Swirler for plasma cutting torches

A diffuser (200) for a plasma cutting torch 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) and at least one channel (207) for the passage of gas; the channel (207) having an inlet (207a) located on the outer lateral surface (206) and an outlet (207b) positioned at the annular lower wall (204) and an axis (A) of extension which is slanting relative to the main axis (X); the projection of the axis (A) of the channel (207) in a plane "at" forming, with the axis (a), an angle (ϕ) in a Cartesian reference system whose centre lies at (O), with an axis (a) parallel with the main axis (X), an axis (r) in a radial direction and an axis (t) perpendicular to the axes (a) and (r); the angle (ϕ) is sized so as to impart to the velocity versor of the gas exiting the channel (207) an axial component "Vass" and a tangential component "Vtan" in such a way that the ratio between the axial component "Vass" and the tangential component "Vtan" is between 0.27 and 0.70, that is to say:

\[
0.27 \leq \frac{Vass}{Vtan} \leq 0.70
\]
Description

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

[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 interposed 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 positioned between the electrode and the nozzle 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 above-mentioned 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] It has been noticed that diffusers for prior art cutting torches do not allow a combination of good arc constriction, needed for good quality cut parts, with minimal wear on the wear parts (electrode and nozzle).


[0019] Said torch has a diffuser forming ducts for the passage of a gas which face a reaction chamber in which the vacuum is created and in which the surface to be treated is positioned.

[0020] The configuration of the ducts for passage of the gas belonging to the diffuser in US5734143 depends on the direction of generation of the microwaves and is designed to prevent the impurities generated by the arc from mixing with the plasma, for improving the purity of the layer deposited. Therefore, US5734143 does not provide any lesson on how to increase the life of the wear parts in a cutting torch.

[0021] 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.

[0022] However, US2007/0284340 proposes a diffuser designed in such a way as to directly support the electrode, and does not provide any lesson on how to increase the life of the wear parts in a cutting torch.

[0023] In this context, the main technical purpose of this invention is to provide a diffuser for plasma cutting torches which allows the combination of good arc constriction, needed for good quality cut parts, with minimal wear of the wear parts.

[0024] One aim of this invention is to provide a diffuser which allows maximisation, in practice, of the rotational velocity of the gas at the mouth of the nozzle orifice.

[0025] Another aim is to provide a diffuser which minimises, in practice, the rotational velocity of the gas close to the cathode emission surface.

[0026] The technical purpose indicated and at least the aims specified are substantially achieved by a diffuser comprising the technical features described in the appended claims.

[0027] In particular, the diffuser according to the invention is a diffuser for a plasma cutting torch which com-
prises a substantially annular main body with a main axis, an annular lower wall, an annular upper wall and a cylindrical outer lateral wall and at least one channel for the passage of gas.

[0028] The channel has an inlet and an outlet which is positioned at the annular lower wall. The channel has a diameter "d1" and an axis of extension which is slanting relative to the main axis.

[0029] 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 "at" 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".

[0030] According to the invention, 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].

[0031] That is to say, the diffuser is 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].

[0032] In particular, the diffuser is 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].

[0033] 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 "φ" is sized in such a way that) the velocity versor of the gas exiting the channel has a radial component (along the axis "t") "Vrad" which is within the range [0 - 0.34].

[0034] In particular, the diffuser is 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 [0 degrees - 20 degrees].

[0035] This invention also provides a plasma cutting torch comprising a diffuser designed as described above (and as described in detail below).

[0036] In particular, said torch is a plasma cutting torch extending around a main axis and comprises:

- an electrode;
- a nozzle comprising a plasma outfeed orifice, coaxial with the electrode;
- a diffuser positioned between the electrode and the nozzle; the electrode, the nozzle and the diffuser delimiting a plasma generation chamber;
- a gas feed system, for feeding the gas into the chamber, the diffuser comprising at least one channel for putting into fluid communication the feed system and the chamber.

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

[0041] The configuration of the diffuser (and in particular of the end portion of the channels of the diffuser ending in the plasma chamber) 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 (that is to say, close to the electrode emission surface). This allows an increase in the lifetime of the wear parts and in particular of the electrode.

[0042] 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 swirl velocity adopted by the gas in the plasma chamber at the mouth of the orifice and close to the electrode emission surface.

[0043] 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 and a diffuser, illustrated in the accompanying drawings, in which:

- Figure 1 is a schematic longitudinal section of a portion of a plasma cutting torch comprising a diffuser 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. With reference to Figure 1, the numerals 1, 2 and 200 respectively denote an electrode, a nozzle and a diffuser for plasma torches.

[0044] 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 BO2009A00049 which is referred to in its entirety herein for completeness of description.
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 into 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.

In particular, the torch 100 is a plasma cutting torch.

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

The nozzle 2 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.

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.

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

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.

In the plasma generation chamber 3 the gas is ionised, for example by means of a high voltage 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.

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

The portion 7 comprises a substantially cylindrical outer surface 8.

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.

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 first portion 10 intended for mounting the nozzle 2 on the body 101 of the torch.

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

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.

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.

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, and for the passage of the plasma.

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

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.

It should be noticed that during mounting on the torch 100, or in general during electrode - nozzle coupling, the infeed 14 of the pre-chamber 13 is coaxial with and facing the tablet 6 of emmitter material.

Figures 2 to 4 show a preferred embodiment of the diffuser 200 according to this invention.

The diffuser 200 comprises a substantially annular main body 201.

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.

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

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.

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.

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.

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.

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.

The example illustrated shows how the holes 208 are arranged in diametrically opposed pairs. Preferably, the diameters on which the two pairs of holes are positioned are at right angles to each other.

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.

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

[0077] 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.

[0078] 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.

[0079] 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.

[0080] 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".

[0081] The axis "A" of each hole 209 is slanting relative to the main axis X of the diffuser.

[0082] 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.

[0083] 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.

[0084] 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".

[0085] The projection of the axis "A" of the hole 209a in the plane "ar" forms, with the axis "a", an angle "θ".

[0086] The projection of the axis "A" of the hole 209a in the plane "at" forms, with the axis "a", an angle "ϕ".

[0087] 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.

[0088] 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:

\[
0.27 \leq \frac{Vass}{Vtan} \leq 0.70 .
\]

[0089] 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:

\[
0.36 \leq \frac{Vass}{Vtan} \leq 0.57 .
\]

[0090] 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:

\[
0.44 \leq \frac{Vass}{Vtan} \leq 0.51 .
\]

[0091] 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:

\[
55° \leq ϕ \leq 75° .
\]

[0092] More preferably, the angle "ϕ" is between 60 and 70 sexagesimal degrees, that is to say:

\[
60° \leq ϕ \leq 70° .
\]

[0093] Even more preferably, the angle "ϕ" is between 63 and 67 sexagesimal degrees, that is to say:

\[
63° \leq ϕ \leq 67° .
\]

[0094] 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.

[0095] 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:

\[
0.4 \leq d1 \leq 0.6 .
\]

[0096] More preferably, the measurement in millimetres of the diameter "d1" is between 0.45 and 0.55, that is to say:
Even more preferably, the measurement in millimetres of the diameter \(d_1\) is between 0.48 and 0.52, that is to say:

\[
0.48 \leq d_1 \leq 0.52 .
\]

With reference to the angle \(\theta\), it should be noticed that said angle is preferably sized in such a way as to impart to the velocity versor a radial component \(V_{rad}\), 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:

\[
0 \leq V_{rad} \leq 0.34 .
\]

To obtain said values of \(V_{rad}\), preferably, the diffuser 200 has said angle \(\theta\) between 0 and 20 sexagesimal degrees.

In the above-mentioned preferred embodiments, the angle \(\theta\) is 11 sexagesimal degrees.

In further preferred embodiments, not illustrated, the angle \(\theta\) is 0 sexagesimal degrees, that is to say, zero.

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.

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:

\[
3 \leq \frac{A1}{B1} \leq 4.5 .
\]

Preferably, in a first embodiment of the torch 1, the ratio between A1 and B1 is equal to 3.76, that is to say:

\[
\frac{A1}{B1} = 3.76 .
\]

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.

Preferably, in a second embodiment of the torch 1, the ratio between A1 and B1 is equal to 3.72, that is to say:

\[
\frac{A1}{B1} = 3.72 .
\]

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.

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

\[
\frac{A1}{B1} = 3.49 .
\]

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 diffuser for a plasma cutting torch comprising 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) and at least one channel (207) for the passage of gas, said channel (207) having an inlet (207a) and an outlet (207b) 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), the axis (A) of the channel (207) intersecting the annular lower wall (204) at a point (O) at the outlet (207b), a projection of the axis (A) of the channel (207) in a plane "ar" forming, with an axis (a), an angle (\(\theta\)) and a projection of the axis (A) of the channel (207) in a plane "at" forming, with the axis (a), an angle (\(\psi\)), the Cartesian refer-
ence 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), the diffuser being characterised in that the angle (ϕ) is sized so as to impart to the velocity versor of the gas an axial component "Vass" and a tangential component "Vtan" whose ratio is between 0.27 and 0.70, that is to say:

\[ 0.27 \leq \frac{Vass}{Vtan} \leq 0.70 \]  

2. The diffuser according to claim 1, 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:

\[ 0.36 \leq \frac{Vass}{Vtan} \leq 0.57 \]  

3. The diffuser according to claim 1, 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:

\[ 0.44 \leq \frac{Vass}{Vtan} \leq 0.51 \]  

4. The diffuser according to any of the foregoing claims, 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:

\[ 0 \leq Vrad \leq 0.34 \]  

5. The diffuser according to any of the foregoing claims, 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:

\[ 55^\circ \leq \varphi \leq 75^\circ \]  

6. The diffuser according to any of the foregoing claims, characterised in that the angle (ϕ) is greater than or equal to 60 sexagesimal degrees and is less than or equal to 70 sexagesimal degrees, that is to say:

\[ 60^\circ \leq \varphi \leq 70^\circ \]  

7. The diffuser according to any of the foregoing claims, characterised in that the angle (ϕ) is greater than or equal to 63 sexagesimal degrees and is less than or equal to 67 sexagesimal degrees, that is to say:

\[ 63^\circ \leq \varphi \leq 67^\circ \]  

8. The diffuser according to any of the foregoing claims, 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:

\[ 0^\circ \leq \theta \leq 20^\circ \]  

9. The diffuser according to any of the foregoing claims, 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:

$$0.48 \leq d_1 \leq 0.52.$$  

10. A plasma cutting torch (100) extending around a main axis (X) and comprising:

- an electrode (1);
- a nozzle (2) comprising a plasma outfeed orifice (12), coaxial with the electrode (1);
- a diffuser (200) positioned between the electrode (1) and the nozzle (2); the electrode (1), the nozzle (2) and the diffuser (200) delimiting a plasma generation chamber (3);
- a gas feed system (4), for feeding the gas into the chamber (3), the diffuser (200) comprising at least one channel (207) for putting into fluid communication the feed system (4) and the chamber (3),

characterised in that the diffuser (200) is a diffuser according to any of the foregoing claims.
The present search report has been drawn up for all claims.

PLACE OF SEARCH: The Hague
DATE OF COMPLETION OF THE SEARCH: 27 June 2011
EXAMINER: Crescenti, Massimo

CATEGORY OF CITED DOCUMENTS:
X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same category
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: earlier patent document, but published on, or after the filing date
D: document cited in the application
L: document cited for other reasons
&: member of the same patent family, corresponding document

DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document with indication, where appropriate, of relevant passages</th>
<th>Relevant to claim</th>
<th>CLASSIFICATION OF THE APPLICATION (IPC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 5 734 143 A (KAWASE TORU [JP] ET AL) 31 March 1998 (1998-03-31)</td>
<td>1-10</td>
<td>INV. H05H1/34</td>
</tr>
<tr>
<td></td>
<td>* abstract; figures 1-6,10 *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* column 2, lines 1-14 *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* column 5, line 51 - column 6, line 43 *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* abstract; claims 5,13,14; figures 6-11 *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* column 14, line 62 - column 15, line 25; figure 6 *</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TECHNICAL FIELDS SEARCHED (IPC):
H05H
ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO. EP 11 16 1871

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

27-06-2011

<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 5734143 A</td>
<td>31-03-1998</td>
<td>CN 1127978 A</td>
<td>31-07-1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69505087 D1</td>
<td>05-11-1998</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69505087 T2</td>
<td>11-03-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 0710054 A1</td>
<td>01-05-1996</td>
</tr>
<tr>
<td>US 2007284340 A1</td>
<td>13-12-2007</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>US 5170033 A</td>
<td>08-12-1992</td>
<td>AU 654949 B2</td>
<td>01-12-1994</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA 2081457 A1</td>
<td>25-10-1991</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69125934 D1</td>
<td>05-06-1997</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69125934 T2</td>
<td>13-11-1997</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 0524970 A1</td>
<td>03-02-1993</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 3100157 B2</td>
<td>16-10-2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 5507237 T</td>
<td>21-10-1993</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5070227 A</td>
<td>03-12-1991</td>
</tr>
</tbody>
</table>

For more details about this annex: see Official Journal of the European Patent Office, No. 12/82
REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader’s convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 5734143 A [0018] [0020]
- US 20070284340 A [0021] [0022]