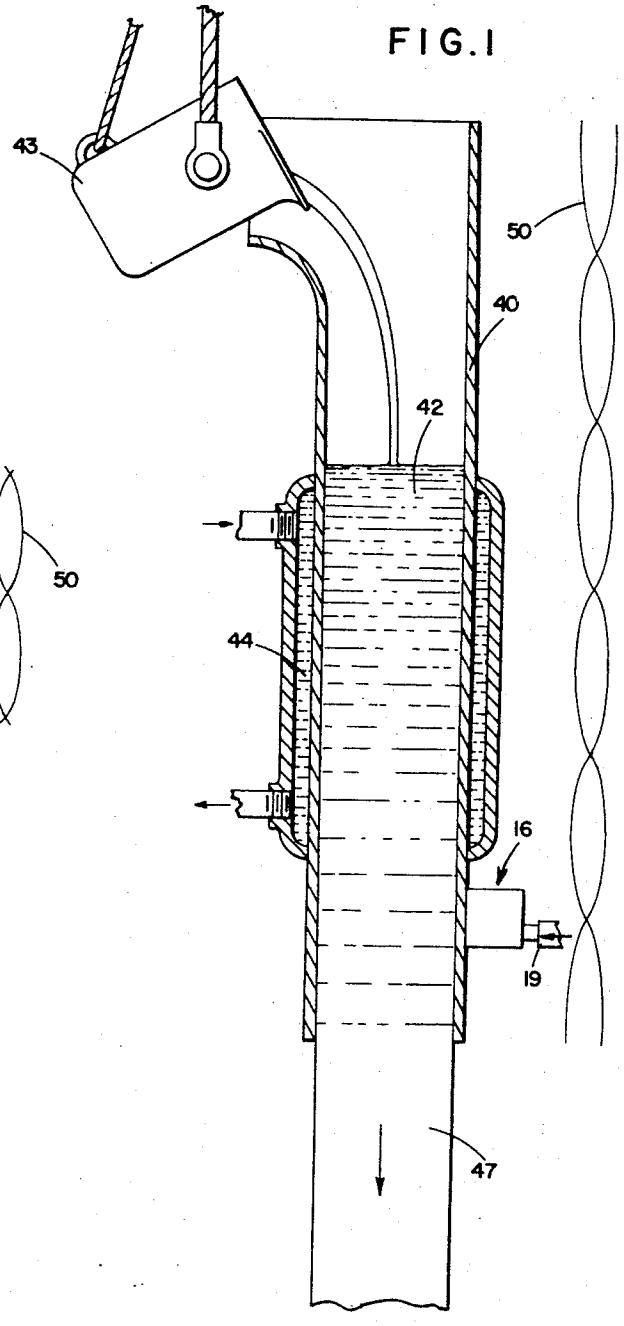
June 3, 1969 A. G. BODINE, JR 3,447,480

METHOD AND APPARATUS FOR GRAVITY FLOW CASTING UTILIZING SONIC ENERGIZATION

Original Filed May 10, 1965

Sheet 1 of 2

FIG. 1



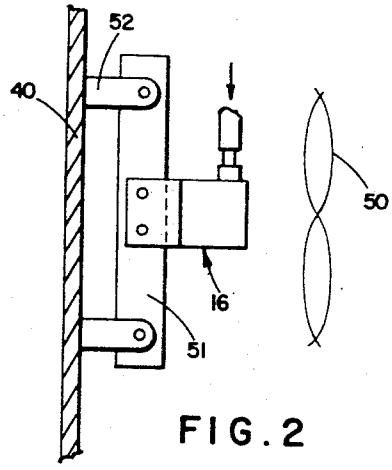


FIG. 2

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METHOD AND APPARATUS FOR GRAVITY FLOW CASTING UTILIZING SONIC ENERGIZATION

Original Filed May 10, 1965 Sheet 2 of 2

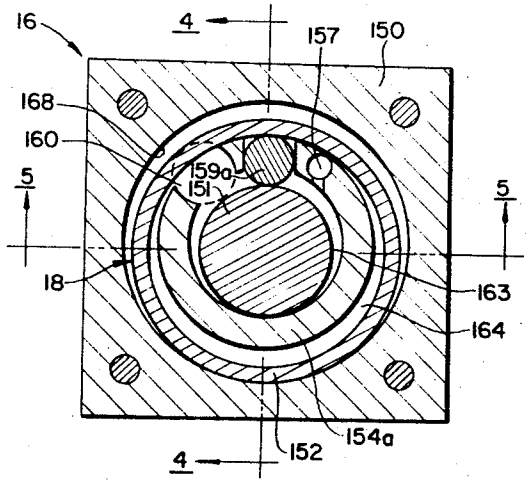


FIG. 3

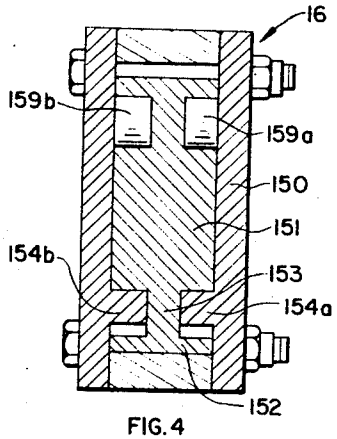


FIG. 4

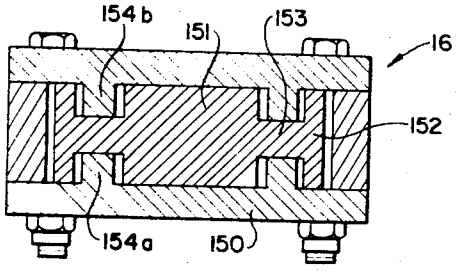


FIG. 5

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3,447,480

METHOD AND APPARATUS FOR GRAVITY FLOW CASTING UTILIZING SONIC ENERGIZATION

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Original application May 10, 1965, Ser. No. 454,335. Divided and this application July 24, 1967, Ser. No. 655,482

Int. Cl. B22d 27/08

U.S. Cl. 164—49

5 Claims

ABSTRACT OF THE DISCLOSURE

Molten material to be cast is poured into a mold having opposite open ends and a cooling jacket therearound to cause such material to solidify as it passes through the mold. The mold is sonically energized by means of an orbiting-mass oscillator which is operated at a frequency such as to cause resonant elastic vibration of such mold. The orbiting-mass oscillator adjusts its frequency and phase to maintain optimum resonant vibration of the mold with changes in the impedance of the material being cast as it solidifies, such high-level sonic energization freeing the sides of the casting from the mold and in addition stress-relieving the cast material to give it improved structural characteristics.

This application is a division of my application Serial No. 454,335 filed May 10, 1965, for Sonic Method and Apparatus for Facilitating Gravity Flow of Fluid Material.

This invention relates to gravity flow casting and more particularly to the use of sonic energy in the implementation of this type of casting.

Gravity flow casting in which liquid material is passed through a mold in a continuous flow-through process while it is transformed from a liquid to a solid state in the mold, is used quite frequently in the casting of metal members. In this type of casting process, liquid material is poured into one end of such an open-ended mold which has a cooling jacket surrounding it which causes the material to solidify as it is passed out the other open end of the mold.

In this type of molding of the prior art, the mold is generally held at an inclined angle so that the material passes through the mold at a slow enough rate so that it has an opportunity to reach the solidification point by the time it reaches the exit position. Several problems are encountered in gravity flow casting of the prior art. Firstly, the material often tends to adhere to the side of the mold, making it necessary to very accurately control the process to avoid such adhesion. Further, this adhesion tendency makes it difficult to make castings having intricate cross-sectional shapes. Further, in gravity flow casting of the prior art, gas and other impurities often become trapped in the casting as it goes from a liquid to a solid phase, which tends to detract from the structural integrity of the casting.

The technique and device of this invention eliminates the aforementioned shortcomings of the prior art, and additionally stress-relieves the cast material as it hardens, making for an end product having improved grain structure.

In carrying out the invention, the casting mold having the opposite ends thereof open is sonically energized by means of an oribting-mass oscillator. The oscillator is operated at a frequency such as to cause resonant elastic vibration of the mold and/or adjacent structure. The mold has a cooling jacket therearound which causes liquid material poured in at one end thereof to solidify as it is exited from the opposite end thereof. The high-level sonic resonant excitation of the mold provides high sonic activity at the interface between the walls of the mold and the casting material, thereby faciliating relative motion therebetween and freeing the casting from the mold. Sonic energy is also transferred to the material being cast, degassing such material to remove impurities therefrom and stress-relieving the material to give it an improved grain structure. An orbiting-mass oscillator is utilized in the device of the invention which automatically adjusts its frequency and phase with changes in the impedance characteristics of the casting as it goes from a liquid to a solid state, thereby assuring optimum resonant operation at all times.

It is therefore an object of this invention to provide an improved gravity flow casting technique.

It is a further object of this invention to improve the structural characteristics of castings made by gravity flow casting.

It is another object of this invention to provide means utilizing sonic energy for facilitating the movement of a casting through its mold in gravity flow casting.

Other objects of this invention will become apparent from the following description taken in connection with the accompanying drawings in which:

FIG. 1 is a cross-sectional view in elevation of a preferred embodiment of the device of the invention;

FIG. 2 is an elevational view in cross-section of an alternative means for coupling the oscillator to the mold of the preferred embodiment;

FIG. 3 is a cross-sectional view of an oscillator that may be utilized in the preferred embodiment of the device of the invention;

FIG. 4 is a cross-sectional view taken along the plane indicated by 4—4 in FIG. 3; and

FIG. 5 is a cross-sectional view taken along the plane indicated by 5—5 in FIG. 3.

Referring to FIG. 1, a preferred embodiment of the device of the invention in a gravity flow casting process is illustrated. The sonic energization provided by the device of the invention enables continuous flow in such a process, thus greatly speeding up the operation and obviating the necessity for the use of sand molds and the like in certain metal casting processes. Casting mold **40** has sonic oscillator **16** attached to the wall thereof. Sonic oscillator **16** may be of the pneumatic type, to be described in connection with FIGS. 3, 4 and 5. Molten casting material **42** is poured from hopper **43** into the mold. A water cooling jacket **44** is provided around the mold to cool the molten material to bring the molten material **42** to a solid state, in which condition it emerges from the bottom of cast **40** as a solid bar **47**. The molten material in its highly viscous state before it solidifies, would normally adhere to the side of cast **40** and would not easily flow therethrough. The sonic energy provided by oscillator **16**, which sets up resonant standing waves **50** in the walls of mold **40**, enables the desired continuous flow. Thus, the wetting effects encountered during the high viscosity phase of the molten material are minimized by virtue of the impedance mismatch at the interface between the molten material and the walls of the cast, which results in high sonic activity at this interface.

The flow rate of the molten mass **42** through the casting conduit **40** can be accurately controlled by varying the sonic output of oscillator **16**. Thus, if the material is moving too fast, the frequency of the oscillator can be changed slightly away from resonance to lower the sonic action, and vice versa. Variations in oscillator frequency can also be used to control the rate of solidification and cooling and the crystal structure formation of the end product. The sonic action on molten mass **42** vibrates the particles of this mass so as to maintain such particles in

an active fluid state. This provides better heat transfer so that there is uniform temperature throughout the mass.

In addition, the sonic vibration of the mass at it hardens stress-relieves the material. Both these factors make for a much better end product, having improved grain structure. The sonic action further tends to de-gas the material and otherwise remove impurities which are being formed as the material is setting up from liquid to solid phase. Other advantages afforded by virture of the mobility afforded to the casting by sonic action include the enabling of the casting of intricate cross-section shapes by a continuous casting process, the enabling of the addition of hgh-temperature material such as carbon to determine the lineal dimension of the cast parts, and the enabling of the operation of the mold at an inclined angle rather than vertically which makes for better elimination of gas.

It is to be noted that this device and technique may be utilized not only in the casting of metal but also in such other applications as the making of ice, the forming of plastic parts, the forming of concrete structures, and other processes involving a conversion from liquid to solid form.

The orbiting-mass oscillator **16** is ideally suited to this application in that it adjusts its output in accordance with changes in the characteristics of the casting, so as to maintain optimum resonant conditions of operation at all times. The fluid driven oscillator of FIGS. 3–5 has a particular advantage where working with high temperature processes in that the drive fluid acts to cool the oscillator.

Referring now to FIG. 2, an alternative means for coupling oscillator **16** to the wall of mold **40** is shown. In this embodiment, oscillator **16** is attached to resonant bar **51** which is fabricated of a material having high "Q" characteristics. Bar **51** is attached to the walls of mold **40** by means of attachment clamps **52**. The use of such a high-Q resonant bar will make for more efficient transfer of the sonic energy to the wall of the mold.

Referring now to FIGS. 3, 4 and 5, a preferred embodiment of the pneumatcally driven orbiting-mass oscillator wich may be utilized with the device of the invention is illustrated. This orbiting-mass oscillator has the unique characteristic of adjusting its frequency of operation with load changes, in effect locking in with a resonant load to maintain such resonant operating condition.

Mounted within case **150** is rotor member **18** which includes a central circular portion **151** and an outer circular portion **152** joined together by a web portion **153**. Extending inwardly from case **150** are a pair of C-shaped portions **154***a* and **154***b*. Pressurized air is fed through inlet port **157** to the interior of casing **150**. Disc-shaped members **159***a* and **159***b* are held between the ends of C-shaped portions **154***a* and **154***b*, respectively. Disc-shaped members **159***a* and **159***b* are held so that they are free to rotate and to move radially and at the same time provide a divider which prevents any significant amount of the inlet air from passing directly from one side thereof to the other. An air outlet is provided from the interior of casing **150** by means of outlet aperture **160**.

The air entering through inlet **157** enters crescent-shaped cavity portions **163** and **164** and tangentially drives both inner portion **151** and outer portion **152** of the rotor in a counterclockwise direction. Such counterclockwise rotation of the rotor on its axis results in a clockwise rolling of the rim of outer rotor portion **152** around the raceway formed by the inner wall **168** of casing **150**. In view of the eccentricity of the rotor in this rolling action, case **150** is vibrated in accordance with the rotor rotation frequency.

The oscillator just described is relatively simple and highly reliable in its operation and is capable of producing a high-amplitude sonic output which automatically locks in at the resonant vibration frequency of the load being driven.

The device and method of this invention thus provide sonic means for enhancing the gravity flow casting of

fluid material in which the adhesion of such material to the flow defining member is minimized. In addition, the sonic action improves the structure of the material and facilitates the forming process for same.

While the device and method of this invention have been described and illustrated in detail, it is to be clearly understood that this is by way of illustration and example only, the spirit and scope of this invention being limited only by the terms of the following claims.

I claim:

1. In a device for continuous casting of liquid material:
   - an open-ended mold having a first open end for receiving said material and a second open end opposite said first end for delivering said material;
   - means for cooling said mold to cause said material to solidify; and
   - orbiting-mass oscillator means attached to said mold for settng up resonant standing wave vibration thereof, said oscillator being adapted to automatically maintain resonant vibration of said mold with changes in the impedance characteristics of said material as it solidifies,
   - whereby said resonant vibration enhances the flow of said material through said mold and improves the formation of said material.

2. The device as recited in claim **1** wherein said means for cooling said mold comprises a water jacket surrounding the mold and means for circulating water through said jacket.

3. The device as recited in claim **1** wherein said orbiting-mass oscillator comprises a housing, a rotor mounted for eccentric rotation in said housing, and pneumatic drive means for rotatably driving said rotor.

4. The device as recited in claim **1** and additionally including a resonant bar, said orbiting-mass oscillator being attached to said resonant bar and means for attaching said resonant bar to said mold.

5. A method for the continuous casting of liquid material comprising:
   - pouring said material into one end of a vertically oriented mold, said mold being open at the opposite ends thereof;
   - cooling said material so as to cause it to solidify as it passes through the mold; and
   - while said material is being solidified, providing high-level sonic energy to said mold and said material by sonically elastically vibrating said mold at a resonant frequency by means of an orbiting-mass oscillator attached thereto.

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U.S. Cl. X.R.

164—83, 154, 260; 264—23, 70