

Aug. 12, 1969

R. E. PUTNAM

3,460,393

LIQUID METAL SAMPLE RETRIEVAL DEVICE

Filed March 24, 1967

3 Sheets-Sheet 1

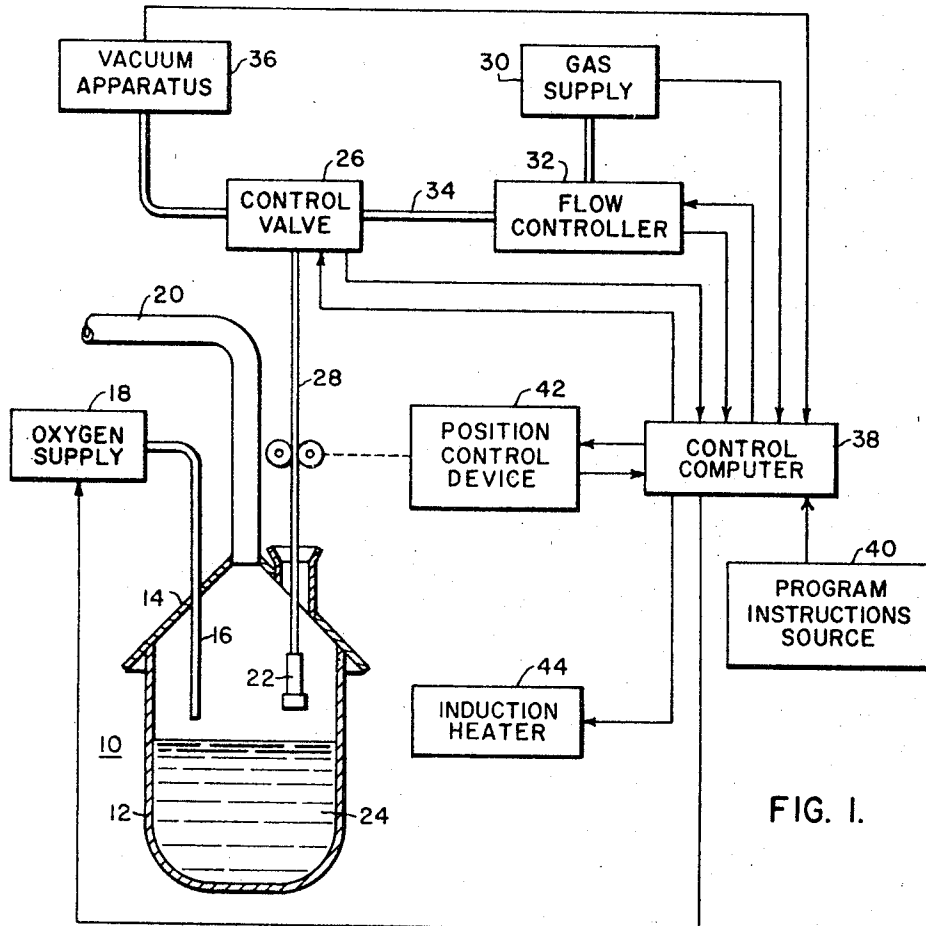


FIG. 1.

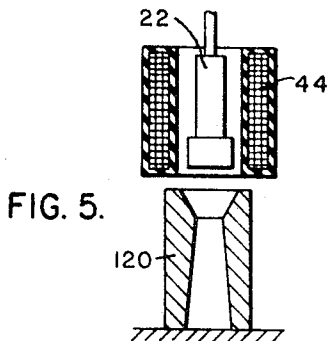


FIG. 5.

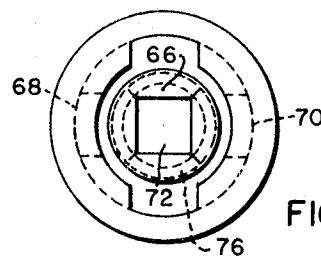


FIG. 4.

WITNESSES:

Leon M. Garman
James F. Young

INVENTOR

Richard E. Putman

BY *R. Brodahl*

ATTORNEY

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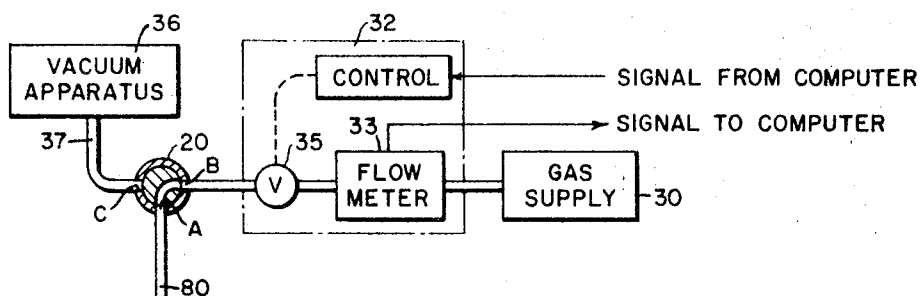


FIG. 2.

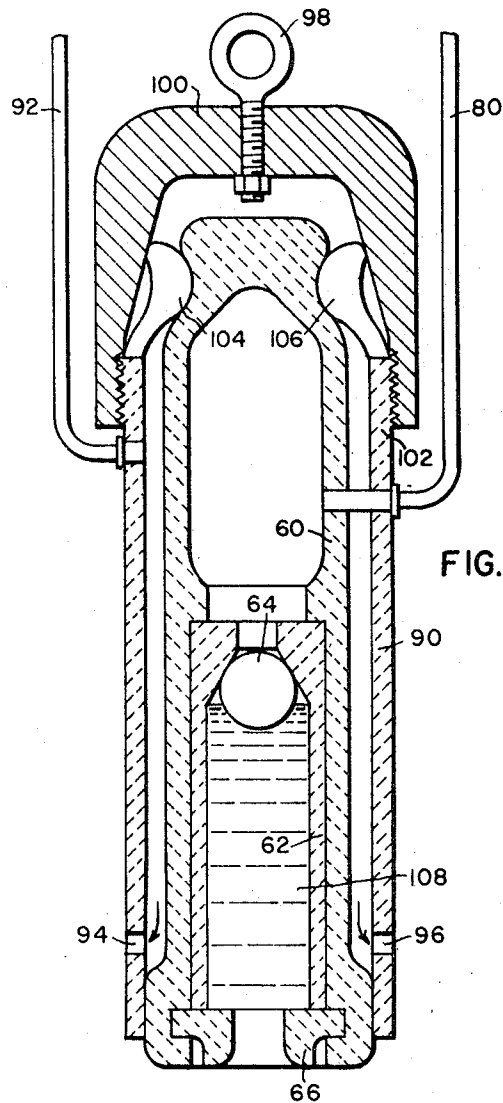
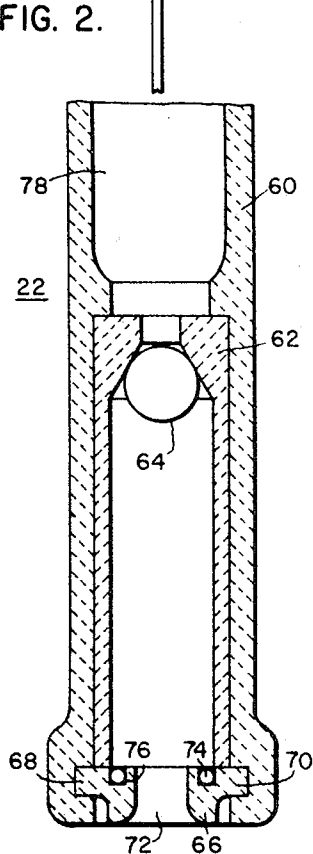


FIG. 3.

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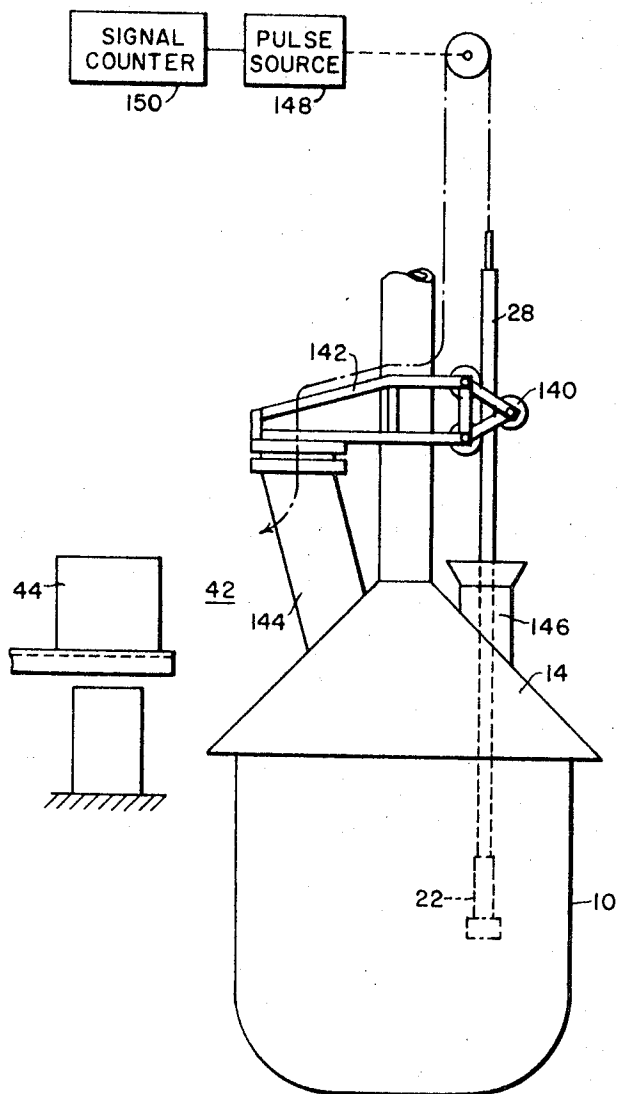


FIG. 6.

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LIQUID METAL SAMPLE RETRIEVAL DEVICE
Richard E. Putnam, Penn Hills, Pittsburgh, Pa., assignor
to Westinghouse Electric Corporation, Pittsburgh, Pa.,
a corporation of Pennsylvania

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3 Claims

ABSTRACT OF THE DISCLOSURE

A high temperature liquid metal sample retrieval device includes a ceramic sleeve supplied with a pressurized inert gas while the device is physically immersed to a desired depth within the liquid metal pool in a furnace and to prevent the entry of slag and undesired impurities into the sleeve. The ceramic sleeve is then subjected to a negative pressure to draw a sample of the liquid metal within the sleeve, until a self-contained valve member prevents further entry of the liquid metal. The device is now transportable to a provided container away from the furnace where an induction heater can be energized to remove the metal sample and deposit same inside the container. The positional movement of the sample device is coordinated with the various desired operations in relation thereto.

BACKGROUND OF THE INVENTION

The present invention relates to liquid metal sample retrieval devices and more particularly to a device to retrieve or take a sample of the liquid metal from a metal bath within an electric arc or basic oxygen furnace and without inclusion of the slag and other impurities, while the furnace is in normal operation.

The prior art teaches the provision of metal sample taking devices made of high temperature withstanding ceramic or refractory material and having an initial closure member adapted to be burned out upon contact with the molten metal to allow the molten metal to then fill an interior sleeve or tube member. An aluminum wire member has previously been provided to kill or deoxidize the molten metal sample taken.

SUMMARY OF THE INVENTION

The present invention relates to a metal sample taking device for operation with the liquid metal bath within a furnace or the like and includes the provision of an initial positive pressurized inert gas within a sleeve made of a suitable material able to stand the high temperatures involved and for the purpose of preventing the entry of undesired portions of the metal bath within the sampling sleeve. Subsequently a negative pressure is provided within the sampling sleeve to assure the desired filling of the sleeve by the liquid metal sample to be taken. A control valve is employed in conjunction with the sleeve to control the supply of the desired initial positive inert gas within the sleeve and the subsequent negative pressure within the sleeve. A float valve member positioned within the sleeve is initially positioned to deter the entry of the metal from the bath into the sleeve and then moves in position when the sleeve is filled to terminate and determine the flow of the liquid metal into the sleeve.

It is an object of this invention to provide an improved metal sampling device operative with the liquid metal bath within a furnace or the like device and better able to obtain a desired metal sample without inclusion of undesired slag or other impurities while the furnace is in normal operation; the present device further is better suited for operation in conjunction with an automatic

control arrangement for the furnace, including the taking of a sample of the metal bath within the furnace; additionally the present device is more suitable for operation during the oxygen blow period of a basic oxygen furnace which period can be in the order of 20 to 30 minutes in length for a given metal bath, and the taking of a sample of the liquid metal from that metal bath should be effected rapidly and toward the end of the blow period to enable reliable evaluation of the proper operation of the furnace to accomplish its objective purposes in regard to achieving the desired chemical and metallurgical relationships within the metal bath.

BRIEF DESCRIPTION OF DRAWINGS

In FIGURE 1 there is shown one application of the metal sample retrieval device in accordance with the present invention.

In FIGURE 2 there is shown in greater detail the metal sample retrieval device itself.

In FIGURE 3 there is shown a modification of the metal sample retrieval device.

In FIGURE 4 there is shown a bottom end view of the sample retrieval device shown in FIG. 2.

In FIGURE 5 there is shown the use of an induction heater to remove the solidified metal sample.

In FIGURE 6 there is shown one suitable arrangement for positioning the sample retrieval device.

There is shown in FIGURE 1 a basic oxygen furnace 10 including a furnace vessel 12, a hood 14 and an oxygen lance 16 which is supplied with oxygen from an oxygen supply 18. The hood 14 is vented through an exhaust gas pipe 20. A liquid metal sample retrieval device 22 is shown positioned above the liquid metal bath 24 within the furnace 10. A control valve 26 is operative initially through a conduit 28 to supply a positive pressure argon or other inert gas from a gas supply 30 through a flow controller 32 and a conduit 34. A negative pressure can then be supplied to the liquid metal sample retrieval device 22 through operation of the control valve 26 to connect a vacuum apparatus 36 with the conduit 28.

A computer 38 operative with predetermined program instructions source 40 controls the position of the control valve 26 in accordance with the position of the liquid metal sample retrieval device 22 as determined by a position control device 42 which in turn provides a position control signal to the computer 38. The computer 38 programs the position of the liquid metal sample retrieval device 22 by suitable control signals supplied to the position control device 42. The computer 38 controls the position of the control valve 26 and in turn senses the actual position of the control valve 26. The computer 38 programs the flow of the gas from gas supply 30 through the flow controller 32 and in turn senses the actual flow of the gas from the gas supply 30 through the flow controller 32. The computer senses the positive pressure of the gas within the gas supply 30 and the computer 38 senses the negative pressure within the vacuum apparatus 36. The computer 38 also controls the supply of oxygen from the oxygen supply 18 through the lance 16. The computer 38 controls the energization of the induction heater 44 to melt the solidified metal sample within the retrieval device 22 when the latter has been positioned to be operative with the inductor heater 44.

There is shown in FIGURE 2 the liquid metal sample retrieval device 22 including a ceramic sleeve 60 within which is positioned a thin walled ceramic insert member 62. A ceramic ball float valve 64 is located inside the insert 62 with the insert 62 and the ball 64 being retained in position by a ceramic end member 66 including two locking dogs 68 and 70 and a square shaped opening 72 to allow rotation of the ceramic end member 66 by a

suitable locking key, not shown. An aluminum wire 74 is provided within a groove 76 in the ceramic end member 66.

The ceramic sleeve 60 includes a hollow inside portion 78 connected through a conduit 80 with the rotating control valve 26. The liquid metal sample retrieval device 22 is adapted to be hung vertically from the position control device 42 shown in FIGURE 1, and which may include a crane boom and is connected to the common port A of the three-way rotating valve 26 by means of a heat resistant or metallic conduit 80. Port B of the control valve 26 would be connected to the gas supply 30 through the flow controller 32 and the conduit 34 while the port C of the control valve 26 is connected through the conduit 37 to the vacuum apparatus 36 for creating a desired negative pressure such as -5 p.s.i. when the control valve 26 is rotated in position to interconnect the port C with the port A. The flow of gas from the gas supply 30 which may be argon or another inert gas is regulated at a constant value by means of the flow controller 32 including a flow metering device 33 and a control valve 35.

There is shown in FIGURE 3 a modification of the liquid metal sample retrieval device 22 including an outside ceramic sleeve 90 provided to receive a supply of coolant through a conduit 92 which passes through the passage between the outside ceramic sleeve and the inside ceramic sleeve 60 and exits through openings 94 and 96 provided within the outside ceramic sleeve 90. A support ring 98 is physically connected to a top cap member 100 which is operative through connection with a threaded portion 102 of the outside sleeve member 90 and wedge members 104 and 106 to support the inside sleeve member 60 as shown in FIGURE 3. The metal sample 108 is shown in FIGURE 3 contained within the ceramic insert 62.

In FIGURE 4 there is shown an end bottom view of the liquid metal sample retrieval device 22 as shown in FIGURE 2 provided to better show the locking dogs 68 and 70 of the end ceramic member 66 and the groove 76 containing the aluminum wire. The square end hole 72 is better shown in FIGURE 4.

There is shown in FIGURE 5 the liquid metal sample retrieval device 22 positioned within the induction heater 44 for the purpose of melting a solidified metal sample contained within the metal sample retrieval device 22. A suitable mold 120 is provided to contain the melted metal sample carried by the metal sample retrieval device 22.

In FIGURE 6 there is shown a suitable arrangement of the position control device 42. The conduit 28 can extend for a sufficient length to be operative with co-operating rollers 140 driven by a motor (not shown) for raising and lowering the metal sample retrieval device 22. The rollers can have gear teeth mating with similar teeth on the conduit 28 or a friction drive arrangement as may be desired. The rollers 140 are carried by a pivotable support member 142 that is supported through a ring bearing by a member 144 welded to the furnace hood 14. A guide funnel 146 is operative to facilitate the entry of the retrieval device 22 into the furnace 10 and the removal of the retrieval device 22 from the furnace 10. Movement of the conduit 28 is sensed by the pulse source 148 operative with signal counter 150 to provide to the computer a signal in accordance with the vertical position of the conduit 28. When the latter conduit 28 is removed from the furnace 10, and above the hood 14, the support member 142 can be pivoted in position on the ring bearing until the sample retrieval device 22 is positioned above the induction heater 44. The motor driven rollers 140 can then lower the sample retrieval device 22 into the induction heater 44 where the sample is melted and removed from the sample retrieval device 22.

In the operation of the device shown in the drawings, when a metal sample is to be retrieved the metal sample

retrieval device 22 is first assembled and the control valve 26 is positioned as shown in FIGURE 2 such that positive pressure inert gas is supplied through the conduit 80 to the inside portion 78 of the ceramic sleeve 60. The control valve 64 will move to its lowermost position in contact with the end ceramic member 66, but, because of the shape of the square hole 72 the positive pressure inert gas will still exit from the interior of the ceramic insert member 62. As the metal sample retrieval device 22 is physically lowered into the liquid metal bath 24 within the furnace vessel 12 the uppermost crust of slag will be blown away and the gas pressure within the ceramic insert member 62 will rise to continue the flow of gas around the ball valve 64 and out through the square hole 72 at the desired flow rate, such that neither slag nor liquid metal will enter the device during the supply of positive pressure gas. The aluminum wire 74 will melt but the groove 76 will retain it in the position shown in FIGURE 2.

When the retrieval device 22 has reached the desired depth within the metal bath 24 the control valve 26 will be rotated such that ports A and C are interconnected and the inner chamber or interior of ceramic insert 62 will now be filled with liquid metal from the bath 24 due to the negative pressure in the interior of the ceramic insert 62. The liquid metal, which in the illustration shown in the drawings is steel, will be killed or deoxidized as it comes into contact with the molten aluminum while the ball valve 64 having a density lower than steel will float and be carried upward until it seats on the top inner cone of the ceramic insert 62, and be in the position shown in FIGURE 2. The metal sample retrieval device 22 may now be lifted out of the metal bath 24, with the negative pressure holding the liquid sample in place. In raising and swinging the device away from the furnace the resultant and rapid loss of heat will cause the metal sample to solidify. The retrieval device will now be swung to a position where the device 22 can be placed within the induction heater 44 allowing the metal sample to be melted and to flow out of the retrieval device 22 into the mold 120 shown in FIG. 5. The metal sample may now be chemically analyzed by a spectrograph as desired.

The ceramic insert 62, the ball valve 64 and the ceramic end member 66 can now be removed from the outer sleeve 60 and replaced in part or in whole as needed and the above metal retrieval operation repeated when desired.

The outside sleeve 60 should be a high duty ceramic, suitable for temperatures in the order of 3500° F. and resistant to slag attack and having good thermal shock and mechanical properties. A graphite-based ceramic either blended with refractory material or having had a suitable metal vapor deposited on it, is suitable for this duty. The ceramic insert 62 and the ball valve 64 can be made of aluminum oxide or a mixture of aluminum and magnesium oxide while the ceramic end member 66 may be made of either material. The physical tolerances between the outside sleeve 60 and the inside sleeve 62 should be tight enough to substantially reduce gas leakage therebetween to a reasonable level but slack enough to allow the inside ceramic member 62 to be readily removed when the ceramic end member 66 is removed. The induction heater 44 can be employed at this time to melt any entrained metal to assist in the removal of the inside ceramic member 62.

The essential features of the metal sample retrieval device 22 as shown in FIGURE 2 are a hollow ceramic device through which an inert gas is blown during insertion of the device into a liquid metal bath, the coupling of same to a source of negative pressure or vacuum when a metal sample is desired within the device, the use of a floating ball valve to limit the quantity of the metal sample taken, and the use of a groove which will retain the aluminum ring used for killing the steel even when the aluminum is molten. Further the use of a replaceable

chemically inert but weaker ceramic insert surrounded by a stronger ceramic container, with the latter perhaps having a greater tendency to contaminate the metal sample but the inner sleeve will protect the metal sample from external contamination in this respect.

In the operation of the modified metal sample retrieval device shown in FIGURE 3, the positive pressure inert gas is initially supplied to the interior of the ceramic sleeve 60 and the inner ceramic insert 62 while the retrieval device 22 is inserted into the metal bath and through the slag crust at the top of the metal bath. When it is desired that a metal sample fill the interior of the ceramic insert 62, a negative pressure apparatus is connected through the conduit 80 to subject the interior of the ceramic sleeve 60 and the insert 62 to a vacuum or negative pressure such that a metal sample is drawn inside the insert 62 with the ball valve 64 floating on the top of that liquid metal sample and terminating the entry of the liquid metal into the insert 62. At this time a suitable flow of inert coolant gas from the gas supply 30 or other source of a suitable liquid is supplied through the conduit 92 into the passage between the outside sleeve and the sleeve 60 such that the liquid metal sample is reduced in temperature to solidify or freeze before the metal sample retrieval device 22 is removed from the liquid metal bath. The coolant medium is supplied through the conduit 92 until after the metal sample retrieval device 22 is removed from the liquid metal bath and is outside the high temperature influence of the liquid metal bath a sufficient distance such that the contained metal sample cannot be melted by the thermal energy of the liquid metal bath 24 within the furnace vessel 12. The remainder of the operation including the removal of the solidified metal sample is substantially the same as was previously described.

While preferred embodiments of the present invention have been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

What is claimed is:

1. Apparatus for taking a sample of a material having a liquid state and a solid state, said apparatus being selectively operative with each of a positive pressure source and a negative pressure source and including
 an elongated container member suitable for immersion within said liquid material and having a hollow inside portion adapted for selective connection to each of said positive pressure source and said negative pressure source,
 pressure control means initially operative to connect said inside portion of the container member to said positive pressure source while immersing the container member within said liquid material,
 said pressure control means being subsequently operative to connect said inside portion of the container member to said negative pressure source for filling said inside portion with said liquid material,
 a valve member responsive to said liquid material within said inside portion to control the filling of said inside portion with said liquid material,
 position control means operative to move said container member into and out of said liquid material, and
 operation control means responsive to the position of said container member and connected to control said pressure control means to determine the pressure condition within said container member in regard to taking a sample of said material.

2. Apparatus for taking a sample of a material having a liquid state and a solid state, said apparatus being selectively operative with each of a positive pressure source and a negative pressure source and including

an elongated container member suitable for immersion within said liquid material and having a hollow inside portion adapted for selective connection to each of said positive pressure source and said negative pressure source,

pressure control means initially operative to connect said inside portion of the container member to said positive pressure source while immersing the container member within said liquid material,

said pressure control means being subsequently operative to connect said inside portion of the container member to said negative pressure source for filling said inside portion with said liquid material, and

a valve member responsive to said liquid material within said inside portion to control the filling of said inside portion with said liquid material,

a control computer operative to control the immersion of said container member and responsive to the resulting position of said container member to control the operation of said pressure control means such that said negative pressure is not provided until a desired sample of the liquid material can be obtained.

3. Apparatus for taking a sample of a material having a liquid state and a solid state, said apparatus being selectively operative with each of a positive pressure source and a negative pressure source and including

an elongated container member suitable for immersion within said liquid material and having a hollow inside portion adapted for selective connection to each of said positive pressure source and said negative pressure source,

pressure control means initially operative to connect said inside portion of the container member to said positive pressure source while immersing the container member within said liquid material,

said pressure control means being subsequently operative to connect said inside portion of the container member to said negative pressure source for filling said inside portion with said liquid material, and

a valve member responsive to said liquid material within said inside portion to control the filling of said inside portion with said liquid material,

said elongated member having said inside portion surrounded by another hollow second portion, and

with said pressure control means being operative to connect said positive pressure source to said second portion during at least a part of said subsequent operation and after said liquid material has filled said inside portion of the container member.

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LOUIS R. PRINCE, Primary Examiner

HARRY C. POST III, Assistant Examiner