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(54) **CONTINUOUS CASTING NOZZLE FOR THE VERTICAL UPWARDS CONTINUOUS CASTING OF METAL**

STRANGGIESSKOKILLE ZUM VERTIKALEN AUFWÄRTSSTRANGGIESSEN VON METALL

LINGOTIERE POUR LA COULEE CONTINUE VERTICALE DE METAUX

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Description

[0001] The invention relates to a continuous casting nozzle apt for the vertical upwards continuous casting of metal into continuous cast products, said nozzle comprising a cooling mantle which includes concentrically a first outermost pipe member, a second middle pipe member, and a third inner pipe member, and therebetween two cylindrical channels co-directional with the pipe members and apt for causing a flow-through of cooling water, and said cooling mantle having a top portion and a bottom portion; a mold section, which consists of a refractory material and which has a top end with its upper frontal surface and a bottom end, said top end extending coaxially into an interior of the third pipe member and being attached with a heat transfer joint to this third pipe member, and said bottom end protruding from said cooling mantle; said third pipe member has an internal pipe cross-section and said mold section has an internal mold cross-section for providing the external shape of said continuous cast product, said pipe cross-section being larger than said mold cross-section.

[0002] US patent 3,872,913 discloses a method and apparatus for the continuous upward casting of profiled articles, such as bars, plates and pipes, wherein melt is drawn by means of a nozzle, establishing a chill mold above the melt surface and having its bottom end immersed in the melt and being connected at its upper part to a cooler support, as well as to a vacuum source, by way of a pipe that is surrounded by a cooling mantle. The cooler consists of three concentric pipes, the spaces therebetween establishing cylindrical channels for cooling water. The nozzle is constructed in one piece of a refractory material and extends by its upper end coaxially into an interior of the cooler. The cooler support features an opening that corresponds to an article to be cast and, with the chill mold connected with this more extensive additional cooling zone, the vacuum source enables melt to be withdrawn into a cooling zone present in the nozzle.

[0003] On the other hand, GB patent 1 307 979 discloses a continuous casting method, comprising applying super-atmospheric pressure to the surface of molten metal in a container and thereby causing molten metal to flow to a mould in which the molten metal solidifies while extracting solidified metal progressively from the mould. In addition, the method comprises applying fluid, such as oil or an inert gas, between the mould and the solidified metal which has cross-sectionally contracted - having thus formed a gap between the mould and the metal. Therefore, adjacent to that part of the mould at which the metal begins to contract inward from the mould wall are provided a plurality of inlets into which fluid is delivered by coiled type plastic tubes passing in radial direction through a water jacket of the mould. The aim is to eliminate or minimize the entry of molten metal into a gap between the mould and the inward contracting metal, which could result from the application of super-atmospheric pressure to the melt surface.

[0004] A problem with both above-described solutions is that various compounds of separating and/or filtering metals and/or alloying elements and/or oxygen may build up and deposit on the surface of a nozzle mold upwards of the point at which the cross-section of a continuously cast article begins to dwindle because of casting contraction. Such compounds, and particularly deposits thereof, hinder the casting process and may undermine the quality of a cast product. Such compounds or deposits are particularly susceptible to forming when the refractory nozzle mold material is graphite, which is otherwise an excellent mold material. The problems will become even more prominent should the metal to be cast be an actively reacting metal, such as aluminum or magnesium, or the metal to be cast is some extra pure alloy, such as oxygen-free copper.

[0005] The foregoing problems can be resolved with a continuous casting nozzle of the invention, which is characterized by what is defined in the characterizing clause of claim 1, and with a usage according to the invention, which is characterized by what is defined in claim 9.

[0006] The invention will now be described in detail with reference to the accompanying drawings.

Fig. 1 shows one embodiment for a continuous casting nozzle of the invention in a longitudinal section view along a plane I-I in fig. 2.

Fig. 2 shows the continuous casting nozzle of fig. 1 in a crosswise section view along a plane II-II in fig. 1.

Fig. 3 shows from outside one embodiment for an innermost pipe member included in the continuous casting nozzle, seen from a direction III in figs. 1 and 2.

Fig. 4 shows an end view of one embodiment for sleeves included in the innermost pipe member of fig. 3, seen from a direction IV in fig 3.

Fig. 5 shows an end view of various embodiments for one sleeve included in the innermost pipe member of fig. 3, seen from a direction V in fig. 3. Solid lines represent one variant of the embodiment, in which the radially directed openings take the form of recesses in the lower frontal surface, and dotted lines represent schematically another variant, in which the radially directed openings are holes.

[0007] The question is about a continuous casting nozzle, which is apt for the vertical upwards continuous casting of metal M into continuous cast products P, as described in parallel publications FI-46810 and US-3,872,913. For this purpose, a continuous casting nozzle 1 comprises first of all a cooling mantle 10, which includes concentrically a first outermost pipe member 11, a second middle pipe member 12, and a third inner pipe member 13, therebetween two cylindrical channels 7a, 7b co-directional with the pipe members and apt for causing a flow-through of cooling water W - to cause a flow-through = forcing to flow through or allowing to flow through. Thus, while the continuous casting nozzle 1 is in operation, the cooling water W is first caused to flow along one channel 7a between the pipe members, which is usually, but not necessarily the outer one of these two channels, from a top portion 1y of the cooling mantle towards a bottom portion 1 a thereof, and then from the bottom portion 1 a back towards the top portion 1 y, and finally out of the cooling mantle. In other words, the cooling water W flows within the cooling mantle along a U-shaped path, thus circling around a bottom edge 24 of the middle pipe member 12 as depicted in fig. 1. In view of entering and exiting the cooling water W, the cooling mantle 10 has its top portion 1 y comprising water connections 21. The cooling mantle 10 has its top portion comprising at least attachment elements 19 of the continuous casting nozzle 1, as well as a penetration opening 23 for extracting the cast product P as it is being produced. Hence, the cooling water W circulates over an entire length L1 of the cooling jacket 10.

[0008] The continuous casting nozzle 1 further comprises a mold section 2, consisting of a refractory material and featuring a top end 2y with its upper frontal surface 2p, and a bottom end 2a. This top end 2y of the mold section 2 extends coaxially into an interior of the above-mentioned cooling mantle 10 and is in attachment with the cooling mantle 10 by way of a heat transfer joint 6. In this context, the top end 2y represents not less than 50% of an entire length H_M of the mold section 2 and the bottom end refers to not more than 50% of the entire length H_M of the mold section 2. More specifically, the mold section 2 can have its top end 2y in attachment, by way of the heat transfer joint 6, either directly with the third inner pipe member 13 of the cooling mantle - this is the case for example when the first pipe member 11 and the third pipe member 13 are connected to each other by bottom edges thereof directly or by way of a lip type member or the like, as shown in publications FI-46810 and US-3,872,913 - or with a torus ring 25 interconnecting the third inner pipe member 13 and the first outermost pipe member 11 - as depicted in fig. 1. Since the torus ring 25 serves as an extension of the third pipe member 13 and as an extension of the first pipe member 11, the mold section 2 can be regarded as being in attachment with the pipe members 11 and 13. It is obvious for a skilled artisan that this part of a continuous casting nozzle can be implemented by using intermediate designs of these two solutions or any other construction. In any event, the mold section has its top end 2y in excellent thermal contact with the cooling mantle 10, the mold section having its top end 2y over its entire length effectively cooled by water W, such that the metal M making its way in a molten condition from below into the mold section 2 has solidified substantially over its entire cross-section as early as along the length of the mold section's top end 2y. In other words, a solidification front SF of the continuous casting metal M lies within the mold section 2, more specifically within the mold section's top end 2y, as depicted in fig. 1. The mold section's bottom end 2a protrudes from the cooling mantle 10 and is thereby in a flow communication with a space for the molten metal M, such as a furnace or a ladle or the like, in which a slag or some other layer S protects the molten metal. Experts are familiar with such furnaces and ladles, thus not described in more detail at this time. The continuous casting nozzle 1 being immersed in molten metal, such metal rises by way of the bottom end 2a of the mold section 2 to a mold cross-section A2 both in response to the hydrostatic pressure of molten metal and in response to the fact that the finished solidified cast product P is pulled upwards in a motion direction Y. At the start-up phase of continuous casting, it is also possible to use an underpressure applied to the mold cross-section A2 by way of the penetration opening 23 and further by way of the cooling mantle 10.

[0009] The mold section 2 includes an internal mold cross-section A2 for providing an external shape of said continuous cast product P. The mold cross-section A2 can be in almost any shape at all consistent with a desired profile shape. Thus, the mold cross-section A2 can be capable of providing not only a strand type cast product P but also a tubular cast product P, as indicated in publications FI-46810 and US-3,872,913. The mold cross-section A2 can be capable of forming a cast product P which is circular, elliptical or other than circular and elliptical in shape. The above-mentioned third inner pipe member 13 has an internal pipe cross-section A3 which is larger than this mold cross-section A2. In this context, the term cross-sections is used in reference to dimensions which are perpendicular to the length H_M of the mold section 2 and to the direction of the pipe members 11, 12, 13 parallel thereto and to the motion direction Y of a cast product parallel thereto.

[0010] In addition, the continuous casting nozzle 1 comprises a fourth innermost pipe member 14 inside the above-mentioned third inner pipe member 13, which is why the fourth pipe member 14 features an outer surface 15, whereby it fits inside the third pipe member 13. Typically, the third pipe member 13 has an internal cross-section A3 which is close to a cross-section established by the fourth pipe member's outer surface 15, such that the fourth pipe member 14 fits inside the third pipe member 13 without substantial clearance and without substantial tightness. The fourth innermost pipe member 14 is provided with a lower frontal surface 4p in abutment with the upper frontal surface 2p of the mold section 2. The fourth innermost pipe member 14 has on its outer surface at least one length channel 9, as well as in its lower frontal surface 4p, or adjacent thereto, one or more radially directed openings 8. This radially directed opening 8 is, or respectively, the radially directed openings 8 are in flow communication with the relevant, at least one length channel 9. This at least one length channel 9 and the at least one radially directed opening 8 are adapted to cause a protective cooling gas G to flow through and to be delivered inside the discussed fourth inner most pipe member 14, more specifically into an intermediate space B between the continuous cast product P rising from the mold section and the fourth pipe member 14. This fourth pipe member 14 extends coaxially inside the third pipe member 13 at least over part of a length L3 of this third pipe member 13. The intermediate space B is partially established by the fact that the fourth pipe member 14 has an internal cooling cross-section A4, whose size is equal to or larger than the mold cross-section A2, and partially by the fact that the cast product P, and thereby the cast product's cross-section A1, contracts in response to cooling. Consequently, the cross-section A1 of the cast product P is slightly smaller in size than the mold cross-section A2. In addition, the cooling cross-section A4 of the fourth pipe member is larger than the mold cross-section A2. The intermediate space B is a sum of these differences, i.e. B = (A2-A1)+(A4-A2). Typically, the intermediate space B has a size of not less than 0,3 mm and not more than 1,5 mm, preferably the intermediate space B lies within the range of 0,5 - 1,0 mm, but may deviate from this, depending on metal being cast and dimensions of the cast product P. The useful protective cooling gas G can be any appropriate gas which is inert and provides a high heat transfer coefficient. In this respect, helium (He) is one of the most preferred gases, but in some cases it is also possible to use argon (Ar), nitrogen (N_2), carbon dioxide (CO_2) and hydrogen (H_2) in various combinations or individually. The gas can be selected on the basis of technical benefits as the gas consumption is generally in the order of a few liters/minute, for example 5 liters/minute, but it should be appreciated that it may fluctuate according to the size of the cast product P, i.e. the size of the cross-section A1. The length channel 9 may have cross-sections for example of 2x2 mm or other than that according to the cross-section size of the cast product P. An inlet for the protective cooling gas G, i.e. a gas connection 22 for the incoming gas in the continuous casting nozzle 1, is located far away from the solidification front SF. Typically a distance between the gas connection 22 and the solidification front SF, which distance is substantially equal to the length L3 of the third inner pipe member 13, is for example in the order of 1000 mm, but may fluctuate within the range of 600 mm - 1500 mm or possibly even within a wider range.

[0011] The fourth innermost pipe member 14 may consist of a single component, not shown in the figures, but preferably the fourth innermost pipe member 14 consists of several sleeves 4 set axially one after the other, as shown in the figures. Either all sleeves 4, or optionally all other sleeves except for the lowermost sleeve 4, have crosswise top and bottom ends 4y, 4a thereof formed with external peripheral chamfers 16y, 16a. In addition, the outer surfaces 15 of all sleeves have the earlier described one or more length channels 9. This one or more length channels 9 extend from the peripheral chamfers 16y of the crosswise top ends to the peripheral chamfers 16a of the crosswise bottom ends. Thus, it can be appreciated that the protective cooling gas G is able to flow downwards along one or more length channels 9 of the upper sleeve, then along a lateral peripheral channel section established by the superimposed chamfers 16y, 16a in the contact area of successive sleeves, and thereafter further downwards along one or more length channels 9 of the next lower sleeve, as shown in fig. 3. One of the sleeves 4 comprises said lower frontal surface 4p, as well as said one or more radially directed openings 8 which is/are disposed either as radially directed holes 8' in line with each length channel above the lower frontal surface 4p - basically at any position above the lower frontal surface, but usually at a relatively small distance from the lower frontal surface - or as recesses 8" in the lower frontal surface 4p in line with each length channel, as shown with solid lines in figs. 3 and 5, or as holes 8' in the area of the lower external peripheral chamfer 16a, as shown with dotted lines in fig. 5, or as recesses 8". Consequently, the protective cooling gas G, flowing downwards along one or more length channels 9 of the lowermost sleeve, is able to flow by way of the holes 8' or the recesses 8" into the gap B existing between the cast product P and the fourth pipe member established by the sleeves. It is obvious that a corresponding functional configuration is obtained by constructing the fourth pipe member 14 of just one component. Under no circumstances does the supply path of the protective cooling gas G penetrate the cooling water mantle. In other words, the gas connection 22 for incoming gas, the subsequent one or more length channels 9, and the further subsequent one or more radially directed openings 8 do not extend through the first pipe member 11, the second pipe member 12, and the third pipe member 13, but, instead, the path of the protective cooling gas G circumnavigates these elements.

[0012] The sleeves 4 according to a first embodiment have between the cooling cross-section A4 and each peripheral chamfer 16y, 16a - innermost in diametral direction - planar end surfaces 17, whereby a desired number of the sleeves 4 can be stacked in a successively sealing manner for constructing the fourth pipe member 14. In this case, the sleeves 4 are not fastened to each other, but instead are resting typically in response to weight or possible a spring load or some other vertical force axially as an extension to each other with the end surfaces 17 in a contact 18d. In second, third, and fourth embodiments, the sleeves 4 are fastened to each other at a position between the cooling cross-section A4 and the peripheral chamfer 16y, 16a by means of welds 18a or threads 18b or compression joints 18c successively in a sealing manner for a stack in order to construct said fourth pipe member 14. The material for the fourth pipe member 14 and/or the sleeves 4 making up the fourth pipe member is graphite and/or ceramics or a ceramic combination and/or a metal or a metal combination, for example copper with a hard chromium plating on its internal surface. The continuous casting nozzle 1 comprises, at appropriate positions in its upper parts 1 y, the gas connections 22 for introducing and discharging the protective cooling gas G. The sleeve has a typical length in the order to 100 mm, but may fluctuate within the range of 20 mm - 200 mm or possibly even within a wider range.

[0013] The continuous casting nozzle 1 further comprises a cup-shaped thermal insulation 20 around the cooling mantle's bottom portion 1 a, the mold section 2 having its bottom end 2a extending through said thermal insulation. This cup-shaped thermal insulation 20, which consists of an appropriate refractory material, such as ceramics, can be secured around the cooling mantle's bottom portion 1 a for example by means of some fireproof paste. When using this type of configuration, the cooling mantle's bottom portion 1 a, along with its protruding bottom end 2a of the mold section 2, is immersible in a melt of the metal M as shown in fig. 1, whereby the metal melt is able to flow into the mold section and further casting upward is enabled. The immersion depth in this type of implementation is usually within the range of 100 mm - 400 mm. It is also possible to use other types of solutions, such as a different immersion depth and/or various protections.

[0014] The continuous casting nozzle 1 is operated or it works as follows. The continuous cast product P travels from the mold section 2 upwards in a motion direction Y and further in the same motion direction Y along an internal face of the fourth pipe member 14 present in the cooling mantle 10 - i.e. inside the cooling cross-section A4 - and then out of the end of the cooling mantle's top portion 1y by way of the penetration opening 23, as shown in fig. 1. The cooling water W is supplied by way of the water connection 21 to pass along one cylindrical cooling mantle channel 7a, which is co-directional with the pipe members, from the cooling mantle's top portion 1 y towards the cooling mantle's bottom portion 1 a and the mold section 2 attached thereto, and thereafter further along a second cylindrical channel 7b, which is co-directional with the pipe members, back to the cooling mantle's top portion 1 y and then out of the cooling mantle 10 by way of the water connection 21. The protective cooling gas G is also supplied into the continuous casting nozzle 1 from the top portion 1y of its cooling mantle, is allowed to flow along at least one length channel 9 towards the mold section 2. Then, the protective cooling gas G is allowed to flow through a radially directed opening or radially directed openings 8 into an intermediate space B between the continuous cast product P and the fourth pipe member 14 in the casting product solidification front area SF or not further away therefrom than a predetermined distance H_s, at which point K the protective cooling gas G comes to contact with a surface of the cast product P. Thereafter, the protective cooling gas G is allowed to flow in the intermediate space B between the fourth pipe member 14 and the cast product P towards the cooling mantle's top portion 1y, i.e. the flowing direction of the protective cooling gas G along an external surface of the cast product P is the same as the motion direction Y of the cast product itself. Thus, the protective cooling gas G flows inside the cooling mantle 10 of the continuous casting nozzle along a U-shaped path, whereby the flowing path of the protective cooling gas does not extend, nor does any of the sections of the protective cooling gas flow channels extend through the channels 7a, 7b of the cooling water W. Finally, the protective cooling gas G exits by way of the penetration opening 23. A flow rate of the protective cooling gas G along a surface of the cast product P is higher than the cast product extraction rate in its motion direction Y. This predetermined distance H_s between the cast product solidification front SF and the point K established by the radially directed opening or openings 8 is not less than 30 mm and not more than 120 mm - by way of which opening or by way of which openings 8, 8', 8" the protective cooling gas is brought to contact with a surface of the cast product P. Hence, in the novel continuous casting nozzle 1, the protective cooling gas G is conducted along a specific channel to the vicinity of the solidification front SF in an effort to protect particularly a graphite nozzle from oxidation and from compounds of various separating metals and oxygen, which build up a continuous-casting hindering deposit of foreign metals and oxygen on a surface of the nozzle at the cast product solidification point or its immediate vicinity. At the same time, the cast product P retains a higher purity regarding the effects of normal atmosphere. This presently described continuous casting nozzle 1 is excellently applicable to the casting of aluminum and aluminum alloys, as well as copper alloys, such as oxygen-free copper. In the above-described construction, the concentric components of the cooling mantle 10, i.e. the first outermost pipe member 11, the second middle pipe member 12, the third inner pipe member 13, and the fourth innermost pipe member 14 can be in any rotated position relative to each other and still both the path of the cooling water W and the paths or channels of the protective cooling gas G are always open. The malfunction possibilities are thereby minimized. Moreover, the construction can be implemented by using threaded components.

Claims

1. A continuous casting nozzle apt for the vertical upwards continuous casting of metal (M) into continuous cast products (P), said nozzle (1) comprising:

- a cooling mantle (10), including concentrically a first outermost pipe member (11), a second middle pipe member (12), and a third inner pipe member (13) and therebetween two cylindrical channels (7a, 7b), which are co-directional with the pipe members and apt for causing a flow-through of cooling water (W), and said cooling mantle having a top portion (1 y) and a bottom portion (1 a);

- a mold section (2), which consists of a refractory material and which has a top end (2y) with its upper frontal surface (2p), and a bottom end (2a), said top end extending coaxially into an interior of said cooling mantle (10) and being, by way of a heat transfer joint (6), in attachment with said cooling mantle, and said bottom end (2a) protruding from the cooling mantle (10);
- said mold section (2) has an internal mold cross-section (A2) for providing an external shape of said continuous cast product (P), and said third pipe member (13) has an internal cross-section (A3) which is larger than said mold cross-section (A2), **characterized in that** the continuous casting nozzle 1 further comprises a fourth innermost pipe member (14) inside said third inner pipe member (13), said fourth pipe member:
- extending coaxially inside the third pipe member at least over part of a length (L3) of this third pipe member and having a lower frontal surface (4p) in abutment with said upper frontal surface (2p) of the mold section (2);
- having an internal cooling cross-section (A4), whose size is equal to or larger than said mold cross-section (A2);
- having an external surface (15), by which this fourth pipe member (14) fits inside the third pipe member (13); and
- comprising on its external surface (15) at least one length channel (9), as well as in its lower frontal surface (4p) or in the vicinity thereof, one or more radially directed openings (8), which is/are in flow communication with said at least one length channel (9), whereby said at least one length channel (9) and the radially directed openings (8) are apt for causing a protective cooling gas (G) to flow through and to be delivered inside this fourth pipe member, into an intermediate space (B) between said continuous cast product (P) and the fourth pipe member (14).

2. A continuous casting nozzle as set forth in claim 1, **characterized in that** said fourth pipe member (14) consists of several axially successively disposed sleeves (4), whose upper and lower lateral ends (4y, 4a) are provided with external peripheral chamfers (16y, 16a), and whose external surfaces (15) are provided with said one or more length channels (9) which extend from the peripheral chamfers (16y) of the upper lateral ends to the peripheral chamfers (16a) of the lower lateral ends.

3. A continuous casting nozzle as set forth in claim 2, **characterized in that** said sleeves (4) are provided, between the cooling cross-section (A4) and each peripheral chamfer (16y, 16a), with planar end surfaces (17), whereby a desired number of sleeves (4) are stackable successively in a relatively sealing manner for constructing said fourth pipe member (14).

4. A continuous casting nozzle as set forth in claim 2, **characterized in that** said sleeves (4), in a zone between the cooling cross-section (4) and the peripheral chamfer (16y, 16a), are fastened by welds (18a) or threads (18b) or compression joints (18c) successively in a mutually sealing manner to form a stack for constructing said fourth pipe member (14).

5. A continuous casting nozzle as set forth in claim 2 or 3 or 4, **characterized in that** one of the sleeves (4) comprises said lower frontal surface (4p) as well as said one or more radially directed openings (8), which is/are located either as recesses (8") in the lower frontal surface (4p) or as holes (8') in the area of the lower external peripheral chamfer (16a).

6. A continuous casting nozzle as set forth in any of the preceding claims, **characterized in that** the material for the fourth pipe member (14) and/or for the sleeves (4) making up the fourth pipe member is graphite and/or ceramics or a ceramic combination and/or a metal or a metal combination.

7. A continuous casting nozzle as set forth in any of the preceding claims, **characterized in that** it further comprises a cup-shaped thermal insulation (20) around the bottom portion (1a) of the cooling mantle, said bottom end (2a) of the mold section extending through said thermal insulation.

8. A continuous casting nozzle as set forth in any of the preceding claims, **characterized in that** the top portion of the cooling mantle (10) comprises at least fastening elements (19) for the continuous casting nozzle, water connections (21) for the entry and exit of cooling water (W), gas connections (22) for the entry and exit of a protective cooling gas (G), as well as a penetration opening (23) for extracting said continuous cast product (P) as it is produced.

9. Use of a continuous casting nozzle according to claim 1, wherein:

- said continuous cast product (P) travels from the mold section (2) and further along inside the fourth pipe member (14) present in the cooling mantle (10) and then out by way of the top portion (1 y) of the cooling mantle;
- the cooling water (W) is supplied to pass along one cylindrical cooling mantle channel (7a), which is co-directional with the pipe members, towards the mold section (2), and further along a second cylindrical channel (7b), which is co-directional with the pipe members, out of the

cooling mantle (10);

- the protective cooling gas (G) is supplied into the continuous casting nozzle (1) by way of the top portion (1y) of its cooling mantle, is allowed to flow along said at least one length channel (9) towards the mold section (2) and then to flow through said radially directed opening or openings (8) into an intermediate space (B) between the continuous cast product (P) and the fourth pipe member (14) in a solidification front area (SF) of the cast product or not further away therefrom than a predetermined distance (H_s), at which point K the protective cooling gas comes to contact with a surface of the cast product (P), whereafter the protective cooling gas (G) continues to flow in the intermediate space (B) between the fourth pipe member (14) and the cast product (P) in the direction towards the cooling mantle's top portion (1 y).

10. Use of a continuous casting nozzle as set forth in claim 9, **characterized in that** said predetermined distance (H_s) between the cast product solidification front (SF) and the point (K), which point is established by the radially directed opening or openings (8) and by way of which the protective cooling gas is brought to contact with a surface of the cast product (P), is not less than 30 mm and not more than 120 mm.

11. Use of a continuous casting nozzle as set forth in claim 9 or 10, **characterized in that** the protective cooling gas (G) is allowed to flow inside the cooling mantle (10) of the continuous casting nozzle along a U-shaped path, whereby the flowing path of the protective cooling gas does not pass through the channels (7a and 7b) of the cooling water (W).

Patentansprüche

1. Stranggießdüse, die zum vertikalen Aufwärtsstranggießen von Metall (M) in Stranggussprodukte (P) geeignet ist, wobei die Düse (1) umfasst:

- einen Kühlmantel (10), der konzentrisch ein erstes äußerstes Rohrleitungselement (11), ein zweites mittleres Rohrleitungselement (12) und ein drittes inneres Rohrleitungselement (13) und dazwischen zwei zylindrische Kanäle (7a, 7b) umfasst, die mit den Rohrleitungselementen kodirektional sind und geeignet sind, einen Durchfluss von Kühlwasser (W) zu bewirken, und wobei der Kühlmantel einen oberen Abschnitt (1 y) und einen unteren Abschnitt (1 a) aufweist;
- einen Formabschnitt (2), der aus einem feuerfesten Material besteht und der ein oberes Ende (2y) mit dessen oberer Vorderfläche (2p) und ein unteres Ende (2a) aufweist, wobei sich das obere Ende koaxial in ein Inneres des Kühlmantels (10) erstreckt und mittels einer Wärmeübertragungsverbindung (6) an den Kühlmantel angebunden ist und das untere Ende (2a) von dem Kühlmantel (10) vorsteht;
- wobei der Formabschnitt (2) einen inneren Formquerschnitt (A2) aufweist, um eine äußere Form des Stranggussproduktes (P) bereitzustellen, und das dritte Rohrleitungselement (13) einen Innenquerschnitt (A3) aufweist, der größer ist als der Formquerschnitt (A2),

dadurch gekennzeichnet, dass die Stranggießdüse (1) weiter ein viertes innerstes Rohrleitungselement (14) innerhalb des dritten inneren Rohrleitungselements (13) umfasst, wobei das vierte Rohrleitungselement:

- sich koaxial innerhalb des dritten Rohrleitungselements mindestens über einen Teil einer Länge (L3) dieses dritten Rohrleitungselements erstreckt und eine untere Vorderfläche (4p), die an der oberen Vorderfläche (2p) des Formabschnitts (2) anliegt, aufweist;
- einen Innenkühlquerschnitt (A4) aufweist, dessen Größe gleich oder größer als der Formquerschnitt (A2) ist;
- eine Außenfläche (15) aufweist, durch die dieses vierte Rohrleitungselement (14) in das dritte Rohrleitungselement (13) passt; und
- auf seiner Außenfläche (15) mindestens einen Längenkanal (9) sowie in seiner unteren Vorderfläche (4p) oder in der Umgebung davon eine oder mehrere radial gerichtete Öffnungen (8) umfasst, die in Strömungsverbindung mit dem mindestens einen Längenkanal (9) stehen, wobei der mindestens eine Längenkanal (9) und die radial gerichteten Öffnungen (8) geeignet sind, zu bewirken, dass ein schützendes Kühlgas (G) hindurchströmt und innerhalb dieses vierten Rohrleitungselements in einen Zwischenraum (B) zwischen dem Stranggussprodukt (P) und dem vierten Rohrleitungselement (14) zugeführt wird.

2. Stranggießdüse nach Anspruch 1, **dadurch gekennzeichnet, dass** das vierte Rohrleitungselement (14) aus mehreren axialen der Reihe nach angeordneten Muffen (4) besteht, deren obere und untere seitliche Enden (4y, 4a) mit äußeren peripheren Fasen (16y, 16a) versehen sind und deren Außenflächen (15) mit dem einen oder den mehreren Längenkanälen (9) versehen sind, die sich von den peripheren Fasen (16y) von den oberen seitlichen Enden zu den peripheren Fasen (16a) von den unteren seitlichen Enden erstrecken.

3. Stranggießdüse nach Anspruch 2, **dadurch ge-**

kennzeichnet, dass die Muffen (4) zwischen dem Kühlquerschnitt (A4) und jeder peripheren Fase (16y, 16a), mit ebenen Endflächen (17) versehen sind, wobei eine gewünschte Anzahl an Muffen (4) der Reihe nach in verhältnismäßig abdichtender Weise zum Erstellen des vierten Rohrleitungselements (14) stapelbar sind.

4. Stranggießdüse nach Anspruch 2, **dadurch gekennzeichnet, dass** die Muffen (4) in einer Zone zwischen dem Kühlquerschnitt (4) und der peripheren Fase (16y, 16a) durch Schweißnähte (18a) oder Gewinde (18b) oder Schneidringverschraubungen (18c) der Reihe nach in gemeinsam abdichtender Weise befestigt sind, um einen Stapel zu bilden und das vierte Rohrleitungselement (14) zu erstellen.

5. Stranggießdüse nach Anspruch 2 oder 3 oder 4, **dadurch gekennzeichnet, dass** eine der Muffen (4) die untere Vorderfläche (4p) sowie die eine oder die mehreren radial gerichteten Öffnungen (8) umfasst, die entweder als Aussparungen (8") in der unteren Vorderfläche (4p) oder als Öffnungen (8') im Bereich der unteren äußeren peripheren Fase (16a) angeordnet sind.

6. Stranggießdüse nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** das Material für das vierte Rohrleitungselement (14) und/oder für die Muffen (4), die das vierte Rohrleitungselement bilden, Graphit und/oder Keramik oder eine Keramikkombination und/oder ein Metall oder eine Metallkombination ist.

7. Stranggießdüse nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** sie weiter eine becherförmige Wärmeisolierung (20) um den unteren Abschnitt (1 a) des Kühlmantels herum umfasst, wobei sich das untere Ende (2a) des Formabschnitts durch die Wärmeisolierung erstreckt.

8. Stranggießdüse nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** der obere Abschnitt des Kühlmantels (10) mindestens Befestigungselemente (19) für die Stranggießdüse, Wasseranschlüsse (21) für den Eintritt und Austritt von Kühlwasser (W), Gasanschlüsse (22) für den Eintritt und Austritt eines schützenden Kühlgases (G) sowie eine Durchdringungsöffnung (23) zum Extrahieren des Stranggussproduktes (P), während es hergestellt wird, umfasst.

9. Verwenden einer Stranggießdüse nach Anspruch 1, wobei:

- sich das Stranggussprodukt (P) vom Formabschnitt (2) und weiter entlang innerhalb des vierten Rohrleitungselements (14), das im Kühlmantel (10) vorhanden ist, und dann über den oberen Abschnitt (1 y) des Kühlmantels heraus fortbewegt;
- das Kühlwasser (W) zugeführt wird, sodass es entlang eines zylindrischen Kühlmantelkanals (7a), der mit den Rohrleitungselementen kodirektional ist, zum Formabschnitt (2) und weiter entlang von einem zweiten zylindrischen Kanal (7b), der kodirektional mit den Rohrleitungselementen ist, aus dem Kühlmantel (10) heraus strömt;
- das schützende Kühlgas (G) in die Stranggießdüse (1) über den oberen Abschnitt (1 y) von deren Kühlmantel zugeführt und ihm ermöglicht wird, entlang von dem mindestens einen Längenkanal (9) zum Formabschnitt (2) zu strömen und dann durch die radial gerichtete Öffnung oder gerichteten Öffnungen (8) in einen Zwischenraum (B) zwischen dem Stranggussprodukt (P) und dem vierten Rohrleitungselement (14) in einen Erstarrungsfrontbereich (SF) des Gießproduktes oder nicht weiter davon weg als eine vorbestimmte Entfernung (H_s) zu strömen, wobei an dem Punkt K das schützende Kühlgas mit einer Fläche des Gießproduktes (P) in Kontakt kommt, wonach das schützende Kühlgas (G) weiter in den Zwischenraum (B) zwischen dem vierten Rohrleitungselement (14) und dem Gießprodukt (P) in der Richtung zum oberen Abschnitt des Kühlmantels (1 y) strömt.

10. Verwenden einer Stranggießdüse nach Anspruch 9, **dadurch gekennzeichnet, dass** die vorbestimmte Entfernung (H_s) zwischen der Gießprodukterstarrungsfront (SF) und dem Punkt (K), der durch die radial gerichtete Öffnung oder gerichteten Öffnungen (8) bestimmt wird und über den das schützende Kühlgas mit einer Fläche des Gießproduktes (P) in Kontakt gebracht wird, nicht kleiner als 30 mm und nicht größer als 120 mm ist.

11. Verwenden einer Stranggießdüse nach Anspruch 9 oder 10, **dadurch gekennzeichnet, dass** dem schützenden Kühlgas (G) ermöglicht wird, innerhalb des Kühlmantels (10) der Stranggießdüse entlang eines U-förmigen Pfades zu strömen, wobei der Strömungspfad des schützenden Kühlgases nicht durch die Kanäle (7a und 7b) des Kühlwassers (W) hindurchgeht.

Revendications

1. Buse de coulée continue, conçue pour couler du métal (M) en continu verticalement vers le haut, de manière à former des produits coulés en continu (P), ladite buse (1) comprenant :

- une garniture de refroidissement (10) comprenant un premier élément de tuyau extérieur (11), un deuxième élément de tuyau central (12) et un troisième élément de tuyau intérieur (13), ainsi que deux canaux cylindriques (7a, 7b) intermédiaires, lesquels s'étendent dans la même direction que les éléments de tuyau et sont conçus pour assurer le passage d'une eau de refroidissement (W), et ladite garniture de refroidissement présentant une partie supérieure (1 y) et une partie inférieure (1 a) ;
- une section de moule (2) constituée d'un matériau réfractaire et présentant une extrémité supérieure (2y) avec sa surface frontale supérieure (2p), et une extrémité inférieure (2a), ladite extrémité supérieure s'étendant coaxialement dans un intérieur de ladite garniture de refroidissement (10), tout en étant reliée à ladite garniture de refroidissement par un joint de transfert thermique (6), et ladite extrémité inférieure (2a) faisant saillie à partir de la garniture de refroidissement (10) ;
- ladite section de moule (2) présentant une section transversale de moule intérieure (A2) destinée à fournir une forme extérieure dudit produits coulés en continu (P), et ledit troisième élément de tuyau (13) présentant une section transversale intérieure (A3) plus grande que ladite section transversale de moule (A2),

caractérisée en ce que la buse de coulée continue (1) comprend en outre un quatrième élément de tuyau intérieur (14) situé à l'intérieur dudit troisième élément de tuyau intérieur (13), ledit quatrième élément de tuyau :

- s'étendant coaxialement à l'intérieur du troisième élément de tuyau, au moins sur une partie d'une longueur (L3) de ce troisième élément de tuyau, et présentant une surface frontale inférieure (4p) en butée avec ladite surface frontale supérieure (2p) de la section de moule (2) ;
- présentant une section transversale de refroidissement intérieure (A4), dont la taille est égale ou supérieure à celle de ladite section transversale de moule (A2) ;
- présentant une surface extérieure (15) par laquelle ce quatrième élément de tuyau (14) s'ajuste à l'intérieur du troisième élément de tuyau (13) ; et
- comprenant, sur sa surface extérieure (15), au moins un canal longitudinal (9), ainsi que, sur sa surface frontale inférieure (4p) ou à proximité de celle-ci, une ou plusieurs ouvertures orientées radialement (8), laquelle/lesquelles est/sont en communication fluidique avec ledit au moins un canal longitudinal (9), moyennant quoi ledit au moins un canal longitudinal (9) et les ouvertures orientées radialement (8) peuvent laisser s'écouler un gaz de refroidissement protecteur (G) à travers et délivrer celui-ci à l'intérieur de ce quatrième élément de tuyau, dans un espace intermédiaire (B) situé entre ledit produits coulés en continu (P) et le quatrième élément de tuyau (14).

2. Buse de coulée continue selon la revendication 1, **caractérisée en ce que** ledit quatrième élément de tuyau (14) est constitué de plusieurs manchons (4) disposés axialement les uns à la suite des autres, dont les extrémités latérales supérieures et inférieures (4y, 4a) sont pourvues de chanfreins périphériques extérieurs (16y, 16a), et dont les surfaces extérieures (15) sont pourvues desdits un ou plusieurs canaux longitudinaux (9), lesquels s'étendent à partir des chanfreins périphériques (16y) des extrémités latérales supérieures (16a) des extrémités latérales inférieures.

3. Buse de coulée continue selon la revendication 2, **caractérisée en ce que** lesdits manchons (4) sont pourvus de surfaces terminales planaires (17) entre la section transversale de refroidissement (A4) et chaque chanfrein périphérique (16y, 16a), avec des surfaces terminales planaires (17), moyennant quoi un nombre souhaité de manchons (4) peut être empilé successivement de manière étanche les uns par rapport aux autres, pour la construction dudit quatrième élément de tuyau (14).

4. Buse de coulée continue selon la revendication 2, **caractérisée en ce que** lesdits manchons (4) sont fixés, dans une zone entre la section transversale de refroidissement (4) et le chanfrein périphérique (16y, 16a), par des soudures (18a) ou des filets (18b) ou des joints de compression (18c), successivement de façon étanche les uns par rapport aux autres, pour former une pile permettant de construire ledit quatrième élément de tuyau (14).

5. Buse de coulée continue selon la revendication 2 ou 3 ou 4, **caractérisée en ce que** l'un des manchons (4) comprend ladite surface frontale inférieure (4p) ainsi que lesdites une ou plusieurs ouvertures orientées radialement (8), lesquelles sont situées soit en tant qu'évidements (8") dans la surface frontale inférieure (4p) ou en tant que trous (8') dans la région du chanfrein périphérique extérieur inférieur (16a).

6. Buse de coulée continue selon l'une quelconque des revendications précédentes, **caractérisée en ce que** le matériau du quatrième élément de tuyau (14) et/ou des manchons (4) constituant le quatrième élément de tuyau est du graphite et/ou une céramique ou une combinaison de céramiques et/ou un métal ou une combinaison de métaux.

7. Buse de coulée continue selon l'une quelconque des revendications précédentes, **caractérisée en ce qu'**elle comprend en outre une isolation thermique en forme de coupelle (20) autour de la partie inférieure (1 a) de la garniture de refroidissement, ladite extrémité inférieure (2a) de la section de moule s'étendant à travers ladite isolation thermique.

8. Buse de coulée continue selon l'une quelconque des revendications précédentes, **caractérisée en ce que** la partie supérieure de la garniture de refroidissement (10) comprend au moins des éléments de fixation (19) pour la buse de coulée continue, des raccords d'eau (21) pour l'entrée et la sortie d'eau de refroidissement (W), des raccords de gaz (22) pour l'entrée et la sortie d'un gaz de refroidissement protecteur (G), ainsi qu'une ouverture d'entrée (23) pour l'extraction dudit produit coulé en continu (P) lors de la production de celui-ci.

9. Utilisation d'une buse de coulée continue selon la revendication 1, dans laquelle :

   - ledit produit coulé en continu (P) quitte la section de moule (2) et se déplace plus loin le long de l'intérieur du quatrième élément de tuyau (14) présent dans la garniture de refroidissement (10), puis ressort par le biais d'une partie supérieure (1 y) de ladite garniture de refroidissement (10) ;
   - l'eau de refroidissement (W) est alimentée de manière à s'écouler le long d'un canal de garniture de refroidissement cylindrique (7a) s'étendant dans la même direction que les éléments de tuyau, vers la section de moule (2), et plus loin le long d'un deuxième canal cylindrique (7b) s'étendant dans la même direction que les éléments de tuyau, à l'extérieur de la garniture de refroidissement (10) ;
   - le gaz de refroidissement protecteur (G) est alimenté dans la buse de coulée continue (1) par le biais d'une partie supérieure (1 y) de sa garniture de refroidissement, peut s'écouler le long dudit au moins un canal longitudinal (9), vers la section de moule (2), puis s'écouler à travers ladite ouverture ou lesdites ouvertures orientée(s) radialement (8), dans un espace intermédiaire (B) entre le produit coulé en continu (P) et le quatrième élément de tuyau (14), dans une zone avant de solidification (SF) du produit coulé, ou pas plus loin que celle-ci qu'une distance prédéterminée (H_s), en un point K où le gaz de refroidissement protecteur entre en contact avec une surface du produit coulé (P), suite à quoi le gaz de refroidissement protecteur (G) continue de s'écouler dans l'espace intermédiaire (B) entre le quatrième élément de tuyau (14) et le produit coulé (P), en direction de la partie supérieure (1 y) de la garniture de refroidissement.

10. Utilisation d'une buse de coulée continue selon la revendication 9, **caractérisée en ce que** ladite distance prédéterminée (H_s) entre la zone avant de solidification du produit coulé (SF) et le point (K) n'est pas inférieure à 30 mm et pas supérieure à 120 mm, ledit point étant défini par ladite ouverture ou lesdites ouvertures orientée(s) radialement (8) et assurant la mise en contact du gaz de refroidissement protecteur avec une surface du produit coulé (P).

11. Utilisation d'une buse de coulée continue selon la revendication 9 ou 10, **caractérisée en ce que** le gaz de refroidissement protecteur (G) peut s'écouler à l'intérieur de la garniture de refroidissement (10) de la buse de coulée continue, le long d'un trajet en forme de U, le trajet d'écoulement du gaz de refroidissement protecteur ne traversant pas les canaux (7a et 7b) de l'eau de refroidissement (W).

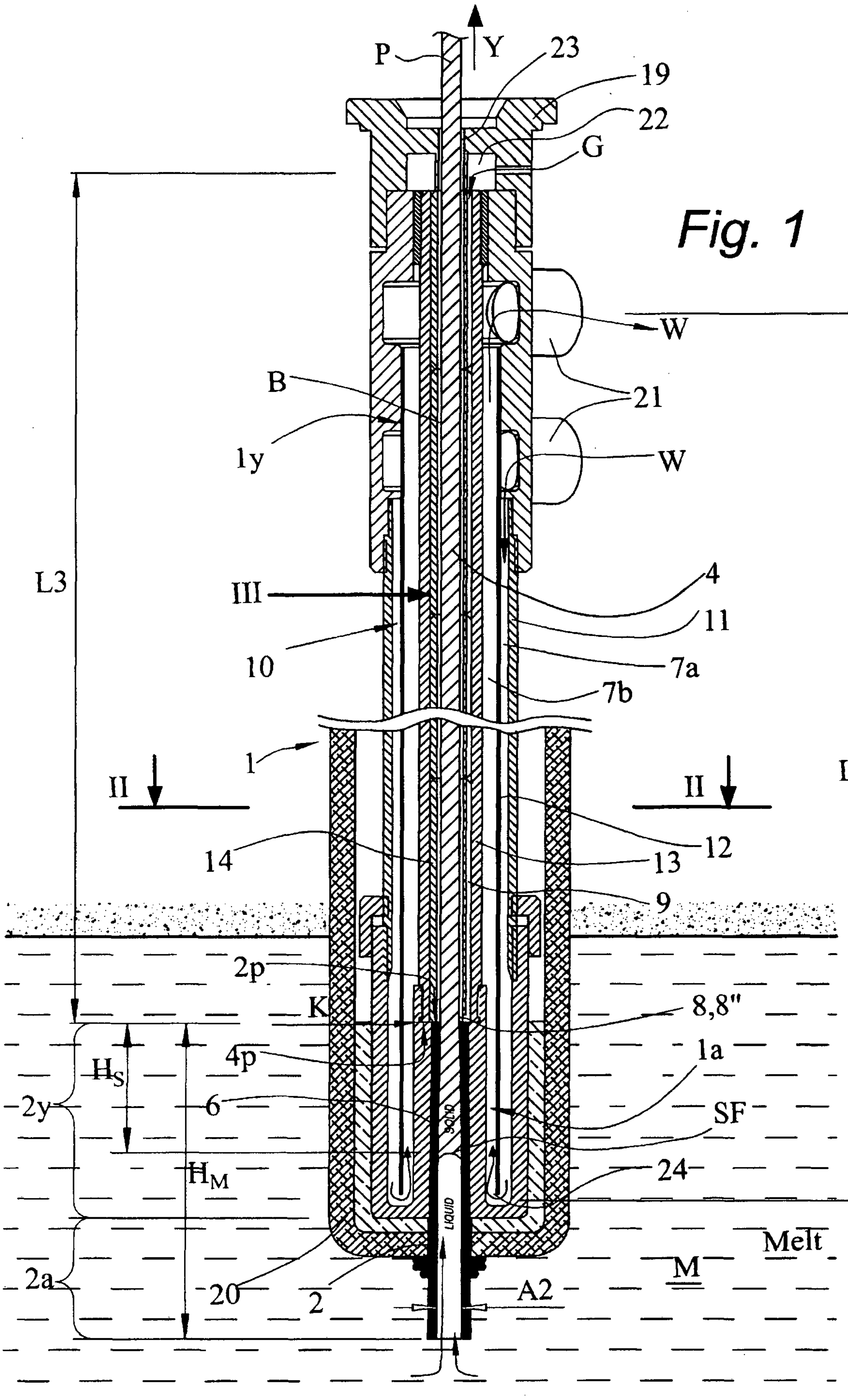
P
Y
23
19
22
G
21
W
W
B
1y
L3
III
4
11
10
7a
7b
1
II
II
L1
12
14
13
9
2p
K
8,8"
1a
4p
HS
2y
6
SOLID
SF
HM
24
LIQUID
Melt
2a
M
20
2
A2

Fig. 1

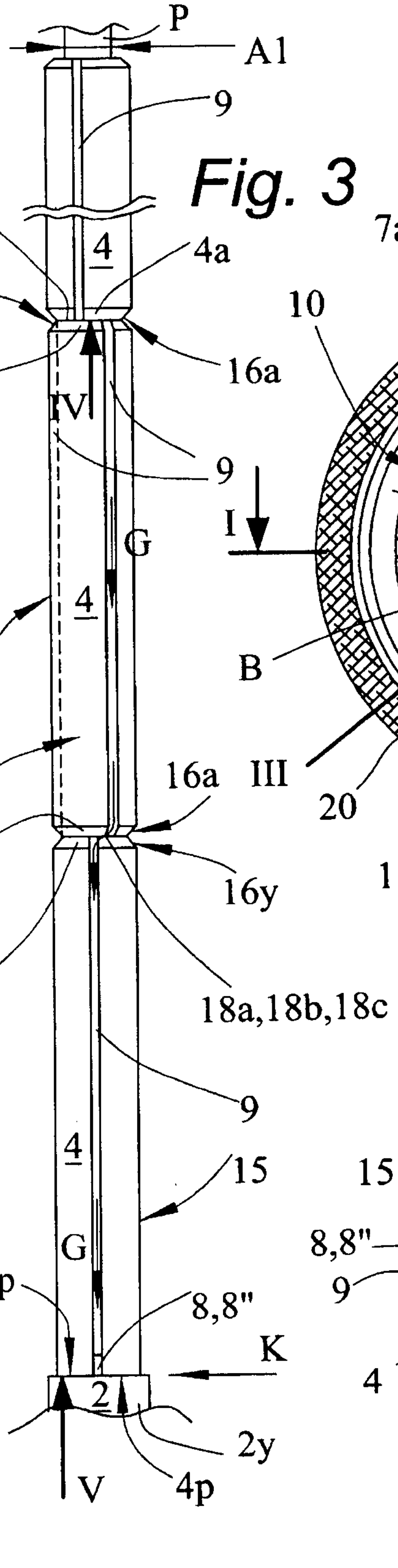

Fig. 3

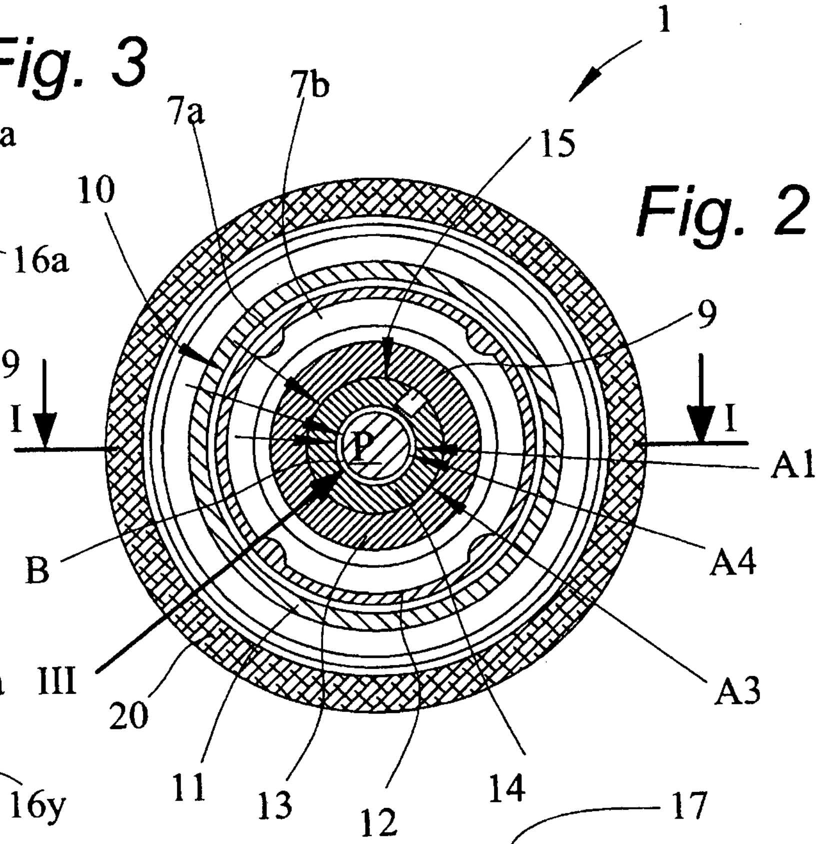

Fig. 2

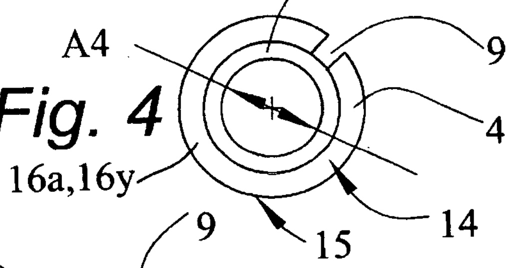

Fig. 4

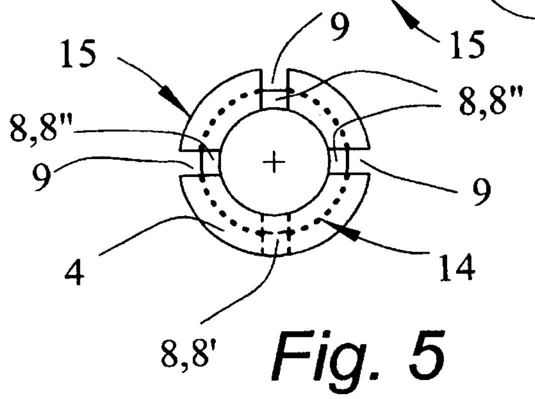

Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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