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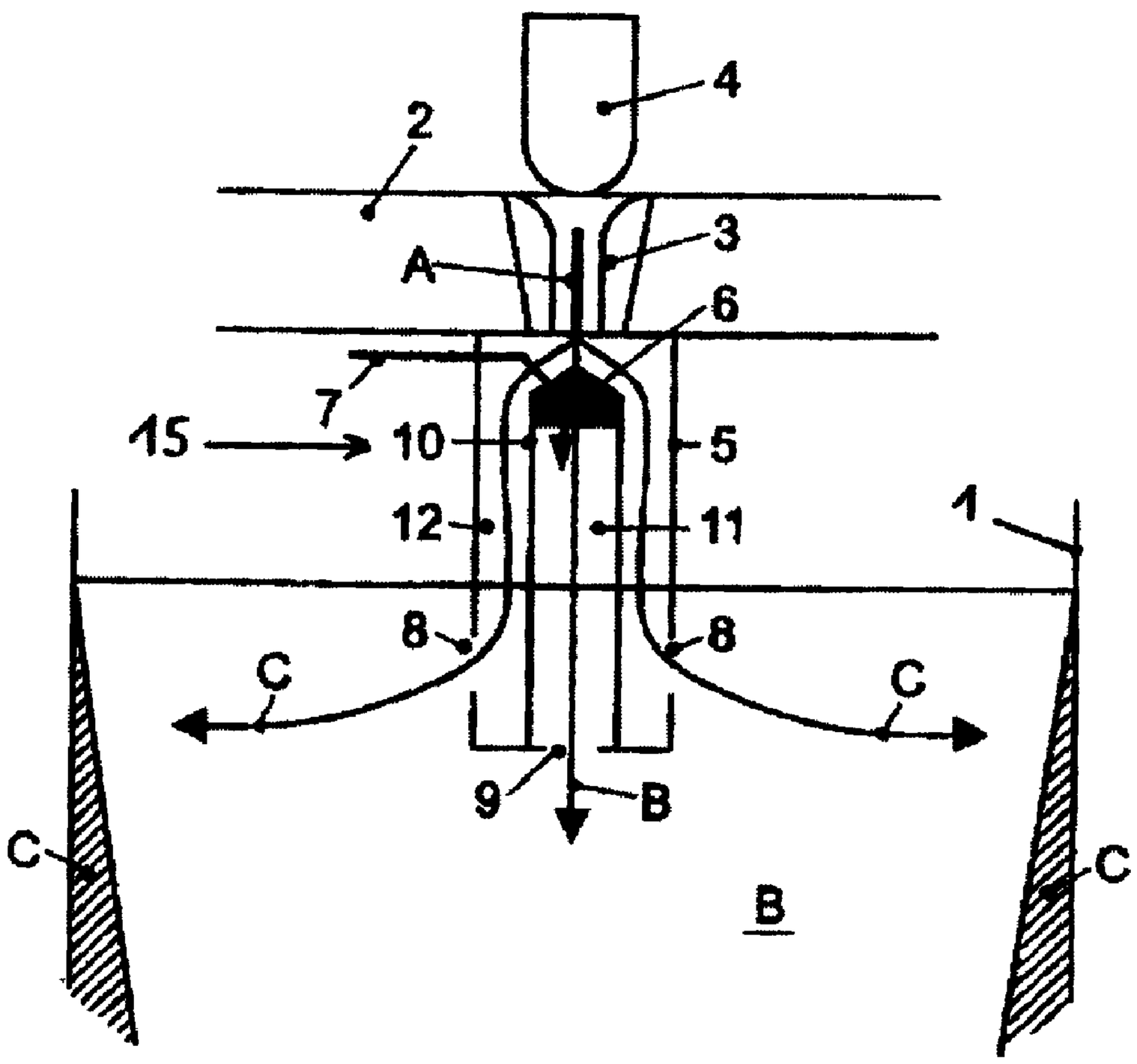
(72) Inventeur/Inventor:
NAVEAU, PAUL, BE

(73) Propriétaire/Owner:
CENTRE DE RECHERCHES METALLURGIQUES A.S.B.L., BE

(74) Agent: GOWLING LAFLEUR HENDERSON LLP

(54) Titre : PROCEDE ET DISPOSITIF POUR COULER EN CONTINU DE L'ACIER LIQUIDE
(54) Title: PROCESS AND DEVICE FOR THE CONTINUOUS CASTING OF LIQUID STEEL



(57) Abrégé/Abstract:
The invention concerns a nozzle mainly consisting, when viewed in vertical position and in the forward movement of the liquid steel from the top downwards, of a vertical conduit (5) comprising in its upper part a distributing member, arranged substantially at the

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(57) Abrégé(suite)/Abstract(continued):
intake of said conduit and including a dome (6) for deflecting the metal penetrating into the nozzle, which is also provided with means for injecting a gaseous, liquid or solid finely divided material beneath said dome (6) into a so-called inner zone (11). The dome (6) of said distributing member is provided with means for separating liquid steel into two jets (B, C), a jet (B) flowing into the so-called inner zone (11) and penetrating into the ingot mould (1) through a first orifice (9) at the lower base of said conduit (5) and a jet (C) flowing into a so-called outer zone (12) and penetrating into the ingot mould (1) through lateral orifices (8) located in the vertical wall of said conduit (5).

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(71) Déposant *(pour tous les États désignés sauf US)* : **CENTRE DE RECHERCHES METALLURTGIQUES, A.S.B.L.** [BE/BE]; 47, rue Montoyer, B-1000 Bruxelles (BE).

(72) Inventeur; et
(75) Inventeur/Déposant *(pour US seulement)* : **NAVEAU, Paul** [BE/BE]; Allée des Fauvettes 16, B-4432 Alleur (BE).

(74) Mandataires : **VAN MALDEREN, Michel** etc.; Office Van Malderen, Bld. de la Sauvenière, 85/043, B-4000 Liege (BE).

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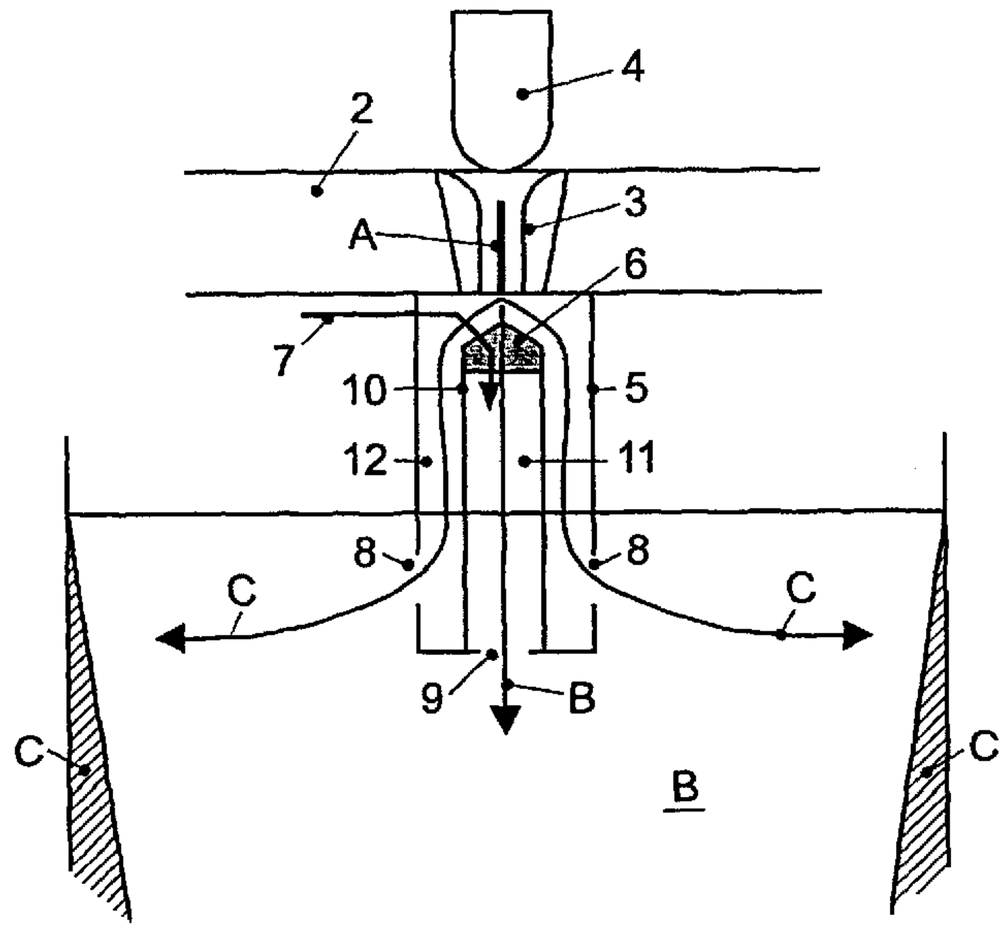
(54) **Title:** METHOD AND DEVICE FOR CONTINUOUS CASTING OF LIQUID STEEL

(54) **Titre :** PROCEDE ET DISPOSITIF POUR COULER EN CONTINU DE L'ACIER LIQUIDE



(57) **Abstract:** The invention concerns a nozzle mainly consisting, when viewed in vertical position and in the forward movement of the liquid steel from the top downwards, of a vertical conduit (5) comprising in its upper part a distributing member, arranged substantially at the intake of said conduit and including a dome (6) for deflecting the metal penetrating into the nozzle, which is also provided with means for injecting a gaseous, liquid or solid finely divided material beneath said dome (6) into a so-called inner zone (11). The dome (6) of said distributing member is provided with means for separating liquid steel into two jets (B, C), a jet (B) flowing into the so-called inner zone (11) and penetrating into the ingot mould (1) through a first orifice (9) at the lower base of said conduit (5) and a jet (C) flowing into a so-called outer zone (12) and penetrating into the ingot mould (1) through lateral orifices (8) located in the vertical wall of said conduit (5).

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En ce qui concerne les codes à deux lettres et autres abréviations, se référer aux "Notes explicatives relatives aux codes et abréviations" figurant au début de chaque numéro ordinaire de la Gazette du PCT.

(57) Abrégé : Busette de coulée continue composée principalement, si elle est décrite en position verticale et considérée dans le sens de progression de l'acier liquide de haut en bas, un conduit vertical (5) présentant dans sa partie supérieure un organe répartiteur, disposé sensiblement à l'entrée dudit conduit et comprenant un dôme (6) permettant de dévier le métal entrant dans la busette, laquelle est également dotée de moyens d'injection de matière gazeuse, liquide ou solide finement divisée sous ledit dôme (6) dans une zone dite interne (11). Le dôme (6) dudit organe répartiteur est pouvrvu de moyens permettant la séparation de l'acier liquide en deux jets (B,C), un jet (B) s'écoulant dans la zone dite interne (11) et pénétrant dans la lingotière (1) par un premier orifice (9), suite à la base inférieure dudit conduit (5) et un jet (C) s'écoulant dans une zone dite externe (12) et pénétrant dans la lingotière (1) par des orifices latéraux (8), situés dans la paroi verticale dudit conduit (5).

PROCESS AND DEVICE FOR THE CONTINUOUS CASTING OF LIQUID STEEL

Subject of the invention

The present invention relates to a new device for the continuous casting of steel, allowing to obtain an end product with a mixed chemical composition, i.e. including, on the one hand, the base steel and, on the other hand, the base steel alloyed with elements added during casting.

The invention likewise relates to the process implemented by means of the device.

Prior art

The continuous casting technique for steel is well known. It essentially consists in supplying molten steel from a tundish into a cooled mould made of copper or of a copper alloy, referred to as a continuous casting mould, the latter being open at its lower end, and in extracting from it a continuous and partially solidified ingot through this opening.

In general, the molten steel is introduced into the casting mould by means of at least one nozzle, i.e. a generally tubular element arranged between the tundish and the casting mould. The lower end of the nozzle is usually provided with one or two outlet orifices located in the axis of the nozzle or laterally, and emerges below the top level of liquid steel present in the casting mould.

The prior art also includes nozzles intended to ensure better cooling of the superheated liquid steel coming from the tundish. The aim is to obtain pasty steel at the inlet of the casting mould. In particular, these nozzles may have a heat exchanger formed by a water-cooled copper tube or even a deflector or dome. The purpose of the latter is to force the superheated steel to trickle along the walls of the nozzle in a

thin layer, which allows, in particular, to increase the surface area for heat exchange. This technique is referred to as "hollow-jet casting".

Moreover, it is common practice to inject inert gas, such as argon, at the level of inlet of the molten steel in the nozzle with a view to avoiding steel oxidation and preventing accidental blockage, especially through the formation of alumina. The technique of hollow-jet casting allows, in particular, to reduce the risk of blockage of the gas supply compared with the case where the inlet orifice of the latter is in direct contact with the liquid steel introduced into the nozzle. Thus, one known technique is to inject the inert gas, such as argon for example, inside the hollow jet. It is likewise possible to inject a certain amount of finely divided material into the hollow jet using a non-oxidising gas under a slight overpressure above atmospheric pressure as a vector in order to prevent any inlet of air. This material is an alloying metal or a ceramic, for example. The aim is to obtain a metallic alloy or a composite, depending on the case.

Nowadays, continuous casting of products based on steel with a mixed or bi-component chemical composition is exciting much interest for a very large number of specific applications, both for long and flat products. The term bi-component designates products in which the chemical composition of the steel differs depending on the location in the product that is investigated, the composition being different, for example, in the skin as compared with the core.

In particular, such a technique can be used, for example:

- to increase the quality of the surface treatment of the products. In the case of galvanisation, for example, it is desirable to reduce the silicon

content in the vicinity of the slab surface in order to improve the suitability of the rolled products for galvanisation;

- to enhance castability, for example, in the case of peritectic steels, whose carbon content is of the order of 0.1 - 0.15% and which are particularly difficult to cast, when modification of the carbon content in the vicinity of the surface is desired;
- to cast products whose mechanical properties vary according to thickness, such as a high strength at the surface and high ductility at the core, for instance.

Processes allowing to obtain metal parts, in particular steel parts, with a mixed chemical composition, such as rolling cylinders, wearing parts, etc., are known in the actual casting sector.

However, the prior art does not include a simple device allowing to obtain mixed-composition steels by continuous casting. The use of at least two tundishes in parallel, each provided with its own nozzle and acting simultaneously to cast mixed-composition steels into the same casting mould, is known. However, such an installation proves very complex and therefore very costly on an industrial scale. Another way of obtaining a bi-component steel, i.e. introducing a metal sheet into the ingot during casting, has been envisaged, but this again proves not very practical.

Aims of the invention

The present invention aims to provide a device and an associated process for the continuous casting of steel in order to obtain products of mixed chemical composition, without the disadvantages of the prior art.

In particular, the invention proposes a new process allowing the use of an existing continuous casting installation with one single specific nozzle.

Main characteristic elements of the invention

The present invention relates to a continuous casting nozzle intended for the steel flow from a tundish into a casting mould; said nozzle, if described in a vertical position and considered in the forward movement of the liquid steel from the top downwards, principally comprising a vertical conduit ended by an upper base having an inlet orifice for the liquid steel from the tundish and a lower base having at least one outlet orifice; said conduit comprising, in its upper part, a distributing member substantially arranged at the inlet of said vertical conduit and comprising a dome allowing to deflect the steel entering the nozzle; said nozzle likewise comprising means for injecting a gaseous, liquid or finely divided solid material under said dome into an inner zone; characterised in that the dome of said distributing member is provided with means for separating the liquid steel into two jets, which separately enter the casting mould.

The dome of said distributing member advantageously has at least four passages, which are interconnected in such a way as to divide the flow of the molten steel into two separate jets respectively flowing through a zone referred to as inner zone and a zone referred to as outer zone towards the casting mould.

The outer zone preferably emerges towards the casting mould by means of at least two lateral orifices, and the inner zone emerges towards the casting mould by means of at least one first orifice.

According to a first embodiment of the invention, the liquid steel passing under the dome in

the zone in which gaseous, liquid or finely divided solid material is injected, is channelled into the inner zone and flows into the casting mould through the first orifice or orifices.

According to a second embodiment of the invention, the liquid steel passing under the dome in the zone in which gaseous, liquid or finely divided solid material is injected, is channelled into the outer zone and flows into the casting mould through the lateral orifices.

A preferred embodiment of the invention relates to a nozzle intended for the steel flow from a tundish into a casting mould. If described in a vertical position and considered in the forward movement of the liquid steel from the top downwards, the nozzle principally comprises a vertical conduit ended by an upper base having an inlet orifice for the liquid steel from the tundish and a lower base having a first outlet orifice. Moreover, the conduit has, in its upper part, a distributing member substantially arranged at the inlet of said vertical conduit and comprising a dome allowing to deflect the steel entering the nozzle and a vertical wall ending the dome at the bottom and extending as far as the lower base of said conduit, said vertical wall having at least two lateral outlet orifices, the distributing member dividing the vertical conduit into two physically separated zones, a zone referred to as an inner zone and a zone referred to as an outer zone. The nozzle likewise comprises means for injecting a gaseous, liquid or finely divided solid material under said dome into the inner zone. The nozzle is characterised by the fact that the dome of said distributing member is provided with means for separating the liquid steel into two jets, a jet flowing into the inner zone and entering the casting mould through said first orifice and a jet flowing into

the outer zone and entering the casting mould through the lateral orifices.

The vertical conduit is preferably cylindrical in shape and has a circular or oval cross-section.

Still in accordance with the invention, the liquid steel forming the jet into which an injection is performed under the dome consists of a mixture of base steel and of material injected under the dome. Moreover, the chemical composition of the steel obtained after having performed an injection under the dome is different from the chemical composition of the base steel.

The finely divided solid material injected under the dome is advantageously in suspension in a non-oxidising gas.

The finely divided solid material injected under the dome advantageously has a particle size of less than 2000 µm.

The particle size of said finely divided material is particularly advantageously between 100 and 300 µm.

According to a particular embodiment, the two jets have different flow rates.

According to the present invention, the flow rate of the liquid steel cast for flat products is between 1.5 and 6 tonnes per minute. The flow rate for long products is between 0.3 and 0.5 tonne per minute.

The vertical conduit is advantageously provided with means for regulating the temperature of the liquid steel flowing through said conduit. However, according to the invention, the means for regulating the temperature of the liquid steel flowing in the part ahead of the distributing member comprising the dome are distinct from the means for regulating the

temperature of the liquid steel flowing in the part after the above-mentioned dome.

In operation, the nozzle of the invention is part of an installation for the continuous casting of steel, preferably in the form of long or flat products, comprising a tundish provided with an outlet orifice and a flow-regulating device, and a casting mould. The nozzle thus allows to cast a steel of mixed composition in the casting mould, starting from the molten base steel in the tundish.

Another aspect of the present invention relates to a new process for the continuous casting of steel, preferably in the form of long or flat products, comprising the following stages:

- casting of a molten base steel from a tundish through an outlet orifice provided with a flow-regulating element into a nozzle comprising a distributing member having a dome and a vertical wall dividing the nozzle into an inner zone and an outer zone;
- separation of the base steel in the distributing member into an inner jet and an outer jet;
- injection of gaseous, liquid or finely divided solid material under said dome into the inner zone and mixing of said material with the base steel in order to form a steel with a different chemical composition from the base steel;
- flowing of the jet of base steel through lateral apertures in the nozzle and solidification of said jet along the walls of the casting mould;
- flowing of the jet of steel of different chemical composition through a lower aperture in the nozzle and solidification of said core jet in the casting mould.

The present invention has the following advantages over the prior art:

- a steel of mixed chemical composition is obtained by continuous casting, using one single nozzle that is compatible with the casting installation;
- simplification compared with a complicated and therefore very costly installation, which is, however, theoretically feasible on an industrial scale, comprising at least two nozzles and/or two tundishes;
- feasibility of continuous casting of a range of steel-manufacturing or metallurgical products, referred to as products of high added value, such as coated products (galvanised, plastic-coated, etc.).

Brief description of the figures

Figure 1 schematically shows in elevation an installation for the continuous casting of steel using a nozzle according to the present invention.

Figure 2 schematically shows in plan view a casting tundish incorporated into a nozzle according to the present invention.

Description of a preferred embodiment of the invention

Figure 1 shows a casting device according to a particular form of the invention, mounted between a continuous casting mould 1 and a casting ladle or tundish 2 having an outlet conduit 3. The outlet conduit 3 is provided with a flow regulator such as a stopper 4 or a slide gate. A nozzle 15, essentially cylindrical in shape and possibly of oval cross-section, fixed on the tundish, is mounted on the casting mould 1. The nozzle 15 can, for example, be provided with a copper heat exchanger provided with a water-cooling system. The upper base of the cylinder is in contact with the conduit 3. This base is provided with an orifice corresponding to the lower orifice of

the conduit. In its lower part, the nozzle 15 has three communication apertures allowing the steel to pass towards the casting mould: two lateral apertures 8 and an aperture 9 located in the lower base of the conduit 5. At the upper end of the nozzle 15, a distributing member in the form of a dome 6 is arranged, the upper surface of said dome slightly slopes, preferably at an angle greater than 10° relative to the horizontal. The dome 6 is fixed to the conduit 5 by means that are not shown. An injection device 7 is located in such a way as to introduce a gas, a liquid or finely divided or powdered solid particles under the dome 6, possibly using a non-oxidising gas as a vector in the latter case. The dome 6 has a lateral wall 10, preferably vertical and cylindrical, extending as far as the bottom of the nozzle 15. This lateral wall allows to isolate a part referred to as the inner part 11 of the conduit 5 from another part, referred to as the outer part 12, of the same conduit 5.

Figure 2 shows one embodiment of a distribution dome 6 comprising four passages for the molten steel communicating in pairs, in a highly schematized form in plan view. Each of the four passages is associated with one opening in the dome 6. Two openings 13 are delimited by cutting the dome between the latter and the inner wall of the nozzle 15. The two other openings 14 are made more towards the centre of the surface of the dome 6, for example, and communicate underneath this surface through the inner part 11 which itself emerges downstream of the nozzle 15. The dome 6 thus allows to separate the jet of steel A coming from the tundish 2 through the conduit 3 into two distinct jets of substantially equal size and physically separated from each other: a first jet B, which flows through the centre 11 of the nozzle 15, and a second jet C, which

flows through the space 12, possibly along the inner lateral wall of the conduit 5 (Figure 1).

The injection device 7 allows to introduce an additional constituent, such as an alloying metal, a gas or a ceramic, into the jet B and thus to modify its composition relative to the base steel. The jet B flows out of the nozzle 15 into the central part of the casting mould 1 through the aperture 9. The jet C flows out of the nozzle 15 through the lateral apertures 8. When it solidifies, the jet C will be distributed over the walls of the casting mould, while the jet B, which is of modified chemical composition, will be more towards the core in the solidified mass.

The material injected by the device 7 under the dome 6 can be in the gaseous, liquid or solid phase. In the latter case, the material is in the form of powder or of finely divided particles. The size of the particles injected is less than 2 mm and is more often between 100 and 300 μm.

The process according to the invention can be used both in continuous casting of flat products, such as slabs, and in that of long products, such as round, square or wire products, etc.

In particular, in the case of flat products, the variation in chemical composition obtained on the cross-section of the product can be preserved during direct rolling. Such steels are consequently ideally suited to galvanisation, owing to the fact, for example, that the outer layer is of modified composition compared with the core of the product and promotes easy binding of the coating layer of zinc, in particular owing to the reduction in the skin of the silicon concentration. In the case of long products, the steel can contain copper (CORTEN steel), for example, in a continuous manner in order to avoid the

problems of surface corrosion. It is thus possible to dispense with stainless steel, which is very expensive. In the process according to the invention, the flow rates of steel in the casting mould correspond to the industrial standards that are the norm in metallurgy. In particular, the flow rate is between 1.5 and 6 tonnes/min. for flat products and between 0.3 and 0.5 tonne/min. for long products.

CLAIMS

1. Continuous casting nozzle intended for the flow of liquid or molten steel from a tundish into a casting mould; said nozzle, if described in a vertical position and considered in the forward movement of the liquid steel from the top downwards, comprising a vertical conduit ended by an upper base having an inlet orifice for the liquid steel from the tundish and a lower base having at least one outlet orifice; said conduit comprising, in its upper part, a distributing member arranged at the inlet of said vertical conduit and comprising a dome allowing to deflect the steel entering the nozzle; said nozzle comprising means for injecting a gaseous, liquid or finely divided solid material under said dome into an inner zone; characterised in that the dome of said distributing member is provided with means for separating the liquid steel into two jets, which separately enter the casting mould.

2. Nozzle according to Claim 1, characterised in that the dome of said distributing member has at least four passages and in that said passages are interconnected in such a way as to divide the flow of the molten steel into two separate jets respectively flowing through the inner zone and an outer zone towards the casting mould.

3. Nozzle according to Claim 2, characterised in that the outer zone emerges towards the casting mould by means of at least two lateral orifices, and in that the inner zone emerges towards the casting mould by means of at least one orifice.

4. Nozzle according to Claim 3, characterised in that the liquid steel passing under the dome in the zone in which gaseous, liquid or finely divided solid material is injected, is channelled into the inner zone and flows into the casting mould through said at least one orifice.

5. Nozzle according to Claim 3,characterised in that the liquid steel passing under the dome in the zone in which gaseous, liquid or finely divided solid material is injected, is channelled into the outer zone and flows into the casting mould through said at least two lateral orifices.

6. Nozzle according to Claim 2, intended for the flow of steel from the tundish into the

casting mould; said nozzle, if described in a vertical position and considered in the forward movement of the liquid steel from the top downwards, comprising a vertical conduit ended by an upper base having an inlet orifice for the liquid steel from the tundish and a lower base having a first outlet orifice; said conduit having, in its upper part, a distributing member arranged at the inlet of said vertical conduit and comprising a dome allowing to deflect the steel entering the nozzle and a vertical wall ending the dome at the bottom and extending as far as the lower base of said conduit, said vertical wall having at least two lateral outlet orifices, the distributing member dividing the vertical conduit into two physically separated zones, the inner zone and the outer zone; said nozzle likewise comprising means for injecting a gaseous, liquid or finely divided solid material under said dome into the inner zone; characterised in that the dome of said distributing member is provided with means for separating the liquid steel into two jets, a jet flowing into the inner zone and entering the casting mould through said first orifice and a jet flowing into the outer zone and entering the casting mould through the lateral orifices.

7. Nozzle according to Claim 1, characterised in that the vertical conduit is cylindrical in shape and has a circular or oval cross-section.

8. Nozzle according to Claim 1, characterised in that the liquid steel forming the jet into which an injection is performed under the dome, consists of a mixture of base steel and of material injected under the dome.

9. Nozzle according to Claim 1, characterised in that the chemical composition of the steel obtained after having performed an injection under the dome is different from the chemical composition of the base steel.

10. Nozzle according to any one of claims 1-9, characterised in that said finely divided solid material injected under the dome is in suspension in a non-oxidising gas.

11. Nozzle according to any one of claims 1-10, characterised in that said finely divided solid material injected under the dome has a particle size of less than 2000 µm.

12. Nozzle according to Claim 11, characterised in that the particle size of said finely divided material is between 100 and 300 µm.

13. Nozzle according to any one of claims 1-12, characterised in that the two jets have different flow rates.

14. Nozzle according to Claim 1, characterised in that the flow rate of liquid steel cast for flat products is between 1.5 and 6 tonnes per minute.

15. Nozzle according to Claim 1, characterised in that the flow rate of liquid steel cast for long products is between 0.3 and 0.5 tonne per minute.

16. Nozzle according to Claim 1, characterised in that the vertical conduit is provided with means for regulating the temperature of the liquid steel flowing through said conduit.

17. Nozzle according to Claim 16, characterised in that the means for regulating the temperature of the liquid steel flowing in the part ahead of the distributing member comprising the dome are distinct from the means for regulating the temperature of the liquid steel flowing in the part after said dome.

18. Installation for the continuous casting of steel, either in the form of long or flat products, comprising a tundish provided with an outlet orifice and a flow-regulating device, a casting mould and a nozzle according to Claim 1, said nozzle enabling a steel of mixed composition to be cast in the casting mould, starting from the molten base steel in the tundish.

19. Process for the continuous casting of steel, either in the form of flat or long products, comprising the following stages:

- casting of a molten base steel from a tundish through an outlet orifice provided with a flow-regulating element in a nozzle comprising a distributing member having a dome and a vertical wall dividing the nozzle into the inner zone and the outer zone;

- separation of the base steel in the distributing member into an inner jet and an outer jet;

- injection of gaseous, liquid or finely divided solid material under said dome into the inner zone and mixing of said material with the base steel in order to form a steel of different chemical composition from the base steel;

- flowing of the jet of base steel through lateral apertures in the nozzle and solidification of said jet along the walls of the casting mould;

- flowing of the jet of steel of different chemical composition through a lower aperture in the nozzle and solidification of said core jet in the casting mould.

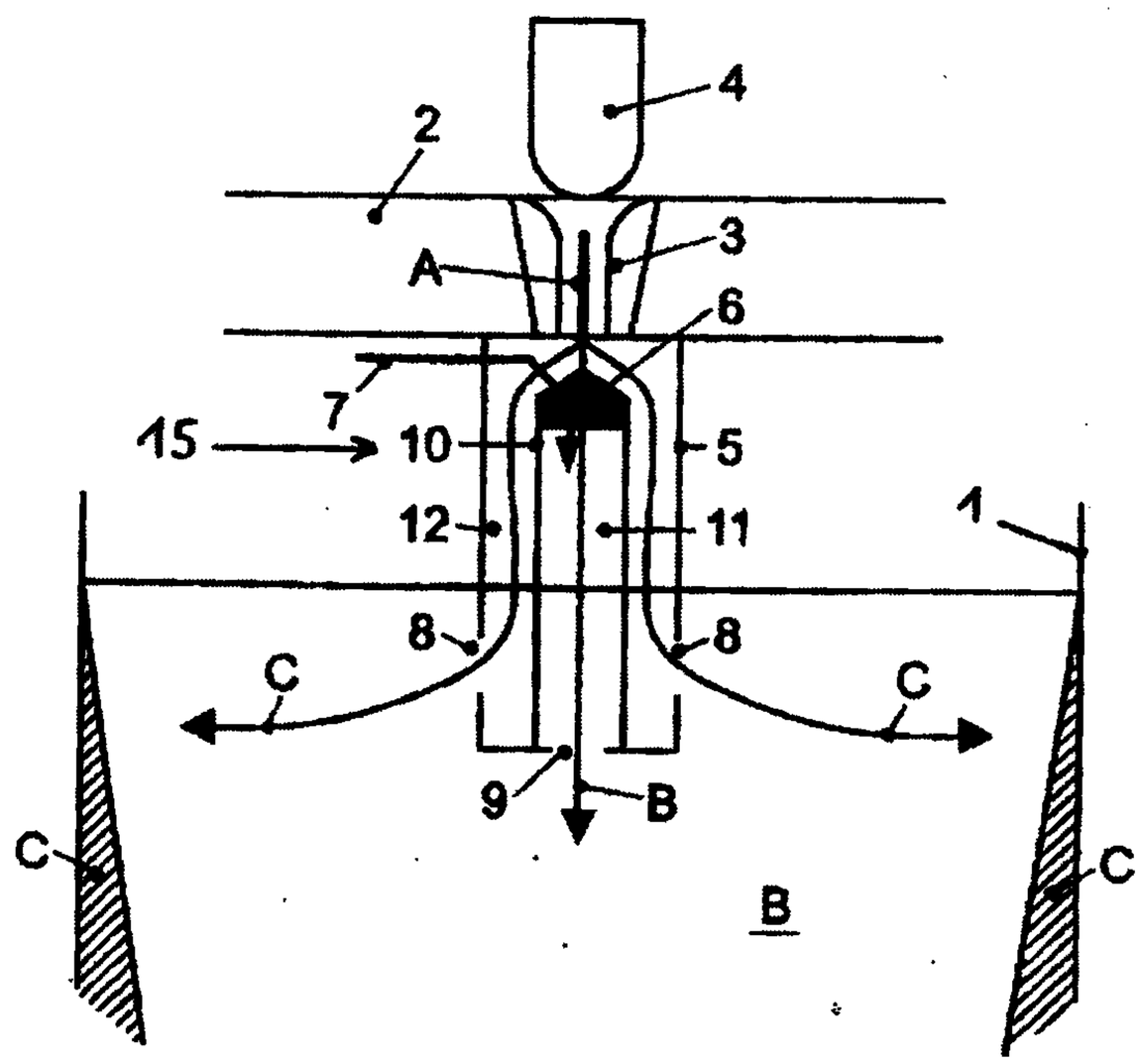


Fig.1

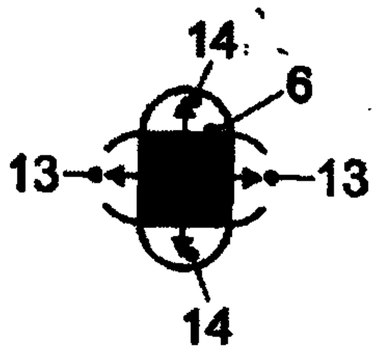
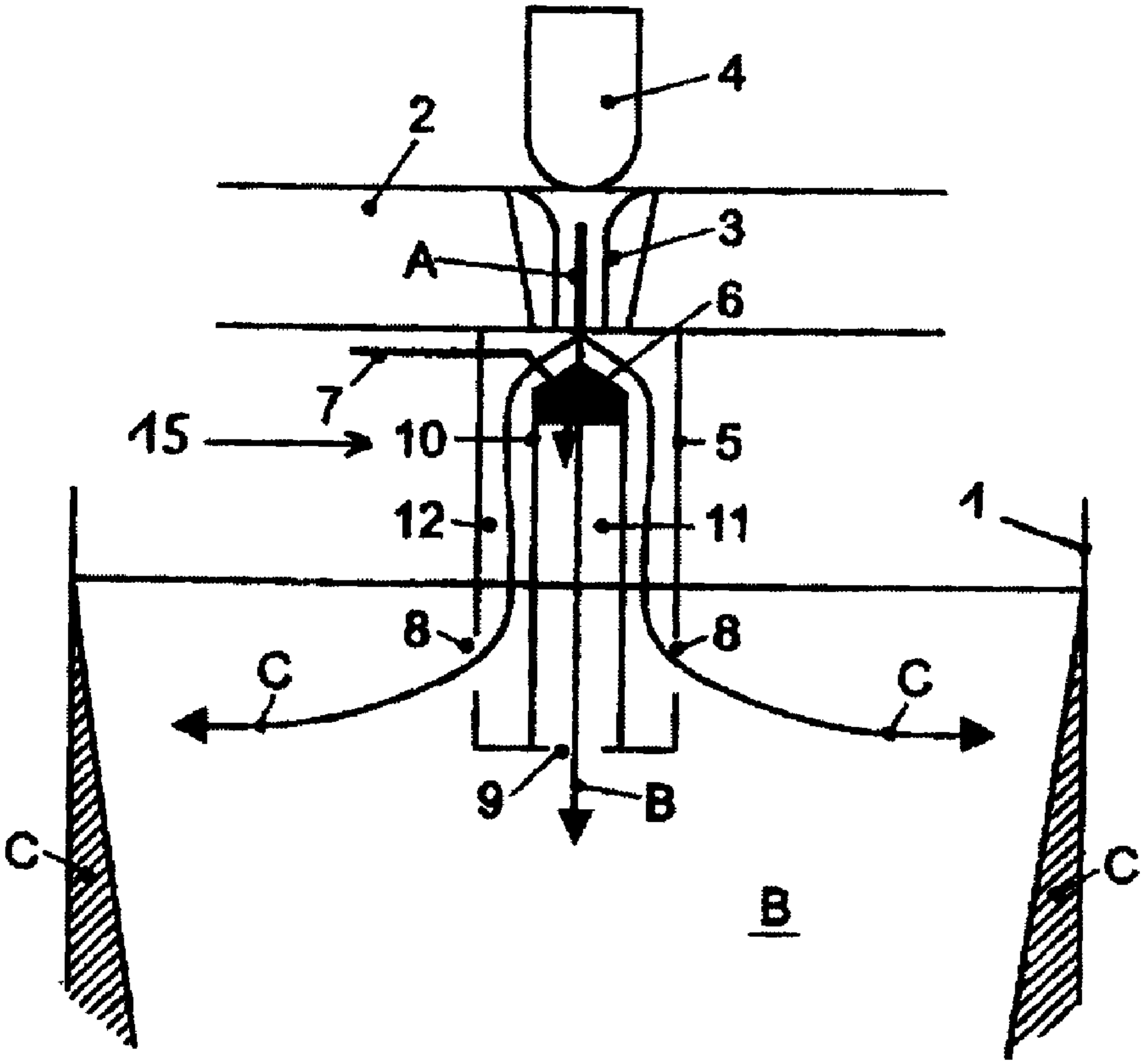


Fig.2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