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(54) **DIE CASTING FURNACE SYSTEM WITH ULTRASONIC UNIT FOR IMPROVED MOLTEN METAL QUALITY**

DRUCKGIESSOFENSYSTEM MIT ULTRASCHALLEINHEIT FÜR VERBESSERTE  
METALLSCHMELZEQUALITÄT

SYSTÈME DE FOUR DE COULÉE SOUS PRESSION AVEC UNITÉ ULTRASONORE POUR  
AMÉLIORER LA QUALITÉ DU MÉTAL FONDU

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**Description**

**[0001]** This PCT International Patent Application claims the benefit of U.S. Provisional Patent Application Serial No. 62/520,940 filed June 16, 2017 entitled "Die Casting Dosing Furnace With Ultrasonic Degassing System For Improved Aluminum Molten Metal Quality".

**BACKGROUND OF THE INVENTION****1. Field of the Invention**

**[0002]** The present disclosure relates generally to a system and method for an improved quality of molten metal in a die casting holding furnace unit.

**2. Related Art**

**[0003]** This section provides background information related to the present disclosure that is not necessarily prior art.

**[0004]** Traditional dosing furnaces are closed holding furnaces with a spout for direct metal (e.g., liquid or molten metal) delivery into a cold chamber die casting machine. Traditional dosing furnaces are designed so the entire furnace has to pressurize for each cycle of the machine. When the metal level in the dosing furnace is pressurized, all of the metal in the dosing furnace physically moves upward. After a shot, the dosing furnace is depressurized and the metal returns to a lowest level. This type of oscillation can generate dross, sludge, oxides, etc. In addition, current dosing furnaces use porous plugs at the bottom of the dosing unit in order to degas or remove hydrogen from the metal (e.g., aluminum). A successful introduction of a rotary degassing unit inside a pressurized dosing furnace has not been achieved because this would cause issues with pressure tightness of the dosing furnace itself and introduce turbulence such as dross, oxides, etc. Attempts have been made to use ultrasonic degassing for small holding furnaces; however, the volume of metal in conventional dosing furnaces is too large for the ultrasonic degassing vibration / wave to be effective. Further relevant Prior Art is described in JP 2007 313 554 A, US 2017/ 056 971 A1, US 5 913 358 A, WO 2016/ 071 613 A1 and US 2013/ 112 042 A1. In particular, JP 2007 313 554 A describes a die casting furnace system comprising a die casting holding furnace unit having a cavity for holding a molten metal and a dosing unit.

**SUMMARY OF THE INVENTION**

**[0005]** This section provides a general summary of the present disclosure and is not a comprehensive disclosure of its full scope, which is defined in the appended claims, or all of its features, aspects, and objectives. In particular, it is provided a die casting furnace system having the features defined in claim 1. Further preferred embodiments are defined in the dependent claims.

**[0006]** A die casting furnace system includes a die casting holding furnace unit defining a cavity for holding a molten metal. The die casting furnace system also includes a dosing unit disposed or positioned within the cavity and defining a dosing area disposed in fluid communication with the cavity for receiving the molten material during a pressurization of the cavity. An ultrasonic unit is operably coupled with the dosing area and is configured to introduce a vibration into the received molten material for facilitating the removal of gases from the received molten material prior to the molten material traveling into a die casting machine.

**[0007]** By utilizing the die casting furnace system with a small dosing unit disposed inside of the die casting holding furnace unit, the ultrasonic unit operates with the optimum volume of molten metal (such as aluminum) in order to allow for the highest possible metal quality directly before the molten metal is introduced into the die casting machine. The present system also obtains the best combination of metal cleanliness and accuracy in a die casting furnace system by using the combination of ultrasonic unit with a dosing unit disposed within a cavity of the die casting furnace unit. The ultrasonic unit thus provides a large improvement in the melt quality of metal. In fact, as will be explained in more detail below, compared to Argon (Ar) rotary degassing and other systems, the amount of dross and/or hydrogen is reduced more than five times. Accordingly, the combination of a finitely sized dosing unit in combination with the ultrasonic unit advantageously provides for a lower hydrogen content, higher density, lower porosity number, and higher tensile properties of the treated molten metal relative to the prior art systems.

**[0008]** These and other objects, features and advantages of the present invention will become more apparent from the following description.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**[0009]** Other advantages of the present invention will be readily appreciated, as the same becomes better understood

by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Figure 1 is a cross-sectional side view of a die casting holding furnace system including a dosing unit illustrated during a refilling cycle;

Figure 2 is a cross-sectional side view of the die casting holding furnace system illustrating a dosing cycle;

Figure 3A is a cross-sectional side view of the die casting holding furnace system illustrating an ultrasonic unit operably coupled with the dosing unit;

Figure 3B is a magnified view of a portion of Figure 3A illustrating a probe of the ultrasonic unit positioned within a molten metal in the dosing unit for introducing a degassing agent and generating cavitation bubbles;

Figure 4 is a cross-sectional side view of the die casting holding furnace system illustrating an automatic grain refining unit operably coupled with the dosing unit;

Figure 5A is a cross-sectional side view of the die casting holding furnace system illustrating an automated feed unit for a metal matrix composite (MMC) operably coupled with the ultrasonic unit; and

Figure 5B is a magnified view of a portion of Figure 5A illustrating the probe of the ultrasonic unit positioned within the molten metal for introducing the degassing agent as well as ceramic particles received from the automated feed unit.

#### DETAILED DESCRIPTION OF THE ENABLING EMBODIMENTS

**[0010]** Referring to the Figures, wherein like numerals indicate corresponding parts throughout the several views, a die casting holding furnace system **100**, known as a dual chamber furnace, is generally illustrated in Figures 1-5. The die casting holding furnace system **100** includes a die casting holding furnace unit **102** defining a cavity **103** having a first storage capacity for holding a molten metal or molten material **104**. The molten metal **104** may include aluminum, Al-Si-Mg alloy (300 series aluminum), or other metal or alloys. Furnace unit **102** is a closed holding furnace with a launder system to a die casting machine shot sleeve **106** for dispensing molten metal **106** from the die casting holding furnace unit **102** through the shot sleeve **104** to a die casting machine **108**.

**[0011]** A dosing unit **110** is disposed or positioned within the cavity **103** and defines a dosing area **112** disposed in fluid communication with the cavity **103** for receiving the molten metal **104** during a refilling cycle. For example, Figure 1 illustrates the die casting holding furnace system **100** during this refilling cycle, in which a pressure, such as 60 millibars (mbar), is reduced or removed from being applied to the dosing area **112**, causing the dosing area **112** to be filled with molten metal **104**. In other words, during the refilling cycle, positive pressure inside of the die casting furnace unit **102** increases the level of molten metal **104** inside of the dosing unit **110** until the molten metal **104** reaches a specific level or range of levels. As illustrated in the Figures, the dosing area **112** defined by the dosing unit **110** has a second storage capacity that is smaller than the first storage capacity of the cavity **103** of the die casting furnace unit **102**. As will be explained in more detail below, this smaller or finite size of dosing area **112** relative to the cavity **103** of the die casting furnace unit **102** provides for optimized processing of the molten metal **104** received during the refilling cycle before its introduction into the die casting machine **108**.

**[0012]** As further illustrated in Figure 1, the dosing area **112** has an inlet **113** disposed in fluid communication with the cavity **103** for receiving the molten metal **104** from the die casting holding furnace unit **102** and an outlet **114** disposed in fluid communication with the shot sleeve **106**. A check valve **115**, such as a one-way ball valve, is disposed in the inlet **113** for allowing molten metal **104** to pass through the inlet **113** during the refilling cycle while preventing the molten metal **104** from returning to the cavity **103** once received within the dosing area **112**.

**[0013]** Figure 2 illustrates the die casting holding furnace system **100** during a dosing cycle. The dosing cycle begins with a positive pressure produced inside the dosing unit **110**, such as reapplication of the 60 mbar described above, so that the check valve **115** is closed and the molten metal **104** is discharged through the shot sleeve **106** and into the die casting machine **108**. When a specific quantity of molten metal **104** is transported into the die casting machine **108**, the dosing process terminates by reducing or relieving the pressure applied to the dosing unit **110**. The specific quantity of molten metal **104** may be a predetermined amount. When the dosing cycle is finished, the level of molten metal **104** in the dosing unit **110** is at a lower level than the level of molten metal **104** before the dosing cycle began. After the dosing cycle is finished, the die casting holding furnace system **100** is ready for the refilling cycle to begin. As shown in Figure 1, the refilling cycle operates until the level of molten metal **104** within the dosing area **112** again returns to the specified level and the die casting holding furnace system **100** is ready for another dosing cycle to begin.

**[0014]** As best illustrated in Figure 3A, the die casting holding furnace system **100** includes an ultrasonic unit **116** operably coupled with the dosing area **112** and configured to introduce a vibration into the molten metal **104** received within the dosing area **112** after a refilling cycle. As will be explained in more detail below, the ultrasonic unit **116** facilitates the removal of gases from the received molten metal **104** prior to being dispensed to the shot sleeve **106**. The ultrasonic unit **116** includes a probe **117** attached to the holding furnace unit **102** and extending downwardly to be positioned within

the molten metal **104** disposed or received in the dosing area **112**. The probe **117** is configured to generate the vibration, and additionally provide a degassing agent **118** within the dosing area **112** to interact with the molten metal **104** prior to the molten metal **104** traveling into the die casting machine **108**. The degassing agent **118** functions to remove gases, such as hydrogen, from the molten metal **104** to provide a purification of the molten metal **104** entering the die casting machine **108**. As discussed previously, the dosing area **110** has a defined or finite storage capacity that is smaller than the cavity **103** of the holding furnace unit **102**. Accordingly, the ultrasonic unit **114** in combination with this finite storage capacity of the dosing area **112** provides for improved purification of the molten metal **104** because the ultrasonic unit is only treating molten metal **104** disposed within the dosing unit **110**, and thus is more appropriately sized to efficiently and effectively degas the molten metal **104**.

**[0015]** As best illustrated in Figure 3B, the degassing agent includes both carrier gas **120** and cavitation bubbles **122** that are introduced into the molten metal **104** by the probe **117**. Cavitation bubbles **122** can transport gases with them as they move throughout the molten metal **104**, including to the surface of the molten metal **104**. However, without any assistance, the cavitation bubbles **122** may collapse before reaching the surface. Thus, the carrier gas **120** can be used to transport the cavitation bubbles **122** and dissolved gases throughout the molten metal **104**. The high-intensity ultrasonic vibration generated from the probe **117** of the ultrasonic unit **114** breaks up the carrier gas **120** bubbles as well as creates large numbers of cavitation bubbles **122**. The carrier gas **120** bubbles can survive in the molten metal **104** because they do not dissolve in the molten metal **104**. As the carrier gas **120** travels throughout the molten metal **104**, the carrier gas **120** collects cavitation bubbles **122** containing dissolved gases and transports them uniformly throughout the molten metal **104**, thereby improving degassing efficiency. In addition, the ultrasonic vibration also creates smaller degassing agent bubbles, which allows for more surface area while degassing the molten metal **104**. After the ultrasonic unit **116** operates with the molten metal **104**, the molten metal **104** travels through the die casting machine shot sleeve **106** toward and into the die casting machine **108**.

**[0016]** To produce high quality aluminum alloy products, close control of the cast structure is required. An effective way to provide a fine and uniform as-cast grain structure is to add grain refiner **128**, such as nucleating agents, to the molten metal **104** to control crystal formation during solidification. As best illustrated in Figure 4, the die casting holding furnace system **100** includes an automated grain refining unit **130** operably coupled with the dosing area **112** to introduce grain refiner **128** into the received molten metal **104**. The grain refining unit **130** includes a wire rod **132** positioned in the dosing unit **110** as molten metal **104** refills the dosing area **112** to introduce the grain refiner **128**. This step is performed between die cast machine (DCM) cycles. The grain refining unit **130** adds grain refiner **128** into the dosing unit **110** for direct contact with the molten metal **104**. Grain refiner **128** can be a chemical, such as  $\text{SiO}_2$  or  $\text{TiB}_2$ , added to the molten metal **104** or alloy to check grain growth.

**[0017]** As best illustrated in Figure 5A, the die casting holding furnace system **100** includes an automated metal matrix composite (MMC) feed unit **134** operably coupled with the ultrasonic unit **116** and configured to provide the ultrasonic unit **116** with ceramic particles **136**. As best illustrated in Figure 5B, the ultrasonic unit **116** then releases both the degassing agent **118** and the ceramic particulates **136** into the molten metal **104** via the probe **117**. The ceramic particles **136** feed directly into the ultrasonic wave for homogenous distribution throughout the molten metal **104**. The ceramic particles **136** may comprise  $\text{SiC}$ ,  $\text{B}_4\text{C}$ , nano alumina ( $\text{Al}_2\text{O}_3$ ), decorated aluminum, or  $\text{SiO}_2$  ceramic composite material or other suitable material.

**[0018]** The ultrasonic assist provided by the automated MMC feed unit **134** includes an electromagnetic pump **138** used for both Lorentz force stirring and Joule heating. As illustrated in Figure 5A, the electromagnetic pump **138** applies an alternating magnetic field (either single phase or multiphase) to a conductor to induce electric currents in the conductor, wherein the magnetic field acts as a nonintrusive stirring device, and passes electric currents through the conductor to produce heat. In other words, the electromagnetic pump **138** is a pump that moves molten metal **104** (i.e., liquid metal or any electrically conductive liquid) using electromagnetism. As molten metal **104** moves into the magnetic field, current passes through it, causing an electromagnetic force that moves the molten metal **104**, together with the degassing agent **118** and ceramic particles **136**. This prevents the ceramic particles **136** from settling in the molten Al-homogenous distribution prior to reaching the die casting machine **108**.

**[0019]** As mentioned above, the ultrasonic vibration with degassing agent provided by the ultrasonic unit **116** in combination with the finite storage capacity of the dosing area **112** allows for a large improvement in the melt quality of the metal. For example, as established by Table 1 below, this combination accounts for a reduction of more than five times the amount of dross as compared to Argon rotary degassing. It also provides for a reduction in the amount of hydrogen as compared to other systems.

**[0020]** In more detail, Table 1 is a comparison of various properties of 250 kg of a degassed Al-Si-Mg alloy after different degassing methods are used on the alloy. For example, using ultrasonic degassing on 250 kg of an Al-Si-Mg alloy results in a molecular hydrogen content of  $0.17 \text{ cm}^3/\text{g}$ , a density of  $2.706 \text{ g/cm}^3$ , a porosity number of 1-2, and tensile properties of a Unified Thread Standard (UTS) of 245 MPa (force per unit area) and 5.1% El (elongation). As compared to the other degassing methods, using ultrasonic degassing is a more beneficial method because it results in a lower hydrogen content, higher density, lower porosity number, and higher tensile properties.

Table 1

| Degassing Method     | H <sub>2</sub> Content (cm <sup>3</sup> /100 g) | Density (g/cm <sup>3</sup> ) | Porosity Number | Tensile Properties |        |
|----------------------|-------------------------------------------------|------------------------------|-----------------|--------------------|--------|
|                      |                                                 |                              |                 | UTS (MPa)          | EI (%) |
| Starting melt        | 0.35                                            | 2.660                        | 4               | 200                | 3.8    |
| Ultrasonic degassing | 0.17                                            | 2.706                        | 1-2             | 245                | 5.1    |
| Vacuum degassing     | 0.20                                            | 2.681                        | 1-2             | 228                | 4.2    |
| Argon lancing        | 0.26                                            | 2.667                        | 2-3             | 233                | 4.0    |

**[0021]** In one embodiment, a low-cost and more effective grain refiner **128**, such as SiO<sub>2</sub>, is introduced to the molten metal **104** via the dosing unit **110**. The grain refiner SiO<sub>2</sub> is less expensive than a more commonly used TiB<sub>2</sub> master alloy and is more effective at grain refinement. In reference to Tables 2-5, a SiC and/or B<sub>4</sub>C ceramic composite material is added to the small dosing until the material becomes an in-situ MMC. This composite can have improved strength and modulus. The composite, however, may have lower ductility.

**[0022]** Table 2 is a comparison of the density characteristics of the in-situ MMC as ceramic composite material is added to the small dosing. For example, as the amount of ceramic composite material is added, the density of the MMC increases (i.e., from 2.65 g/cm<sup>3</sup> with none added to 2.82 g/cm<sup>3</sup> with the ceramic composite material constituting 15% of the MMC).

Table 2

| Aural 2 SiC (wt%)            | Aural 2 + SiC (0%) | Aural 2 + SiC (5%) | Aural 2 + SiC (10%) | Aural 2 + SiC (15%) |
|------------------------------|--------------------|--------------------|---------------------|---------------------|
| Density (g/cm <sup>3</sup> ) | 2.65               | 2.72               | 2.79                | 2.82                |

**[0023]** Table 3 is a comparison of the hardness characteristics of the in-situ MMC as ceramic composite material is added to the small dosing. For example, as the amount of ceramic composite material is added, the hardness of the MMC increases (i.e., from 62 HBW with none added to 72 HBW with the ceramic composite material constituting 15% of the MMC).

Table 3

| Aural 2 SiC (wt%) | Aural 2 + SiC (0%) | Aural 2 + SiC (5%) | Aural 2 + SiC (10%) | Aural 2 + SiC (15%) |
|-------------------|--------------------|--------------------|---------------------|---------------------|
| Hardness (HBW)    | 62                 | 66                 | 67                  | 72                  |

**[0024]** Table 4 is a comparison of the tensile modulus characteristics of the in-situ MMC as ceramic composite material is added to the small dosing. For example, as the amount of ceramic composite material is added, the tensile modulus of the MMC increases (i.e., from 75 GPa with none added to 125.25 GPa with the ceramic composite material constituting 15% of the MMC).

Table 4

| Aural 2 SiC (wt%) | Aural 2 + SiC (0%) | Aural 2 + SiC (5%) | Aural 2 + SiC (10%) | Aural 2 + SiC (15%) |
|-------------------|--------------------|--------------------|---------------------|---------------------|
| Modulus (GPa)     | 75                 | 91.75              | 108.5               | 125.25              |

**[0025]** Table 5 is a comparison of the tensile properties of the in-situ MMC as ceramic composite material is added

to the small dosing. For example, as the amount of ceramic composite material is added, the force per unit area of the MMC increases (i.e., from 205 UTS with none added to 260 UTS with the ceramic composite material constituting 15% of the MMC) and the elongation of the MMC decreases (i.e., from 15% El with none added to 13% El with the ceramic composite material constituting 15% of the MMC).

**Table 5**

| Aural 2 T7 SiC | Aural 2 + SiC (0%) | Aural 2 + SiC (5%) | Aural 2 + SiC (10%) | Aural 2 + SiC (15%) |
|----------------|--------------------|--------------------|---------------------|---------------------|
| UTS            | 205                | 230                | 250                 | 260                 |
| %Elong         | 15                 | 14.5               | 14                  | 13                  |

**[0026]** The die casting holding furnace system 100 having the combination of the dosing unit 110 and the ultrasonic unit 116 as described in this disclosure has various beneficial results. One beneficial result is ultra clean molten metal 104, such as molten aluminum. Another benefit is its dosing accuracy within +/-1%. Furthermore, the dosing is accurate when the dosing area 112 is both being refilled with molten metal 104 and pressurized simultaneously. This is unlike conventional systems that have issues pressurizing the system due the proportional valve getting confused during the refilling, changing metal level of the furnace, etc. Another benefit is better temperature control of the dosing metal.

**[0027]** Yet another benefit is that the die casting holding furnace system 100 allows for small additions of grain refiner 128, for example TiB<sub>2</sub> and/or SiO<sub>2</sub>, to be added directly to the molten metal 104, resulting in homogeneous distribution due to ultrasonic wave. The die casting holding furnace system 100 also allows for small additions of ceramic particulates 136 to be added directly to the molten metal 104, resulting in homogeneous distribution due to ultrasonic wave that creates an in-situ MMC material.

**[0028]** The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the invention, as defined in the appended claims.

## Claims

1. A die casting furnace system (100), comprising:

a die casting holding furnace unit (102) defining a cavity (103) for holding a molten metal (104);  
a dosing unit (110) disposed within said cavity (103) and defining a dosing area (112) disposed in fluid communication with said cavity (103) for receiving the molten metal (104) during a pressurization of said cavity (103); and  
an ultrasonic unit (116) operably coupled with said dosing area (112) and configured to introduce vibration into the received molten metal (104) for facilitating the removal of gases from the received molten metal (104), wherein said ultrasonic unit (116) includes a probe (117) extending into said dosing area (112) to establish said operable coupling between said ultrasonic unit (116) and said dosing area (112) and additionally introduce a degassing agent into the received molten metal (104).

2. A die casting furnace system (100) as set forth in Claim 1, wherein said cavity (103) of said die casting holding furnace unit (102) has a first storage capacity and said dosing area (112) of said dosing unit (110) has a second storage capacity being less than said first storage capacity.

3. A die casting furnace system (100) as set forth in Claim 2, wherein said dosing area (112) has an inlet (113) disposed in fluid communication with said cavity (103) for receiving the molten metal (104) from said die casting holding furnace unit (102) and an outlet (114) disposed in fluid communication with a shot sleeve (106) for dispensing the molten metal (104) from said dosing unit (110) and into a die casting machine (108) after treatment with said degassing agent.

4. A die casting furnace system (100) as set forth in Claim 3, wherein said degassing agent includes a carrier gas and said probe (117) is configured to generate an ultrasonic vibration for breaking up said carrier gas and introducing

a plurality of cavitation bubbles into the received molten metal (104).

5 5. A die casting furnace system (100) as set forth in Claim 4, further comprising an automated grain refining unit (130) operably coupled with said dosing area (112) to introduce grain refiner into the received molten metal (104).

6. A die casting furnace system (100) as set forth in Claim 5, wherein said automated grain refining unit (130) includes a wire rod (132) positioned within said dosing area (112) to establish said operable coupling between said automated grain refining unit (130) and said dosing area (112).

10 7. A die casting furnace system (100) as set forth in Claim 6, wherein said grain refiner includes at least one of  $\text{SiO}_2$  or  $\text{TiB}_2$ .

8. A die casting furnace system (100) as set forth in Claim 4, further comprising:

15 an automated metal matrix composite feed unit (134) operably coupled with said ultrasonic unit (116) and configured to provide said ultrasonic unit (116) with ceramic particles; and said probe (117) configured to introduce said ceramic particles into the received molten metal (104) along with said carrier gas and said cavitation bubbles.

20 9. A die casting furnace unit (100) as set forth in Claim 8, wherein said ceramic particles include at least one of  $\text{SiC}$ ,  $\text{B}_4\text{C}$ , or nano alumina ( $\text{Al}_2\text{O}_3$ ) decorated aluminum.

25 10. A die casting furnace unit (100) as set forth in Claim 8, further comprising an electromagnetic pump (138) operably coupled with said shot sleeve (106) for moving the molten metal (104) dispensed from said outlet (114) of said dosing area (112) through said shot sleeve (106) and preventing said ceramic particles from settling out of the dispensed molten metal (104) prior to reaching the die casting machine (108).

30 11. A die casting furnace unit (100) as set forth in Claim 10, wherein said electromagnetic pump (138) is configured to generate both Lorentz force stirring and Joule heating of the dispensed molten metal (104).

35 12. A die casting furnace unit (100) as set forth in Claim 3, wherein said inlet (113) of said dosing area (112) includes a check valve (115) for allowing molten metal (104) to pass through said inlet (113) during said pressurization of said cavity (103) of said die casting holding furnace unit (102) and preventing the molten metal (104) from returning to said cavity (102) once received within said dosing area (112).

13. A die casting furnace unit (100) as set forth in Claim 1, wherein said die casting holding furnace unit (100) is a closed holding furnace.

40 14. A die casting furnace unit (100) as set forth in Claim 1, wherein said probe (117) is secured to said die casting holding furnace unit (102) and extends downwardly into said dosing area (112).

## Patentansprüche

45 1. Druckguss-Ofensystem (100), umfassend:

eine Druckguss-Halteofeneinheit (102), die einen Hohlraum (103) zum Halten eines geschmolzenen Metalls (104) definiert;

50 eine Dosiereinheit (110), die innerhalb des Hohlraums (103) angeordnet ist und einen Dosierbereich (112) definiert, der in Fluidverbindung mit dem Hohlraum (103) zur Aufnahme des geschmolzenen Metalls (104) während einer Druckbeaufschlagung des Hohlraums (103) angeordnet ist; und

eine Ultraschalleinheit (116), die funktionsfähig mit dem Dosierbereich (112) gekoppelt und so konfiguriert ist, dass sie Vibrationen in das aufgenommene geschmolzene Metall (104) einführt, um die Entfernung von Gasen aus dem aufgenommenen geschmolzenen Metall (104) zu erleichtern, wobei die Ultraschalleinheit (116) eine Sonde (117) umfasst, die sich in den Dosierbereich (112) erstreckt, um die funktionsfähige Kopplung zwischen der Ultraschalleinheit (116) und dem Dosierbereich (112) herzustellen und zusätzlich ein Entgasungsmittel in das aufgenommene geschmolzene Metall (104) einzuführen.

2. Druckguss-Ofensystem (100) nach Anspruch 1, wobei der Hohlraum (103) der Druckguss-Halteofeneinheit (102) eine erste Speicherkapazität aufweist und der Dosierbereich (112) der Dosiereinheit (110) eine zweite Speicherkapazität aufweist, die geringer ist als die erste Speicherkapazität.
- 5 3. Druckguss-Ofensystem (100) nach Anspruch 2, wobei der Dosierbereich (112) einen Einlass (113) aufweist, der in Fluidverbindung mit dem Hohlraum (103) zur Aufnahme des geschmolzenen Metalls (104) aus der Druckguss-Halteofeneinheit (102) angeordnet ist, und einen Auslass (114), der in Fluidverbindung mit einer Gießhülse (106) zur Abgabe des geschmolzenen Metalls (104) aus der Dosiereinheit (110) und in eine Druckgussmaschine (108) nach Behandlung mit dem Entgasungsmittel angeordnet ist.
- 10 4. Druckguss-Ofensystem (100) nach Anspruch 3, wobei das Entgasungsmittel ein Trägergas enthält und die Sonde (117) so konfiguriert ist, dass sie eine Ultraschallschwingung zum Aufbrechen des Trägergases und zum Einbringen einer Vielzahl von Kavitationsblasen in das aufgenommene geschmolzene Metall (104) erzeugt.
- 15 5. Druckguss-Ofensystem (100) nach Anspruch 4, ferner umfassend eine automatische Kornverfeinerungseinheit (130), die betriebsmäßig mit dem Dosierbereich (112) gekoppelt ist, um Kornverfeinerungsmittel in das aufgenommene geschmolzene Metall (104) einzuführen.
- 20 6. Druckguss-Ofensystem (100) nach Anspruch 5, wobei die automatische Kornverfeinerungseinheit (130) einen Walzdraht (132) umfasst, der in dem Dosierbereich (112) positioniert ist, um die betriebsfähige Verbindung zwischen der automatischen Kornverfeinerungseinheit (130) und dem Dosierbereich (112) herzustellen.
7. Druckguss-Ofensystem (100) nach Anspruch 6, wobei das Kornverfeinerungsmittel mindestens eines von  $\text{SiO}_2$  oder  $\text{TiB}_2$  enthält.
- 25 8. Druckguss-Ofensystem (100) nach Anspruch 4, ferner umfassend:  

eine automatisierte Metallmatrix-Verbundwerkstoff-Zuführeinheit (134), die betriebsmäßig mit der Ultraschalleinheit (116) gekoppelt und so konfiguriert ist, dass sie die Ultraschalleinheit (116) mit Keramikpartikeln versorgt;  
30 und  
die Sonde (117), die so konfiguriert ist, dass sie die Keramikpartikel zusammen mit dem Trägergas und den Kavitationsblasen in das aufgenommene geschmolzene Metall (104) einbringt.
- 35 9. Druckguss-Ofensystem (100) nach Anspruch 8, wobei die Keramikteilchen mindestens eines von  $\text{SiC}$ ,  $\text{B}_4\text{C}$  oder mit Nano-Aluminiumoxid ( $\text{Al}_2\text{O}_3$ ) dekoriertem Aluminium enthalten.
- 40 10. Druckguss-Ofensystem (100) nach Anspruch 8, ferner umfassend eine elektromagnetische Pumpe (138), die betriebsmäßig mit der Gießhülse (106) gekoppelt ist, um das geschmolzene Metall (104), das aus dem Auslass (114) des Dosierbereichs (112) abgegeben wird, durch die Gießhülse (106) zu bewegen und zu verhindern, dass sich die Keramikteilchen aus dem abgegebenen geschmolzenen Metall (104) absetzen, bevor sie die Druckgießmaschine (108) erreichen.
- 45 11. Druckguss-Ofensystem (100) nach Anspruch 10, wobei die elektromagnetische Pumpe (138) so konfiguriert ist, dass sie sowohl ein Rühren mit Lorentz-Kräften als auch eine Joule-Erwärmung dem abgegebenen geschmolzenen Metall (104) erzeugt.
- 50 12. Druckguss-Ofensystem (100) nach Anspruch 3, wobei der Einlass (113) des Dosierbereichs (112) ein Rückschlagventil (115) aufweist, um zu ermöglichen, dass geschmolzenes Metall (104) während der Druckbeaufschlagung des Hohlraums (103) der Druckguss-Halteofeneinheit (102) durch den Einlass (113) fließt, und um zu verhindern, dass das geschmolzene Metall (104) in den Hohlraum (102) zurückkehrt, sobald es in dem Dosierbereich (112) aufgenommen wurde.
- 55 13. Druckguss-Ofensystem (100) nach Anspruch 1, wobei die Druckguss-Halteofeneinheit (100) ein geschlossener Halteofen ist.
14. Druckguss-Ofensystem (100) nach Anspruch 1, wobei die Sonde (117) an der Druckguss-Halteofeneinheit (102) befestigt ist und sich nach unten in den Dosierbereich (112) erstreckt.

## Revendications

### 1. Système de four de coulée sous pression (100), comprenant :

une unité de four d'attente de coulée sous pression (102) définissant une cavité (103) pour maintenir un métal fondu (104) ;  
 une unité de dosage (110) disposée au sein de ladite cavité (103) et définissant une zone de dosage (112) disposée en communication fluïdique avec ladite cavité (103) pour recevoir le métal fondu (104) au cours d'une pressurisation de ladite cavité (103) ; et  
 une unité à ultrasons (116) couplée en fonctionnement avec ladite zone de dosage (112) et configurée pour introduire une vibration dans le métal fondu reçu (104) pour faciliter l'élimination de gaz hors du métal fondu reçu (104), dans lequel ladite unité à ultrasons (116) inclut une sonde (117) s'étendant dans ladite zone de dosage (112) pour établir ledit couplage en fonctionnement entre ladite unité à ultrasons (116) et ladite zone de dosage (112) et additionnellement introduire un agent de dégazage dans le métal fondu reçu (104) .

2. Le système de four de coulée sous pression (100) tel que revendiqué à la revendication 1, dans lequel ladite cavité (103) de ladite unité de four d'attente de coulée sous pression (102) présente une première capacité de stockage et ladite zone de dosage (112) de ladite unité de dosage (110) présente une deuxième capacité de stockage inférieure à ladite première capacité de stockage.

3. Le système de four de coulée sous pression (100) tel que revendiqué à la revendication 2, dans lequel ladite zone de dosage (112) présente une entrée (113) disposée en communication fluïdique avec ladite cavité (103) pour recevoir le métal fondu (104) de ladite unité de four d'attente de coulée sous pression (102) et une sortie (114) disposée en communication fluïdique avec une chambre de coulée (106) pour acheminer le métal fondu (104) depuis ladite unité de dosage (110) et vers la machine de coulée sous pression (108) après traitement avec ledit agent de dégazage.

4. Le système de four de coulée sous pression (100) tel que revendiqué à la revendication 3, dans lequel ledit agent de dégazage inclut un gaz porteur et ladite sonde (117) est configurée pour générer une vibration ultrasonore pour désagréger ledit gaz porteur et introduire une pluralité de bulles de cavitation dans le métal fondu reçu (104).

5. Le système de four de coulée sous pression (100) tel que revendiqué à la revendication 4, comprenant en outre une unité d'affinage de grain automatisée (130) couplée en fonctionnement avec ladite zone de dosage (112) pour introduire un affineur de grain dans le métal fondu reçu (104) .

6. Le système de four de coulée sous pression (100) tel que revendiqué à la revendication 5, dans lequel ladite unité d'affinage de grain automatisée (130) inclut un fil machine (132) positionné au sein de ladite zone de dosage (112) pour établir ledit couplage en fonctionnement entre ladite unité d'affinage de grain automatisée (130) et ladite zone de dosage (112).

7. Le système de four de coulée sous pression (100) tel que revendiqué à la revendication 6, dans lequel ledit affineur de grain inclut au moins un de  $\text{SiO}_2$  ou  $\text{TiB}_2$ .

8. Le système de four de coulée sous pression (100) tel que revendiqué à la revendication 4, comprenant en outre :

une unité d'alimentation en composites à matrice de métaux automatisée (134) couplée en fonctionnement avec ladite unité à ultrasons (116) et configurée pour fournir à ladite unité à ultrasons (116) des particules de céramique ; et  
 ladite sonde (117) configurée pour introduire lesdites particules de céramique dans le métal fondu reçu (104) accompagnées dudit gaz porteur et desdites bulles de cavitation.

9. L'unité de four de coulée sous pression (100) telle que revendiquée à la revendication 8, dans laquelle lesdites particules de céramique incluent au moins un de  $\text{SiC}$ ,  $\text{B}_4\text{C}$  ou aluminium garni de nanoparticules d'alumine ( $\text{Al}_2\text{O}_3$ ).

10. L'unité de four de coulée sous pression (100) telle que revendiquée à la revendication 8, comprenant en outre une pompe électromagnétique (138) couplée en fonctionnement avec ladite chambre de coulée (106) pour déplacer le

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métal fondu (104) acheminé depuis ladite entrée (114) de ladite zone de dosage (112) à travers ladite chambre de coulée (106) et empêcher lesdites particules de céramique de se déposer hors du métal fondu acheminé (104) avant d'atteindre la machine de coulée sous pression (108).

- 5      **11.** L'unité de four de coulée sous pression (100) telle que revendiquée à la revendication 10, dans laquelle ladite pompe électromagnétique (138) est configurée pour générer à la fois une agitation par force de Lorentz et un chauffage par effet Joule du métal fondu acheminé (104) .
- 10      **12.** L'unité de four de coulée sous pression (100) telle que revendiquée à la revendication 3, dans laquelle ladite entrée (113) de ladite zone de dosage (112) inclut un clapet anti-retour (115) qui permet au métal fondu (104) de traverser ladite entrée (113) au cours de ladite pressurisation de ladite cavité (103) de ladite unité four d'attente de coulée sous pression (102) et empêche le métal fondu (104) de revenir dans ladite cavité (102) une fois réceptionné au sein de ladite zone de dosage (112) .
- 15      **13.** L'unité de four de coulée sous pression (100) telle que revendiquée à la revendication 1, dans laquelle ladite unité de four d'attente de coulée sous pression (100) est un four d'attente fermé.
- 20      **14.** L'unité de four de coulée sous pression (100) telle que revendiquée à la revendication 1, dans laquelle ladite sonde (117) est fixée à ladite unique de four d'attente de coulé sous pression (102) et s'étend vers le bas dans ladite zone de dosage (112).

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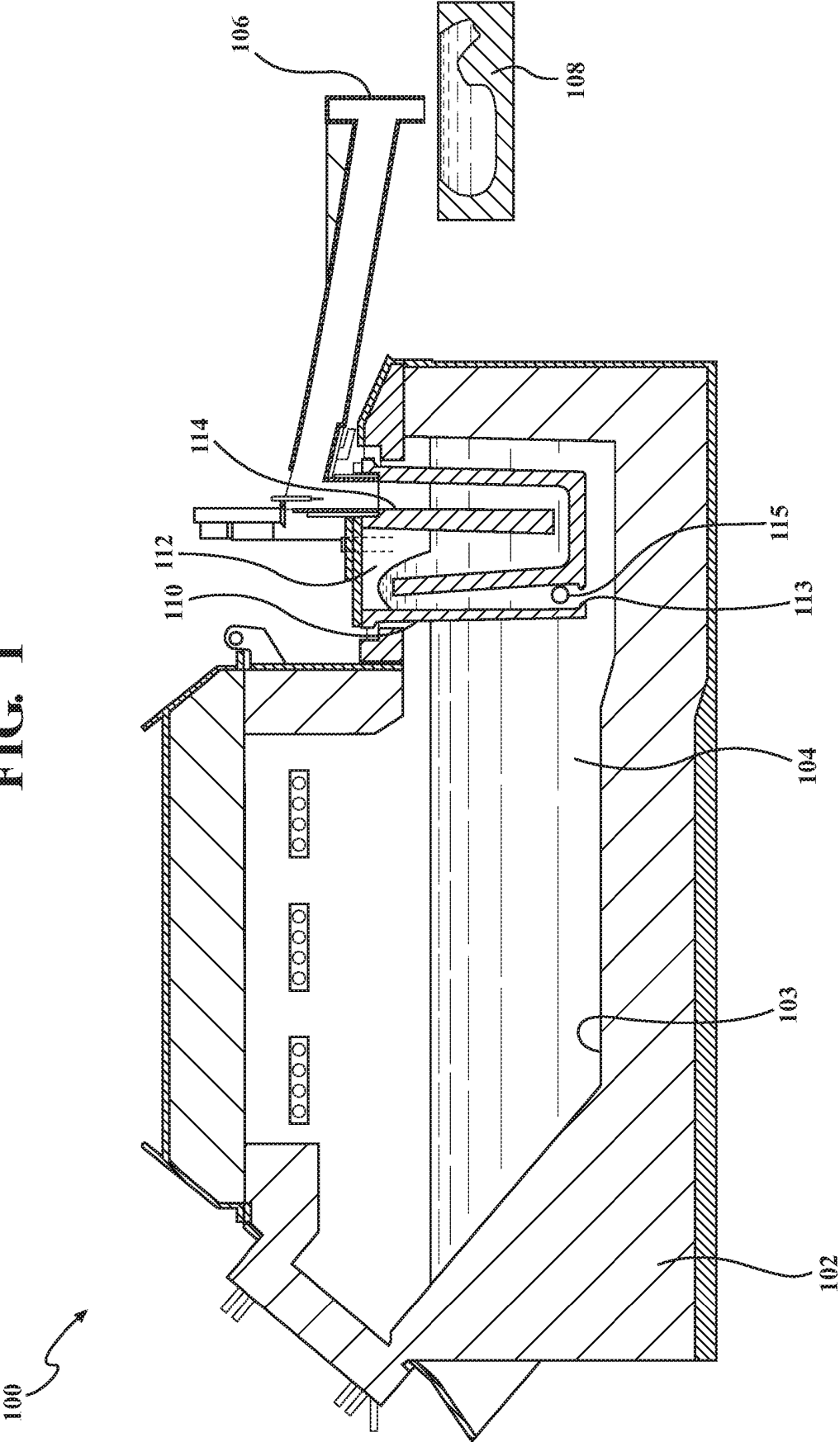
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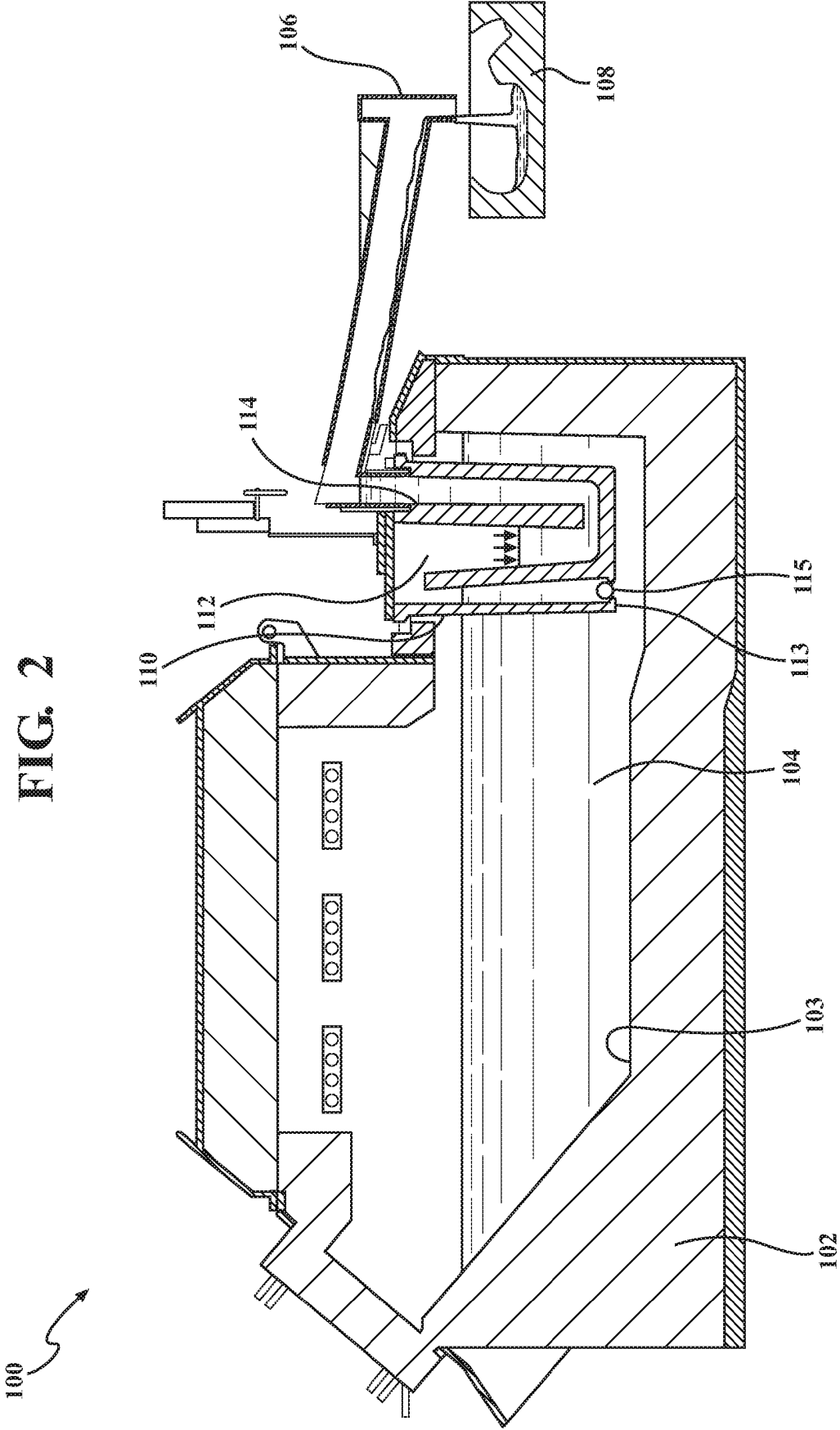
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FIG. 1





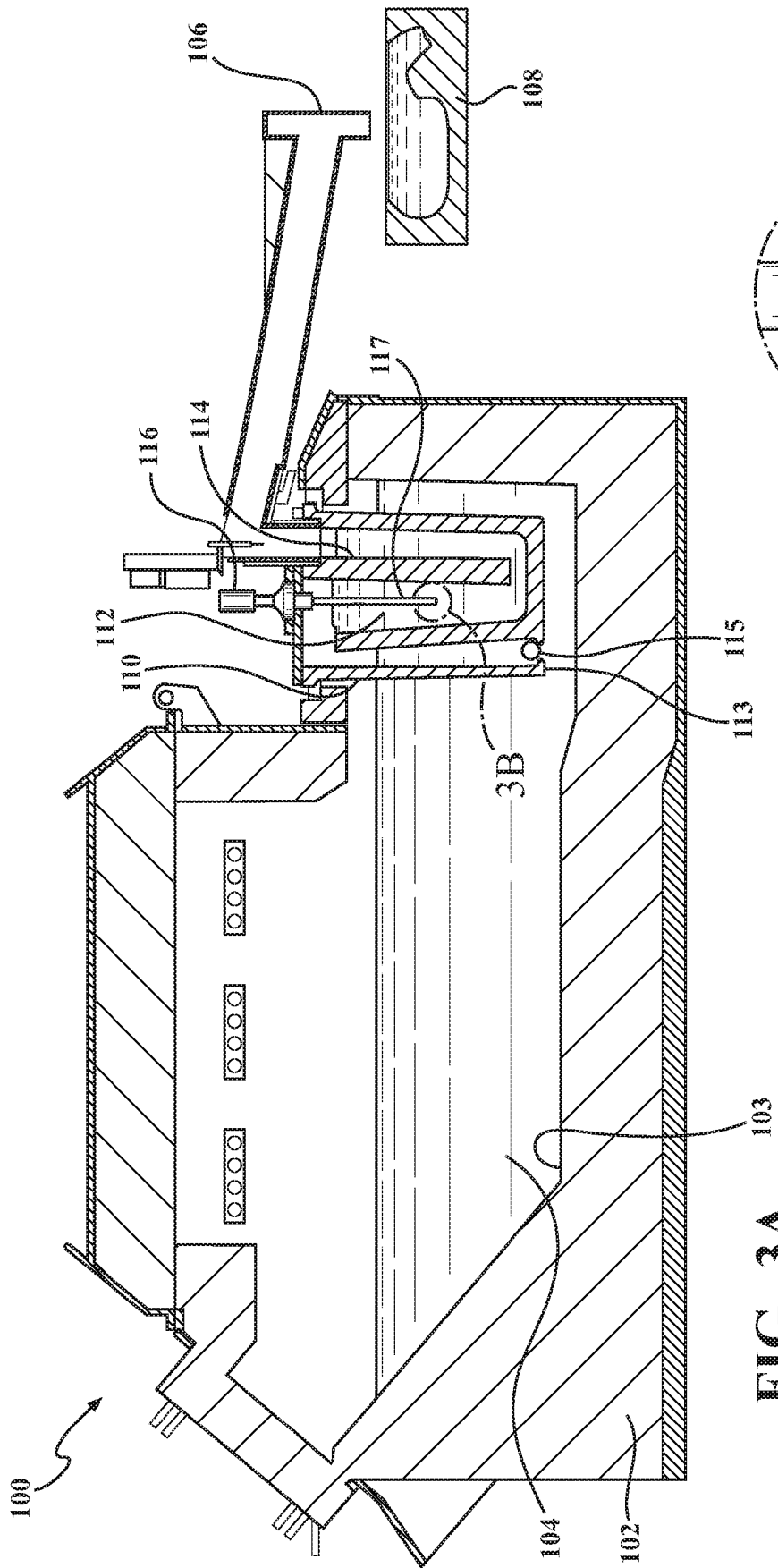


FIG. 3A

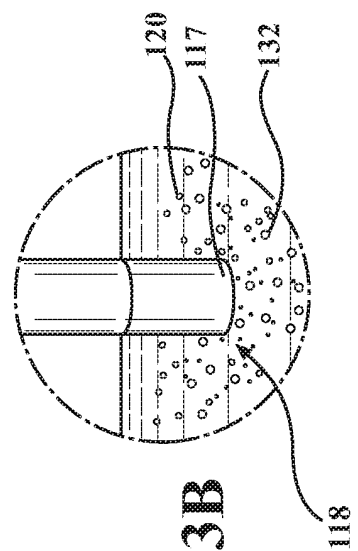
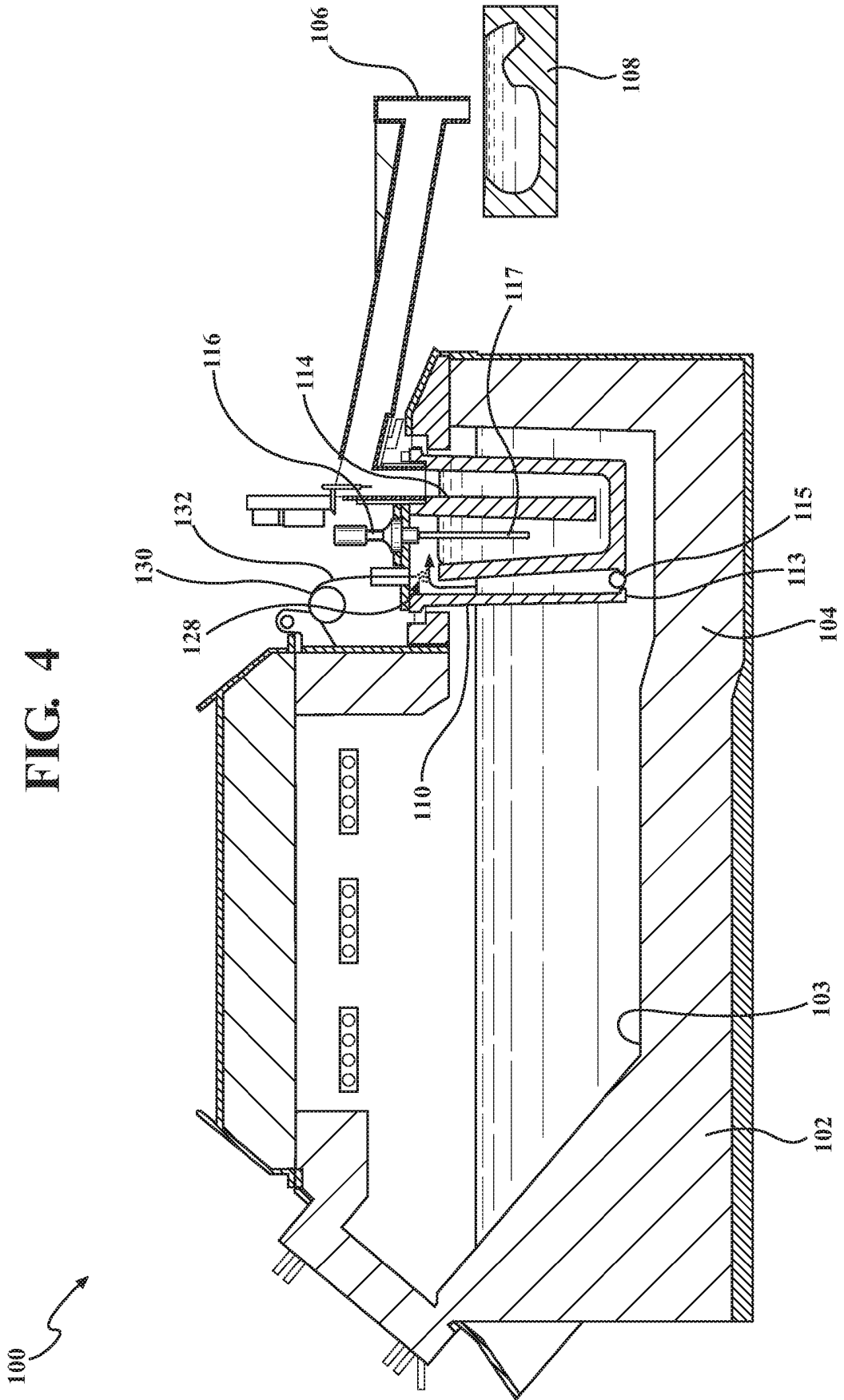
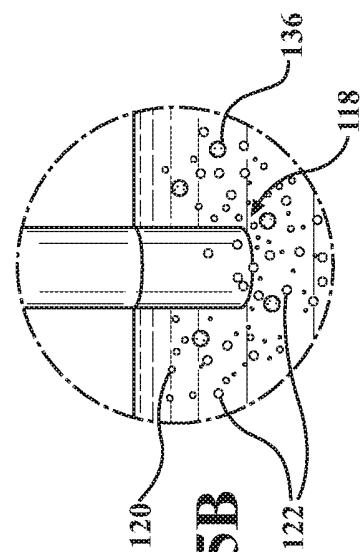
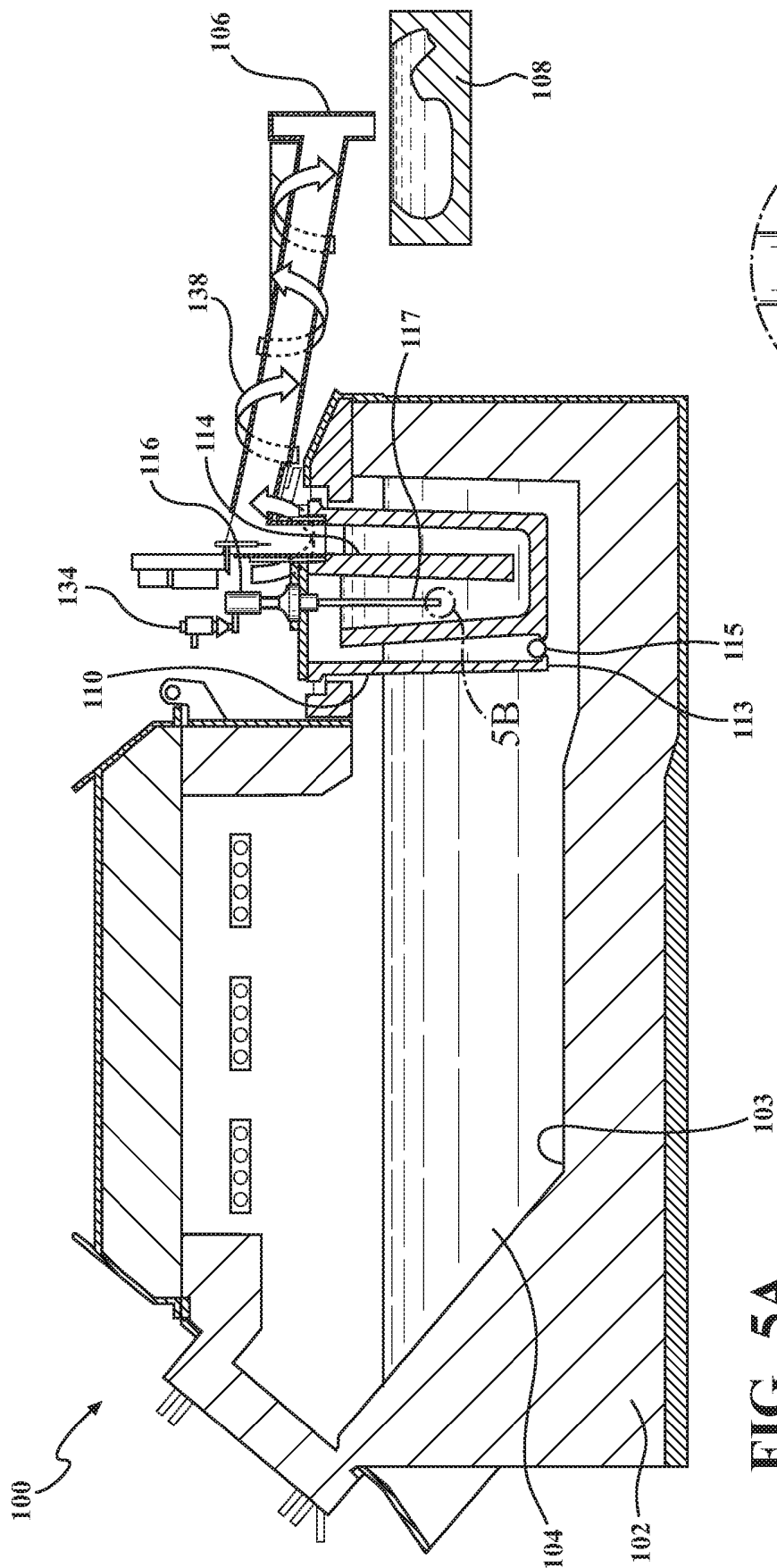


FIG. 3B





**REFERENCES CITED IN THE DESCRIPTION**

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