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Nozzle for a liquid-cooled plasma torch and plasma torch head having the same

Description

The present invention relates to a nozzle for a liquid-cooled plasma torch as well as to a plasma torch head having the same.

A thermally highly heated, electrically conductive gas which consists of positive and negative ions, electrons and excited and neutral atoms and molecules, is designated as plasma.

Different gases, for example monatomic argon and/or the diatomic gases hydrogen, nitrogen, oxygen or air are used as plasma gas. Said gases ionize and disassociate by means of the energy of an arc. The arc constricted by a nozzle is then designated as a plasma jet.

The parameters of the plasma jet can be severely influenced by the development of the nozzle and electrode. Said parameters of the plasma jet are, for example, the jet diameter, the temperature, energy density and the flow speed of the gas.

In the case of plasma cutting, for example, the plasma is constricted by a nozzle which can be gas-cooled or water-cooled. As a result, energy densities of up to $2x10^6$ W/cm^2 are achieved. Temperatures of up to 30,000 °C, which realize very high cutting speeds on materials in conjunction with the high flow speed of the gas, are generated in the plasma jet.

Plasma torches can be operated directly or indirectly. In the case of the direct method of operation, the current flows from the power source by means of the electrode of the plasma torch, the plasma jet generated by means of the arc and constricted by means of the nozzle, directly back to the power source via the workpiece. In the case of the direct method of operation, electrically conductive materials are able to be cut.

In the case of the indirect method of operation, the current flows from the power source by means of the electrode of the plasma torch, the plasma jet generated by means of the arc and constricted by means of the nozzle and the nozzle, back to the power source. In this case, the nozzle is loaded more heavily than in the case of direct plasma cutting as it not only restricts the plasma jet but also realizes the starting point of the arc. With the indirect method of operation, both electrically conductive and non-electrically conductive materials are able to be cut.

On account of the high thermal load of the nozzle, said nozzle is produced, as a rule, from a metal material, preferably copper on account of its high electrical conductivity and thermal conductivity. The same applies to the electrode holder which can also be produced, however, from silver. The nozzle is then inserted into a plasma torch, the main components of which are a plasma torch head, a nozzle cap, a plasma guiding part, a nozzle, a nozzle holder, an electrode receiving means, an electrode holder with electrode insert and, in the case of modern plasma torches, a nozzle protector cap holder and nozzle protector cap. The electrode holder fixes a pointed electrode insert produced of tungsten which is suitable for the use of non-oxidizing gases as plasma gas, for example an argon-hydrogen mixture. A so-called flat electrode, the electrode insert of which consists, for example, of hafnium, is also suitable for using oxidizing gases as plasma gas, for example air or oxygen. In order to achieve a long service life for the nozzle, it is cooled in this case with a liquid, for example water. The cooling liquid is guided by means of a water supply toward the nozzle and a water return away from the nozzle and, in this case, traverses a cooling liquid chamber which is defined by the nozzle and the nozzle cap.

DD 36014 B1 describes a nozzle. Said nozzle consists of a material which has good conductivity, for example copper, and has a geometric form associated with the respective model of plasma torch, for example a conically realized discharge chamber with a cylindrical nozzle outlet. The outer form of the nozzle is realized as a cone, an approximately identical wall thickness being achieved which is dimensioned such that good stability of the nozzle and good thermal conductivity to the cooling liquid is ensured. The nozzle sits in a nozzle holder. The nozzle holder consists of corrosion-resistant material, for example tin, and inside has a centring receiving means for the nozzle as well as a groove for a sealing rubber which seals the discharge chamber against the cooling liquid. In addition, bores for the cooling liquid supply and return, which are offset by 180°, are situated in the nozzle holder. A groove for an O-ring for sealing the cooling liquid chamber against the atmosphere and a thread and a centring receiving means for a nozzle cap are situated on the outside diameter of the nozzle holder. The nozzle cap, also produced from corrosion-resistant material, for example tin, is realized in an acutely-angled manner and has a wall thickness which is dimensioned in an expedient manner for diverting radiant heat to the cooling liquid. The smallest inside diameter is provided with a gasket. In the simplest case, water is used as cooling liquid. Said arrangement is to enable simple production of the nozzles with economical use of material and rapid exchanging of the same and, as a result of the acutely-angled design, pivoting of the plasma torch in relation to the workpiece and consequently diagonal cuts.

DE disclosure 1 565 638 describes a plasma torch, preferably for plasma arc cutting of materials and for welding edge preparation. The narrow form of the torch head is achieved by using a particularly acutely-angled cutting nozzle, the inside and outside angles of which are identical amongst one another and also identical to the inside and outside angles of the nozzle cap. A cooling liquid chamber is formed between the nozzle cap and the cutting nozzle, in which cooling liquid chamber the nozzle cap is provided with a collar which seals metallically to the cutting nozzle such that, as a result, a uniform ring gap is created as the cooling liquid chamber. The supplying and removing of the cooling liquid, generally speaking water, is effected through slots, which are arranged offset by 180 ° with respect to one another, in the nozzle holder.

DE 25 25 939 describes a plasma arc torch, in particular for cutting or welding, where the electrode holder and the nozzle body form one exchangeable construction unit. The outside cooling liquid supply is formed substantially by a sleeve cap which includes the nozzle body. The cooling liquid flows via channels into an annular chamber which is formed by the nozzle body and the sleeve cap.

DE 692 33 071 T2 relates to an arc plasma cutting device. An embodiment of a nozzle for a plasma arc cutting torch is described therein, which is formed from a conducting material and has an outlet opening for a plasma gas jet and a hollow body portion which is realized such that it has a generally conical thin-walled configuration which is inclined in the direction toward the outlet opening and comprises an enlarged head portion which is realized integrally with the body portion, wherein the head portion is solid with the exception of a central channel which is aligned with the outlet opening and comprises a generally conical outer surface which is also inclined in the direction toward the outlet opening and has a diameter adjoining the adjacent body portion which exceeds the diameter of the body portion in order to form a cut-back recess. The arc plasma cutting device has a secondary gas cap. In addition, a water-cooled cap is arranged between the nozzle and the secondary gas cap in order to form a water-cooled chamber for the outer surface of the nozzle for highly-efficient cooling. The nozzle is characterized by a large head which surrounds an outlet opening for the plasma jet, and a pointed undercut or a recess to a conical body. Said nozzle design promotes the cooling of the nozzle.

In the case of the previously described plasma torches, the cooling liquid is guided via a water supply channel toward the nozzle and via a water return channel away from the nozzle. Said channels are offset by 180° with respect to one another in the majority of cases and the cooling liquid is to wash around the nozzle as uniformly as possible on the way from the supply to the return. Nevertheless, overheating is ascertained again and again in the vicinity of the nozzle channel.

Another cooling liquid guide means for a torch, preferably a plasma torch, in particular for plasma welding, plasma cutting, plasma fusing and plasma injecting purposes which withstand high thermal loads of the nozzle and the cathode, is described in DD 83890 B1. In this case, a cooling media guide ring, which is easily insertable into and removable from the nozzle holding part, is arranged for the cooling of the nozzle, said cooling media guide ring for defining the cooling media guide to a thin layer of a maximum of 3 mm thick along the outer nozzle wall comprises a circumferential form groove, into which more than one, preferably two to four cooling liquid lines, which are mounted in a star-shaped manner with respect to said form groove and radially and symmetrically to the nozzle access and in a star-shaped manner to the same at an angle of between 0 and 90 °, open out in such a manner that it is adjacent to two cooling liquid media outflows each and each cooling liquid media outflow to two cooling liquid media inflows.

The disadvantage of said arrangement, once again, is that higher expenditure is necessary for the cooling as a result of using an additional component, the cooling liquid media guide ring. In addition, the entire arrangement is enlarged as a result.

To improve the water cooling for the nozzle, DE 10 2007 005 316 A1 incorporates a water supply channel and a water return channel in the nozzle.

Consequently the object underlying the invention is to avoid overheating in the vicinity of the nozzle channel or the nozzle bore in a simple manner.

Said object is achieved according to the invention by a plasma torch head, comprising:

a nozzle according to one of Claims 1 to 14,
a nozzle holder for holding the nozzle, and

a nozzle cap, wherein the nozzle cap and the nozzle form a cooling liquid chamber which is connectable by means of two bores which are offset in each case by 60° to 180° to a cooling liquid supply line or cooling liquid return line respectively, wherein the nozzle holder is designed such that the cooling liquid passes into the cooling liquid chamber so as to strike the nozzle approximately at right angles to the longitudinal axis of the plasma torch head, and/or passes from the cooling liquid chamber into the nozzle holder approximately at right angles to the longitudinal axis.

In addition, the present invention supplies a nozzle for a liquid-cooled plasma torch, comprising a nozzle bore for the emergence of a plasma gas jet at a nozzle tip, a first section, the outer surface of which is substantially cylindrical, and a second section, which adjoins said first section in the direction of the nozzle tip and the outer surface of which narrows substantially conically toward the nozzle tip, wherein at least one liquid supply groove and/or at least one liquid return groove is/are provided which extend over the second section in the outer surface of the nozzle toward the nozzle tip and wherein the liquid supply groove or at least one of the liquid supply grooves and/or one liquid return groove or at least one of the liquid return grooves also extends/extend over a part of the first section, and, in the first section, there is situated at least one groove which is connected to the liquid supply groove or to at least one of the liquid supply grooves or to the liquid return grove or to at least one of the liquid return grooves. Substantially cylindrical is to be understood as the outer surface, at least when imagining the grooves, such as the liquid supply and return grooves, being on the whole cylindrical. In an analogous manner, "narrows substantially conically" is to be understood as the outer surface, at least when imagining the grooves, such as the liquid supply and return grooves, being on the whole narrowed in a tapering manner.

According to a particular embodiment of the plasma torch head, the nozzle comprises at least one liquid supply groove and at least one liquid return groove, and the nozzle cap has, on its inner surface, at least three recesses whose openings, facing toward the nozzle, each extend over an arc dimension (b2), wherein the arc dimension (b4; c4; d4; e4) of the regions, which adjoin the liquid supply groove(s) and/or liquid return groove(s) in the circumferential direction and which protrude outwardly in relation to the liquid supply groove(s) and/or liquid return groove(s), of the nozzle is in each case at least equal to the arc dimension (b2). A shunt from cooling liquid supply to the cooling liquid return is avoided in a particularly neat manner in this way.

In addition, it can be provided in the case of the plasma torch head that the two bores each extend substantially parallel to the longitudinal axis of the plasma torch head. The achievement here is that cooling liquid lines can be connected in a space-saving manner to the plasma torch head.

In particular, the bores can be arranged offset by 180°.

In an advantageous manner, the arc dimension of the section between the recesses of the nozzle cap amounts to at most half of the minimum arc dimension of the liquid return groove(s) and/or of the minimum arc dimension of the liquid supply groove(s) of the nozzle.

In a particular embodiment of the nozzle, at least two liquid supply grooves and/or at least two liquid return grooves are provided.

In an advantageous manner, the central point of the liquid supply groove or of at least one of the liquid supply grooves and the central point of the liquid return groove or of at least one of the liquid return grooves are arranged offset with respect to one another by 180° over the circumference of the nozzle.

In an advantageous manner, the width of the liquid supply groove or at least of one of the liquid supply groove(s) and/or the width of the liquid return groove or at least of one of the liquid return groove(s) extend(s) in the circumferential direction over a range of 10° to 270°.

According to a particular embodiment, the sum of the widths of the liquid supply grooves and/or liquid return grooves is between 20° and 340°.

It can also be provided that the sum of the widths of the liquid supply grooves and/or of the liquid return grooves is between 60° and 300°.

It can be provided that the groove or one of the grooves extends in the circumferential direction of the first section of the nozzle over the entire circumference.

In particular, it can be provided in this case that the groove or at least one of the grooves extends in the circumferential direction of the first section of the nozzle over an angle $\zeta 1$ or $\zeta 2$ in the range of 60° to 300°.

In particular, it can be provided in this case that the groove or at least one of the grooves extends in the circumferential direction of the first section of the nozzle over an angle $\zeta 1$ or $\zeta 2$ in the range of 90° to 270°.

In the case of a further embodiment of the nozzle, precisely two liquid supply grooves and precisely two liquid return grooves are provided.

In particular, the two liquid supply grooves can be arranged over the circumference of the nozzle symmetrically with respect to a straight line which extends from the central point of the liquid return grooves at right angles through the longitudinal axis of the nozzle, and the two liquid return grooves can be arranged over the circumference of the nozzle symmetrically with respect to a straight line which extends from the central point of the liquid supply groove at right angles through the longitudinal axis of the nozzle.

In an advantageous manner, the central points of the two liquid supply grooves and/or the central points of the liquid return grooves are arranged offset with respect to one another over the circumference of the nozzle by an angle which is in the range of 20° to 180°.

In addition, it can be provided that the two the two liquid supply grooves and/or the two liquid return grooves are connected to one another in the first section of the nozzle.

In an expedient manner, at least one of the grooves extends beyond the liquid supply groove or at least one of the liquid supply grooves or beyond the liquid return groove or at least one of the liquid return grooves.

Underlying the invention is the surprising knowledge that as a result of supplying and/or removing the cooling liquid at right angles to the longitudinal axis of the plasma torch head instead of – as in the prior art – parallel to the longitudinal axis of the plasma torch head, better cooling of the nozzle is obtained as a result of the clearly longer contact between the cooling liquid and the nozzle and as a result of guiding the cooling liquid through grooves in the nozzle in the cylindrical region toward the nozzle holder.

If more than one liquid supply groove is provided, particularly good turbulence of the cooling liquid can consequently be obtained in the region of the nozzle tip as a result of the cooling liquid flows striking against one another, which is also usually linked to better cooling of the nozzle.

Further features and advantages of the invention are produced from the accompanying claims and the description below, in which several exemplary embodiments are explained in detail by way of the schematic drawings, in which:

Fig. 1 shows a longitudinal sectional view through a plasma torch head with plasma and secondary gas supply with a nozzle according to a particular embodiment of the present invention;

Fig. 1a shows a sectional representation along the line A-A of Figure 1;

Fig. 1b shows a sectional representation along the line B-B of Figure 1;

Fig. 2 shows individual representations (top left; top view from the front; top right: longitudinal sectional view; bottom right: side view) of the nozzle from Figure 1;

Fig. 3 shows individual representations (top left; top view from the front; top right: longitudinal sectional view; bottom right: side view) of a nozzle according to a further particular embodiment of the invention;

Fig. 4 shows individual representations (top left; top view from the front; top right: longitudinal sectional view; bottom right: side view) of a nozzle according to a further particular embodiment of the invention;

Fig. 5 shows a longitudinal sectional view through a plasma torch head with plasma and secondary gas guiding with a nozzle according to a further particular embodiment of the present invention;

Fig. 5a shows a sectional representation along the line A-A of Figure 5;

Fig. 5b shows a sectional representation along the line B-B of Figure 5;

Fig. 6 shows individual representations (top left; top view from the front; top right: longitudinal sectional view; bottom right: side view) of a nozzle according to a further particular embodiment of the invention; and

Fig. 7 shows individual representations of the nozzle cap 2 used in Figure 1, left: longitudinal sectional view, right: view from the left of the longitudinal section.

A groove is to be understood above and also below, for example, also as a flattening.
Embodiments of nozzles, which comprise at least one liquid supply groove, here designated as a cooling liquid supply groove, and at least one liquid return groove, here designated as a cooling liquid return groove, in particular in each case precisely one and in each case precisely two, are described in the following description. However, the invention is not restricted to this. A greater number of liquid supply and return grooves can be present and/or the number of liquid supply and return grooves can be varied.
The plasma torch head 1 shown in Figure 1 receives by way of an electrode receiving means 6 an electrode 7, in the present case by means of a thread (not shown). The electrode 7 is realized as a flat electrode. Air or oxygen can be used as plasma gas (PG) for the plasma torch. A nozzle 4 is received by a substantially cylindrical nozzle holder 5. A nozzle cap 2, which is fastened on the plasma torch head 1 by means of a thread (not shown), fixes the nozzle 4 and forms a cooling liquid chamber with said nozzle. The cooling liquid chamber is sealed by a seal, which is realized by way of an O-ring 4.16 which is situated in a groove 4.15 of the nozzle 4, between the nozzle 4 and the nozzle holder and by a seal, which is realized by an O-ring 4.18 which is situated in a groove 4.17, between the nozzle 4 and the nozzle holder 5.
A cooling liquid, for example water or water mixed with antifreeze, traverses the cooling liquid chamber from a bore of the cooling liquid supply WV to a bore of the cooling liquid return WR, the bores being arranged offset with respect to one another by 90° (see Figure 1b).
In the case of plasma torches in the prior art, the nozzle 4 overheats again and again in the region of the nozzle bore 4.10. There can, however, also be overheating between a cylindrical section 4.1 (see Figure) of the nozzle 4 and the nozzle holder 5. This occurs in particular in plasma torches which are operated with a high pilot current or indirectly. This is shown by the copper discolouring after a short operating time. In this case, discolouration occurs after a short time (e.g. 5 minutes) even at currents of 40A. The sealing point between the nozzle 4 and the nozzle cap 2 is also overloaded, which leads to damage to the O-ring 4.16 and consequently to leaks and cooling liquid leakages. Tests have shown that this effect occurs in particular on the side of the nozzle 4 facing the cooling liquid return. It is accepted that the region under the most thermal stress, the nozzle bore 4.10 of the nozzle 4, is insufficiently cooled because the cooling liquid traverses the part 10.20 of the cooling liquid chamber located closest to the nozzle bore in an unsatisfactory manner and/or this is hardly reached in particular on the side facing the cooling liquid return.
In the present plasma torch head according to Figure 1, the cooling liquid is directed into the cooling liquid chamber from the nozzle holder 5 so as to strike the nozzle 4 approximately at right angles to the longitudinal axis of the plasma torch head 1. To this end, the cooling liquid is diverted 1 in a diversion chamber 10.10 of the cooling liquid chamber from the direction parallel to the longitudinal axis in the bore of the cooling liquid supply WV of the plasma torch approximately at right angles to the longitudinal axis of the plasma torch head into the direction of the first section 4.1 (see Figure 2). The cooling liquid then flows through a groove 4.6 (see Figures 1b and 2) which extends in the circumferential direction of the first section 4.1 along a part circumference, i.e. over approximately 110°, into the part 10.11 formed by a cooling liquid supply groove 4.20 (see Figures 1a, 1b and 2) of the nozzle 4 and of the nozzle cap 2 into the part 10.20 of the cooling liquid chamber surrounding the nozzle bore 4.10 and there flows around the nozzle 4. The cooling liquid then flows back through a chamber 10.15, which is formed by a cooling liquid return groove 4.22 of the nozzle 4 and of the nozzle cap 2, to the cooling liquid return WR, the transition being effected here substantially parallel to the longitudinal axis of the plasma torch head (not shown).

In addition, the plasma torch head 1 is provided with a nozzle protector cap holder 8 and a nozzle protector cap 9. A secondary gas SG, which surrounds the plasma jet, flows through said region. The secondary gas SG, in this case, traverses a secondary gas guide 9.1 and can be set into rotation by the same.

Figure 1a shows a sectional representation along the line A-A of the plasma torch from Figure 1. This shows how the part 10.11, which is formed by the cooling liquid supply groove 4.20 of the nozzle 4 and of the nozzle cap 2, prevents a shunt between the cooling liquid supply and the cooling liquid return as a result of sections 4.41 and 4.42 of outwardly protruding regions 4.31 and 4.32 of the nozzle 4 in combination with the inner surface 2.5 of the nozzle cap 2. Thus, efficient cooling of the nozzle 4 in the region of the nozzle tip is achieved and thermal overheating is prevented. It is ensured that as much cooling liquid as possible reaches the part 10.20 of the cooling liquid chamber. During tests, there was no longer any discolouration of the nozzle in the region of the nozzle bore 4.10. There were also no longer any leaks between the nozzle 4 and the nozzle cap 2 and the O-ring 4.16 was not overheated.

Figure 1b includes a sectional representation along the line B-B of the plasma torch head of Figure 1 which shows the plane of the diversion chamber 10.10 and the connection between the cooling liquid supply and the bores, arranged offset by 90°, for the cooling liquid inflow WV the cooling liquid return WR by means of the groove 4.6, which runs around approximately 110°, in the nozzle 4.

Figure 2 shows the nozzle 4 of the plasma torch head of Figure 1. It has a nozzle bore 4.10 for the emergence of a plasma gas jet at a nozzle tip 4.11, a first section 4.1, the outer surface 4.4 of which is substantially cylindrical, and a second section 4.2 which adjoins said first section in the direction of the nozzle tip 4.11, the outer surface 4.5 of which narrows substantially conically toward the nozzle tip 4.11. The cooling liquid supply groove 4.20 extends over a part of the first section 4.1 and over the second section 4.2 in the outer surface 4.5 of the nozzle 4 toward the nozzle tip 4.11 and ends in front of the cylindrical outer surface 4.3. The cooling liquid return groove 4.22 extends over the second section 4.2 of the nozzle 4. The central point of the cooling liquid supply groove 4.20 and the central point of the cooling liquid return groove 4.22 are arranged offset with respect to one another by 180° over the circumference of the nozzle 4. The outwardly protruding regions 4.31 and 4.32 with the associated sections 4.41 and 4. 42 are situated between the cooling liquid supply groove 4.20 and the cooling liquid return groove 4.22.

Figure 3 shows a nozzle according to a further special embodiment of the invention which can also be used in the plasma torch head according to Figure 1. The cooling liquid supply groove 4.20 is connected to a groove 4.6 which here extends in the circumferential direction over the entire circumference. The advantage of this is that the bore for the cooling liquid supply WV and the cooling liquid return WR can be arranged offset in an arbitrary manner in the plasma torch head. In addition, this is advantageous for the cooling of the transition between the nozzle holder 5 and the nozzle 4. The same can naturally also be used in principle for a cooling liquid return groove 4.22.

Figure 4 shows a nozzle according to a further special embodiment of the invention which can also be used in the plasma torch head according to Figure 1. The cooling liquid grooves 4.30 and 4.21 extend over a part of the first section 4.1 and over the second section 4.2 in the outer surface 4.5 of the nozzle 4 toward the nozzle tip 4.11 and end in front of the cylindrical outer surface 4.3. The cooling liquid return grooves 4.22 and 4.23 extend over the second section 4.2 of the nozzle 4. The outwardly protruding regions 4.31, 4.32, 4.33 and 4.34 with the associated sections 4.41, 4.42, 4.34 and 4.44 are situated between the cooling liquid supply grooves 4.20 and 4.21 and the cooling liquid return grooves 4.22 and 4.23. The cooling liquid supply grooves 4.20 and 4.21 are connected together by a groove 4.6 of the nozzle 4 which extends in the circumferential direction of the first section 4.1 of the nozzle 4 along a part circumference between the nozzles 4.20 and 4.21, i.e. over approximately 160°.

Figure 5 shows a plasma torch head according to a further special embodiment of the invention. Here too, the cooling liquid is directed into a cooling liquid chamber from a nozzle holder 5 so as to strike the nozzle 4 approximately at right angles to the longitudinal axis of the plasma torch head 1. To this end, the cooling liquid is diverted 1 in the diversion chamber 10.10 of the cooling liquid chamber from the direction parallel to the longitudinal axis in the bore of the cooling liquid supply WV of the plasma torch approximately at right angles to the longitudinal axis of the plasma torch head into the direction of the first section 4.1. The cooling liquid then flows through the parts 10.11 and 10.12 (see Figure 5a) formed by the cooling liquid supply grooves 4.20 and 4.21 of the nozzle 4 and of the nozzle cap 2 into the region 10.20 of the cooling liquid chamber surrounding the nozzle bore 4.10 and there flows around the nozzle 4. The cooling liquid then flows back through the parts 10.15 and 10.16 formed by the cooling liquid return grooves 4.22 and 4.23 of the nozzle 4 and of the nozzle cap 2, to the cooling liquid return WR, the transition being effected here approximately at right angles to the longitudinal axis of the plasma torch head, through the diversion chamber 10.9.

Figure 5a is a sectional representation along the line A-A of the plasma torch head of Figure 5 which shows how the parts 10.11 and 10.12, which are formed by the cooling liquid supply grooves 4.20 and 4.21 of the nozzle 4 and the nozzle cap 2, prevent a shunt between the cooling liquid supplies and the cooling liquid returns as a result of the sections 4.41 and 4.42 of the outwardly protruding regions 4.31 and 4.32 of the nozzle 4 in combination with the inner surface 2.5 of the nozzle cap 2. At the same time, a shunt between the parts 10.11 and 10.12 is prevented by the section 4.43 of the protruding region 4.33 and between the parts 10.15 and 10.16 by the section 4.44 of the protruding region 4.43.

Figure 5b is a sectional representation along the line B-B of the plasma torch head of Figure 7, which shows the plane of the diversion chambers 10.9 and 10.10.

Figure 6 shows the nozzle 4 of the plasma torch head of Figure 5. It has a nozzle bore 4.10 for the emergence of a plasma gas jet at a nozzle tip 4.11, a first section 4.1, the outer surface 4.4 of which is substantially cylindrical, and a second section 4.2, which adjoins said first section in the direction of the nozzle tip 4.11 and the outer surface 4.5 of which narrows substantially conically toward the nozzle tip 4.11. The cooling liquid supply grooves 4.20 and 4.21 and the cooling liquid return grooves 4.22 and 4.23 extend over a part of the first section 4.1, and over the second section 4.2 in the outer surface 4.5 of the nozzle 4 toward the nozzle tip 4.11 and end in front of the cylindrical outer surface 4.3. The central point of the cooling liquid supply groove 4.20 and the central point of the liquid return groove 4.22 as well as the central point of the cooling liquid supply groove 4.21 and the central point of the liquid return groove 4.23 are arranged offset with respect to one another by 180° over the circumference of the nozzle 4 and are the same size. An outwardly protruding region 4.31 with the associated section 4.41 is situated between the cooling liquid supply groove 4.20 and the cooling liquid return groove 4.22 and an outwardly protruding region 4.32 with the associated section 4.42 is situated between the cooling liquid supply groove 4.21 and the cooling liquid return groove 4.23. An outwardly protruding region 4.33 with the associated section 4.43 is situated between the cooling liquid supply grooves 4.20 and 4.21. An outwardly protruding region 4.34 with the associated section 4.44 is situated between the cooling liquid return grooves 4.22 and 4.23.

Even though, where possible, this were to be described or shown differently above, the (angular) widths of the liquid supply grooves can be varied. The same also applies to the (angular) widths of the liquid return flows.

Figure 7 shows individual representations of a nozzle cap 2 used in the plasma torch head 1 of Figure 1. The nozzle cap 2 comprises an inner surface 2.2 which narrows substantially conically and, in this case, comprises fourteen recesses 2.6 in a radial plane. The recesses 2.6 are arranged equidistantly over the inner circumference and are semicircular in radial section.

The features of the invention disclosed in the present description, in the drawings as well as in the claims are fundamental both individually and also in arbitrary combinations to the realization of the invention in its different embodiments.

EP2449862

Fúvóka folyadékkal hűtött plazma égőfejhez, valamint a fúvókával ellátott plazma égőfej

Szabadalmi igénypontok

1. Fúvóka (4) folyadékkal hűtött plazma égőfejhez, amely tartalmaz fúvókanyílást (4.10) a fúvókacsúcson (4.11) plazmasugár kilépése számára, egy első szakaszt (4.1), amelynek külső felülete (4.4) lényegében hengeres, és egy azon a fúvókacsúcsra (4.11) záródó második szakaszt (4.2), melynek külső felülete (4.5) a fúvókacsúcshoz (4.11) kifelé lényegében kehely alakban szűkül, ahol legalább két folyadék bevezető horony (4.20 és 4.21), és legalább két folyadék visszavezető horony (4.22 és 4.23) van, amelyek a második szakaszon (4.2) keresztül a fúvóka (4) külső felületében (4.5) a fúvókacsúcshoz (4.11) terjednek ki, ahol a folyadék bevezető hornyok (4.20; 4.21) legalább egyike, és/vagy a folyadék visszavezető hornyok (4.22; 4.23) legalább egyike ugyancsak az első szakasz (4.1) egy részén keresztül terjed/terjednek ki és az első szakaszban (4.1) legalább egy további horony (4.6, vagy 4.7) található, amelyek legalább egy folyadék bevezető horonnyal (4.20; 4.21), vagy legalább egy folyadék visszavezető horonnyal (4.22, 4.23) összeköttetésben vannak.

2. Az 1. igénypont szerinti fúvóka, **azzal jellemezve, hogy** a folyadék bevezető hornyok (4.20; 4.21) legalább egyikének és a folyadék visszavezető hornyok (4.22; 4.23) legalább egyikének középpontja egymáshoz képest 180°-kal elforgatva, a fúvóka (4) kerületén van elrendezve.

3. Az 1. vagy 2. igénypontok egyike szerinti fúvóka, **azzal jellemezve, hogy** a folyadék bevezető hornyok (4.20; 4.21) legalább egyike, és/vagy a folyadék visszavezető hornyok (4.22; 4.23) legalább egyike kerületi irányban 10°-270° tartományon keresztül terjed ki.

4. Az előző igénypontok egyike szerinti fúvóka, **azzal jellemezve, hogy** a fúvóka első szakaszának (4.1) kerületi irányába további horony (4.6), vagy további hornyok (4.6, vagy 4.7) a teljes kerületen keresztül terjednek ki.

5. Az 1.-3. igénypontok egyike szerinti fúvóka, **azzal jellemezve, hogy** a következő horony (4.6), vagy a következő hornyok legalább egyike (4.6, vagy 4.7) a fúvóka (4) első szakaszának (4.1) kerületi irányába $\zeta 1$, vagy $\zeta 2$ szögön keresztül 60°-300°-os tartományban terjed ki.

6. Az 5. igénypont szerinti fúvóka, **azzal jellemezve, hogy** a következő horony (4.6), vagy a következő hornyok legalább egyike (4.6, vagy 4.7) a fúvóka (4) első szakaszának (4.1) kerületi irányába $\zeta 1$, vagy $\zeta 2$ szögön keresztül 90°-270°-os tartományban terjed ki.

7. Az előző igénypontok egyike szerinti fúvóka, **azzal jellemezve, hogy** pontosan két folyadék bevezető horony (4.20; 4.21) és pontosan két folyadék visszavezető horony (4.22; 4.23) áll rendelkezésre.

8. A 7. igénypont szerinti fúvóka, **azzal jellemezve, hogy** a két folyadék bevezető horony (4.20, 4.21), és/vagy a két folyadék visszavezető horony (4.22; 4.23) a fúvóka (4) első szakaszában (4.1) egymással össze van kapcsolva.

9. Az előző igénypontok egyike szerinti fúvóka, **azzal jellemezve, hogy** a további hornyok (4.6, és/vagy 4.7) a folyadék bevezető hornyok (4.20; 4.21) legalább egyikén keresztül, vagy a folyadék visszavezető hornyok (4.22; 4.23) legalább egyikén keresztül továbbhaladnak.

10. Plazma égőfej, amely az alábbiakat tartalmazza:

az 1.-9. igénypontok szerinti fúvókát,

fúvókatartót (5) a fúvóka (4) tartásához, és

fúvóka sapkát (2), ahol a fúvóka sapka (2) és a fúvóka (4) hűtőfolyadék teret képeznek, amely egymáshoz képest két-két, 60°-180°-ban eltolt furaton keresztül egy hűtőfolyadék bevezetéshez, illetve hűtőfolyadék elvezetéshez hozzákötheto, ahol a fúvókatartó (5) úgy van kialakítva, hogy a hűtőfolyadék, a fúvókával (4) a plazma égőfej (1) hossztengelyéhez képest nagyjából merőlegesen találkozva jut el a hűtőfolyadék térbe, és/vagy a hossztengelyhez képest nagyjából merőlegesen a hűtőfolyadék térből a fúvókatartóba (5).

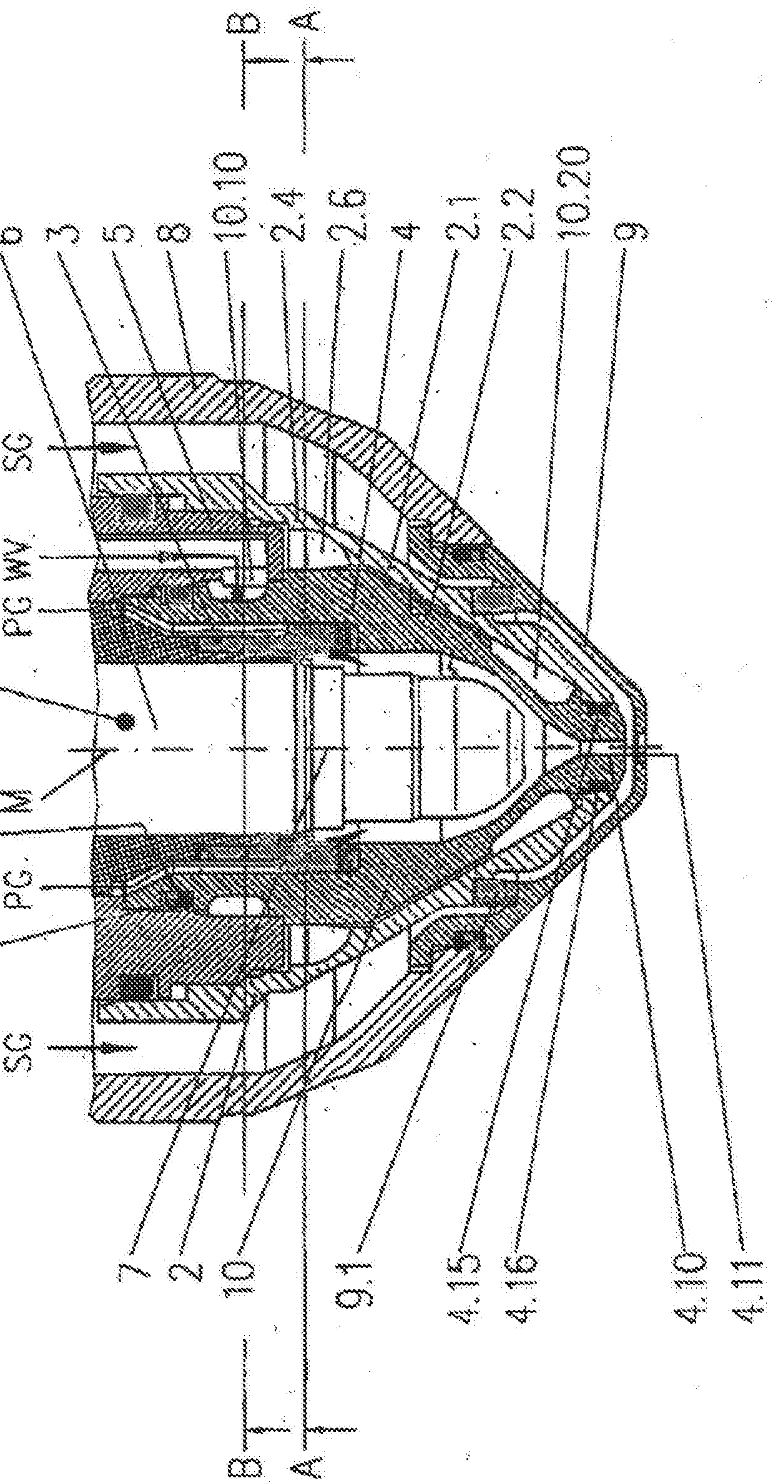
11. A 10. igénypont szerinti plazma égőfej (1), **azzal jellemezve, hogy** a fúvóka sapkának (2) belső felületén (2.5) legalább három kimélyítése (2.6) van, amelynek a fúvóka (4) felőli nyílásai egy ívmértéknyit (b_2) terjednek ki, ahol a fúvóka kerületi irányban a folyadék bevezető hornyokra (4.20; 4.21) és a folyadék visszavezető hornyokra (4.22; 4.23) határos, a folyadék bevezető hornyokkal és a folyadék visszavezető hornyokkal szembe, kifelé kiálló tartományainak (4.31; 4.32; 4.33; 4.34) ívmértéke (b_4, c_4, d_4, e_4) mindig legalább pontosan akkora, mint a (b_4) ívmérték.

12. A 10. vagy 11. igénypont szerinti plazma égőfej (1), **azzal jellemezve, hogy** a két furat lényegében mindig a plazma égőfej (1) hossztengelyéhez képest párhuzamosan helyezkedik el.

13. A 10.-12. igénypontok egyike szerinti plazma égőfej (1), **azzal jellemezve, hogy** a furatok 180°-kal eltolva vannak elrendezve.

14. A 10.-13. igénypontok egyike szerinti plazma égőfej (1), **azzal jellemezve, hogy** a fúvóka sapka (2) kimélyítései (2.6) közötti szakasz ívmértéke (c2) maximálisan fele akkora, mint a fúvóka (4) folyadék visszavezető hornyainak (4.22 és 4.23) minimális ívmértéke (a42, a43), vagy a folyadék bevezető hornyok (4.20 és 4.21) minimális ívmértéke (a40, a41).

Fig 1



B
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4.11
B
A

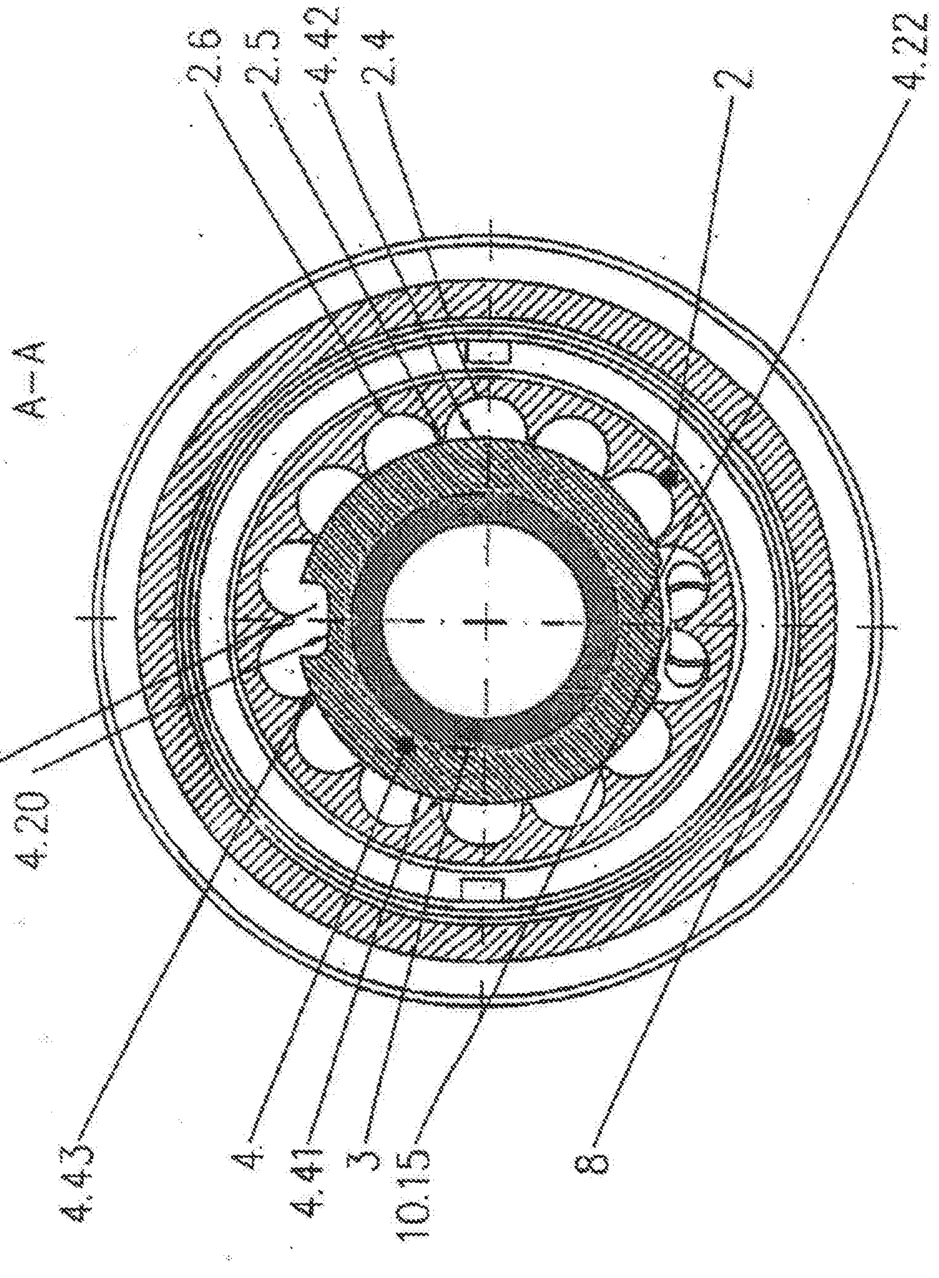


Fig 1a

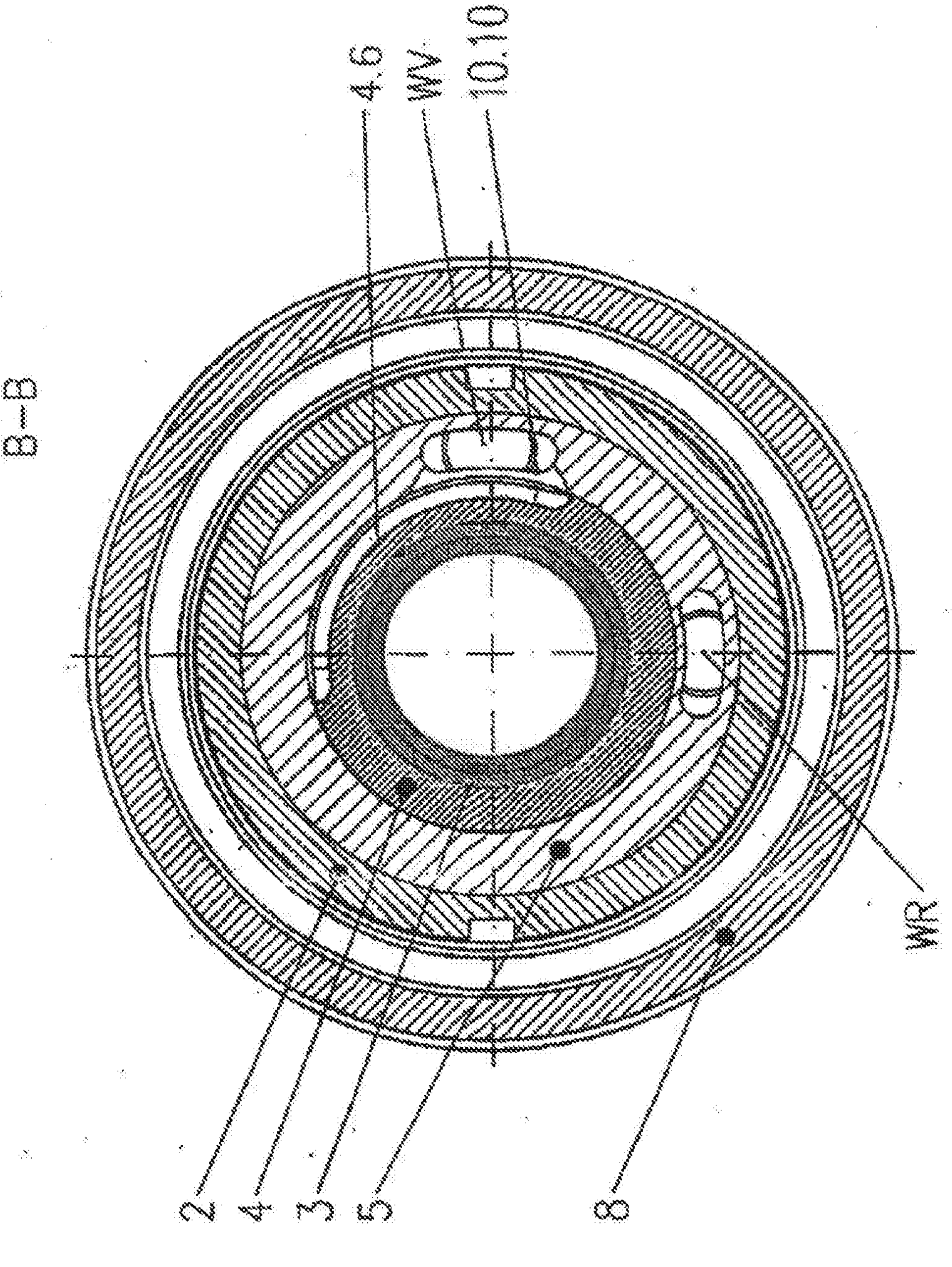
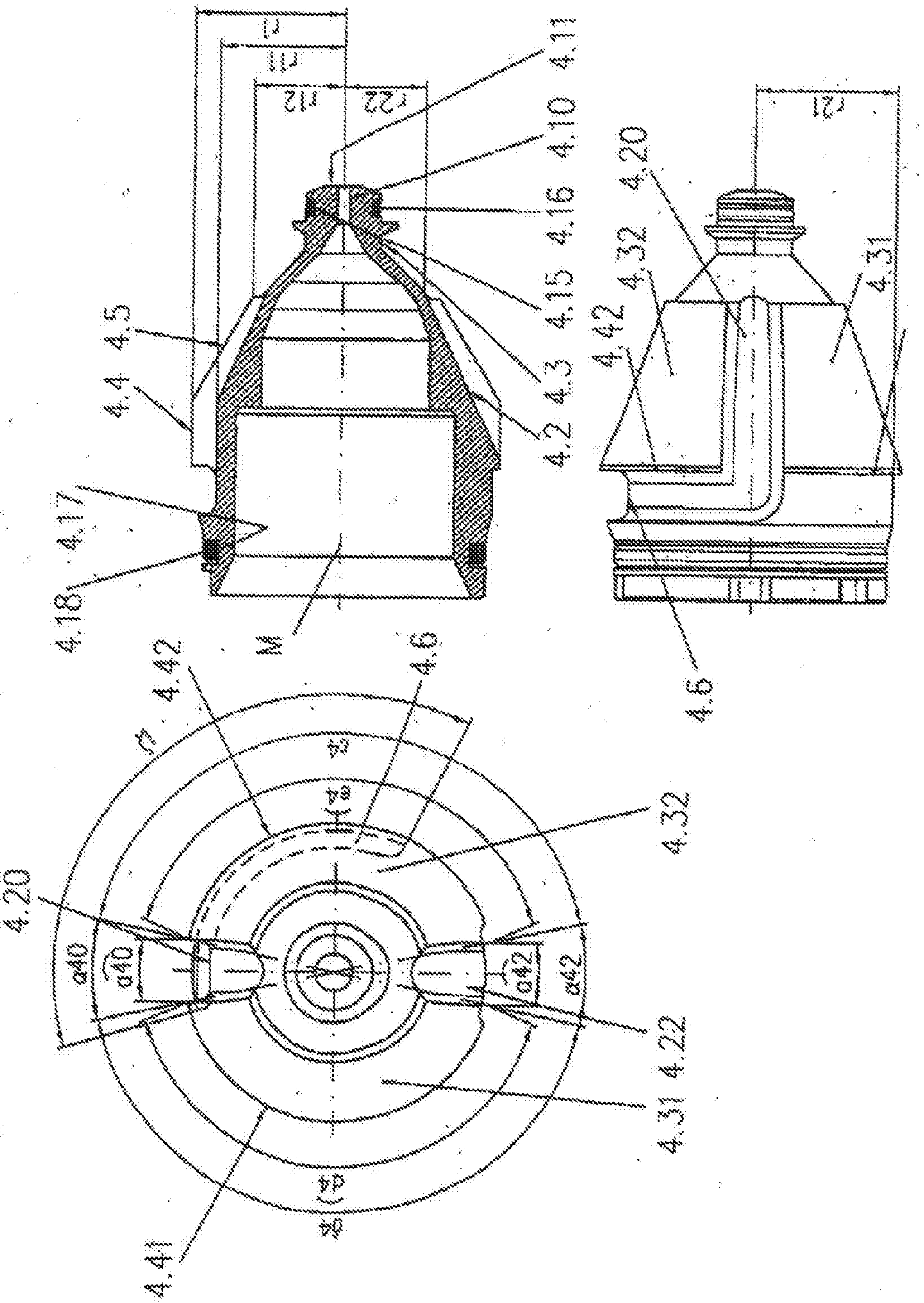


Fig 1b

Fig 2


r
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M
r21
4.20
4.32
4.31
4.42
4.6
r7
4.42
c4
d4
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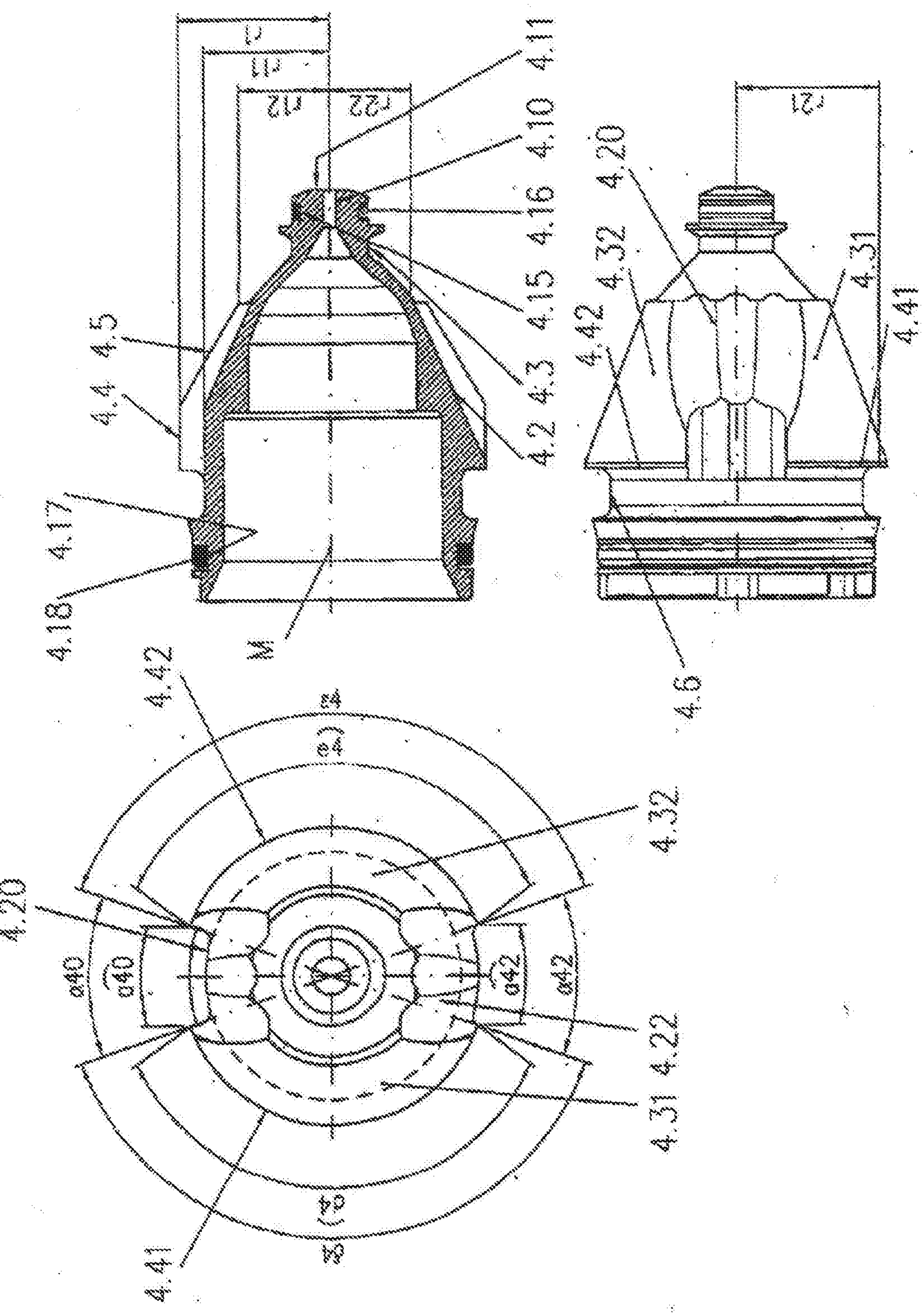
4.32
4.20
α40
α42
4.22
4.31
4.41

Fig 3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4.20
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α42
4.22
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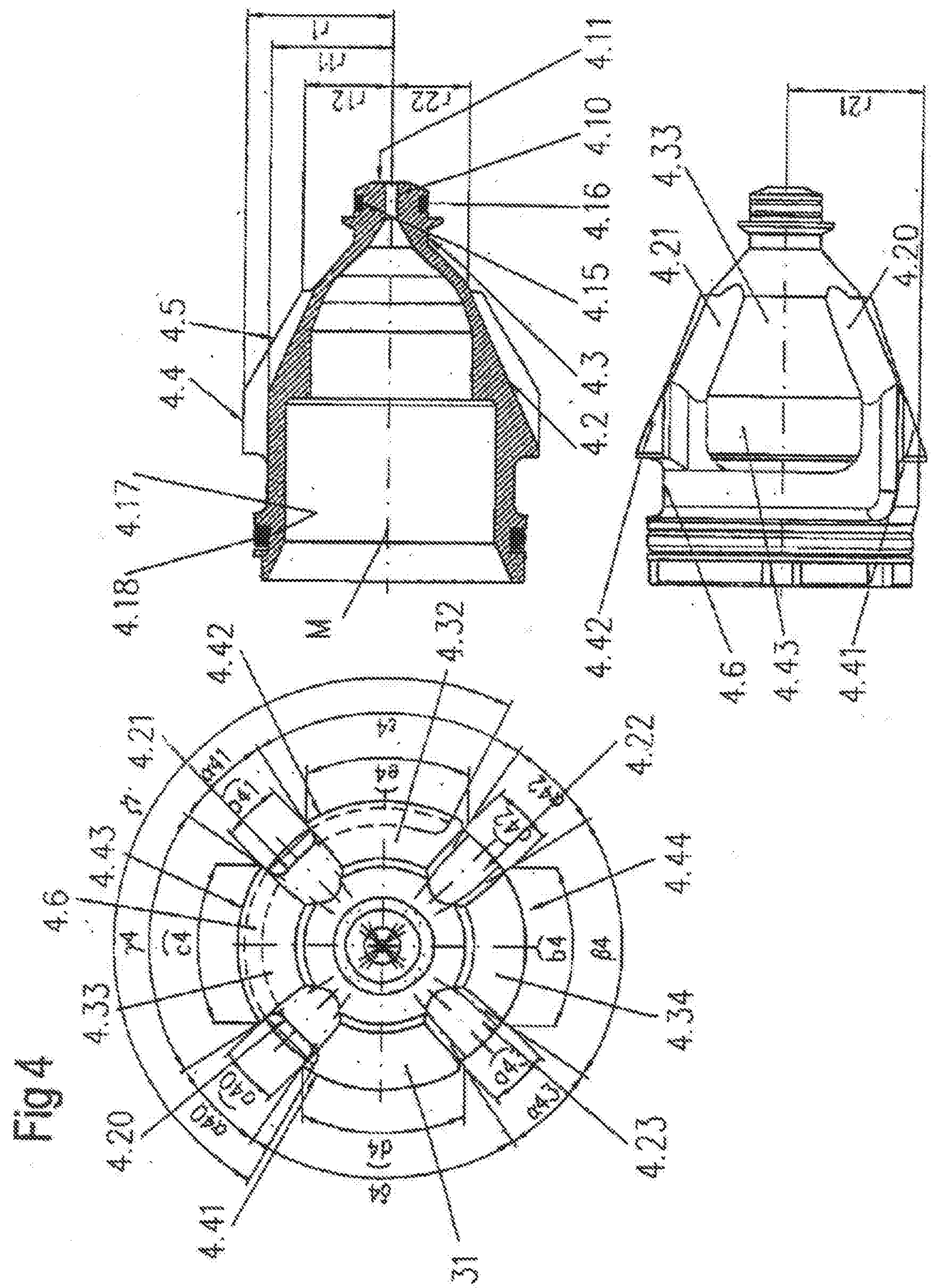
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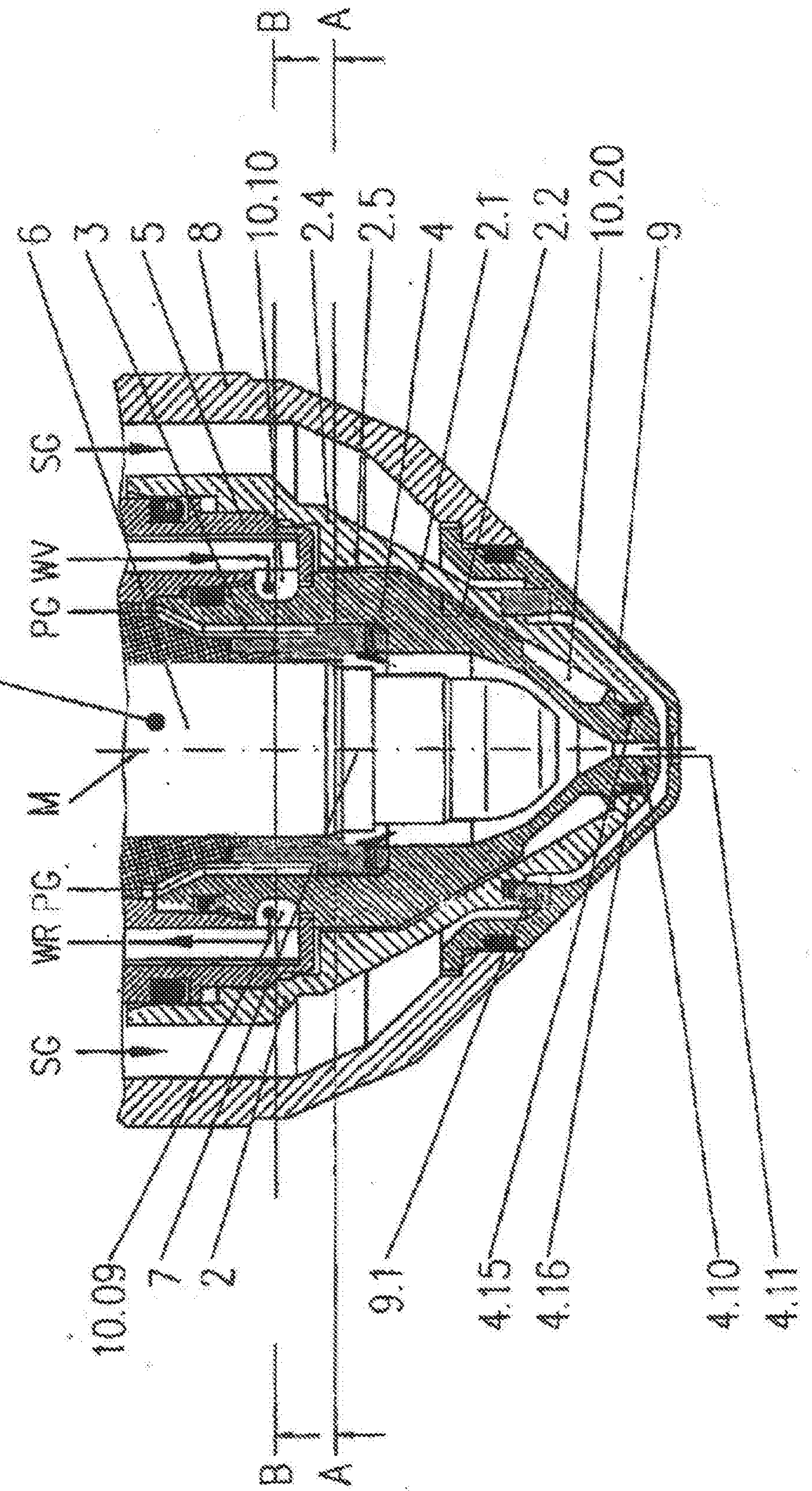
4.31

Fig 4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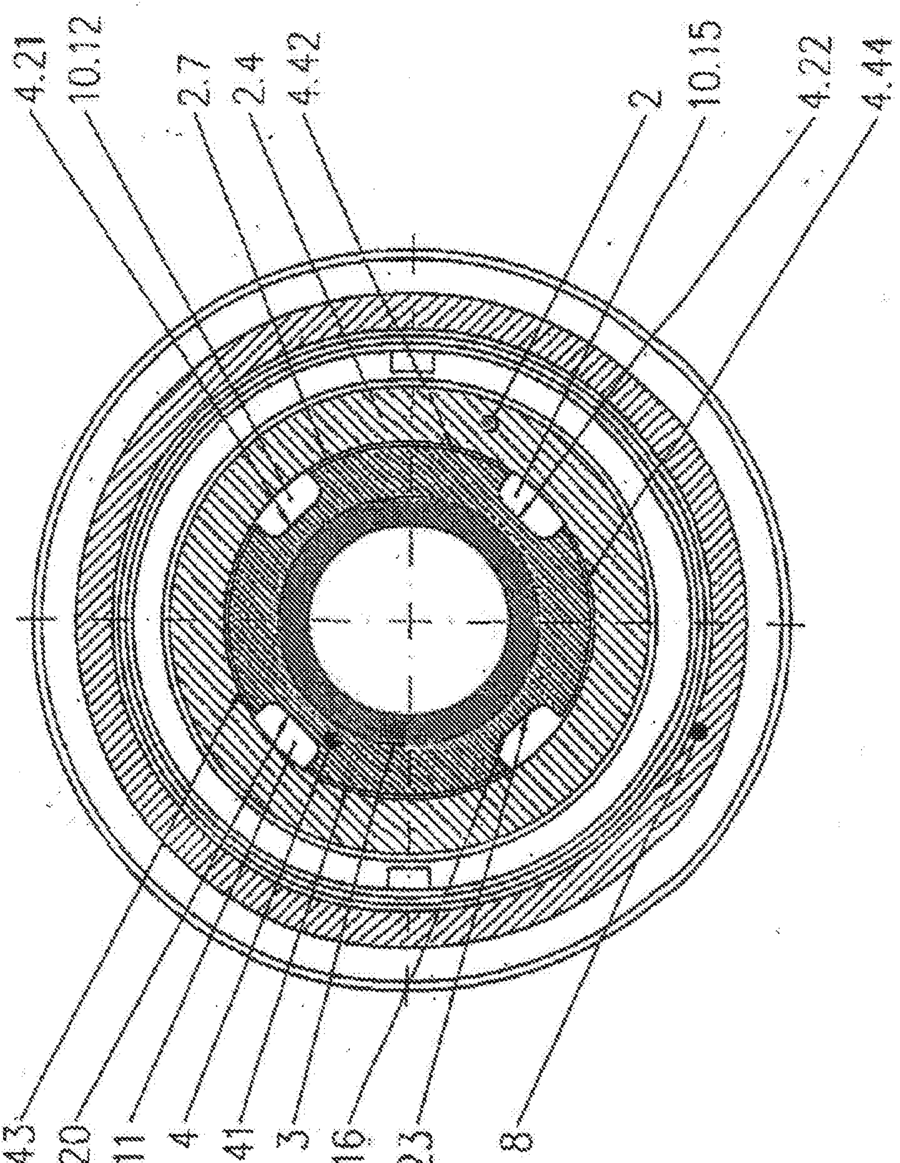
4.11
A
B

Fig 5


A—A
4.21
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8

Fig 5a

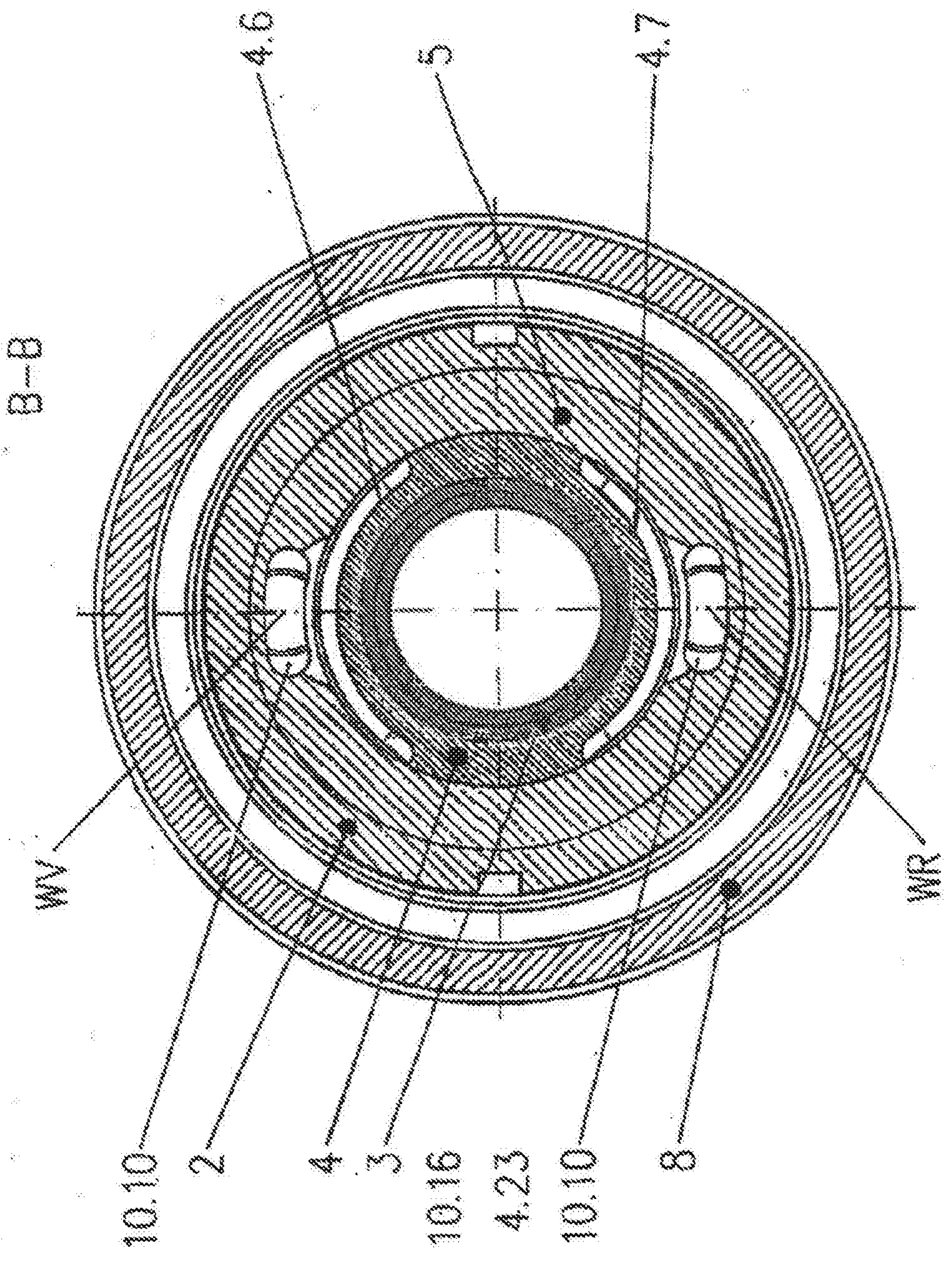

Fig 5b

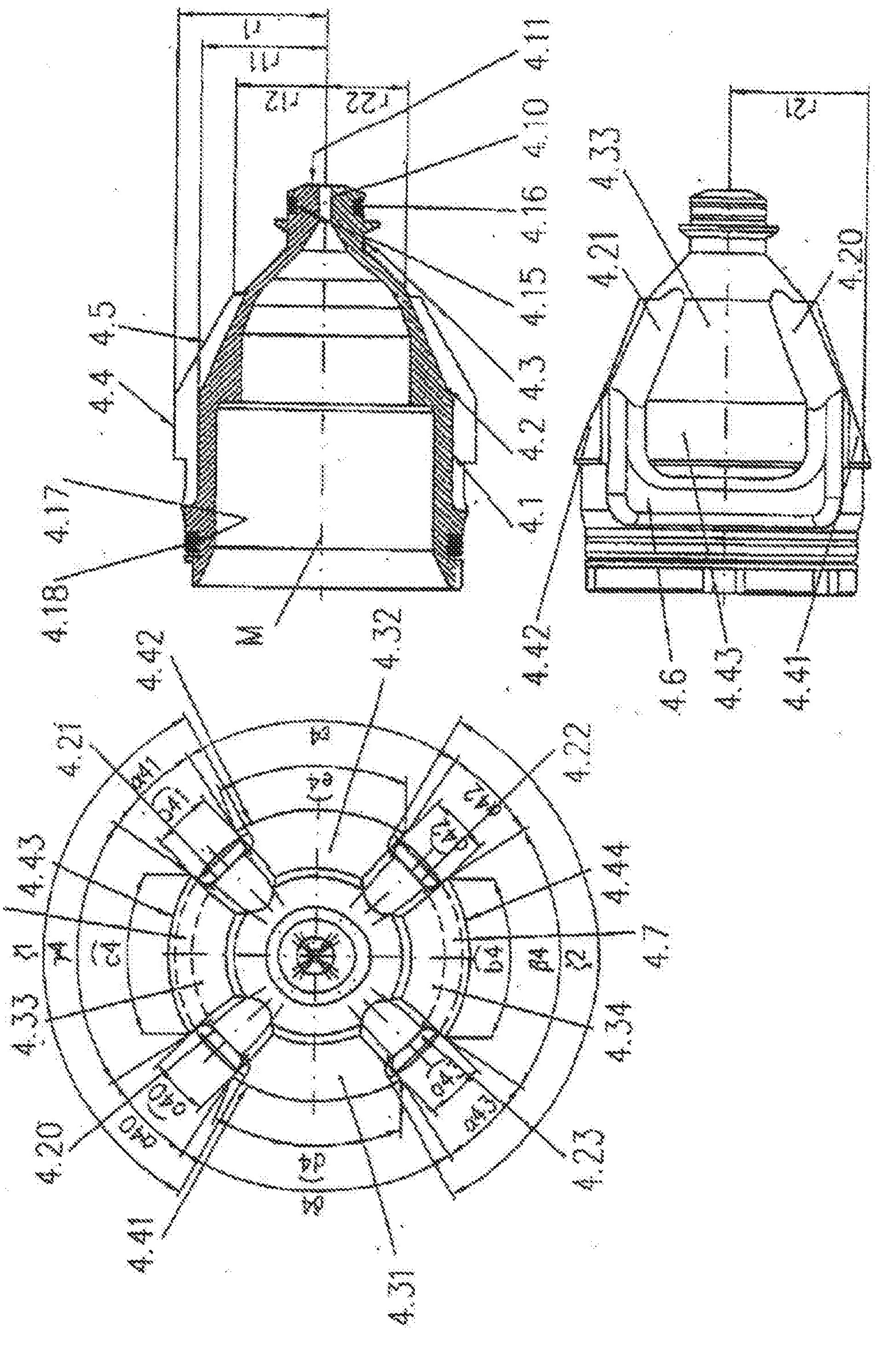
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Fig 6

Fig 7