# United States Patent

[11] 3,589,199


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[21] Appl. No. **12,802**
[22] Filed **Feb. 19, 1970**
[45] Patented **June 29, 1971**
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[54] **VACUUM SAMPLER WITH POROUS MOLD INSERT**
**4 Claims, 1 Drawing Fig.**


[52] **U.S. Cl.** ..... **73/425.6,** 164/255
[51] **Int. Cl.** ..... **G01n 1/14**
[50] **Field of Search** ..... 73/421; 164/4, 255, 111



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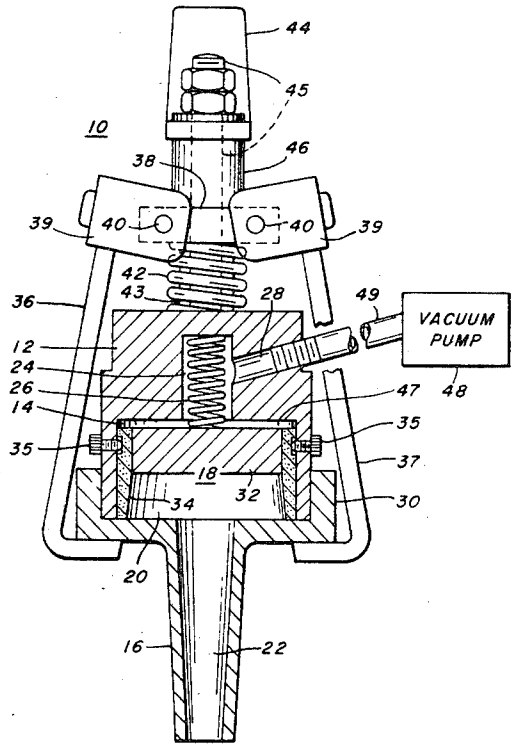
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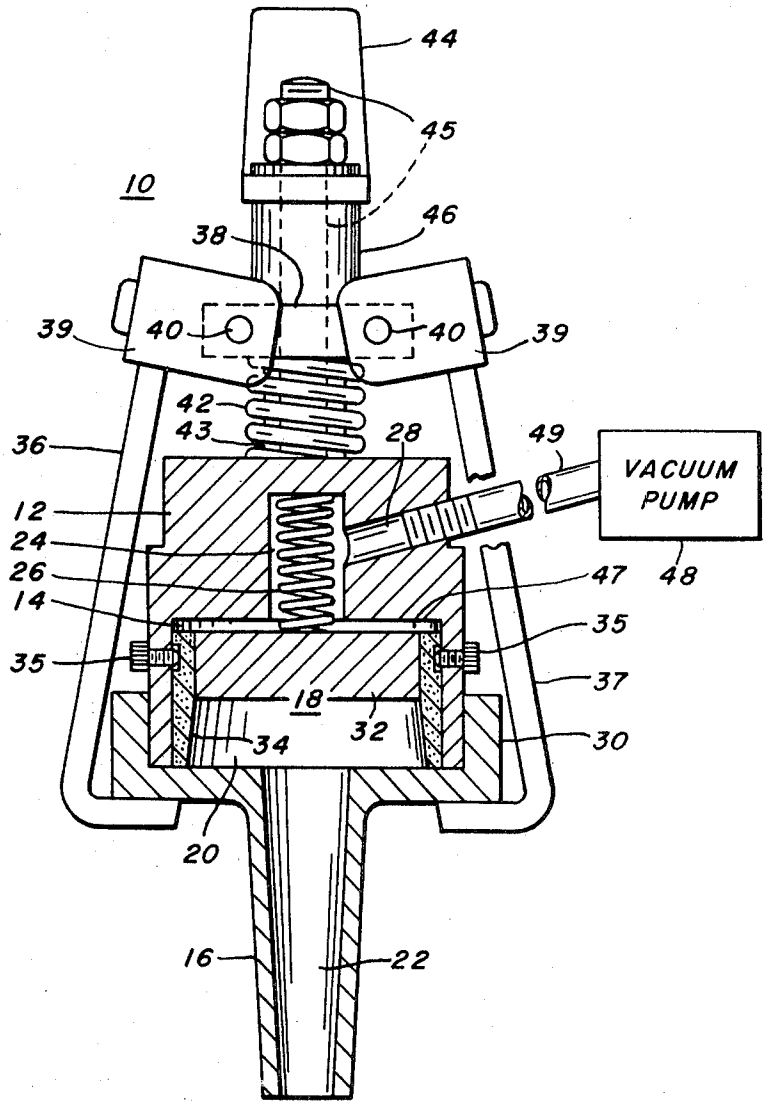


**ABSTRACT:** Apparatus for casting molten metal, particularly for sampling purposes, the apparatus including a mold housing having a hollow space therein, and a mold entrance portion, removably attached to the housing so as to close the space therein except for an opening in the entrance portion. A porous mold insert is disposed within the housing space, the insert having a cavity therein facing the mold entrance portion for receiving and holding a casting or sample of molten metal therein. A vacuum means is attached to the housing for drawing air from the cavity through the pores of the insert to draw molten metal into the cavity when the entrance portion is disposed in fluid communication with a source of molten metal.

PATENTED JUN 29 1971

3,589,199




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# VACUUM SAMPLER WITH POROUS MOLD INSERT

## BACKGROUND OF THE INVENTION

The present invention relates generally to vacuum casting devices, and particularly to a simple, inexpensive device for casting metal, particularly samples or small shapes, without the problems encountered in prior art devices and apparatus presently to be explained.

In the art of producing metal, it is desirable and necessary to cast samples of the initial molten metal product for the purpose of determining the composition of the metal by spectrochemical analysis of the samples. The results of the analysis are then used to control the composition of the molten metal source, i.e. the bath of the metal from which the samples were taken. Spectrochemical analysis involves the use of an electric discharge between the tip of a shaped graphite electrode and a flat surface of the sample, the discharge providing radiant energy, the spectra of which are analyzed to determine the composition of the sample. The discharge penetrates a small distance into the sample so that it is important to have minimum segregation of components within the sample so as not to obscure the results of the analysis.

Heretofore, in casting samples of molten metal, a hand sampling ladle has been used to dip each sample from an open molten metal source and to transfer the sample to a chill sample mold, or, if the ladle itself is a chill sample mold, to a location where the sample is allowed to cool and solidify. Such a sampling operation has certain obvious drawbacks, namely the operation is slow and the cup of the ladle catches dross and impurity inclusions floating on the surface of the molten metal when it is removed from the metal. Such dross and inclusions result in a contaminated, low quality sample which may not be compositionally indicative of the molten metal source. The slowness of the process allows for substantial heat loss which results in the further problem of premature cooling of the sample in the sampling ladle. With the delay and premature cooling, components in the sample tend to settle out and solidify to form a skull in the ladle, the substance finally delivered to the chill sample mold being, in some instances, something other than the source of molten metal from which the sample was taken. Thus, the results of analytical tests conducted on such samples may not be accurate for purposes of controlling the composition of the source of the molten metal.

Sampling devices using a vacuum to draw molten metal into a chill mold have become known, and have certain advantages over the hand ladle. These devices, however, have disadvantages of their own. Generally, prior art vacuum sampling devices have used a solid steel mold body having an internal cavity for receiving a sample of molten metal, and various channels and vents communicating with the cavity to evacuate the same. With the creation of a vacuum and the drawing of the metal into the cavity, the metal enters and solidifies in the channels and vents as well as in the cavity, the portions of the metal in the channels and vents forming integral extensions of the metal sample which make it difficult to remove the sample from the mold. These integral extensions, hereinafter termed "flash," further, must be machined off or otherwise removed from the body of the sample in order to provide flat, planar surfaces necessary for spectrochemical analysis. In addition, the flash tends to accumulate in the channels and vents to the extent that they may become completely clogged by the flash thereby rendering the mold useless until the flash is removed from the channels and vents.

A further disadvantage with this older type of vacuum casting and sampling device is the complexity of the mold which, in turn, makes the mold a costly device. The channels and vents must be drilled, machined or otherwise provided in the mold, such manufacturing processes adding substantially to the cost of the mold.

A fairly typical prior art device is shown in Russian Pat. No. 159,060, wherein air is removed from a mold cavity by vacuum producing means connected to the cavity through a channel in the mold. The channel extends to the bottom surface of mold which is covered by an entrance lid having a roughened surface facing the bottom surface of the mold. The rough surface forms a clearance between the two surfaces, the clearance allowing fluid communication between the evacuating channel and the mold cavity. This clearance would, in all probability allow metal flash to form adjacent the base of the sample as the metal would tend to follow the vacuum towards the channel. Further, in the Russian design, the vacuum is drawn only from the bottom of the cavity thereby tending to create a nonuniform flow of air from the cavity as the metal entering therein would tend to trap air and other gases within the cavity. Such trapped air and gases tend to segregate the compositional elements of the molten metal as well as producing a porous casting. Again, such compositional segregation and porosity would obscure the results of spectrochemical analysis thereby rendering control of the molten metal, based on such analysis, very difficult.



## BRIEF SUMMARY OF THE INVENTION

The present invention provides a vacuum casting and sampling device in which a porous insert having a mold cavity is located within a mold housing. The cavity faces a tip entrance portion through which the molten metal is drawn, the tip portion being removably attached to the mold housing. The porous insert has smooth external and internal surfaces (the internal surfaces defining the cavity), and the bottom surface of the cavity seats tightly against the tip portion (and about an entrance opening therein) when the device is properly assembled. The cavity is evacuated, and molten metal drawn into the cavity, by withdrawing air and other gases from the top and walls of the cavity through the pores of the insert. When the casting or sample solidifies, the tip is removed and the sample easily withdrawn, there being no vents, channels or grooves in the porous insert into which the metal can flow. The pores of the insert are of a size that will not permit the flow of metal into the pores and thereby clog the same, yet the pores are sufficient to allow an ample flow of air therethrough to permit rapid and uniform evacuation of the cavity. Since the flow of air from the mold cavity is uniform and from the side and top portions thereof (i.e. with little or no trapping of air), segregation of components and the production of pores within the sample is reduced to minimal proportions.

## THE DRAWINGS

The invention, along with its advantages and objectives, will become more apparent from the following detailed description when read in connection with the accompanying drawing in which the sole FIGURE shows a vertical section (with portions in elevation) of a vacuum casting and sampling device constructed in accordance with the principles of the invention. A mechanism for clamping the parts of the device together is shown in elevation.

## PREFERRED EMBODIMENT

Specifically, the FIGURE shows a vertical section of a vacuum casting and sampling device of the invention, the device being generally designated by the numeral **10**. The device comprises essentially, an outer mold housing **12** having an outer cylindrical contour (preferably) and an internal hollow space **14**, a mold entrance tip **16** closing the hollow space, and a porous insert **18** disposed within the hollow space. The insert has a cavity **20** facing the entrance tip, and is closed off by the tip except for an entrance opening **22** in the tip.

The housing **12** is solid structure except for the hollow space **14**, a cavity **24** accommodating a coil spring **26** and an opening **28** connecting the inner portions of the housing to the outside thereof. The housing is preferably made of steel though other metals and substances may be used that can withstand and conduct away the heat of molten metal drawn into the housing.

The mold tip 16 is preferably a stainless steel structure having an upper circular flange portion 30 engaging the lower periphery and bottom surface of the housing 12. As seen in the FIGURE, the tip is an elongated structure extending downwardly from the flange portion so that the entrance opening 22 is essentially an elongated (and tapered) bore extending between the cavity 20 of the insert to the lower end of the tip.

The porous insert 18, as shown in the FIGURE, is a composite structure consisting of a solid impervious center or base portion 32 made of a metal of high heat conductivity, copper for example, and an outer tubular wall structure 34 made of porous material such as Grade 61 (30 microns) porous bronze, though other powdered or porous materials may be used. The insert could be, for example, a unitary, porous graphite structure, though the composite insert depicted in the FIGURE has several advantages thereover as will be more apparent from the operation of the mold and insert as explained hereinafter. The portion of the tubular wall below the base 32 is tapered to provide the cavity with an expanding dimension towards the entrance tip 16. The base and wall portions of the insert are bonded together to provide a unitary insert for easy disposal in and removal from the mold space 14. The insert may be fabricated by molding bronze powder of a controlled porosity around a copper disc and sintering or heating the insert at a temperature at which the porous bronze metallurgically bonds with the copper disc forming a one piece insert.

To retain the insert 18 within the hollow of the mold housing 12 when the tip 16 and housing are separated, setscrews 35 are provided which extend through corresponding threaded holes in the sidewall of the housing to engage insert 18 within recesses in the periphery of the insert as shown in the FIGURE. In the FIGURE, only two such screws are shown; additional screws can be used as desired and needed. The diameters of the setscrews are somewhat smaller than the diameters of the recesses in the periphery of the insert, allowing the insert to float a fixed amount. When the mold is assembled, the setscrews are positioned to lightly engage the insert so that at the urging of the spring 26, the bottom surface of the insert seats against the upper wall surface of the tip. In this manner, the possibility of a flash forming space between the edge of the insert wall 34 and the tip is substantially eliminated. The mold tip 16 may be secured to and released from the bottom of the mold housing 12 by any suitable means, the clamping mechanism shown in the FIGURE being given by way of example only. The mechanism shown includes two L-shaped clamping arms 36 and 37, the lower ends of which engage the underside of the tip while the upper ends of the arms are pivotally connected to a plate 38 by arm supports 39 and pins 40 located above the mold housing. The plate rests on the upper end of a coil spring 42, the lower end of the spring engaging the top of the mold housing and disposed around an integral extension 43 of the housing protruding into the bore of the spring. With the lower ends of the arms engaging the underside of the mold tip 16 as shown in the FIGURE, the spring is in compression, the spring forcing the housing and the tip together. Above the plate 38 is a lever-handle 44 operable to release the clamping arms in a manner explained hereinafter. The lever is attached to the plate by a bolt 45 extending between the plate and lever, and through a sleeve 46 located between the plate and lever. Two nuts are shown threaded on the upper end of the bolt to secure the plate, the sleeve and the lever together.

The simplicity of the housing and mold components can be appreciated from the view of the device 10 shown in the FIGURE. Further, the components are easily assembled and disassembled. The mold insert 18 is simply placed within the hollow space 14 of the mold housing 12, and the entrance tip 16 disposed against the bottom of the housing after the clamping arms moved out of the way. The arms are moved by depressing the lever-handle 44 down against the plate 38 and the force of the spring 42. The plate moves down against the spring to move the arm support structures 39 about pivot pins 40, allowing the outer portions of the structures to swing in an upward direction which swings the arms outwardly from the mold housing. With the tip in place against the bottom of the housing, the lever-handle is released to allow the arms to swing inwardly, the L-portion of each arm moving beneath the flange 30 of the tip to secure the tip and housing tightly together. The tip, in turn, forces the insert against the force of the spring 26, the spring forcing the insert in a downward direction to maintain the bottom edge of porous wall 34 of the insert flush with the bottom edge of the housing 12 and against the upper surface of the entrance tip. As shown in the FIGURE, the height of the insert is slightly less than the depth of the hollow 14 to provide a space 47 between the upper surface of the insert and the upper wall of the housing.

To provide a vacuum within the cavity 20, and thereby draw molten metal from a source or bath thereof (not shown), a source of vacuum is provided as indicated diagrammatically in the FIGURE by a vacuum pump 48. The pump is preferably a lightweight, portable unit, so that with the sampling device 10, it can be carried about to make samplings from a plurality of molten metal sources, for example, as would be found in an ingot plant furnace room employed in the production of aluminum ingot, though the invention is not limited to sampling or casting only molten aluminum.

The vacuum pump 48 is connected in fluid communication with the cavity 20 by a suitable conduit 49, a stainless steel pipe for example, having a threaded end portion for threading into a corresponding threaded portion provided in the opening 28 of the housing 12. For purposes of illustration and in order to limit the number of views of the sample casting device 10, the opening 28 and the conduit 49 are shown in the FIGURE on the same side of the mold housing as the clamping arm 37. In actual practice, however, the arm and conduit-opening are displaced by approximately 90° so that one structure does not interfere with the other. For this reason, the arm 37 is shown broken away adjacent the conduit 49.

The operation of the device 10 is as follows. The assembled device, as shown in the FIGURE, is taken to the location of a bath of molten metal. The entrance tip 16 is disposed in the bath a distance below the top level thereof, and the vacuum pump 48 operated to evacuate the cavity 20 of the insert 18. The air within the cavity is withdrawn upwardly through the pores of the wall 34 of the insert, through the space 47 between the insert and the upper wall of the mold, through the spring cavity 24 and through the opening 28 in the housing to the pipe 49 and the vacuum pump.

With the evacuation of the cavity 20, the molten metal in the bath is drawn up through the bore 22 in the tip 16 and into the cavity. When the cavity is filled, the pump 48 is turned off and the tip removed from the bath.

The metal of the mold housing and tip, and the solid center piece 32 of the insert function to quickly chill the molten metal in the cavity 20 to form a solid casting ready for analytical test purposes. Further, the solid center 32 of the insert, being made of a high heat conductivity metal such as copper, freezes the casting in a substantially uniform manner which minimizes segregation of the elements in the casting. And since the air is withdrawn from above the molten metal as it enters the cavity, air and other gases within the cavity are not trapped therein by the metal thereby providing a porous free, solid sample casting.

When the molten metal within the cavity 20 solidifies to form the casting, the casting is easily removed from the cavity by separating the entrance tip 16 from the housing 12 after the clamping arms 36, 37 are spread apart by the lever-handle 44. The setscrews 35 hold the insert 18 within the hollow of the mold housing while the taper of wall 34 allows the casting to be easily slipped from the insert.

As can be readily appreciated, the casting has the smooth, simple form of the cavity 20 without the flash portions associated with prior art sampling devices, the structure of the present invention having no openings or grooves communicating with the cavity for the molten metal to enter when the

structure is evacuated. The pores in the wall **34** of the insert are sufficient to pass air and other gases without the molten metal entering the pores to solidify and clog the same. In this manner, the porous insert of the invention can be used many times to cast molten metal without the necessity to clean the mold as is the case with prior art devices. Thus, the mold of the present invention provides economies in maintenance not found in the prior art.

The invention has been described with primary reference to sample castings for analysis purposes in order to control, on the basis of the analyses, the composition of the molten metal from which the sample was taken. The principles of the invention, however, can be used to make castings other than for sample purposes.

It should now be apparent from the foregoing description that new and useful casting apparatus has been disclosed which produces a solid casting particularly suitable for test analysis purposes, the apparatus including a porous mold insert through which the mold is evacuated without the use of evacuating channels into which molten metal can flow. Such a structure provides for easy removal of the casting from the mold, the casting produced has smooth, planar surfaces necessary for point-to-plane spectrochemical analysis, with minimum segregation of compositional elements within the sample. In addition, the apparatus is economical to maintain and make since the components have smooth, simple configurations requiring a minimum of manufacturing effort.

Though the invention has been described with a certain degree of particularity, changes may be made therein without departing from the spirit and scope thereof.

What I claim is:

**1.** A device for casting molten metal comprising

a mold housing having a hollow space therein,

a mold end portion having an entrance opening for disposal in fluid communication with a source of molten metal, said end portion being removably attached to said housing so as to close said hollow space except for the entrance opening,

a unitary porous mold insert disposed within said hollow space, and having a cavity therein facing the mold entrance for receiving and holding molten metal, said insert comprising an outer tubular wall structure of porous metal and a base of solid, impervious metal of high thermal conductivity metallurgically bonded within said tubular wall structure, and

means for drawing air from said cavity through said porous insert to provide a vacuum in the cavity and thereby draw molten metal into said cavity when said mold end portion is disposed in fluid communication with a source of the molten metal,

said housing, mold end portion and insert being effective to chill the molten metal drawn into the cavity to provide a solidified casting of the metal.

**2.** The device of claim **1** in which the metal of the solid base is copper.

**3.** Apparatus for sampling molten metal comprising

a mold housing having a hollow space therein,

a mold entrance tip adapted for disposal into a bath of molten metal, and being removably attached to said housing so as to close said hollow space except for an opening in the tip,

a unitary porous mold insert disposed within said space, and having a cavity therein facing the mold entrance tip for receiving and holding a sample of molten metal, said insert comprising an outer tubular wall structure of porous metal and a base of solid, impervious metal of high thermal conductivity metallurgically bonded within said tubular wall structure, and

means for drawing air from said cavity through said porous insert to provide a vacuum in said cavity and thereby draw molten metal into said cavity when said mold tip is disposed in a bath of molten metal,

said housing, porous insert and mold entrance tip being effective to chill the molten metal drawn into said cavity to provide a solidified sample of the metal

**4.** The apparatus of claim **3** in which the solid base of metal is copper.