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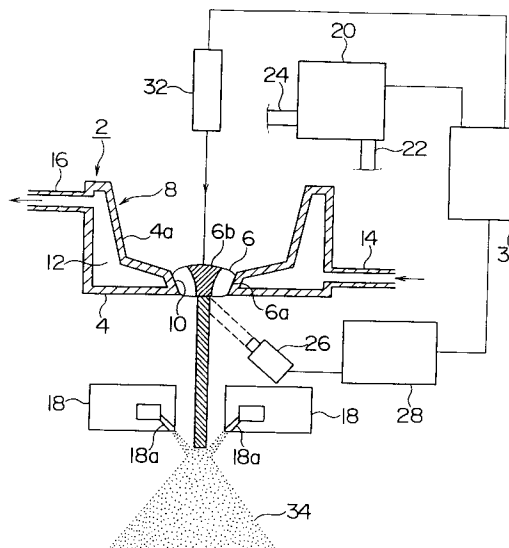
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High-purity metal melt vessel and the method of manufacturing thereof and purity metal powder producing apparatus.

A vessel for melting a high-purity metal has a vessel body (2) provided with a cooling jacket (12) and with an opening (10) of a predetermined size formed in the bottom thereof, and a lid (6) made of the same material as the high-purity metal to be molten and closing the bottom opening of the vessel body. Disclosed also is an apparatus for producing powder of a high-purity metal, including: a melting vessel having a vessel body provided with an opening of a predetermined size formed in the bottom thereof, and a lid made of the same material as the high-purity metal to be molten and closing the bottom opening of the vessel body; a cooling system for cooling the inner surface region of the vessel body; a beam generating device; a measuring device (26) for measuring the size of an output port formed in the lid and an analyzer; and a control device (30) which controls one or both of the beam output power of the beam generating device and the rate of cooling effected by the cooling system in accordance with the output from the measuring device.

FIG. 4



BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a vessel for melting a high-purity metal (referred to simply as "melting vessel") without causing contamination of the metal and to a method of producing such a melting vessel. The invention also is concerned with an apparatus for melting high-purity metal employing the vessel and with an apparatus for producing powder of high-purity metal with a high degree of uniformity of particle size.

(2) Description of the Related Art

Hitherto, various methods and techniques including gas-atomizing method have been broadly used in the production of powders, ribbons and foils of high-purity metals. On the other hand, various melting vessels have been proposed for use in these methods and techniques, such as vessels made of tantalum, molybdenum, rhenium or other refractory metal.

The use of such a vessel made of a refractory metal, however, still suffers from a problem in that the metal constituting the vessel is inevitably dissolved into the molten high-purity metal in the vessel so as to contaminate the metal. This problem is serious particularly when the high-purity metal has high melting point and large reactivity.

In order to carry out the gas-atomizing method or a modification of such method, various apparatuses for producing powdered high-purity metal (referred to simply as "powder producing apparatus", hereafter) have been proposed which comprise a melting vessel for melting a high-purity metal therein, and a gas jetting means which directs a gas to the molten high-purity metal falling from the vessel. Improvements also have been achieved in this field of technique, such as the use of a refractory metal, e.g., tantalum, molybdenum or rhenium, as the vessel material. Such improvements, however, are still unsatisfactory for the reason stated above.

Another problem of the known art is that the known melting vessels do not have any means for adjusting the size of the molten metal outlet port formed in the vessel bottom. Thus, the vessels could not be stably used in the gas atomizing method.

SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the invention to overcome the above-described problems of the known arts.

More specifically, it is an object of the present invention to provide a melting vessel which can melt a high-purity metal without contaminating the latter and which has means for adjusting the size of the metal outlet port formed in the vessel bottom.

It is also an object of the present invention to provide an apparatus which, by employing the above-mentioned vessel, produces powder of a high-purity metal with a high degree of uniformity of the particle size.

To these ends, according to one aspect of the present invention, a vessel for melting a high-purity metal comprising a vessel body provided with a cooling jacket and with an opening of a predetermined size formed in the bottom thereof, and a lid made of the same material as the high-purity metal to be molten and closing the bottom opening of the vessel body.

According to another aspect of the present invention, there is provided a high-purity metal, including: a melting vessel having a vessel body provided with an opening of a predetermined size formed in the bottom thereof, and a lid made of the same material as the high-purity metal to be molten and closing the bottom opening of the vessel body; a cooling system for cooling the inner surface region of the vessel body; a beam generating device; a measuring device for measuring the size of an output port formed in the lid and an analyzer; and a control device which controls one or both of the beam output power of the beam generating device and the rate of cooling effected by the cooling system in accordance with the output from the measuring device.

The above and other objects, features and advantages of the present invention will become clear from the following description of the preferred embodiments when the same is read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic illustration of an embodiment of the melting vessel in accordance with the present invention;

Fig. 2 is a schematic illustration of a method for producing a melting vessel of the type shown in Fig. 1;

Fig. 3 is an illustration of the melting vessel in the state of use;

Fig. 4 is an illustration of an embodiment of a powder producing apparatus in accordance with the present invention; and

Fig. 5 is an illustration of another embodiment of the powder production apparatus.

Fig. 6 is an illustration of the particle distribution between the sample of the invention and the conventional sample powder.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Briefly, the melting vessel of the present invention has a vessel body having an opening of a predetermined size formed in the bottom thereof, means for cooling the inner surface region of the vessel wall and a lid made of the same material as the metal to be molten in the vessel and closing the bottom opening of the vessel.

The lid may be attached to the vessel body by, for example, preparing the lid of the same metal as the metal to be molten and fitting the lid into the opening. Alternatively, the lid may be formed by a process including the steps of preparing a closure member having a substantially flattened upper surface, closing the bottom opening by the closure member by bringing the latter into abutment with the lower bottom surface of the vessel body, melting a small amount of the metal to be molten in the vessel so as to allow the molten metal to fill the concavity defined by the closure member and the vessel bottom wall surrounding the opening, and allowing the metal to solidify so as to fill the opening.

Embodiment 1:

Preferred embodiments of the present invention will be described with reference to the drawings.

Referring to Fig. 1 which schematically illustrates an embodiment of the melting vessel of the present invention, the melting vessel has a vessel body denoted by 2 which is a substantially cylindrical cup-like bottom-equipped structure having an internal cavity or recess 8. In this embodiment, the vessel body 2 is made of copper. A tapered opening 10 converging downward is formed in the center of the bottom of the vessel body 2. The vessel body 2 is double-walled to provide a jacket space 12 which communicates with the interior of the pipes 14 and 16 connected to the side wall of the vessel body 2. The arrangement is such that cooling water is supplied into the jacket space 12 through the pipe 14 so as to cool the inner surface region of the vessel body 2 and is then discharged through the pipe 16.

A lid 6 having a tapered outer peripheral surface 6a fits in the opening 10 of the vessel body 2, so as to close the opening 10. This lid 6 is made of the same metal material as the melting object, i.e., the high-purity metal to be molten in the vessel.

Thus, the melting vessel of this embodiment includes the vessel body 2 and the lid 6. The lid 6 may be separately formed in another vessel and then fitted in the opening 10 to close the latter. Alternatively, the lid 6 may be formed by a method

which will be described hereinafter with reference to Fig. 2.

Embodiment 2:

Referring to Fig. 2, there is prepared a closure member 50 having a flattened upper surface. The closure member 50 is brought into abutment with the lower bottom surface of the vessel body 2 to cover the opening 10. Then, a small amount of the metal M, which is the same metal as the high-purity metal to be industrially molten in the vessel 2, is placed in the vessel. This small amount of metal M is then molten by, for example, application of a voltage between the vessel body 2 and the metal M, while the vessel body 2 and the closure member 50 are being cooled. Consequently, the molten metal M flows into the recess 60 defined by the closure member 50 and the bottom wall of the vessel body 2 around the opening 10. The molten metal M is then allowed to solidify within the recess 60. Then, the closure member 50 is removed from the vessel body 2, whereby the lid 6 "fitting" in the opening 10 is obtained in the same form as that shown in Fig. 1.

In operation of the melting vessel of this embodiment, the melting vessel is charged with an appropriate amount of high-purity metal and is molten by, for example, application of a voltage between the vessel body 2 and the high-purity metal to be molten, while the vessel body is cooled by a cooling medium such as water circulated through the jacket space 12.

Consequently, the portion of the molten high-purity metal contacting the cooled inner wall surface of the vessel body 2 is cooled to solidify so as to form a thin solidified layer or shell covering the entire area of the inner wall surface of the vessel body 2. This solidified metal layer is stably held as long as the cooling of the vessel body 2 is continued. Since the thin solidified metal layer is of the same metal as the high-purity metal molten in the vessel body 2, there is no risk that the metal, i.e., copper constituting the vessel body 2 is molten to contaminate the molten high-purity metal in the vessel body 2.

The lid 6 is not substantially molten because it is cooled as the vessel body 2 is cooled. That is to say, the cooling of the vessel body 2 is so controlled as to satisfy also the demand to maintain the lid 6 in solid state. Upper part of the lid 6 contacting the molten high-purity metal may be molten but this does not cause any contamination of the molten high-purity metal because the lid 6 is of the same high-purity metal as that molten in the vessel body 2.

Embodiment 3:

The high-purity metal molten in the vessel body 2 is then made to fall downward from the vessel body 2 for the purpose of, for example, production of the metal powder. To this end, as shown in Fig. 3, a beam such as a laser beam, electron beam or a plasma beam is applied to the center of the lid 6 by a beam generator 32 which is disposed right above the lid 6, so that the central portion of the lid 6 is molten by the beam energy so as to form an outlet 6b. The molten high-purity metal is discharged through this outlet 6b. The size of the outlet is easily adjustable by controlling the rate of cooling of the vessel body 2 and the beam power.

As will be understood from the foregoing description, according to the described embodiment of the melting vessel and vessel forming method of the present invention, contamination of the molten high-purity metal, which inevitably occurred in the known art, is avoided whole through the period of operation including the melting period and discharging period in which the molten high-purity metal is discharged downward. In addition, the size of the outlet port for discharging the molten high-purity metal downward can easily be adjusted. Thus, the described embodiments enables steady supply of a molten high-purity metal to a process such as a gas-atomizing powder production process, without any risk of contamination of the molten high-purity metal.

The present invention also provides an apparatus for producing powder of a high-purity metal by using the above-described melting vessel for high-purity metal. According to the invention, in order to attain uniform particle size of the powder, the powder producing apparatus is embodied in various forms as stated below, with specific consideration of the size of the bottom outlet port formed in the lid, as well as the particle size distribution of the powder which is formed by gas-atomization effected on the molten high-purity metal discharged through the bottom outlet port.

(1) An apparatus for producing powder of a high-purity metal, comprising: a melting vessel for melting the high-purity metal therein, the melting vessel including a vessel body having an opening formed in the bottom thereof and a lid which closes the opening and which is made of the same material as the high-purity metal to be molten in the vessel; cooling means for cooling the inner surface region of the vessel body; a gas jetting device which directs a jet of gas towards the downward stream of the molten high-purity metal discharged from the vessel; a beam generating device disposed right above the lid, for applying a beam to the central por-

tion of the lid; a port size detecting means disposed under the lid, for detecting the size of an outlet port formed in the central portion of the lid by the beam; and control means for controlling the rate of cooling effected by the cooling means in accordance with the output from the port size detecting means.

(2) An apparatus for producing powder of a high-purity metal, comprising: a melting vessel for melting the high-purity metal therein, the melting vessel including a vessel body having an opening formed in the bottom thereof and a lid which closes the opening and which is made of the same material as the high-purity metal to be molten in the vessel; cooling means for cooling the inner surface region of the vessel body; a gas jetting device which directs a jet of gas towards the downward stream of the molten high-purity metal discharged from the vessel; a beam generating device disposed right above the lid, for applying a beam to the central portion of the lid; a port size detecting means disposed under the lid, for detecting the size of an outlet port formed in the central portion of the lid by the beam; and control means for controlling the beam output power of the beam generating means in accordance with the output from the port size detecting means.

(3). An apparatus for producing powder of a high-purity metal, comprising: a melting vessel for melting the high-purity metal therein, the melting vessel including a vessel body having an opening formed in the bottom thereof and a lid which closes the opening and which is made of the same material as the high-purity metal to be molten in the vessel; cooling means for cooling the inner surface region of the vessel body; a gas jetting device which directs a jet of gas towards the downward stream of the molten high-purity metal discharged from the vessel; a beam generating device disposed right above the lid, for applying a beam to the central portion of the lid; a port size detecting means disposed under the lid, for detecting the size of an outlet port formed in the central portion of the lid by the beam; and control means for controlling the rate of cooling effected by the cooling means and the beam output power of the beam generating means in accordance with the output from the port size detecting means.

(4) An apparatus for producing powder of a high-purity metal, comprising: a melting vessel for melting the high-purity metal therein, the melting vessel including a vessel body having an opening formed in the bottom thereof and a lid which closes the opening and which is made of the same material as the high-purity metal to be molten in the vessel; cooling means for cool-

ing the inner surface region of the vessel body; a gas jetting device which directs a jet of gas towards the downward stream of the molten high-purity metal discharged from the vessel; a beam generating device disposed right above the lid, for applying a beam to the central portion of the lid; a particle size detecting means disposed under the lid, for detecting the particle size of the high-purity metal powder generated by the jet of gas acting on the downward stream of the molten high-purity metal; and control means for controlling the rate of cooling effected by the cooling means in accordance with the output from the particle size detecting means.

(5) An apparatus for producing powder of a high-purity metal, comprising: a melting vessel for melting the high-purity metal therein, the melting vessel including a vessel body having an opening formed in the bottom thereof and a lid which closes the opening and which is made of the same material as the high-purity metal to be molten in the vessel; cooling means for cooling the inner surface region of the vessel body; a gas jetting device which directs a jet of gas towards the downward stream of the molten high-purity metal discharged from the vessel; a beam generating device disposed right above the lid, for applying a beam to the central portion of the lid; a particle size detecting means disposed under the lid, for detecting the particle size of the high-purity metal powder generated by the jet of gas acting on the downward stream of the molten high-purity metal; and control means for controlling the beam output power of the beam generating means in accordance with the output from the particle size detecting means.

(6) An apparatus for producing powder of a high-purity metal, comprising: a melting vessel for melting the high-purity metal therein, the melting vessel including a vessel body having an opening formed in the bottom thereof and a lid which closes the opening and which is made of the same material as the high-purity metal to be molten in the vessel; cooling means for cooling the inner surface region of the vessel body; a gas jetting device which directs a jet of gas towards the downward stream of the molten high-purity metal discharged from the vessel; a beam generating device disposed right above the lid, for applying a beam to the central portion of the lid; a particle size detecting means disposed under the lid, for detecting the particle size of the high-purity metal powder generated by the jet of gas acting on the downward stream of the molten high-purity metal; and control means for controlling the rate of cooling effected by the cooling means and the beam output

power of the beam generating means in accordance with the output from the particle size detecting means.

(7) An apparatus for producing powder of a high-purity metal as stated in one of the foregoing paragraphs (1) to (6), wherein the beam generating device generates one of a laser beam, an electron beam, a plasma beam and an arc beam.

Embodiments of the powder producing apparatus of the present invention will be described hereinafter with reference to the drawings.

Fig. 4 shows an embodiment of the powder production apparatus of the present invention, in which a control is done by adjusting the size or diameter of the outlet port formed in the bottom of the melting vessel. A melting vessel is composed of a vessel body 2 and a lid 6.

The vessel body 2 is a substantially cylindrical cup-shaped bottom equipped vessel having an internal recess 8. A tapered opening 10 is formed in the center of the bottom of the vessel body 2 so as to converge downward. The vessel body 2 is double-walled so that an internal jacket space 12 is formed in communication with pipes 14 and 16 connected to the side wall of the vessel body 2.

The pipe 14 and the pipe 16 are respectively connected to a water supply pipe 22 and a water return pipe 24 of a cooling system 20 which constitutes cooling means. The arrangement is such that cooling water is supplied through the pipe 14 into the jacket space 12 so as to cool the inner surface region of the vessel body 2 and then discharged and collected through the pipe 16. The cooling system 20 supplies cooling water of a constant temperature and has a function to measure the calorific value removed by cooling per unit time (cooling rate) on the basis of the difference between the constant temperature of water supplied into the melting vessel and the temperature of the water collected therefrom, as well as functions to control the initial temperature of the cooling water to be supplied and the volume of the cooling water delivered per unit time.

The lid 6 is made of the same high-purity metal as the high-purity metal which is to be industrially molten in the melting vessel body 2. The lid 6 has a tapered outer peripheral surface 6a which closely fits the tapered wall defining the opening 10 in the vessel body 2 thereby closing the opening 10.

Gas jetting devices 18, 18 disposed under the melting vessel body 2 have nozzles 18a, 18a which jet an inert gas such as Ar gas of a constant pressure to the stream of the molten high-purity metal discharged from the melting vessel body 2, thereby atomizing the molten metal to form particles of the high-purity metal.

A size measurement device 26 such as a camera, disposed near the bottom side of the melting vessel body 2, measures the size, e.g., diameter, of the outlet port formed in the center of the lid 6. The size measuring device 26 is connected to a control device 30 serving as control means, through an analyzer 28 which performs image processing and other operations. The measuring device 26 and the analyzer 28 in cooperation form a port diameter detecting means. The control device 30 includes a central processing unit (CPU), a program ROM and various I/O interfaces.

A beam generating device 32 which is disposed right above the lid 6 emits and directs a beam towards the central portion of the lid 6. The beam generating device 32 is connected to the control device 30 mentioned before. The beam generating device 32 may be of the type which generates a laser beam, an electron beam, a plasma beam or an arc beam.

The control device 30 also is connected to the cooling system 20 to control the cooling rate.

In operation of this embodiment, the melting vessel body 2 is charged with an appropriate amount of high-purity metal and is molten by, for example, application of a voltage between the vessel body 2 and the high-purity metal to be molten, while the inner surface region of the vessel body 2 is cooled by a cooling medium such as water circulated through the jacket space 12.

Consequently, the portion of the molten high-purity metal contacting the cooled inner wall surface 2a of the vessel body 2 is cooled to solidify so as to form a thin solidified layer or shell covering the entire area of the inner wall surface 2a of the vessel body 2. This solidified metal layer is stably held as long as the cooling of the vessel body 2 is continued. Since the thin solidified metal layer is of the same metal as the high-purity metal molten in the vessel body 2, there is no risk that the metal, i.e., copper constituting the vessel body 2 is molten to contaminate the molten high-purity metal in the vessel body 2.

The lid 6 is not substantially molten because it is cooled as the vessel body 2 is cooled. That is to say, the cooling of the vessel body 2 is so controlled as to satisfy also the demand to maintain the lid 6 in solid state. Upper part of the lid 6 contacting the molten high-purity metal may be molten but this does not cause any contamination of the molten high-purity metal because the lid 6 is of the same high-purity metal as that molten in the vessel body 2.

When the melting of the high-purity metal in the melting vessel has reached equilibrium state, a beam is applied by the beam generating device 32 to the central portion of the lid 6 so as to perforate the central region 6b of the lid 6 thereby forming

an outlet port. Consequently, the molten high-purity metal inside the vessel body 2 progressively flows out downward through the outlet port, and the downward fall of the molten high-purity metal is cooled and solidified and, in addition, micronized upon collision with the inert gas jetted from the gas jetting devices 18, whereby a powder of the high-purity metal is produced continuously.

Meanwhile, the control device 30 operates to control either one or both of the beam power of the beam generating device 32 and the cooling device 20, based on information concerning the size of the outlet port derived from the measuring device 26 and the analyzer 28, so as to maintain the size of the outlet port constant.

More specifically, the control device 30 operates such that, for example, when the size of the outlet port is greater than an appropriate size, the cooling rate is increased to enhance the effect of cooling of the lid 6 thereby reducing the size of the outlet port, whereas, when the size of the outlet port is smaller than the appropriate value, the beam power is increased relative to the cooling rate so as to apply greater heat to the central region 6b of the lid 6 to enlarge the outlet port.

According to the described embodiment of the powder production apparatus, the size of the outlet port formed in the lid 6 is maintained constant, so that the molten high-purity metal is discharged steadily at a constant rate, thereby ensuring that the produced metal powder has high degree of uniformity of particle size.

Embodiment 5:

A description will now be given of an embodiment in which a control is done on the basis of the particle size of the high-purity metal powder obtained through gas-atomization, with specific reference to Fig. 5. In this Figure, the same reference numerals are used to denote the same or corresponding parts or portions as those appearing in Fig. 4, and description of such parts or portions is omitted to avoid duplication of explanation.

The powder production apparatus shown in Fig. 5 lacks the size measuring device 26 and the analyzer 28 employed in the embodiment shown in Fig. 4 but, instead, incorporates a particle size measuring device 40 which constitutes particle size detecting means. This particle size measuring device 40 measures particle size of the product powder by making use of laser diffraction. Part of the high-purity metal powder produced through the gas jetting devices 18, 18 is made to pass through the particle size measuring device 40 for measurement of the powder particle size. The output data from the particle size measuring device 40 is delivered to the control device 30.

The process for producing high-purity metal powder in this embodiment is substantially the same as that in the embodiment shown in Fig. 4. In this embodiment, however, the control of the beam output and/or the cooling rate is conducted based upon the powder particle size obtained from the particle size measuring device 40, in contrast to the preceding embodiment of Fig. 4 in which the control is performed in accordance with the data concerning the size of the outlet port derived from the measuring device 26. Thus, the embodiment shown in Fig. 5 ensures that the product powder has a high degree of uniformity of the particle size.

More specifically, the control device 30 operates such that, for example, when the measured powder particle size is greater than an appropriate size, the cooling rate is increased to enhance the effect of cooling of the lid 6 thereby reducing the size of the outlet port, whereas, when the size of the outlet port is smaller than the appropriate value, the beam power is increased relative to the cooling rate so as to apply greater heat to the central region 6b of the lid 6 to enlarge the outlet port.

Thus, in the powder production apparatus of Fig. 5, the flow of the molten high-purity metal discharged from the melting vessel is steadily controlled to ensure that the particle size of the product powder is controlled precisely to a constant size.

Although the invention has been described through its specific forms, it is to be understood that the described embodiments are only illustrative and not intended to limit the scope of the invention.

For instance, the term "high-purity metal" used in this specification should be understood to cover not only pure metals but also alloys and intermetallic compounds.

It is also possible to combine each of the described embodiment with a known technique in which the particle size of the atomized metal is controlled by suitably adjusting the flow rate of the gas jetted from the gas jetting devices.

Other changes and modifications are also possible within the scope of the present invention which is limited solely by the appended claims.

Claims

1. A melting vessel for melting a high-purity metal, comprising:
 - a vessel body (2) having an opening (10) of a predetermined size formed in the bottom and means (12, 20) for cooling inner surface region (8) thereof; and
 - a lid (6) closing said opening (10) and made of the same material as the high-purity metal to be molten in said vessel body (2).

2. An apparatus for melting a high-purity metal, comprising:
 - a vessel in accordance with claim 1 and
 - a beam generating device (32) disposed right above said lid (6), for applying a beam to the central portion of said lid.
3. An apparatus in accordance with claim 2 comprising:
 - port size detecting means (26) disposed under said lid (6), for detecting the size of an outlet port (6b) formed in said lid (6) by said beam.
4. An apparatus in accordance with claim 3 for producing powder of a high-purity metal, comprising:
 - a gas jetting device (18, 18a) which directs a jet of gas towards the downward stream (34) of the molten high-purity metal discharged from said vessel.
5. An apparatus in accordance with claim 2 for producing powder of a high-purity metal, comprising:
 - a gas jetting device (18, 18a) which directs a jet of gas towards the downward stream (34) of the molten high-purity metal discharged from said vessel; and
 - a particle size detecting means (40) disposed under said lid (6), for detecting the particle size of the high-purity metal powder generated by said jet of gas acting on said downward stream of the molten high-purity metal.
6. An apparatus in accordance with one of the claims 3 to 5, comprising:
 - control means (28, 30) for controlling the beam output power of said beam generating means (32) in accordance with the output from said port size detecting means (26) or from said particle size detecting means (40).
7. An apparatus in accordance with one of the claims 3 to 6, comprising:
 - control means for controlling the rate of cooling effected by said cooling means in accordance with the output from said port size detecting means (26) or from said particle size detecting means (40).
8. An apparatus according to one of the claims 2 to 7, wherein said beam generating device generates one of a laser beam, an electron beam, a plasma beam and an arc beam.

9. A method of producing a melting vessel in accordance with claim 1, comprising: preparing a vessel body (2) having an opening (10) of a predetermined size formed in the bottom and means (12, 20) for cooling inner surface region (8) thereof; 5
forming a lid (6) formed separately from said vessel body from the same material as the high-purity metal to be molten in said vessel body; and 10
fitting said lid (6) in said opening (10) to close said opening.
10. A method in accordance with claim 9, wherein the following lid forming steps are used: 15
closing said opening (10) by bringing a closure member (50) having a substantially flattened upper surface into abutment with the lower bottom surface of said vessel body (2);
melting a small amount of said high-purity metal (11) in said vessel body (2) so as to fill the recess (60) formed by said closure member (50) and the bottom wall of said vessel body (2) defining said opening (10) with the molten high-purity metal; 20
allowing the molten high-purity metal to solidify in said recess; and 25
removing said closure member from said vessel body. 30

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FIG. 1

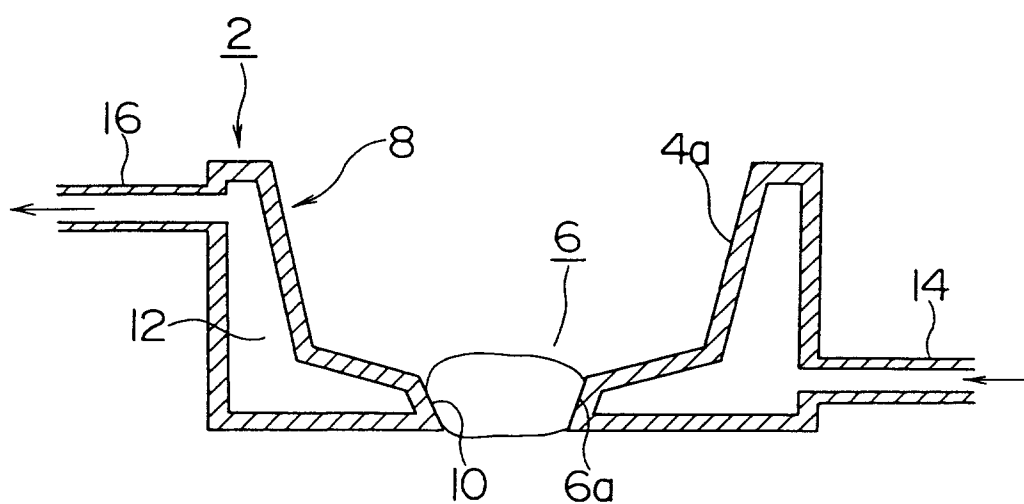


FIG. 2

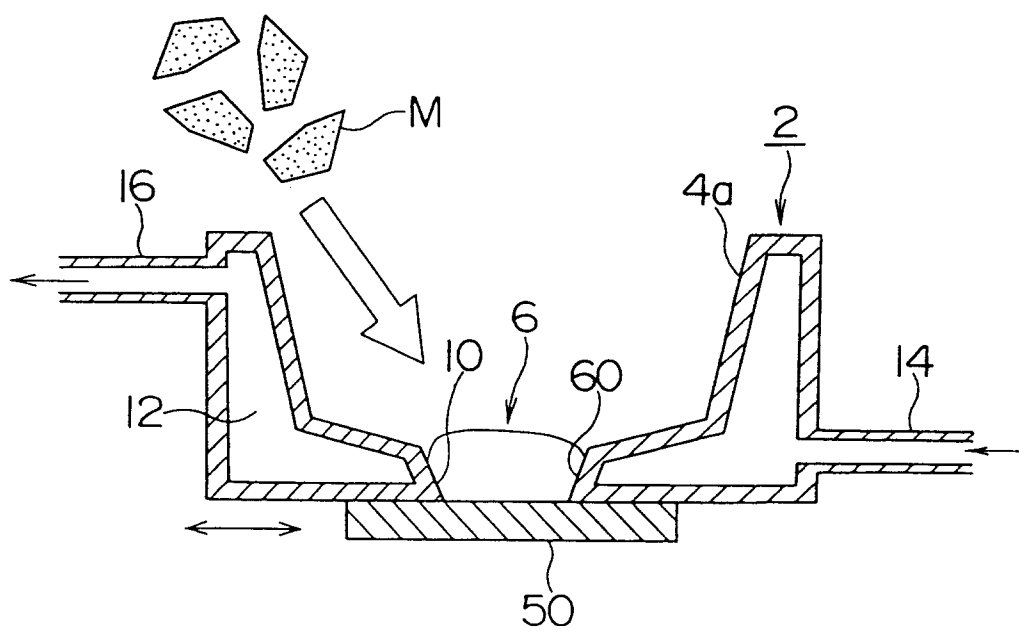


FIG. 3

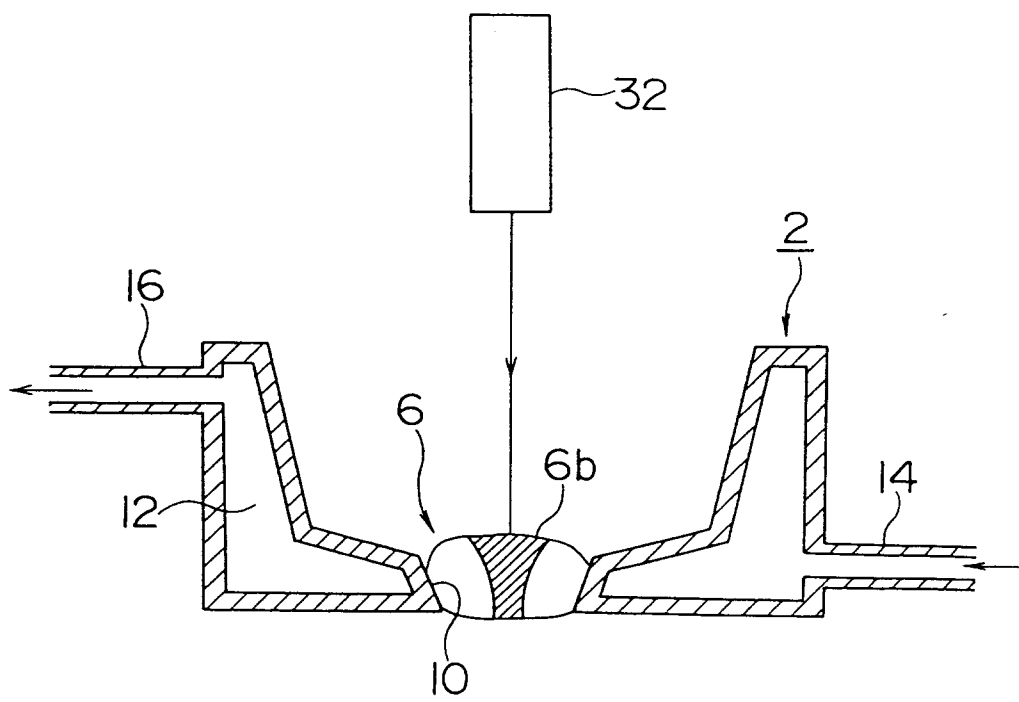


FIG. 4

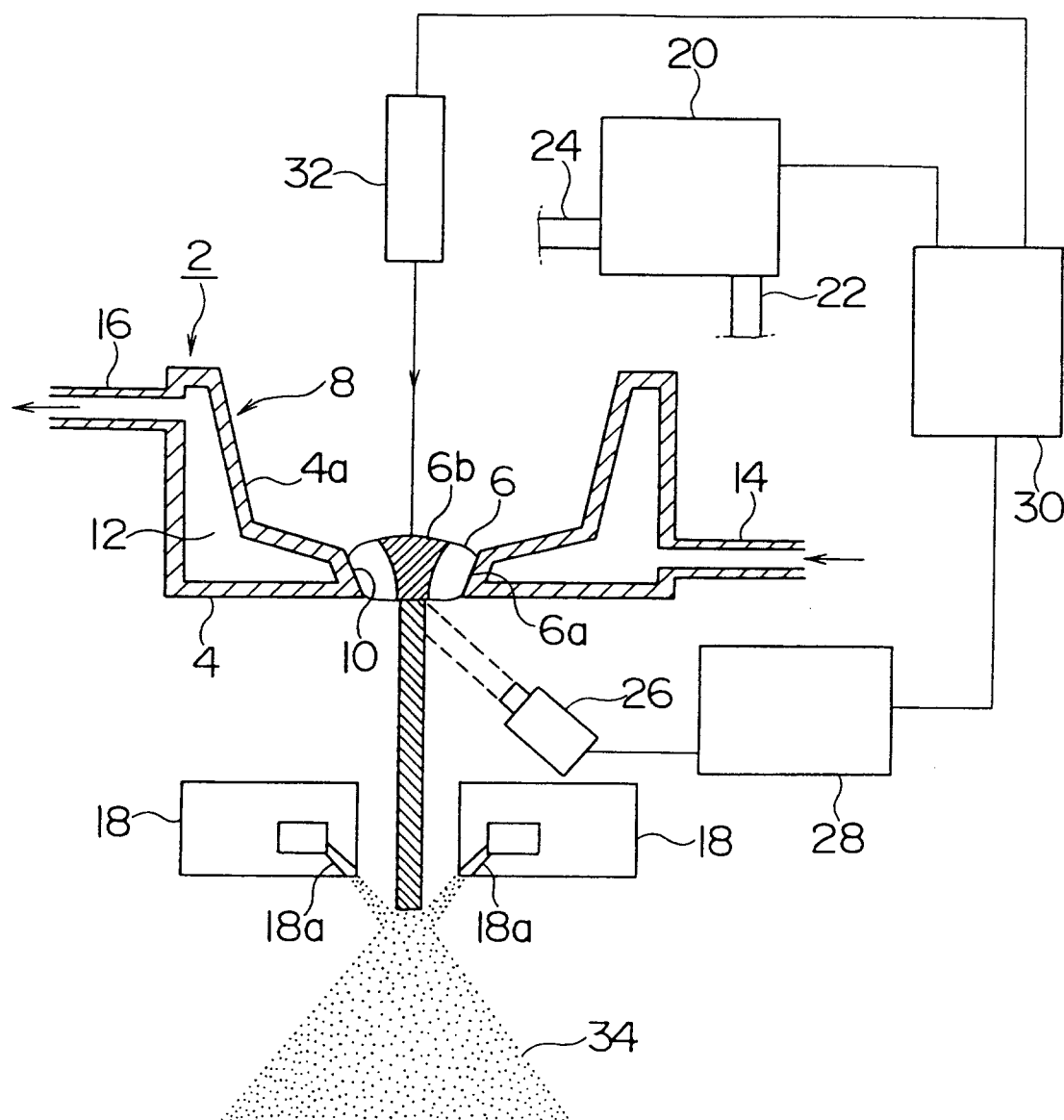


FIG. 5

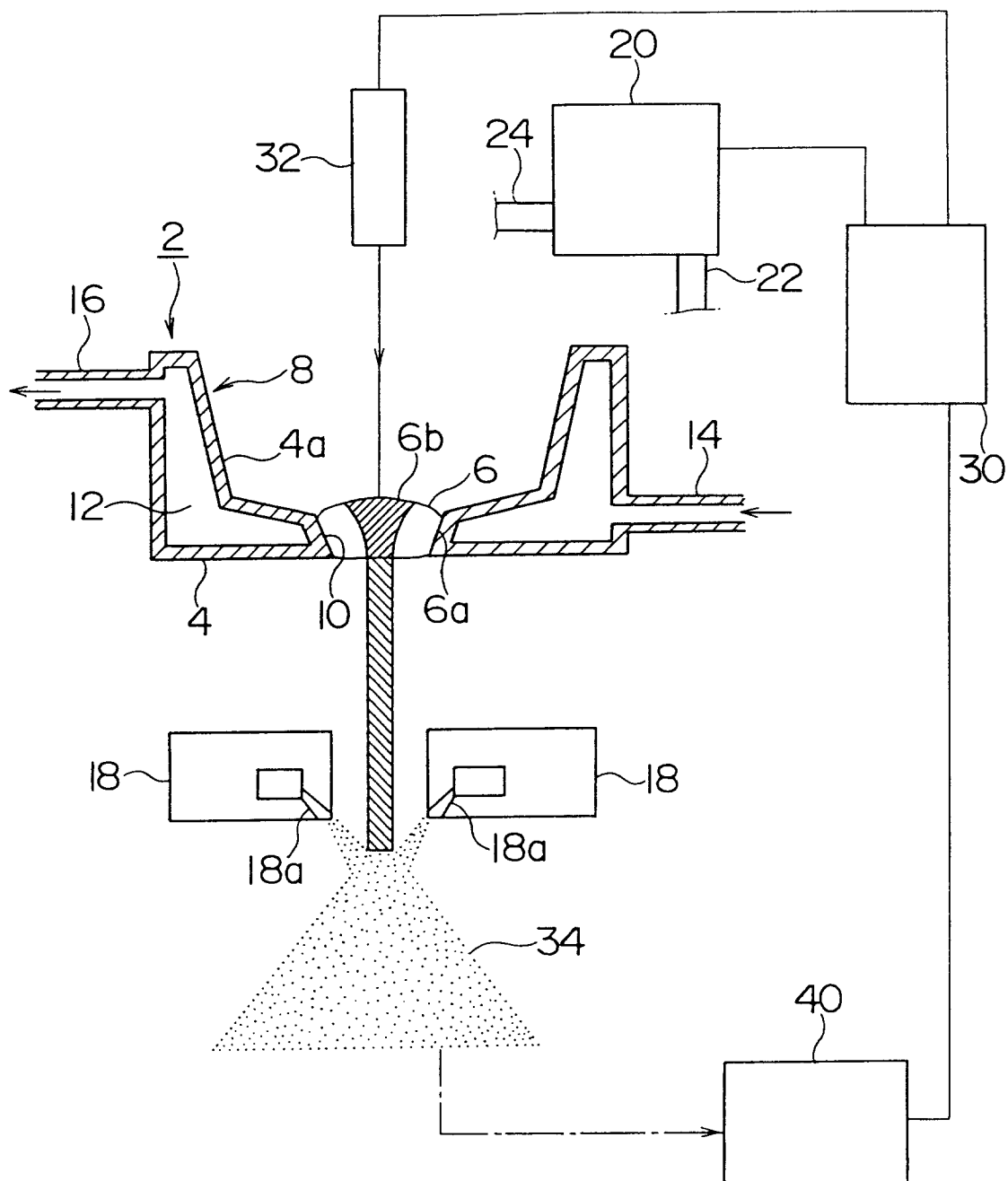
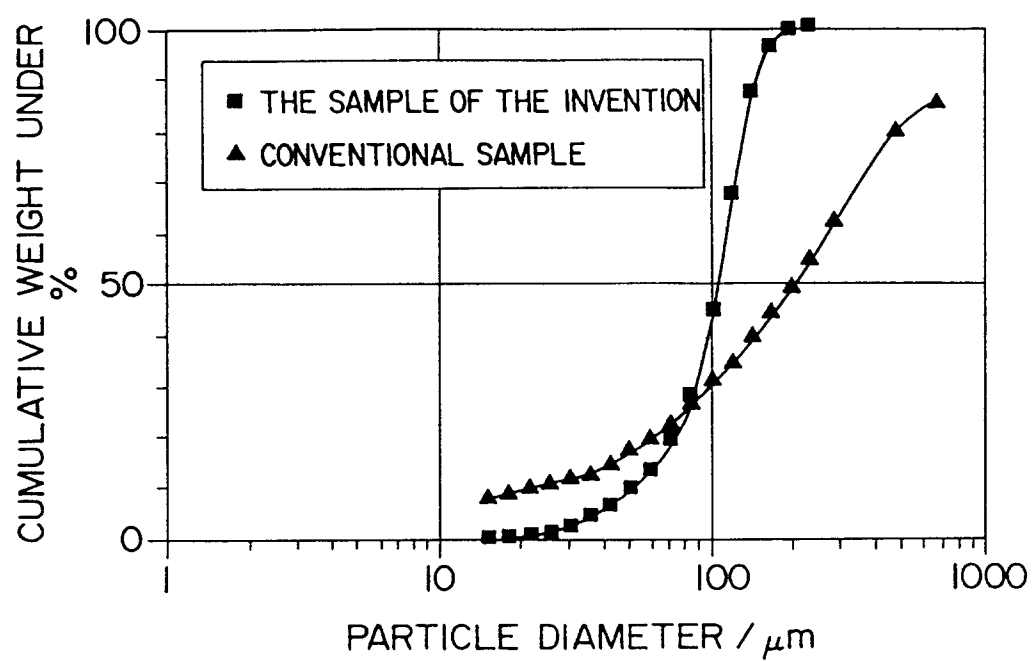


FIG. 6





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 10 8457

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	US-A-3 665 083 (CLARK)	1	B22F9/08
Y	* column 3, line 6 - line 14; figures 1-3 *	9	B22D21/00

X	EP-A-0 199 199 (GENERAL ELECTRIC COMPANY)	1	
	* column 118, line 13 - line 32; figure *		

Y	EP-A-0 420 393 (CRUCIBLE MATERIALS CORP.)	9	
A	* claim 1; figures 1,2 *	4	

A	EP-A-0 427 379 (CRUCIBLE MATERIALS CORP.)		
	* column 4, line 24 - line 36 *		

			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			B22F B22D C22B
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		29 November 1993	Ashley, G
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