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(54) **A METHOD AND AN ARRANGEMENT FOR MELTING AND DECANTING A METAL**

(57) The invention relates to a method for melting and decanting a metal (7) into a tundish (3), wherein a liquefied inert shielding gas (20) is supplied to a melt of the metal (7) during melting, wherein the liquefied shielding gas (20) is supplied to the metal (7) through at least two different lance outlet nozzles (61, 62, 61a, 62a), wherein the liquefied shielding gas (20) is supplied during

melting through one (61, 61a) of the at least two lance outlet nozzles (61, 62, 61a, 62a) to the metal (7) located in a crucible (1) and wherein the liquefied shielding gas (20) is supplied during decanting through another one (62, 62a) of the at least two lance outlet nozzles (61, 62, 61a, 62a) to a flow of the decanting molten metal and/or to the metal (7) located in the tundish (3).

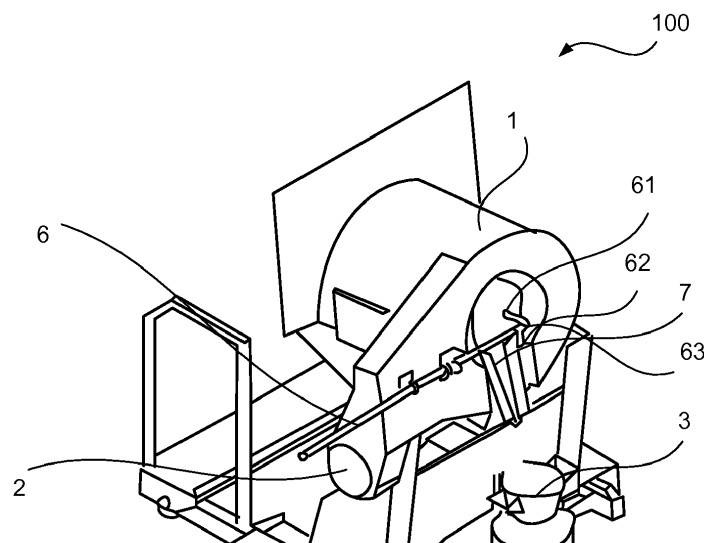


Fig. 2

Description

[0001] The present invention provides a method for melting and decanting a metal according to the preamble of claim 1 and an arrangement for performing such a method.

Prior art

[0002] It is known to use an inert shielding gas for inertising a metal during a melting process. The inert shielding gas protects the metal from oxidation and from impurities.

[0003] During a melting process metal is molten in a crucible. A crucible is a pot that is used for keeping metals for melting in a furnace. In order to remove molten metal from the crucible, the crucible is usually tilted such that the molten metal is decanted into a collecting container or a tundish. The tundish may be a transfer ladle, a mold, or something different.

[0004] It is possible to drop a liquefied shielding gas onto the hot molten metal, because the vaporisation of the liquefied shielding gas leads to a quick expansion of the inert shielding gas. This is advantageous in order to achieve a flushing around of the shielding gas on and around the surface of the molten metal and therefore to achieve an optimized shielding effect.

[0005] However, the requirements for the melting process and for the decanting process are different. The shielding of the hot molten metal during the melting process and during the decanting process may still be optimized.

Disclosure of the Invention

[0006] The invention proposes a method for melting and decanting metal and an arrangement for performing said method according to the independent patent claims. Advantageous embodiments result from the respective subclaims and the following description.

Advantages of the Invention

[0007] According to a first aspect of the invention a method for melting and decanting a metal into a tundish is suggested, wherein a liquefied inert shielding gas is supplied to a melt of the metal during melting, wherein the liquefied shielding gas is supplied to the metal through at least two different lance outlet nozzles, wherein the liquefied shielding gas is supplied during melting through one of the at least two lance outlet nozzles to the metal located in a crucible and wherein the liquefied shielding gas is supplied during decanting through another one of the at least two lance outlet nozzles to a flow of the decanting molten metal and/or the metal located in the tundish..

[0008] In this way not only during melting, but also during decanting the decanting metal is effectively shielded

against oxidization and impurities. By providing at least two different lance outlet nozzles the liquefied inert shielding gas may better be distributed onto the metal surface of the molten metal during the melting and/or decanting process. The prior art lance outlet nozzle may be located for an optimized supply of liquefied shielding gas during the melting process only.

[0009] Expediently, the liquefied shielding gas is dropped by gravity onto the metal through the lance outlet nozzles. In this way a good distribution of the expanding shielding gas is achieved.

[0010] In an advantageous embodiment two of the lance outlet nozzles are protruding from the same lance by a bifurcation, wherein a second lance outlet nozzle of said at least two lance outlet nozzles protrudes at least partially from the lance in the radial direction in respect to a longitudinal lance direction, such that during melting, when the crucible is substantially in a horizontal position, the liquefied shielding gas is not supplied to the metal through the second lance outlet nozzle, and such that, during decanting, by tilting the crucible, the liquefied shielding gas is by gravity supplied to the metal through the second lance outlet nozzle. This is advantageous, because in this way there is no need to separately control the at least two lance outlet nozzles by valves or the like. The flow of liquefied shielding gas through the second outlet nozzle can be controlled by the tilting angle of the crucible.

[0011] Preferably, the directional component of the radial direction of the second lance outlet nozzle has an angle between 0 and 45°, preferably 2 to 35°, more preferably 5 to 25° to a plane parallel to a bottom of the crucible usually to the horizontal. In this way, when the crucible is in the horizontal position, the liquefied shielding gas cannot be supplied through the second lance outlet nozzle, because it cannot flow upwards against gravity. When the crucible is sufficiently tilted, the liquefied shielding gas can by gravity be supplied through the second lance outlet nozzle.

[0012] According to a second aspect of the invention, an arrangement for performing a method according to the first aspect of the invention is suggested, the arrangement comprising: a crucible, a collecting vessel or tundish and at least one lance for supplying a liquefied inert shielding gas and at least two lance outlet nozzles arranged such that the liquefied shielding gas is supplyable during melting through one of the at least two lance outlet nozzles to the metal located in a crucible and wherein the liquefied shielding gas is supplyable during decanting through another one of the at least two lance outlet nozzles to a flow of the decanting molten metal and/or the metal located in the tundish.

[0013] This arrangement allows the performance of the inventive method being applied to a furnace crucible.

[0014] According to an advantageous embodiment two of the lance outlet nozzles are protruding from the same lance by a bifurcation. In this way, the supply of the liquefied shielding gas may be efficiently provided by only

one lance.

[0015] Preferably, the bifurcation is formed as a t-piece or as a y-piece. This allows a partially radial protrusion of one outlet nozzle and a longitudinal protrusion of the other outlet nozzle.

[0016] Expediently, a first lance outlet nozzle of the at least two lance outlet nozzles extends in a longitudinal lance direction. This allows an arrangement of the first lance outlet nozzle immediately above a centre of the crucible in order to optimize the supply of liquefied shielding gas during the melting process.

[0017] According to an alternative advantageous embodiment a first lance outlet nozzle of the at least two lance outlet nozzles extends in the direction to a bottom of the crucible. This allows an even more advantageous supply of the liquefied shielding gas onto the metal surface in the crucible during the melting process. Also the first lance outlet nozzle may first extend in a longitudinal lance direction and then in the direction to a bottom of the crucible. This is advantageous, because in this way evaporated shielding gas may be used to shield the crucible when the crucible is tilted and the liquid shielding gas is already directed through the second lance outlet. The first lance outlet may end at an edge of the crucible opening. This is advantageous in order not to disturb a manual filling process of metal bars into the crucible or not to expose the lance material to radiant heat of hot molten metal. The second lance outlet may end beyond the crucible outlet channel.

[0018] Preferably, a second lance outlet nozzle of said at least two lance outlet nozzles extends at least partially in the radial direction in respect to a longitudinal lance direction. This allows providing a different drop direction for the supply of liquefied shielding gas.

[0019] Expediently, the directional component of the radial direction of the second nozzle has an angle between 0 and 45° or between 2 and 35° or between 5 and 25° to plane parallel to a bottom of the crucible. The plane of the bottom of the crucible corresponds to the horizontal plane, if the crucible is in a melting position. In this way, during a decanting process, the supply direction of the liquefied shielding gas through the second nozzle is substantially parallel to a decanting direction of the molten metal during a decanting process. In this way, the shielding of the molten metal during the decanting process can be optimized.

[0020] According to another advantageous embodiment the arrangement comprises additionally or alternatively at least two lances, each having at least one lance outlet nozzle. In this way the supply of the liquefied shielding gas may be controlled individually for each lance and each lance outlet nozzle.

[0021] Expediently, the crucible is tiltable as a decanting device for decanting molten metal into the collecting vessel or tundish. This is an advantageous construction for allowing decanting the molten metal from the crucible.

[0022] Further advantages and embodiments of the invention result from the description and the enclosed

drawings.

[0023] It is understood that the features mentioned above and the features to be explained below can be used not only in the combination indicated, but also in other combinations or in a unique position, without leaving the scope of this invention.

[0024] The invention is shown schematically in the drawings using examples and is described below with reference to the drawings.

[0025] Short description of the drawings

Figure 1 shows an arrangement for melting and/or decanting a metal according to the prior art in a perspective view;

Figure 2 shows an arrangement for melting and/or decanting a metal according to an advantageous embodiment of the present invention in a perspective view;

Figure 3 shows an arrangement for melting and/or decanting a metal according to a further advantageous embodiment of the present invention in a schematic planar side view in an untilted crucible position;

Figure 4 shows an arrangement for melting and/or decanting a metal according to a further advantageous embodiment of the present invention in a schematic planar side view in a tilted crucible position;

Figure 5 shows a lance of an arrangement for melting and/or decanting a metal according to a further advantageous embodiment of the present invention with two lance outlet nozzles in a schematic view;

Figure 6 shows a lance of an arrangement for melting and/or decanting a metal according to a further advantageous embodiment of the present invention with two lance outlet nozzles in a schematic view;

Figure 7 shows an arrangement for melting and/or decanting a metal according to a still further advantageous embodiment of the present invention in a perspective view.

Detailed description of the drawings

[0026] Figure 1 shows an arrangement for melting and decanting a metal according to the prior art, designated with reference numeral 101, in a perspective view. The arrangement comprises a crucible 1. The arrangement 101 further comprises a tilting axis 2 for tilting the crucible in order to decant molten metal 7. In the drawing the crucible 1 is illustrated in a tilted position such that molten

metal 7 is running out of the crucible 1 and into a collecting container or tundish 3.

[0027] The crucible 1 is a ceramic or a metal container in which metals may be melted and subjected to very high temperatures above the melting temperature of the metal to be melted. It may be positioned in a furnace in order to melt the metal. The tundish 3 may be formed of a similar material as the crucible 1. The tundish 3 may be a transfer ladle which is adapted to transport the molten metal to a place for further processing. For example, the molten metal may further be processed to metal powder usable for an additive manufacturing method. Especially for additive manufacturing very pure metal is required. Thus, an inert shielding gas may be supplied to the metal during the melting process. An advantageous shielding gas is Argon, which is heavier than air, remains inert in comparison to nitrogen when it is exposed to high temperatures and has good shielding capabilities.

[0028] In order to supply the shielding gas to the metal, a supply line may be provided like for example a lance. The shielding gas may be supplied to the metal in gaseous form or in a liquefied form. Dropping the shielding gas from above onto the molten metal has the advantage that only small amounts of the shielding fluid are to be provided. That is, because the liquefied inert gas expands quickly after getting in contact with the hot molten metal and effectively covers the metal surface.

[0029] Thus, the prior art arrangement of Fig. 1 comprises a lance 5 with one lance outlet nozzle 51. The lance 5 is provided parallel to the tilting axis 2 of the arrangement. The lance outlet nozzle 51 is located such that liquefied inert shielding gas may drop onto the molten metal 7 during the melting process.

[0030] However, the coverage of the metal surface with shielding gas may be improved.

[0031] Figure 2 shows an arrangement for melting and decanting a metal according to an advantageous embodiment of the invention, designated with reference numeral 100. The difference between the prior art arrangement 101 and the arrangement 100 according to the illustrated embodiment is that the arrangement 100 according to the embodiment provides a lance 6 with at least two lance outlet nozzles 61, 62 through which the liquefied shielding gas is supplyable to the metal 7. The two lance outlet nozzles 61, 62 are protruding from the same lance 6 by a bifurcation 63. A first lance outlet nozzle 61 of the at least two lance outlet nozzles 61, 62 extends in the direction to a bottom of the crucible 1. This allows an advantageous supply of the liquefied shielding gas onto the metal surface in the crucible 1 during the melting process and furthermore allows shielding the crucible by the evaporated shielding gas during the tilting process. A second lance outlet nozzle 62 of said at least two lance outlet nozzles 61, 62 extends in the radial direction in respect to a longitudinal lance direction. The directional component of the radial direction of the second nozzle 62 has an angle between 0 and 30° to a plane parallel to a bottom of the crucible 1. In this, way, during the de-

canting process, the supply direction of the liquefied shielding gas through the second nozzle 62 is substantially parallel to a decanting direction of the molten metal 7 during a decanting process. In this way, the shielding of the molten metal during the decanting process can be achieved and can be optimized. The second outlet nozzle 62 may be arranged beyond the crucible outlet channel when the first lance outlet nozzle 61 may end at the edge of the crucible opening.

[0032] Figure 3 shows a schematic planar side view of a further advantageous embodiment of the melting and/or decanting arrangement of the invention. The difference between this embodiment and the embodiment of Figure 2 is that the first lance outlet nozzle 61 extends in a longitudinal lance direction out of a plane of the drawing. In this drawing the crucible 1 is tilted into a melting position. The liquefied shielding gas drops are designated with reference numeral 20 dropping onto the surface of the molten metal 7 in the crucible 1. The expanding gaseous shielding gas is designated with reference numeral 30. The second lance outlet nozzle 62 is provided in a direction which has an angle greater than 0° to a plane parallel to a bottom of the crucible 1, but smaller than 30° to this plane parallel to the bottom of the crucible. This is advantageous, because in this way in the melting position gravity prevents the liquid shielding gas from dropping through the second lance outlet nozzle 62 such that in the melting position the liquid shielding gas is only provided through the first lance outlet nozzle 61.

[0033] Figure 4 shows a schematic planar side view of a further advantageous embodiment of the melting and/or decanting arrangement of the invention. In this embodiment the first lance outlet nozzle 61 extends in a direction to the bottom of the crucible as in Figure 2 to shield the crucible by the evaporated shielding gas during the tilting process. In this drawing the crucible 1 is tilted into a decanting position. In this position liquefied shielding fluid 20, 30 is provided through both of the lance outlet nozzles 61, 62 as well to the molten metal 7 in the crucible 1 as to the molten metal 7 running from the crucible 1 into the collecting container 3.

[0034] Figures 5 and 6 each show a lance 6 with a bifurcation 63 and two lance outlet nozzles in a schematic view. In Figure 5 the bifurcation is provided as a t-piece. In Figure 6 the bifurcation is provided as y-piece. Both examples allow an at least partially radial protrusion of a second lance outlet nozzle 62 and a longitudinal protrusion of a first lance outlet nozzle 61. The invention is not limited to these examples of a bifurcation 63 for an embodiment of the arrangement 100, according to the present invention.

[0035] Figure 7 shows a further advantageous embodiment of an arrangement 100 according to the invention in a perspective view. The difference between this embodiment and the other embodiments is that two lances 6a and 6b, which preferably end close to an edge of the crucible opening, are provided each having at least one lance outlet nozzle 61a and 62a, respectively. In this way

the supply of the liquefied shielding gas during melting and decanting may be controlled individually for each lance 6a, 6b and each lance outlet nozzle 61a, 62a.

Claims

1. A method for melting and decanting a metal (7) into a tundish (3), wherein a liquefied inert shielding gas (20) is supplied to a melt of the metal (7) during melting,

characterised in that

the liquefied shielding gas (20) is supplied to the metal (7) through at least two different lance outlet nozzles (61, 62, 61a, 62a), wherein the liquefied shielding gas (20) is supplied during melting through one (61, 61a) of the at least two lance outlet nozzles to the metal (7) located in a crucible (1) and wherein the liquefied shielding gas (20) is supplied during decanting through another one (62, 62a) of the at least two lance outlet nozzles to a flow of the decanting molten metal and/or to the metal (7) located in the tundish (3).

2. The method according to claim 1, wherein the liquefied shielding gas (20) is dropped onto the metal (7) through the lance outlet nozzles (61, 62, 61a, 62a).

3. The method according to claim 2, wherein two of the lance outlet nozzles (61, 62) are protruding from the same lance (6) by a bifurcation (63), wherein a second lance outlet nozzle (62) of said at least two lance outlet nozzles (61, 62) protrudes at least partially from the lance (6) in the radial direction in respect to a longitudinal lance direction, such that during melting, when the crucible (1) is substantially in a horizontal position, the liquefied shielding gas is not supplied to the metal through the second lance outlet nozzle (62), and such that, during decanting, by tilting the crucible, the liquefied shielding gas (20) is by gravity supplied to the metal through the second lance outlet nozzle (62).

4. The method according to claim 3, wherein the directional component of the radial direction of the second lance outlet nozzle (62) has an angle between 0 and 45°, or 2 to 35°, or 5 to 25° to a plane parallel to a bottom of the crucible (1)

5. An arrangement (100) for performing a method of any one of the preceding claims, comprising: a crucible (1), a tundish (3) and at least one lance (6, 6a, 6b) for supplying a liquefied inert shielding gas (20) and at least two lance outlet nozzles (61, 62, 61a, 62) arranged such that the liquefied shielding gas (20) is supplyable during melting through one (61, 61a) of the at least two lance outlet nozzles to the metal (7) located in a crucible (1) and wherein

the liquefied shielding gas (20) is supplyable during decanting through another one (62, 62a) of the at least two lance outlet nozzles to a flow of the decanting molten metal and/or to the metal (7) located in the tundish (3).

6. The arrangement (100) according to claim 5, wherein two of the lance outlet nozzles (61, 62) are protruding from the same lance (6) by a bifurcation (63).

7. The arrangement (100) according to claim 6, wherein the bifurcation (63) is formed as a t-piece or as a y-piece.

8. The arrangement (100) according to claim 6 or 7 wherein a first lance outlet nozzle (61) of the at least two lance outlet nozzles (61, 62) extends in a longitudinal lance direction.

9. The arrangement (100) according to any one of claims 6 to 8, wherein a first lance outlet nozzle (61) of the at least two lance outlet nozzles (61, 62) extends in the direction to a bottom of the crucible (1).

10. The arrangement (100) according to any one of claims 6 to 9, wherein a second lance outlet nozzle (62) of said at least two lance outlet nozzles (61, 62) extends at least partially in the radial direction in respect to a longitudinal lance direction.

11. The arrangement (100) according to claim 10, wherein the directional component of the radial direction of the second lance outlet nozzle (62) has an angle between 0 and 45°, or 2 to 35°, or 5 to 25° to a plane parallel to a bottom of the crucible (1).

12. The arrangement (100) according to any one of claims 5 to 11, comprising at least two lances (6a, 6b), each having at least one lance outlet nozzle (61a, 62a).

13. The arrangement (100) according to any one of claims 5 to 12, wherein the crucible (100) is tiltable as a decanting device for decanting molten metal (7) into the tundish (3).

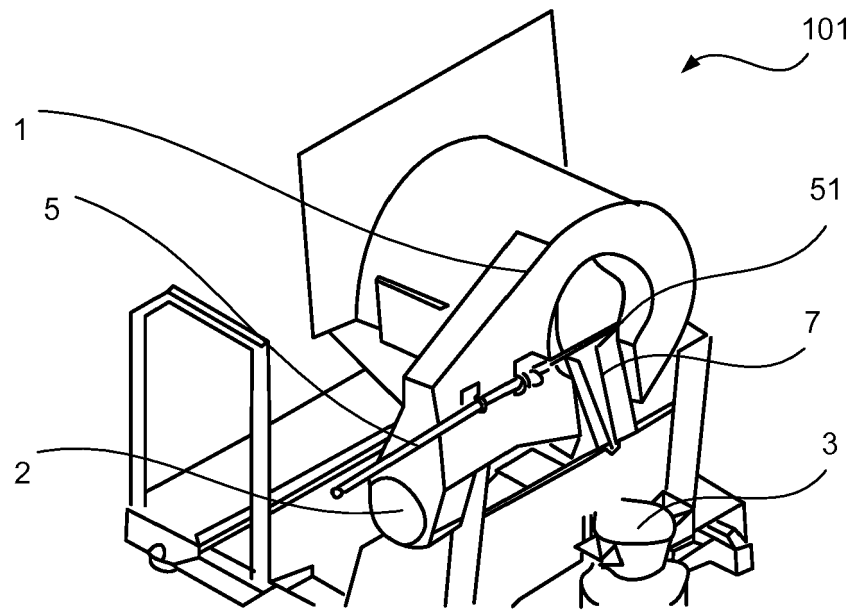


Fig. 1

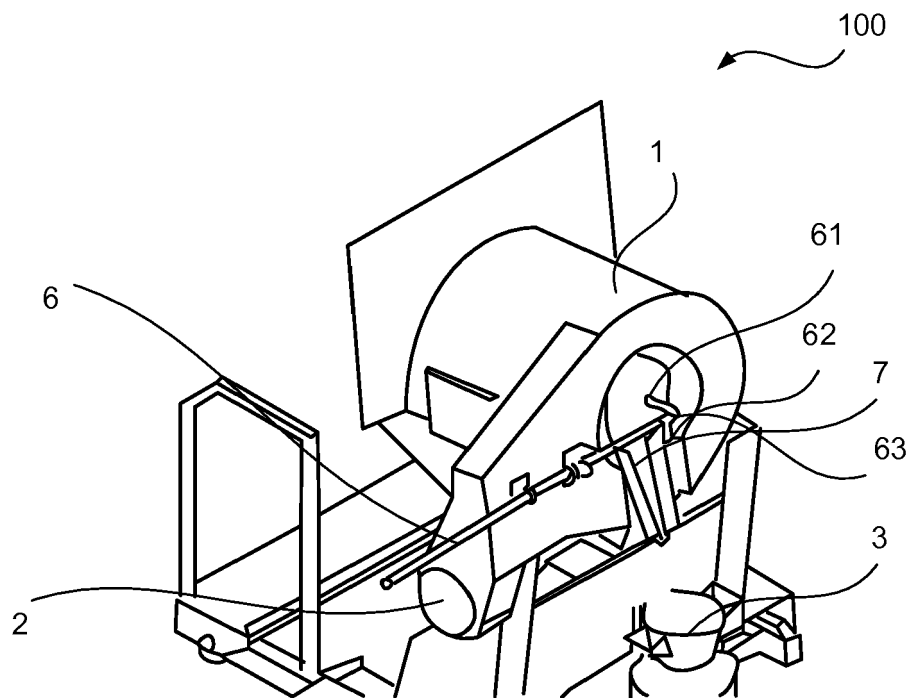


Fig. 2

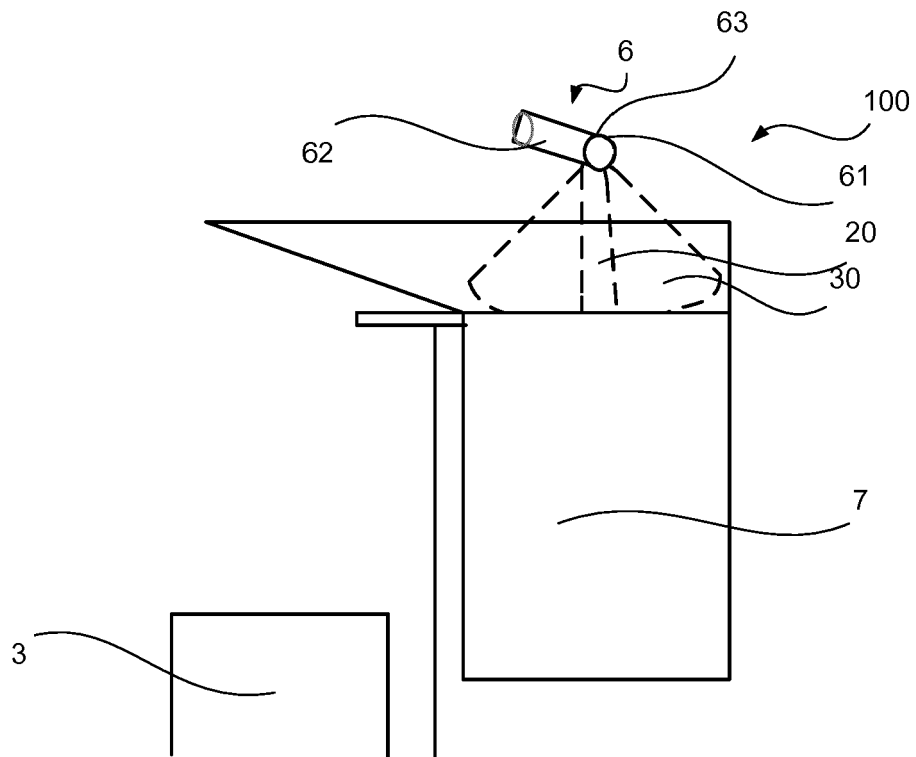


Fig. 3

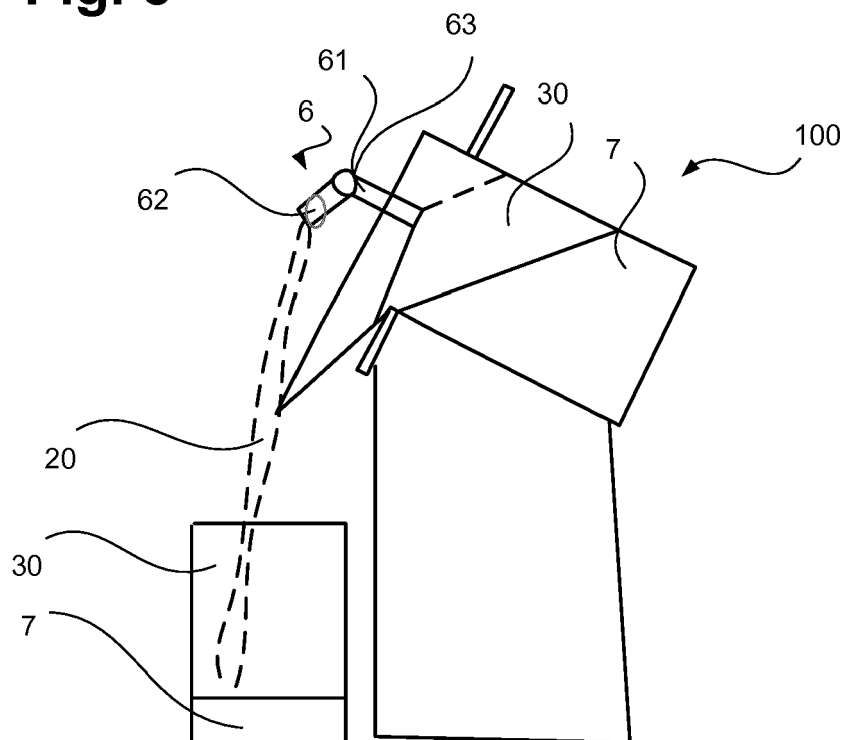


Fig. 4

Fig. 5

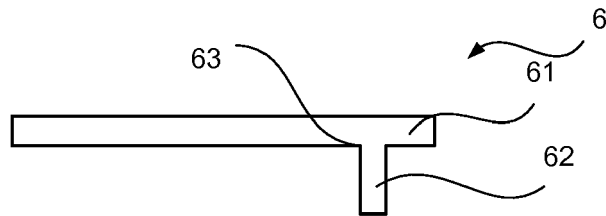


Fig. 6

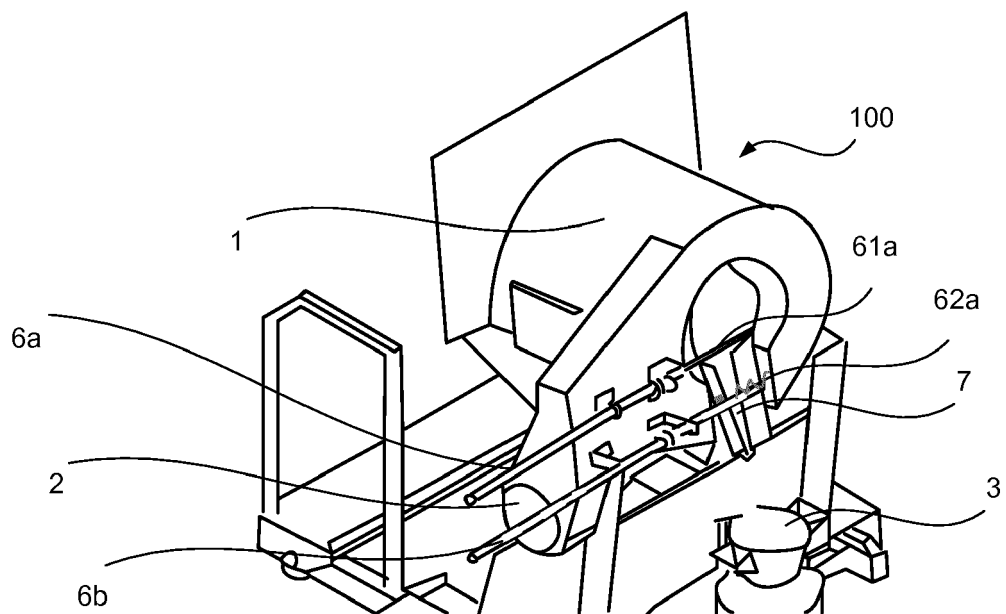
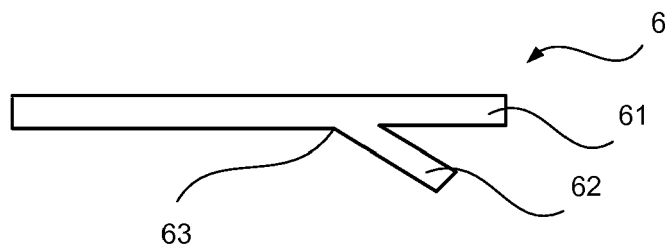


Fig. 7



EUROPEAN SEARCH REPORT

Application Number
EP 19 02 0539

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 2015 188893 A (NIPPON STEEL & SUMITOMO METAL CORP) 2 November 2015 (2015-11-02)	5	INV. F27B14/08 B22D35/02 B22D41/04
Y	* abstract; figure 1 *	1-4,6-13	

X	US 3 467 167 A (MAHIN WILLIAM E) 16 September 1969 (1969-09-16)	5	
Y	* column 3, line 50 - column 5, line 4; figure 1 *	1-4,6-13	

X	US 6 241 798 B1 (DIMITROV STEFAN [AT] ET AL) 5 June 2001 (2001-06-05)	5	
Y	* column 6, line 33 - column 8, line 17; figures 1-6 *	1-4,6-13	
	* column 13, line 10 - line 45; claims 1,18 *		

Y	US 2008/184848 A1 (LA SORDA TERENCE D [US]) 7 August 2008 (2008-08-07)	1-4,6-13	
	* paragraphs [0040], [0044], [0045]; claims 1,7,12,22; figures 1,2 *		

Y	GB 1 372 801 A (AIR LIQUIDE) 6 November 1974 (1974-11-06)	1-4,6-13	TECHNICAL FIELDS SEARCHED (IPC) F27B B22D F27D
	* claim 1; figure 2 *		

A	US 4 047 936 A (CHANG YI-CHUNG) 13 September 1977 (1977-09-13)	1,5	
	* the whole document *		

The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 19 December 2019	Examiner Gavriliu, Alexandru
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 19 02 0539

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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40

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50

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2015188893 A	02-11-2015	JP 6273962 B2 JP 2015188893 A	07-02-2018 02-11-2015
US 3467167 A	16-09-1969	NONE	
US 6241798 B1	05-06-2001	AT 186332 T AT 404841 B AU 698067 B2 BR 9604922 A CA 2217896 A1 CN 1181113 A CZ 291900 B6 DE 59603568 D1 EP 0820528 A1 JP H11503204 A KR 19980703744 A PL 322871 A1 RU 2147039 C1 TW 301674 B US 6241798 B1 WO 9632505 A1 ZA 9602631 B	15-11-1999 25-03-1999 22-10-1998 30-03-1999 17-10-1996 06-05-1998 18-06-2003 09-12-1999 28-01-1998 23-03-1999 05-12-1998 02-03-1998 27-03-2000 01-04-1997 05-06-2001 17-10-1996 07-10-1996
US 2008184848 A1	07-08-2008	AR 062491 A1 AT 508822 T EP 2059358 A1 JP 5717963 B2 JP 2010501820 A TW 200831210 A US 2008184848 A1 US 2009288520 A1 US 2012103137 A1 US 2014047953 A1 WO 2008023229 A1	12-11-2008 15-05-2011 20-05-2009 13-05-2015 21-01-2010 01-08-2008 07-08-2008 26-11-2009 03-05-2012 20-02-2014 28-02-2008
GB 1372801 A	06-11-1974	AU 471226 B2 CA 969323 A ES 402610 A1 FR 2137090 A1 GB 1372801 A IT 955407 B SE 379658 B	15-04-1976 17-06-1975 16-11-1975 29-12-1972 06-11-1974 29-09-1973 20-10-1975
US 4047936 A	13-09-1977	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82