a view in side elevation of the segment produced illustrating in phantom lines the portions of the mold that have been removed to produce the finished segment;

Fig. 5 is a view in side elevation of the segment illustrating in phantom lines portions of the mold that have been removed;

Fig. 6 is a perspective view of the finished segment that forms a part of the complete centrifugal mold;

Fig. 7 is a top plan view of the completed centrifugal mold, parts being broken away and shown in horizontal section, the mold being made up of a plurality of segments of the character illustrated in Fig. 6;

Fig. 8 is a vertical section through the mold taken substantially upon the line 8—8 upon Fig. 7;

Fig. 9 is a diametrical section through the completed mold;

Fig. 10 is a partial view in plan illustrating a portion of the casting produced prior to its being divided into the individual turbine blades;

Fig. 11 is a sectional view through the portion of the casting illustrated in Fig. 10;

Figs. 12, 13, and 14 are views of the casting produced, Fig. 12 being a view in side elevation of one side of the turbine blade; Fig. 13 an end elevation of the same; and Fig. 14 a view in side elevation of the reverse side of the blade;

Fig. 15 is a sectional view similar to Fig. 8, but illustrating a slightly modified form of construction whereby a much greater multiplicity of castings may be produced from a single pour;

Fig. 16 is a view similar to Fig. 15, the section however having been taken through the mold on a plane between adjacent segments whereas Fig. 15 is a section taken through the mold cavities in superposed segments;

Fig. 17 is a view similar to Fig. 11 illustrating a portion of the casting produced from the mold illustrated in Figs. 15 and 16.

Referring to the accompanying drawings wherein similar reference characters designate similar parts throughout, and referring particularly to Figs. 12, 13, and 14, there is illustrated in these figures the nature of the finished casting that it is desired to produce for the blades of the turbine of the supercharger. With this construction in mind, although it will be appreciated that the invention is in no way restricted thereto but is applicable to all shapes of castings, a diecast pattern is first produced of the approximate shape as illustrated in Fig. 1 wherein the central portion **10** corresponds in size and shape to the shape of the finished casting, due allowance being made for shrinkage of the metal on cooling. At the sides of the casting there are enlargements **11** and **12** which serve to mold or shape entrances to the mold cavity in the mold. At the bottom of the pattern there is an enlargement **13** terminating in a cylindrical stud **14**. This enlargement is designed to mold or shape the riser or outlet from the mold cavity in the mold that is produced. The pattern is preferably diecast so that in making a multiplicity of patterns it is relatively easy to make the patterns identical. The metal used for making the pattern is preferably tin as this metal has the required melting point to enable the mold to be properly baked and on baking to be ultimately melted out.

The pattern illustrated in Fig. 1 is positioned in a suitable flask **15** which is normally cylindrical in form and which is formed of carbon. In the bottom **16** of the flash there is formed an aperture **17** that snugly receives the stud **14**. Grooves **18** are formed at diametrically opposite sides of the flask adjacent the top thereof to receive portions of the enlargements **10** and **11** at the sides of the pattern. Thus, with the stud **14** fitting in the aperture **17** and the enlargements **11** and **12** fitting in the grooves **18** in the flask the pattern is properly and accurately positioned within the flask. A molding composition **19** is then rammed or tamped up about the pattern within the flask. This molding composition has certain definite requirements in order to produce the desired results. As the metal that is to be poured has a relatively high melting point and is normally poured at a temperature of approximately 3000° F. it is manifest that the mold must resist burning or melting. Also, it cannot be so extremely hard that as the casting cools and shrinks therein that it will resist crushing to such an extent that the casting will pull or crack itself apart.

As a result of a great deal of experimentation we have ascertained that a molding composition composed of the following ingredients in approximately the following proportions gives very satisfactory results.

Graphitic carbon, 200 mesh and finer	pounds	9
Fire clay	do	½
Glucose	do	1½
Water	ounces	4

Such a mixture is prepared by mulling together the graphitic carbon and fire clay while dry for approximately five minutes. The glucose and water are warmed to about 150° F. and added thereto and the ingredients thoroughly mixed. The resulting mixture is damp and will hold together on squeezing. We find that it is very suitable for making a mold for casting such metals as that sold under the trade-name of Silfram consisting of chromium approximately 33%, nickel approximately 10%, silicon approximately 2%, and the balance iron; Vitalium, an alloy composed of approximately 65% cobalt, 30% chromium, and 5% molybdenum, or that Stellite that is composed of approximately 65% cobalt, 26% chromium, 5¾% tungsten, 1% iron, 1¼ silicon, and 1% carbon.

The molding composition is tamped up rather firmly about the pattern and when the flask is thus filled it is placed in an oven and baked. It is usually advisable to bake the flask and mold therein contained for a considerable length of time at approximately 150° F. to drive out the moisture without creating voids in the mold. The temperature can then be raised to approximately 300 to 400° F. to thoroughly bake the mold and finally its temperature is raised to approximately 585° F. During this latter treatment the tin pattern melts out of the mold leaving the mold cavity **20** formed in the mold equipped with lateral entrances **21** adjacent its outer end and a riser **22** extending inwardly from its inner end.

A very satisfactory procedure in baking the molds has been to heat the molds for the following periods at the following temperatures in consecutive order:

7 hours at 150° F.;
½ hour at 175° F.;
½ hour at 225° F.;
½ hour at 275° F.;
3 hours at 300° F.;
1 hour at 400° F.;
2 hours at 470° F.; and
1 hour at 585° F.

While it is not necessary to precisely follow this procedure it is important to have the mold thoroughly cured and entirely shrunk about the pattern before the tin pattern melts out. When the mold is thus produced the flask may be broken away leaving the cylindrical mold illustrated in phantom lines in Figs. 4 and 5, and in full lines in Fig. 3. Those portions between the full lines and the phantom lines on Figs. 3, 4, and 5 are then removed, such as by mounting the mold on a suitable jig and grinding away the excess mold material, forming a segmental shaped mold as illustrated in Fig. 4 having a flat top and bottom as shown in Fig. 5. The beveled surfaces **23** at the upper outer corners of the segment are portions of the original cylindrical surface on the exterior of the mold that are not removed in grinding or shaping the mold to the segmental shape.

The inner end of the mold is cut away opposite the inner end of the riser 22 and above this cut away portion there is a shoulder 24 having a beveled under surface 25. Grooves 26 are then routed down the outwardly divergent sides of the mold segment to a point indicated at 27 beyond the entrances 21 to the mold cavity.

When a plurality of these mold segments are made they are positioned in side-by-side relationship on a suitable carrier 28, see Figs. 7 and 8. This carrier has a central aperture 29 formed therethrough and radial grooves 30 on its under surface. A carbon ring 31 is positioned on the bottom of the carrier and preferably extends inwardly a short distance over the top of the aperture 29. The segments fit together within an outer upstanding flange 32 around a hollow carbon cone 33 having a vertical or cylindrical lower portion 34. On top of the segments there is positioned a carbon plate 35 having a conical gate 36 formed therein. The bottom of the cone immediately above the cylindrical portion 34 fits against the beveled surface 25 beneath the shoulder 24 so that the top surface of the cone 33 together with the inner wall of the gate cooperate to direct the metal that is poured through the radial passages 37 that are formed by opposed grooves 26 on adjacent segments. It will be noted that the cylindrical portion at the bottom of the cone 33 has apertures or passages 38 formed therein which register with the inner ends of the risers 22 on the mold segments so that egress from the mold cavity of gases and air is readily permitted through the risers 22 and the passages 38, the aperture 29 and the radial grooves 30. The carrier 28 and the mold parts that are thus assembled are then positioned on a suitable rotary table or other rotating device, the axis of rotation of which is coincident with the vertical axis through the cone 33 and through the gate 36.

The metal that is to be poured may be one of the specific metals above mentioned and is normally poured at a temperature of approximately 3000° while the mold is being rotated at a fair rotational speed, such as 1500 R. P. M. The metal that is poured into the central gate 36 encounters the cone 33 and is distributed and thrown outwardly through the radial passages 37 formed by the grooves 36. The initial metal that enters these passages is apt to become somewhat chilled and it may be oxidized and if there is any dirt present in the passages it is apt to pick up this dirt. This initial metal is consequently carried outwardly to the extreme outer end 27 of the passage and being received in this recess or pocket, remains there. When the pocket is filled succeeding metal flows laterally into the entrances 21 at the sides of the adjacent segments filling the mold cavity and entering the riser 22. Usually a sufficient amount of metal is poured to completely fill the riser which should have a volume nearly equal to the volume of the casting under ordinary circumstances. It will of course be understood that the metal in the passages 37 and in the risers 22 is constantly being subjected to centrifugal action, the metal in the riser being urged outwardly toward the mold cavity and the metal in the passages 37 being urged outwardly toward the entrances 21. Consequently, the metal in the mold cavity is subjected to pressure from the metal in the passages 37 and the metal in the risers, both being urged outwardly with the result that the casting produced is normally clean, free of oxides, and very dense. Any gases or air that is in the mold cavity and in the riser prior to the filling of the mold cavity is readily expelled by the metal through the riser, the passages 38, aperture 29, and grooves 30 so that there will normally be an entire absence of any blow holes. Metals of the above described characteristics are apt to pipe somewhat badly. However, with sufficient length of risers 22 and the long passages 37 those pipes that do form are formed in waste metal that is ultimately cut off to form the finished casting and this metal can of course be reheated and repoured.

When the metal cools a single casting is produced, a portion of which is illustrated in Figs. 10 and 11 consisting of the metal left remaining in the passages 37, the risers, and the castings themselves. The castings may then be cut free by cutting on the phantom lines indicated in Fig. 10, thus obtaining the finished article illustrated in Figs. 12, 13, and 14. The cutting may be accomplished with any high speed cutting mechanism used for cutting hard metals of this character. It will be found that if the molding composition is properly prepared and is properly baked that a casting produced in this manner will have an extremely smooth surface requiring no finish machining. The castings will also be identical in weight, shape, and size, having no voids or blow holes and being substantially free of oxides and dirt. There will also be an absence of any shrinkage cracks due to the mold resisting the shrinkage of the metal as it cools.

In Figs. 1 to 9, inclusive, the mold is illustrated as being made up of segments arranged in a single layer on the carrier 28. It is possible, however, to double the number of castings produced per pouring operation, as illustrated in Figs. 15 to 17, inclusive. In this form of construction of the mold the mold is produced in the flask in the same manner as above described. Those segments 40 that form the lower layer do not have their inner ends shaped as illustrated in Figs. 5 and 6 but extend inwardly the full distance so as to provide a support for the bottom of the cone 33. These lower segments also do not have the grooves 26 routed in their sides. When these segments are arranged to form a lower layer on the carrier 28 an upper row of segments 42 is positioned thereon in vertical alignment. These segments 42, however, are of the same size and shape as that previously described and illustrated in Fig. 6. It will be noted from an inspection of Fig. 6 that there is a small web 43 at the bottom of each entrance 21. These webs of course will be present in the top of each of the lower mold segments 40. The webs 43 of the upper and lower segments are broken out so that metal may flow from the passages 37 produced by the grooves 36 not only into the entrances 21 of the upper mold segments but may also flow downwardly to the entrances to the lower mold segments. In using this form of construction the advantages are substantially the same as above described in that the initial metal is first thrown out to the extreme ends of the radial passages 37 and this metal, which may have been chilled, oxidized, or may have picked up dirt, is entrapped or pocketed at the outer ends of the passages. The succeeding metal enters the mold cavities of the upper and lower segments filling the mold cavities and expelling the air and gases therefrom, finally filling or substantially filling the risers.

Thus, by employing upper and lower rows of segments as illustrated in Figs. 15 and 16 double the number of castings may be produced per casting operation. The casting produced from this type of mold is illustrated in Fig. 17 prior to the cutting off of the risers and of the metal in the passages.

The present application may be considered as a continuation-in-part of our copending application Serial No. 424,370, filed December 24, 1941. The molding composition herein disclosed is not herein claimed but is claimed in our copending application filed collaterally herewith entitled Molding composition.

Various changes may be made in the details of construction without departing from the spirit or scope of the invention as defined by the appended claims.

We claim:

1. The method of centrifugally casting metal which includes throwing metal outwardly from a central gate towards the pocket by centrifugal action so that the initial metal poured remains in the pocket, causing succeeding metal to flow laterally into one or more mold cavities and while under centrifugal pressure to fill the mold cavities towards risers arranged inwardly with respect to the mold cavity.

2. A mold for centrifugally casting having a mold cavity, the entrance to the cavity being adjacent its outer end and the riser for the mold being adjacent its inner end, there being a passage for molten metal leading from adjacent the center of rotation of the mold to a point beyond the entrance to the mold cavity to form a pocket into which the initial metal poured may flow and be trapped.

3. A mold for centrifugally casting having a mold cavity arranged off center with respect to the axis of rotation of the mold, said cavity having entrances at each side adjacent its outer end, and a riser adjacent its inner end, there being passages at each side of the mold cavity leading from adjacent the axis of rotation of the mold toward the entrances.

4. A mold for centrifugally casting having a mold cavity arranged off center with respect to the axis of rotation of the mold, said cavity having entrances at each side adjacent its outer end, and a riser adjacent its inner end, there being passages at each side of the mold cavity leading from adjacent the axis of rotation of the mold to points beyond the entrances to the cavity so as to provide pockets for receiving and retaining the initial metal poured.

5. A mold for centrifugally casting made up of segments arranged around a central gate, each segment having a mold cavity formed therein having an entrance adjacent its outer end and a riser adjacent its inner end, there being passages formed between the segments leading from the gate toward the entrances.

6. A mold for centrifugally casting made up of segments arranged around a central gate, each segment having a mold cavity formed therein having an entrance adjacent its outer end and a riser adjacent its inner end, there being passages formed between the segments leading from the gate to points beyond the entrances to provide pockets that receive and retain the initial metal poured.

7. A mold for centrifugally casting comprising a plurality of segments arranged about a central gate, each segment having a mold cavity formed therein having one or more entrances adjacent its outer end and a riser adjacent its inner end, each segment having passages leading outwardly toward the entrances from the gate, a cone providing the bottom of the gate for directing metal poured into the gate into said passages, said cone being passaged to provide outlets from the risers.

8. A mold for centrifugally casting comprising a plurality of segments arranged about a central gate, each segment having a mold cavity formed therein having one or more entrances adjacent its outer end and a riser adjacent its inner end, each segment having passages formed on its sides leading outwardly to points beyond the entrances from the gate, a cone providing a bottom for the gate for directing metal poured into the gate into the passages, said cone being passaged to provide outlets from the risers.

9. A mold for centrifugally casting comprising upper and lower layers of segments arranged about a central gate, each segment having a mold cavity formed therein having one or more entrances adjacent its outer end, each mold cavity having a riser adjacent its inner end, the segments of the upper layer having passages leading outwardly toward the entrances from the gate, and a cone providing the bottom for the gate for directing metal poured into the gate into said passages.

10. A mold for centrifugally casting comprising upper and lower layers of segments arranged about a central gate, each segment having a mold cavity formed therein having one or more entrances adjacent its outer end, each mold cavity having a riser adjacent its inner end, the segments of the upper layer having passages leading outwardly toward the entrances from the gate, and a cone providing the bottom for the gate for directing metal poured into the gate into said pasages, said cone being passaged to provide outlets from at least some of the risers.

11. A mold for centrifugally casting comprising a carrier having a central aperture therethrough, grooves on the underside of the carrier, a plurality of segments arranged about the aperture in the carrier, each segment having a mold cavity formed therein having one or more entrances adjacent its outer end and a riser adjacent its inner end communicating with the aperture through the carrier, each segment having passages leading outwardly toward the entrances from the center of the carrier, and means for directing metal poured in the center of the carrier into the passages for permitting air and gases in the mold cavities to escape through the risers.

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