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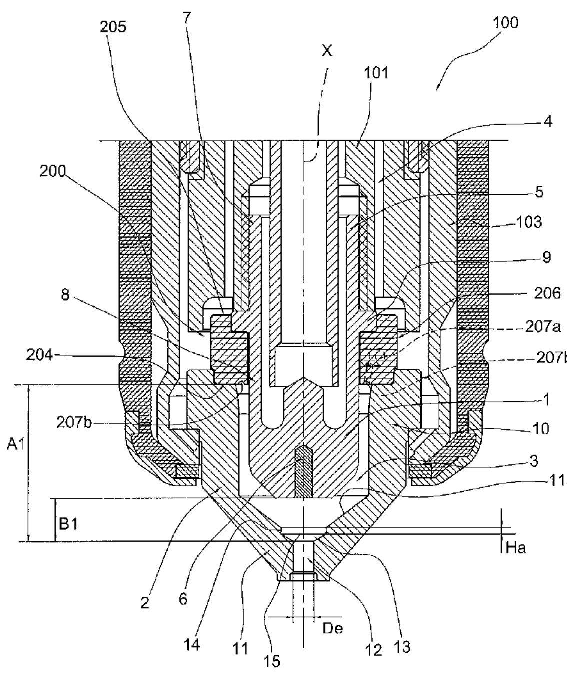
(54) **Plasma cutting torch**

(57) A plasma cutting torch (1) extending about a main axis (X) and comprising an electrode (1), a nozzle (2), having a plasma outlet orifice (12), coaxial with the electrode (1), a diffuser (200) acting between the electrode and the nozzle; the torch comprising a gas feed system (4) for feeding gas into the plasma generation chamber (3) which is delimited by the electrode (1), the nozzle (2) and the diffuser (200) which comprises a plurality of channels (207) for putting the feed system (4) and the chamber (3) in fluid communication; labelling "A1" the distance, measured according to the direction (X), between an outlet section of the channels (207) and an inlet section of the orifice (12) and labelling "B1" the distance, measured according to the main axis (X), between an end section of the electrode (1) and the inlet section of the orifice (12), the ratio between "A1" and "B1" is greater than or equal to 3 and is less than or equal to 4.5, that is to say:

$$3 \leq \frac{A1}{B1} \leq 4.5 .$$

FIG.1



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Description

[0001] This invention relates to a plasma cutting torch, and specifically to a transferred arc plasma cutting torch.

[0002] The plasma cutting torches referred to extend longitudinally around a central axis and comprise, schematically:

- a nozzle from which the plasma comes out through a respective orifice;
- an electrode (cathode), usually made of copper and provided with an insert made of a thermionic emission material, having the opposite polarity to the nozzle, substantially cylindrical, partly inserted in the nozzle;
- a gas diffuser acting between the electrode and the nozzle.

[0003] The nozzle, the electrode and the diffuser delimit a plasma generation chamber into which the gas is fed through the diffuser.

[0004] The gas fed into the chamber comes from a respective gas feed system.

[0005] Prior art torches also comprise a main body or torch body; a nozzle holder designed to support the nozzle and mounted on one end of the torch body and also surrounding the electrode which is mounted centrally on the torch body.

[0006] The nozzle, the electrode and the diffuser, and therefore the chamber, are supplied by respective electric and pneumatic circuits to initiate and sustain, when suitably controlled, the electric arc and the plasma column.

[0007] As indicated, the pneumatic supply circuit comprises a diffuser through which the gas for generating the plasma accesses the chamber.

[0008] In general, the diffuser has a plurality of holes for letting gas into the chamber and said holes ensure that the gas enters the chamber with a predetermined velocity vector.

[0009] In particular, there is normally a rotational component ("swirl" velocity) around the axis of the torch imparted to the velocity of the gas, which allows concentration of the electric arc at the mouth of the orifice.

[0010] In general, the electrode, comprising the abovementioned insert, is connected by a wire to the negative pole (cathode) of a current generator.

[0011] The nozzle is electrically isolated from the electrode and is connected, during the known pilot arc step, by a wire, to the positive pole (anode) of the current generator.

[0012] A tubular electric isolating element is interposed between the respective electric power supply circuits of the electrode and the nozzle.

[0013] The electrode, the nozzle and the diffuser are the wear components of the torch, hereinafter also referred to simply as "wear parts", and must be regularly substituted to guarantee correct operation of the torch.

[0014] As already indicated, the electrode, the nozzle and the diffuser, once assembled in the torch, form the plasma generation chamber.

[0015] Generally, substitution of the electrode and the nozzle is simultaneous because, operating coupled together, they must always both be in optimum conditions.

[0016] A widespread problem in the use of such torches is the life of the wear parts, in particular the cathode, and maintaining a high cutting quality, where the expression cutting quality refers to correct creation of the cut profile (clean cut), with the absence of burrs on the worked zones, which greatly depends on the state of wear of the electrode and the nozzle.

[0017] To overcome these disadvantages, nozzles were developed which have been worked inside in such a as to form, with the electrode, a second chamber usually called the pre-chamber or arc stabilising chamber, located between the plasma generation chamber and the plasma outlet orifice (or channel) made in the nozzle, as in the solution described in application BO2006A000156 by this Applicant.

[0018] The pre-chamber results in the presence of a cold gas sheath which helps to stabilise and collimate the discharge thanks to a more gradual passage towards the nozzle channel. Moreover, in those cases in which it is useful for maximising the torch cutting capacity, it allows an increase in the discharge length and therefore its power, although keeping the length of the orifice constant.

[0019] However, experimental results have shown how, in transferred arc conditions, that is to say, during cutting operations, for pre-camera depth values greater than a critical value the electrode/nozzle voltage has a greatly oscillating trend with high peaks, an indicator of discharge that is not well-confined. Indeed, an excessive pre-chamber depth results in worse confinement of the plasma discharge inside it, leading to an increase in the radial dimensions of the arc and a reduction in the thickness of the cold sheath with consequent overall excessive consumption of the emitter as well as a loss of cutting quality.

[0020] It has also been noticed that prior art diffusers do not allow a combination of good arc constriction with minimal wear on the wear parts (electrode and nozzle).

[0021] Document US5591356 describes a plasma cutting torch. That document focuses on the problem of avoiding the adhesion of burrs on the parts cut. However, US5591356 does not teach how to increase the lifetime of wear parts in a cutting torch. Moreover, US5591356 does not indicate how to combine good arc constriction with minimal wear on the wear parts.

[0022] Document US5444209 describes a plasma cutting torch for deposition. That document deals with the problem of reducing the cathode workload, causing cooling of the end of the cathode.

[0023] However, US5444209 does not directly indicate how to increase the lifetime of wear parts in a cutting torch.

[0024] Patent document US5170033 describes a plasma torch in which the diffuser has a plurality of axial holes, designed to give the gas a "swirl" movement, and a plurality of radial holes.

[0025] The function of the radial holes is that of a gas axial flow contribution, during stable (steady state) operation of the torch. However, the radial holes are arranged in a higher position (that is to say, further from the nozzle) than the axial holes, so that, during torch normal operation the flow generated by the axial holes dominates that generated by the radial holes.

[0026] Moreover, patent document US2007/0284340 describes a plasma torch for treating surfaces or objects which has a diffuser with ducts for imparting a vortex trajectory to a gas.

[0027] However, US2007/0284340 proposes a diffuser designed in such a way as to directly support the electrode, and does not provide any direct lesson on how to increase the life of the wear parts in a cutting torch.

[0028] In this context, the main technical purpose of this invention is to provide a plasma cutting torch which allows the combination of good arc constriction, needed for good quality cut parts, with minimal wear of the wear parts.

[0029] One aim of this invention is to provide a torch in which wear on the nozzle, during use of the torch, is noticeably reduced compared with prior art wear parts.

[0030] Another aim of this invention is to provide a torch which guarantees a longer lifetime for the wear parts (electrode and nozzle) and good confinement of the plasma discharge.

[0031] Yet another aim of this invention is to provide a torch which allows maximisation of the rotational velocity of the gas at the mouth of the nozzle orifice.

[0032] A further aim is to provide a torch which minimises, in practice, the rotational velocity of the gas close to the cathode emission surface.

[0033] The technical purpose indicated and at least the aims specified are substantially achieved by a plasma cutting torch comprising the technical features described in the appended claims.

[0034] In particular, the torch according to the invention is a plasma cutting torch, extending around a main axis X and comprising:

- an electrode;
- a nozzle comprising a plasma outfeed orifice, coaxial with the electrode;
- a diffuser acting between the electrode and the nozzle; the electrode, the nozzle and the diffuser delimiting a plasma generation chamber.

[0035] The torch comprises a gas feed system for feeding the gas into the chamber.

[0036] The diffuser comprises at least one channel for putting the feed system and the chamber in fluid communication.

[0037] In particular, said torch is a transferred arc torch.

[0038] In particular, said torch is a torch powered with direct current.

[0039] Moreover, the feed system is a system for feeding gas containing oxygen, allowing the torch to cut soft iron.

[0040] Preferably, the tablet of electrode emitter material is made of hafnium, or another material suitable for use in a plasma cutting torch in which the gas contains oxygen.

[0041] According to the invention, in the plasma chamber, labelling "A1" the distance, measured according to the direction X, between an outlet section of the channel and an inlet section of the orifice, and labelling "B1" the distance, measured according to the main axis X, between an end section of the electrode and the inlet section of the orifice, the ratio between "A1" and "B1" is within the range [3 - 4.5].

[0042] The geometry of the plasma chamber, and in particular the ratio between the distances "A1" and "B1", advantageously allows an increase in the ratio of the values adopted by the gas swirl velocity (in the plasma chamber) at the mouth of the orifice and close to the emitter electrode. In this way, the swirl velocity of the gas in the plasma chamber is at its maximum at the mouth of the orifice and at its minimum close to the emitter electrode.

[0043] This allows an increase in the lifetime of the wear parts and in particular of the electrode, maintaining a high constriction of the plasma stream.

[0044] Indeed, the research and experimentation by the Applicant has shown that, in a transferred arc cutting torch having a plasma chamber forming at least one annular portion and one end portion in communication with an orifice of a nozzle for issuing plasma, the lifetime of the wear parts (and in particular of the emitter electrode) is correlated with the ratio between the distances "A1" and "B1".

[0045] The following should be noticed relative to the diffuser of the plasma torch according to the invention.

[0046] The diffuser according to the invention comprises a substantially annular main body with a main axis coinciding with the main axis X of the torch. Moreover, the diffuser has an annular lower wall, an annular upper wall and a cylindrical outer lateral wall and at least one channel for the passage of gas, the channel comprising an inlet and an outlet which is positioned at the annular lower wall, the channel having a diameter "d1" and an axis of extension which is slanting relative to the main axis.

[0047] The axis of the channel intersects the annular lower wall at a point "O" at the outlet. A projection of the axis of the channel in a plane "ar" forms, with an axis "a", an angle "θ" and a projection of the axis of the channel in a plane "at" forms, with the axis "a", an angle "φ". Therefore, a Cartesian reference system is defined, having its centre at "O", an axis "a" parallel with the main axis, an axis "r" in a radial direction and an axis "t" perpendicular to the axes "a" and "r".

[0048] Preferably, the angle "φ" is sized to impart to the velocity versor of the gas an axial component "Vass" and a tangential component "Vtan" whose ratio is within the range [0.27 - 0.70].

[0049] That is to say, the diffuser is preferably designed in such a way (in particular the at least one channel of the diffuser has an end portion designed in such a way) that (the angle "φ" is sized in such a way that) the velocity versor of the gas exiting the channel has an axial component (along the axis "a") "Vass" and a tangential component (along the axis "t") "Vtan" whose ratio is within the range [0.27 - 0.70].

[0050] In particular, the diffuser is preferably designed in such a way (in particular the at least one channel of the diffuser has an end portion designed in such a way) that the angle "φ" is within the range [55 degrees - 75 degrees].

[0051] Moreover, the diffuser is preferably designed in such a way (in particular the at least one channel of the diffuser has an end portion designed in such a way) that (the angle "θ" is sized in such a way that) the velocity versor of the gas exiting the channel has a radial component (along the axis "r") "Vrad" which is within the range [0 - 0.34].

[0052] In particular, the diffuser is preferably designed in such a way (in particular the at least one channel of the diffuser has an end portion designed in such a way) that the angle "θ" is within the range [0 degrees - 20 degrees].

[0053] The configuration of the diffuser (and in particular of the end portion of the channels of the diffuser ending in the plasma chamber) advantageously and surprisingly allows an increase in the ratio of the values adopted by the gas swirl velocity (in the plasma chamber) at the mouth of the orifice and close to the emitter electrode. In this way, the swirl velocity of the gas in the plasma chamber is at its maximum at the mouth of the orifice and at its minimum close to the emitter electrode.

[0054] This allows a further increase in the lifetime of the wear parts and in particular of the electrode. Further features and advantages of this invention are more apparent in the non-limiting description which follows of a preferred non-limiting embodiment of a plasma cutting torch, illustrated in the accompanying drawings, in which:

- Figure 1 is a schematic longitudinal section of a portion of a plasma cutting torch according to this invention;
- Figure 2 is a schematic side view of the diffuser of the torch of Figure 1;
- Figure 3 is a schematic top plan view of the diffuser of Figure 2;
- Figure 4 is a schematic cross-section of the diffuser according to the line IV - IV of Figure 2;
- Figure 5 is a diagram relating to the trend of the electrode - nozzle voltage as time passes, with a prechamber with optimised height according to this invention;
- Figure 6 is a diagram relating to the trend of the electrode - nozzle voltage as time passes, with a prechamber whose height has not been optimised;
- Figure 7 shows the temperature ranges in the plasma chamber with a nozzle whose dimensions are not optimised and with a nozzle according to this invention.

[0055] With reference to Figure 1, the numerals 1, 2 and 200 respectively denote an electrode, a nozzle and a diffuser for plasma torches.

[0056] An example of a plasma torch 100 for which the electrode 1, the nozzle 2 and the diffuser 200 are intended, partly illustrated in Figure 1, is described in application BO2009A000496 which is referred to in its entirety herein for completeness of description.

[0057] The torch 100, extending around a main axis X, basically comprises the electrode 1, the nozzle 2 and the diffuser 200 which delimit a plasma generation chamber 3, a gas feed system 4 for feeding the gas to the plasma generation chamber 3, a circuit for supplying electricity to the electrode, which allows its connection to the negative pole (cathode) of a current generator, and a circuit for supplying electricity to the nozzle for connecting it to the positive pole (anode) of the generator.

[0058] In particular, the torch 100 is a plasma cutting torch.

[0059] In particular, the torch 100 is a transferred arc plasma (cutting) torch.

[0060] The torch 100 comprises a supporting body 101 for the electrode 1. The electrode 1 and the nozzle 2 are mounted in such a way that they are coaxial with the axis X.

[0061] It should be noticed that for simplicity, the term axis X hereinafter also refers to the main axis of the separate components of the torch.

[0062] In particular, the torch 100 comprises a nozzle holder 103 for mounting the nozzle on the diffuser 200.

[0063] As shown in Figure 1, interposed between the electrode 1 and the nozzle 2 there is the diffuser 200, described in more detail below, for feeding the gas into the chamber 3.

[0064] In the plasma generation chamber 3 the gas is ionised, for example by means of a high voltage, high frequency pulse applied across the electrode and the nozzle or with other known techniques, in such a way that an electric arc can be initiated. The arc initiated in this way is maintained lit during cutting by applying, between the electrode and the workpiece being processed, an operating voltage typically between 100 Volts and 150 Volts. In particular with reference to Figure 1, it should be noticed that the electrode 1 comprises a supporting element 5 for a tablet 6 of emitter material or an emitter, preferably coaxial with the electrode 1.

[0065] The element 5 comprises an upper portion 7, with reference to Figure 1, which is substantially cylindrical, extending around the main axis X.

[0066] The portion 7 comprises a substantially cylindrical outer surface 8.

[0067] A tooth 9 projects from the surface 8 around the entire circumference of the element 5 and is provided for coupling with the diffuser 200, as is described in more detail below.

[0068] Looking in more detail at the nozzle 2, with particular reference to Figure 1, it should be noticed that the nozzle comprises a substantially tubular, preferably cylindrical first portion 10 for coupling with the rest of the components of the torch 1.

[0069] In particular, according to what is illustrated, the nozzle 2 is coupled to the diffuser 200.

[0070] The nozzle 2 comprises a second, tip portion 11 in which there is a hole or orifice 12 having a diameter "De" from which the plasma is issued.

[0071] The tip portion 11 has a tapered inner surface 11a which, with the nozzle 2 mounted on the torch 100, is facing the electrode 1 to at least partly form the plasma generation chamber 3.

[0072] The inside of the nozzle, between the surface 11a and the orifice 12, has a "funnel" shape which forms a second chamber or pre-chamber 13, since it is located upstream of the orifice 12 for the passage of the plasma gas.

[0073] The pre-chamber 13 is coaxial with the orifice 12 and the electrode 1 once installed.

[0074] More precisely, the pre-chamber 13 has a cylindrical infeed 14, with depth or height Ha and a tapered connecting stretch 15 between the infeed 14 and the orifice 12.

[0075] It should be noticed that during mounting on the torch 100, or in general during electrode - nozzle coupling, once the electrode 1 and the nozzle 2 are mounted in the torch, the infeed 14 of the pre-chamber 13 is coaxial with and facing the tablet 6 of emitter material.

[0076] According to this invention, with optimum sizing of the pre-chamber 13 the ratio between the height Ha of the infeed 14 and the diameter De of the nozzle 2 orifice is greater than or equal to 0.15 and it is less than or equal to 0.5, that is to say:

$$0.15 \leq \frac{Ha}{De} \leq 0.5 \ .$$

[0077] In another embodiment, the ratio between the height "Ha" of the infeed 14 and the diameter "De" of the orifice 12 is greater than or equal to 0.2 and less than or equal to 0.48, that is to say:

$$0.2 \leq \frac{Ha}{De} \leq 0.48 \ .$$

[0078] That range may preferably be further restricted and in a further embodiment the ratio between the height "Ha" of the infeed 14 and the diameter "De" of the orifice 12 is greater than or equal to 0.22 and less than or equal to 0.46, that is to say:

$$0.22 \leq \frac{Ha}{De} \leq 0.46 \ .$$

[0079] A first preferred embodiment of the nozzle 2 has the following dimensions:

Ha = 0.35 mm
De = 1.8 mm

[0080] The upper and lower limits of the above-mentioned ranges have been determined through experimentation by means of analysis of the electrode - nozzle voltage during cutting, for improving cutting quality and the lifetime of the wear parts.

[0081] The electrode - nozzle voltage is greatly influenced by the shape of the discharge, by its distance from the walls and by the electronic temperature, and is therefore an excellent indicator of the stability of the discharge.

[0082] Figure 6 is a diagram relating to the trend of the electrode - nozzle voltage as time passes, with a pre-chamber whose height has not been optimised

$$\left(\frac{Ha}{De} = 1, \ \text{curve A}\right).$$

[0083] Figure 5 is a diagram relating to the trend of the electrode - nozzle voltage as time passes, with a pre-chamber with optimised height according to this invention

$$\left(\frac{Ha}{De} = 0.2, \ \text{curve B}\right).$$

[0084] It should be noticed how the curve A has a greatly oscillating trend with high voltage peaks, indicating a discharge that is not well confined, whilst curve B has a voltage trend that is continuous and without oscillations.

[0085] With reference to Figure 7, it should also be noticed that an excessive depth of the pre-chamber (pre-chamber not optimised according to the invention, on the right of the axis X, compared with a pre-chamber whose height is optimised in accordance with this description, on the left of the axis X) results in an increase in the radial dimensions of the arc and a reduction in the thickness of the cold sheath. It should be noticed how the discharge on the right is more "dome-shaped", a sign of an insufficient flow of gas and of tangential component for its collimation.

[0086] The preferred height or depth of the pre-chamber, expressed depending on the diameter of the nozzle orifice and limited to the above-mentioned size range therefore allows important advantages to be obtained.

[0087] The minimum value proposed allows the pre-chamber to be deep enough to guarantee an effect on the fluid-dynamics of the plasma gas compared with a nozzle whose pre-chamber height is not optimised according to this invention in terms of stabilisation and collimation of the discharge and insulation by means of the cold gas sheath. The same minimum value also allows an increase, compared with a nozzle without a pre-chamber, in the total length of the discharge and therefore of the voltage drop and power transferred by Joule effect to the plasma, which will then be partly transferred to the material to be cut, the length of the orifice being equal.

[0088] The maximum value proposed avoids reaching an excessive depth which may result in plasma instability of the kink type, labelled 130 in Figure 6, linked to an excessive length of the discharge in the pre-chamber which the gas flow, limited to the value that can pass through the nozzle orifice, is unable to stabilise. Such instabilities may cause an increase in electrode erosion, an increase in the possibility of a double arc and a worsening of the cutting quality.

[0089] The upper limit of the range also prevents an excessive increase in the plasma power due to an increase in the length of the arc and therefore of the thermal load on the wall which, without liquid cooling, may result in nozzle overheating and deterioration of the surfaces.

[0090] Figures 2 to 4 show a preferred embodiment of the diffuser 200.

[0091] The diffuser 200 comprises a substantially annular main body 201.

[0092] Figure 4 shows how the diffuser main body 201 has an annular groove 202 made in an inner wall of the body 201 and intended to receive, once the diffuser 200 is mounted in the torch 100, the tooth 9 present on the outer surface 8 of the electrode 1.

[0093] The diffuser 200 is kept coupled to the electrode 1 in such a way that the tooth 9 is engaged in the groove 202.

[0094] On the opposite side to the groove 202, in the diffuser body 201 there is an annular chamfer 203 for coupling with the nozzle 2.

[0095] The chamfer 203 extends on the outer surface of the diffuser body 201 and is formed, in practice, by an annular portion 203 having a diameter which is less than that of the diffuser body 201.

[0096] For a simple description, with reference to the accompanying drawings, the diffuser 200 comprises an annular lower surface or wall 204, an annular upper surface or wall 205 and a cylindrical outer lateral surface or wall 206.

[0097] The diffuser 200 comprises a plurality of channels 207, four in the example illustrated, for putting into fluid communication the gas feed system 4 and the plasma generation chamber 3.

[0098] In the embodiment illustrated by way of example, each channel 207 comprises a first radial hole 208 with diameter "d" and depth "P" extending from the outer lateral surface 206.

[0099] In the example illustrated, the diffuser comprises a first pair of diametrically opposed holes and a second pair of diametrically opposed holes.

[0100] The first and second pairs of holes lie on perpendicular diameters.

[0101] Preferably, the diameters on which the two pairs of holes are positioned are at right angles to each other.

[0102] Figure 4 shows how the axes of the holes 208, only one of which is illustrated for greater clarity, are positioned at a height "h" relative to the lower surface 204.

[0103] The channels 207 each comprise a second hole 209 extending from the annular wall 204 to the corresponding hole 208.

[0104] Each hole 208 is in fluid communication with the corresponding hole 209 and overall they form the respective channel 207 for putting in fluid communication the gas feed system 4 and the plasma generation chamber 3.

[0105] It is important to notice that, according to this invention, the channels 207 extend from the outer lateral surface 206 and lead to the annular lower surface 204.

[0106] In other words, each channel 207 has an inlet 207a on the outer lateral wall 206 and an outlet 207b on the annular lower surface 204.

[0107] As illustrated in Figures 2 and 3, each hole 209 comprises an axis "A" and a diameter "d1". The axes "A" of the holes 209, at an outlet section of the holes 209 on the wall 204, intersect a shared circle with its centre at the axis X and radius "R", each at a respective point "O".

[0108] The axis "A" of each hole 209 is slanting relative to the main axis X of the diffuser.

[0109] In alternative embodiments not illustrated, the channels 207 are formed only by the hole 209 having the inlet 207a and the outlet 207b and the axis "A" slanting relative to the main axis X.

[0110] In particular, as indicated, the outlet 207b is provided at the annular lower wall 204 in such a way that the gas passing through it reaches the chamber 3, whilst the inlet 207a is provided on the outer lateral wall 206.

[0111] Consider, by way of example, for one hole 209a of the above-mentioned four holes 209, a Cartesian reference system with its centre at "O", an axis "a" parallel with the axis "X" of the diffuser 200, an axis "r" in a radial direction and an axis "t" perpendicular to the first two axes and at a tangent to the circle with radius "R".

[0112] The projection of the axis "A" of the hole 209a in the plane "ar" forms, with the axis "a", an angle "θ".

[0113] The projection of the axis "A" of the hole 209a in the plane "at" forms, with the axis "a", an angle "φ".

[0114] The above-mentioned angle "φ" is sized to impart to the velocity versor of the gas entering the chamber 3 through the channel 209a, an axial component "Vass" and a tangential component "Vtan" (according to the above-mentioned axis "t") so as to impart to the velocity of the entering gas a tangential component according to the axis t which is optimum for containment of the arc.

[0115] Preferably, the ratio between the axial component "Vass" and the tangential component "Vtan", due to the diffuser 200 and in particular to the holes 209 in the diffuser, is between 0.27 and 0.70, that is to say:

$$0.27 \le \frac{Vass}{V\tan} \le 0.70 \,.$$

[0116] More preferably, the ratio between the axial component "Vass" and the tangential component "Vtan", due to the diffuser 200, is between 0.36 and 0.57, that is to say:

$$0.36 \le \frac{Vass}{V\tan} \le 0.57 \,.$$

[0117] Even more preferably, the ratio between the axial component "Vass" and the tangential component "Vtan", due to the diffuser 200, is between 0.44 and 0.51, that is to say:

$$0.44 \le \frac{Vass}{V\tan} \le 0.51 \,.$$

[0118] In order to impart to the velocity of the passing gas a tangential component according to the axis t which is optimum for containment of the arc, the angle "φ" is preferably between 55 and 75 sexagesimal degrees, that is to say:

$$55° \le \varphi \le 75° \,.$$

[0119] More preferably, the angle "φ" is between 60 and 70 sexagesimal degrees, that is to say:

$$60° \le \varphi \le 70° \,.$$

[0120] Even more preferably, the angle "φ" is between 63 and 67 sexagesimal degrees, that is to say:

$$63° \le \varphi \le 67° \,.$$

[0121] Preferably, in a first embodiment of the diffuser 200, the angle "φ" is equal to 45 sexagesimal degrees.

[0122] It should be noticed that yet more preferably, the above-mentioned values of the angle "φ" are advantageously used in torches 100 in which the radius "R" measurement is 11 mm.

[0123] It should be noticed that, in general, the measurement in millimetres of the diameter "d1" is preferably between 0.4 and 0.6, that is to say:

$$0.4 \le d1 \le 0.6 \,.$$

[0124] More preferably, the measurement in millimetres of the diameter "d1" is between 0.45 and 0.55, that is to say:

$$0.45 \le d1 \le 0.55 \,.$$

[0125] Even more preferably, the measurement in millimetres of the diameter "d1" is between 0.48 and 0.52, that is to say:

$$0.48 \le d1 \le 0.52 \,.$$

[0126] With reference to the angle "θ", it should be noticed that said angle is preferably sized in such a way as to impart to the velocity versor a radial component "Vrad", that is to say directed according to the axis "r" of the above-mentioned reference systems, which is between 0 and 0.34, that is to say:

$$0 \le Vrad \le 0.34 \,.$$

[0127] To obtain said values of "Vrad", preferably, the diffuser 200 has said angle "θ" between 0 and 20 sexagesimal degrees.

[0128] In the above-mentioned preferred embodiments, the angle "θ" is 11 sexagesimal degrees.

[0129] In further preferred embodiments, not illustrated, the angle "θ" is 0 sexagesimal degrees, that is to say, zero.

[0130] With reference to Figure 1, "A1" is the distance, measured according to the direction X, between the outlet section of the channels 207 and the inlet section of the orifice 12, and "B1" is the distance, measured according to the direction X, between the end section of the electrode 1 and the inlet section of the orifice 12.

[0131] To optimise the "swirl" velocity of the gas, minimising wear on the wear parts, the ratio between A1 and B1 is preferably between 3 and 4.5, that is to say:

$$3 \le \frac{A1}{B1} \le 4.5 \,.$$

[0132] Preferably, in a first embodiment of the torch 1, the ratio between A1 and B1 is equal to 3.74, that is to say:

$$\frac{A1}{B1} = 3.74 \ .$$

[0133] Said sizing of the ratio between A1 and B1 is advantageously applied in torches 100 having operating currents which are several dozen Amperes above 100 Amperes, for example in 160 Ampere torches.

[0134] Preferably, in a second embodiment of the torch 1, the ratio between A1 and B1 is equal to 3.7, that is to say:

$$\frac{A1}{B1} = 3.7 \ .$$

[0135] Said sizing of the ratio between A1 and B1 is advantageously applied in torches 100 having operating currents which are around a hundred Amperes, for example in 100 Ampere torches.

[0136] In a third preferred embodiment of the diffuser 100, the ratio between A1 and B1 is equal to 3.49, that is to say:

$$\frac{A1}{B1} = 3.49 \ .$$

[0137] Said sizing of the ratio between A1 and B1 is advantageously applied in torches 100 having operating currents which are around several dozen Amperes, for example in 60 Ampere torches.

Claims

1. A plasma cutting torch extending about a main axis (X) and comprising an electrode (1), a nozzle (2), having a plasma outlet orifice (12), coaxial with the electrode (1), a diffuser (200) acting between the electrode (1) and the nozzle (2); the electrode (1), the nozzle (2) and the diffuser (200) delimiting a plasma generation chamber (3), the torch comprising a gas feed system (4) for feeding the gas into the chamber (3), the diffuser (200) comprising at least one channel (207) for putting the feed system (4) and the chamber (3) in fluid communication, the torch being **characterised in that**, in the chamber (3), labelling "A1" the distance, measured according to the direction (X), between an outlet section of the channel (207) and an inlet section of the orifice (12) and labelling "B1" the distance, measured according to the main axis (X), between an end section of the electrode (1) and the inlet section of the orifice (12), the ratio between "A1" and "B1" is greater than or equal to 3 and is less than or equal to 4.5, that is to say:

$$3 \leq \frac{A1}{B1} \leq 4.5 \ .$$

2. The torch according to claim 1, **characterised in that** the ratio between A1 and B1 is greater than or equal to 3.3 and is less than or equal to 4, that is to say:

$$3.3 \leq \frac{A1}{B1} \leq 4 \ .$$

3. The torch according to claim 1 or 2, **characterised in that** the ratio between A1 and B1 is equal to 3.74, that is to say:

$$\frac{A1}{B1} = 3.74$$

or is equal to 3.7, that is to say:

$$\frac{A1}{B1} = 3.7$$

or is equal to 3.64, that is to say:

$$\frac{A1}{B1} = 3.64$$

or is equal to 3.58, that is to say:

$$\frac{A1}{B1} = 3.58$$

or is equal to 3.49, that is to say:

$$\frac{A1}{B1} = 3.49 \ .$$

4. The torch according to any of the foregoing claims,

characterised in that the nozzle (2) comprises a pre-chamber (13) coaxial with the orifice (12), the pre-chamber (13) having a cylindrical infeed (14) with height (Ha) and a tapered connecting stretch (15) between the infeed (14) and the orifice (12), the ratio between the height (Ha) of the infeed (14) and the diameter (De) of the orifice (12) being greater than or equal to 0.15 and less than or equal to 0.5, that is to say:

$$0.15 \leq \frac{Ha}{De} \leq 0.5 .$$

5. The torch according to claim 4, **characterised in that** the ratio between the height (Ha) of the infeed (14) and the diameter (De) of the orifice (12) is greater than or equal to 0.2 and less than or equal to 0.48, that is to say:

$$0.2 \leq \frac{Ha}{De} \leq 0.48$$

or being **characterised in that** the ratio between the height (Ha) of the infeed (14) and the diameter (De) of the orifice (12) is greater than or equal to 0.22 and less than or equal to 0.46, that is to say:

$$0.22 \leq \frac{Ha}{De} \leq 0.46 .$$

6. The torch according to any of the foregoing claims, **characterised in that** the diffuser (200) comprises a substantially annular main body (201) with a main axis (X), an annular lower wall (204), an annular upper wall (205) and a cylindrical outer lateral wall (206), the channel (207) having an inlet and an outlet which is positioned at the annular lower wall (204), the channel (207) having a diameter (d1) and an axis (A) of extension which is slanting relative to the main axis (X), a projection of the axis (A) of the channel (207) in a plane "ar" forming, with an axis (a), an angle (θ) and a projection of the axis (A) of the channel (207) in a plane "at" forming, with the axis (a), an angle (φ), the Cartesian reference system having its centre at (O), an axis (a) parallel with the main axis (X), an axis (r) in a radial direction and an axis (t) which is perpendicular to the axes (a) and (r) and at a tangent to the circle with radius (R), the angle (φ) being sized so as to impart to the velocity versor of the gas an axial component "Vass" and a tangential component "Vtan", the ratio between the axial component "Vass" and the tangential component "Vtan" being between 0.27 and 0.70, that is to say:

$$0.27 \leq \frac{Vass}{V\tan} \leq 0.70 .$$

7. The torch according to claim 6, **characterised in that** the ratio between the axial component "Vass" and the tangential component "Vtan" is between 0.36 and 0.57, that is to say:

$$0.36 \leq \frac{Vass}{V\tan} \leq 0.57 .$$

8. The torch according to claim 6, **characterised in that** the ratio between the axial component "Vass" and the tangential component "Vtan" is between 0.44 and 0.51, that is to say:

$$0.44 \leq \frac{Vass}{V\tan} \leq 0.51 .$$

9. The torch according to any of the claims from 6 to 8, **characterised in that** the angle (θ) is sized to impart to the velocity versor of the gas a radial component "Vrad", between 0 and 0.34, that is to say:

$$0 \leq Vrad \leq 0.34 .$$

10. The torch according to any of the claims from 6 to 9, **characterised in that** the angle (φ) is greater than or equal to 55 sexagesimal degrees and is less than or equal to 75 sexagesimal degrees, that is to say:

$$55° \leq \varphi \leq 75°$$

or is greater than or equal to 60 sexagesimal degrees and is less than or equal to 70 sexagesimal degrees, that is to say:

$$60° \leq \varphi \leq 70°$$

or is greater than or equal to 63 sexagesimal degrees and is less than or equal to 67 sexagesimal degrees, that is to say:

$$63^\circ \leq \varphi \leq 67^\circ .$$

11. The torch according to any of the claims from 6 to 10, **characterised in that** the angle (θ) is greater than or equal to 0 sexagesimal degrees and is less than or equal to 20 sexagesimal degrees, that is to say:

$$0^\circ \leq \theta \leq 20^\circ .$$

12. The torch according to any of the claims from 6 to 11, **characterised in that** the diameter (d1) of the channels (207) is greater than or equal to 0.4 mm and is less than or equal to 0.6 mm, that is to say:

$$0.4 \leq d1 \leq 0.6$$

or is greater than or equal to 0.45 mm and is less than or equal to 0.55 mm, that is to say:

$$0.45 \leq d1 \leq 0.55$$

or is greater than or equal to 0.48 mm and is less than or equal to 0.52 mm, that is to say:

$$0.48 \leq d1 \leq 0.52 .$$

FIG.1

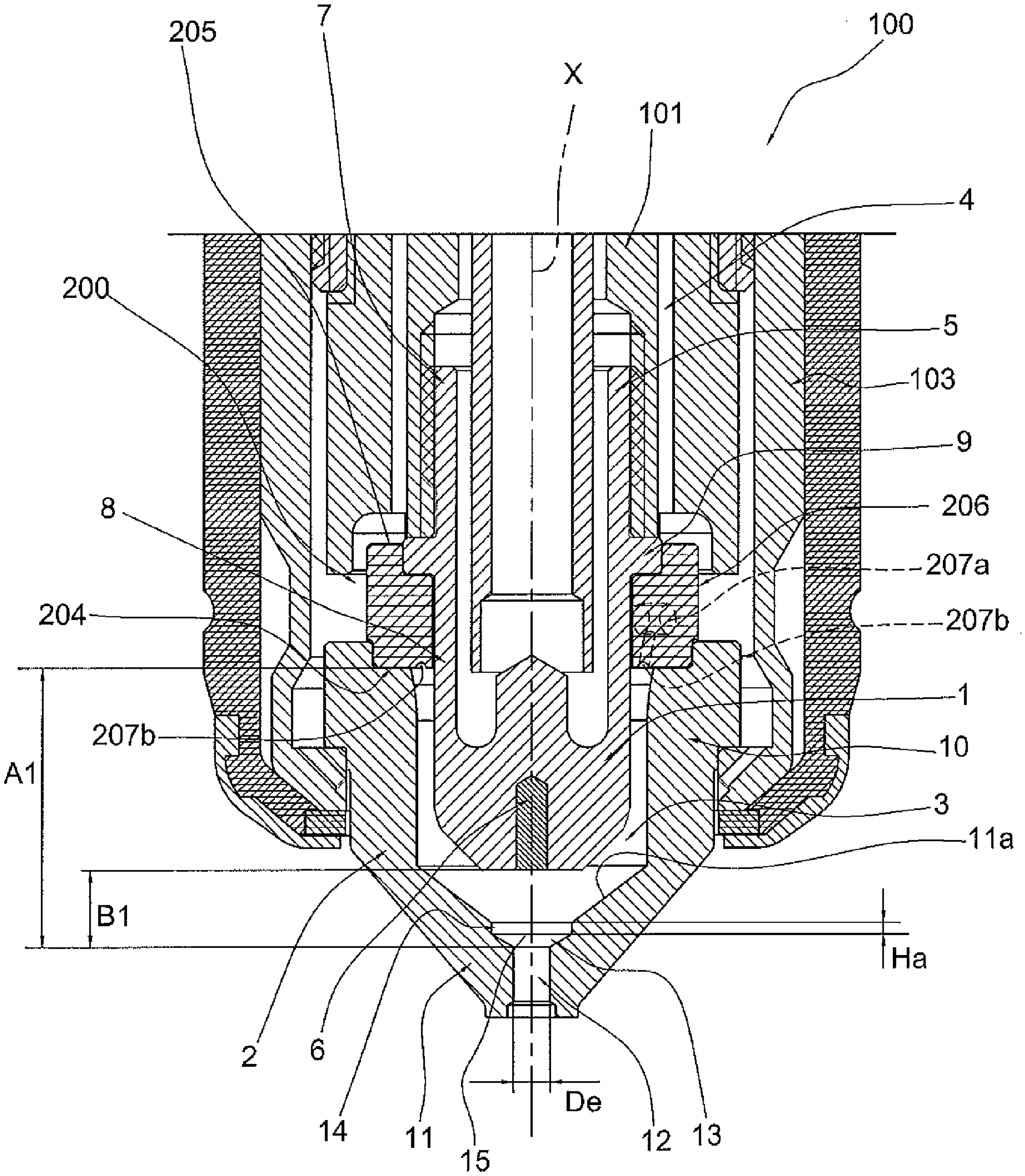

205
7
X
100
101
4
200
5
103
9
8
206
207a
204
207b
207b
1
10
A1
3
11a
B1
Ha
2
6
De
14
11
15
12
13

FIG.2

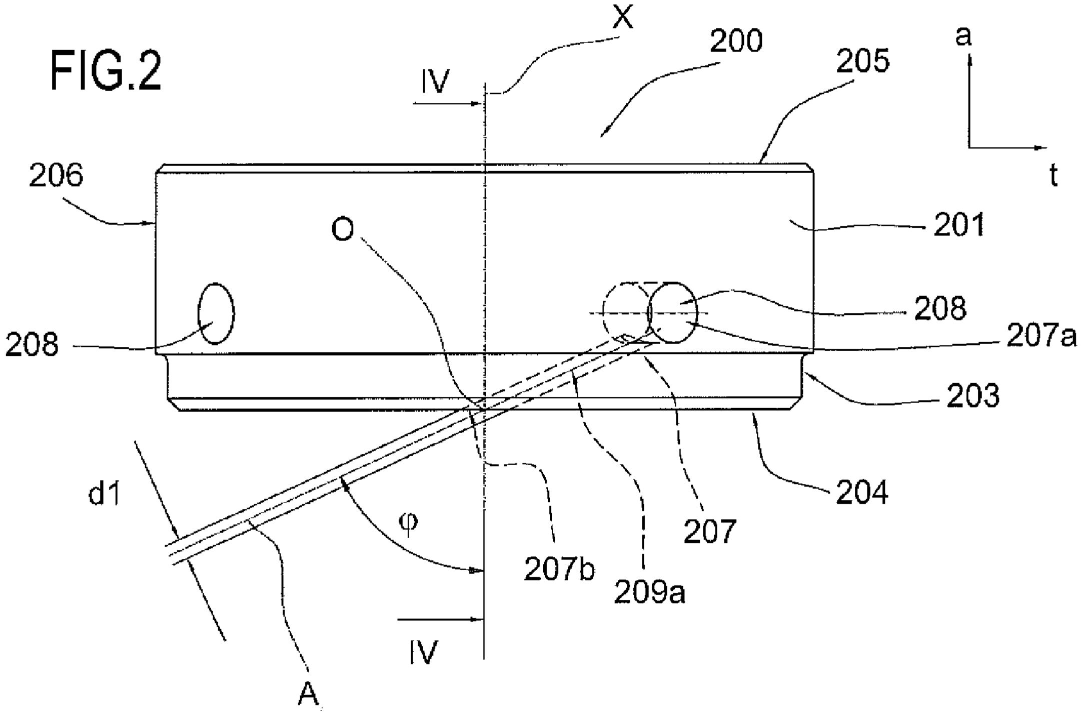
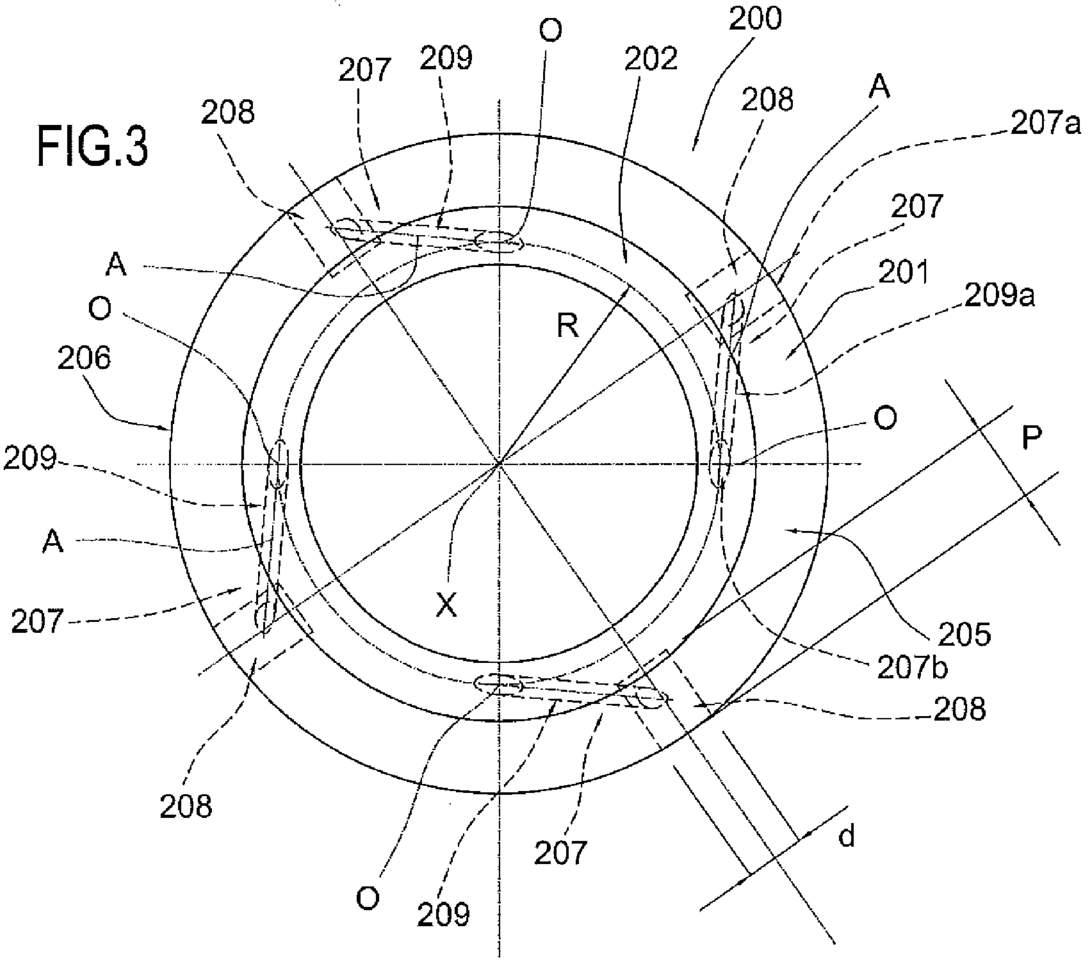

X
IV
200
205
a
t
206
O
201
208
208
207a
203
204
d1
φ
207
207b
209a
IV
A

FIG.3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208
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207a
207
A
201
O
209a
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R
O
P
209
A
X
207
205
207b
208
208
207
d
O
209

FIG.4

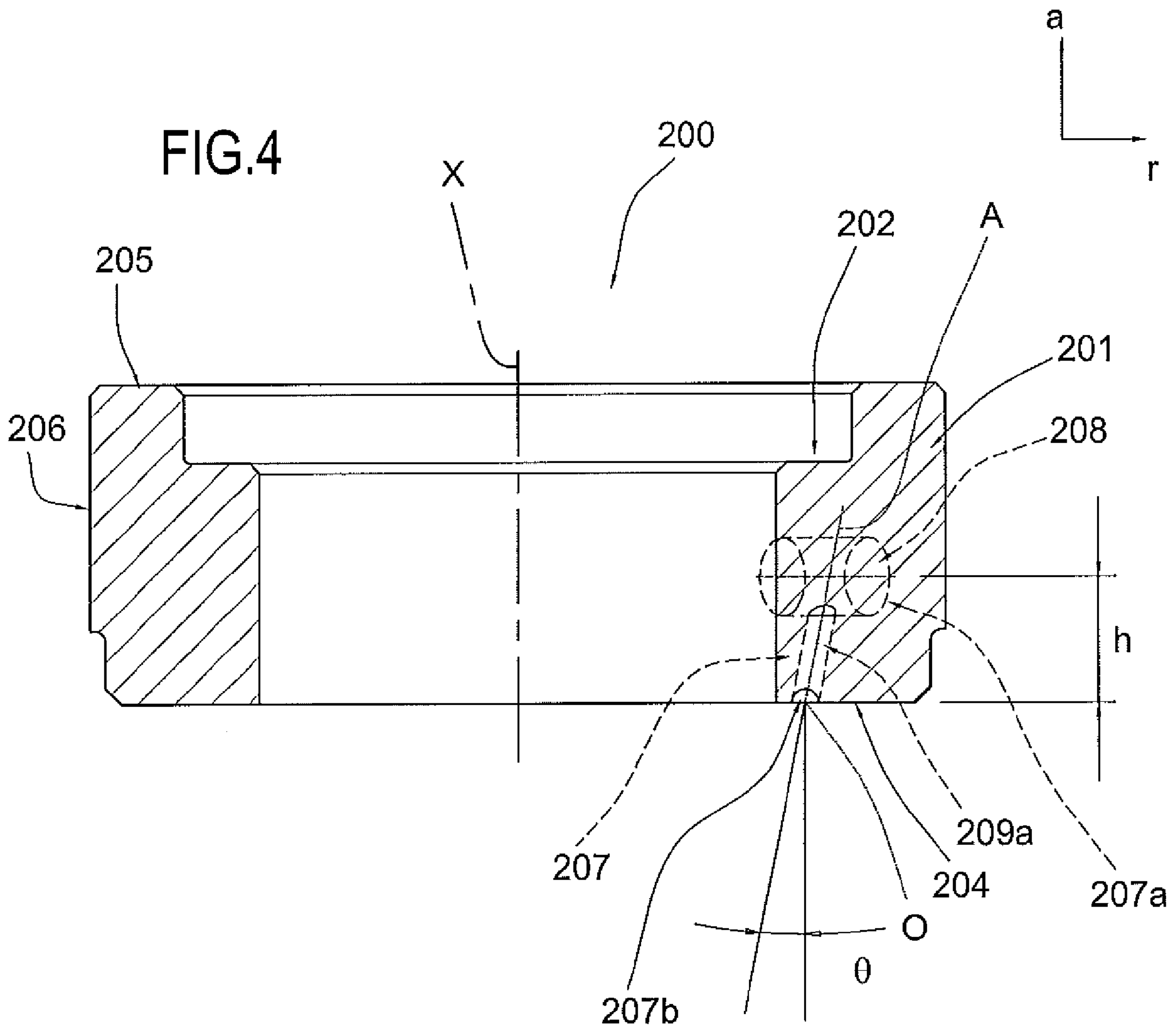


FIG.5

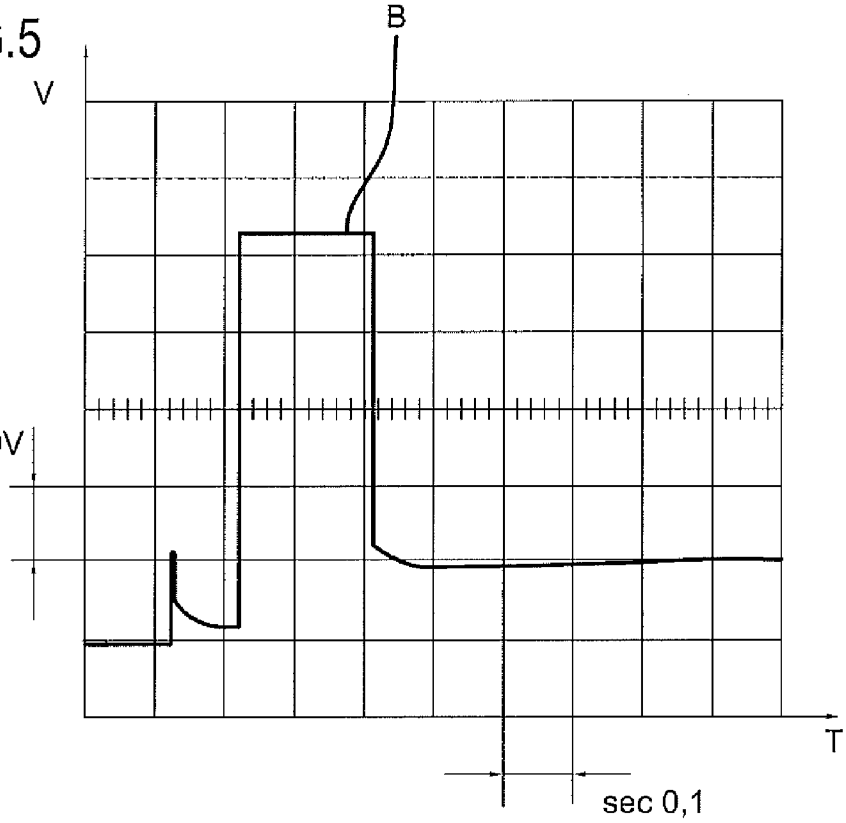
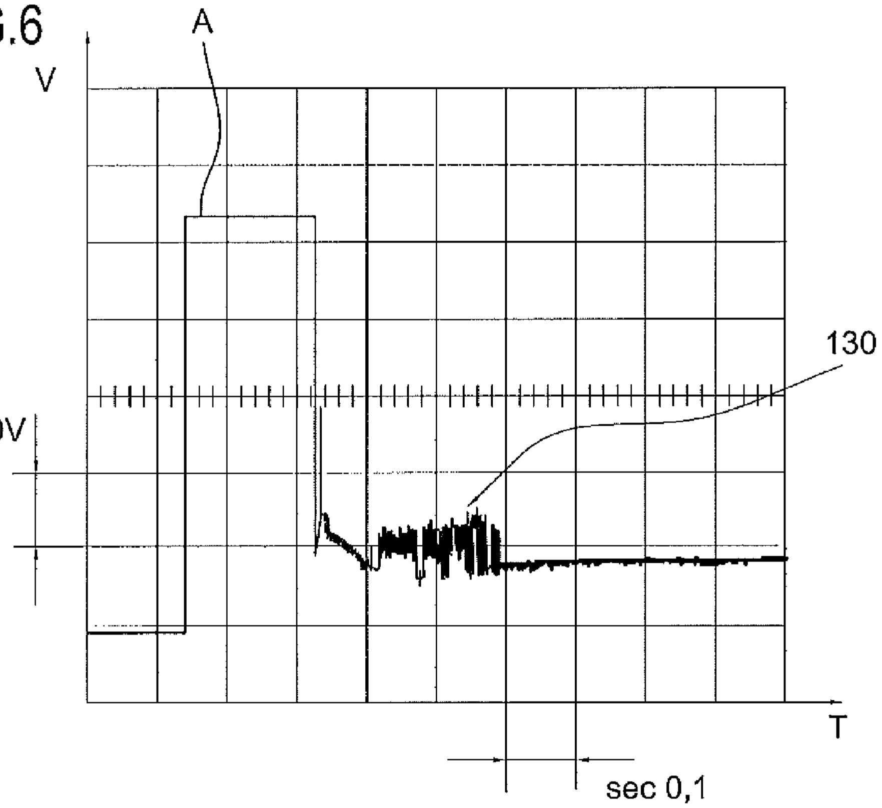
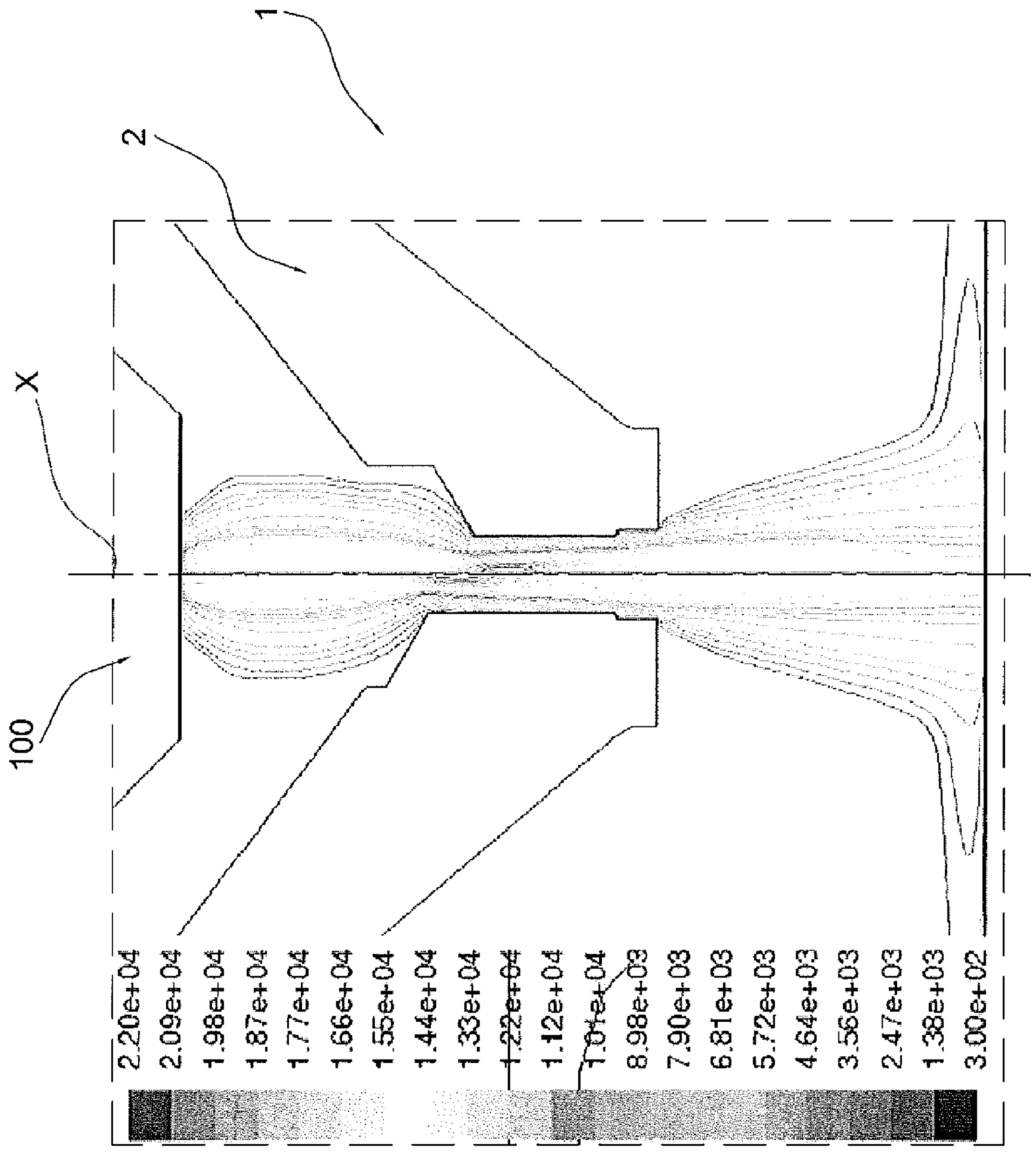


FIG.6




1
2
X
100
2.20e+04
2.09e+04
1.98e+04
1.87e+04
1.77e+04
1.66e+04
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1.44e+04
1.33e+04
1.22e+04
1.12e+04
1.01e+04
8.98e+03
7.90e+03
6.81e+03
5.72e+03
4.64e+03
3.56e+03
2.47e+03
1.38e+03
3.00e+02

FIG.7

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EUROPEAN SEARCH REPORT

Application Number
EP 11 16 1876

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H05H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	23 August 2011	Crescenti, Massimo

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