(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 616 866 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **94104720.1**

(51) Int. Cl.[5]: **B22D 41/48**, B22F 9/08

(22) Date of filing: **24.03.94**

(30) Priority: **26.03.93 JP 68878/93**

(43) Date of publication of application:
28.09.94 Bulletin 94/39

(84) Designated Contracting States:
DE GB

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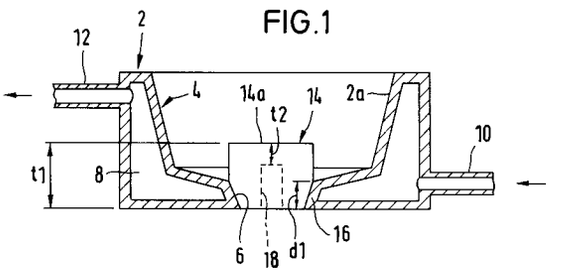
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(54) Vessel for melting a high purity metal and a method for manufacturing its stopper.

(57) A vessel body (2) has an opening (6) of a specified diameter formed in the bottom and a device for cooling an inner surface region (2a). A lid (14) made of the same material as a metal to be molten is attachably fixed to the opening (6) of the vessel body (2). The lid (14) projects upward from the opening (6) and has a cylindrical recess (18) at a lower central part.

FIG.1



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The present invention relates to a vessel for melting a high purity metal (hereinafter referred to merely as "melting vessel") which is used for producing powders of a high purity metal and in which a high purity metal is molten without contamination, and also to a method for manufacturing the same.

As a method for producing powders of a high purity metal, there have been widely used a variety of methods including a gas-atomizing method and modified methods thereof. A variety of melting vessels are at present used as the one for use with these methods, but are unsatisfactory in that they contaminate the high purity metal and cannot be used stably.

In order to overcome these problems, the inventors have developed a melting vessel including a vessel body having an opening of a specified diameter formed in the bottom and means for cooling an inner surface region, and a lid made of the same material as a metal to be molten for closing the opening of the vessel body, and have filed this invention (Japanese Patent Application No. 4-132857; EP-A-0 587 993).

When the above melting vessel is used to produce powders of a high purity metal, it is necessary to, after the metal is molten in the vessel, direct a beam such as a laser beam at the center of the lid from a beam generator arranged right above the lid, so that a portion of the lid melts to form a bore and the molten metal falls downward therethrough. However, it is difficult to form, in this vessel, the bore accurately at the center of the lid (beam directed position) for the following reasons. In order to upgrade the quality of metal powders, there has been a demand for a melting vessel in which a bore can be formed accurately in the lid.

One of the reasons which cause the bore to be formed at a position displaced from the beam directed position is the influence of the nonuniform cooling of the lid. While the beam is directed, the lid is cooled constantly through a portion thereof connected with the vessel body. It is, however, impossible to connect the lid with the vessel body perfectly uniformly over the periphery of the lid, which causes a cooling rate to vary over this periphery of the lid. Thus, the bore tends to be formed at a position displaced from the beam directed position toward the portion of the lid where the cooling rate is lower.

One of the other reasons is the requirement of a large amount of energy to melt the lid. Particularly, in the case of the metal to be molten which requires high energy to be molten, such as the one having a high melting point, a larger amount of energy is required to form the bore in the lid. Although it is desirable to direct a sufficiently large energy at one time to form the bore, an output of the beam generator is in fact limited and therefore only a limited amount of energy can be supplied to form the bore. When the energy required to form the bore is larger than the suppliable beam output, the position of the bore is subject to the nonuniform cooling of the lid and other factors, thus making it difficult to form the bore accurately at a desired position. In order to compensate for this, the depth of a molten metal bath should be reduced to an extremely low level, which is, however, disadvantageous for the production of metal powders.

In view of the problems residing in the prior art, an object of the invention is to provide a melting vessel with which a bore can be formed in a lid accurately at a position where a beam is directed, so as to upgrade the quality of produced metal powders, and to provide a method for manufacturing the melting vessel.

A melting vessel according to the invention comprises a vessel body having an opening of a specified diameter formed in the bottom and means for cooling an inner surface region; and a lid made of the same material as a metal to be molten for closing the opening of the vessel body, the lid having a thin center portion.

One of methods for manufacturing the melting vessel according to the invention comprises the steps of preparing a vessel body having an opening of a specified diameter formed in the bottom and means for cooling an inner surface region; and fittably fixing to the opening a lid made of the same material as a metal to be molten and having a thin center portion, so as to close the opening.

The other method comprises the steps of preparing a vessel body having an opening of a specified diameter formed in the bottom and means for cooling an inner surface region; closing the opening from below by a closure member having a substantially flat upper surface and a cylindrical projection projecting upward from the upper surface, such that the projection is located at the center of the opening; melting the metal in the vessel body; solidifying the molten metal whose surface level is such that the molten metal covers the projection of the closure member; and removing the closure member.

In a preferred embodiment, a vessel body with dimensions of about 250 mm diameter and 100 mm height is used with a lid, the thin portion of which has a thickness of 3 mm to 10 mm, preferably 4 to 6 mm, more preferably 5 mm with an amount of molten metal of 5 to 10 kg (Fe-base).

Hereafter, an embodiment of the invention will be described with reference to the accompanying drawings, wherein:

Fig. 1 is a schematic diagram showing a melting vessel as an embodiment of the invention;

Fig. 2 is a schematic diagram showing a method for manufacturing the melting vessel; and

Fig. 3 is a diagram showing the melting vessel in use.

In the drawings, indicated at 2 is a vessel body. The vessel body 2 is a bottom-equipped cylindrical container inside which a substantially cup-like recess 4 is formed, and is made of copper or like material. At a bottom center portion of the vessel body 2 is formed a tapered opening 6 which converges downward. In the vessel body 2 is formed a jacket space 8 which communicates with the interior of pipes 10, 12 connected to a side wall of the vessel body 2. The pipes 10, 12 are respectively connected to an unillustrated cooling water supply device. The arrangement is such that cooling water supplied through the pipe 10 cools an inner surface region 2a of the vessel body 2 and is then collected through the pipe 12.

In the opening 6 of the vessel body 2 is fittably fixed a substantially cylindrical lid 14 having a tapered lower outer peripheral surface 16, in such a manner that the surface 16 closes the opening 6 sealably. A thickness (height) t1 of the lid 14 is greater than a depth d1 of the opening 6. A cylindrical recess 18 is formed at the center of a lower part of the lid 14, so that a thickness t2 of a center portion 14a of the lid 14 is smaller than the thickness t1. The lid 14 is made of the same material as a high purity metal to be molten in the melting vessel 2 (metal to be molten).

The melting vessel according to the invention includes the vessel body 2 and the lid 14. As a method of fitting (or forming) the lid 14 to the vessel body 2, the lid 14 prefabricated in another melting furnace may be fittably fixed in the opening 6 from the inside of the vessel body 2 to close the opening 6. As another method may be used a method described hereinbelow with reference to Fig. 2.

According to the method shown in Fig. 2, the opening 6 of the vessel body 2 is closed from below by a closure member 20 having a flat upper surface 20a and a cylindrical projection 22 projecting upward from the surface 20a, such that the projection 20 is located in the middle of the opening 6 (a state shown in Fig. 2). Subsequently, a small amount of metal M to be molten is introduced into the vessel body 2. The introduced metal M is molten by means of, for example, application of a voltage between the vessel body 2 and the metal M while cooling the vessel body 2 and the closure member 20. The level of the molten metal in the vessel body 2 is set such that the projection 22 is covered by the molten metal (e.g., the level indicated by a one-dot-chain line P in Fig. 2). In this state, the molten metal M is solidified. If the closure member 20 is removed from the vessel body 2 thereafter, there remains a lid projecting from the opening 6. The lid formed according to this method is different from the lid 14 shown in Fig. 1 in the shape of an upper part, but is similar to the lid 14 in that it projects upward from the opening 6 and a cylindrical recess is formed at the center of a lower part. When a high purity metal (metal to be molten) is molten in this melting vessel, the metal is introduced into this vessel, and is molten by applying a voltage between the vessel body 2 and the metal or other method, while cooling the vessel body 2.

At this time, a portion of the molten metal contacting the inner surface region 2a of the vessel body 2 is cooled to solidify, thereby forming a thin solidified metal layer covering entirely over the inner surface region 2a. This solidified metal layer is stably held so long as the vessel body 2 is cooled. Since this layer is made of the same material as the metal to be molten, there is no risk that the metal constituting the vessel body 2 is molten and dissolved to contaminate the molten metal. The lid 14 fitted to the vessel body 2 is hardly molten since it is also cooled by the vessel body 2. Although an upper part of the lid 14 may be molten, it will never contaminate the molten metal since the lid 14 is made of the same material as the metal to be molten.

When thus molten metal in the melting vessel should be caused to fall downward from the vessel so as to produce metal powders, a beam generator 24 disposed right above the lid 14 may be used, as shown in Fig. 3, to direct a beam at the center portion 14a of the lid 14. The beam generator 24 generates a laser beam, electron beam, plasma beam, or the like. The beam melts a part of the portion 14a (oblique lined part in Fig. 3) to form a bore therein. The molten metal is then allowed to fall downward through this bore.

Since the center portion 14a is thinned by forming the recess 18, the energy required to melt the center portion 14a can be certainly reduced compared to the conventional melting vessels. Further, since the part of the lid 14 to be molten (oblique lined part in Fig. 3) is away from a portion of the lid 14 in contact with the opening 6, the influence of the nonuniform cooling at the periphery of the lid 14 can be also reduced compared to the conventional melting vessels. Thus, the bore can be formed accurately at a beam directed position, thereby upgrading the quality of metal powders to be produced. It goes without saying that the same effect is also obtainable when the lid fabricated according to the method shown in Fig. 2 is used.

Although the lid projects upward from the opening of the vessel body in the foregoing embodiment, the shape of the lid should not be nec-

essarily such. For example, when the depth of the opening is large, the lid may be in line with the upper end of the opening.

A recess may be formed at the center of the upper part of the lid, instead of at the center of the lower part thereof. Further, the center portion of the lid may be thinned by forming recesses at the center of both the upper and lower parts of the lid. When the lid is so formed as to have a recess at the center of the upper part, the lid prefabricated into such a shape may be fixed fittably to the opening from the inside of the vessel body.

It will be appreciated that the term "high-purity metal" in this specification covers compounds including alloys, intermetallic compounds, and ceramics.

As described above, according to the invention, an energy required to form a bore in a lid can be reduced; the influence of the nonuniform cooling at the periphery of the lid can be reduced; the bore can be formed accurately at a beam directed position; and the quality of metal powders to be produced can be upgraded.

LIST OF REFERENCE NUMERALS

2	Vessel Body
6	Opening
14	Lid
18	Recess
20	Closure
22	Projection

Claims

1. A vessel for melting a high purity metal, comprising:

a vessel body (2) having an opening (6) of a specified diameter formed in the bottom and means (8, 10, 12) for cooling an inner surface region (2a); and a lid (14) made of the same material as a metal to be molten for fittably closing the opening (6) of the vessel body (2), the lid (14) having a thin (t2) portion (14a) which is located on or near a center line crossing the center of the opening (6) and at a predetermined minimum distance from the periphery of the lid (14).

2. A vessel according to claim 1 in which the thin (t2) portion (14a) leaves a recess extending over the remaining height (t1-t2) of the lid (14), the diameter of which is smaller than that of the opening (6), the recess or the thin (t2) portion (14a) being located within the opening (6) with their outer periphery having a predetermined distance from the periphery of the opening (6).

3. A vessel according to claim 1 or 2 in which the center of the thin (t2) portion (14a) is located on or near the center line.

4. A vessel according to one or more of claims 1-3 in which, in the closing position of the lid (14), the thin (t2) portion (14a) is provided in the upper thereof.

5. A vessel according to one or more of claims 1-4 in which, along the center line, the thickness (t2) of the thin portion (14a) is less than a half, preferably less than one third of the thickness (t1) of the lid (14).

6. A vessel according to claim 5 in which the thin portion (14a) has a thickness (t2) of 3 to 10 mm, preferably 4 to 6 mm, and most preferably 5 mm on the basis of vessel body dimensions of about 250 mm diameter and 100 mm height and the use of about 5 to 10 kg molten metal.

7. A vessel according to claim 5 or 6 in which the thickness (t2) of the thin portion (14a) is determined so that it may be molten by a plasma beam of 1300 to 1500 A.

8. A method for manufacturing a lid (14) fitting into an opening (6) of a vessel according to one or more of claims 1-6, comprising the steps of:

closing the opening (6) from below by a closure member (20) having a substantially flat upper surface (20a) and a cylindrical projection (22) projecting upward from the upper surface, such that the projection (22) is located at the center of the opening (6);

melting the metal (M) in the vessel body (2);

solidifying the molten metal whose surface level (P) is such that the molten metal covers the projection (22) of the closure member (20); and

removing the closure member (20).

FIG.1

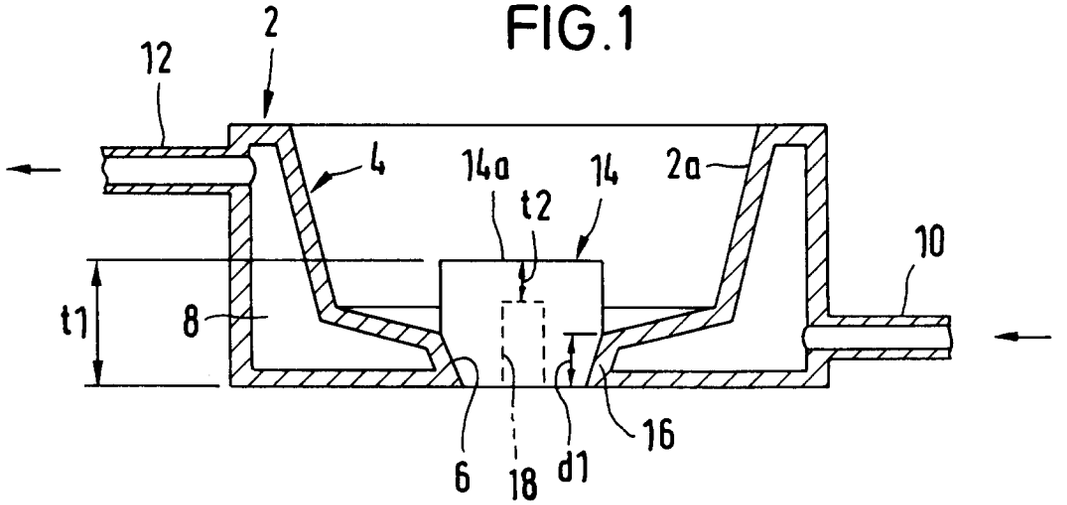


FIG.2

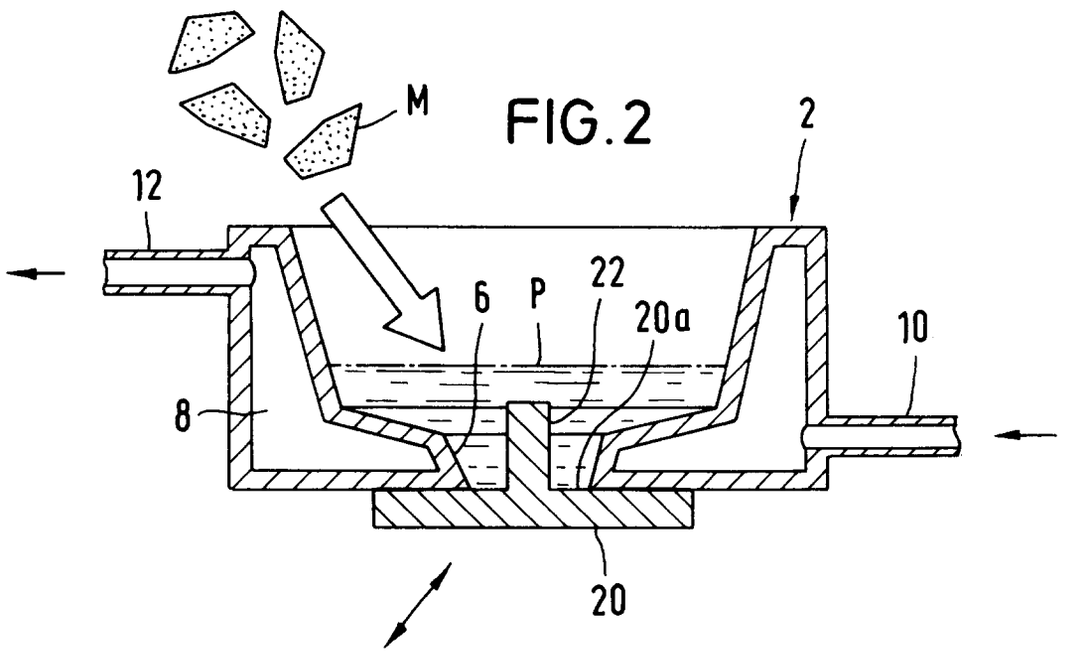
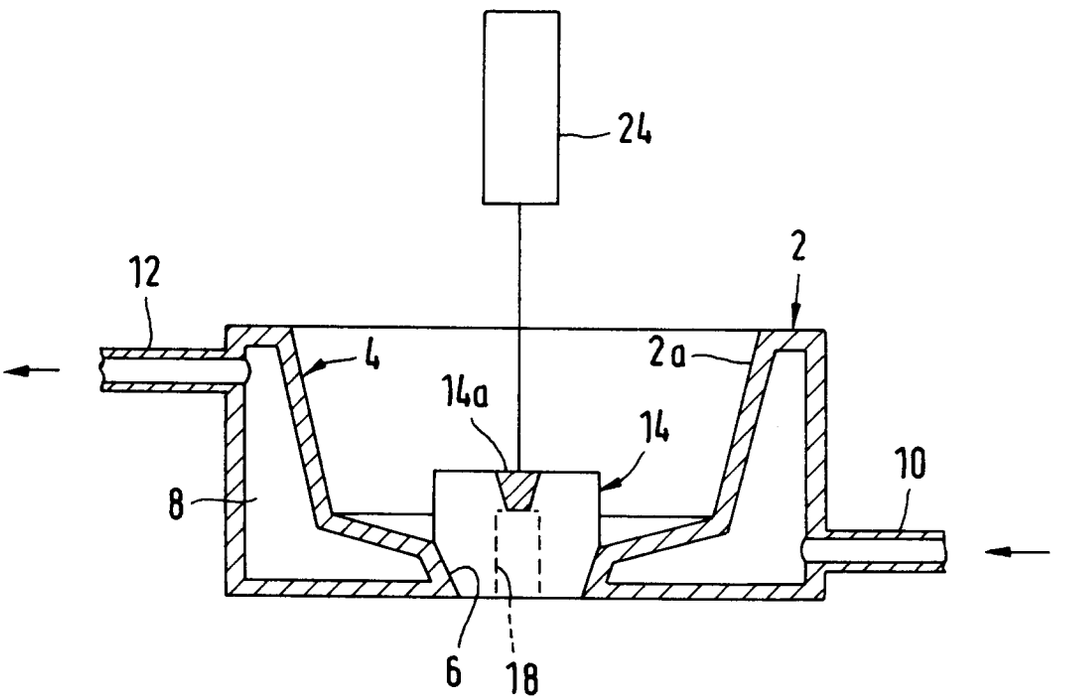


FIG. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 94 10 4720

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	FR-A-678 106 (J.M.R.SINNIGER) * page 2, line 21 - line 28; figure * * abstract *	1-5	B22D41/48 B22F9/08
X	EP-A-0 080 087 (MANNESMANN REXROTH) * claim 4 *	1-5	
A	GB-A-1 235 374 (CONSOLIDUS LTD) * page 2, line 1 - line 4; claim 2 *	1-5	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)
B22D B22F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 July 1994	Schruers, H

CATEGORY OF CITED DOCUMENTS

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