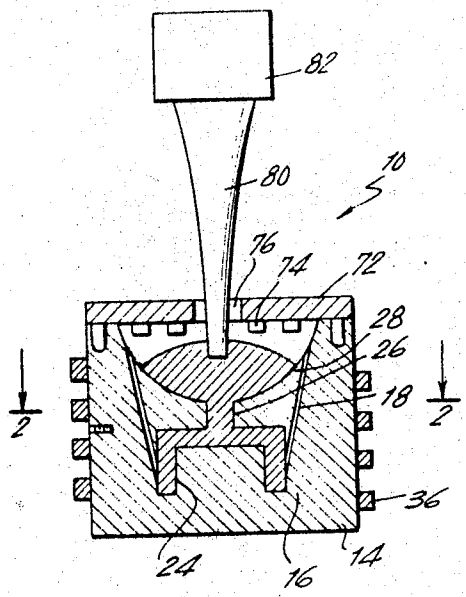
Aug. 19, 1969 R. HOFFMAN ETAL 3,461,942

METHOD FOR PROMOTING THE FLOW OF MOLTEN MATERIALS INTO A MOLD USING ULTRASONIC ENERGY VIA PROBE MEANS

Filed Dec. 6, 1966

FIG. 1



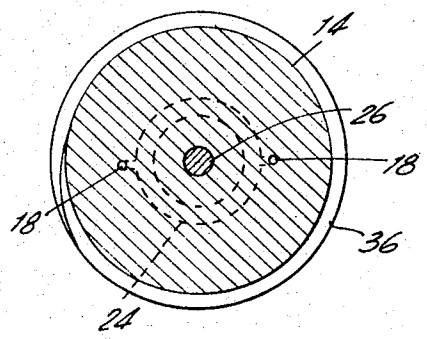


FIG. 2

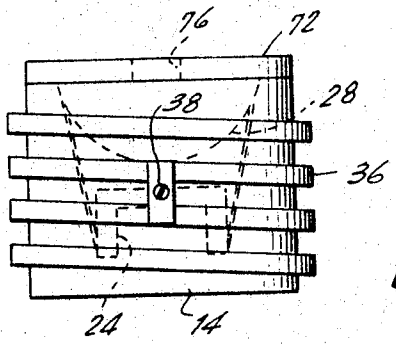


FIG. 3

INVENTORS
ROBERT HOFFMAN
LEO GROSS
Kenneth S Gaylord
ATTORNEY

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METHOD FOR PROMOTING THE FLOW OF MOLTEN MATERIALS INTO A MOLD USING ULTRASONIC ENERGY VIA PROBE MEANS

Robert Hoffman, 17 Copper Beech Place, Merrick, N.Y. 11566, and Leo Gross, 36—11 217th St., Bayside, N.Y. 11361

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U.S. Cl. 164—49 5 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to a method of casting metals comprising the steps of heating metallic material to a liquid state, promoting metallic flow of the molten metallic material into a mold with ultrasonic vibrations applied to sprue material by directly contacting an ultrasonic probe therewith, and simultaneously heating the mold and further heating the metallic material from an external source while subjecting the metallic material to ultrasonic vibrations.

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 using ultrasonic energy. This application is a continuation-in-part of the patent to Robert Hoffman, No. 3,338,294, filed October 20, 1964, and issued August 29, 1967 for Method of Casting Materials in Layers.

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, while also promoting flow within the mold cavity.

Accordingly, it is an object of the invention to provide a method and apparatus for making dental castings, jewelry and other precision 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 castings to a suitably prolonged heat treatment as necessary, but also vibrating the smelt 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 and improve grain structure.

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 coupled 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 in the concavity above the sprue hole. A probe vibrating at ultrasonic frequencies is introduced into the melt, causing molecular movement, reducing surface tension and driving the molten metal into the mold, entirely filling every conformation of the mold cavity. The ultrasonic energy is applied outside the mold case until solidification, but its radiation passes through the sprue to improve the grain structure and reduce porosity and gas inclusions.

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.

A further object of this invention is to promote flow of complex materials containing metal and ceramic particles, or just ceramic particles. These particles, when part of an appropriate vehicle, are cast into the mold with ultrasonic vibrations. The subsequent heat treatment results in binding the cast particles.

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 precision 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, a preferred embodiment of the apparatus being illustrated in the accompanying drawing, by way of example only, wherein:

FIG. 1 is a vertical sectional view illustrating details of construction of an apparatus for casting metals constructed in accordance with the concepts of the present invention;

FIG. 2 is a horizontal sectional view taken along line 2—2 in FIG. 1; and

FIG. 3 is a side elevational view of the invention with probe removed.

With continuing references to the accompanying drawing, wherein like reference numerals designate similar parts throughout the various views, reference numeral 10 generally designates an apparatus constructed in ac-

cordance with the concepts of the present invention for use in the ultrasonic casting of metallic material. This apparatus **10** includes a mold **14**. The mold **14** is provided with a cavity **24** surrounded by investment material **16** having vents **18** formed therein.

The mold **14** may be formed in any of the constructions set forth in the aforesaid patent No. 3,338,294 and include a mold cavity **24** terminating in a sprue **26**. The cavity **24** is of the shape of the desired casting, and the material to be cast is placed into the cavity **28**.

A spiral electrical heating ring **36** is disposed about the mold **14** and may be held in place by tightening screw **38** or any other suitable fastening means. The heating coil may be connected through a suitable conventional electric plug. The precise controls and electrical heating connections for the electric heating coil **36** are optional. It is within the concept of the invention to employ other heating means as desired.

The heating coil **36** 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**.

In order to retain applied heat on the mold, a removable or hinged cover **72** is disposed on the mold **14**. This cover may be provided with suitable electrical heating elements **74**. The cover is provided with an opening **76** therein for entry of a vibrating probe **80** connected to a transducer **82**. The transducer is preferably a magnetostrictive transducer capable of imparting vibrations in the order of 20,000 cycles per second on the probe **80**.

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 cavity **28** of the apparatus **10**. Simultaneously, the transducer is actuated and the probe **80** is inserted through opening **76** subjecting the metallic material to vibrations in the order of 20,000 to 25,000 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 probe 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 is first cast into the mold. The molten metal is simultaneously subjected to vibrations through use of the transducer and probe **80** and to heat from an external source by actuating the heating coils. Then, a second material is cast in layer-like relation on top of the first metal. The molten metals are continuously subjected to the ultrasonic vibrations through the probe **80** though the external temperature of the heating coil may be reduced. Then, a third layer of another metal is cast on top of the second metal 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 headed 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 probe 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 be then 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 and probe 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 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.

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.

We claim:

1. A method of casting metals comprising the steps of heating metallic material to a liquid state, promoting metallic flow with ultrasonic vibrations transmitted to said metallic material in its liquid state in a mold by applying said ultrasonic vibrations directly to a layer of said metallic material in a liquid state located above said mold and continuously driving said metallic material while in a liquid state into a mold, and simultaneously heating said mold and further heating said metallic material from an external source while subjecting said metallic material to ultrasonic vibrations.

2. A method of casting different materials in layers comprising the steps of separately heating a first material and a second material to their liquid states, driving the first material 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 transmitting to said first material in its liquid state ultrasonic vibraions of constant frequency by direct contact between an ultrasonic probe and a layer of said first metallic material in its liquid state located above said mold and then driving 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 transmitting ultrasonic vibrations to both of said materials by directly contacting an ultrasonic probe with a layer of said second material in its liquid state located above said mold to patrially diffuse said first and second materials to provide for a cohesive bonding without substantial alloying of major amounts of said first and second materials.

3. A method of casting according to claim **2**, wherein said first material is gold and said second material is silver.

4. A method according to claim 3, wherein said first material is a metal and said second material is a ceramic.

5. A method according to claim 3, wherein said first and second materials are metals, said step of further applying heat causing said metals to fuse.

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J. SPENCER OVERHOLSER, Primary Examiner

R. SPENCER ANNEAR, Assistant Examiner

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164—96, 260; 264—23, 250