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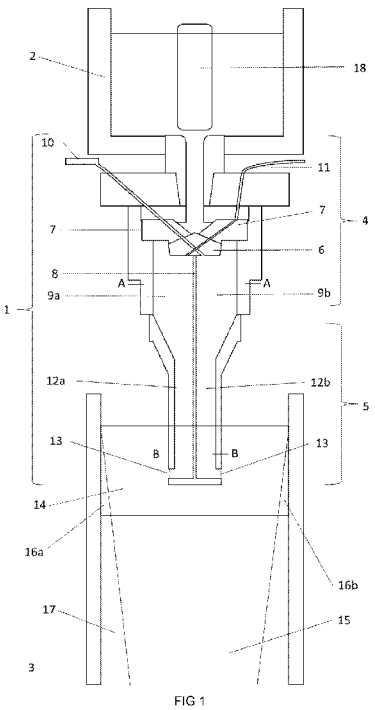


FIG 1

(57) Abstract: The invention relates to a continuous casting nozzle for manufacturing a composite metallic product having a distinct shell and bulk, wherein said shell is separated into two parts having different compositions, said compositions being different from the composition of the bulk, said nozzle comprising: – a dome comprising means for splitting the initial stream of liquid metal into at least two separate streams, – an internal wall located below the dome, creating at least two chambers, – means for injecting powder through the dome, to allow mixing with the liquid metal – a lower part composed of at least two channels, extending from the upper part into the mold and opening into the mold by means of at least one lateral outlet for each channel The invention also relates to a method of continuously casting and to the products related, using a continuous casting nozzle related to the invention.

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CONTINUOUS CASTING EQUIPMENT

[0001] The invention relates to a continuous casting equipment. In particular, the invention relates to a continuous casting nozzle, with an improved design, made for manufacturing a composite metallic product.

[0002] Composite metallic materials are a well-known category of products. Their specificity lies in their ability to associate different mechanical properties thanks to their structure consisting of different metals of different compositions. Clad steels are an example of composite metallic materials, having a bulk composed of a certain type of metal and a surface or a shell composed of one or two other types of metal.

[0003] However, these products are mainly manufactured using batch processes. Manufacturing methods using a continuous process are very scarce.

[0004] European Patent Application EP3804874 describes a device and method for the continuous manufacturing of clad metal strips. The method uses a metallic coil as a base metal and uses different devices and process steps to add different layers of metal on the surface of said metal, including a step of continuous casting with two different tundishes. This method allows the continuous manufacturing of a composite metallic product having a bulk formed of one metal composition and a shell composed of one or two other metal compositions.

[0005] However, the solution proposed in the prior art comprises too many steps and associated devices, thus making it difficult to implement in an industrial facility.

[0006] The present invention discloses a continuous casting nozzle for manufacturing a composite metallic product having three different metal compositions, using a simple equipment, and having a sufficient stability to obtain a product of great quality.

[0007] A first object of the invention is a continuous casting nozzle 1 for manufacturing a composite metallic product having a distinct shell 16a, 16b and

bulk 17, wherein said shell 16a, 16b is separated into two parts having different compositions, said compositions being different from the composition of the bulk 17, said nozzle 1 being located between a tundish 2 and a mold 3, said nozzle 1 comprising:

- an upper part 4 disposed downstream of the tundish 2 with respect to the direction of travel of the liquid metal,
- a dome 6 disposed at the inlet of the upper part 4, said dome 6 comprising means for splitting the initial stream of liquid metal into at least two separate streams,
- an internal wall 8 located below the dome 6, creating at least two chambers 9a, 9b, said separate streams of liquid metal flowing respectively in each of said chambers 9a, 9b,
- means for injecting powder 10 through the dome 6 into at least one of said chambers 9a, 9b, to allow mixing with the liquid metal flowing into said chamber 9a, 9b,
- a lower part 5 composed of at least two channels 12a, 12b, extending from the upper part 4 into the mold 3 and opening into the mold 3 by means of at least one lateral outlet 13 for each channel 12a, 12b, wherein one of said channels is connected to one chamber 9a, 9b, said channel allowing the liquid metal to flow into one part of the mold 3, and wherein the other channels are connected to the other chambers 9a, 9b, said channels allowing the liquid metal to flow into the other part of the mold 3.

[0008] The continuous casting nozzle 1 according to the invention may also have the optional features listed below, considered individually or in combination:

- the channels 12a, 12b, have at least two outlets for each channel,
- the outlets 13 have their axis positioned towards the corners of the mold 3
- the composite metallic product is a slab, and the outlets 13 have their axis positioned towards the narrow faces of the mold 3

- the dome 6 further comprises a means for injecting gas 11 through the dome 6,
- the dome further comprises support arms 7.

[0009] A second object of the invention is a method of a composite metallic product having a distinct shell 16a, 16b and bulk 17, wherein said shell 16a, 16b is separated into two parts having different compositions, said compositions being different from the composition of the bulk 17, using a continuous casting nozzle 1 according to any one of the preceding claims wherein:

- liquid metal is poured in a tundish 2 located above said continuous casting nozzle 1,
- said liquid metal flows from the tundish 2 into the upper part 4 of said casting nozzle 1 creating an initial stream,
- said initial stream collides onto the dome 6, thus separating it into at least two separate streams,
- said separate streams flow into the chambers 9a, 9b of the nozzle 1,
- powder is injected into at least one of said chambers 9a, 9b and mixed with the stream of liquid metal flowing into said chamber 9a, 9b thus modifying its composition,
- said separate streams are then distributed into the channels 12a, 12b of the lower part of said continuous casting nozzle 1,
- said liquid metal is poured into the mold 3, wherein the liquid metal flowing in one channel 12b, 12c is poured into one part of the mold 3 by means of at least one outlet 13 and the liquid metal flowing into the other channels 12a is poured into the other part of the mold by means of at least one outlet 13 for each channel.

[0010] The method of continuous casting according to the invention may also have the optional features listed below, considered individually or in combination:

- the liquid metal is steel,

- an upstream part 14 of the mold 3 contains two liquid metals of different composition located on two parts,
- the composition of the liquid metal in one part of the upstream part 14 of the mold 3 is made of the base metal coming from the tundish 2 only and the composition of the liquid metal in the other part of the upstream part 14 of the mold 3 is made of the base metal coming from the tundish 2 mixed with the powder injected below the dome 6,
- the composition of the liquid metal in one part of the upstream part 14 of the mold 3 is made of the base metal coming from the tundish 2 mixed with one type of powder injected below the dome 6 and the composition of the liquid metal in the other part of the upstream part 14 of the mold 3 is made of the base metal coming from the tundish 2 mixed with another type of powder injected below the dome 6,
- a downstream part 15 of the mold 3 contains a liquid metal with a composition resulting from the mix of the compositions coming from the two parts of the upstream part 14 of the mold 3,

[0011] A third object of the invention is a composite metallic billet or bloom having a distinct shell 16a, 16b and bulk 17, wherein said shell 16a, 16b is separated into two parts having different compositions, said compositions being different from the composition of the bulk 17.

[0012] A fourth object of the invention is a composite metallic slab having a distinct shell 16a, 16b and bulk 17, wherein said shell 16a, 16b is separated into two parts having different compositions, said compositions being different from the composition of the bulk 17.

[0013] The invention will be described, in a non-limitative way, in reference to the following drawings:

- Fig 1: general view of the nozzle according to the invention, in a usage configuration,
- Fig 2: dome observed with a view from above,

- Fig 3: cross-sectional view A-A of the upper part of the nozzle below the dome of Fig 1
- Fig 4: cross-sectional view B-B of the mold and the nozzle with representation of the flows for billet or bloom type products
- Fig 5: cross-sectional view B-B of the mold and the nozzle with representation of the flows for slab type products
- Fig 6: submerged part of the nozzle with a representation of the compositions and the flows in the mold
- Fig 7: section of the composite metallic billet or bloom obtained by continuous casting using the invention
- Fig 8: section of the composite metallic slab obtained by continuous casting using the invention

[0014] The aim of the invention is to cast a composite metallic product.

[0015] Fig 1 shows a nozzle 1 disposed between a tundish 2 and a mold 3. The nozzle 1 is composed of an upper part 4 and a lower part 5.

[0016] A dome 6 is disposed at the inlet of the upper part 4 and closes a part of it. The top of the dome 6 preferably has a slope of a certain angle, higher than 15° for example. The dome 6 also has a lateral side, preferably forming a sharp edge with the slope. The dome 6 is fixed to the upper part 4 by one or more support arms 7.

[0017] An internal wall 8, located below the dome 6, creates at least two chambers 9a, 9b in the upper part 4. In the configuration presented in Fig 1, two chambers are present 9a, 9b.

[0018] A means for injecting powder 10 and a means for injecting gas 11 are also comprised in the upper part 4, each one being partly located in one of the support arms 7 and passing through the dome 6. The means for injecting powder 10 can be an endless screw, for example, linked to a powder tank.

[0019] Fig 2 shows a configuration of the dome 6 having four support arms 7 and having one passage for powder injection 10 located in one of the support arms 7 and three passages for gas injection 11 located in the other three

support arms 7. Another configuration, not represented, has two passages for two powder injections 10 located on two opposed support arms 7.

[0020] The dome 6 can also have other configurations with less or more support arms 7. A configuration with two or three support arms 7, for example, can be considered.

[0021] As shown on Fig 1, the lower part 5 of the nozzle 1 is composed of two channels 12a, 12b extending from the chambers 9a, 9b of the upper part 4 and ending into the mold 3. The channels 12a, 12b are opened into the mold 3 by means of at least one lateral outlet 13 for each channel 12a, 12b.

[0022] The number and the configuration of the outlets 13 depends on the type of cast product. In the case of a billet or a bloom type product, the mold 3 has a square section and thus, it is preferable to have at least two outlets 13 for each channel 12a, 12b with their axis positioned towards the corners of the mold 3. In the case of a slab type product, the mold 3 has a rectangular section and thus, it is preferable to have at least one outlet 13 for each channel 12a, 12b with their axis positioned towards the narrow faces of the mold 3. The two described configurations of outlets 13 depending on the type of product are represented in Fig 4 and Fig 5 which are representations of the bottom of the nozzle 1 and the mold 3 with a view from above. Fig 4 is a representation of the nozzle 1 in the mold 3 for the billet or bloom type product and Fig 5 is a representation of the nozzle 1 in the mold 3 for the slab type product.

[0023] In the present embodiment, the channels 12a, 12b are of circular shape. In a preferred embodiment, the channels 12a, 12b have a semi-oblong section

[0024] Fig 3 shows the cross-sectional view A-A of the nozzle 1 in the configuration described in Fig 1. Fig 2 is disposed with the same orientation than Fig 3. Fig 2 can be superposed with Fig 3 to have a cross-sectional view of the nozzle 1 above the dome 6.

[0025] As shown in Fig 3, the internal wall 8 creates two chambers 9a, 9b having the same volume. Each chamber 9a, 9b is connected to its respective channel 12a, 12b.

[0026] In other configurations, the internal wall 8 has a different shape and creates a different number of chambers. For example, with a sectional view, a Y-shape can create three chambers, or a V-shape can create two chambers with different volumes.

[0027] The invention in a usage configuration is shown in Fig 1 and thus its usage will be described using Fig 1 as a reference.

[0028] A liquid metal of a defined composition is poured from a ladle into a tundish 2. In a preferred embodiment, the liquid metal is steel and the usage of the nozzle 1 will be described with it. The steel flows into the upper part 4 of the continuous casting nozzle 1, thus creating an initial stream. A stopper rod 18 allows the control of the initial flow rate.

[0029] The dome 6, being placed in the trajectory of the steel, forces the initial stream to collide on it. The slope of the dome 6 makes the steel flow towards its edge. The support arms 7 create different areas on the dome 6, dividing the steel into a plurality of separate streams. The number of separate streams is determined by the design of the dome 6 and its support arms 7. In this specific embodiment, the number of separate streams is four.

[0030] The separate streams flow then into the different chambers 9a, 9b. In this configuration, half of the streams flows into one chamber 9a and the other half flows into the other chamber 9b. Powder is injected at the same time into at least one of the chambers 9a, 9b. The design of the chambers 9a, 9b allows the steel to be slowed down and to accumulate in the chambers 9a, 9b. In consequence, the powder can be mixed efficiently with the steel into said chamber 9a, 9b to modify its composition, and starts melting.

[0031] Another configuration, not represented, uses two powder injectors 10 to add different powder to the two chambers 9a, 9b.

[0032] The powder injected into the steel can be of various composition, for example, it can be FeSi, Ni, FeAl, FeTi, FeCr, FeNb, FeB, FeCe, FeMo, etc...

[0033] The injection of powder is facilitated by a gas injection 11 that creates a gas flow which maintains the steel flowing down the dome 6 towards

the exterior of the upper part 4 of the nozzle 1, thus creating a zone below the dome 6 without steel. This hollow zone prevents any contact between the steel and the powder injection 10 thus avoiding potential clogging of the powder injection 10.

[0034] The gas is preferably non-oxidizing, Ar for example, to prevent any reaction with the steel during casting.

[0035] After the injection, the two chambers 9a, 9b contain two types of steel with different composition.

[0036] The steels flow then into the channels 12a, 12b of the lower part 5 of the nozzle 1. They are then poured into the mold 3 through the outlets 13 of the channels 12a, 12b.

[0037] The configuration of the channels 12a, 12b and the outlets 13 allows the steel coming from one chamber 12a to be poured into one part of the mold 3 and the steel coming from the other chamber 12b to be poured into the other part of the mold 3.

[0038] Fig 6 shows the immerged part of the nozzle 1 and the mold 3 as well as highlighting the different compositions of steel created into the mold 3. An upstream part 14 of the mold 3 consists of the two different steels poured by the two channels 12a, 12b, located in each of its parts. The flow of liquid metal coming from each outlet 13 divides into an ascending flow 19 and a descending flow 20. The descending flow ends into a vortex type thus creating remixing deeper into the mold.

[0039] In a first embodiment, when there is only one powder injection 10, the composition of the liquid metal in one part is made of the base metal coming from the tundish 2 only and the composition of the liquid metal in the other part is made of the base metal coming from the tundish 2 mixed with the powder injected below the dome 6.

[0040] In another embodiment, when there are two powder injections 10, the composition of the liquid metal in one part is made of the base metal coming from the tundish 2 mixed with one type of powder injected and the composition of the liquid metal in the other part is made of the base metal coming from the tundish 2 mixed with the other type of powder injected.

[0041] Due to remixing as the liquid metal goes down into the mold, a downstream part 15 of the mold 3 is created, comprising a third composition resulting from the mix of the compositions coming from the two parts of the upstream part 14 of the mold 3.

[0042] In the mold 3, the steel of the upstream part 14 solidifies first thus creating a shell 16a, 16b. The steel of the downstream part 15 solidifies then inside the shell 16a, 16b thus creating the bulk 17 of the material. After full solidification, the material obtained is a composite metallic product having a distinct shell 16a, 16b and bulk 17. Its shell 16a, 16b is separated into two parts having different compositions and its bulk 17 have a different composition from the two compositions of the shell 16a, 16b. It allows the cast product to have different properties in the two parts of its shell 16a, 16b.

[0043] The two types of products from the two preferred embodiments are represented in Fig 7 for the billet or bloom type product and in Fig 8 for the slab type product.

[0044] In a preferred embodiment, the nozzle 1 is mainly composed of a refractory material surrounded by a metal ring.

[0045] In its usage configuration, the continuous casting nozzle 1 meets the expectations in terms of stability. It allows a stable casting speed and the different streams of liquid metal allow a great stability of the different areas of the mold 3. This stability results in a great quality of the semi-finished products with a well-defined gradient of composition between the two parts of its shell 16a, 16b as well as its bulk 17.

CLAIMS

1. Continuous casting nozzle (1) for manufacturing a composite metallic product having a distinct shell (16a, 16b) and bulk (17), wherein said shell (16a, 16b) is separated into two parts having different compositions, said compositions being different from the composition of the bulk (17), said nozzle (1) being located between a tundish (2) and a mold (3), said nozzle (1) comprising:
   - an upper part (4) disposed downstream of the tundish (2) with respect to the direction of travel of the liquid metal,
   - a dome (6) disposed at the inlet of the upper part (4), said dome (6) comprising means for splitting the initial stream of liquid metal into at least two separate streams,
   - an internal wall (8) located below the dome (6), creating at least two chambers (9a, 9b), said separate streams of liquid metal flowing respectively in each of said chambers (9a, 9b),
   - means for injecting powder (10) through the dome (6) into at least one of said chambers (9a, 9b), to allow mixing with the liquid metal flowing into said chamber (9a, 9b),
   - a lower part (5) composed of at least two channels (12a, 12b), extending from the upper part (4) into the mold (3) and opening into the mold (3) by means of at least one lateral outlet (13) for each channel (12a, 12b), wherein one of said channels is connected to one chamber (9a, 9b), said channel allowing the liquid metal to flow into one part of the mold (3), and wherein the other channels are connected to the other chambers (9a, 9b), said channels allowing the liquid metal to flow into the other part of the mold (3).
2. Continuous casting nozzle (1) according to claim 1, wherein said channels (12a, 12b) have at least two outlets (13) for each channel (12a, 12b).
3. Continuous casting nozzle according to claim 2, wherein said outlets (13) of said channels (12a, 12b) have their axis positioned towards the corners of the mold (3).

4. Continuous casting nozzle according to claim 1, wherein said composite metallic product is a slab and wherein said outlets (13) of said channels have their axis positioned towards the narrow faces of the mold (3).
5. Continuous casting nozzle (1) according to any of the preceding claims, wherein said dome (6) further comprises a means for injecting gas (11) through the dome (6).
6. Continuous casting nozzle (1) according to any one of the preceding claims, wherein said dome further comprises support arms (7).
7. A method of continuous casting of a composite metallic product having a distinct shell (16a, 16b) and bulk (17), wherein said shell (16a, 16b) is separated into two parts having different compositions, said compositions being different from the composition of the bulk (17), using a continuous casting nozzle (1) according to any one of the preceding claims wherein:
   - liquid metal is poured in a tundish (2) located above said continuous casting nozzle (1),
   - said liquid metal flows from the tundish (2) into the upper part (4) of said casting nozzle (1) creating an initial stream,
   - said initial stream collides onto the dome (6), thus separating it into at least two separate streams,
   - said separate streams flow into the chambers (9a, 9b) of the nozzle (1),
   - powder is injected into at least one of said chambers (9a, 9b) and mixed with the stream of liquid metal flowing into said chamber (9a, 9b) thus modifying its composition,
   - said separate streams are then distributed into the channels (12a, 12b) of the lower part of said continuous casting nozzle (1),
   - said liquid metal is poured into the mold (3), wherein the liquid metal flowing in one channel (12b, 12c) is poured into one part of the mold (3) by means of at least one outlet (13) and the liquid metal flowing into the other channels (12a) is poured into the other part of the mold by means of at least one outlet (13) for each channel.
8. A method according to claim 7, wherein the liquid metal is steel.

9. A method according to claim 7 or 8, wherein an upstream part (14) of the mold (3) contains two liquid metals of different composition located on two parts.

10. A method according to claim 9, wherein the composition of the liquid metal in one part of the upstream part (14) of the mold (3) is made of the base metal coming from the tundish (2) only and the composition of the liquid metal in the other part of the upstream part (14) of the mold (3) is made of the base metal coming from the tundish (2) mixed with the powder injected below the dome (6).

11. A method according to claim 9, wherein the composition of the liquid metal in one part of the upstream part (14) of the mold (3) is made of the base metal coming from the tundish (2) mixed with one type of powder injected below the dome (6) and the composition of the liquid metal in the other part of the upstream part (14) of the mold (3) is made of the base metal coming from the tundish (2) mixed with another type of powder injected below the dome (6).

12. A method according to claim 9 to 11, wherein a downstream part (15) of the mold (3) contains a liquid metal with a composition resulting from the mix of the compositions coming from the two parts of the upstream part (14) of the mold (3).

13. A composite metallic billet or bloom having a distinct shell (16a, 16b) and bulk (17), wherein said shell (16a, 16b) is separated into two parts having different compositions, said compositions being different from the composition of the bulk (17).

14. A composite metallic slab having a distinct shell (16a, 16b) and bulk (17), wherein said shell (16a, 16b) is separated into two parts having different compositions, said compositions being different from the composition of the bulk (17).

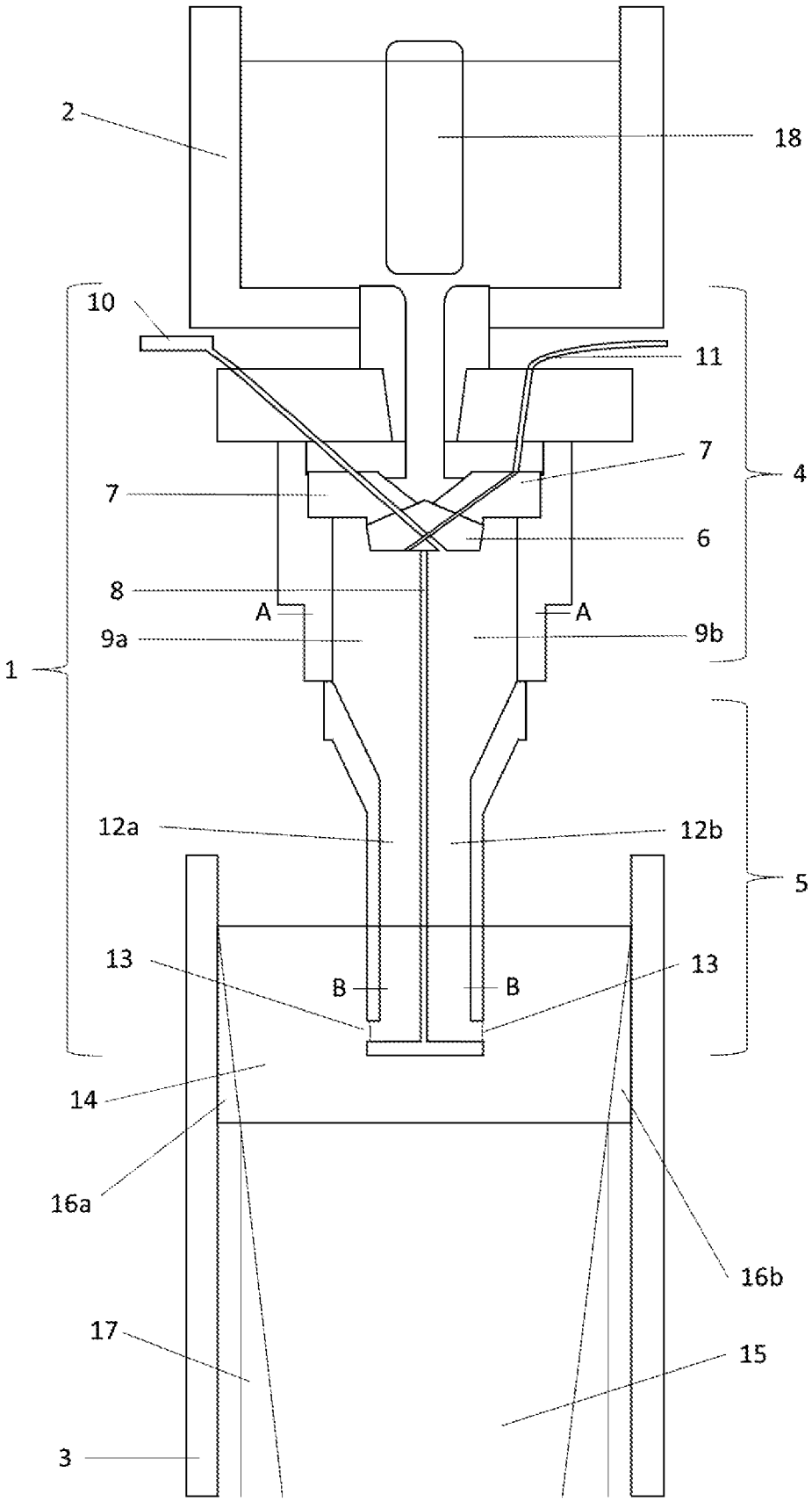


FIG 1

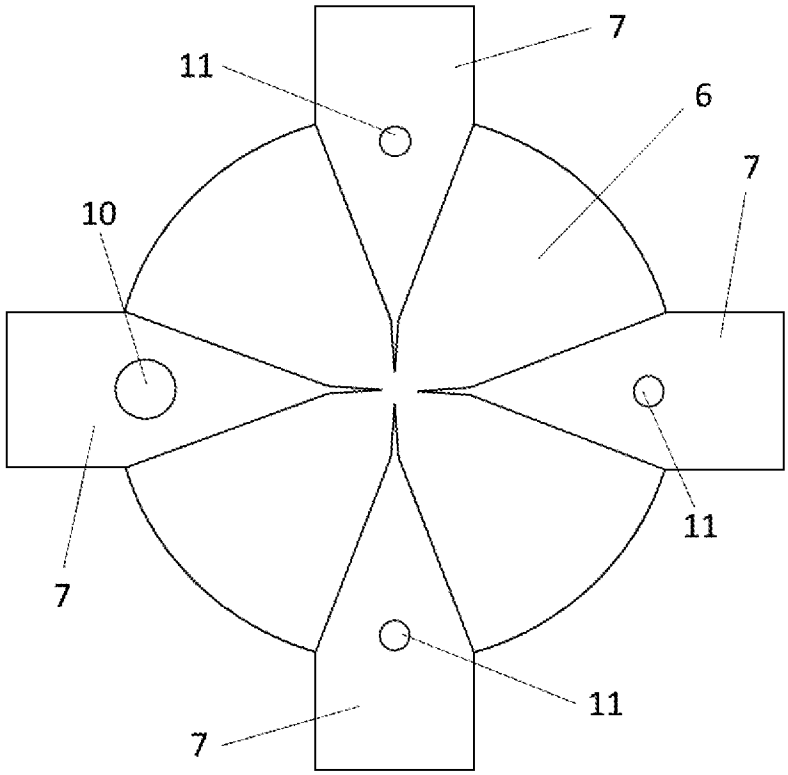


FIG 2

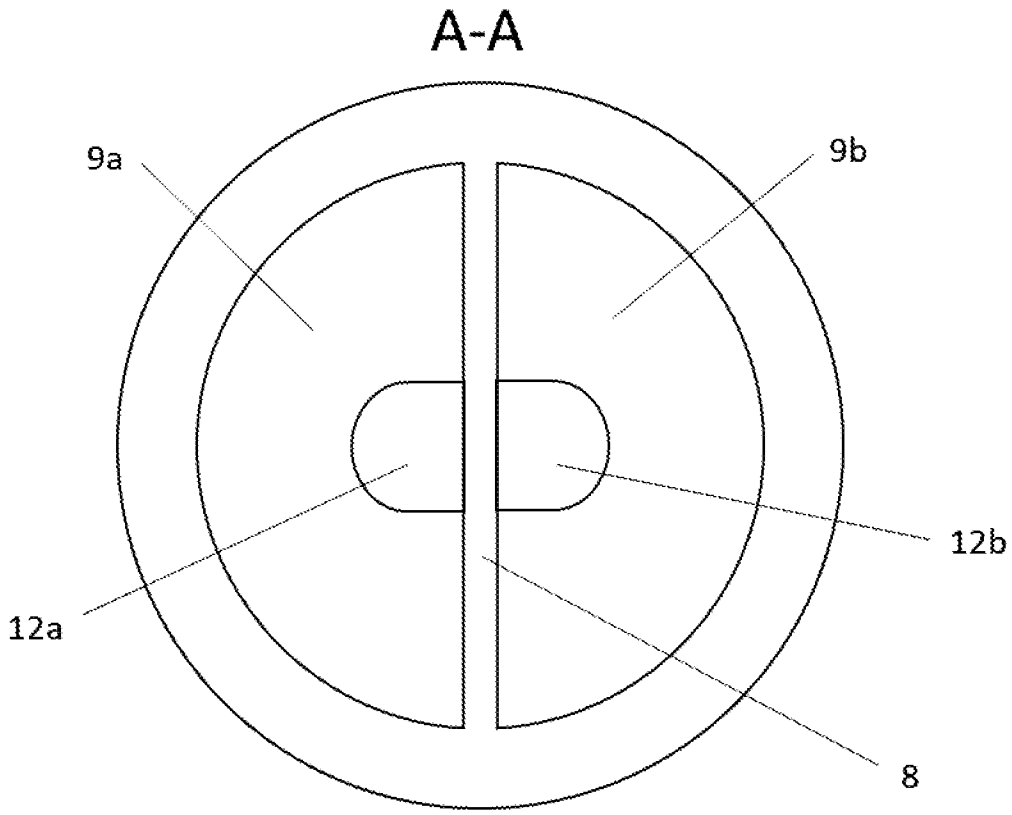


FIG 3

B-B

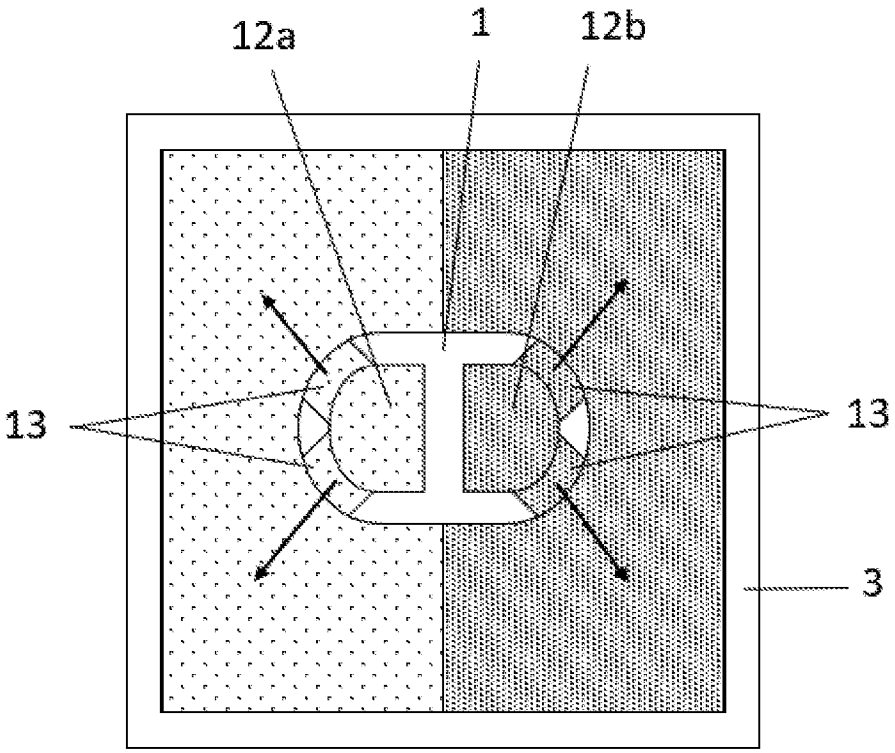


FIG 4

B-B

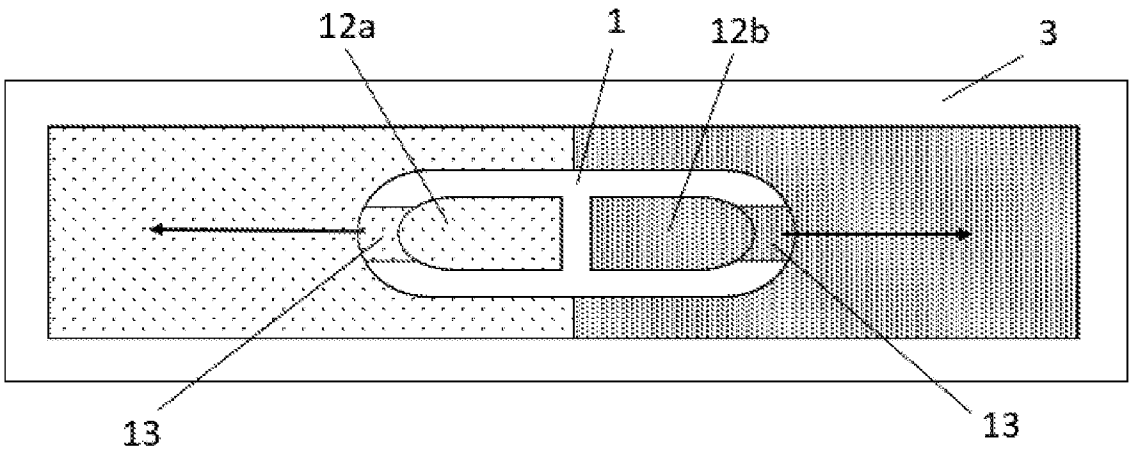


FIG 5

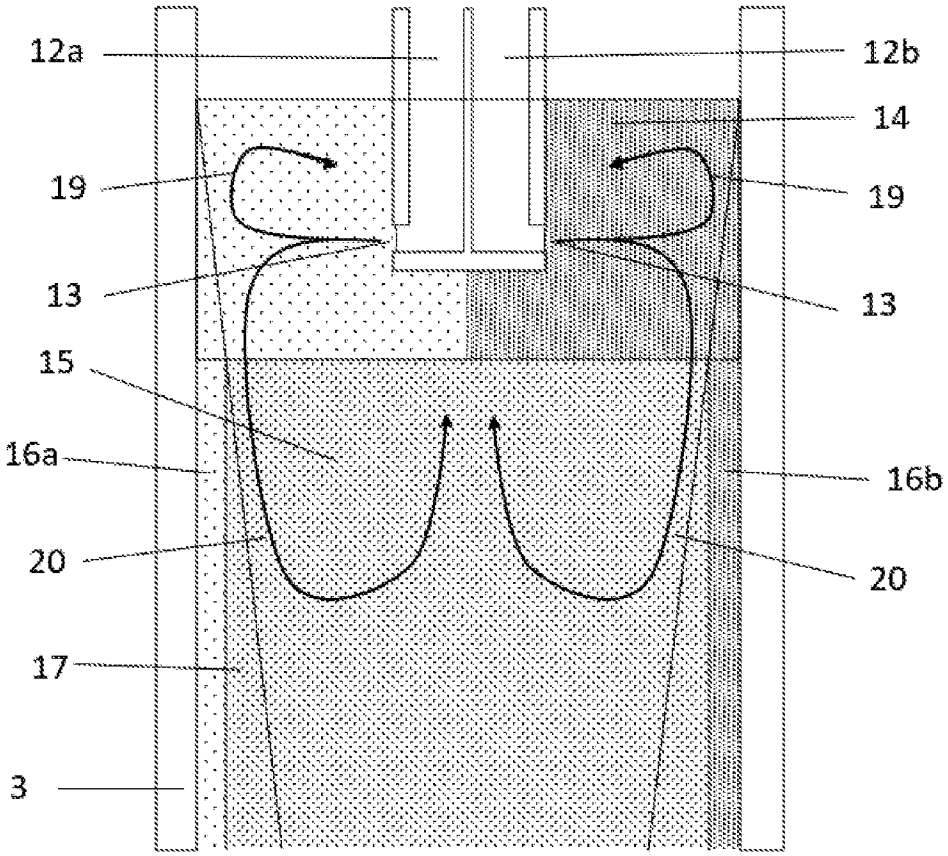


FIG 6

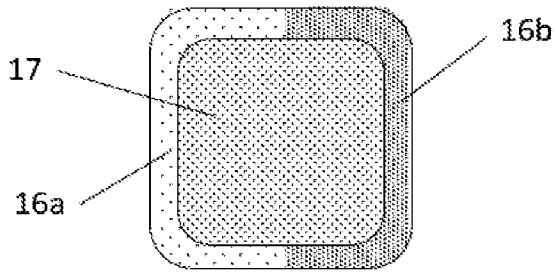


FIG 7

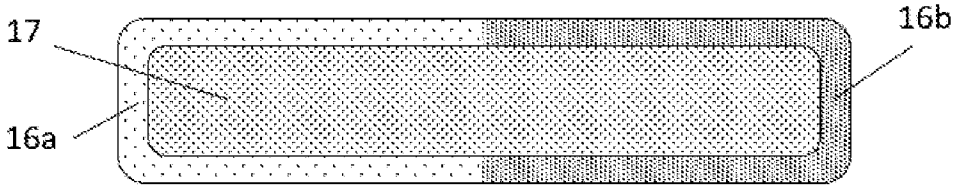


FIG 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/053252

A. CLASSIFICATION OF SUBJECT MATTER
INV. B22D11/108 B22D41/50 B22D41/52 B22D41/58
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.
A	WO 02/30598 A1 (CT DE RECH S METALLURTGIQUES A [BE]; NAVEAU PAUL [BE]) 18 April 2002 (2002-04-18) figures 1, 2 page 1, line 5 - line 10 page 2, line 32 - page 3, line 32 page 6, line 30 - page 8, line 25	1-14
A	JP H11 197807 A (KAWASAKI STEEL CO) 27 July 1999 (1999-07-27) figures 1-3 paragraph [0001] paragraph [0004] - paragraph [0008] paragraph [0009] - paragraph [0018]	1-14

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[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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