

Jan. 8, 1946.

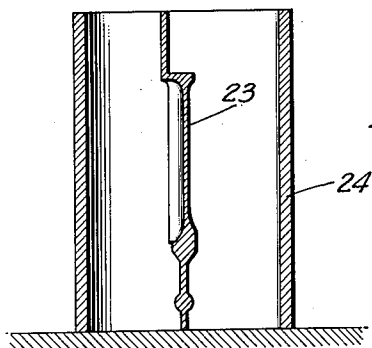
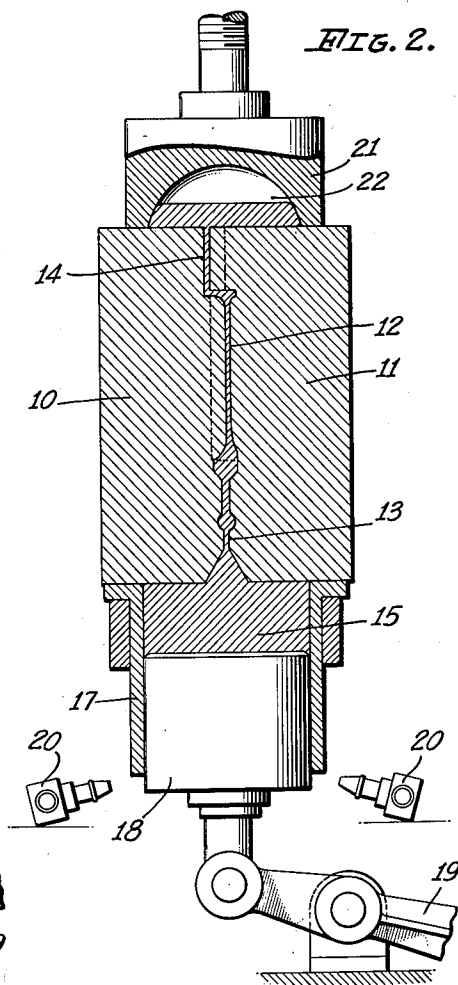
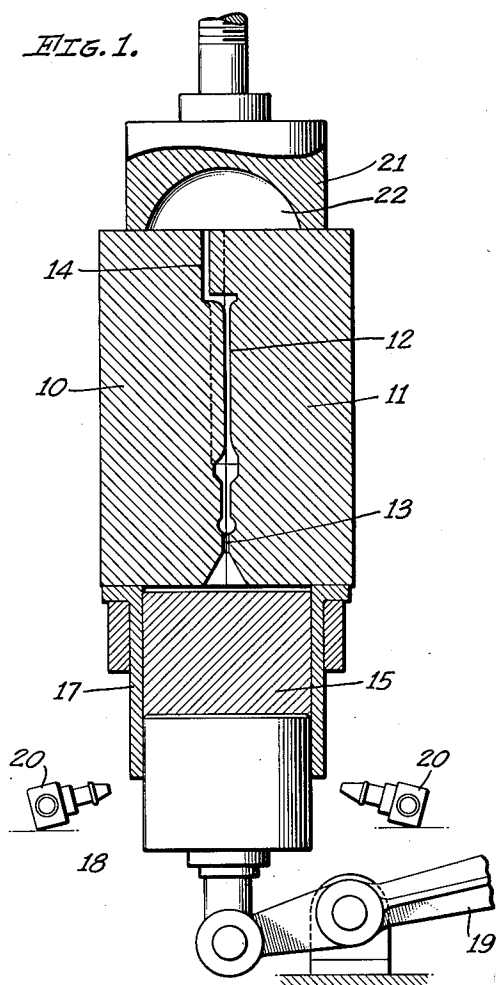
S. M. STOODY ET AL

2,392,510

METHOD OF MAKING PRECISION CASTINGS

Filed Dec. 24, 1941

2 Sheets-Sheet 1



SHELLY M. STOODY,
RALPH L. ABOS,
INVENTOR.

BY *Hazard & Miller*

ATTORNEYS.

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FIG. 4.

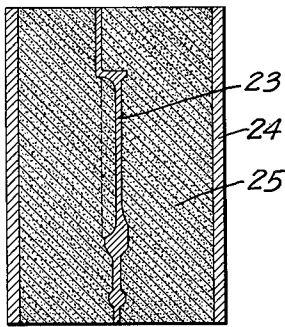


FIG. 5.

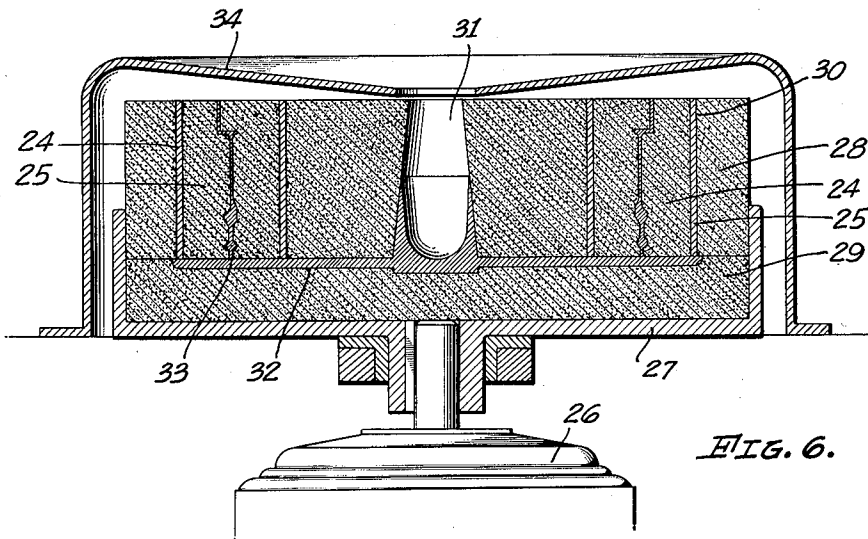
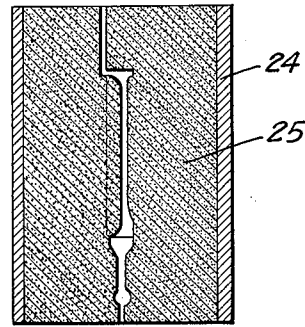


FIG. 6.

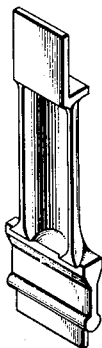


FIG. 7.

SHELLY M. STODY,
RALPH L. ABOS,
INVENTOR.

BY *Hazard and Miller*

ATTORNEYS.

UNITED STATES PATENT OFFICE

2,392,510

METHOD OF MAKING PRECISION CASTINGS

Shelley M. Stoody and Ralph L. Abos, Whittier,
Calif., assignors to Stoody Company, Whittier,
Calif., a corporation of California

Application December 24, 1941, Serial No. 424,370

3 Claims. (Cl. 22—196)

This invention relates to a method of making precision castings.

A primary object of the invention is to provide a method whereby a multiplicity of castings may be produced which is perfectly formed so as to obviate the necessity of finish machining them, the castings being characterized by the fact that they are formed of a corrosion-resistant strong, high melting point metal which, because of its characteristics, is inherently hard. The invention has been primarily developed for the production of the turbine rotor blades of a supercharger of the character invented by Sanford A. Moss, and while it is applicable to any situation where a multiplicity of precision castings is desired, the invention will be described in reference to the rotor blades of the Moss supercharger because of the high requirements present in their construction.

In the Moss supercharger there is a rotary turbine having blades driven by the exhaust gases of an internal combustion engine usually an airplane motor. The rotor carrying these blades is driven at high speeds usually in the neighborhood of 20,000 revolutions per minute. The blades on the rotor, which are subject to the direct action of the exhaust gases from the airplane engine, are heated to a temperature in the neighborhood of 1200° F. The metal forming the blades must be resistant to the burning action of the exhaust gases under these high temperatures and yet must be of great tensile strength to resist centrifugal forces developed therein under the high rotary speeds. Normally such metal should be capable of possessing a tensile strength of approximately 70,000 pounds per square inch at a temperature of 1200° F.

Metals that possess the desirable characteristics usually contain various percentages of cobalt, chromium, and tungsten. Some of the metals sold under the trade-name of Stellite, Vitalium, and Stoodite are suitable. These metals, however, have the common characteristics of high melting point and the fact that they are inherently hard, being considerably harder than ordinary steel. For this reason, they are very difficult to machine, and when the casting is in the form of an irregular shape, as in the case of a turbine blade, its shape together with the extreme hardness of the metal makes the machining operation of each

blade extremely expensive. The purpose of the present invention is to devise a method wherein these high melting point, inherently hard materials can be very accurately cast to the exact shape desired so that finish machining can be practically entirely avoided, thus reducing the labor cost on the construction of the blades. Manifestly, with a rotor turning at high speed the blades must be not only accurately formed but uniform for the reason that only small differences in the weights of the blades will throw the entire rotor out of balance under its running conditions. It will therefore be understood that the present method contemplates the manufacturing of a multiplicity of accurately formed castings wherein finish machine work is reduced to a very small minimum and characterized by the fact that a high melting point, inherently hard metal is used which in the casting is of uniform density and homogeneous throughout.

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 sectional view through a die casting apparatus illustrating the die in position therein preparatory to the die casting of the pattern;

Fig. 2 is a view similar to Fig. 1 illustrating the pattern as having been die cast;

Fig. 3 is a sectional view through a carbon flask illustrating the die cast pattern in position therein, preparatory to ramming up the carbonaceous mold;

Fig. 4 is a sectional view through the flask illustrating the carbonaceous mold as having been rammed up about the pattern;

Fig. 5 is a view similar to Fig. 4, but illustrating the die cast pattern as having been mailed out or removed from the mold;

Fig. 6 is a vertical section through a centrifugal casting apparatus illustrating the molds as having been filled by the cast metal; and

Fig. 7 is a perspective view of the casting produced.

Referring to the accompanying drawings wherein similar reference characters designate similar parts throughout, and referring first to Figs. 1

and 2, inasmuch as each of the multiplicity of rotor blades that is to be produced is an exact duplicate of each other, it is desirable to produce a multiplicity of patterns all of which will be exact duplicates of each other. To this end the patterns are die cast. The die is indicated as having been made up of two opposed parts 10 and 11 and in the opposed faces of these parts there is formed the mold cavity 12 which is of the exact size and shape of the finished rotor blade or casting that is to be produced allowance being made merely for the shrinkage involved in the casting of the metal that finally forms the finished product.

Below the mold cavity 12 there is a small sprue 13 which is designed to form the mold entrance and at the top of the die there is an extension of the mold cavity 11, the extension being indicated at 14 which provides a vent for the mold. Die casting metal 15 is heated in a suitable container 17 having at its bottom a plunger 18 that can be lifted by a lever 19. This die casting metal is heated and melted by one or more burners 20. On the top of the die there is a cover 21 having a cavity 22 which receives excess metal from the die as shown in Fig. 2. The metal that we preferably employ for the pattern is a die casting metal known in the trade as Rose metal. It comprises approximately 50% bismuth, 28% lead, and 22% tin. It melts at approximately 212° F. and has the characteristic that on solidifying it neither expands or contracts materially.

The first step of the present method consists of die casting the pattern wherein the molten metal 15 is forced up through the die by the piston or plunger 18 filling the die with the excess metal entering cavity 22 as shown in Fig. 2. By die casting the pattern it is manifest that a multiplicity of patterns can be produced, all of which will be exact duplicates of each other. One of such patterns is indicated at 23 which, after having the excess metal at the top and bottom trimmed off, is positioned in a carbon flask 24. While other materials might be suitable for use as a flask graphitic carbon is preferred. Into the flask is placed a carbonaceous molding material 25.

A feature of the invention resides in the use of the correct composition of molding material. The preferred composition for the mold consists of the following ingredients in the following proportions;

	Ounces	Per cent
Carbon.....	4 1/2	76.5
Fire clay.....	1 1/4	4.2
Glucose.....	1/4	12.6
Boiled linseed oil.....	1/4	4.2
Water.....	1/8	2.5
	5 7/8	100.0

The carbon employed is in the nature of graphitic carbon and is usually obtained from cutting or turning carbon electrodes. It is of some importance to have this carbon sufficiently fine and we have found that it should be reduced so as to be capable of passing through a 200 mesh screen. The fire clay employed may be any conventional type of fire clay which is highly uniform, although we prefer to employ that fire clay that is sold under the trade-name of Hi-Link. The fire clay serves somewhat as a binder for the carbon particles. The glucose and boiled linseed oil also serve somewhat as a binder and carburizer during the baking process subsequently described. The water is added to moisten the mass and it is preferable to add to the water a

trace of "aerosol," a dioctyl ester of sodium sulpho-succinate. This material is usually obtainable in a 10% aqueous cloudy solution and a trace is added to the water so that the boiled linseed oil will quickly form an emulsion with the water. The aerosol acts as a very good emulsifying agent for this purpose. These ingredients are thoroughly mixed and are rammed or tamped in the flask 24 around the pattern. Some degree of skill is required in order to properly ram up the mold, and the best way to describe the ramming of the mold is to state that approximately a fifty pound tamp is used.

When the mold is completely rammed up about the pattern as shown in Fig. 4, the flask and the continuous carbonaceous material are then placed in a heated oven. It is first heated to a temperature of approximately 150° for twelve hours during which period the mold is thoroughly dried. Following the twelve hour drying the mold is then heated to approximately 450° F. for a period of one and one-half hours. During this period the mold becomes definitely set. It will be noted of course that during this baking period that the temperature is well in excess of the melting point of the die cast metal forming the pattern. The pattern consequently quickly melts and runs out either or both ends of the mold. It is preferable to wash the mold at the end of the baking period. This can be accomplished by dipping the mold in hot mercury which has the property of dissolving or amalgamating with any small particles of die casting metal that may remain in corners of the mold. The mercury may be heated from 300° to 350° F. The use of mercury is somewhat objectionable due to its toxic effect and as an alternative the mold may be dipped several times in molten lead to wash out all remaining particles of the pattern. When this operation is completed the mold will be found to be reasonably hard and it is then in condition to be used in centrifugally casting the finished casting.

As a means for centrifugally casting a casting machine is illustrated in Fig. 6 wherein a motor 26 rotates a carrier 27 about a vertical axis. This carrier receives upper and lower mold parts 28 and 29. In the upper mold part there is formed a plurality of cylindrical apertures 30 each of which receives a flask 24 and its contained mold. The upper part 28 has a central gate 31 which communicates with the inner ends of radial passages 32 formed in the lower part 29. The mold entrances communicate with these radial passages at points 33 disposed inwardly of the outer ends of the passages. The vents from the mold are open at the top thereof and any excess metal forced out of the vents is confined by a suitable cover 34.

The alloy that is to be cast is poured in molten condition into the central gate 31 and flows outwardly into the passages while the mold is being rotated by the motor 26. In making castings of this character using the metal hereafter described we prefer to rotate the mold at approximately 1500 R. P. M. with the centers of the molds radially spaced approximately 4" from the center of rotation. That metal which first enters the gate 31 and the inner ends of passages 32 may be regarded as initial metal. This metal is somewhat chilled by the cold walls of these passages and may encounter and pick up dirt or loose particles in the passages. As the initial metal is also utilized to force air out of the passages it may become considerably oxidized. This initial metal does not enter the mold but instead is drawn out

centrifugally to the outer ends of the passages 32. The succeeding or trailing metal poured into the gate 31 is not chilled to such a great extent as the initial metal and is not contaminated by any dirt in the passages. There is also very little opportunity for it to become oxidized. This trailing metal is drawn out centrifugally and builds up behind the initial metal that is entrapped or bypassed in the outer ends of the passages. Only the trailing metal is caused to enter the mold cavities with the result that the casting produced will be of fine grain and homogeneous being characterized by an entire absence of blow holes or gas pockets. Sufficient metal is poured into the gate 31 to fill all of the mold cavities. Usually there is a small excess which runs out the top through the vents.

The metal that we prefer to employ for the purpose of manufacturing rotor blades of the Moss supercharger is the metal known in the trade as "Stoodite #6." It comprises approximately 69% cobalt, 25% chromium, 5% tungsten carbide (W3C), and 1% of 85% ferrosilicon. This metal is highly resistant to the effects of exhaust gases from an internal combustion engine even when the metal is subjected to a 1200° temperature. It has the required tensile strength to resist separation under the high centrifugal forces that are developed therein when the metal is serving as a rotor blade of the supercharger. Such a metal has a relatively high melting point and is inherently hard. Because of its high melting point a carbonaceous mold material is practically essential to the present process. Other mold materials, such as for example those materials used for making investments in dental casting, are incapable of serving as mold materials for the present process. These investment materials break down under the high temperature of the metal. A carbonaceous molding material such as that herein described will stand up regardless of the high temperature.

The mold material used in the present process must not only be capable of standing up under high temperature but it also must be sufficiently hard so that the metal rushing into the mold will not wash away corners of the mold cavity or cause small projections in the mold cavity to break off. Although the mold material must be sufficiently hard to resist damage by the metal at the same time after the baking operation it must still be sufficiently soft or friable so as to be capable of giving or crushing slightly when the casting contracts on solidifying and cooling. If the mold is extremely hard, then the casting on contracting will be held against contraction by the hard mold material resulting in the cracking of the casting because of the fact that the mold will not give or crush under it. A rather delicate balance must thus be obtained, namely that the mold must be sufficiently hard to stand up under the effects of the metal rushing into it, yet it must not be so hard as to resist contraction of the cooling casting. Molding material made as above-described satisfactorily meets all of the above-mentioned requirements. A molding material composed of

gave reasonably satisfactory results, but was subject to the criticism that the mold was slightly too soft, resulting in the mold being damaged by the metal rushing into it. Mold materials having the following ingredients gave reasonably satisfactory results:

	Ounces	Percent
Carbon.....	4 1/2	77.4
Fire clay.....	1 1/2	4.3
Glucose.....	3/4	12.9
Boiled linseed oil.....	3/4	4.3
Water.....	1/16	1.1
	5 3/4	100.0

	Ounces	Percent
Carbon.....	4 1/2	73.5
Fire clay.....	1 1/2	4.1
Glucose.....	1 1/4	16.3
Boiled linseed oil.....	1 1/4	4.1
Water.....	3/8	2.0
	6 3/4	100.0

The requirements of the mold material will vary somewhat depending upon the type of metal used and casting conditions, and to some extent the requirements of the mold material will depend upon the size and shape of the casting that is to be produced. We have found with our molding material that the structure and the hardness of the mold can to some extent be controlled by the amount of glucose, boiled linseed oil, and water added, the hardness increasing mainly with the addition of water and glucose. We have proposed substituting for the glucose caramel, but prefer the glucose due to the fact that it is cheaper, seems to be more effective, and produces a molding material that seems to be easier to work. We have also proposed using dextrin in place of glucose but found that glucose gives superior results. In place of the fire clay we have proposed using Portland cement as a binder for the carbon but find that when the mold material is baked in this manner that the surface of the mold seems to break down and the hot metal tends to cut or eat into the surface of the mold. We have also proposed using pitch but find that this is objectionable in that the pitch tends to burn the surface of the mold, tends to break down under the high temperature of the metal, and a mold that is too hard is normally produced. If the mold is baked at too high a temperature constituents of the pitch also volatilize. We have found, however, that a natural yellow clay obtainable near Santa Ana, California, may be substituted for fire clay and produce reasonably satisfactory results. Care should be taken to have the carbon finely ground that is capable of passing through a 200 mesh screen. If the carbon particles are of larger size we find that we are unable to get the same binding action in making the mold and the wall surfaces of the mold cavity are affected by being quite rough.

By carefully following the preferred steps of the method as above outlined, we are able to obtain an intricate casting of the character illustrated in Fig. 7, which is perfectly formed, having smooth surfaces requiring no other machining than the grinding off of the metal in the mold entrance and the metal in the vent. As the patterns are made by die casting they may be very accurately produced with the result that a multiplicity of rotor blades can be produced which will be of exactly the same size, shape, and weight. This

	Ounces	Percent
Carbon.....	4 1/2	78.0
Fire clay.....	1 1/2	4.4
Glucose.....	3/4	13.2
Boiled linseed oil.....	3/4	4.4
	5 3/4	100.0

ability to produce exactly uniform castings is of equal importance to the avoidance of machine work in constructing a turbine rotor for a supercharger. It will be obvious, however, that the present method may be utilized whenever it is desired to employ a strong metal and avoid machine work.

The method of centrifugal casting is not claimed herein but forms the subject matter of another application which we have filed contemporaneously herewith, Serial No. 424,371 filed December 24, 1941. Also, the molding composition is not claimed herein but forms the subject matter of another application which we have filed contemporaneously herewith Serial No. 424,369 filed December 24, 1941.

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 making castings of cobalt-chromium tungsten alloys which includes making a diecast pattern, ramming up a carbonaceous

mold composed principally of finely divided carbon and a binder about the pattern, baking the mold, melting out the pattern and centrifugally casting molten cobalt-chromium tungsten alloy into the mold.

2. The method of making castings of cobalt-chromium tungsten alloys which includes making a diecast pattern, ramming up a carbonaceous mold composed principally of finely divided carbon and a binder about the pattern, baking the mold, melting out the pattern and centrifugally casting molten cobalt-chromium tungsten alloy into the mold without causing the initial metal to enter the mold.

3. The method of making castings of cobalt-chromium tungsten alloys which includes making a diecast pattern of low melting point metal, ramming up a carbonaceous mold composed principally of finely divided carbon and a binder, drying the mold, baking the mold and melting out the pattern, and centrifugally casting molten cobalt-chromium tungsten alloy into the mold.

SHELLEY M. STOODY.
RALPH L. ABOS.