May 1, 1945. C. E. SORENSEN ET AL 2,374,902

METHOD AND MOLD FOR CASTING HOLLOW ARTICLES

Filed Feb. 12, 1943 2 Sheets-Sheet 1

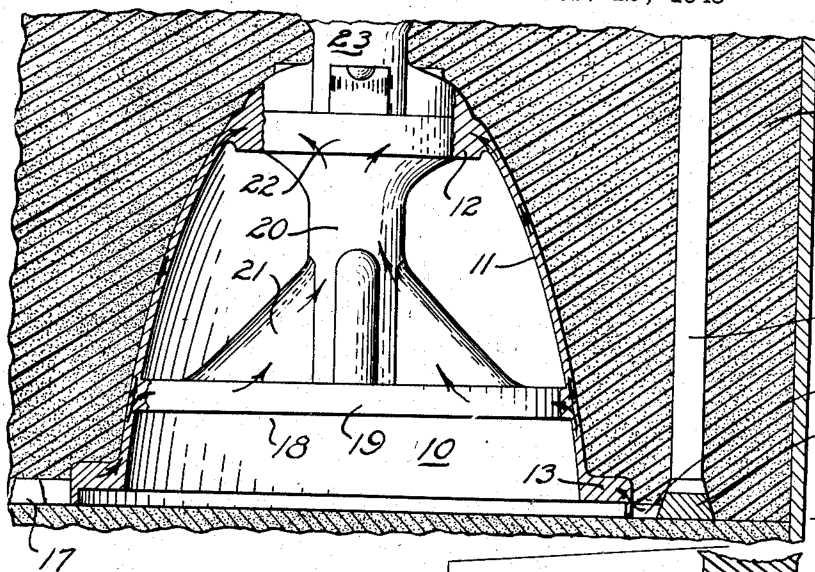

Fig. 1

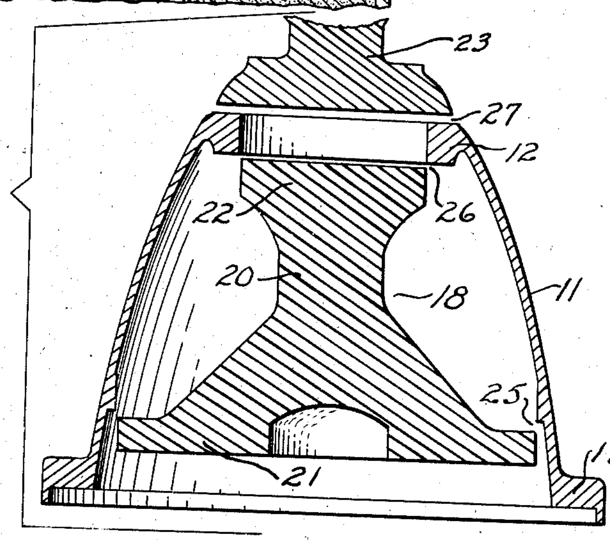

Fig. 2

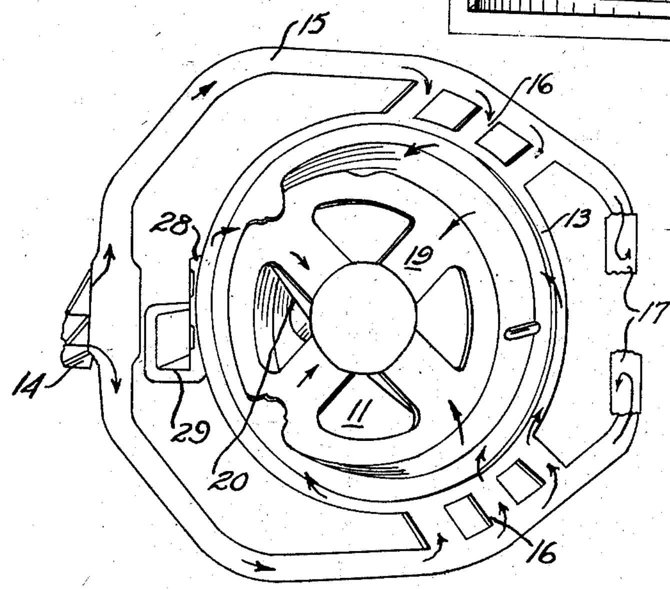

Fig. 3

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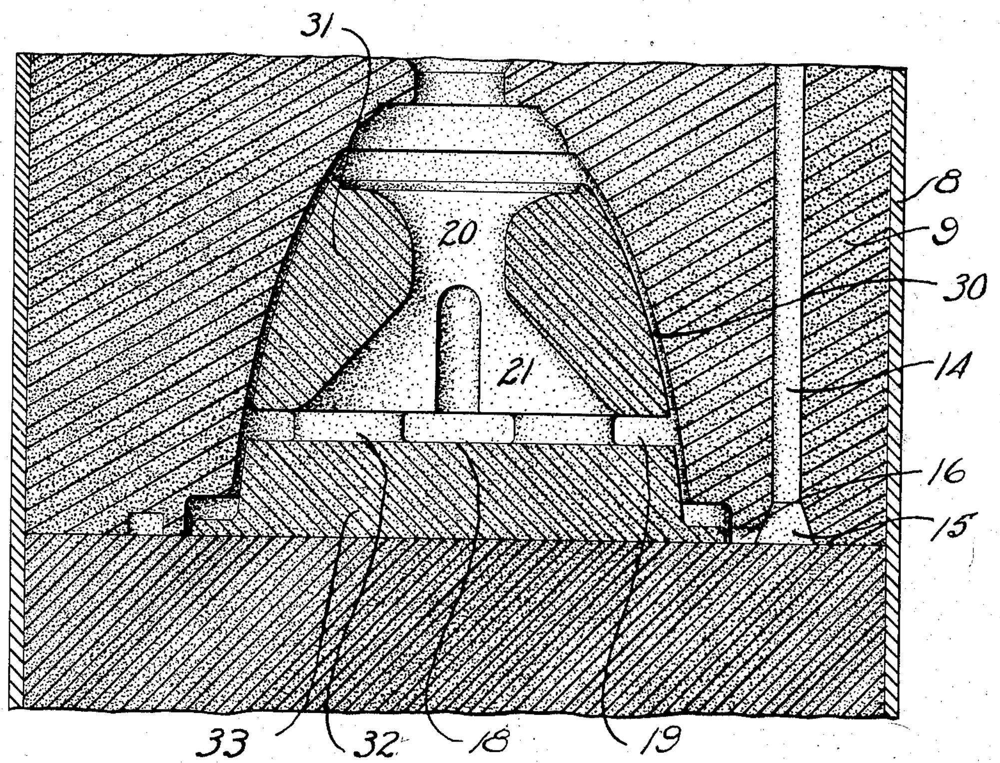

Fig. 4

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METHOD AND MOLD FOR CASTING HOLLOW ARTICLES

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Application February 12, 1943, Serial No. 475,619

3 Claims. (Cl. 22—134)

This invention concerns the casting of light metals; and, more particularly, a mold to be used in the casting of hollow articles from magnesium articles and a method of casting to be applied thereto.

The object of this invention is to devise a method which is particularly applicable to the casting of hollow objects from the lighter metals including magnesium and its alloys and to design a mold which may be advantageously used for this class of objects. An advantage of this invention is that it avoids defects in the cast article due to irregular flow through the sections or porosity attributable to uneven cooling. Another advantage is that it cuts down materially the weight of metal required for gates and risers in casting the object; and still, another advantage is that it reduces the amount of machine work required in removing the necessary gates and risers and, as a consequence, produces articles of superior finish.

The difficulties encountered in casting magnesium and its alloys are attributable, fundamentally, to low thermal capacity of the metal coupled with its low specific gravity. Reference to the following table, in which magnesium is compared with several of the common casting metals, both on the basis of weight and volume, clearly shows these characteristics of the material:

Comparison of thermal capacity of magnesium with other metals

Metal	Mean specific heat		Latent heat of fusion	Mean specific heat		Latent heat of fusion	Specific gravity
	Solid	Liquid		Solid	Liquid		
	On weight basis cal./grm./° C.			On volume basis cal./cm.³/° C.			
Pb	0.03	------	6	0.34	------	68	11.3
Mg	0.28	0.30	50	0.50	0.54	90	1.8
Al	0.25	0.26	92	0.68	0.70	250	2.7
Cu	0.10	0.12	50	0.89	1.06	440	8.9
Fe	0.16	0.17	64	1.25	1.34	500	7.8

A contributing factor is that since magnesium is primarily used because it permits considerable saving in weight, the sections to be cast are generally rather thin and the difficulties normally encountered in casting thin sections are accentuated when the low thermal capacity and specific gravity of this material are considered. It is, of course, possible to pour the metal at somewhat higher temperatures when thin sections are to be cast, but there is a distinct limitation on this expedient and, when the object has sections varying in thickness, such superheating further contributes to the difficulties in casting. Similarly, its lightness reduces the effect of the hydrostatic head causing flow through the mold.

Heretofore, the general practice has been to provide a large number of risers distributed by trial and error around the surface of the article to be cast, both to provide the necessary heat reservoirs to keep the metal molten and the hydrostatic head required to insure its complete distribution. As a result, in casting articles of the type illustrated in the drawings, ten or more risers might be required and, due to the lightness of the metals, their size would be considerable, so that in many instances their weight would be more than double the finished weight of the casting. This gate and riser material represents scrap which may be remelted but as there is a substantial loss of metal in remelting, it is very important to reduce the riser weight where possible. Furthermore, each of the risers has to be cut off the casting individually, and, as they are generally attached to the outer surface, it is practically impossible to obtain a clean finished casting without considerable machine work.

It was understood, of course, that due to the low thermal capacity, the metal would cool much more rapidly at the walls of the mold than is usual with other metals, and as its fluidity decreases rapidly with the lowering temperature, there would be considerable variation in the metal distribution depending largely upon the volume of metal which flows through any particular section. In the prior art, a multiplicity of risers was provided as reservoirs to counteract this variation due to differences in temperature, and these were added or removed or their position changed purely by trial and error. In the present invention, the emphasis is laid upon the even distribution of metal throughout the mold so that the temperature obtained is uniform because of the flow of metal rather than relying upon static reservoirs. As a result, the number of risers is greatly diminished and the gate and riser weight markedly reduced. Another consideration is that the metal is directed to avoid segregated flow through any particular part of the mold which would overheat that portion and result in a poor-grained structure or the formation of relatively large sections which cool after the remainder of the mold and hence are liable to porosity.

The principal advantage of this invention is to provide uniform lines of flow for the metal throughout the casting and ultimately concentrating the initial flow of metal in risers, thus establishing uniform temperature gradient without overheating on the one hand, or leaving portions of the mold too cold to obtain a sound metal flow on the other. From this flow the other advantages that have been pointed out are, namely, the saving in gate and riser material, the reduction of machine work, and a superior finish of the article cast.

With these and other objects in view, the invention consists in the arrangement, construction and combination of the various parts of the improved device and the steps of the method of use thereof, as described in the specification, claimed in the claims and illustrated in the accompanying drawings in which:

Figure 1 is a transverse section through a portion of a mold for a reduction gear housing showing the cast article in place and omitting the central coring in the interest of clarity.

Figure 2 is a similar view of the same object, showing the gates removed and the risers cut preliminary to removal.

Figure 3 is a perspective view from beneath, showing the interior of the article as cast with the gate and risers in place.

Figure 4 is a transverse section through the mold showing the central coring and the resultant mold cavity.

Referring to Figure 1, **8** indicates a flask and **9** the molding matrix, which may be either green or baked sand defining the molded article, which is the reduction gear housing, generally cup-shaped in form, customarily used on radial aircraft engines. This is taken as illustrative of an object which is adapted to the present method, but it will be understood that it may be applied as well to hollow articles generally. The finished form of the article is best shown in Figure 2 in which it will be seen that it comprises a thin-walled section **11** and top and bottom flanges **12** and **13**. The showing is greatly simplified for this purpose and in addition to the structure shown, there would probably be internal strengthening ribs, as well as external bosses and various attaching means; but as these are not significant in the present invention, their showing is omitted in the interest of clarity.

Normally, this object has been cast vertically with bottom feed and a plurality of risers—10 to 15 in number—feeding various points on its exterior surface. In the present instance, a multi-entry gate **14** runs vertically to the channel **15** which substantially surrounds the base of the object. Leading from the channel **15** are the entrance gates **16** which lead into the bottom flange **13** of the object. The channel continues past these gates to a sump **17** so that the initial metal flowing into the channels carries with it any oxides or debris and deposits them in the sump rather than admitting them to the interior of the mold proper.

Disposed within the interior of the housing is the internal gate **18**, which comprises a ring **19** integral with the walled section **11** of the object spaced a short distance above the bottom flange **13**, a riser portion **20** (preferably cylindrical in section), joined to the ring **19** by the conduits **21** and culminating in the top section **22** which is integral with the top flange **12** and including reservoir **23** extending beyond the upper part of the object. The mold cavity so defined is designated as **30** in Figure 4, and the central core **31** defining the principal part of the cavity, is supported by pedestals **32** on the base core **33**.

After the object has been cast, the internal gate **18** is removed, as shown in Figure 2, the ring being cut from the walled section as indicated at **25**, the top section **22** from the top flange **12**, as shown at **26**, and the reservoir section from the upper face of the top flange as shown at **27**. Thus but three cuts are required to remove the major part of the gating and these are such that the finish of the object is not affected. In addition, where bosses of considerable mass such as **28** are to be formed on the outer surface of the castings, an auxiliary riser **29** may be required which also may be cut off in the usual manner.

Figure 3 indicates by arrows the initial flow of metal from the risers to the channel and then through the entrance gate to the bottom flange. As this latter is of considerable extent, the flow from the gates is at once distributed equally substantially throughout the flange area. After that the metal flows substantially uniformly up the walled section **11** of the object and continues into the ring **19**, as well as continuing upwardly in the object itself. However, the metal tends to follow its initial flow course so that the wall section **11** is filled completely by metal flowing upwardly through it rather than by any downflow from flange **12**. The metal which enters the ring **19** flows through the conduit **21** to the riser section **20** and thence the top section **22** into the top flange **12**. Inasmuch as there is considerable volume of metal in the internal gate **18**, the flow therethrough is relatively unimpeded and the metal proceeding therethrough is at substantially higher temperature at flange **12** than is the metal which initially flowed through wall **11** to the flange **12**.

It thus follows that the initial flow through the thin-walled section is substantially unidirectional and the metal so flowing heats the mold walls to the proper temperature and then is concentrated in the reservoir **23** and forms no part of the finished casting. However, the central gate provides a large mass of metal at higher temperature adjacent each end of the thin-wall section. Therefore, cooling of the cast object will normally commence in the thin-wall section mediate the upper and lower flange and proceed in solidification upwardly and downwardly from that point but at all times in communication with a still molten mass of metal represented by reservoir **23** and ring **19**, respectively. Accordingly, the mere pouring of the metal accomplishes the controlled heating of the mold, the segregation of chilled metal in a nonessential part of the object, and permits solidification to proceed in such a manner that molten metal is always available to make up for contraction. The ring **19** is preferably located out of alignment with flange

13 so that direct flow between the two is impossible, thus preventing higher velocity flow through the central riser 20 than through the wall section 11 and yet permitting a substantial area of contact between the ring 19 and the wall 11 allowing uninterrupted communication during solidification.

The mold is not subjected to an excess of high-temperature metal adjacent the gates, and any metal at substantially lower temperatures is concentrated in risers rather than in the casting itself. The mold cavity proper is heated to a substantially uniform temperature throughout by the initial flow of metal so that complete filling is assured. A large volume of metal is provided for contraction on cooling and this metal is disposed uniformly adjacent the upper and lower flanges in which the larger quantities are required, and yet they supply the thin-walled section as well. This equalization of cooling avoids the occurrence of internal cavities at any point in the structure, as well as sinking cavities on the surface, inasmuch as any tendency toward these deformations is located in the riser itself, which is not essential. Finally, actual comparison of weights of metal of objects cast by this method and the methods formerly practiced will show the saving in metal:

	Pouring weight	Article weight	Gates and risers	Metal scrap
	Pounds	*Pounds*	*Pounds*	*Per cent*
New method	106	47	59	146
Conventional method	181	47	134	285

Some changes may be made in the steps of the method disclosed and in the apparatus described without departing from the spirit of the invention and it is the intention to cover by the claims such changes as may reasonably be included within the scope thereof.

The invention claimed is:

1. A method of casting substantially cup-shaped articles having relatively thin-walled sections from the light metals which comprises the steps of introducing molten metal to a mold cavity defining said object at a plurality of points adjacent the bottom thereof, uniformly circulating said molten metal through the lower portion of said mold cavity, flowing a portion of said molten metal uniformly upwardly to fill said mold cavity, withdrawing the remaining portion of said molten metal from said mold cavity and adjacent the lower part thereof and transferring it upwardly separately from said first portion, removing the initial part of said first portion from said mold cavity proper, and reintroducing a part of said remaining part to said mold cavity adjacent the top thereof.

2. In a mold for casting substantially cup-shaped hollow articles of light metals having a low thermal capacity, associated refractory masses having a mold cavity vertically disposed therein conforming to the article to be cast, means formed in said masses to introduce molten metal to said mold cavity adjacent the bottom portion thereof and to direct said metal uniformly through the lower portion of said mold cavity, internal conduit means formed in said masses interiorly of said mold cavity, said conduit being in communication with said mold cavity adjacent the lower portion of said masses and extending upwardly therefrom through said masses and being in communication with said mold cavity adjacent the upper part of said mold cavity to provide lines of flow for metal independent of flow through said mold cavity, said conduit extending above the top of said mold cavity, said conduit being so proportioned in area to the area of said mold cavity that said mold cavity is substantially filled by metal flow upwardly therethrough and the initial portion of such flow continues to the extending portion of said conduit while metal of substantially higher temperature flows through said conduit and is in communication with the metal in said mold cavity adjacent the lower and upper portions of said mold cavity before solidification of the metal in said mold cavity.

3. A method of casting substantially cup-shaped hollow objects of light metals having a low thermal capacity which comprises the steps of arranging a mold having a cavity defining said object with the walls thereof substantially vertical, introducing molten metal to said mold cavity adjacent the lower portion thereof, obtaining uniform circulation of the metal within said lower portion of said mold cavity, flowing the lesser portion of said molten metal upwardly through said mold cavity to overfill said cavity, removing the excess part of said lesser portion from said mold cavity, flowing the greater portion of said molten metal upwardly apart from said mold cavity, re-establishing contact between said greater portion and said mold cavity adjacent the upper portion of said mold cavity, the rate of flow of said greater portion being such that the temperature thereof at the upper portion of said mold cavity exceeds the temperature of the metal rising hereto through said mold cavity whereby initial solidification of the metal in said mold cavity takes place at a point intermediate the top and bottom of said mold cavity and proceeds substantially vertically therefrom.

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