

[54] IMMERSION SAMPLER FOR MOLTEN MATERIAL

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Related U.S. Application Data

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[51] Int. Cl. G01n 1/12

[58] Field of Search 73/425.4, DIG. 9; 164/4

[56] **References Cited**

UNITED STATES PATENTS

3,646,816 3/1972 Hance 73/425.4

FOREIGN PATENTS OR APPLICATIONS

1,235,306 6/1971 United Kingdom 73/DIG. 9

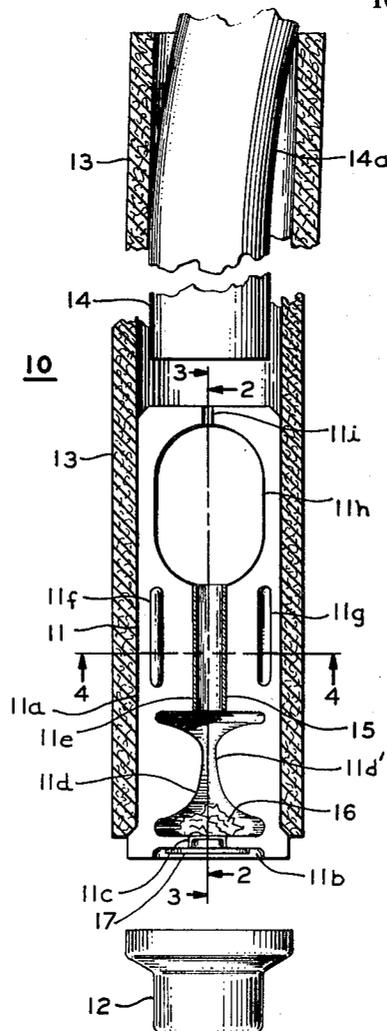
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 Raymond F. MacKay

[57] **ABSTRACT**

An immersion molten material sampling device of a type usable to obtain a sample of molten steel from a furnace. The device includes a sectional mold structure having a vented sample receiving cavity and an entrance passage for molten material to flow into said sample receiving cavity. The entrance passage is characterized by the inclusion of a venturi which minimizes resistance to flow and effects smoother flow of molten material into the sample receiving cavity. The venturi throat which is surrounded by thick wall structure of the mold acts as a thermal valve to prevent loss of sample from the sample receiving cavity by maximizing heat removal from the molten material through heat conduction to the thick wall structure of the mold surrounding the throat. The resulting high heat conduction away from the molten material at the venturi throat, once the molten material has stopped flowing into the sample cavity, causes the material in the throat to freeze first thus trapping the sample inside the sample cavity to prevent loss of molten material therefrom during removal of the device from a bath of molten material. The body of the sampler is preferably of the split mold type with a gasket of porous material between the mold halves to provide more uniform venting for the sample receiving cavity.

10 Claims, 6 Drawing Figures



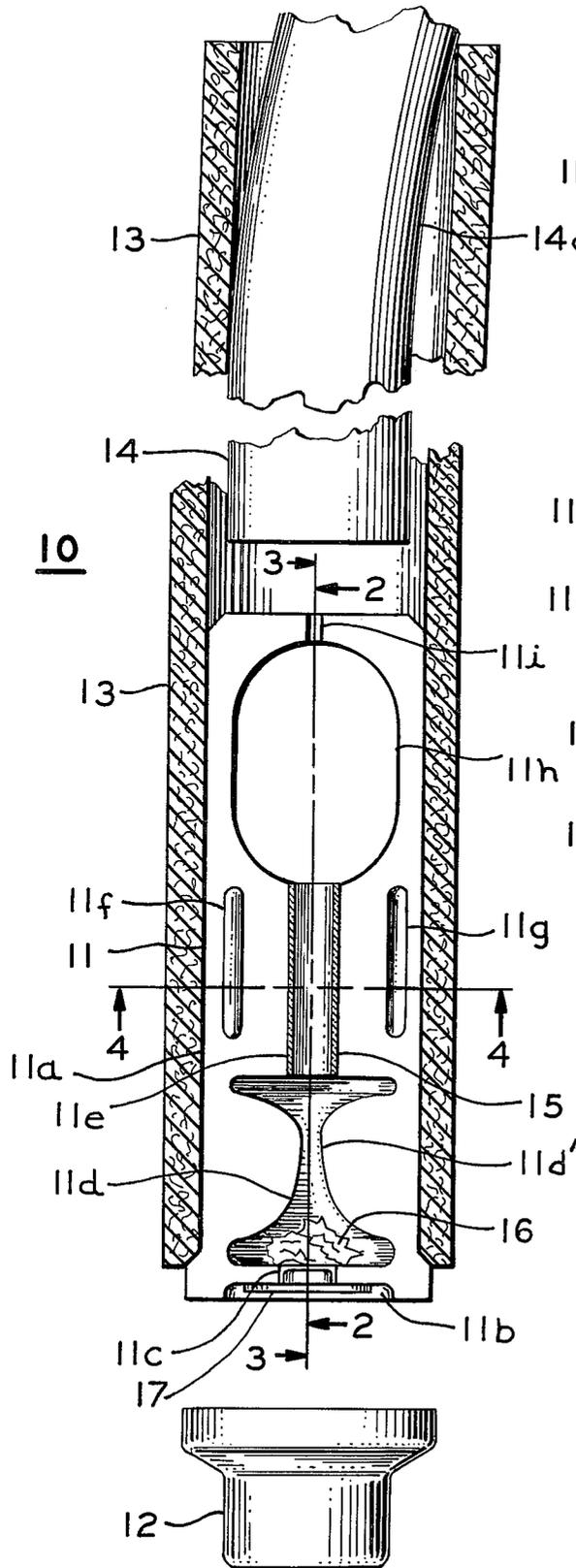


FIG. 1

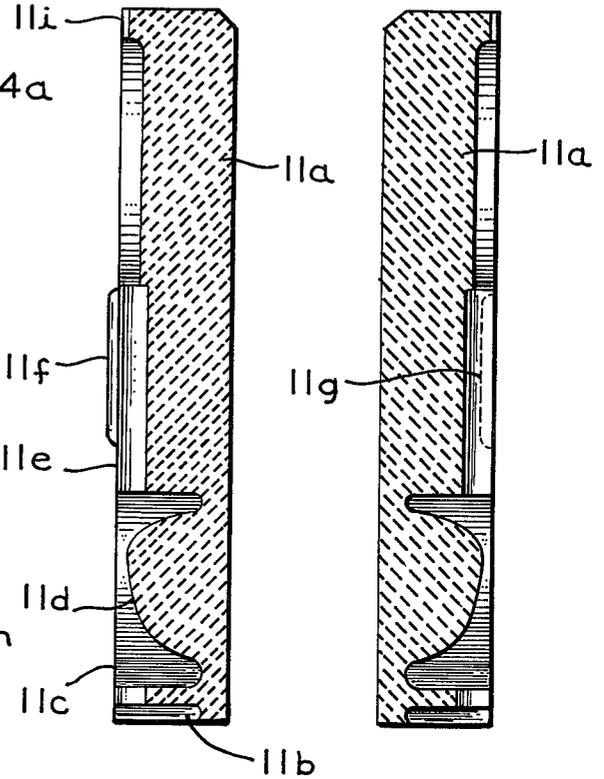


FIG. 2

FIG. 3

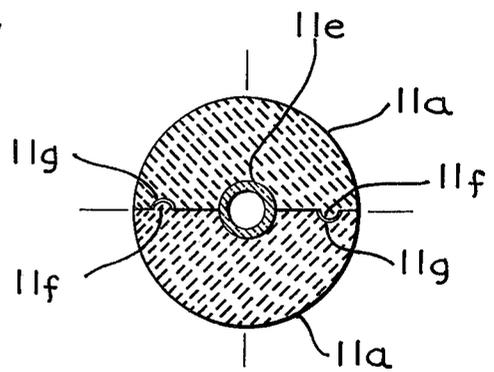


FIG. 4

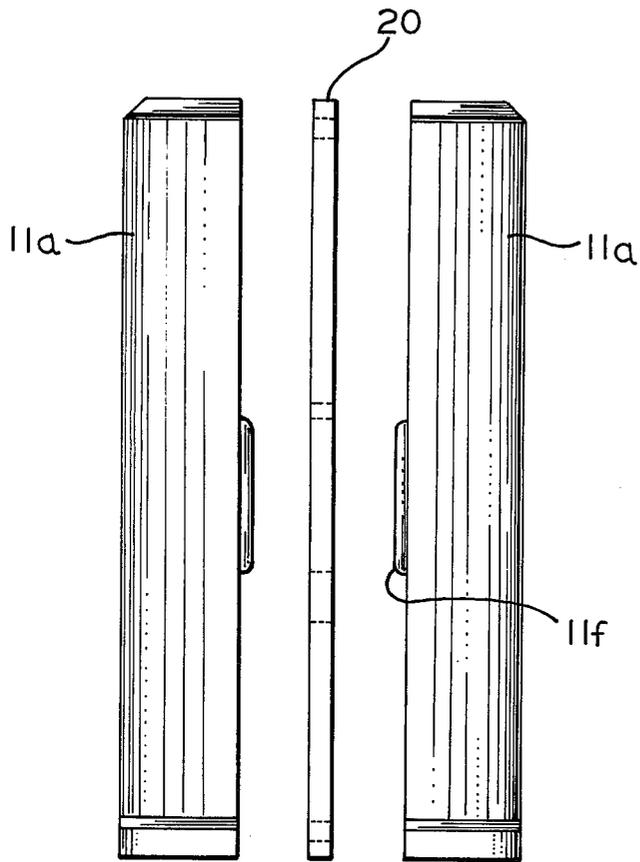


FIG. 5

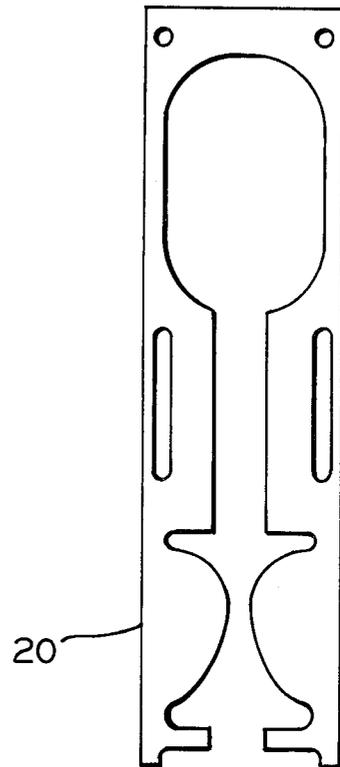


FIG. 6

IMMERSION SAMPLER FOR MOLTEN MATERIAL RELATED APPLICATION

This application is a continuation-in-part of my application Ser. No. 454,332 filed Mar. 25, 1974, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to apparatus for obtaining a sample of molten material. Such apparatus is generally to be found in U.S. Pat. Office Subclasses relating to Measuring and Testing, Sampler and Toller, Implements, With Receptacle, Liquid, etc.

2. Description of the Prior Art

For a long time there has been a continuing effort, particularly by individuals associated with the steel industry, to provide a satisfactory method and apparatus for the collection of solidified samples of molten material to be used for constituent analysis. Samples have been obtained by pouring molten material into a mold having a cavity configuration of a desired shape. Samples have also been obtained by immersing the closed end of a metal or heat-resistant glass suction tube or a mold or more complex configuration into a bath of molten material so that upon destruction of an end closure molten material would be sucked up into the device. Suction was achieved either by connection to suction producing means or using a sealed evacuated device. There have also been utilized immersible mold structures having a top, bottom, or side entrance passage to a cavity of a desired shape, the cavity of the mold being filled by inflow caused by gravity or by the hydraulic head of the molten material. In these latter modifications the sample receiving cavity must be vented to atmosphere.

It has long been known to obtain samples comprised of a head portion of any desired shape attached to a stem portion. It is also known in the prior art to employ samplers comprised of split mold structures wherein the mating parts of the mold when placed together form a sampler having one or more sample receiving cavities, one or more vent passages for venting the cavity or cavities to atmosphere and an entrance passage the normally open end of which is temporarily closed by heat destructible material to prevent ingress of slag which may exist in a bath of molten material by maintaining the entrance passage closed until the sampler has been immersed into a molten bath below the level of any slag existing therein. A relatively recent patent disclosing many of the foregoing features is U.S. Pat. No. 3,646,816 issued to Hance et al and assigned to the same assignee as the present application.

Samplers of the type where the molten material enters the sampler through a passage having its opening in an end face at the immersion end of a mold have certain advantages, however, considerable difficulty has been experienced with such samplers due to run-out of the material being sampled as the sampler is withdrawn from a bath of molten material thus resulting in the samples being hollow or tubulated instead of solid all the way through. Some difficulty has also been experienced with split mold samplers in that molten material tends to run between the mold halves, which are almost always slightly warped. This results in the production of unwanted flashing on the edges of the sample.

In order to prevent loss of gas from the sample cavity of a mold structure it is known as taught in U.S. Pat. No. 3,315,529 to include, in an evacuated apparatus for taking samples from melts, a multi-part mold structure having a cooling jacket disposed about wall structure defining a sample receiving cavity and wall structure defining a cavity which is a portion of the flow passage which conveys molten material to the sample receiving cavity. A metal plate or disk is secured between the mold sections the walls of which define the above cavities. This plate has a through passage which provides a narrow or restricted path for the flow of sample to the sample cavity. The through passage opening is provided with sharp edges, by using any of several configurations illustrated in the patent, and the plate and its parts tinned or covered with a non-gassing fluxing agent so that upon solidification of the molten material in the sample cavity the material closes around the disk and will weld itself thereto particularly if the above mentioned sharp edges are provided.

It is also taught in French Pat. No. 1,436,377 to provide the tube of an evacuated glass tube type of sampler with a narrowing in order to reduce the speed of circulation during the aspiration of the liquid and to ensure the formation of a compact sample, free of hollow areas. U.S. Pat. No. 3,455,164 teaches the use of sampler bodies made of a porous shell molded sand. Such materials while satisfactory for some applications are not suitable for use in a sampler wherein it is required to exclude substances from the sample which are given off by the resin coated binder materials utilized in the shell molding process.

Applicant has discovered that a totally expendable immersion sampler device of the split mold type can be constructed which includes means to prevent the formation of unwanted flashing on a sample while enhancing venting in a manner to promote a uniform fill, and means further promoting uniform fill and at the same time functioning to prevent run-back, i.e. loss of sample from the sample receiving cavity of a mold upon withdrawal of the sampler from the bath of molten material and which does not require the use of a cooling jacket to cool an orifice plate and the walls defining cavities of a mold to promote freezing of the sample.

SUMMARY OF THE INVENTION

In accordance with applicant's invention there is provided an improved low cost totally expendable immersion sampler device of the hydraulic fill type. The mold structure of the sampler has wall portions defining a sample cavity having a configuration to produce a casting of any desired shape, a passage for venting the cavity, and a flow passage for filling the cavity with molten material. The improvement is in the flow passage wherein wall portions of the mold structure define a flow passage having an entrance in an end face at the immersion end of the mold structure and a venturi which reduces the resistance to flow and effects smoother flow of the molten material into the sample cavity and the thicker wall portions in the region of the venturi throat serve to extract heat from the molten material in a manner to effect freezing of molten material in the throat to prevent loss of sample from the sample receiving cavity.

Further in accordance with applicant's invention it is an object to provide an immersion sampler device for obtaining a sample from a bath of molten material. The

sampler includes a split mold body of the type having a pair of mating half sections each including recessed areas which when said sections are held together form a sample cavity, a vent passage, and a passage for filling the mold with the improvement wherein the recessed areas of each of the half sections, which together form the passage for filling the mold, have portions of a configuration to form a venturi, and a gasket made of a porous material, which will withstand a high temperature is disposed between halves of the split mold to prevent formation of flash or fins on the edges of a sample and provide additional venting means which promotes uniform filling of the sample cavity.

It is still further an object of applicant's invention to provide an immersion sampler device having a holder made of material suitable for immersion into a bath of molten material. The holder supports a mold at an end thereof to be immersed. The mold is comprised of body structure having wall portions defining therein a cavity for producing a cast sample of a desired shape, means to vent the cavity, and a fill passage for the mold. The wall portions of the mold defining the fill passage include portions constructed and arranged so that molten material enters the mold from the immersion end thereof. The wall portions defining the fill passage also include portions defining a venturi with the wall portions surrounding the throat of the venturi being substantially thicker than other of said wall portions and serving to extract heat from the molten material in a manner to effect freezing of molten material in said throat to prevent loss of sample from the immersion end of the mold. A deoxidizing material may be contained in one end of the venturi and/or in the form of a closure for the fill passage. The sampler device may include a heat destructible cover temporarily to close the fill passage while the device is being immersed through a slag layer, if one exists on the surface of the bath of molten material from which one wishes to obtain a sample, and/or the holder may be a tube of heat resistant material such as cardboard with the mold secured in an immersion end thereof.

It is also an object of applicant's invention to provide an immersion sampler device of the type wherein a split mold is supported in the end of a cardboard tube immersible in a bath of molten material. The mold is of refractory material defining an entrance passage for molten material, a sample receiving cavity, and a vent passage for venting fluid displaced by the molten material as it enters the mold. Recessed portions of the material defining the entrance passage include a portion defining a venturi constructed and arranged to receive molten material at the immersion end of the mold and provide smooth inward flow of the molten material. Thicker wall portions in the region of the venturi additionally effect freezing of the molten material in the throat of the venturi to prevent loss of sample from the sample cavity when the sampler is withdrawn from the bath.

It is further an object of Applicant's invention to include in an immersion sampler comprised of complementary mold sections providing an entrance passage and a sample receiving cavity a gasket of porous material to eliminate flash or fins from the edges of the sample and provide additional and uniform venting for the sample receiving cavity.

Applicant's invention may best be understood by reading the following description together with reference to the various figures of drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a side elevation partly in section showing the relationship between the mold, a holder therefor, a closure member, and a handle or manipulator used for immersing the mold in a bath of molten material,

FIG. 2 is a sectional view along the line 2,2 of FIG. 1 with mold inserts omitted,

FIG. 3 is a sectional view taken along the line 3,3 of FIG. 1 with mold inserts omitted,

FIG. 4 is a sectional view taken along the line 4,4 of FIG. 1,

FIG. 5 is an exploded side elevation of the sampler of FIGS. 1-4 showing the location of a porous gasket in accordance with applicant's invention, and

FIG. 6 is a plan view of the gasket of FIG. 5.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIG. 1, there is shown an immersion sampler device for obtaining a sample from a bath of molten material. A split mold 11 only one-half 11a of which is shown in FIG. 1 is comprised of two identical halves which are assembled in face-to-face relation with or without a gasket as shown in FIGS. 4 and 5. The mold halves are preferably made of a ceramic material called cordierite which is composed of alumina, magnesia, and silica. The mold halves may be cemented together with a refractory cement or otherwise secured in a manner which avoids leakage of molten material into any space between the halves which might exist should the faces of the mold halves not be perfectly flat. Generally the mold halves will be slightly warped so that either a cement or a gasket should be used. It has been found by applicant that by using a gasket made of a material which is porous that not only is leakage of molten metal into spaces between the mold halves prevented, thus avoiding flash or fins on the sample upon solidification of the molten material, but that additionally more uniform venting of the sample cavity appears to be effected which results in a complete fill with varying amounts of superheat of the molten material. In view of the foregoing a gasket 20, as shown in FIG. 6 is inserted between the mold halves as shown in FIG. 5. The gasket 20 is made of a porous material that will withstand exposure to the molten material of the bath. For obtaining samples of molten steel it has been found that a gasket about 0.01-0.02 inch thick made of felted refractory fibers which is a material obtainable from Refractory Products Company, Mount Prospect, Illinois under the trademark FIBERFRAX has been found suitable. After the gasket is properly placed and the mold halves secured as by a piece of adhesive tape (not shown) a heat destructible cap 12 is affixed thereto. For obtaining a sample of steel the cap 12 is preferably thin-walled and of mild carbon steel so that it will quickly melt away after immersion into the bath. As is well known to those skilled in the art such caps are utilized to prevent the ingress of slag when the immersion sampler penetrates a slag layer as it is being inserted into the molten bath to obtain a sample therefrom. Those skilled in the art have found it desirable sometimes to include a thin coat of paper, plastic, or other suitable material on the outside

of the cap 12 to prevent slag from sticking to the cap. If slag sticks to the cap when the cap is destroyed slag might enter the sampler which, of course, is undesirable. No such coat is shown on cap 12 since it per se is not always necessary and forms no part of applicant's invention. It is also to be understood that when no slag is present no fusible cap is necessary.

The sampler unit comprised of the assembly of the two identical halves 11a of the mold 11 with gasket 20 between them and the cap 12 is inserted into the end of a protection tube 13 which may be made of cardboard, graphite, ceramic, or other suitable material and secured therein as by means of any suitable adhesive to form a device ready for use. As those skilled in the art are aware, a sampler device as just described is withdrawn from a supply thereof and pushed onto a manipulator or handle which may be in the form of a black iron pipe 14 of suitable length. In order to regulate the distance that the pipe extends into tube 13 it may be bent as at 14a. The binding action between a cardboard tube and the bend in the pipe, which is otherwise a loose fit within the cardboard tube, is sufficient to secure the sampler device on the pipe. Of course other means may be used as a tube stop and to secure the tube to a manipulator.

Since the mold halves 11a are identical it is only necessary to describe one of them. The material of the mold halves may be any which will withstand immersion into the molten baths at the usual bath temperature and which will not conduct heat in a manner to prevent filling of the mold. When taking samples of molten steel the material must withstand temperatures up to and in excess of 3,000° Fahrenheit in which case the ceramic mentioned above is suitable. The mold piece 11a may include a recess 11b at the immersion end thereof. The term "immersion end" as utilized throughout the specification and claims is intended to refer to that end of the immersion sampler which first enters the bath of molten material. As viewed in FIG. 1 it is the lower end facing cap 12. The recesses 11b together form a countersunk part of a mold which can be utilized to support a disk 17 to close an entrance port 11c and may be of any material which may be melted by the heat of the bath. The disk can be of a material which will melt and thereafter mix with the molten material which enters the mold structure. As well known to those skilled in the art it is sometimes desirable to utilize a deoxidizing material, for example aluminum, to kill a sample of steel as it enters the mold. For this purpose it has been found desirable to make disk 17 hat-shaped, as shown, so that it will extend into the entrance port of the mold. The reference number 11c designates the entrance port which, in the device illustrated, is a part of the flow passage for material entering the mold. Wall portions of the mold are constructed and arranged to form a venturi 11d. As defined in Webster's New International Dictionary, Second Edition, Unabridged, Published 1954, a venturi tube or venturi 1. Hydraulics, is a short tube, inserted in a pipe line, whose internal surface consists of two truncated cones connected at the small ends by a very short cylinder called the "venturi throat." In applicant's specification and claims the term "venturi" is employed with reference to the cone shaped sections connected by the short small diameter passage which when the mold halves are assembled form the venturi 11d having a venturi throat 11d'. The function of the venturi tube or,

as commonly designated, the venturi in accordance with applicant's invention is to minimize resistance to the inward flow of molten material to the sample cavity and effect a reduction in the pressure of the inwardly flowing material. The venturi throat functions as a thermal valve to help prevent back-flow of the molten material. The thicker wall structure of the body in the region of the throat maximizes removal of heat from the molten material in a manner such that when the inward flow ceases the material freezes in the throat thus trapping the sample inside the sample cavity. Applicant has also found from an inspection of cast samples obtained from samplers constructed in accordance with his invention that the venturi appears to effect a marked reduction in splash as the molten material enters the sample receiving cavity thus producing more homogeneous samples. The end of the venturi opposite the immersion end opens into the sample cavity comprised of the sections 11e and 11h of the mold.

Those skilled in the art are aware of the fact that for various reasons the shape of the sample cavity is a matter of choice and may be of almost any conceivable configuration. As shown in U.S. Pat. No. 2,970,350 the cast sample may be in the form of a head and stem obtained from a mold such as is depicted in FIG. 2 of that patent or as indicated in the description of FIG. 4, column 3, lines 58-62, of that patent, "The mold body 4, which. . . is provided with a hollow space or mold cavity 5 which may contain various inserts for the purpose of producing castings of complex configuration." While for applicant's purpose a ceramic mold is preferred it is believed clear that the shape of the sample to be cast may be of any desired configuration and other materials may be used for the mold as a matter of choice to suit the application.

Still referring to FIG. 1, a semi-circular recess 11e in each mold half joins with a flat bottomed somewhat oval recess 11h. These recesses cooperate with similarly recessed portions of the other mold half, when the mold halves are assembled, resulting in a sample receiving cavity which produces a sample piece comprised of a flat head-like portion affixed to a round stem. As known to those skilled in the art it is customary, in order to provide the round stem of the sample with superior surface characteristics and promote the flow of molten material into the cavity portion formed by the recess 11h, to include a tubular element 15 of heat resistant glass, quartz, or a suitable ceramic, such as cordierite which may be disposed in the recesses 11e and secured therein as by the use of a refractory cement. In order that air and gas may escape from the mold as the molten material enters the mold venting means is provided. For this purpose a groove 11i is included in each mold half which, when the mold halves are assembled, results in the formation of a passage of small diameter which serves together with the porous gasket 20 as means for venting the sample cavity and hence the entire mold. To maintain the mold halves in proper alignment it will be found desirable to provide in each mold half a projection such as a rib 11f and a recess 11g of complementary shape. The projecting rib 11f is best seen in FIG. 2, the recess 11g of complementary shape is best seen in FIG. 3 and the manner in which the ribs and recesses cooperate is best illustrated in FIG. 4.

While mention has already been made of the possibility of supporting a disk of deoxidizing material such as

aluminum in the recess 11*b*, it is to be understood that the amount of aluminum to be used has been found to be somewhat critical. Too much not only spoils the sample for spectrographic analysis but also appears to cause loss of sample due to run-back. Too small an amount of aluminum results in incomplete deoxidation of the sample. Applicant has found that using a mold having a configuration in accordance with his invention as shown and with dimensions such that the weight of a steel casting obtained from the mold is about 87 grams, for this weight of steel the weight of the aluminum should be about 0.2 grams. If the weight of the aluminum in disk 17 needs to be augmented this can be accomplished by adding a quantity of deoxidizing material 16, such as aluminum foil, a small disk, or the equivalent weight needed in some other form in one of the end portions of the venturi 11*d*, as shown in FIG. 1.

The immersion sampler device as above described employs low cost materials and is relatively inexpensive to manufacture. It is easily broken open to retrieve the desired sample. The device used for illustrative purposes contemplates a mold body approximately 5 inches long and having a diameter such that it may be cemented into a cardboard tube having an I.D. of about 1 and five-sixteenth inches and a wall thickness of about one-quarter to three-eighths of an inch.

While in describing applicant's invention specific materials have been referred to and a sample cavity having a shape to produce a pingpong paddle-shaped sample has been illustrated, it is clearly to be understood that more than one sample cavity may be fed through a single venturi and other changes may be made without departing from the scope of applicant's invention. The foregoing description is merely illustrative and is in no way to be construed as limiting.

What is claimed is:

1. An immersion sampler device for obtaining a sample from a molten bath, said sampler including a mold structure having wall portions defining: a sample cavity having a configuration to produce a casting of the desired shape, means for venting said cavity, and a flow passage for filling said cavity, and the improvement wherein said wall portions define a flow passage having an entrance in an end face at the immersion end of said mold structure and a venturi which minimizes resistance to flow and effects smoother flow of molten material to said cavity and a thicker wall portion in the region of the venturi throat serving to extract heat from the molten material in a manner to effect freezing of molten material in said throat to prevent loss of sample from said cavity.

2. An immersion sampler device for obtaining a sample from a bath of molten material, said sampler including a split mold body of the type having a pair of mating half sections each including recessed areas which when said sections are held together form a sample cavity, a vent, and a passage for filling said mold, the recessed areas of each half section which together form said passage for filling being of a configuration to form a venturi and said mating half sections being formed so as to provide thicker wall portions in the region of the throat

of said venturi for extraction of heat from the molten material in said throat to prevent loss of sample from said sample cavity, and a gasket made of a porous material disposed between said mating half sections.

3. An immersion sampler device comprising a holder made of material suitable for immersion into a bath of molten material, said holder supporting a mold at an end thereof to be immersed, said mold being comprised of body structure having wall portions defining therein a cavity for producing a cast sample of a desired shape, means to vent said cavity, and a fill passage for said mold constructed and arranged so that molten material enters said mold from the immersion end of said mold, said wall portions defining said fill passage including portions defining a venturi with the wall portions surrounding the throat of said venturi being substantially thicker than other of said wall portions and serving to extract heat from the molten material in a manner to effect freezing of molten material in said throat to prevent loss of sample from the immersion end of said mold.

4. A sampler device according to claim 3 including a quantity of a deoxidizing material at one end of said venturi.

5. A sampler device according to claim 3 wherein said body structure includes mating sections with a gasket of porous material between said mating sections.

6. A sampler device according to claim 3 including a closure of heat destructible material covering the entrance to said fill passage.

7. A sampler device according to claim 3 wherein said holder comprises a tube of heat resistant material with said mold supported in an immersion end thereof.

8. A sampler device according to claim 3 wherein said fill passage has an entrance in a plane substantially perpendicular to the longitudinal axis of said immersion end of said tube.

9. An immersion sampler of the type including a cardboard tube immersible into a bath of molten material and a split mold supported in the immersion end of said tube, said mold being of a refractory material defining an entrance passage for molten material, a sample cavity, and a vent passage for venting fluid displaced by said molten material, the improvement comprising recessed portions of the material of said mold forming a venturi in said entrance passage which is constructed and arranged to receive molten material at the immersion end of said mold and provide smooth inward flow of molten material to said sample cavity and to have thicker wall portions of refractory material in the region of said venturi throat to effect freezing of molten material in the throat of said venturi to prevent loss of sample from said cavity when said sampler has been immersed for obtaining a sample.

10. An immersion sampler of the type comprised of complementary mold sections providing an entrance passage and a sample receiving cavity and the improvement wherein gasket structure of a porous material is disposed between mold sections to provide venting for said sample receiving cavity.

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