Sept. 17, 1968 D. R. PARILLE 3,401,738

CORE LOCATION IN PRECISION CASTING

Filed Feb. 10, 1966 2 Sheets-Sheet 1

FIG. 1

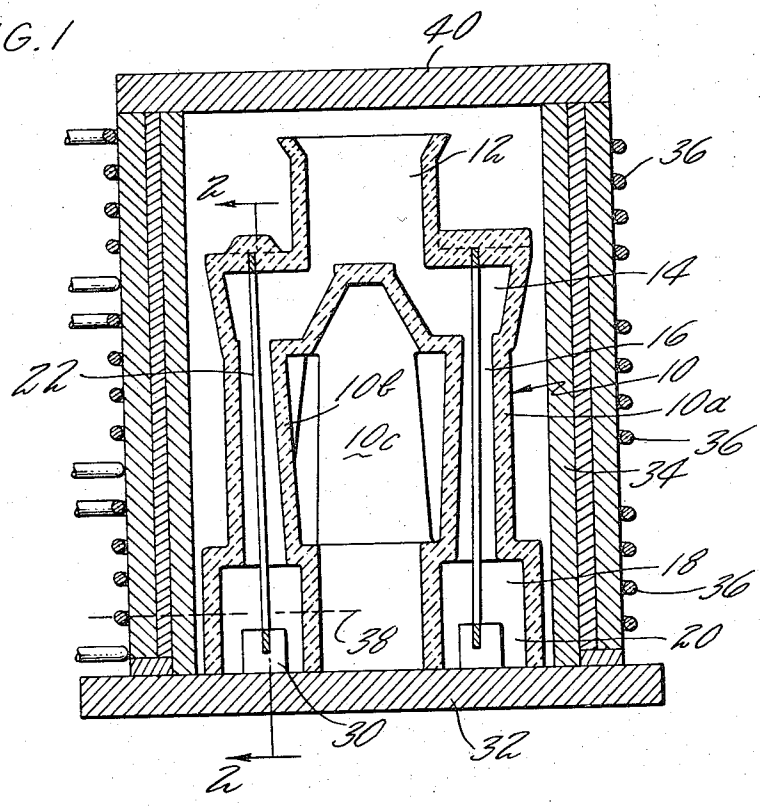


FIG. 2

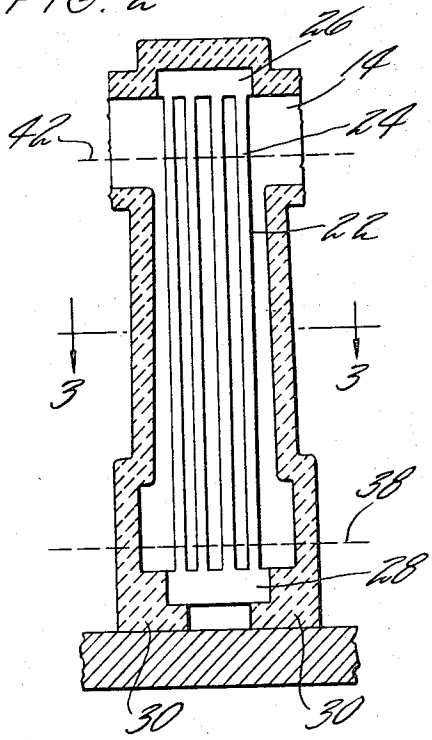


FIG. 3

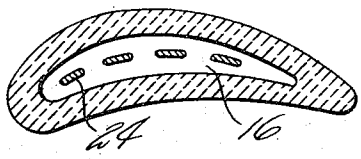
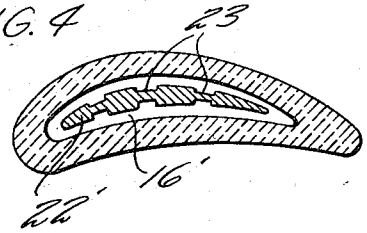


FIG. 4



INVENTOR
DONALD R. PARILLE
BY Charles A. Warren
ATTORNEY

Sept. 17, 1968 D. R. PARILLE 3,401,738

CORE LOCATION IN PRECISION CASTING

Filed Feb. 10, 1966 2 Sheets-Sheet 2

FIG. 5

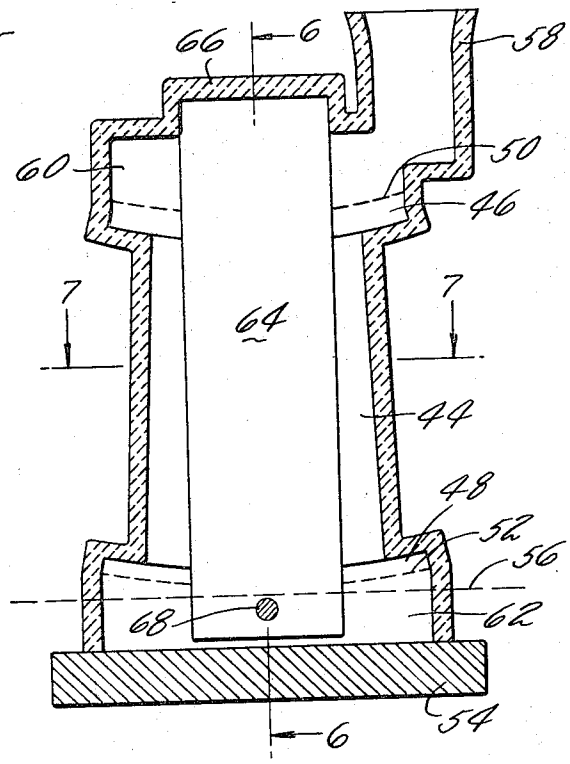


FIG. 6

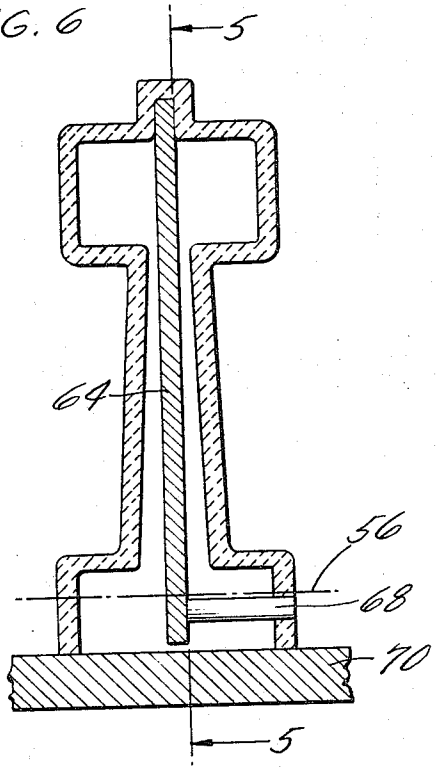
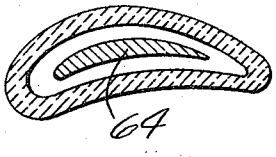


FIG. 7



United States Patent Office 3,401,738 Patented Sept. 17, 1968

3,401,738

CORE LOCATION IN PRECISION CASTING

Donald R. Parille, Wapping, Conn., assignor to United Aircraft Corporation, East Hartford, Conn., a corporation of Delaware

Filed Feb. 10, 1966, Ser. No. 526,432
6 Claims. (Cl. 164—353)

ABSTRACT OF THE DISCLOSURE

An improved mold for investment casting hollow articles, wherein the core is supported, at the end adjacent to the chill plate, by lateral projections located in a growth zone separate from the finished article and where the core support is out of contact with the chill plate.

This invention relates to a mold for investment casting of hollow articles and more particularly to elongated articles having one or more passages extending longitudinally therethrough from end-to-end of the article.

One feature of the invention is an arrangement for supporting the core which forms the passages in the finished article in such a manner within the mold that the cast article will have the desired grain structure within the portion of the cast article that becomes the finished part.

Cast parts are being produced which use, for example, turbine vanes and blades in which by directional solidification the grains within the finished part extend in a particular direction. In a turbine blade or vane it is desirable for certain purposes to have the grains running in a direction longitudinally of the portion of the blade over which the gas flow is directed. This may be accomplished by casting the article in a heated mold, one end of which is in engagement with a chill plate with the mold cavity opening directly into the plate. One feature of the invention is the support of the core adjacent to the chill plate such that the grain structure of the part is not affected and such that the passages formed by the core will be precisely located within the article.

Such cast articles when produced in this manner have a growth portion formed adjacent to the chill plate that is subsequently removed in forming the finished article ready for use. A feature of the invention is the location of the core supporting structure within this growth zone and outside of the finished article with the support so arranged as not to affect the desired grain growth.

Other features and advantages will be apparent from the specification and claims, and from the accompanying drawings which illustrate an embodiment of the invention.

FIG. 1 is a sectional view through a mold and the surrounding heating structure for casting a turbine blade.

FIG. 2 is a fragmentary sectional view along the line 2—2 of FIG. 1.

FIG. 3 is a transverse section along the line 3—3 of FIG. 2.

FIG. 4 is a view similar to FIG. 3 showing a modification.

FIG. 5 is a fragmentary sectional view of a modified mold for use in casting a turbine vane.

FIG. 6 is a sectional view along the line 6—6 of FIG 5.

FIG. 7 is a transverse sectional view along the line 7—7 of FIG. 6.

Referring first to FIG. 1, the mold **10** is shown as made up of a plurality of individual mold elements **10***a*, **10***b* and **10***c* which in the particular arrangement shown are used for producing turbine blades. The mold is formed by the investment casting process and to accomplish this a pattern is provided in the usual way around which the mold material is formed as by successively dipping and drying the pattern with coatings of suitable slurries in a well-known manner for making shell molds.

In forming the mold there is a pouring spout **12** which communicates with a top filler **14** for each of the blade patterns. Below the filler **14** is the airfoil section **16** of the blade and at the bottom of the airfoil section is the root portion **18**. Communicating and over substantially the same dimension as the root portion is a growth portion **20**, described in detail later. The wax pattern used in forming the mold supports a core element **22** for each of the blades. As best shown in FIG. 2, the core element includes a plurality of parallel small diameter rods **24**, FIG. 2, interconnected by a top crossbar **26** and a bottom crossbar **28**. The top bar is embedded in the mold material in the portion of the mold above the filler **14** and the bottom crossbar **28** is supported by inwardly extending mold projections **30** which support opposite ends of the crossbar and which, as shown in FIG. 1, are spaced from opposite side walls of the growth zone **20**. The bars **24** may be of any desired cross section but in the arrangement shown they are relatively flat with curved opposite edges, as best shown in FIG. 3.

After the mold has been completed and the wax pattern has been melted out to produce a mold, as shown in FIG. 1, the latter is mounted on a chill plate **32** to which the growth portion of the mold cavity is directly open. The chill plate **32** is preferably water cooled for the rapid removal of heat from the material when the desired metallic alloy has been poured into the mold. The mold is surrounded by a cylindrical graphite susceptor **34** and the latter is surrounded by a plurality of heating coils **36** in axially spaced relation to the susceptor. By selectively energizing these coils the entire mold may be heated to the desired temperature before any alloy is poured therein and the rate of cooling of the mold may be adjusted by suitable de-energizing of the coils.

To obtain the desired directional grain growth within the mold, the entire mold is heated by the coils to a temperature of above that of the melting of the alloy and the chill plate is kept at a temperature of preferably below that of the boiling point of water by the circulation of water therethrough. When a metallic alloy is poured into the mold cavity the alloy begins to solidify upwardly from the chill plate and because of the directional solidification a grain growth is obtained such that from a point above the top edge of the growth zone, represented by the dotted line **38**, the growth is in parallel grains vertically located within the mold. By selectively and successively de-energizing the coils beginning with the lowermost coil, the rate and thereby the directional growth of the grains is controlled to obtain the desired grain structure. A cap **40** may be placed on top of the mold after the alloy has been poured in order to retain heat at this end of the mold during the solidification process.

After the alloy is cooled within the mold the growth zone is removed by cutting the casting along the line **38** and the tip of the blade is cut off, for example, along the line **42** thereby removing the crossbars **26** and **28** and leaving a turbine blade element having passages extending longitudinally therethrough. Obviously, the core material will have been removed in any desired way, as by leaching.

The core may be of different configurations dependent upon the shape of the passage desired. For example, as shown in FIG. 4, the airfoil section **16'** of the blade has a hollow therein formed by a single core element **22'** with grooves **23** on opposite side walls thereof to form a ridged inner wall surface on the blade, as will be apparent.

In the arrangement shown in FIGS. 5, 6 and 7, the mold is used to produce a turbine vane having an airfoil portion **44**, an inner shroud **46** and an outer shroud **48**. The dotted line **50** represents material removed from the cast article to produce the finished shroud **46** and a similar dotted line **52** represents the portion of the cast article removed to form the outer shroud **48**. The growth zone between the chill plate **54** and the finished portion of the cast article is that portion of the casting below the dotted line **56** which represents the approximate upper edge of the so-called growth zone.

In this arrangement, a wax pattern is arranged so that when it is successively and repeatedly dipped in a slurry of mold material and dried, it will be producing a top filler **58** communicating with the space **60** within the mold which is above and substantially coextensive with the inner shroud **46**. Below the airfoil section **44** is the outer shroud **48** and the growth zone **62** is coexistence laterally therewith. The pattern supports a core **64**, the upper end of which extends beyond the pattern itself and is therefore embedded in a portion **66** of the mold located vertically above the portion **60**. The lower portion of the core is supported by a transverse core plug **68** which extends laterally from the core and is embedded in the mold material forming a portion of the boundary of the growth zone. The plug **68** which may extend laterally in both directions if desired for more secure support serves to support the lower end of the core with which it is integral in precise position within the airfoil portion of the mold after the pattern material has been melted out. By locating the plug **68** below the upper limits of the growth zone, it will be clear that the lateral opening forming in the casting by the plug **68** is removed during the machining process that completes the vane.

In this arrangement, as in FIGS. 1, 2 and 3, the mold having been completed and the pattern material having been melted out, the mold is positioned on a chill plate **70** in the same manner that the mold is placed on the chill plate of FIG. 1. After this is completed the heating structure for the mold is placed therearound, as in FIG. 1, and the casting procedure is carried out in the same manner.

The growth zone, which has been referred to above, is described in greater detail in the copending application of Sink, Ser. No. 472,530, filed July 16, 1965, having the same assignee as the present application. A heating arrangement and chill plate by which the mold is heated and by which the cooling of the mold is controlled is described in the application of Barrow et al., Ser. No. 472,644, filed July 16, 1965, and also having the same assignee as the present application.

It is to be understood that the invention is not limited to the specific embodiment herein illustrated and described but may be used in other ways without departure from its spirit as defined by the following claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A mold for the production of cast hollow articles including, a shell having a main cavity corresponding substantially in shape to the article to be cast, and a core positioned within the cavity corresponding substantially

in shape to the opening within the cast article, a filling space in the mold at one end of, and forming a continuation of the main cavity, the end of the core extending beyond the filling space and being positioned in and supported by the mold, a cavity extension at the other end of the main cavity, and supporting elements extending laterally from the mold into contact with the adjacent end portion of the core, the latter end portion being located within said cavity extension, the end of the cavity extension being open to be positioned on a chill plate, and the cavity extension providing a growth zone in the casting which is outside the dimensions of the finished article.

2. A mold as in claim **1** in which the supporting elements are located in the growth zone.

3. A mold for the production of cast hollow articles which are directionally solidified by casting in a heated mold with one end of the casting against a chill plate, said mold including a shell having a main cavity corresponding in shape to the article, a filling cavity forming an extension at one end of the main cavity, and a growth zone cavity extension at the opposite end of the main cavity, the growth zone cavity extension having an open end for contact with the chill plate, and a core positioned within the cavities and extending from the filling cavity through the main cavity and into the growth zone to define a space within the cast article, said core extending into and being supported by the portion of the mold defining the filling cavity, the other end of the core terminating within the growth zone cavity extension (short of the open end to be out of contact with the chill plate), said mold in this growth zone extension having inwardly extending elements to engage and support the end of the core to locate it within the growth zone.

4. A mold as in claim **3** in which the elements are located externally of the part of the cast article that is used as a finished part.

5. A mold as in claim **3** in which the lateral dimension of the extensions is such as not to interfere with the desired grain growth in the cast article.

6. A mold as in claim **3** in which the temperature of the mold and the chill plate is so controlled as to produce directional grain growth from the growth zone to the filling cavity, and the core supporting elements are so positioned and have such a lateral dimension as not to affect detrimentally the directional grain growth within the casting.

References Cited

UNITED STATES PATENTS

239,609	4/1881	Hartman	164—399
404,187	5/1889	Fisher	164—399
1,952,500	3/1934	Huetteman	164—368
2,651,823	9/1953	Hohlfelder	164—398
2,985,930	5/1961	Hohlfelder	164—398
3,233,294	2/1966	Carpousis et al.	164—353X

J. SPENCER OVERHOLSER, *PrimaryExaminer.*

E. MAR, *Assistant Examiner.*