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METHOD OF AND MEANS FOR MAKING CASTINGS

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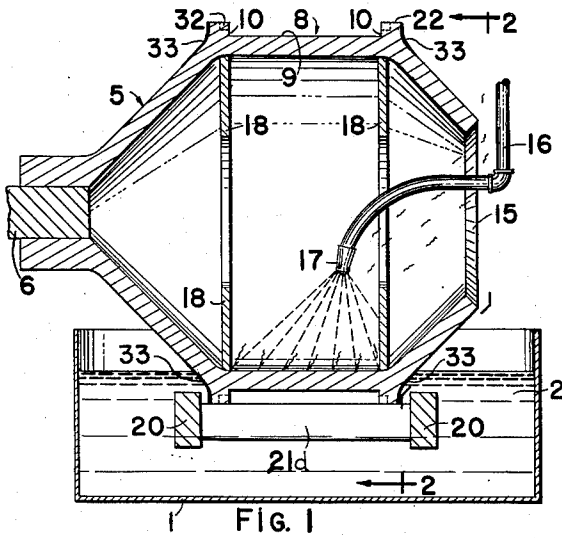


Fig. 1

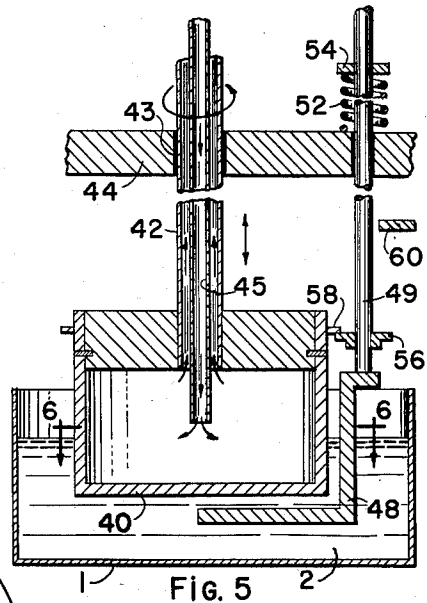


Fig. 5

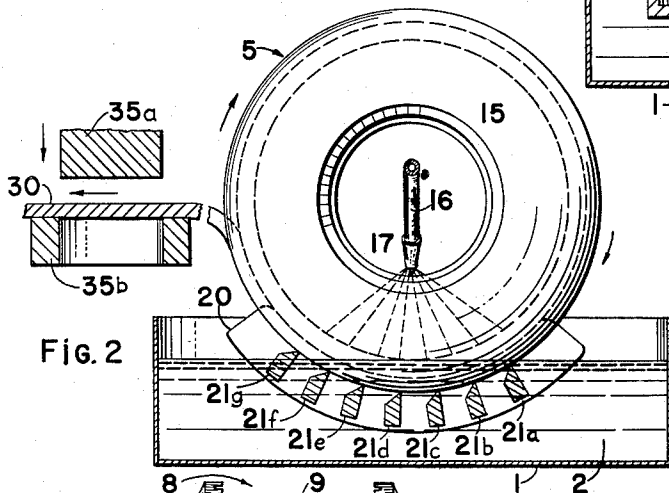


Fig. 2

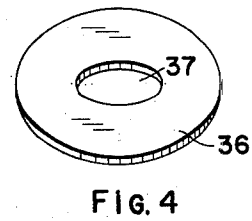


Fig. 4

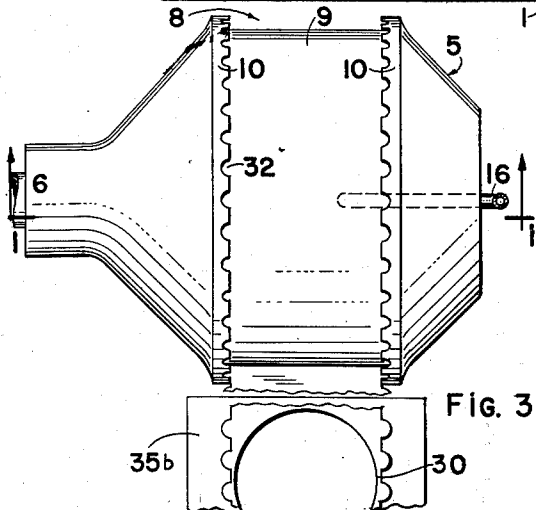


Fig. 3

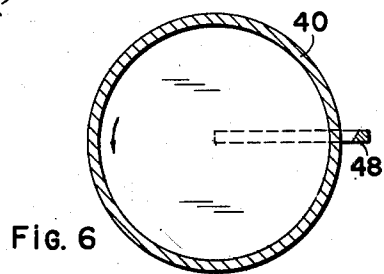


Fig. 6

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METHOD OF AND MEANS FOR MAKING CASTINGS

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This invention relates to an apparatus for and a method of making castings, particularly castings of the type wherein metal to be cast is built up on a cooled die surface until the metal reaches the desired thickness.

It is one of the objects of the present invention to provide a method of making a casting whereby a cooled die is immersed in a bath of liquid metal to be cast and the die is maintained cool so that the liquid metal solidifies along the cooled die surface and progressively increases in thickness as the cooling of the die is continued, until the desired thickness is reached.

It is a still further object of the present invention to provide a method of and means for making a metal casting by the progressive solidification of liquid metal in contact with a cooled die and wherein any excess solidified metal on any part of the casting is removed while the casting is still in contact with the mass of liquid metal.

It is a still further object of the present invention to provide a method of and means for making castings wherein the liquid metal is progressively solidified to form a casting and wherein solidified parts of the casting are machined to the required dimensions, or are shaped, while other parts of the casting are still being formed by the continuing solidification of liquid metal onto portions of the casting metal previously solidified.

It is a still further object of the present invention to provide a method of and a machine for making castings wherein machining or working operations are performed on a casting while the casting is immersed in a bath of the metal of which the casting was made.

It is a still further object of the present invention to provide a method of and means for making a casting wherein the solidified metal of the casting is displaced by physical action thereon while the solid casting metal being displaced is still within a bath of liquid metal of the same composition as the metal of the casting.

The attainment of the above and further objects of the invention will be apparent from the following specification taken in conjunction with the accompanying drawings forming a part thereof.

In the drawings:

Fig. 1 is a longitudinal section showing, diagrammatically, apparatus for carrying out the present invention as a continuous process for making slugs or the like;

Fig. 2 is a diagrammatic section taken along the line 2—2 of Fig. 1 and looking in the direction of the arrows;

Fig. 3 is a top plan view of the apparatus shown in Fig. 1;

Fig. 4 is a perspective view of a slug made by the apparatus of Fig. 1;

Fig. 5 is a fragmentary view showing a modification of the present invention; and

Fig. 6 is a fragmentary sectional view taken along the line 6—6 of Fig. 5.

Reference may now be had more particularly to the

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drawings wherein like reference numerals designate like parts throughout.

In Fig. 1 there is shown at 1, diagrammatically, the crucible of a metal melting furnace of known construction. Suitable means, such as, for instance, gas flames, heat the crucible either to melt the metal therein or to maintain it in its molten state, as the case may be. The bath of liquid metal is indicated at 2. The metal in this case is aluminum or any aluminum alloy. Above the crucible there is mounted a hollow die or mold 5 that is secured to and carried by an axially rotatable shaft 6 that is motor driven at a fixed speed determined by the operator or the setting of the equipment. The die or mold, in this instance, is shaped for making strip material and includes a peripherally extending, outwardly facing cavity 8 defined by the outer surfaces of a wall 9, and a pair of flanges 10—10 that extend from the wall 9 a distance equal to the height or thickness of the material to be cast and are spaced apart a distance equal to the width of the material to be cast. The mold has a side opening 15 into which a cooling medium is injected. In this instance, the cooling medium consists of a spray of water that enters the mold through a pipe 16 carrying a suitable spray nozzle 17 at the end thereof. The water is introduced as a spray against the surfaces to be cooled and leaves the interior of the mold, through the opening 15, as steam or vapor. It is within the purview of the present invention to use means other than water for cooling the die, for instance, a blast of air. The die is adapted to be raised or lowered so that the bottom of the die may be immersed below the liquid level of the bath 2.

The portion of the die or mold 5 that dips within the liquid metal 2 during the rotation of the mold, but excluding the mold cavity 8 and the surfaces 22—22, are coated with a heat insulating refractory material 33 to prevent solidification of liquid metal onto those surfaces. Any suitable heat insulating refractory material may be used. For instance, this coating may consist of an asbestos fiber that is impregnated with a binder consisting of a blackstrap molasses such as is used in the making of molding cores in the metal casting industry. Any other suitable heat insulating refractory material may be used. The inner surfaces of those walls that do not form the mold cavity are not as effectively cooled as the adjacent surfaces of the walls of the mold cavity, due to the presence of annular disks 18—18 on the inside of the mold or die 5.

Within the crucible 1 and submerged within the molten liquid there is mounted a die-supporting frame 20 carrying a number of cutting tools or dies 21a, 21b, 21c, 21d, 21e, 21f and 21g. The die-supporting frame and the cutting tools are made of material which is inert with the liquid metal in which they are submerged. A suitable material is tungsten carbide. The tools 21 scrape against the surfaces 22 at the periphery of the flanges 10—10.

The die 5 is immersed in the liquid metal 2 and is slowly rotated by the shaft 6. At the same time, the interior of the die is being cooled. The liquid metal 2 is maintained 50 to 100° F. above its melting temperature. Metal from the bath 2 solidifies on the die due to the fact that the die is being cooled. As the die turns, the cutting tools 21a through 21g cut away any metal of the bath 2 that has solidified on the mold at the portions thereof immersed in the bath of liquid metal, except at the wall portions 9 and 10 that constitute the mold cavity 8. Metal from the bath 2 therefore continues to solidify in the mold cavity 8 until the thickness of the material built up in the mold cavity brings it beyond the height of the side walls or flanges 10. When this occurs, then, as the die or mold 5 continues to rotate

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to bring the built up portion of the solidified metal to the next cutting tool 21, that cutting tool cuts away the excess solidified molded metal, leaving the thickness of the solidified metal on the mold 5 equal to the height of the flange 10. As the die or mold 5 continues to turn in the bath of liquid metal 2, there will be further solidification of liquid metal onto the previously solidified metal in the mold cavity 8, which additional solidified metal is cut off by the next tool 21. This further solidification that occurs on a surface at which a cut has been taken by one of the tools 21a-21f does not result in a welding or chemical union of the further solidified metal with the previously solidified metal. Therefore, the subsequent cutting action is a comparatively easy action. The rate of rotation of the shaft 6 is such as to allow enough time for the metal to build up to the full thickness of the mold cavity 8 as the die 5 turns from a position where a portion on the periphery thereof first enters the liquid, until that point reaches the cutting tool 21e or 21f. The subsequent cutting tools and the last cutting tool 21g which is either at or slightly above the top level of the liquid in the crucible 1, provide a margin of safety to assure that the necessary thickness of the casting has been attained, and they cut away the excess that may be built up on the previously cut surface on the casting in the die cavity 8.

A strip of material cast is indicated at 30. This strip moves in a direction to the left as seen in Fig. 2. In order to prevent pulling of the strip through the die 5, one or both of the flanges 10 is provided with a series of spaced apart short notches 32 each of which forms a short projection or nib at the edge of the strip 30. These nibs interlock with the die and prevent pulling the strip 30 through the die at a rate faster than that determined by the rotation of the shaft 6.

If the end product desired is a slug, slugs may be stamped from the strip 30. This is accomplished by moving the strip 30 through stamping punch sets 35a-35b which, in this instance, stamp out circular slugs 36 each having a central opening 37.

In Figs. 5 and 6 there is shown, in diagrammatic form, a machine embodying the principles of the present invention applied to the casting of individual cup-shaped objects as intermittent operations instead of continuous operations. In this instance, a die 40 is mounted at the lower end of a rotatable tube or quill 42 that extends through a bearing 43 in a stationary structure 44, the quill or tube 42 being axially rotatable and also longitudinally movable. Within the tube 42 there is a tube 45. Cooling water is circulated through the die, flowing downwardly through the tube 45, thence into the die 40 and out again through the space between the tube 45 and the tube 42. An L-shaped cutting tool or die 48, of tungsten carbide or any other suitable cutting material that is not affected by the liquid aluminum 2 in the crucible 1 is provided. The tool 48 has a vertical cutting edge and a radially extending longitudinal cutting edge a fixed distance below the die 40 and is supported on a non-rotatable rod 49 that is guided for longitudinal movement by a bearing in the stationary structure 44 and by a suitable upper guide, not shown, so that the rod is always maintained vertical and in parallelism with the center of the quill or tube 42. The rod 49 is supported by a spring 52, the lower end of which rests on the stationary structure 44 and the upper end of which bears against a collar 54 that is locked to the rod 49. Adjacent to its lower end the rod 49 has a collar 56 secured thereto which collar is engaged by a ring collar 58 in the form of a disk secured to the die 40.

When the rotating die 40 moves from its casting position illustrated in Fig. 5 to its upper position, the upward movement of the collar 58 thereon permits the rod 49 to be moved upwardly by the spring 52 and thereby to raise the cutting tool 48, that tool following the upward movement of the die 40 until that tool is above the level of the

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liquid 2 in the crucible 1. At that time the collar 56 engages a stationary stop 60 that limits further upward movement of the rod 49. The die 40 continues to move upwardly, carrying with it the casting that has been formed thereon during its previous immersion in the liquid 2, as will be presently explained, to a point where the rotation of the die is stopped and the casting is thereafter stripped from the die 40 and is carried away on a chute or the like. The chute may be moved into position between the bottom of the die 40 and the crucible when the die has been raised to a sufficient height. After the casting has been stripped from the die 40 the die is lowered and the rotation thereof is resumed. As soon as the collar 58 reaches a position below that of the stop 60 it engages the collar 56 on the rod 49 and pushes it downwardly, so that continued descent of the rotating die 40 carries with it the cutting tool 48, which is not rotating. The cutting tool 48 is thus maintained at a fixed distance from the die 40. At the same time, cooling water is being circulated through the die 40 to keep the bottom and lower peripheral wall of the die cool. When the die enters the liquid metal 2, solidification immediately commences along the water cooled surface of the die. The die is rotated at a considerable speed but below the speed at which centrifugal force would have any considerable effect on the metal formed thereon. When any part of the periphery or the base of the metal that has solidified around the die 40 reaches a thickness such that it engages the tool 48, a machining operation commences whereby the tool 48 machines away any excess metal that has been formed. Those parts of the casting that have not yet been built up to the desired thickness are not engaged by the die 48 so that the building up of metal on those parts continues. After the metal has been formed around the die 40, the entire structure is elevated in the manner hereinabove set forth, and the rotation of the die stopped, and the casting at the bottom of the die is stripped therefrom as above set forth.

While I have herein shown a structure wherein the casting is of a cylindrical shape, it is, of course, within the purview of the present invention to make the casting of the machine of Fig. 5 of any other shape which is a surface of revolution, in which event the die and the cutting tool 48 would be of corresponding shapes.

When solid metal is formed by the progressive solidification of liquid metal, each particle of liquid metal unites with the subjacent already solidified metal only of the subjacent solidified metal is of the same temperature as that of the liquid metal solidifying thereon. When the solid metal which is in contact with the liquid metal is of a temperature less than that of the solidifying liquid metal the liquid metal will not unite integrally with the metal around which it is solidifying but will merely adhere thereto. This principle is utilized in the present invention. When the liquid metal first solidifies in contact with the cold die it does not unite with the die but it does form a layer of metal thereon. This solidified metal is of exactly the same temperature as that of the liquid metal at the interface between the two. Thereafter, as heat is continuously extracted from the interface, by the action of the cooling water within the die, each particle of metal giving up its latent heat of fusion is at the same temperature as the temperature of the interface between the solid and liquid metal, and therefore complete union of the metal being built up takes place. Once a cut is made into the built up metal by the tools 21 of Fig. 1 or the tool 48 of Fig. 5, the interface between the liquid metal and solid metal of the casting is removed, leaving a new interface that is at a temperature slightly below the temperature of the former interface, therefore, slightly below the temperature of the liquid metal. That newly cut surface of the solid metal within the liquid metal will now extract heat from the liquid metal in contact therewith to cause solidification of that liquid

metal. However, this initial solidification on that surface is a solidification of liquid metal onto cooler metal and therefore there is no union between the two. As a result, in the next cutting operation by a subsequent cutting tool 21b through 21g of Fig. 1 or by the subsequent revolution of the die in Fig. 5, the force required to remove that subsequently solidified metal is very small.

I have herein shown the principles of the present invention as applied to the machining of simple forms during the process of molding of the same. It is, however, to be understood that the principles of the present invention are equally applicable to mold complicated forms within the teachings of the present invention.

In compliance with the requirements of the patent statutes I have here shown and described a preferred embodiment of my invention. It is, however, to be understood that the invention is not limited to the precise construction here shown, the same being merely illustrative of the principles of the invention. What I consider new and desire to secure by Letters Patent is:

1. The method of making a metal casting which comprises placing a die into a bath of liquid metal to be cast, cooling the die so that the liquid metal solidifies at the wall of the die, and while the die is in the bath of liquid metal cutting away the excess metal from the solidified metal on the wall of the die below the top surface of the metal in the bath, and thereby reducing the temperature of the interface between the cut metal and the liquid metal.

2. The method of making a metal casting which comprises placing a die into a bath of liquid metal to be cast, cooling the die so that the liquid metal solidifies at the wall of the die, and while the die is in the bath of liquid metal cutting away in small successive increments the excess metal from the solidified metal on the wall of the die at the places in the bath where the metal has solidified to an excessive thickness while at the same time maintaining the die in the liquid metal and continuing the solidification of liquid metal onto the casting.

3. The method of casting metal which comprises moving a die in a bath of liquid metal, cooling the die so that the liquid metal solidifies at its contact with the die and the solidified mass moves with the die and continues to build up in thickness, and removing excess solidified material from the mass in the bath in small successive increments at an excessively solidified part thereof as the mass is moving in the bath of liquid metal.

4. The method which comprises mechanically shaping a metal body by the physical cutting away of solid metal thereof while the portion of the body being cut is in a bath of liquid metal of the composition of the body.

5. The method which comprises mechanically shaping a metal body by the physical cutting away of solid metal thereof while the portion being cut is in a bath of liquid metal of the composition of the body, and at the same time cooling the body to cause metal of the bath to solidify on the body.

6. Metal casting apparatus comprising means for holding a supply of liquid metal to be cast, a mold immersed in said means with a portion of the mold extending into the liquid metal in said means, means for cooling the mold to cause solidification of metal on the portion of the mold immersed in the liquid metal, and means in the supply of liquid metal for cutting away excess metal from the metal that has solidified on the mold wall while the mold wall is immersed in the liquid metal.

7. Metal casting apparatus comprising means for holding a supply of liquid metal to be cast, a mold immersed in said means with a portion of the mold extending into the liquid metal in said means, means for cooling the mold to cause solidification of metal on the portion of the mold immersed in the liquid metal, means for rotating the mold and maintaining the same part of the mold

continuously immersed in the liquid metal while solidification of liquid metal is taking place on the mold, and means for machining away excess solidified metal during said rotation.

8. Metal casting apparatus comprising means for holding a supply of liquid metal to be cast, a mold immersed in said means with a portion of the mold extending into the liquid metal in said means, means for cooling the mold to cause solidification of metal on the portion of the mold immersed in the liquid metal, means for rotating the mold and maintaining the same part of the mold continuously immersed in the liquid metal while solidification of liquid metal is taking place on the mold, and means for machining away excess solidified metal during said rotation, said metal machining means being also immersed in the liquid metal being cast.

9. The method which comprises mechanically shaping a metal body by the physical cutting away of solid metal thereof while the portion of the body being cut is in a bath of liquid metal of the composition of the body and is being subjected to cooling action to cause metal of the bath to solidify on the body so that there is a temperature gradient between the bath of liquid metal and the surface of the metal body exposed at the place of cutting at the instant of cutting, and thereafter removing any of the metal of the bath that solidifies on the previously cut-away portion of the body all while the body is at a temperature approaching the melting point of the metal.

10. The method of making a metal casting which comprises maintaining a die in contact with liquid metal to be cast, cooling the die so that the liquid metal solidifies at the wall of the die and the solidified metal is continuously built up as to thickness, and while the thickness of the solidified metal is being built up continuously and repeatedly gauging successively different parts thereof as to the thickness of the solidified metal beyond the desired thickness and removing the excess thickness if any all while continuing the solidification of metal at the remainder of the die in contact with the liquid metal, and repeatedly gauging at the same places on the solidified metal while maintaining each place that is gauged continuously in contact with the liquid metal between successive gauging.

11. The method of making a metal casting which comprises moving a die in a bath of liquid metal and maintaining the die cooled so that the metal solidifies on the surface of the die and while the die is in the bath of liquid metal repeatedly severing in the metal bath excess solidified metal from the surface of the solidified metal mass formed on the die.

12. The method of producing a metal casting which comprises progressively solidifying liquid metal by its contact with a cooled mold and while the progressive solidification of the metal is still taking place severing solidified metal from liquid surface of the casting where the metal has solidified beyond its desired thickness while the surface where the severance is taking place is in contact with the liquid metal, and after a time interval repeating the same severing operation of solid metal at the same place where metal was previously severed from the casting while maintaining the metal surface immersed in the liquid metal between successive severing operations.

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