July 3, 1962 A. G. WILDER 3,041,688

SHELL MOLD FOR INVESTMENT CASTINGS AND METHOD OF MAKING SAME

Filed Aug. 15, 1958

FIG. 1

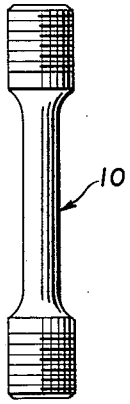


FIG. 2

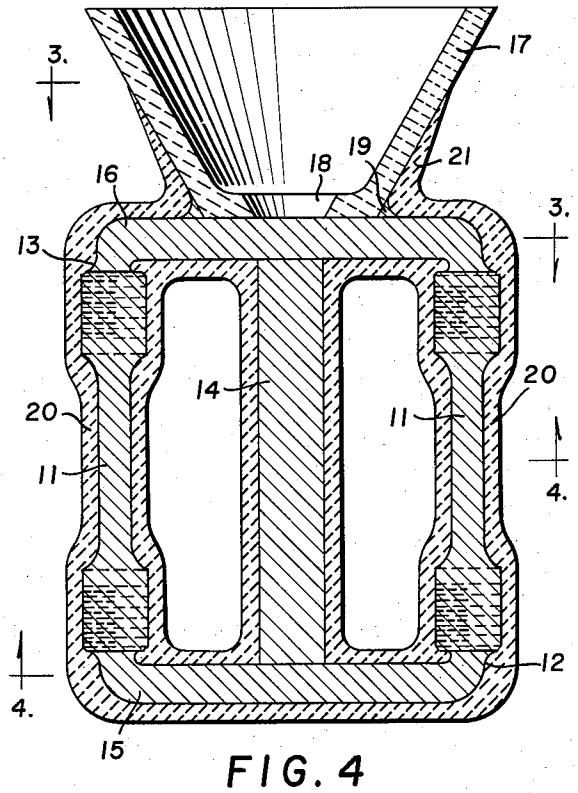


FIG. 3

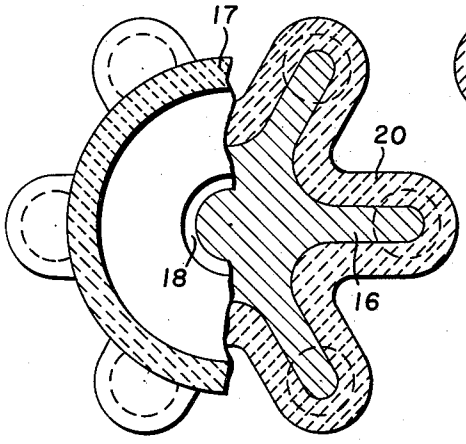
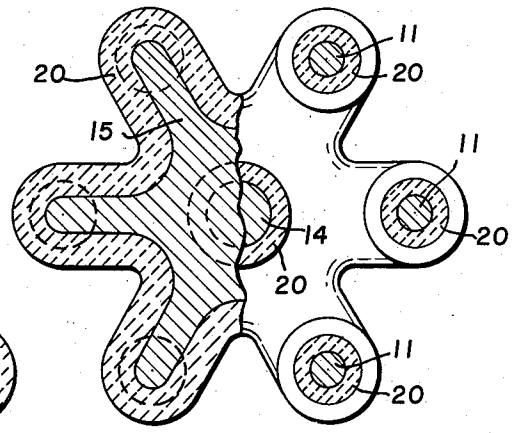


FIG. 4



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SHELL MOLD FOR INVESTMENT CASTINGS AND METHOD OF MAKING SAME

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This invention has particular value in connection with the production of metal castings by the investment or "lost wax process," which is centuries old and was used by the 16th century sculptor Benvenuto Cellini. The process in general is well described in a booklet entitled "Investment Casting Engineering and Design Manual," published and copyrighted in 1957 by the Technical Committee of Investment Casting Institute, 27 East Monroe Street, Chicago 3, Illinois.

According to the usual modern methods of making metal castings by the "lost wax process," the first step in the making of the mold generally involves the building up of a wax pattern or replica of the desired casting or group of castings, if the mold is to have more than one cavity. This wax pattern is also provided with connected wax replicas of the shape of the gate or gates which admit the metal to the cavity, and normally is formed with a replica of the sprue which conducts the molten metal from the pour opening or pouring basin to the gate or gates leading to the cavity or cavities.

In the investment casting process, it is often considered good practice to feed the molten metal into the bottom of the cavity and permit the level of the molten metal to rise in the cavity until the cavity is completely filled or overflows. This method of casting involves the use of a vent which preferably is at the highest point of the cavity and which usually leads into the top of the sprue opening. This vent is also represented by a wax replica which is attached to the upper end of the wax pattern, and as stated, may connect the same with the sprue part of the wax assembly.

The various parts of the wax pattern or replica and its asscciated connected parts such as the gates, vents, or the sprue may be united together by fused wax connections to the extent that it is not possible to form the entire wax assembly in a separable metal mold in a single wax casting operation. A wax replica of the interior of the pouring cup or basin may be attached to the top of the sprue.

After the completed wax assembly or pattern has been constructed as above described, the entire assembly is dipped into a slurry of a refractory mineral powder, preferably dispersed in water containing a suitable binder. The assembly is then removed from the slurry and set aside for a few hours until the coating has dried. Then the assembly is usually dipped into a coarser slurry of powdered or granulated refractory material, then removed and dried. This dipping and drying operation is repeated until there has been formed over the outer surface of the wax pattern a layer of refractory material about ⅛ inch more or less in thickness, depending upon the character and dimensions of the pattern. It should be noted that these drying operations, if heat is used, should be carried out at a temperature substantially less than is required to fuse or soften the wax.

The coated pattern is then heated at a low temperature, generally about 110°–120° C., to set the binder in the outer refractory layer, after which the assembly is placed in an oven and fired at a temperature of between 1300° F. and 1850° F. to remove any residual wax or other unwanted material such as carbonaceous or organic substances. The shell mold constructed as aforesaid is then in finished condition and is ready for pouring.

As I have stated, the "lost wax process" is of great antiquity. The steps as above outlined have been used in the production of investment castings for centuries, notwithstanding the fact that there has always been a loss of product, and an amount sometimes amounting to as much as 50 percent of the theoretical rated output, due to mold damage generally caused by the fragility of the refractory enrobing layer. Breakage of that part of the mold around the sprue hole has been particularly serious due to the fact that during the pouring operation in the foundry, the upper end of the mold is often damaged in spite of the utmost care in using the ladle and in pouring the metal into the sprue.

The purpose of the present invention is to provide an improved and efficient mold for making metal investment castings at low cost, and to provide an efficient method of making same, whereby the cost of making and using shell molds and investment castings will be materially reduced, while better and more accurate, top-grade castings can be produced.

Among other advantages which contribute to the attainment of the purposes above set forth, as will hereinafter appear, the use of the invention enables the wax assembly to be constructed more conveniently; the finished mold may be made in such a manner as to provide for easier pouring and in a manner which will provide a source of molten metal so as to avoid shrinkage. Also, by the use of my invention, a better and more uniform pouring rate can be established thereby assuring controlled cooling of the metal in the mold and uniformity as between the molds and the castings made therefrom.

In the drawings accompanying this application, I have disclosed a six-cavity shell mold made in accordance with my invention for producing a metal test piece such as is often used in measuring or rating the tensile strength or other characteristics of a metal such as steel or other metal, or metal alloys. In said drawings:

FIGURE 1 is a side view of a test piece suitable for casting in a shell mold made in accordance with my invention;

FIGURE 2 is a vertical section of a shell mold made in accordance with my invention before removal of the wax;

FIGURE 3 is a section taken on the line 3—3 of FIGURE 2; and

FIGURE 4 is a section taken on the line 4—4 of FIGURE 2.

Referring to the drawings, the numeral **10** (see FIGURE 1) represents the test piece as a whole. For each such casting desired to be made, a wax replica is constructed in a suitable mold, preferably a two-part steel die. At each end of each wax replica **11** there is a short extension or neck, the neck **12** at the lower end of the replica **11** representing the gate opening, and the extension or neck **13** at the upper end of the wax replica representing the vent hole from the cavity.

Six of these replicas **11** are arranged concentrically around a central stem **14** which takes the form of a cylinder of wax having a length substantially equal to that of the wax replica **11**. The lower ends of the six wax replicas **11** and the central stem **14** are carried by and fused to a flat star-shaped wax slab **15** (see FIGURE 4), and the upper ends of the said parts are similarly united to a similar flat wax slab **16**.

According to my invention, special arrangements are made to provide a relatively sturdy and infrangible header or pouring cup for the upper end of the shell mold, and to this end, instead of relying upon a thin shell of fragile material such as results from the old methods of making shell molds of this general character, I employ a previously, independently manufactured cone **17** of dense, tough and refractory material of a composition

such as is used in making fire clay crucibles. The cone **17** may serve as an assembly base for the wax construction, and is shaped to be useful as a hot top to provide a source of molten metal and thereby avoid shrinkage. Said fire clay cone **17** is made with a central aperture **18** for downward delivery of the fluid metal and is centered over the top end of the stem **14** which represents the sprue of the mold. Since the cone **17** is of specific dimension, the pouring rate is fixed, thereby assuring controlled cooling of the metal in the mold and uniformity as between molds. As shown, the lower end of said cone **17** is flat and rests upon the top of the upper wax slab **16** and may be secured to the top of said wax slab **16** by a peripheral outer fillet of melted wax **19**.

After the cone **17** has been secured to the top slab **16** of the pattern assembly, the assembly with the top or cone **17** presented upwardly is dipped into the slurry or slurries and dried between the dipping steps in the manner previously described. I prefer to use for the initial dipping a slurry of fine grained silica with a binder of sodium silicate dispersed in water. The later drippings are made in a slurry of the same materials, but in this case, the silica refractory is coarse grained. It will be understood that the enrobing layer **20** of refractory material need not extend much above the bottom of the cone **17**, but only enough to make a proper connection between the layer **20** and the lower end of the outer wall of the cone **17**, as indicated at **21**.

During the dipping and drying steps, which may be of the same character as to time and temperature as in the old method, the assembly can be held or handled by the outer end of the cone **17**, and during the firing step, the assembly can be inverted and supported on the outer end of the cone so that the enrobing layer **20** will be subjected to a minimum of handling or possibility of abrasion.

Although the invention is of particular value in the manufacture of symmetrically arranged multiple cavity shell molds, it will be understood that the invention is also applicable to single cavity molds and molds for producing castings of asymmetrical shapes.

The refractory cone can be constructed of standard shape and dimensions and can be turned out in large quantities at a trifling cost for use in the making of molds for a great number of different sizes and types of castings.

Various of the features of the invention believed to be new are set forth in the following claims.

I claim:

1. The process of making a shell mold for an investment casting, which comprises making a wax pattern which includes a counterpart of the article to be cast and a counterpart of a gate for conducting liquid metal into the cavity of the mold, attaching to said pattern the bottom of a pouring cup of refractory material, said cup having an aperture in said bottom for access to said gate,

then dipping said assembly into a slurry comprising a comminuted refractory mineral dispersed in a liquid vehicle, the temperature of the slurry being lower than the fusing point of the wax, so as to coat the counterparts and a portion of the cup with a layer of said slurry, permitting the assembly to dry at a temperature less than the fusing point of the wax so as to make a coating of sufficient thickness to form a self-sustaining structure after the wax is removed, and then heating the structure to a temperature high enough to remove the wax.

2. The process of making a shell mold for an investment casting, which comprises making a wax pattern which includes a counterpart of the article to be cast and a counterpart of a gate for conducting liquid metal into the cavity of the mold, attaching to said pattern the bottom of a pouring cup of refractory material, said cup having an aperture in said bottom for access to said gate, then dipping said pattern and the bottom of said cup into a slurry comprising a comminuted refractory mineral dispersed in a liquid vehicle, the temperature of the slurry being lower than the fusing point of the wax, so as to coat the counterparts and a portion of the cup with a layer of said slurry, then drying the assembly at a temperature less than the fusing point of the wax, repeating the dipping and drying steps until the coating is of sufficient thickness to form a self-sustaining structure after the wax is removed, then heating the structure to a temperature high enough to remove the wax.

3. An assembly for making a shell mold for an investment type metal casting comprising in combination a plurality of wax counterparts of the articles to be cast, a counterpart of a gate for each of said articles, each of said gate counterparts being also made of wax and contacting the adjacent article counterpart, a flat wax slab fused to the corresponding ends of each of said counterparts, a second flat wax slab fused to the opposite ends of said counterparts, a pre-formed pouring cup of refractory material having an open end secured to one of said flat wax slabs, a duct leading from said open end of said pouring cup to said gate counterparts, and a layer of refractory investing material applied to the surfaces of said wax counterparts whereby when the combination is heated, the wax will be removed, while the layer of investing material will remain to serve as a finished shell mold having a cavity for each of the articles and having a gate leading to each cavity and communicating with said cup opening.

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