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(54) Title: REMOVABLE UPPER PORTIONS OF LADLES, LADLES INCLUDING THE SAME, AND RELATED SYSTEMS
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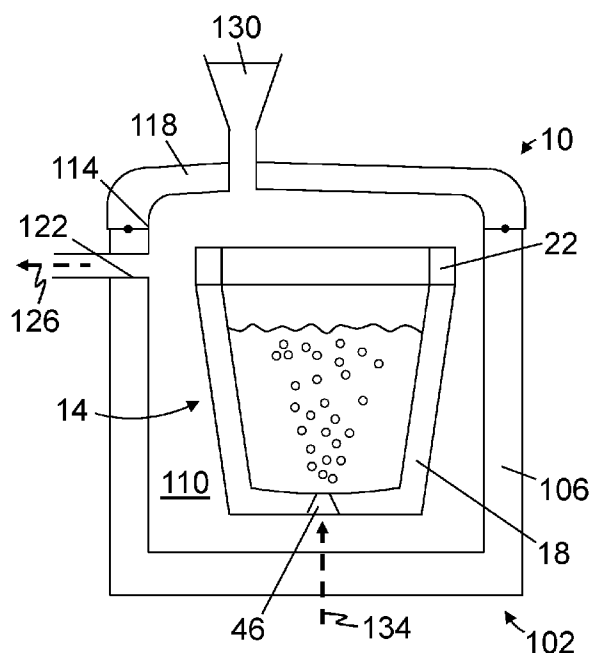


FIG. 2

(57) Abstract: This disclosure includes removable upper portions of ladles (e.g., ladle extensions), ladles including the same, and related methods for use in molten metal processing. Some removable upper portions of ladles include an open bottom end, a top end, and a sidewall extending between the bottom end and the top end, wherein the bottom end of the upper portion is configured to be removably coupled to an open top end of a lower portion of a ladle, the lower portion further including a closed bottom end and a sidewall extending between the top end and the bottom end, such that, when molten metal is disposed within the lower portion, the upper portion increases the freeboard of the ladle.

**REMOVABLE UPPER PORTIONS OF LADLES, LADLES INCLUDING THE
SAME, AND RELATED SYSTEMS AND METHODS FOR USE IN MOLTEN
METAL PROCESSING**

5 **CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application claims the benefit of priority of U.S. Provisional Patent Application No. 62/340,274, filed May 23, 2016, which is hereby incorporated by reference in its entirety.

BACKGROUND

10 **1. Field of Invention**

[0002] The present invention relates generally to molten metal processing, and more specifically, but not by way of limitation, to removable upper portions of ladles (e.g., ladle extensions), ladles including the same, and related systems and methods for use in molten metal processing, such as, for example, vacuum degassing.

15 **2. Description of Related Art**

[0003] Vacuum degassing is a common metallurgical process in which molten metal (e.g., steel, iron, aluminum, and/or the like) disposed within a ladle is exposed to vacuum. In some instances, vacuum degassing may be enhanced by passing inert gases through the molten metal (e.g., to displace reactive gases within the molten metal, encourage mixing of the
20 molten metal, and/or the like). Vacuum degassing can be advantageously performed to remove reactive gases, such as hydrogen, and/or undesired trace elements from molten metal, as well as limit oxidation of reactive elements and/or the formation of non-metallic oxide inclusion within the molten metal, which can ultimately provide for a better casting using the molten metal.

25 [0004] During vacuum degassing, molten metal within a ladle may be subject to splashing. To account for such splashing, often times a freeboard, or a distance between the surface of the molten metal and the top of the ladle, needs to be relatively large. For example, in some instances, a freeboard appropriate for vacuum degassing may be 25% or more of the otherwise usable depth of the ladle.

30 **SUMMARY**

[0005] Certain molten metal processing techniques, such as vacuum degassing, may impose a limitation on usable volume of a ladle, thereby limiting an amount of molten metal

that can be otherwise transported, processed, and/or the like using the ladle. Some embodiments of the present ladle upper portions (e.g., ladle extensions) can be removably coupled to a ladle lower portion to provide for a (e.g., temporary) increase of the freeboard of the ladle, allowing for such molten metal processing techniques without unduly limiting an amount of molten metal that can be otherwise transported, processed, and/or the like using the ladle.

[0006] The term “coupled” is defined as connected, although not necessarily directly, and not necessarily mechanically; two items that are “coupled” may be unitary with each other. The terms “a” and “an” are defined as one or more unless this disclosure explicitly requires otherwise. The term “substantially” is defined as largely but not necessarily wholly what is specified (and includes what is specified; e.g., substantially 90 degrees includes 90 degrees and substantially parallel includes parallel), as understood by a person of ordinary skill in the art. In any disclosed embodiment, the terms “substantially” and “approximately” may be substituted with “within [a percentage] of” what is specified, where the percentage includes .1, 1, 5, and 10 percent. “Approximately” may refer to a range around what is specified, within which the functionality of what is specified would not be impaired.

[0007] Further, a device or system that is configured in a certain way is configured in at least that way, but it can also be configured in other ways than those specifically described.

[0008] The terms “comprise” (and any form of comprise, such as “comprises” and “comprising”), “have” (and any form of have, such as “has” and “having”), and “include” (and any form of include, such as “includes” and “including”) are open-ended linking verbs. As a result, an apparatus that “comprises,” “has,” or “includes” one or more elements possesses those one or more elements, but is not limited to possessing only those elements. Likewise, a method that “comprises,” “has,” or “includes” one or more steps possesses those one or more steps, but is not limited to possessing only those one or more steps.

[0009] Any embodiment of any of the apparatuses, systems, and methods can consist of or consist essentially of – rather than comprise/have/include – any of the described steps, elements, and/or features. Thus, in any of the claims, the term “consisting of” or “consisting essentially of” can be substituted for any of the open-ended linking verbs recited above, in order to change the scope of a given claim from what it would otherwise be using the open-ended linking verb.

[0010] The feature or features of one embodiment may be applied to other embodiments, even though not described or illustrated, unless expressly prohibited by this disclosure or the nature of the embodiments.

[0011] Some details associated with the embodiments described above and others are described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The following drawings illustrate by way of example and not limitation. For the sake of brevity and clarity, every feature of a given structure is not always labeled in every figure in which that structure appears. Identical reference numbers do not necessarily indicate an identical structure. Rather, the same reference number may be used to indicate a similar feature or a feature with similar functionality, as may non-identical reference numbers. The figures are drawn to scale (unless otherwise noted), meaning the sizes of the depicted elements are accurate relative to each other for at least the embodiment depicted in the figures.

[0013] FIGs. 1A and 1B are schematic side views of one embodiment of the present ladles, including one embodiment of the present ladle extensions.

[0014] FIG. 1C is a schematic top view of the ladle of FIGs. 1A and 1B.

[0015] FIG. 2 is a schematic side view of one embodiment of the present systems for vacuum degassing of molten metal, which may be suitable for use with the ladle of FIGs. 1A and 1B.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0016] FIGs. 1A-1C are schematic views of one embodiment 14 of the present ladles, including one embodiment 22 of the present ladle extensions. Ladle 14 can be a vessel used for receiving, transporting, processing, pouring, and/or the like molten metal. As shown, ladle 14 can include a lower portion 18 and an upper portion 22, sometimes referred to as a ladle extension, that can be removably coupled to the lower portion (described in more detail below). Lower portion 18 can include a sidewall 26 that extends between a top end 30 and a bottom end 34 to define an interior volume 38. Top end 30 of lower portion 18 can be open; for example, the top end can define an opening 42 in communication with interior volume 38 and through which molten metal can be provided to and from the interior volume. Bottom end 34 of lower portion 18 can be closed in that the bottom end is impermeable to molten metal; nevertheless, portion(s) of the closed bottom end, such as porous plug 46, can be permeable to gas (e.g., to facilitate vacuum degassing, as described in more detail below). Lower portion 18 can be sized to hold any suitable amount of molten metal, such as, for example, approximately 160 tons of molten steel. Lower portion 18 can comprise any

suitable material, such as, for example, steel, and can include a refractory material (e.g., a refractory lining disposed on an inner surface of sidewall 26 and/or top end 30), such as, for example, alumina, magnesia, silica, and/or the like. In some embodiments, a lower portion (e.g., 18) can be a conventional ladle.

5 **[0017]** Upper portion 22 of ladle 14 can have a sidewall 50 extending between a bottom end 54 and a top end 58 to define an interior volume 62. Bottom end 54 of upper portion 22 can be open in that the bottom end defines an opening 66 in communication with interior volume 62. Similarly, top end 58 of upper portion 22 can be open in that the top end defines an opening 70 in communication with interior volume 62. As shown, bottom end 54 and top
10 end 58 of upper portion 22 each define a single opening, 66 and 70, respectively; however, in other embodiments, an upper portion (e.g., 22) can include a bottom end (e.g., 54) and a top end (e.g., 58), each defining any suitable number of openings (e.g., 66, 70), such as, for example, 2, 3, 4, 5, 6, 7, 8, 9, 10, or more openings. Upper portion 22 can extend any suitable height 74 between bottom end 54 and top end 58, such as, for example, from 20 to 50
15 centimeters (cm), which can be selected based upon a desired amount of freeboard to be added to ladle 14 when the upper portion is coupled to lower portion 18. As shown, upper portion 22 has a circular outer perimeter (FIG. 1C) (e.g., which corresponds to a circular outer perimeter of lower portion 18); however, in other embodiments, an upper portion (e.g., 22) can have any suitable shape, such as, for example, having an outer perimeter that is
20 square, rectangular, or otherwise polygonal, elliptical, or otherwise rounded. Upper portion 22 can comprise any suitable material, such as, for example, steel, and can include a refractory material (e.g., a refractory lining disposed on an inner surface of sidewall 50, top end 58, bottom end 54, and/or the like), which can facilitate removal of the upper portion from lower portion 18.

25 **[0018]** As discussed above, upper portion 22 of ladle 14 can be removably coupled to lower portion 18 of the ladle such that, when molten metal is disposed within the lower portion, the upper portion increases the freeboard of the ladle (e.g., from 78a to 78b, as shown in FIG. 1B). Upper portion 22 can be removably coupled to lower portion 18 such that, for example, bottom end 54 of the upper portion is coupled to top end 30 of the lower
30 portion, sidewall 50 of the upper portion contributes to the freeboard of ladle 14, at least a portion of an inner surface 82 of sidewall 50 of the upper portion is substantially flush with at least a portion of an inner surface 86 of sidewall 26 of the lower portion, interior volume 62 of the upper portion is in communication with interior volume 38 of the lower portion, and/or the like. Such removable coupling between an upper portion (e.g., 22) and a lower portion

(e.g., 18) can be accomplished in any suitable fashion, such as, for example, via fastener(s) (e.g., pins), engaging features of the upper portion and the lower portion (e.g., projection(s) of one of the upper portion and the lower portion that are receivable by recess(es) of the other of the upper portion and the lower portion), a weight of the upper portion (e.g., the upper portion can rest on the lower portion), hinge(s), clamp(s), and/or the like.

[0019] Bottom end 54 of upper portion 22 can have opening(s) (e.g., 66) that correspond to (e.g., having substantially similar shape(s), dimension(s), and/or the like as) opening(s) (e.g., 42) of top end 30 of lower portion 18. For example, opening 66 of bottom end 54 of upper portion 22 can have a maximum first transverse dimension 90, opening 42 of top end 30 of lower portion 18 can have a maximum second transverse dimension 94, and the first transverse dimension can be substantially equal to the second transverse dimension. Upper portion 22 can extend a first height (e.g., height 74) between bottom end 54 and top end 58, lower portion 18 can extend a second height 98 between bottom end 34 and top end 30, and the first height can be 5, 10, 15, 20, 25, 30, 35, 40%, or more (e.g., from 10 to 30%) of the second height. In these ways and others, upper portion 22 can be removably coupled to lower portion 18 to provide for a (e.g., temporary) increase of the freeboard of ladle 14, allowing the ladle to be used in molten metal processing techniques that may require an increased freeboard, such as vacuum degassing, without unduly limiting an amount of molten metal that can be otherwise transported, processed, and/or the like using the ladle.

[0020] Referring now to FIG. 2, shown is a schematic view of one embodiment 10 of the present systems for vacuum degassing of molten metal, which may be suitable for use with ladle 14. System 10 can include a vacuum chamber 102 within which ladle 14 can be disposed such that the vacuum chamber can be used to vacuum degas molten metal disposed within the ladle. For example, vacuum chamber 102 can include a housing 106 defining an interior volume 110 and an opening 114 through which ladle 14, or at least lower portion 18 thereof, can be passed through the housing and into the interior volume. Vacuum chamber 102 can include a cover 118 (e.g., a lid) that can be (e.g., removably, pivotally, and/or slidably) coupled to housing 106 to cover and seal opening 114. Vacuum chamber 102 can include a port 122 through which fluid may be communicated (e.g., generally along a direction indicated by arrow 126), for example, using a vacuum pump, to reduce an internal pressure within interior volume 110. As shown, vacuum chamber 102 can include a hopper 130 through which additives, such as alloying additives, can be provided to molten metal disposed within interior volume 110.

[0021] As described above, ladle 14, and more particularly, lower portion 18, can include a porous plug 46 through which inert gas(ses), such as, for example, argon, helium, and/or the like, can be supplied (e.g., generally along a direction indicated by arrow 134) to molten metal disposed within the lower portion. In this way, reactive gas(ses), such as, for example, oxygen, carbon dioxide, and/or the like within the molten metal may be displaced by such inert gas(ses), mixing of the molten metal can be encouraged, and/or the like, thereby facilitating the vacuum degassing process.

[0022] In some embodiments, an upper portion (e.g., 22) of a ladle (e.g., 14) can be a component of a vacuum chamber (e.g., 102). For example, in some embodiments, an upper portion (e.g., 22) of a ladle (e.g., 14) can be coupled to a vacuum chamber (e.g., 102) such that, for example, when a lower portion (e.g., 18) of the ladle is disposed within an interior volume (e.g., 110) of the vacuum chamber such that vacuum degassing of molten metal disposed within the lower portion can be performed, the upper portion is coupled to the lower portion, and, in such embodiments, the upper portion can remain coupled to the vacuum chamber after the lower portion is removed from the interior volume. To illustrate, in some embodiments, an upper portion (e.g., 22) of a ladle (e.g., 14) can be coupled to a cover (e.g., 118) of a vacuum chamber (e.g., 102) such that, for example, when a lower portion (e.g., 18) of the ladle is disposed within an interior volume (e.g., 110) of the vacuum chamber, placement of the cover to seal at least a portion of the vacuum chamber may couple the upper portion to the lower portion.

[0023] Some embodiments of the present methods for processing molten metal disposed within a lower portion (e.g., 18) of a ladle (e.g., 14), the lower portion including a closed bottom end (e.g., 34), an open top end (e.g., 30), and a sidewall (e.g., 26) extending between the bottom end and the top end, comprise coupling an open bottom end (e.g., 54) of an upper portion (e.g., 22) of the ladle to the top end of the lower portion, the upper portion further including a top end (e.g., 58) and a sidewall (e.g., 50) extending between the bottom end and the top end, wherein the coupling is performed such that the upper portion increases the freeboard of the ladle (e.g., from 78a to 78b, as shown in FIG. 1B). Some methods comprise removing the upper portion from the lower portion.

[0024] Some methods comprise, after the coupling of the upper portion to the lower portion is performed, applying vacuum (e.g., using vacuum chamber 102) to the molten metal. Some methods comprise passing a gas, such as, for example, an inert gas, through the molten metal. Some methods comprise removing the upper portion from the lower portion after the applying vacuum to the molten metal is performed.

[0025] Some embodiments of the present apparatuses comprise a removable upper portion of a ladle, the upper portion including: an open bottom end, a top end, and a sidewall extending between the bottom end and the top end, wherein the bottom end of the upper portion is configured to be removably coupled to an open top end of a lower portion of a ladle, the lower portion further including a closed bottom end and a sidewall extending between the top end and the bottom end, such that, when molten metal is disposed within the lower portion, the upper portion increases the freeboard of the ladle. Some apparatuses comprise the lower portion of the ladle.

[0026] Some embodiments of the present apparatuses include a ladle comprising: a lower portion having a closed bottom end, an open top end, and a sidewall extending between the bottom end and the top end, and an upper portion having an open bottom end, a top end, and a sidewall extending between the bottom end and the top end, wherein the bottom end of the upper portion is configured to be removably coupled to the top end of the lower portion such that, when molten metal is disposed within the lower portion, the upper portion increases the freeboard of the ladle.

[0027] In some embodiments, the lower portion is sized to hold approximately 160 tons of molten metal. In some embodiments, the top end of the upper portion is open. In some embodiments, the upper portion extends a height between the bottom end and the top end that is from 20 to 50 centimeters (cm). In some embodiments, the upper portion comprises a refractory material. In some embodiments, the refractory material comprises at least one of: alumina, silica, and magnesia.

[0028] In some embodiments, the upper portion extends a first height between the bottom end and the top end, the lower portion extends a second height between the bottom end and the top end, and the first height is from 10 to 30% of the second height. In some embodiments, the bottom end of the upper portion defines an opening having a maximum first transverse dimension, the top end of the lower portion defines an opening having a maximum second transverse dimension, and the first transverse dimension is substantially equal to the second transverse dimension. In some embodiments, when the upper portion is coupled to the lower portion, an inner surface of the sidewall of the upper portion is substantially flush with an inner surface of the sidewall of the lower portion.

[0029] Some embodiments comprise a vacuum chamber, wherein the ladle is configured to be disposed within the vacuum chamber.

[0030] Some embodiments of the present methods for processing molten metal disposed within a lower portion of a ladle, the lower portion including a closed bottom end, an open

top end, and a sidewall extending between the bottom end and the top end, comprise: coupling an open bottom end of an upper portion of the ladle to the top end of the lower portion, the upper portion further including a top end and a sidewall extending between the bottom end and the top end, wherein the coupling is performed such that the upper portion
5 increases the freeboard of the ladle. Some embodiments comprise removing the upper portion from the lower portion.

[0031] Some embodiments comprise, after the coupling the upper portion to the lower portion is performed, applying vacuum to the molten metal. Some embodiments comprise passing a gas through the molten metal. Some embodiments comprise removing the upper
10 portion from the lower portion after the applying vacuum to the molten metal is performed.

[0032] The above specification and examples provide a complete description of the structure and use of illustrative embodiments. Although certain embodiments have been described above with a certain degree of particularity, or with reference to one or more individual embodiments, those skilled in the art could make numerous alterations to the disclosed embodiments without departing from the scope of this invention. As such, the
15 various illustrative embodiments of the methods and systems are not intended to be limited to the particular forms disclosed. Rather, they include all modifications and alternatives falling within the scope of the claims, and embodiments other than the one shown may include some or all of the features of the depicted embodiment. For example, elements may be omitted or combined as a unitary structure, and/or connections may be substituted. Further, where
20 appropriate, aspects of any of the examples described above may be combined with aspects of any of the other examples described to form further examples having comparable or different properties and/or functions, and addressing the same or different problems. Similarly, it will be understood that the benefits and advantages described above may relate
25 to one embodiment or may relate to several embodiments.

[0033] The claims are not intended to include, and should not be interpreted to include, means-plus- or step-plus-function limitations, unless such a limitation is explicitly recited in a given claim using the phrase(s) “means for” or “step for,” respectively.

CLAIMS

1. An apparatus comprising a removable upper portion of a ladle, the upper portion including:
an open bottom end;
a top end; and
a sidewall extending between the bottom end and the top end;
wherein the bottom end of the upper portion is configured to be removably coupled to
an open top end of a lower portion of a ladle, the lower portion further
including a closed bottom end and a sidewall extending between the top end
and the bottom end, such that, when molten metal is disposed within the lower
portion, the upper portion increases the freeboard of the ladle.
2. The apparatus of claim 1, comprising the lower portion of the ladle.
3. An apparatus including a ladle comprising:
a lower portion having:
a closed bottom end;
an open top end; and
a sidewall extending between the bottom end and the top end; and
an upper portion having:
an open bottom end;
a top end; and
a sidewall extending between the bottom end and the top end;
wherein the bottom end of the upper portion is configured to be removably coupled to
the top end of the lower portion such that, when molten metal is disposed
within the lower portion, the upper portion increases the freeboard of the ladle.
4. The apparatus of claim 2 or 3, wherein, when the upper portion is coupled to the
lower portion, an inner surface of the sidewall of the upper portion is substantially
flush with an inner surface of the sidewall of the lower portion.

5. The apparatus of any of claims 2-4, wherein:
the bottom end of the upper portion defines an opening having a maximum first transverse dimension;
the top end of the lower portion defines an opening having a maximum second transverse dimension; and
the first transverse dimension is substantially equal to the second transverse dimension.
6. The apparatus of any of claims 2-5, wherein:
the upper portion extends a first height between the bottom end and the top end;
the lower portion extends a second height between the bottom end and the top end;
and
the first height is from 10 to 30% of the second height.
7. The apparatus of any of claims 2-6, wherein the lower portion is sized to hold approximately 160 tons of molten metal.
8. The apparatus of any of claims 2-7, comprising:
a vacuum chamber;
wherein the ladle is configured to be disposed within the vacuum chamber.
9. The apparatus of any of claims 1-8, wherein the top end of the upper portion is open.
10. The apparatus of any of claims 1-9, wherein the upper portion extends a height between the bottom end and the top end that is from 20 to 50 centimeters (cm).
11. The apparatus of any of claims 1-10, wherein the upper portion comprises a refractory material.
12. The apparatus of claim 11, wherein the refractory material comprises at least one of: alumina, silica, and magnesia.

13. A method for processing molten metal disposed within a lower portion of a ladle, the lower portion including a closed bottom end, an open top end, and a sidewall extending between the bottom end and the top end, the method comprising:
coupling an open bottom end of an upper portion of the ladle to the top end of the lower portion, the upper portion further including:
a top end; and
a sidewall extending between the bottom end and the top end;
wherein the coupling is performed such that the upper portion increases the freeboard of the ladle.
14. The method of claim 13, comprising removing the upper portion from the lower portion.
15. The method of claim 13, comprising, after the coupling the upper portion to the lower portion is performed, applying vacuum to the molten metal.
16. The method of claim 15, comprising passing a gas through the molten metal.
17. The method of claim 15 or 16, comprising removing the upper portion from the lower portion after the applying vacuum to the molten metal is performed.

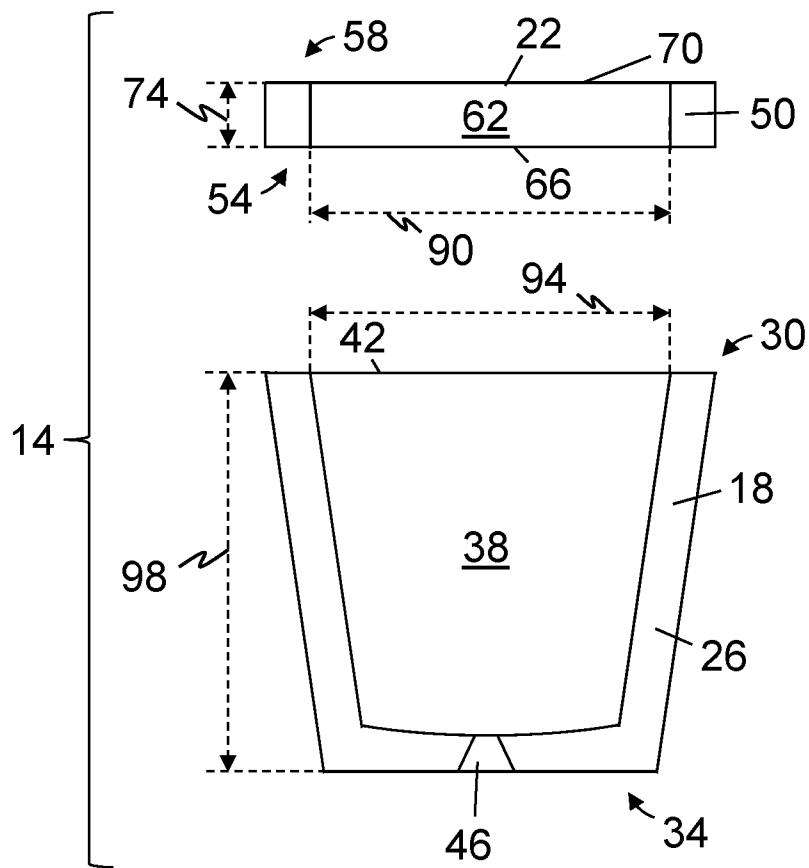


FIG. 1A

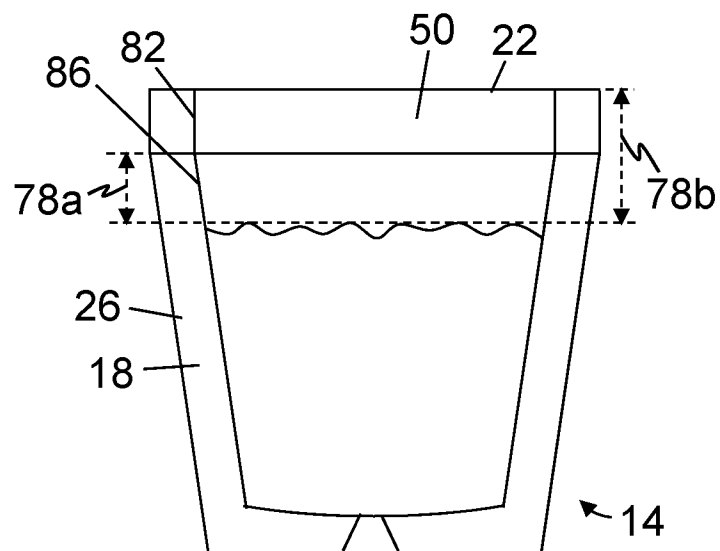


FIG. 1B

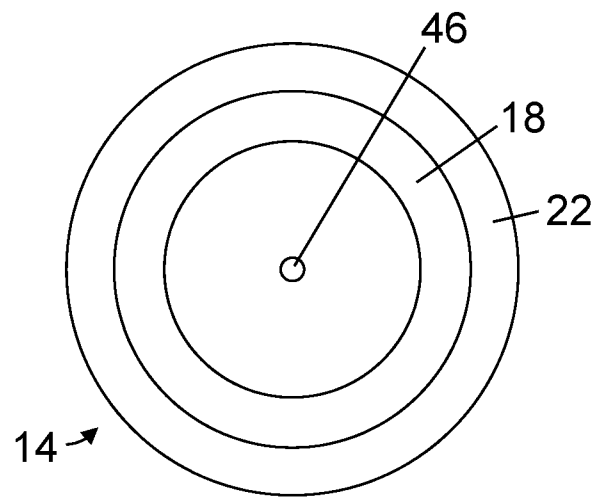


FIG. 1C

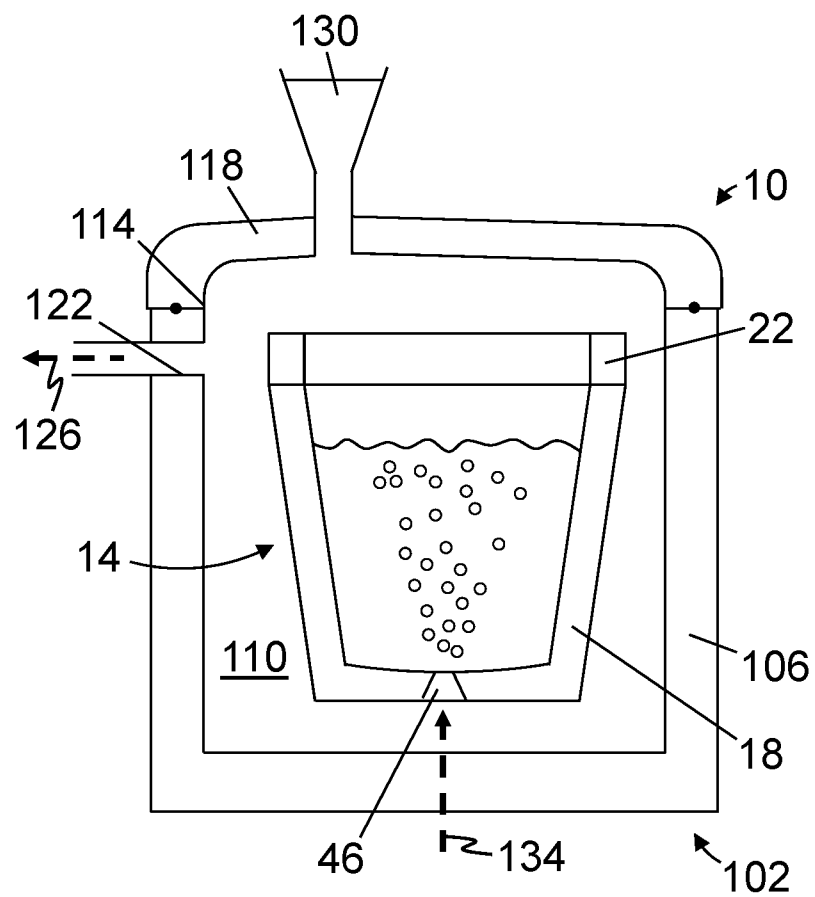


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. B22D27/00 B22D27/15 B22D41/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B22D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 3 458424 B2 (KAWASAKI STEEL CO) 20 October 2003 (2003-10-20) paragraph [0011]; claim 1; figure 1 -----	1-10, 13-17 11,12
X A	US 4 708 738 A (MASTERSON IAN F [US] ET AL) 24 November 1987 (1987-11-24) column 2, lines 61-62; figure 1 column 4, lines 34-54 -----	1-4,6,7, 9-14 5,8, 15-17
X A	US 4 647 019 A (MASTERSON IAN F [US] ET AL) 3 March 1987 (1987-03-03) column 2, lines 56-57; figure 1 column 4, lines 32-52 -----	1-4,6,7, 9-14 5,8, 15-17
A	DE 10 2009 036699 A1 (REFRATECHNIK HOLDING GMBH [DE]) 10 February 2011 (2011-02-10) abstract; figures 1,2 ----- -/-	1-17



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

18 July 2017

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INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 101 352 755 A (YAN DONG [CN]) 28 January 2009 (2009-01-28) the whole document -----	1-17

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date	
JP 3458424	B2	20-10-2003	JP 3458424 B2	20-10-2003
		JP H07126737 A		16-05-1995

US 4708738	A	24-11-1987	NONE	

US 4647019	A	03-03-1987	AU 588658 B2	21-09-1989
		BR 8700010 A		12-01-1988
		CA 1310193 C		17-11-1992
		CS 275836 B6		18-03-1992
		DE 3765966 D1		13-12-1990
		EP 0239717 A1		07-10-1987
		JP H0416526 B2		24-03-1992
		JP S62235415 A		15-10-1987
		MX 165748 B		03-12-1992
		US 4647019 A		03-03-1987

DE 102009036699	A1	10-02-2011	NONE	

CN 101352755	A	28-01-2009	NONE	
