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(54) **METHOD FOR PRODUCING SEMI-FINISHED METALLURGICAL PRODUCTS AND SHAPED CASTINGS, AND DEVICE FOR CARRYING OUT SAID METHOD**

(57) The invention refers to the metallurgical and foundry industry and can be implemented in the production of metals and alloys under gas pressure, in vacuum, in atmospheric conditions and in special gas medium. The device contains a furnace autoclave 1, a pouring autoclave 2 connected by a shutoff device 3 with a built-in gastight gate 4. The pouring autoclave 2 is disconnected by a gastight gate 5. A feed pipe 6 is secured to the bottom part of a tray 7 of a mould 8. In a capsule 9 at

"high mode", casting of ingots (slabs, shaped castings), bimetallic and three-layered ingots of two or three alloy grades as well as conventional ingots, is carried out. The furnace autoclave 1 is produced with an induction furnace 12. A specific feature of the invention is the use of a replaceable device for intensive cooling of the melt, which provides for substantial increase in the output of the device.

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Description

[0001] The invention refers to the metallurgical and foundry industry and can be used for production of metals and alloys under gas pressure, in a vacuum, in atmospheric conditions and in special gaseous medium.

[0002] A device is known [Rasheva I.A., Petkanchin L.T., Pat. 2001/6887.23 August 2001, Equipment for Production and Casting of Alloys, Republic of South Africa] for producing and casting of metals and alloys under gas pressure, in a vacuum and in atmospheric conditions or in special gaseous medium, which can produce monolithic (mono) ingots, remelted electrodes and casting of steels, alloyed with high nitrogen concentrations and easily evaporated elements, such as Cu, Pb, Mg, Zn and others. The equipment includes furnace and pouring autoclaves, airtight capsule with a feed pipe, which can be produced hermetically as an integral whole or as hermetically autonomous with a hermetic connection between them. In the furnace autoclave there is an induction furnace and in the pouring autoclave - a set of moulds for mono-ingots, remelted electrodes or a casting form. The furnace and pouring autoclaves may have a common workspace and when necessary the autoclaves can be autonomously separated by means of two gastight gates. A hermetic capsule with a metallurgical or casting set, moves vertically in the pouring autoclave and capsule can be with autonomous gas pressure (independent of the total work pressure in the pouring autoclave or in the common vessel under pressure, formed by the furnace and pouring autoclaves). There is a mould (form) in the pouring capsule, in which the liquid metal is poured anti-gravitationally. The feed pipe is secured hermetically to the capsule. The upper and lower moving platforms are moving along horizontal rails, and the furnace and pouring autoclaves are moved vertically by elevators.

[0003] The shortcomings of this known device are:

- low productivity, since the ceramic feed pipe have low heat conductivity and hence a waiting period is necessary until the liquid metal (melt) in it is crystallized and the two autoclaves have to be disconnected in order to start the next melting;
- limited assortment, excluding the possibility of producing two- and three-layered ingots and castings;
- increased consumption of electric power, water, refractory and other expendable materials, since the induction furnace continues its operation after filling the mould (form);
- lower effectiveness of liquid charge application since the crystallization in the pouring chamber restricts all production processes;
- replacement of the expensive feed systems after each melting, since a solid alloy plug is formed in the refractory pipe.

[0004] The technical result, aimed by the proposed method for producing, semi-finished metallurgical prod-

ucts and shaped castings and device for its implementation, consists in increasing the productivity, decreasing the power consumption and broadening the assortment of production.

[0005] The technical result of implementing the method is achieved since the method of producing metallurgical products and shaped castings consists in filling the furnace autoclave with liquid or solid charge, which is melted and due to the pressure difference the melt is introduced through the feed pipe in the mould or form of the pouring autoclave and a replaceable device for intensive cooling of the melt is fixed between the feed pipe and the bottom tray of the mould, which is used for the local crystallization of the melt after filling the mould or form and the subsequent gas compaction. Water or other cooling agent can be introduced in the replaceable device for intensive cooling.

[0006] When producing multilayered alloys, at least one metallurgical product, preliminarily placed in the mould, is heated before introducing the melt.

[0007] To obtain metallurgical products and shaped castings with various properties, the melt in the furnace autoclave is processed under gas, for example nitrogen, pressure.

[0008] The technical result in the device implementation is reached in a device for producing metallurgical products and shaped castings, consisting of a movable furnace autoclave and a pouring autoclave with at least one mould or form, connected by a corresponding feed pipe and a locking system, the bottom tray of the mould and the end of the feed pipe being produced with the possibility of connecting with a replaceable device for intensive cooling of the melt.

[0009] The replaceable device for intensive cooling can include a high heat-conducting sleeve, encompassed by a high heat-conducting cooling sleeve.

[0010] The bottom tray of the mould can be produced with the possibility for placing into a conical refractory sleeve, conjugated with a high heat-conducting sleeve and a high heat-conducting cooling sleeve.

[0011] In the pouring autoclave for manufacturing multilayered alloys with the possibility of displacement there is a heater placed in the mould of the metallurgical blank and a gas-permeable lid covering the mould.

[0012] The quantity of the furnace and pouring autoclaves is determined by the production volume.

The essence of the invention is explained by drawings.

Fig. 1 - a general outlook of the device of producing metallurgical products and shaped castings;

Fig. 2 - a replaceable device for intensive cooling of the melt;

Fig. 3 - a scheme for producing a bimetallic ingot;

Fig. 4 - a scheme for producing a three-layered ingot;

Fig. 5 - a scheme for producing a bimetallic slab.

[0013] The device for producing metallurgical products and shaped castings consists of mobile, immobile and

autonomous parts: a furnace autoclave 1 and a pouring autoclave 2, connected with a stationary shutoff device 3 with an incorporated gastight gate 4. The pouring autoclave 2 is disconnected by a gastight gate 5. The feed pipe 6 is fixed to the lower part of the bottom tray 7 of the mould 8. The pouring capsule 9 is moved vertically by the mechanism 10 and horizontally - together with the pouring autoclave 2 on a carriage 11.

[0014] In the capsule 9 at "high mode" anti-gravitationally the casting of ingots (slabs, shaped castings) of the type of bimetallic and three-layered ingots of two or three alloy grades as well as conventional ingots, is carried out. The furnace autoclave 1 together with the induction furnace 12 is moved vertically by the elevator 13 to the bayonet stationary shutoff device 3 and it is moved horizontally by the carriage 14. The stationary shutoff device 3 connects to the furnace autoclave 1 and the pouring autoclave 2 and the carriages 11 and 14 move along the rails 15 and 16.

[0015] There is an induction furnace 12 in the furnace autoclave 1 and in the pouring autoclave 2 - a set of moulds 8 for ingots (casting forms), used for producing mono-ingots, remelted electrodes, shaped castings, two- or three-layered ingots and castings. The castings of the pouring autoclaves and the capsule 9 can be low and high (in the case of bimetallic and three-layered ingots-slabs). Both autoclaves 1 and 2 can have common workspace but can also be with autonomous atmosphere. The capsule 9 in the pouring autoclave 2 moves vertically with the casting form or with the pouring set for the mono-ingot, bimetallic ingot, ingot of three different metal layers or ingot of three layers of two alloys. The capsule 9 is also produced in hermetic version with autonomous gas medium and has a heater(s) 18 to heat the internal surface of the ingot (slab) 19 immediately before filling the mould 8. At the bottom of the capsule (in the tray) 7 a high heat-conducting sleeve 20 is installed in contact with a copper water-cooled sleeve 21. The feed pipe 6 is fixed hermetically below them at the bottom tray 7.

[0016] The furnace autoclave 1 consists of a casing 22, a cover 23, coupled with a bayonet connection 24. The pouring autoclave 2 consists of a casing with a lower part 25 and an upper part 26, coupled with a bayonet connection 27. The capsule 9 has a lower part 28 and an upper part 29, coupled with a bayonet connection 30.

[0017] The device for intensive cooling of the melt in addition to above mentioned sleeves 20 and 21 contains plastic sealing coating 31, flow sensor for water (cooling agent) and an automatic tap at the control panel, which turns on maximum water cooling flow (cooling agent) immediately after the signal for filling the mould 8, but also taking into account the time for pressing the liquid metal for a dense seam with the ingot (slab) 19 and decreasing the shrinkage sink of the newly casted ingot.

[0018] A replaceable refractory conical sleeve 32 ("stone") is placed in the bottom tray 7.

[0019] When producing alloys in the mould 8 a slab (semi-ingot) 19 is firmly fixed and occupies part of the

workspace of the mould 8. The heater 18 is lowered by a manipulator in the free half-space of the mould 8 and it is used for heating of the internal surface of the ingot (slab) 19. After reaching the set temperature (different for the different metals and alloys) the heater 18 is lifted and the liquid metal 33 is introduced for the formation of the second part of the bimetallic or the third part of the three-metallic alloy.

[0020] An upper gastight gate 5 is installed in the bottom of the pouring autoclave 2. A lower gastight gate 4 is installed in the stationary shutoff device 3, connecting the autoclaves 1 and 2. The induction furnace 12 is stationary installed in the casing 22 of the furnace autoclave 1, which is mounted by trunnions 34 on a moving carriage 14.

[0021] In case of the production of a three-layered ingot (slab) (Fig. 4) the sequence of operation is analogous to the production of bimetallic ingot(s).

[0022] When the operation is based on solid charge, the induction furnace 12 is filled with solid charge, which is melted and processed under atmospheric conditions. The pouring autoclave 2 is prepared for melting at the device itself or on the rail road 16. At the lower surface (Fig. 2) of the bottom tray 7 the "stone" (conical sleeve) 32 is installed, which is in contact with the high heat-conducting sleeve 20 (covered with the plastic coating 31) and the high heat-conducting cooling copper sleeve 21 is laid and then the feed pipe 6 is installed. The copper sleeve 21 is connected at the control panel with two sensors with thermocouples, inserted in the lid of the mould 8 for recording the metal casting process. Then the slab (part of ingot) 19 is installed and firmly fixed in the mould 8 and the heater 18 is lowered next to it. After heating to the set temperature of the internal surface of the slab 19, the heater 18 is lifted and after it the gas-permeable lid 35 is placed, the lid 29 of the capsule 9 is fixed by the bayonet connection 27. The upper part 26 of the pouring autoclave 2 is placed on the lower part 25 and is fixed by the bayonet connection 27.

[0023] The induction furnace 12 moves along a rail road 15 by means of the carriage 14 and is centered under the pouring autoclave 2, lifted by the elevators 36 until it stops at the stationary shutoff device 3 and is fixed by the bayonet connection 24. The liquid alloy 33 is processed under gas pressure and then the capsule 9 is lowered in a controlled manner until the lower end of the feed pipe 6 is submerged in the liquid metal. In this way conditions for transportation are created - pressure difference ($\Delta P = P_2 - P_1$) in the common workspace of the furnace autoclave 1 and the pouring autoclave 2, and the liquid metal starts to flow anti-gravitationally through the feed pipe 6 into the mould 8. After filling the free volume of the mould 8 (Fig. 3), the most intensive water cooling flow (cooling agent) is turned on and local crystallization of the liquid metal takes place in the unit (device) by controlled crystallization (Fig. 2). After the local crystallization in the zone of the sleeve 20 the gastight gate 5 is closed. The pressure P_2 becomes higher than the pressure P_3

and the pressure of the gas P1 in the furnace autoclave 1 is decreased to the atmospheric pressure. The bayonet connection 24 is opened, the furnace autoclave 1 is lowered to the end lower position by the elevators 36, the furnace autoclave 1 is moved to the end left position and the induction furnace 12 is prepared for the charge of the next melting.

[0024] When operated with liquid charge, the induction furnace 12 receives liquid charge and the furnace autoclave 1 is moved and centered under the pouring autoclave 2. The sequence of the other operations is analogous to the variant with the operations with solid charge.

[0025] The operation of the device implements the method for producing metallurgical products and shaped castings and the following ingots are obtained:

1. Monolithic conventional ingot.

[0026] The induction furnace 12 is heated to the temperature 1580-1600°C. The pressure P1 in the furnace autoclave 1 and P2, P3 respectively in the pouring autoclave 2 and the capsule 9 is equalized in the course of 20s. High-nitrogen ferrochromium is introduced after the pressure equalization, which is absorbed in the course of 10 min. In the capsule 9 negative differential pressure is formed $\Delta P = P1 - P3 = 0.05$ MPa.

[0027] The feed pipe 6 is filled in the course of 6 s, the differential pressure is increased to 0.25 MPa and the mould 8 is filled with a melt, which is solidified, for example, after 10 min. Then the ingot is compacted for about 6 min, the device for intensive cooling is turned on and after 2 min the casting become completed. The pressure P3 above the ingot in the capsule 9 is kept on the level of 0.45 MPa for 2 min. Then in the course of 15 s the pressure P1 in the furnace autoclave 1 become reduced and the device 1 is moved to be charged for new melting.

2. Bimetallic ingot (Fig. 3)

[0028] The operations proceed as in paragraph 1, but the mould 8 is different - a solid alloy semi-ingot 19 is placed in it earlier and heated to 100-150°C by the heater 18.

3. Three-layered ingot (Fig. 4)

[0029] The operations proceed as in paragraph 2, but in the mould 8 two semi-ingots 19 are placed.

4. Bimetallic slab (sheet) ingot (Fig. 5)

[0030] The operations proceed as in paragraph 1 but the solid semi-ingot 19 have parallelepiped formation. The device and method have the following advantages:

- the device for intensive controlled cooling out of the section of the feed channel out of the feed ceramic pipe 6 allows to decrease the time for pouring and

to increase the productivity of the equipment;

- the device for intensive controlled cooling is situated outside of the feed pipe 6, which increases the service life in tens of times;
- 5 - the possibility is ensured for multiple application of the expensive feed system;
- wider assortment of production, including high tech production of bi- and tri-metals welded in a metallurgical way;
- 10 - decreased consumption of electric power, water, materials, etc. due to the shorter melting time;
- higher effectiveness of the operation with liquid charge, which is the basis for higher competitiveness of the whole production process;
- 15 - decreasing the time of the harmful effect of the high-temperature mirror of the liquid melt (1600-1700°C, irradiation, dust, gases) on the polished cylinders and polished guide columns of the elevation mechanism;
- 20 - substantial reduction for the risk of industrial accidents due to the longer service interval of the feed system;
- the device allows melting under pressure and atmospheric conditions and, including, in vacuum;
- 25 - the method for producing metallurgical products and shaped castings and the device for its implementation can be used for the production and casting of metals and alloys under gas pressure, in vacuum or in atmospheric conditions, as well as in special gas medium, to obtain conventional (mono) ingots (slabs), monometallic, bimetallic, three-layered with two or three grades of metals or alloys, remelted electrodes; shaped castings, conventional, nitrogen (NS), high nitrogen (HNS) steels, alloyed with easily evaporated elements like calcium, lead, zinc, magnesium, manganese, etc., as well as non-ferrous metals and alloys.
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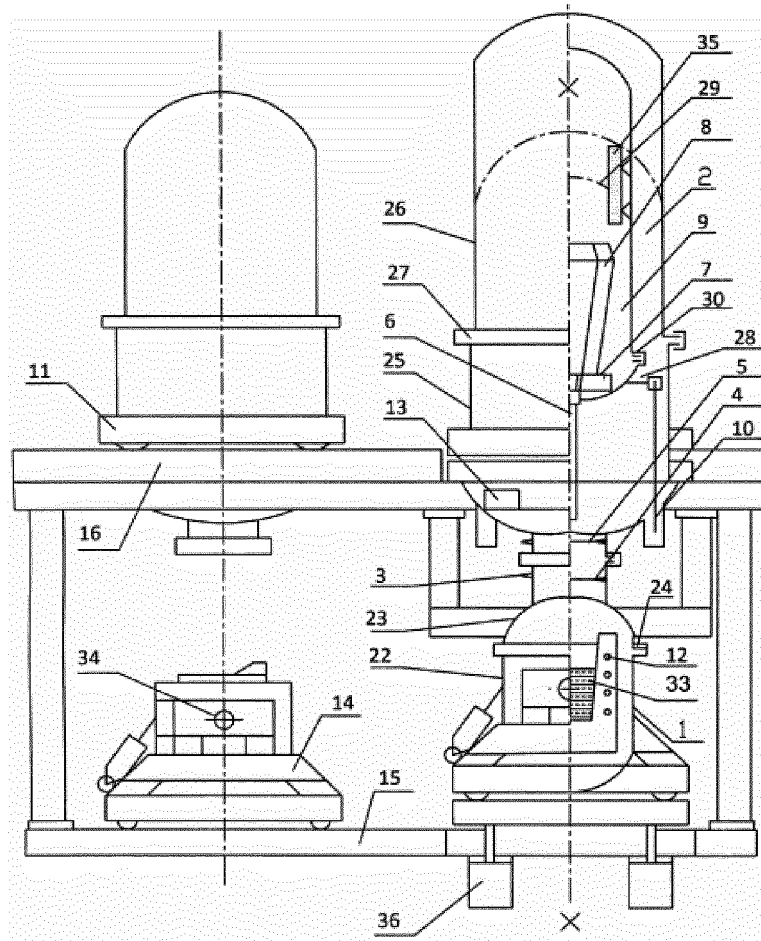
40 Claims

1. A method for producing semi-finished metallurgical products and shaped castings, according to which the furnace autoclave is filled with liquid charge or solid melting charge that is introduced due to the pressure difference through a feed pipe into the mould or into the form of the pouring autoclave, wherein, before introducing the melt through the feed pipe, between it and the bottom tray of the mould or form, a replaceable device for intensive cooling of the melt is placed, which is used after filling the mould or form with the melt and the subsequent gas compaction for local crystallization of the melt.
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- 50
- 55 2. A method, according to claim 1, wherein water or other cooling agent introduced in the replaceable device for intensive cooling of the melt.

3. A method, according to claim 1 or 2, wherein at least one preliminary placed in the mould or form metallurgical blank is heated before introducing the melt.
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4. A method, according to claim 1 or 2, wherein the melt is processed in the furnace autoclave under gas pressure.
5. A method, according to claim 4, wherein nitrogen is used. 10
6. A method, according to claim 3, wherein the melt is processed in the furnace autoclave under gas pressure. 15
7. A method, according to claim 6, wherein nitrogen is used.
8. A device for producing semi-finished metallurgical products and shaped castings, consisting of a removable furnace autoclave and a pouring autoclave with at least one mould or form, connected with a respective feed pipe or locking system, wherein the mould bottom tray and the end of the feed pipe allow the possibility of coupling with a replaceable device for intensive cooling of the melt. 20 25
9. A device, according to claim 8, wherein device for intensive cooling of the melt is replaceable, which includes a high heat-conducting sleeve, encompassed by a high heat-conducting cooling sleeve. 30
10. A device, according to claim 9, wherein a bottom tray of the mould or form allow the possibility for inserting in it a replaceable conical refractory sleeve, connected with a high heat-conducting sleeve and a high heat-conducting cooling sleeve. 35
11. A device, according to any of claims 8-10, wherein the pouring autoclave have the possibility of displacement with a heater which is positioned in the mould or form of the metallurgical blank and a gas-permeable lid covering the mould or form. 40 45

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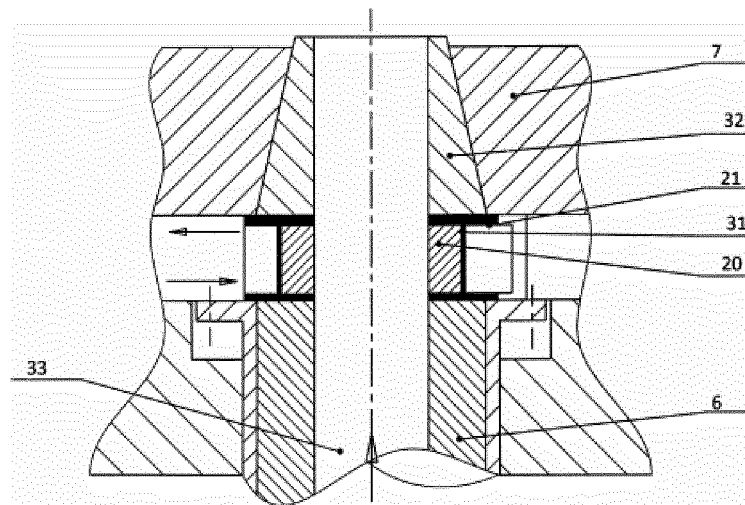


Fig. 2

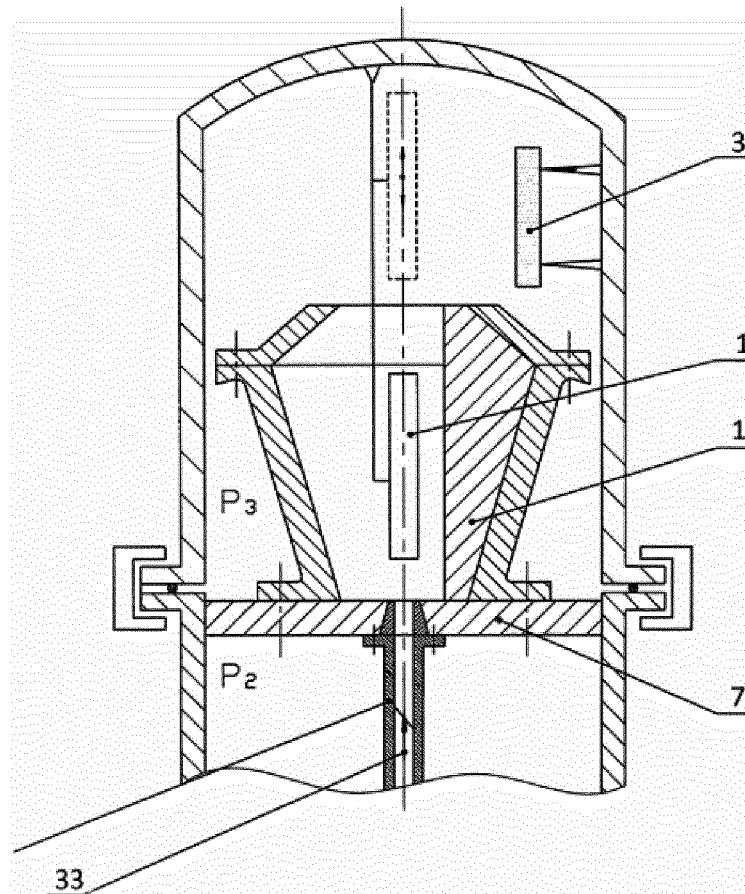


Fig. 3

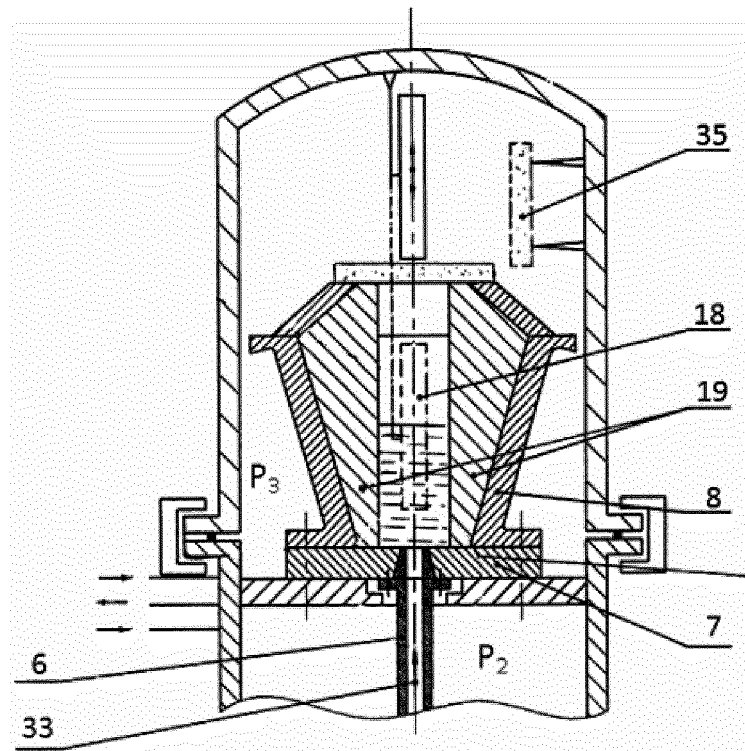


Fig. 4

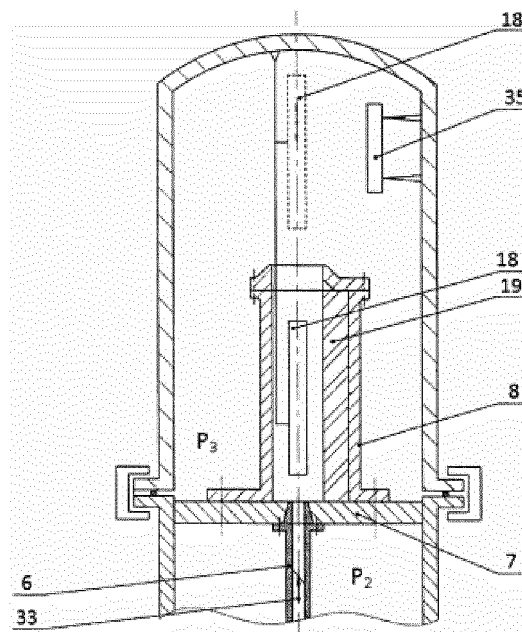


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/RU 2016/000218

A. CLASSIFICATION OF SUBJECT MATTER B22D 18/04 (2006.01) 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 18/00, 18/04, 18/06, 27/00, 27/09, 27/13															
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) PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE, Information Retrieval System of FIPS															
C. DOCUMENTS CONSIDERED TO BE RELEVANT															
<table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>Y, D A</td> <td>ZA 20016887 A (HIGH NITROGEN STEEL (PTY) LTD) 21.08.2001, p. 5-10, fig. 1</td> <td>1-2, 4-8 3, 9-11</td> </tr> <tr> <td>Y</td> <td>RU 2127172 C1 (GEORG FISHER DISA A/S) 10.03.1999, p. 8 par. 5, fig 8a, 8b</td> <td>1-2, 4-8</td> </tr> <tr> <td>A</td> <td>SU 1482751 A1 (SIBIRSKY METALLURGICHESKY INSTITUT im. SERGO ORDZHONIKIDZE) 30.05.1989</td> <td>1-11</td> </tr> <tr> <td>A</td> <td>US 4616808 A (INSTITUTE RO METALOZNANIE I TECHNOLOGIA NA METALITE) 14.10.1986</td> <td>1-11</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	Y, D A	ZA 20016887 A (HIGH NITROGEN STEEL (PTY) LTD) 21.08.2001, p. 5-10, fig. 1	1-2, 4-8 3, 9-11	Y	RU 2127172 C1 (GEORG FISHER DISA A/S) 10.03.1999, p. 8 par. 5, fig 8a, 8b	1-2, 4-8	A	SU 1482751 A1 (SIBIRSKY METALLURGICHESKY INSTITUT im. SERGO ORDZHONIKIDZE) 30.05.1989	1-11	A	US 4616808 A (INSTITUTE RO METALOZNANIE I TECHNOLOGIA NA METALITE) 14.10.1986	1-11
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Date of the actual completion of the international search 08 August 2016 (08.08.2016)	Date of mailing of the international search report 18 August 2016 (18.08.2016)														
Name and mailing address of the ISA/ RU	Authorized officer														
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Patent documents cited in the description

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[0002]