

[54] **IMMERSION MOLTEN METAL SAMPLER**

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Related U.S. Application Data

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[51] Int. Cl.G01n 1/12

[58] Field of Search73/421 MM, DIG. 9, 425.4, 425.6; 164/4

[56] **References Cited**

UNITED STATES PATENTS

3,369,406 2/1968 Lowdermilk.....73/425.6
3,415,124 12/1968 Collins.....73/425.4

3,457,790 7/1969 Hackett73/421
3,481,201 12/1969 Falk.....73/421

FOREIGN PATENTS OR APPLICATIONS

249,417 9/1966 Austria73/DIG. 9

Primary Examiner—S. Clement Swisher

Attorney—Woodcock, Washburn, Kurtz & Mackiewicz

[57] **ABSTRACT**

An immersion-type molten material sampling unit comprised of a body of refractory material including an entrance passage, a first cavity for the production of a flat disclike sample, one or more additional cavities for the production of one or more pin-type samples, and an air compression chamber vented to atmosphere which facilitates rapid filling of the sample cavities. The unit is mounted in one end of a protection tube to form a low-cost expendable assembly which may be readily slipped onto the end of a piece of pipe which serves as a handle for immersing the unit in a bath of molten material. In a preferred embodiment the first cavity desirably includes a pair of chill plates to produce more rapid freezing of the disclike sample and a pair of smoother surfaces which require less clean-up prior to use of the disc for spectrographic analysis.

3 Claims, 4 Drawing Figures

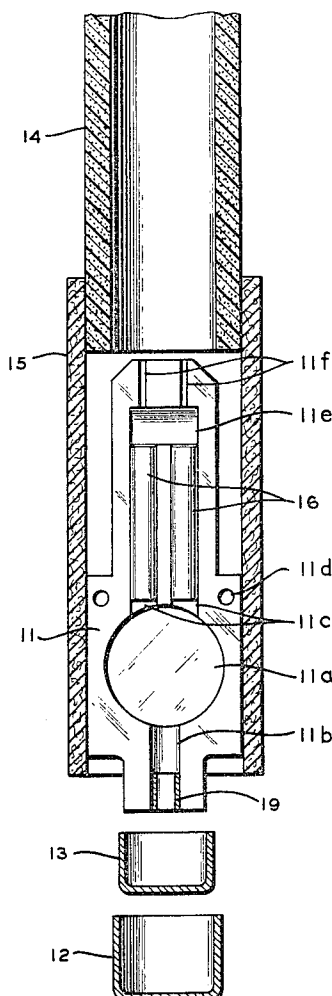


Fig. 1

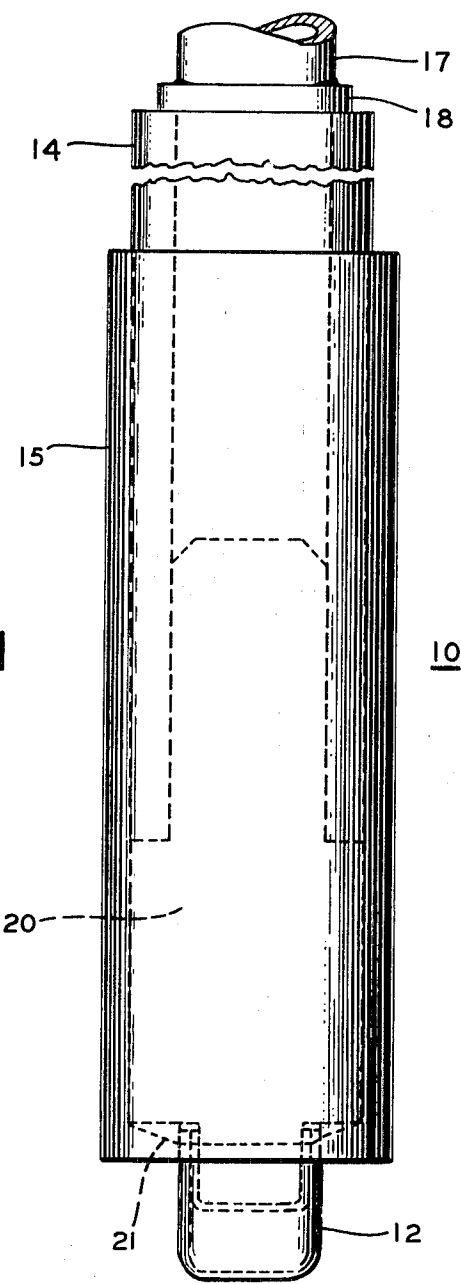
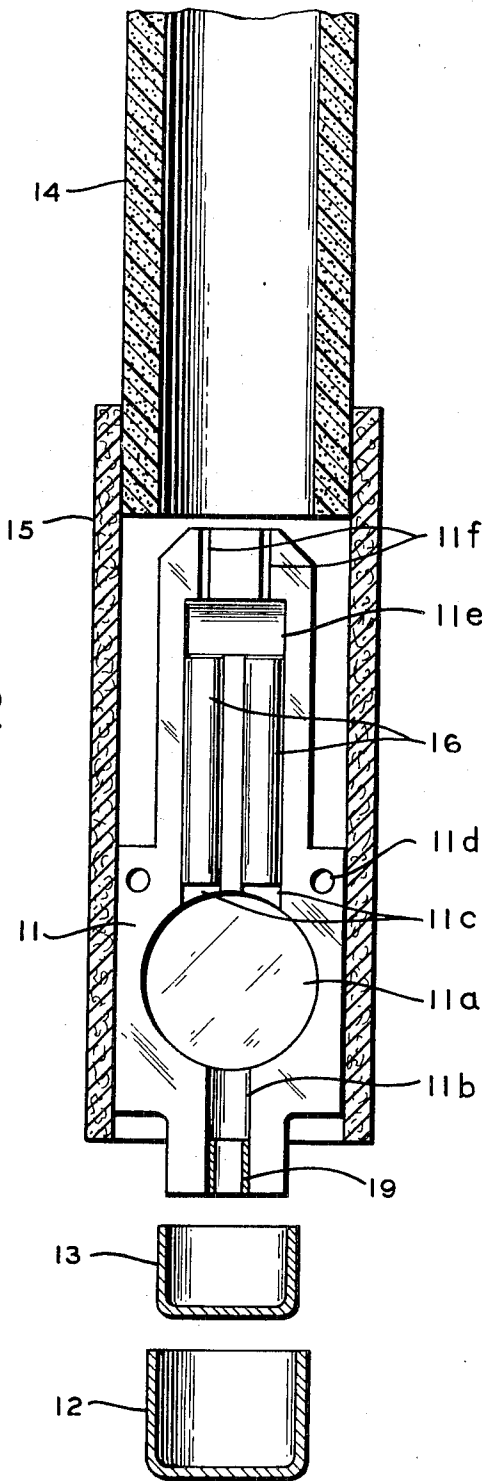


Fig. 2



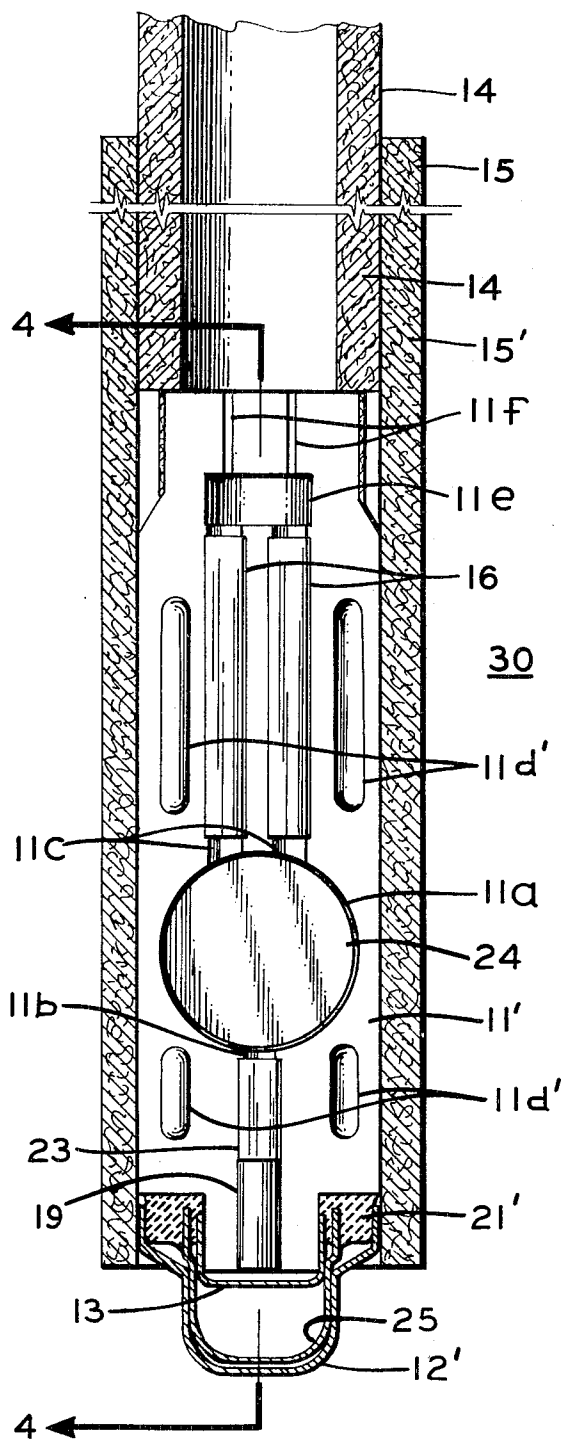


Fig. 3

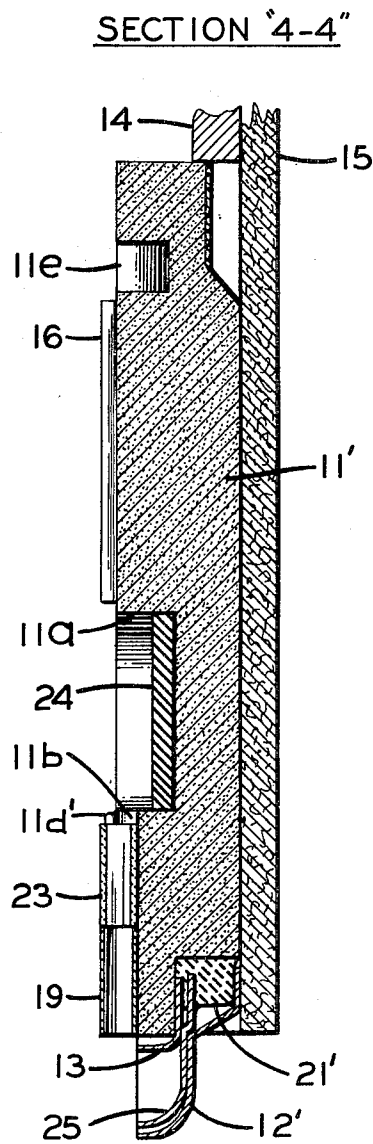


Fig. 4

IMMERSION MOLTEN METAL SAMPLER

CROSS-REFERENCES

This is a continuation-in-part of the parent application Ser. No. 850,961, filed Aug. 18, 1969, 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. Patent Office classes relating to Measuring and Testing, Sampler and Toller, Implements, With Receptacle, Liquid, etc.

2. Description of the Prior Art

For over 30 years there has been a continuing effort, particularly by individuals employed in 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. Pin-type samples have been obtained by immersing the closed end of a metal or heat-resistant glass suction tube into a bath of molten material so that upon destruction of the end closure molten material will be sucked up into the tube. Suction was achieved either by connection to suction producing means or using a sealed evacuated tube. Other sampling apparatus disclosed in published material is comprised of an immersible mold structure having a covered top, bottom, or side entrance passage to a cavity of a desired shape, the mold structure being supported by a handle so that it could be immersed in a bath of molten material and the cavity filled by gravity or the hydraulic head of the molten material. In each of these latter modifications the cavities are vented to atmosphere.

Recent examples of the latter type of sampling apparatus are described in papers published by R. Houston and F. Death, pages 40-52, Proceedings of Electric Furnace Conference, 1962; and D. A. Dukelow, H. F. Ramstead and H. W. Meyer, pages 81-99, Proceedings of Open Hearth Steel Conference 1962, Volume 45. Both are published by The Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers. The foregoing papers each describe molten material samplers comprised of a capped tube supported at the immersion end of an elongated pipe employed as a handle. The tubes are vented to atmosphere and either contain an amount of deoxidizing material and/or are capped with a deoxidizing material such as aluminum. The tubes in both the Houston et al., and Dukelow et al., articles are of metal. The one described by Dukelow et al., article is specifically referred to as a "steel chill mold" which is supported in the end of a cardboard tube.

An article by D. E. Grimes, "A New Device for Sampling of Hot Metal at Inland's BOF Shop," Open Hearth Proceedings, A.I.M.E., 1968, pages 73-77, describes an immersion molten metal sampler comprised of a three-piece copper chill mold of a design to provide a pair of flat disclike metal samples. This structure while functioning to produce samples of a type desired is relatively speaking expensive and is not suitable for mass production and further requires the reconditioning of parts thereof for reuse.

U.S. Pat. Nos. 3,369,406; 3,455,164; and 3,481,201 also disclose features of construction utilized in various types of molten metal samplers. For example, U.S. Pat. No. 3,455,164—G. P. Boyle, which is assigned to applicants' assignee, discloses the use of shell molded sand sample mold halves supported in a cardboard tube, etc. U.S. Pat. No. 3,481,201—R. A. Falk, discloses use of a metal chill plate in an expendable sampler.

While such prior art devices have been very useful, there have been problems resulting in failure each time to obtain a sound, satisfactory sample and/or the cost and inconvenience associated with the use thereof has been burdensome.

More recently it has been found desirable to obtain both a "pin-type" sample and a flat, square or disc sample of a bath of molten material to satisfy the needs of various types of analysis equipment employed in a single laboratory. For this reason samplers have evolved with molds having a cavity configuration simultaneously to provide both a flat and pin sample. In U.S. Pat. Nos. 3,415,124 and 3,415,125 there is disclosed immersion sampling equipment constructed and arranged simultaneously to provide both a pin and flat sample.

Prior art samplers have varied greatly as to their complexity, cost, and their ability each time to provide a satisfactory sample. Several of the simplest, least expensive, and easiest to use devices have been unsatisfactory since they sometimes produce incomplete, piped, or porous samples and while applicant has employed many of the parts and forms of construction disclosed in the references set forth above, he has associated the parts in a configuration not taught by nor believed obvious from the prior art to produce a low-cost expendable immersion sampler which produces superior results at minimum cost.

SUMMARY OF THE INVENTION

In accordance with applicants' invention there is provided a dual sample unit and an assembly thereof simultaneously to obtain both a "flat" and a "pin" sample. The unit is characterized by its simplicity of construction compared to known prior art dual units, its low cost, and its features of construction which enhance the flow of molten material into the sample cavities in a manner to produce samples free of defects.

In accordance with applicants' invention the sampling unit per se is comprised of a body structure which is desirably a simple two-piece body of shell molded sand construction. The pieces are complementary and together form a body structure which includes an entrance passage of limited length and restricted cross section at the immersion end thereof. The entrance passage opens into a large flat disclike cavity which provides a round flat sample portion. One or more tubular passages which are desirably lined with high-temperature glass tubing connect the flat sample cavity with an air compression chamber which is vented to atmosphere through a hollow manipulator structure. A tube of material for deoxidizing the molten sample is disposed in the entrance passage. Additionally, the entrance passage may be closed with a cap of deoxidizing material over which there is secured a protective cap which prevents entry of molten material until the unit has passed through foreign material and reached the molten material to be sampled. The tube of deoxidizing material and the cap of deoxidizing material cooperate in a manner to deoxidize the material which initially flows into the sampler and continuously to deoxidize the sample as it is accepted by the sampler until it is completely filled so that all of the sample is uniformly deoxidized. The sample unit is retained in the immersion end of a heavy walled cardboard tube which receives a pipe employed as a handle for immersing the device into a bath of molten material and a lightweight cardboard tube surrounds the immersion end in protective relation with the shell molded sand body to prevent damage thereto during handling and shipment. All of the materials utilized in the same device are very low in cost thereby to make the entire structure economically expendable.

Further, in accordance with applicants' invention, it has been found preferable to include in the flat disclike cavity a pair of chill plates secured to the flat surfaces thereof to aid in the production of flatter samples, prevent loss of metal at high superheat, prevent sample porosity, minimize dendritic growth and when sampling iron alloys produce a chilled sample structure thus to avoid the presence of free graphite in the sample which would preclude the accurate analysis of carbon, phosphorous, and sulfur using a vacuum spectrometer.

Also, in accordance with a preferred form of applicants' invention, the sample unit instead of being retained in the immersion end of the heavy walled cardboard tube which

receives the pipe employed as a handle is retained within and by a short length of heavy cardboard in abutting relation with the tube which receives the handle. An end of the short length of tube which supports the sample unit surrounds and is cemented to an end of a smaller diameter cardboard tube which receives the pipe employed as a handle. In use the short length of cardboard tube burns thin and is easily knocked off and/or crushed for sample removal.

Further, in accordance with the preferred form of applicants' invention, it has been found that under conditions of high superheat it is desirable to further restrict the entrance passage by including therein a short length of glasslike material such as quartz tubing to aid the flow of sample into the unit and prevent partial drainage of sample from the unit.

It is an object of the invention to provide an expendable immersion sampler device of the type comprised of a mold body structure having therein one or more sample cavities to be filled by a sample of molten material characterized by an unobstructed air compression cavity connected with a sample cavity and vented to atmosphere through a restricted passage.

It is also an object of the invention to provide an expendable immersion sampler of the type comprised of a split mold body structure having therein one or more sample cavities to be filled by a sample of molten material characterized by first and second mold halves each including a complementary shallow cavity having a flat wall of substantial area, a pair of metal chill plates, and means securing one of said pair of metal chill plates to said flat wall of each of said first and second mold halves.

It is a further object of the invention to provide an expendable immersion sampler of the type comprised of a mold body structure having therein one or more sample cavities to be filled by a sample of molten material characterized by a short cardboard tube supporting said mold body structure, and a longer cardboard tube for supporting a handle, said short cardboard tube extending a sufficient length in surrounding relation and affixed to said longer cardboard tube for supporting said mold structure externally of said longer cardboard tube to facilitate recovery of the sample of molten material by crushing said short cardboard tube and its contents.

Additional objects and a better understanding of applicants' invention will be had by a reading of applicants' specification and the appended claims and referring to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is an elevation showing applicants' invention assembled and ready for immersion in a bath of molten material,

FIG. 2 is an elevation partly in section showing the interior construction of applicants' sampler,

FIG. 3 is an elevation partly in section of a slightly different form of applicants' sampler, and

FIG. 4 is a side elevation partly in section taken along the lines 4—4 of FIG. 3.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIG. 1, a sample receiving shell mold 20 of sand having a cap 12 closing the entrance passage of the mold is supported at the immersion end of a heavy walled cardboard tube 14. A relatively thin cardboard tube 15 surrounds the portion of the sand body protruding from the cardboard tube 14 in order to protect the relatively fragile sand mold during handling and shipment. This thin cardboard tube 15 extends in overlapping relation with the cardboard tube 14. These assembled parts form a sampler 10. While specific materials such as a shell mold of sand and cardboard are preferred it will be appreciated that other materials such as refractory clay products, graphite, and metal parts covered with refractory substances and cements may be used. The materials described herein are preferred because of their low cost, ready availability, and the knowledge that they are suitable for immersion

in a bath of molten material such as molten steel. Additional information concerning these materials is clearly set forth in U.S. Pat. No. 3,455,164 and patents referred to therein.

The length of the tube 14 is not critical and will depend upon the type of vessel containing the molten material which is to be sampled. When it is desired to obtain samples of molten steel from an open hearth furnace, for example, a cardboard tube approximately 4 feet long may be used and into this may be inserted the end of an approximately 8-foot long piece of ¾-inch extra heavy iron pipe 17 having an outside diameter which is a snug fit with respect to the inside diameter of the cardboard tube 14. A protuberance may be provided on the pipe to assure a snug fit. Such a protuberance is shown in FIG. 5 of the above-mentioned U.S. Pat. No. 3,455,164. A metal ring 18 is desirably welded at a distance of about 3 feet from the immersion end of the pipe 17 thus to provide a stop for the cardboard tube 14 so that the pipe 17 projects into the cardboard tube 14 for a distance of about 3 feet which provides ample clearance between the end of the pipe which functions as a handle or manipulator and the mold 20 in the immersion end of the cardboard tube.

In prior immersion sampling devices it has been a problem each time to secure a satisfactory sample, that is to say, with many prior devices satisfactory samples are obtained only 70 to 90 percent of the time. Imperfect or unsatisfactory samples are characterized by a lack of complete filling of a sample cavity and/or undesirable porosity of the sample. Applicants have discovered that in addition to providing sufficient material for deoxidizing a sample as taught in the prior art a further improvement in sampler performance can be obtained by providing a free, unobstructed space to serve as an air compression chamber within the mold thus to promote rapid and complete filling of the sample cavities. With this improvement satisfactory samples are obtained almost every time a sample is taken.

In accordance with the foregoing, as more clearly shown in FIG. 2, the sample mold 20 of FIG. 1 is comprised of a pair of symmetrical halves 11. Each half 11 includes grooves and recesses described hereinafter which together form an entrance passage, a first sample cavity, one or more additional sample cavities, an air compression chamber, and passages venting the air compression chamber to atmosphere. The reference numbers hereinafter applied to the grooves and recesses may likewise be considered as applying to the passages and cavities they form when the parts of the mold are assembled. The entrance passage of restricted cross section and relatively short length is formed by grooves 11b in each mold half. The first sample cavity is formed by depressions 11a in each mold half. An additional sample cavity or, as shown, additional sample cavities are formed by one or more grooves 11c in each mold half. An air compression chamber is formed by mating recesses 11e. This feature not found in the prior art promotes rapid and complete filling of the sample cavities in avoidance of piping and porosity. One or more vents to atmosphere are formed by one or more small grooves 11f in each of the mating halves. These grooves being quite narrow cooperate with the porosity of the sand body as described in U.S. Pat. No. 3,455,164 to release air but are nevertheless small enough quickly to freeze molten material so that it will not flow on into the cardboard tube 14.

One mold half desirably has a plurality of recesses or depressions such as 11d which mate with correspondingly shaped protrusions in the mating mold half thereby properly to align the mold halves when they are placed together. At the mouth of the entrance passage 11b there is desirably included a tube 19 of deoxidizing material such as aluminum. As pointed out in the above-mentioned paper by Houston and Death, tubes 16 of a refractory material having a smooth surface such as high-temperature glass, fused silica or the like in grooves 11c aid the flow of the molten material and produce pins which are smooth and of uniform diameter. With items 16 and 19 in place the mold halves are spread with a thin coat of cement and placed in abutting sealed relation. It has been

found desirable, however, prior to cementing the molded halves together to cover the walls of the cavity portion 11a with a refractory cement thus to seal the porous sand surface.

After the two halves have been secured together an aluminum cap 13 is slid over the immersion end of the mold thus to supply additional deoxidizing material at the entrance to passage 11b. Deoxidation of the material of the sample is commonly referred to in the art as "killing" the sample. The aluminum cap "kills" the steel in the immediate vicinity of the entrance passage. This steel is the first to enter the cavity. The aluminum tube 19 is fixed by refractory cement in the entrance passage so that the steel must pass through the aluminum tube. The tube 19 is reacted with the steel from its inner wall toward its outer wall, killing also the last portion of steel to enter the cavity. A cover 12 which may be in the form of a thin steel cap is cemented in place over the aluminum cap 13. This cap will withstand a higher temperature thus to prevent molten material from reaching the entrance to the sampler until after the sampler has been immersed below the slag level. The cement is indicated in FIG. 1 by the dotted line bearing the reference numeral 21.

Since the shell molded sand is of a relatively soft and crumbly material it has been found desirable to protect it with a thin cardboard tube 15 which completely covers the exposed portion of the mold 20 and extends in overlapping relation with the cardboard tube 14 into which the sample mold is inserted for use. The use of cardboard tubes in expendable immersion temperature measurements is well known to those skilled in the art. The expendable immersion techniques being described in U.S. Pat. Nos. 2,999,121 and 3,038,951 issued to H. G. Mead.

In use the immersion sampler 10 is slid onto the immersion end of the pipe 17 of FIG. 1 and into abutting relation with the ring 18. The sample is immersed into a bath of molten material for a period of a few seconds during which time the molten material fills the sample cavities. The material will solidify in the entrance passage 11b thus to retain the molten material in the sample cavities while the device is withdrawn. After withdrawal the mold is immersed in cold water to speed the solidification process after which the thin cardboard tube 15 having been consumed permits removal of the mold from the cardboard tube 14. After removal of the mold the mold is easily fractured and the solidified sample retrieved. Excess material is removed and the pins cut apart for analysis.

In FIGS. 3 and 4 there is shown a modification of applicants' immersion sampler 10 which has been designated by the reference numeral 30. In these two figures the same reference numerals are used for those parts which are identical to the parts shown in FIGS. 1 and 2. Parts which correspond in function to those shown in FIGS. 1 and 2 but differ in their configuration are given the same reference numeral with a prime added. New parts have been given new reference numerals.

The symmetrical halves 11' of FIG. 3 differ slightly from those shown in FIGS. 1 and 2 in that the portions of each mold half 11' containing the grooves 11c, and part of the length of mating recesses 11e, extend the maximum width of the mold halves which together form a diameter which is a slide fit into a cardboard tube 15' which is somewhat thicker than the cardboard tube 15. The end portions of the symmetrical halves 11', adjacent the grooves 11f, have a width less than maximum together to produce an end on the sample mold of somewhat smaller diameter making it easier to insert the sample mold into the short tube 15'. It may be observed in FIG. 3 that the end of the sample mold abuts the end of the longer cardboard tube 14 instead of being supported therein. This construction facilitates recovery of the sample. In use after the sampler is withdrawn from the bath of molten material, the cardboard tube 15' will have disintegrated by an amount sufficient such that it is easily broken away from the protected portion of cardboard tube 14 so that the cardboard tube 15' may be crushed and the sample easily removed therefrom. In the modification of FIGS. 3 and 4 the tubes 14 and 15' are cemented or otherwise fastened together.

The recesses and depressions 11d' which mate with corresponding shaped recesses and protrusions in the mating mold half in the device of FIGS. 3 and 4 are elongated and have rounded surfaces thus to provide for easier alignment of the mold halves.

As best shown in FIG. 4 each of the circular cavities 11a of the mold halves 11' is relatively shallow and of substantial area and has secured therein as by a refractory cement a flat metal disc 24 which may be, for example, an approximately 1 1/4 inches diameter cold rolled steel disc approximately one-eighth of an inch thick. These discs serve as chill plates quickly to freeze the molten metal as it flows into the cavity 11a. It has been found that over a wide range of molten metal temperatures varying from little or no superheat to substantial superheat of the molten metal better disclike samples are obtained in that on the average they are flatter and require less cleanup for use in a vacuum spectrometer. Additionally, the chill plates serve to prevent loss of metal at high superheat, prevent sample porosity, and minimize the dendritic growth in the sample. Additionally, if the sampler be used for sampling iron alloys, the chill plates produce a chilled sample structure thus to avoid the presence of free graphite in the sample which would preclude the accurate analysis of carbon, phosphorous, and sulphur when using a vacuum spectrometer.

By the addition of a fused quartz tube or other glasslike material resistant to the temperature of the molten material in the entrance passage 11b further to restrict the internal diameter of the entrance passage, it is found that particularly under conditions of high superheat partial drainage of sample from the unit is minimized.

Under some conditions it may be found desirable to employ two steel caps, particularly when using applicants' sampler in a basic open-hearth furnace to provide added protection during the time the sampler is traversing the distance through the furnace prior to immersion in the molten material contained in the furnace. When this is done the cap 12' will have a configuration such that a second steel cap 25 may be placed thereunder.

Immersion samplers of the types disclosed in FIGS. 1-4 may be comprised of two molded halves 11 or 11' about 5 1/2 to 6 inches long having an outside diameter of approximately 1 1/4 inches. The tubes 16 may be made of high-temperature glass such as Vycor or fused quartz 2 inches long having an outside diameter of approximately nine thirty-seconds of an inch and an inside diameter of about one-fourth inch. The sleeve 19 of deoxidizing material may be a piece of aluminum tubing about three-fourths of an inch long, have an outside diameter about five-sixteenths of an inch, and an inside diameter of about nine thirty-seconds of an inch. In the modification shown in FIGS. 3 and 4 the tube 23 may desirably be of high-temperature glass or fused quartz having an outside diameter of about nine thirty-seconds of an inch and an internal diameter of about thirteen sixty-fourths of an inch. The circular sample cavity 11a in each mold half may be about three-eighths of an inch deep.

While the invention has been described in terms of preferred embodiments and some specific dimensions have been set forth as illustrative, the material set forth should not be considered limiting, inasmuch as the principles underlying the invention will suggest to those skilled in the art many modifications which come within the scope of the claims.

What is claimed is:

1. An expendable immersion sampler device comprising a tube of material capable of withstanding immersion in a molten bath for a time sufficient to permit obtaining a sample,

a mold of refractory material supported by the immersion end of said tube,

said mold having a pair of symmetrical halves each including grooves and recesses which together form a plurality of serially connected passages and sample cavities including an entrance passage formed by grooves, a first sample cavity formed by recesses of a shape and depth to produce a "flat" sample, one or more additional sample

cavities formed by grooves having a shape to produce a "pin" sample, an air compression chamber formed by recesses, and grooves forming a vent for venting said air compression chamber to atmosphere,

a closure member of deoxidizing material at the entrance of said entrance passage, and
a tubular member of deoxidizing material in said entrance passage, said members of deoxidizing material cooperating in a manner to kill said sample in the vicinity of the entrance passage prior to flow thereof into said sampler and thereafter continuously to kill said sample as it flows through said tubular member including the last portion of said sample entering said sampler.

2. An expendable immersion sampler device according to claim 1 wherein a chill plate is supported in the recess of each mold half which recesses together form said first sample cavity.

3. An expendable immersion sampler device according to claim 1 wherein said tube of material is a first cardboard tube having a wall thickness which is thinner and a length which is shorter than a second cardboard tube which supports the first cardboard tube with respect to a handle thus to facilitate recovery of a sample of molten material by crushing said first cardboard tube and its contents.

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