Aug. 29, 1967 R. HOFFMAN 3,338,294

METHOD OF CASTING DIFFERENT MATERIALS IN LAYERS

Filed Oct. 20, 1964

Fig-1

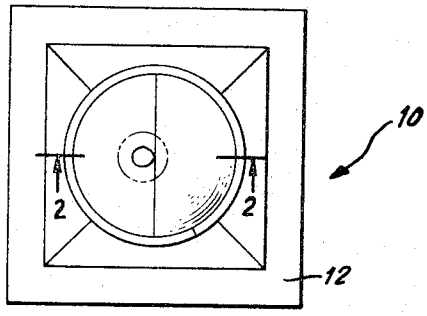
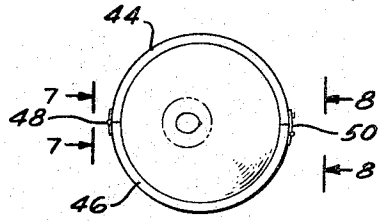


Fig-4



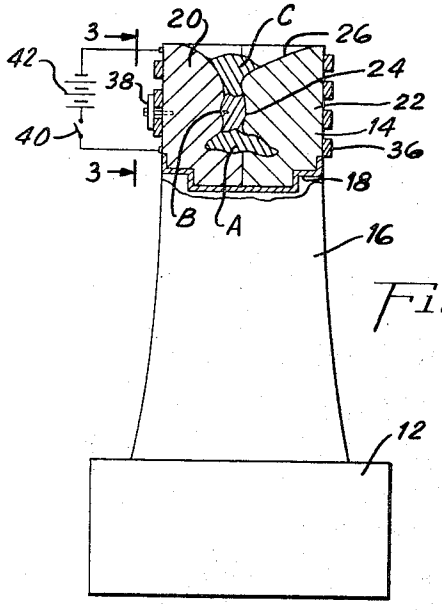


Fig-2

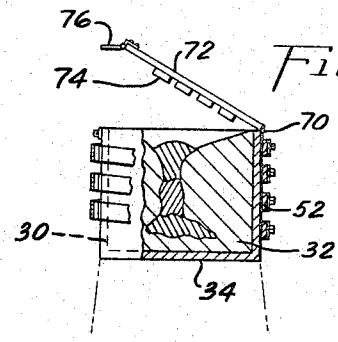


Fig-5

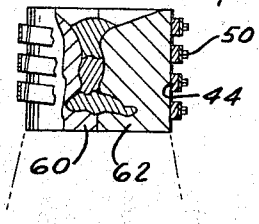


Fig-6

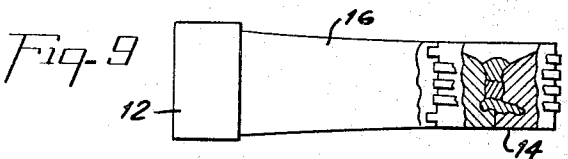


Fig-9

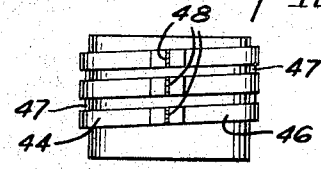


Fig-7

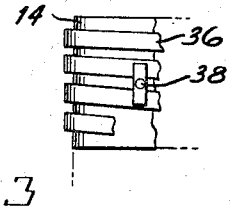


Fig-3

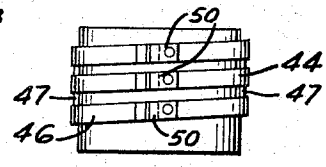


Fig-8

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METHOD OF CASTING DIFFERENT MATERIALS IN LAYERS

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ABSTRACT OF THE DISCLOSURE

A method of casting different materials in layers comprising the steps of separately heating a first material such as a precious metal and a second material such as another precious metal or a ceramic metal to their liquid states, pouring the first metal while in a liquid state into a mold, simultaneously heating said mold and further supplying heat to said first material from an external source while subjecting said first material to ultrasonic vibrations, and then pouring the second material while in a liquid state into the mold on top of said first material while simultaneously further applying heat on said mold and said first and second materials from an external source and subjecting said mold to ultrasonic vibrations to partially diffuse said first and second materials to provide for a cohesive bonding.

The present invention relates to the art of casting metals, and more particularly to methods and apparatus for the ultrasonic casting and treating of metallic matter such as gold, silver, platinum, etc. and alloys thereof.

In the past various procedures and methods have been devised and used in attempts to prevent incomplete casting, miscasting and to reduce gas porosity in metallic castings, and to insure dense castings which completely fill the mold and eliminate voids inside the casting. To accomplish this purpose, molds have been devised which permit the application of pressure, or the inclusion of escape holes, or the use of porous investment material to permit escape of entrapped gases or the use of centrifugal forces to compact the denser metal. However, this has been only partially successful because remote gas pockets are usually so entrapped that the gas cannot be liberated. No method of casting yet devised permits the heat treatment of the casting to proceed within the mold while simultaneously acting to remove gas inclusion and render the casting more dense.

Accordingly, it is an object of the invention to provide a method and apparatus for making dental, jewelry and other fine castings, which will to a higher degree eliminate gas pockets in the casting and reduce gas porosity, while also serving to increase the density of the castings and substantially increase the strength of the castings.

A further object of the invention is to provide for better appearing castings of measurably better physical characteristics by not only subjecting the casting to a suitably prolonged heat treatment as necessary, but also vibrating the casting at ultrasonic frequencies so as to compact and densify the casting, render the casting more homogeneous, increase the tensile and yield strength of the casting, conform the casting more clearly to the contours of the mold in which the material is being cast, and reduce gas porosity.

An additional object of the invention is to provide an easy method and a simple apparatus which will permit the successive casting in a single mold of more than one metal while assuring diffusion and cohesive bonding of the successive diverse layers of metallic material to an extent heretofore not possible to be achieved.

A yet further object of this invention resides in the provision of an apparatus for facilitating the casting of

metals in layers in a manner so that the different metals used in the different layers diffuse with each other at the junction of the layers so as to provide for cohesive bonding without substantial alloying or intermixing the respective metals.

The concept of this invention features an apparatus for the ultrasonic casting of metals which includes mold means having a cavity for receiving metallic material. The mold means may be in the form of a unitary body of a suitable investment material, or it may be desired to use complementary mold halves. An ultrasonic transducer capable of imparting ultrasonic vibrations in the order of 20,000 cycles per second or greater as best determined for the desired casting material and mold dimensions is connected to the mold means. Electrical heating means in the form of a heating coil or the like is removably disposed about the mold means. This heating coil may be used in connection with mold halves to hold the mold halves in an assembled position while imparting heat to the mold and to the metallic material being cast in the cavity of the mold while the transducer is simultaneously vibrating the mold means and the metallic material, thereby increasing the density of the metallic matter and reducing gas porosity while also causing a better casting to be achieved.

Another of the features of the invention is the concept of providing heating means for simultaneous operation with ultrasonic vibratory means.

Another feature of the invention resides in the concept of using the same heating means for heating the mold and the metallic material to hold the mold in an assembled condition.

Still further objects and features of this invention reside in the provision of a method and apparatus for casting metals including the concept of casting different metals in layers which is simple to employ, efficient in operation, and especially adapted for uses in jewelry foundings, jewelry manufacture, dentistry, and for making other similar fine castings.

These, together with the various ancillary objects and features of the invention which will become apparent as the following description proceeds, are attained by this method and apparatus for ultrasonic casting of metals, preferred embodiments of the apparatus being illustrated in the accompanying drawings, by way of example only, wherein:

FIG. 1 is a plan view of an embodiment of an apparatus for casting metals constructed in accordance with the concepts of the present invention;

FIG. 2 is a vertical sectional view taken along the plane of line 2—2 in FIG. 1, illustrating details of construction of the mold and heating coil and illustrating in elevation the base in which the transducer is mounted;

FIG. 3 is an enlarged detail view looking along the arrows of line 3—3 in FIG. 2, illustrating in particular means for securing a heating coil in position;

FIG. 4 is a plan view of a modified embodiment of the heating coil arranged in hinged half sections;

FIG. 5 is a sectional detail view of the modified form of the invention employing in conjunction with a suitable metal ring for holding the investment material;

FIG. 6 is a sectional detail view of a modified embodiment of the invention which employs two complementary mold sections with the heating coil holding the mold sections in assembled condition;

FIG. 7 is an elevational view looking along the plane of line 7—7 in FIG. 4, illustrating the hinge means joining the heating coil sections; and

FIG. 8 is an elevational view looking along the plane of line 8—8 in FIG. 4, illustrating the security means used for holding the heating coil sections together; and

FIG. 9 is a sectional view similar to FIG. 2, but shown arranged in a substantially horizontal position.

With continuing reference to the accompanying drawings, wherein like reference numerals designate similar parts throughout the various views, reference numeral **10** generally designates an apparatus constructed in accordance with the concepts of the present invention for use in the ultrasonic casing of metallic material. This apparatus **10** includes a base **12** of any suitable construction, it being recognized that this apparatus may be formed of different materials, and in different sizes and shapes as may be desired. Mounted within the base, not shown, is a conventional ultrasonic transducer. This transducer may be a mechanical transducer or may be and preferably is a magnetostrictive transducer capable of imparting vibrations upon the mold **14** in the order of 20,000 cycles per second and preferably thereabove.

The base **12** may have a suitable coupling device **16** designed to couple the ultrasonic energy from base **12** to the mold. The coupling device **16** may be provided with a suitable depression for receiving a support ring **18** in which the mold **14** may be disposed. The mold **14** may be integrally formed of one piece and the mold material utilized may be any suitable investment material. The mold **14** as shown in FIG. 2 employs two half mold sections **20** and **22** which together form a mold cavity **24** terminating in a sprue **26**. The cavity **24** is of the shape of the desired casting, and molten material is poured directly into the cavity **24**. Of course, as is shown in FIG. 5, a metallic ring **30** having investment material **32** of an integral body contained therein may be utilized and the investment ring itself may be provided with a bottom **34** if such is desired.

In the form of the invention as is shown in FIGS. 1 through 3, a spiral electrical heating coil **36** is disposed about the mold **14** and may be held in place by tightening screw **38** or any other suitable fastening means. Of course, it is within the concept of this invention to use other heating means such as infrared heating means, radiofrequency induction means, direct heat through gas torch or the like as may be desired. The heating coil may be connected through a suitable conventional electric plug, switch, and timer **40** to a suitable source of electrical power schematically designated at **42**. The precise controls and electrical heating connections for the electric heating coil **36** are optional.

The heating coil **46** is preferably in the form of suitable bands of iron or steel preferably arranged in a spiral connection and fitting tightly about the mold **14**. As shown in FIG. 4, the spiral coil may be formed out of a pair of heating coil half sections **44** and **46** held together by suitably porcelain rods **47** or other insulators, and a series of suitable hinges **48** may be used for hingedly connecting the half spiral heating coil sections **44** and **46** together. Suitable latching means are shown in FIG. 8 and indicated at **50** serve to hold the heating coil in a closed position about the mold.

When a metallic ring such as shown in FIG. 5 is utilized, the heating coils are, of course, suitably insulated as at **52** from the metallic ring. In order to retain applied heat on the mold, a hinged cover **72** may be hingedly secured by hinges **70** to the mold **14**. This cover may be provided with suitable heating elements **74**.

As is shown in FIG. 6, the heating coil half sections **44** and **46** may clampingly hold the mold half sections **60** and **62** in an assembled condition.

Procedures have been devised for utilizing this apparatus to provide for high density castings of a predetermined metallic material wherein the casting quality is substantially improved and in which the gas porosity is substantially reduced. In carrying out these procedures, the material being used is raised above its melting point in sprue **26** of the apparatus **10**. Simultaneously, the transducer, not shown, within the base and connected through the coupling device **16** to the mold **14** is actuated subjecting the mold to vibrations in the order of 20,000 cycles per second. An example of a silver casting of increased tensile strength and increased yield point and a fine quality is as follows:

Example I

After the apparatus has been arranged, a suitable amount of silver to form the casting was heated approximately 25° above its melting point of 960.5° C. At the same time, the heating coils were excited until their external temperature was measured at 1000° C. Simultaneously, the transducer was excited causing ultrasonic vibrations to be applied to the mold at 22,000 cycles per second. The casting was subjected to such heat and vibrations for a period of one and one-half minutes, after which time the heat in the coil was removed. A high quality casting of reduced gas porosity was obtained.

It has been found that this apparatus may be employed in a novel method of casting different material in layers. The new method is especially adapted for dental and jewelry castings and includes the concept of separately heating two or more differing metals to their liquid states. The first metal shown in FIG. 2 at A, and which for example may be platinum, is first cast into the mold. The mold is simultaneously subjected to vibrations through use of the transducer and to heat from an external source by actuating the heating coils. Then, a second material, such as gold, as indicated at B is cast in layer-like relation on top of the material A. The mold is continuously subjected to the ultrasonic vibrations though the external temperature of the heating coil may be reduced. Then, a third layer of another metal C is cast on top of the metal B with heat and vibrations still being simultaneously applied. This achieves a cohesive bonding of the various layers of metals without substantial alloying or intermixing of the first and second metals, or of the second and third metals.

An example of the foregoing method is as follows.

Example II

Platinum is heated approximately 50° above its melting point of 1773.5° C. While it is in the molten state, it is cast into the mold and vibrations on the order of 25,000 cycles per second are continuously applied on the mold and the platinum material therein for a period of one and one-half minutes. Heat is simultaneously applied from a source externally of the mold by means of an electric heating coil having an external surface temperature of 1800° C. Approximately one minute is permitted to elapse and the amount of current in the heating coil is reduced so that its outside temperature will then be 1100° C. At that time, gold which has been heated to approximately 1100° C. is then cast to form a layer on top of the platinum with the transducer still imparting vibrations in the order of 25,000 cycles per second. After two minutes, a layer of silver is then cast directly on the gold and the vibrations and heat are permitted to continue. A cohesively bonded high quality casting of three metals in layers was achieved.

It is to be recognized that any suitable rheostat or potentiometer may be used to control the amount of heat to the heating coil **36**, the precise control means being selected as desired.

The present invention may be used for casting ceramic material in a mold by subjecting the mold and material to ultrasonic vibrations, and thereafter fusing the casting by application of heat through use of the heating coils.

The present invention permits the production of castings of combinations of metals and ceramics and the like in one unit at one time.

It is to be noted that both horizontal and vertical vibrations may be imparted to the casting mold without affecting the efficiency of the molding method, as the direction of the vibration will not affect the casting process.

A latitude of modification, substitution and change is intended in the foregoing disclosure, and in some instances, some features of the invention will be employed without a corresponding use of other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the spirit and scope of the present invention.

I claim:

1. A method of casting different metals in layers comprising the steps of separately heating a first metal and a second metal to their liquid states, pouring the first metal while in a liquid state into a mold, simultaneously heating said mold and further supplying heat to said first metal from an external source while subjecting said first metal to ultrasonic vibrations, and then pouring the second metal while in a liquid state into the mold on top of said first metal while simultaneously further applying heat on said mold and said first and second metals from an external source and subjecting said mold to ultrasonic vibrations to partially diffuse said first and second metals to provide for a cohesive bonding without substantial alloying of major amounts of said first and second metals.

2. A method of casting different metals in layers comprising the steps of separately heating gold and silver to their liquid states, pouring the gold while in a liquid state into a mold, simultaneously heating said mold and further supplying heat to said gold from an external source while subjecting said gold to ultrasonic vibrations, and then pouring silver while in a liquid state into the mold on top of said gold while simultaneously further

applying heat on said mold and said gold and silver from an external source and subjecting said mold to ultrasonic vibrations to partially diffuse said gold and silver to provide for a cohesive bonding without substantial alloying of major amounts of said gold and silver.

3. A method of simultaneously casting metals and ceramic materials comprising the steps of heating said metallic and ceramic materials to a liquid state within a mold, and simultaneously further heating said metallic and ceramic materials from an external source while subjecting said metallic and ceramic materials and said mold to ultrasonic vibrations.

4. A method of casting metallic and ceramic materials simultaneously comprising the steps of heating said metallic material within a mold, imparting ultrasonic vibrations to said mold, adding ceramic material to said mold, heating said ceramic material to its melting point, imparting ultrasonic vibrations to said mold to fuse said ceramic material to said metallic material.

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