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(54) Title: METHOD AND APPARATUS FOR FABRICATING A COPPER PRODUCT

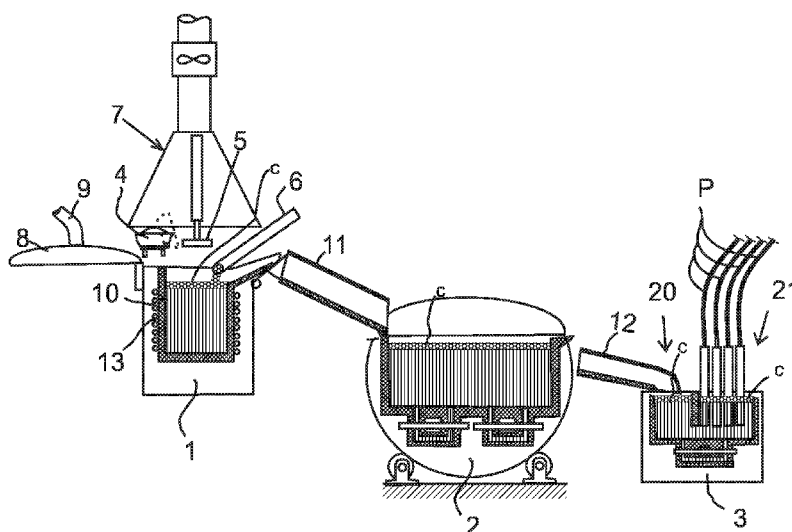


Fig. 1

(57) Abstract: A method and apparatus for fabricating an oxygen-free copper product (P), such as oxygen-free copper wire, tube or rod, from copper oxide powder. The method comprises the reduction and melting of copper powder, and casting of molten oxygen-free copper into a copper product (P). Copper oxide is melted in an induction crucible furnace (1) and the oxygen-containing melt is reduced by bringing it into contact with a carbon-containing material (c). The apparatus includes an induction crucible furnace (1), which is arranged to function as a melting and reduction furnace for melting copper oxide into an oxygen-containing melt and reducing the oxygen-containing melt.



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METHOD AND APPARATUS FOR FABRICATING A COPPER PRODUCT**FIELD OF THE INVENTION**

5 The invention relates to the method defined in the preamble of claim 1. The invention relates to the apparatus defined in the preamble of claim 14.

BACKGROUND OF THE INVENTION

10 It is known in the prior art for example from publication FI 119439 B, that reduction of copper oxide powder in the so-called HydroCopper® process is carried out using hydrogen gas in a belt furnace. Subsequently the reduced product, copper powder, is melted in a rotary kiln heated with channel inductors.
15 Melt from the rotary kiln is poured into a casting furnace heated by a channel inductor and cast into the final product, such as wire, tube or rod.

20 The problem is the large size and investment costs of the belt furnace used for the reduction. In addition, the energy bound to the product in the copper reduction process is lost, because the product is cooled from a temperature of approx. 900°C to below 100°C at the last end of the belt furnace. The steel
25 belt may also contaminate the product with iron.

It is well known that LME Grade A copper cathodes are used as raw material in the production of oxygen-free copper wire, and that they are melted in a rotary kiln
30 heated with channel inductors. The melt is reduced with wood charcoal. The melt from the melting furnace is poured periodically along launders to a casting furnace heated by a channel inductor, from which the melt is cast into wire by a vertical casting method.

It is further known in the prior art that induction crucible furnaces have been used generally for melting copper metals particularly in the kinds of applications where briquetted or baled scrap is used as raw material. The benefit of the induction crucible furnace known per se is the strong flow of the melt, which facilitates effective melting.

PURPOSE OF THE INVENTION

The purpose of the invention is to eliminate the above-mentioned deficiencies.

In particular the purpose of the invention is to disclose a method and apparatus with low investment costs.

A further purpose is to disclose an apparatus that is substantially smaller in size than the configuration known in the prior art.

In addition, the purpose of the invention is to disclose a method and apparatus that enable good energy efficiency.

A further purpose of the invention is to disclose a method and apparatus, with which the contamination of copper with iron can be avoided.

A further purpose of the invention is to introduce an apparatus, in which simple, effective, commercially available equipment is used.

A further purpose of the invention is to introduce an apparatus, the maintenance of which can be arranged in accordance with existing practices.

SUMMARY OF THE INVENTION

The method accordant with the invention is characterised by that presented in claim 1. Furthermore, the apparatus accordant with the
5 invention is characterised by that presented in claim 14.

In the method according to the invention, copper oxide is melted in an induction crucible furnace and the
10 oxygen-containing melt is reduced by bringing it into contact with a carbon-containing material.

The apparatus according to the invention includes an induction crucible furnace, which is arranged to
15 function as a melting and reduction furnace for melting copper oxide into an oxygen-containing melt and reducing said oxygen-containing melt.

In one embodiment of the method the carbon-containing
20 material is wood charcoal.

In one embodiment of the method wood charcoal is made into a covering for the melt in the induction crucible furnace, and the copper oxide is pressed through said
25 wood charcoal covering into the melt, so that the wood charcoal is plunged inside the melt.

In one embodiment of the method, wood charcoal powder or sawdust is mixed with the copper oxide powder to be
30 fed into the induction crucible furnace before it is fed into the melt to intensify reduction.

In one embodiment of the method the rotation speed of the melt in the induction crucible furnace is raised
35 periodically by increasing the inductor power to mix the wood charcoal powder efficiently inside the melt in order to intensify reduction.

In one embodiment of the method hardwood sticks are pushed into the melt in the induction crucible furnace in order to intensify reduction.

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In one embodiment of the method, once the oxygen content of the melt in the induction crucible furnace has fallen to a predetermined first value, the melt is conveyed from the induction crucible furnace along a first gas-tight launder, in which there is a reducing CO atmosphere, to a holding furnace.

In one embodiment of the method a covering of wood charcoal is arranged on top of the melt in the holding furnace, the reduction of the melt is continued in the holding furnace by means of the wood charcoal covering until the oxygen content of the melt has decreased to a second predetermined value.

In one embodiment of the method, when the oxygen content of the melt in the holding furnace has decreased to a desired second value, the melt is routed from the holding furnace along a second gas-tight launder, in which there is a reducing CO atmosphere, to a vertical casting furnace, from where the melt is cast by a vertical casting method into a copper product.

In one embodiment of the method the melt is pumped from the induction crucible furnace to the first launder.

In one embodiment of the method the melt is pumped from the holding furnace to the second launder.

In one embodiment of the method copper oxide is charged into the induction crucible furnace in substantially

small charging batches in relation to the amount of melt in the furnace.

5 In one embodiment of the method the amounts of melt transferred from the induction crucible furnace to the holding furnace and from the holding furnace to the casting furnace are substantially small in relation to the amount of melt in the furnaces.

10 In one embodiment of the apparatus, the apparatus includes a charging device for charging copper oxide powder into the induction crucible furnace.

15 In one embodiment of the apparatus, the apparatus includes a plunging device for plunging copper oxide inside the melt.

20 In one embodiment of the apparatus, the apparatus includes a feeding device for feeding carbon-containing material as a covering for the melt.

25 In one embodiment of the apparatus, the apparatus includes a degassing unit, which is arranged above the induction crucible furnace to remove the flue gases during charging.

30 In one embodiment of the apparatus the induction crucible furnace includes a lid that can be closed gas-tight, in which there is a discharge conduit for removing flue gases.

In one embodiment of the apparatus, the induction crucible furnace includes a fire-resistant magnesite lining, which contains mostly magnesia (MgO).

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In one embodiment of the apparatus, the apparatus includes a gas-tight first launder, which is arranged

between the induction crucible furnace and the holding furnace to convey the melt from the induction crucible furnace to the holding furnace.

- 5 In one embodiment of the apparatus, the apparatus includes a gas-tight second launder, which is arranged between the holding furnace and the casting furnace to convey the melt from the holding furnace to the casting furnace.

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In one embodiment of the apparatus, the holding furnace is a channel induction furnace equipped with a double channel inductor.

- 15 In one embodiment of the apparatus, the casting furnace is a vertical casting furnace adapted for continuous upward-directed vertical casting.

- 20 In one embodiment of the apparatus, the vertical casting furnace is a channel induction furnace.

In one embodiment of the apparatus, the apparatus includes a first pump for pumping the melt from the induction crucible furnace to the first launder.

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In one embodiment of the apparatus, the apparatus includes a second pump for pumping the melt from the holding furnace to the second launder.

- 30 In one embodiment of the apparatus, the first pump and/or the second pump is a gas-lift pump.

- 35 In one embodiment of the apparatus, the gas-lift pump includes a riser tube, which includes an upper end that extends above the melt and opens into the launder and a lower end that is submerged in the melt. In addition, the gas lift pump includes a gas feed pipe,

through which a reducing gas is arranged to be fed into the melt inside the riser tube.

LIST OF DRAWINGS

5 The invention is described below in detail by means of the example embodiments with reference to the appended drawing, where

Figure 1 is a schematic presentation of one first
10 embodiment of the apparatus accordant with the invention, and

Figures 2 and 3 schematically illustrate the gas lift pump used in one second embodiment of the apparatus
15 accordant with the invention.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 is a schematic representation of an apparatus for fabricating an oxygen-free copper product P, such
20 as oxygen-free copper wire, copper tube or copper rod, using copper oxide powder as the raw material.

An induction crucible furnace 1 and a holding furnace 2 are full of melt, and the amount of copper
25 oxide/molten copper to be added at a time is small, so that the amount added does not cause major changes to the oxygen content of the melt. Dried and baled/briquetted copper oxide (copper(I) oxide, Cu_2O , oxygen content 10%) is melted in the induction
30 crucible furnace 1 (full furnace approx. 30 t) and 500 kg are charged into the induction crucible furnace 1 at a time using a charging car 4 or charging tongs. According to the tests carried out, when the moisture content of the raw material is 0.4 % or less, no melt
35 splashing occurs during charging. Raw material melting can be optimised by using a hydraulic plunger 5.

The temperature of the melt in the induction crucible furnace 1 when charging commences is around 1300 °C (the melting temperature of copper oxide is 1235 °C). Flue gases are routed to gas treatment by means of degassing unit 7, which comprises here a hood and a blower. If the formation and vaporization of CuCl_2 is a problem when melting the raw material, it is possible to proceed in the following way: a CuCl_2 -containing gas is routed via degassing to a gas scrubber, the copper ions dissolved in water are precipitated with NaOH as $\text{Cu}(\text{OH})_2$, which is changed upon heating into copper(II) oxide CuO . The CuO that is formed can be mixed into the copper(I) oxide Cu_2O that will be charged into the melting furnace. Alternatively, copper chloride can be recovered by condensing.

The oxygen content of the melt in the induction crucible furnace 1 increases to around 2700 ppm during charging, assuming that the oxygen content at the start of charging is 1000 ppm. Reduction of the melt occurs primarily with a wood charcoal covering c, through which the copper oxide powder to be charged is plunged inside the melt.

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The melt in the induction crucible furnace 1 is in fast rotation, which is why reduction is fast particularly at a high oxygen content. The wood charcoal to be charged along with the copper oxide powder is plunged inside the melt, thus improving reduction even further.

After charging, the furnace can be closed from above with a lid 8, in which there is a flue gas discharge conduit 9. An induction coil 13 of the furnace 1 extends as far as the upper section of the furnace, pre-

venting the melt from solidifying and the formation of a crust on the surface of the melt.

The induction crucible furnace 1 has a magnesite lining 10, which contains mostly magnesia (MgO). Magnesia withstands the wearing effect of oxygen-containing copper melt well.

Reduction in the induction crucible furnace 1 can be enhanced using the following procedures:

1. Mixing wood charcoal powder or sawdust into the copper oxide powder to be charged before compaction,
2. "Pumping" the wood charcoal lumps and powder periodically inside the melt with high inductor power.
3. Pushing hardwood sticks into the melt.

In procedures 1-3, reduction takes place as a reaction of the oxygen dissolved in the melt with carbon. When using sawdust and sticks of wood, reduction also occurs by means of the hydrocarbons that are formed. Due to the high oxygen content of the melt, the impurities contained in the materials used in reduction do not dissolve into the melt, but react with the oxygen, rising to the surface of the melt as slag. After pouring, if required, the furnace 1 is slagged by scraping the slag and ash over the edge of the furnace 1.

When the oxygen content falls to 1000 ppm, 500 kg of melt are poured from the induction crucible furnace 1 into the holding furnace 2 along a gas-tight first launder 11. The induction crucible furnace 1 is coupled to the furnace spout. The joint between the induction crucible furnace 1 and a first launder 11 is sealed using cylinder-shaped surfaces that slide against each other during pouring. Separate heating is not required in the first launder 11. There is a

reducing CO atmosphere flowing from the holding furnace 2 in the first launder 11. The holding furnace 2 is a 30-ton rotary kiln heated with one inductor (double channel inductor - long service life), which has low energy consumption, a good efficiency ratio and low investment costs since it requires only a single inductor. Slagging of the holding furnace 2 is carried out where necessary through slag doors. The amount of copper, which has an oxygen content of 1000 ppm, poured out of the induction crucible furnace raises the oxygen content of the melt in the holding furnace 2, so that it rises to 76 ppm owing to the pouring, assuming that the oxygen content was 60 ppm before pouring. The reduction of the melt in the holding furnace 2 is effective because of the wood charcoal covering c and the closed construction of the furnace (charging takes place in the preceding melting furnace 1 unlike in current solutions).

When the oxygen content of the melt in the holding furnace 2 has fallen to 60 ppm, 500 kg of melt are poured along a gas-tight second launder 12 into a pouring side 20 of a casting furnace 3, where there is a covering of wood charcoal c. Reducing carbon monoxide flows into the second launder 12 from the casting furnace 3. The casting furnace 3 is a 10-ton channel inductor furnace. The casting furnace 3 is a vertical casting furnace for continuous upward-directed vertical casting, from a casting side 15 of which the oxygen-free copper product P is cast, for example wire filament, tube or rod. If necessary, a wood charcoal covering c can be used on a casting side 21. Due to the pouring, the oxygen content of the melt in the casting furnace 3 rises to 5 ppm, assuming that the oxygen content was 2 ppm before pouring. Before the subsequent pouring, the oxygen content will have

fallen to 2 ppm (the oxygen content of oxygen-free copper, Cu-OF, has to be below 10 ppm).

5 The reduction rate and time (10 min) required to reduce the melt in the induction crucible furnace 1 is realistic, because the reduction rate increases exponentially as the oxygen content increases. In addition, the induction crucible furnace 1 enhances reduction due to the strong flow of the melt and
10 reduction also takes place during charging. In the same way, the reduction of the melt in the holding furnace 2 from 76 ppm to 60 ppm and from 5 ppm to 2 ppm in the casting furnace 3 in 10 min is achievable.

15 Figures 2 and 3 present applications in which pouring from the induction crucible furnace 1 into the first launder 11 and from the holding furnace 2 into the second launder 12 is replaced by pumping.

20 Copper oxide is fed continuously into the induction crucible furnace 1, which is operating as a melting and reduction furnace, in which the oxygen level of the melt remains almost constant the whole time (e.g. 2000 ppm). Copper melt is pumped continuously in accordance
25 with Figure 2 from the induction crucible furnace 1 into the holding furnace 2, in which the oxygen level also remains almost constant the entire time (e.g. 60 ppm). Correspondingly, in accordance with Figure 3, molten copper is pumped continuously from the holding
30 furnace 2 into the casting furnace 3, in which the oxygen level also remains constant (e.g. 2 ppm).

In accordance with Figures 2 and 3, the pumping of copper melt can be carried out best using a gas lift
35 pump. The gas lift pump 14, 15 includes a riser tube 16. The upper end 17 of the riser tube 16 extends above the melt and opens into the launder 11, 12. The

lower end 18 of the riser tube 16 is submerged into the molten copper. The gas is arranged to be fed into the molten copper inside the riser tube 16 via a gas feed pipe 19. The reduction of copper is facilitated by using either CO gas or hydrogen as the pumping gas fed via the gas feed pipe 19. Bubbles caused by the gas being fed in reduce the density of the copper column inside the gas lift pump. The gas lift pump and the actual furnace function like communicating vessels and thus the surface of the lighter copper column inside the riser tube 16 rises higher than the surface of the copper melt in the furnace. ($H_1 \times \text{density of furnace copper} = (H_1 + H_2) \times \text{density of copper/gas column}$.) When the copper column inside the riser tube 16 achieves a sufficient height, the pump starts to operate and the copper flows out of the furnace into the launder 11, 12.

The copper melt can be lifted continuously from the furnaces 1, 2 into the launders 11, 12 with the gas lift pumps 14, 15: in Figure 2 from the induction crucible furnace 1 into the first launder 11 and in Figure 3 from the holding furnace 2 into the second launder 12.

The invention is not restricted to the example embodiments presented above, but many variations are possible within the scope of the inventive idea defined in the patent claims.

PATENT CLAIMS

1. A method for fabricating an oxygen-free copper product (P), such as oxygen-free copper wire, tube or rod, from copper oxide powder, where said method comprises reduction and melting of copper oxide, and casting of oxygen-free molten copper into a copper product (P), **characterised** in that the copper oxide is melted in an induction crucible furnace (1) and the oxygen-containing melt is reduced by bringing it into contact with a carbon-containing material (c).
2. A method according to claim 1, **characterised** in that the carbon-containing material(c) is wood charcoal.
3. A method according to claim 1 or 2, **characterised** in that wood charcoal is arranged as a melt covering (c) in the induction crucible furnace (1), and the copper oxide is plunged through the aforementioned wood charcoal covering (c) into the melt, whereupon the wood charcoal is plunged inside the melt.
4. A method according to any of claims 1 - 3, **characterised** in that wood charcoal powder or sawdust is mixed into the copper oxide powder to be fed into the induction crucible furnace (1) before feeding it into the melt to intensify reduction.
5. A method according to any of claims 1 - 4, **characterised** in that the rotational speed of the melt is increased in the induction crucible furnace (1) periodically by increasing the inductor power to mix the wood charcoal powder effectively inside the melt in order to intensify reduction.

6. A method according to any of claims 1 - 5, **characterised** in that hardwood sticks are pushed into the melt in the induction crucible furnace (1) to intensify reduction.

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7. A method according to any of claims 1 - 6, **characterised** in that, when the oxygen content of the melt in the induction crucible furnace (1) has fallen to a first predetermined value, the melt is routed
10 from the induction crucible furnace (1) along a gas-tight first launder (11), in which there is a reducing CO atmosphere, to a holding furnace (2).

8. A method according to claim 7, **characterised** in
15 that a wood charcoal covering (c) is arranged on top of the melt in the holding furnace (2), the reduction of the melt is continued in the holding furnace (2) by means of the wood charcoal covering until the oxygen content of the melt has decreased to a second
20 predetermined value.

9. A method according to claim 8, **characterised** in
that, when the oxygen content of the melt in the holding furnace (2) has decreased to the desired
25 second value, the melt is routed from the holding furnace (2) along a gas-tight second launder (12), in which there is a reducing CO atmosphere, to a vertical casting furnace (3), from where the melt is cast by a vertical casting method into a copper product (P).

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10. A method according to any of claims 1 - 9, **characterised** in that the melt is pumped from the induction crucible furnace (1) into the first launder
(11).

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11. A method according to any of claims 1 - 10, **characterised** in that the melt is pumped from the holding furnace (1) into the second launder (13).
- 5 12. A method according to any of claims 1 - 11, **characterised** in that copper oxide is charged into the induction crucible furnace (1) in substantially small charging batches in relation to the amount of melt in the furnace.
- 10 13. A method according to any of claims 7 - 12, **characterised** in that the amounts of melt transferred from the induction crucible furnace (1) to the holding furnace (2) and from the holding furnace (2) to the
- 15 casting furnace (3) are substantially small in relation to the amount of melt in the furnaces.
14. An apparatus for fabricating an oxygen-free copper product (P), such as copper-free wire, tube or rod,
- 20 from copper oxide powder, where said apparatus comprises a reduction furnace (1) for reducing copper oxide, a holding furnace (2) and a casting furnace (3) for casting molten oxygen-free copper into a copper product (P), **characterised** in that the apparatus
- 25 includes an induction crucible furnace (1), which is arranged to function as a melting and reducing furnace for melting copper oxide into an oxygen-containing melt and reducing said oxygen-containing melt.
- 30 15. An apparatus according to claim 14, **characterised** in that the apparatus includes a charging device (4) for charging copper oxide powder into the induction crucible furnace (1).
- 35 16. An apparatus according to claim 14 or 15, **characterised** in that the apparatus includes a

plunging device (5) for plunging the copper oxide inside the melt.

17. An apparatus according to any of claims 14 - 16,
5 **characterised** in that the apparatus includes a feeding device (6) for feeding carbon-containing material as a covering for the melt.

18. An apparatus according to any of claims 14 - 17,
10 **characterised** in that the apparatus includes a degassing unit (7), which is arranged above the induction crucible furnace (1) in order to remove flue gases during charging.

15 19. An apparatus according to any of claims 14 - 18, **characterised** in that the induction crucible furnace (1) includes a lid (8) that can be shut gas-tight, in which there is a discharge conduit (9) for removing flue gases.

20

20. An apparatus according to any of claims 14 - 19, **characterised** in that the induction crucible furnace (1) includes a fire-resistant magnesite lining (10), which contains mostly magnesia (MgO).

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21. An apparatus according to any of claims 14 - 20, **characterised** in that the apparatus includes a gas-tight first launder (11), which is arranged between the induction crucible furnace (1) and the holding
30 furnace (2) to convey the melt from the induction crucible furnace to the holding furnace.

22. An apparatus according to any of claims 14 - 20, **characterised** in that the apparatus includes a gas-tight second launder (12), which is arranged between
35 the holding furnace (2) and the casting furnace (3) to

convey the melt from the holding furnace to the casting furnace (3).

23. An apparatus according to any of claims 14 - 22,
5 **characterised** in that the holding furnace (2) is an induction channel furnace equipped with a double channel inductor.

24. An apparatus according to any of claims 14 - 23,
10 **characterised** in that the casting furnace (3) is a vertical casting furnace adapted for continuous upward-directed vertical casting.

25. An apparatus according to claim 24, **characterised**
15 in that the vertical casting furnace (3) is an induction channel furnace.

26. An apparatus according to any of claims 14 - 25,
20 **characterised** in that the apparatus includes a first pump (14) for pumping melt from the induction crucible furnace (1) into the first launder (11).

27. An apparatus according to any of claims 12 - 26,
25 **characterised** in that the apparatus includes a second pump (15) for pumping melt from the holding furnace (2) into the second launder (12).

28. An apparatus according to claim 27, **characterised**
30 in that the first pump (14) and/or the second pump (15) is a gas lift pump.

29. An apparatus according to claim 28, **characterised**
in that the gas lift pump (14, 15) comprises
- a riser tube (16), which comprises an upper
35 end (17), which extends above the melt and opens into a launder (11; 12), and a lower end (18), which is submerged in the melt,

- a gas feed pipe (19), through which the reducing gas is arranged to be fed into the melt inside the riser tube (16).

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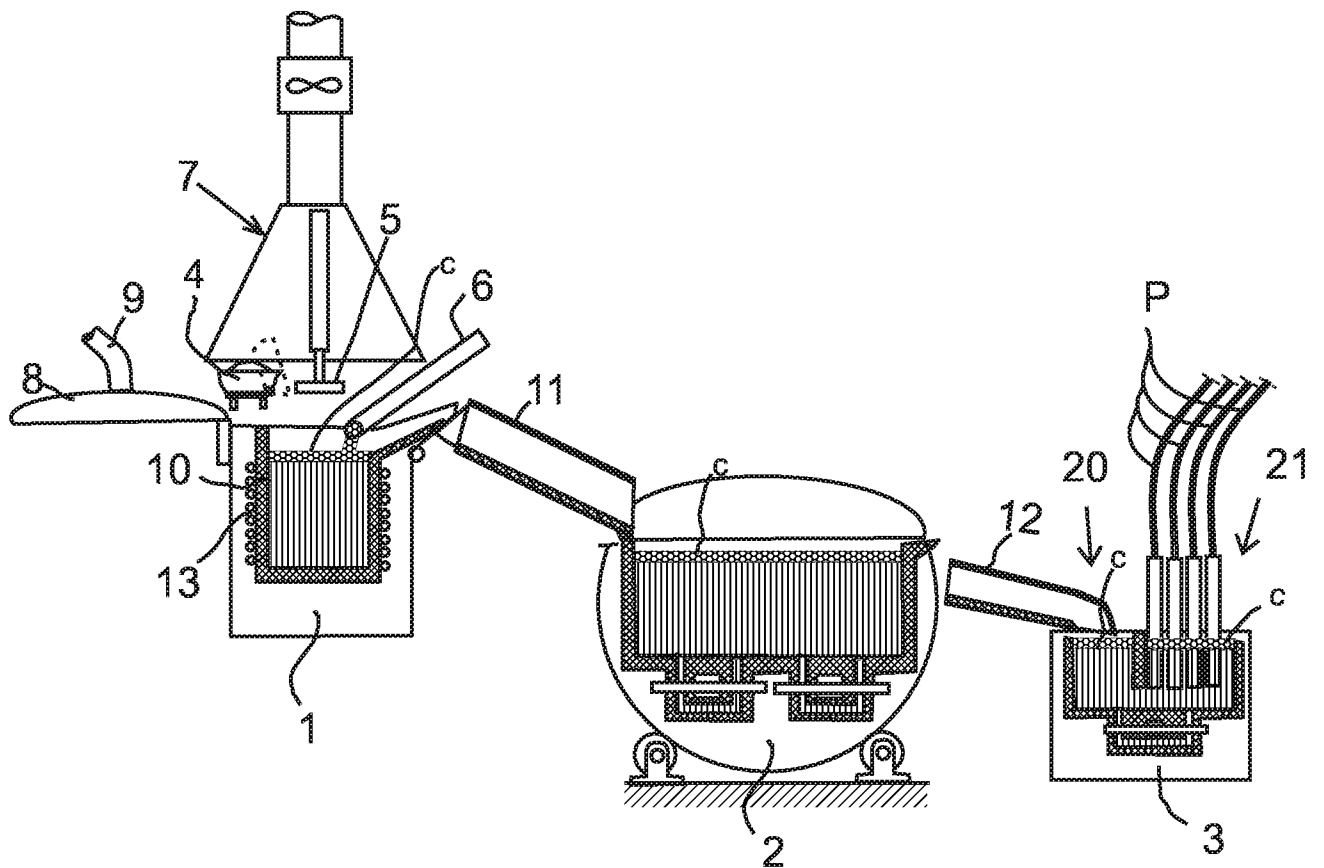


Fig. 1

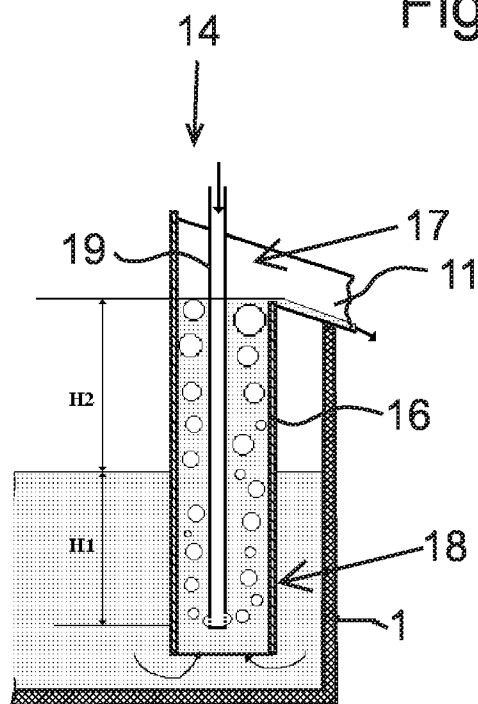


Fig. 2

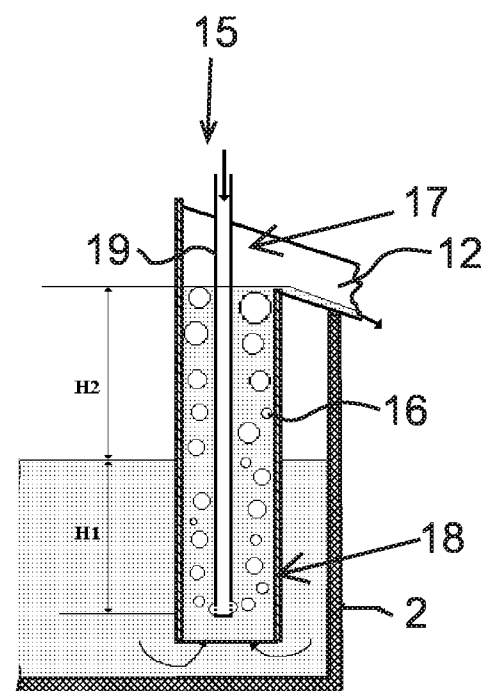


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No

PCT/FI2012/050404

A. CLASSIFICATION OF SUBJECT MATTER

INV. C22B15/00 F27B14/06 F27B19/04
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)

C22B F27B

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.
A	WO 2008/125726 A1 (OUTOTEC OYJ [FI]; EEROLA HEIKKI [FI]; KARONEN JANNE [FI]; MANNINEN JAA) 23 October 2008 (2008-10-23) the whole document	1-29
A	HYVARINEN O ET AL: "HydroCopper(TM)-a new technology producing copper directly from concentrate", HYDROMETALLURGY, ELSEVIER SCIENTIFIC PUBLISHING CY. AMSTERDAM, NL, vol. 77, no. 1-2, 1 April 2005 (2005-04-01), pages 61-65, XP027652499, ISSN: 0304-386X [retrieved on 2005-04-01] the whole document	1-29

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

28 September 2012

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09/10/2012

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INTERNATIONAL SEARCH REPORT

International application No

PCT/FI2012/050404

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2007/157761 A1 (BRATINA JAMES E [US]) 12 July 2007 (2007-07-12) the whole document -----	14-29

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/FI2012/050404

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2008125726 A1	23-10-2008	AR 066046 A1	22-07-2009
		CL 9032008 A1	22-08-2008
		PE 16282008 A1	10-12-2008
		WO 2008125726 A1	23-10-2008

US 2007157761 A1	12-07-2007	AU 2007204927 A1	19-07-2007
		BR PI0706624 A2	05-04-2011
		CA 2636155 A1	19-07-2007
		US 2007157761 A1	12-07-2007
		WO 2007082030 A2	19-07-2007
		ZA 200806171 A	29-07-2009
