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(54) **Abrasive water jet cutting nozzle**

(57) The present invention relates to an abrasive water jet cutting nozzle (44) comprising a first body (66), a second body (82), a collet (60), a jewel element (75). The first body (66) comprises a first downwardly diverging frusto conical shaped recess (78) and the collet (60) comprises a first downwardly diverging frusto conical shaped surface (80) adapted to fit in the first downwardly diverging frusto conical shaped recess (78). The second body (82) comprises a second downwardly diverging frusto conical shaped recess (90). The first body (66) further comprises a second downwardly diverging frusto conical shaped surface (94) adapted to fit into the second downwardly diverging frusto conical shaped recess (90).

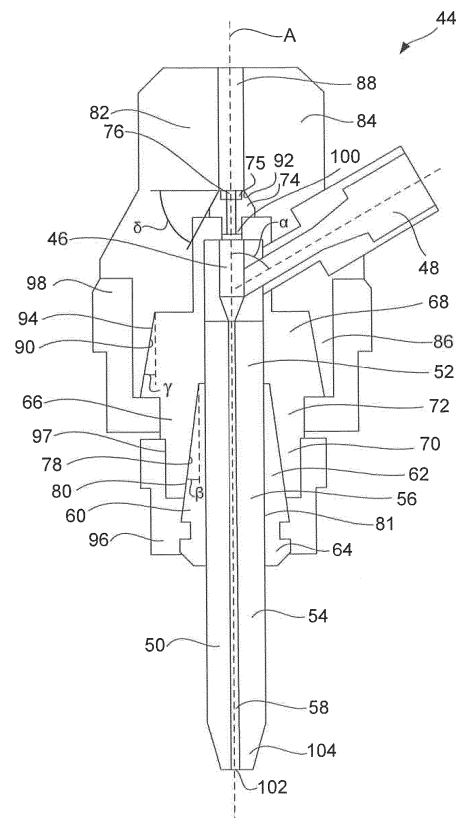


Fig. 3a

Description

TECHNICAL FIELD

[0001] The present invention relates to an abrasive water jet cutting nozzle according to the preamble of claim 1.

TECHNICAL BACKGROUND

[0002] A water jet cutting machine is an industrial tool capable of cutting a wide variety of materials using a high-pressure jet of water, or a mixture of water and abrasive material. Water jet cutting machines are often used during fabrication of machine parts. Water jet cutting is a preferred method when the material being cut is sensitive to high temperatures generated by other machining methods. It is used in various industries including mining and aerospace for cutting, shaping, and reaming.

[0003] To enhance the cutting power of the water jet cutting machine, abrasive material is added to the water jet. This technique is called abrasive water jet cutting and enables cutting through dense materials such as metal or granite. An abrasive water jet cutting machine comprises a water pump which increases the pressure of the water. It also comprises an abrasive water jet cutting nozzle with a jewel element holder comprising a jewel element having a small orifice. The water is forced through the jewel element to generate a high-velocity water jet. The abrasive material is added to the water downstream from the orifice of the jewel element into a mixing chamber, wherein the abrasive material is mixed with the water jet. After passing through the mixing chamber, the abrasive jet exits from the mixing chamber through an elongated outlet nozzle called focusing tube, which accelerates the jet and directs the jet toward the work piece being cut.

[0004] The mixing chamber can be a single component or it can be integrated in the focusing tube. A focusing tube which does not comprise a mixing chamber, a mixing chamber which is not integrated in a focusing tube, a focusing tube with integrated mixing chamber and a jewel element holder are all removably insertable in the abrasive water jet cutting nozzle. The focusing tube and the mixing chamber are the most wearable parts in the water jet cutting machine due to the presence of abrasive material suspended in the high-velocity water jet and therefore needs to be replaced periodically depending on requested cutting quality requirements.

[0005] It is expensive and time consuming to replace the focusing tube and the mixing chamber. To maximize the life of the focusing tube and the mixing chamber it is important that the focusing tube, the mixing chamber and the jewel element are in axial alignment. If the focusing tube, the mixing chamber and the jewel element are not concentrically arranged, the water forced through the jewel element will be off centre with respect to the mixing chamber and the jet exiting the mixing chamber will be off centre with respect to the focusing tube. That will result

in increased component wear due to collisions between the jet and the inner sides of the mixing chamber and the focusing tube. It may also result in degrading the jet stream itself to such an extent that the cutting ability of the abrasive water jet cutting nozzle is reduced. That results in that the cutting process is slowed and an excess of abrasive material is consumed in performing the cutting operation.

[0006] A problem with abrasive water jet cutting nozzles on the market today is that it is difficult and time consuming to concentrically arrange the jewel element, the mixing chamber and the focusing tube in the abrasive water jet cutting nozzle. The fluid path through the abrasive water jet cutting nozzle is several centimetres long and therefore even small alignment errors are enough to cause increased wear. The persons who replaces and aligns the jewel element, the mixing chamber and the focusing tube in the abrasive water jet cutting nozzle must have a certain degree of skill to be able to accomplish these tasks. Even if the persons have a certain degree of skill the tasks involves the risk of human error in alignment.

[0007] Components with tight tolerances are used to ensure that the jewel element, the mixing chamber and the focusing tube are in axial alignment. It is however expensive to manufacture components with tight tolerances because machining and inspection of the components are time consuming and the component rejection rate increases. Even if the components have tight tolerances it is difficult to achieve a jewel element, a mixing chamber and a focusing tube that are concentrically arranged because the several tolerances need to cooperate with each other.

[0008] An example of a known cutting head for a water jet cutting machine is shown in document US-5018670-A. The cutting head disclosed in document US-5018670-A has a generally upright body having a water inlet chamber. The cutting head further comprises a coupling having a passage open to the chamber to deliver ultra high pressure water to the chamber. An internal threaded sleeve having threads at the upper end of the body accommodates a male threaded end of the coupling. Because the body and the coupling are threadedly connected to each other it is difficult to reach a perfect alignment of the jewel element, the mixing chamber and the focusing tube.

[0009] All the above problems result in less efficient manufacturing processes and higher manufacturing costs in industries using water jet cutting machines.

[0010] As a consequence, in light of the above drawbacks, there is a need of an improved abrasive water jet cutting nozzle which allows the jewel element, the mixing chamber and the focusing tube to be axial aligned so as to minimize wear due to misalignment and thereby maximize the life of the focusing tube and the mixing chamber. There is also a need of an improved abrasive water jet cutting nozzle which provides for easy and quick replacement of wear parts and that is less time consuming and less expensive to produce.

[0011] An improved abrasive water jet cutting nozzle will allow more efficient manufacturing processes and lower manufacturing costs in industries using water jet cutting machines.

SUMMARY OF THE INVENTION

[0012] The subject of the present invention is to eliminate the drawbacks according to prior art.

[0013] This subject has been fulfilled with the abrasive water jet cutting nozzle according to the claims.

[0014] More specifically the abrasive water jet cutting nozzle comprises a mixing chamber, an abrasive material inlet in communication with the mixing chamber and a focusing tube. The focusing tube comprises a first focusing tube portion, a second focusing tube portion, an intermediate focusing tube portion and a conduit. The intermediate focusing tube portion is arranged between the first focusing tube portion and the second focusing tube portion. The abrasive water jet cutting nozzle further comprises a collet arranged in circumferential abutment to the intermediate focusing tube portion. The collet comprises a first collet portion and a second collet portion. The abrasive water jet cutting nozzle further comprises a first body having an upper first body portion, a lower first body portion and an intermediate first body portion. The intermediate first body portion is arranged between the upper first body portion and the lower first body portion. The first body is supporting a jewel element holder comprising a jewel element with an orifice and is arranged in circumferential abutment to the first collet portion, the first focusing tube portion and the mixing chamber. The first body comprises a first downwardly diverging frusto conical shaped recess and the collet comprises a first downwardly diverging frusto conical shaped surface adapted to fit in the first downwardly diverging frusto conical shaped recess.

[0015] The abrasive water jet cutting nozzle further comprises a second body. The second body comprises an upper second body portion, a lower second body portion and a water inlet. The second body is arranged in circumferential abutment to the upper first body portion and the jewel element holder. Further, the second body comprises a second downwardly diverging frusto conical shaped recess. The first body comprises a second downwardly diverging frusto conical shaped surface adapted to fit into the second downwardly diverging frusto conical shaped recess.

[0016] This result in that the first body and the jewel element holder are self centred when inserted into the second body and that the collet, and thereby also the focusing tube and the mixing chamber, are self centred when inserted into the first body. Thereby the conduit of the focusing tube, the mixing chamber and the orifice of the jewel element are always in axial alignment when inserted in the water jet cutting nozzle. Thus the focusing tube, the mixing chamber and the jewel element holder can be removed and replaced with new parts without

realigning and an accurate tool centre point, i.e. a point lying on a centre line of the water jet cutting nozzle and at the downstream end thereof, is always maintained. The wear due to misalignment is minimized and thereby the life of the focusing tube and the mixing chamber is maximized. Also components with less tight tolerances can be used, which results in an abrasive water jet cutting nozzle that is less time consuming and less expensive to produce. This will in turn allow more efficient manufacturing processes and lower manufacturing costs in industries using water jet cutting machines.

[0017] In another aspect of the invention the jewel element holder is integrated in the first body. This results in that the abrasive water jet cutting nozzle comprises fewer components. Thereby fewer tolerances need to cooperate with each other and the assembling of the abrasive water jet cutting nozzle's components is simplified.

[0018] In a further aspect of the invention the mixing chamber is integrated in the focusing tube. This results in that the mixing chamber and the focusing tube always are axially aligned. Further, it results in that the abrasive water jet cutting nozzle comprises fewer components. Thereby fewer tolerances need to cooperate with each other and the assembling of the abrasive water jet cutting nozzle's components is simplified. This also results in that air is prevented from leaking between the mixing chamber and the focusing tube and thereby air is prevented from disturbing the water jet inside the abrasive water jet cutting nozzle.

[0019] In yet another aspect of the invention the abrasive water jet cutting nozzle further comprises a first locking means arranged in circumferential abutment to the second collet portion and the lower first body portion. The first locking means provides for easy and quick replacement of a worn mixing chamber and a worn focusing tube.

[0020] In another aspect of the invention the abrasive water jet cutting nozzle further comprises a second locking means arranged in circumferential abutment to the intermediate first body portion and the lower second body portion. The second locking means provides for easy and quick replacement of a worn jewel element and a worn jewel element holder.

[0021] In a further aspect of the invention the second body further comprises a third downwardly diverging frusto conical shaped recess. The third downwardly diverging frusto conical shaped recess is adapted to fit onto the jewel element holder.

[0022] The abrasive water jet cutting nozzle will allow more efficient manufacturing processes and thereby lower manufacturing costs in industries using water jet cutting machines.

[0023] Other objectives, embodiments and advantages of the present invention are described in closer detail in the description and in the subsequent patent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] In the following prior art and the invention will be described with reference to embodiments of prior art, embodiments of the present invention and the accompanying drawings, in which:

- Fig. 1 shows a schematic view of an abrasive water jet cutting system according to prior art,
- Fig. 2 shows a cross sectional view of an abrasive water jet cutting nozzle according to prior art,
- Fig. 3a shows a cross sectional view of the abrasive water jet cutting nozzle in a first embodiment according to the present invention, and
- Fig. 3b shows a cross sectional view of the abrasive water jet cutting nozzle in a second embodiment according to the present invention.

DETAILED DESCRIPTION OF PRIOR ART AND THE INVENTION

[0025] In the following a number of embodiments of prior art and the invention are shown and described. The same reference numbers have been used for the same or similar features throughout the description in the embodiments disclosed below.

[0026] Fig. 1 shows a schematic view of an abrasive water jet cutting system 1 according to prior art and fig. 2 shows a cross sectional view of an abrasive water jet cutting nozzle 2 according to prior art. The abrasive water jet cutting system 1 will be described with reference to both fig. 1 and fig. 2. The abrasive water jet cutting system 1 comprises a water pump 4. Water 6 is supplied to the water pump 4 from a source of water 8 through a water conduit 10. The water pump 4 increases the pressure of the water 6 to generate desired water pressure.

[0027] The abrasive water jet cutting nozzle 2 comprises an inlet body 12. The inlet body 12 comprises a water inlet 14 with a jewel element holder 16 comprising a jewel element 17 having a small diameter orifice 18, at an upstream end 20 of the inlet body 12. The jewel element 17 can for example comprise sapphire, ruby or diamond or any other erosion resistant material. Water 6 is supplied to the water inlet 14 of the abrasive water jet cutting nozzle 2 from the water pump 4 through the water conduit 10. The water 6 is forced through the jewel element 17 to generate a high-velocity water jet which travels longitudinally towards a downstream end 22 of the jewel element holder 16.

[0028] To enhance the cutting properties of the jet, abrasive material 24 is added to the water jet. The abrasive material 24 can for example comprise garnet, silica or aluminium oxide. The abrasive water jet cutting nozzle 2 comprises, downstream from the orifice 18 of the jewel element 17, an abrasive material inlet 26. The abrasive

material 24 is transported from a source of abrasive 28 to the abrasive material inlet 26 through an abrasive material conduit 30. The abrasive material inlet 26 is in direct communication with a longitudinally extending mixing chamber 32, wherein the abrasive material 24 is received and mixed with the water 6.

[0029] After passing through the mixing chamber 32, the abrasive jet exits from the mixing chamber 32 through an elongated outlet nozzle called focusing tube 34, which is inserted in the abrasive water jet cutting nozzle 2 and which accelerates the jet and directs the jet toward the work piece being cut 36. The water jet cutting focusing tube 34 comprises an outlet 38 at a downstream end 40 of the water jet cutting focusing tube 34. The jet 42 (comprising abrasive and water) exits from the water jet cutting focusing tube 34 through the outlet 38. The mixing chamber 32 can be a single component or it can be integrated in the water jet cutting focusing tube 34. All the above mentioned parts in the abrasive water jet cutting nozzle 2, except for the jewel element 17 and the water jet cutting focusing tube 34, are usually comprising high tensile strength steel so as to withstand hydrostatic pressures and related hydrodynamic shock loads during operation of the abrasive water jet cutting nozzle 2. The water jet cutting focusing tube 34 usually comprises tungsten carbide or ceramic material.

[0030] Fig. 3a shows a cross sectional view of the abrasive water jet cutting nozzle 44 in a first embodiment according to the present invention. The abrasive water jet cutting nozzle 44 comprises a mixing chamber 46, an abrasive material inlet 48 in communication with the mixing chamber 46 and a focusing tube 50 with a circular cross section. The mixing chamber 46 can be a single component or it can be integrated in the focusing tube 50. Preferably, the mixing chamber 46 is integrated in the focusing tube 50. The focusing tube 50 comprises a first focusing tube portion 52, a second focusing tube portion 54 and an intermediate focusing tube portion 56. The intermediate focusing tube portion 56 is arranged between the first focusing tube portion 52 and the second focusing tube portion 54. The focusing tube 50 further comprises a conduit 58 in the centre of the focusing tube 50. The conduit 58 is in fluid communication with the mixing chamber 46. The abrasive water jet cutting nozzle 44 further comprises a collet 60 arranged in circumferential abutment to the intermediate focusing tube portion 56. The collet 60 comprises a first collet portion 62 and a second collet portion 64.

[0031] The abrasive water jet cutting nozzle 44 further comprises a first body 66. The first body 66 comprises an upper first body portion 68, a lower first body portion 70 and an intermediate first body portion 72. The intermediate first body portion 72 is arranged between the upper first body portion 68 and the lower first body portion 70. The first body 66 supports a jewel element holder 74 and is arranged in circumferential abutment to the first collet portion 62, the first focusing tube portion 52 and the mixing chamber 46. The jewel element holder 74

comprises a jewel element 75. The jewel element holder 74 and the jewel element 75 are coaxially arranged to each other. The jewel element 75 is arranged in the portion of the jewel element holder 74 furthest away from the first body 66. The jewel element 75 comprises, in the centre of the jewel element 75, an orifice 76. The orifice 76 is in fluid communication with the mixing chamber 46. The jewel element holder 74 can be a single component or it can be integrated in the first body 66. Preferably, the jewel element holder 74 is integrated in the first body 66. The first body 66 comprises a first downwardly diverging frusto conical shaped recess 78 and the collet 60 comprises a first downwardly diverging frusto conical shaped surface 80 adapted to fit in the first downwardly diverging frusto conical shaped recess 78. The collet 60 has a cylindrical inner surface 81.

[0032] The abrasive water jet cutting nozzle 44 further comprises a second body 82. The second body 82 comprises an upper second body portion 84, a lower second body portion 86 and a water inlet 88. The abrasive material inlet 48 extends generally radially, at an angle α with respect to a longitudinal centre axis A of the abrasive water jet cutting nozzle 44, from the exterior of the second body 82 to the mixing chamber 46. Preferably, the angle α can be about 60 degrees. An angle α of about 60 degrees permits a smooth flow and efficient entrainment of the abrasive material in the water. However, the present invention is not limited to an angle α of 60 degrees since any angle between about 0 to about 90 degrees is possible. The second body 82 is arranged in circumferential abutment to the upper first body portion 68 and the jewel element holder 74. The second body 82 comprises a second downwardly diverging frusto conical shaped recess 90 and a third downwardly diverging frusto conical shaped recess 92. The first body 66 comprises a second downwardly diverging frusto conical shaped surface 94 adapted to fit into the second downwardly diverging frusto conical shaped recess 90. The third downwardly diverging frusto conical shaped recess 92 is adapted to fit onto the jewel element holder 74. In the embodiment in fig. 3a a jewel element holder 74 with a conical outer surface is shown. Preferably, the jewel element holder 74 comprises a conical outer surface. However, it is possible for the jewel element holder 74 to not comprise a conical outer surface. For example, the jewel element holder 74 can only comprise a cylindrical outer surface.

[0033] The first downwardly diverging frusto conical shaped recess 78 and the first downwardly diverging frusto conical shaped surface 80 extends at an angle β with respect to the longitudinal centre axis A of the abrasive water jet cutting nozzle 44. The second downwardly diverging frusto conical shaped recess 90 and the second downwardly diverging frusto conical shaped surface 94 extends at an angle γ with respect to the longitudinal centre axis A of the abrasive water jet cutting nozzle 44. The third downwardly diverging frusto conical shaped recess 92 and the conical surface of the jewel element holder 74 extends at an angle δ with respect to the flat upper

surface of the jewel element 75. The angle β and γ can be in the range from about 0 degrees to about 45 degrees and they do not have to be the same. For example angle β can be 6 degrees and the angle γ can be 12 degrees. The angle δ can be in the range from about 0 degrees to about 60 degrees.

[0034] The abrasive water jet cutting nozzle 44 further comprises a first locking means 96 arranged in circumferential abutment to the second collet portion 64 and the lower first body portion 70. The first locking means 96 comprises an upstream inner wall 97. The upstream inner wall 97 and the lower first body portion 70 are threadedly engaged (not shown). Further, the abrasive water jet cutting nozzle 44 comprises a second locking means 98 arranged in circumferential abutment to the intermediate first body portion 72 and the lower second body portion 86. The second locking means 98 is threadedly engaged (not shown) to the intermediate first body portion 72 and the lower second body portion 86.

[0035] The focusing tube 50 and the mixing chamber 46 wear out quicker and thereby needs to be replaced more often than the jewel element holder 74 and the jewel element 75. It is therefore advantageous with an abrasive water jet cutting nozzle 44 comprising two locking means 96, 98 instead of one locking means because thereby not all the components of the abrasive water jet cutting nozzle 44 need to be reassembled when the jewel element holder 74, the jewel element 75, the mixing chamber 46 or the focusing tube 50 is replaced.

[0036] Fig. 3b shows a cross sectional view of the abrasive water jet cutting nozzle 44 in a second embodiment according to the present invention. The first and the second embodiment is the same except from that the abrasive water jet cutting nozzle 44 in the second embodiment comprises a water inlet body 99 and it is the water inlet body 99 that comprises the water inlet 88. The water inlet body 99 is removably insertable in the second body 82. The water inlet body 99 and the second body 82 can be threadedly (not shown) connected to each other. Thus, the second body 82 is in circumferential abutment to the water inlet body 99. The water inlet body 99 comprises a fourth downwardly diverging frusto conical shaped recess 92' adapted to fit onto the jewel element holder 74. The fourth downwardly diverging frusto conical shaped recess 92' extends at an angle δ with respect to the flat upper surface of the jewel element 75. The angle δ can be in the range from about 0 degrees to 60.

[0037] During use of the abrasive water jet cutting nozzle 44, water is supplied to the water inlet 88 of the second body 82 (according to fig. 3a) or of the water inlet body 99 (according to fig. 3b). The water is forced through the jewel element 75 to generate a high-velocity water jet which travels longitudinally towards a downstream end 100 of the jewel element holder 74. The mixing chamber 46 receives abrasive material from the abrasive material inlet 48 and the abrasive material is mixed with the water jet in the mixing chamber 46. After passing through the mixing chamber 46, the abrasive jet exits from the mixing

chamber 46 through the focusing tube 50, which accelerates the jet and directs the jet toward the work piece being cut. The focusing tube 50 comprises an outlet 102 at a downstream end 104 of the conduit 58. The jet (comprising abrasive and water) exits from the focusing tube 50 through the outlet 102.

[0038] The present invention is of course not in any way restricted to the preferred embodiments described above, but many possibilities to modifications, or combinations of the described embodiments, thereof should be apparent to a person with ordinary skill in the art without departing from the basic idea of the invention as defined in the appended claims.

[0039] The liquid most frequently used to form a jet is water, but numerous other liquids can be used without departing from the scope of the invention, and the recitation of the jet comprising water should not be interpreted as a limitation.

Claims

1. Abrasive water jet cutting nozzle (44) comprising a mixing chamber (46), an abrasive material inlet (48) in communication with the mixing chamber (46), a focusing tube (50), having a first focusing tube portion (52), a second focusing tube portion (54), an intermediate focusing tube portion (56), arranged between the first focusing tube portion (52) and the second focusing tube portion (54), and a conduit (58), further comprising a collet (60) arranged in circumferential abutment to the intermediate focusing tube portion (56) and having a first collet portion (62) and a second collet portion (64), further comprising a first body (66) having an upper first body portion (68), a lower first body portion (70) and an intermediate first body portion (72), arranged between the upper first body portion (68) and the lower first body portion (70), wherein the first body (66) is supporting a jewel element holder (74) comprising a jewel element (75) with an orifice (76) and is arranged in circumferential abutment to the first collet portion (62), the first focusing tube portion (52) and the mixing chamber (46), wherein the first body (66) comprises a first downwardly diverging frusto conical shaped recess (78) and the collet (60) comprises a first downwardly diverging frusto conical shaped surface (80) adapted to fit in the first downwardly diverging frusto conical shaped recess (78), **characterized in that** further comprising a second body (82), having an upper second body portion (84), a lower second body portion (86) and a water inlet (88), arranged in circumferential abutment to the upper first body portion (68) and the jewel element holder (74), wherein the second body (82) comprises a second downwardly diverging frusto conical shaped recess (90) and the first body (66) comprises a second downwardly di-

verging frusto conical shaped surface (94) adapted to fit into the second downwardly diverging frusto conical shaped recess (90), such that the focusing tube (50), the mixing chamber (46) and the jewel element (75) are in axial alignment.

2. The abrasive water jet cutting nozzle according to claim 1, **characterized in that** the jewel element holder (74) is integrated in the first body (66).
3. The abrasive water jet cutting nozzle according to claim 1 or 2, **characterized in that** the mixing chamber (46) is integrated in the focusing tube (50).
4. The abrasive water jet cutting nozzle according to any of the above claims, **characterized in that** the abrasive water jet cutting nozzle (44) further comprises a first locking means (96) arranged in circumferential abutment to the second collet portion (64) and the lower first body portion (70).
5. The abrasive water jet cutting nozzle according to any of the above claims, **characterized in that** the abrasive water jet cutting nozzle (44) further comprises a second locking means (98) arranged in circumferential abutment to the intermediate first body portion (72) and the lower second body portion (86).
6. The abrasive water jet cutting nozzle according to any of the above claims, **characterized in that** the second body (82) comprises a third downwardly diverging frusto conical shaped recess (92) adapted to fit onto the jewel element holder (74).

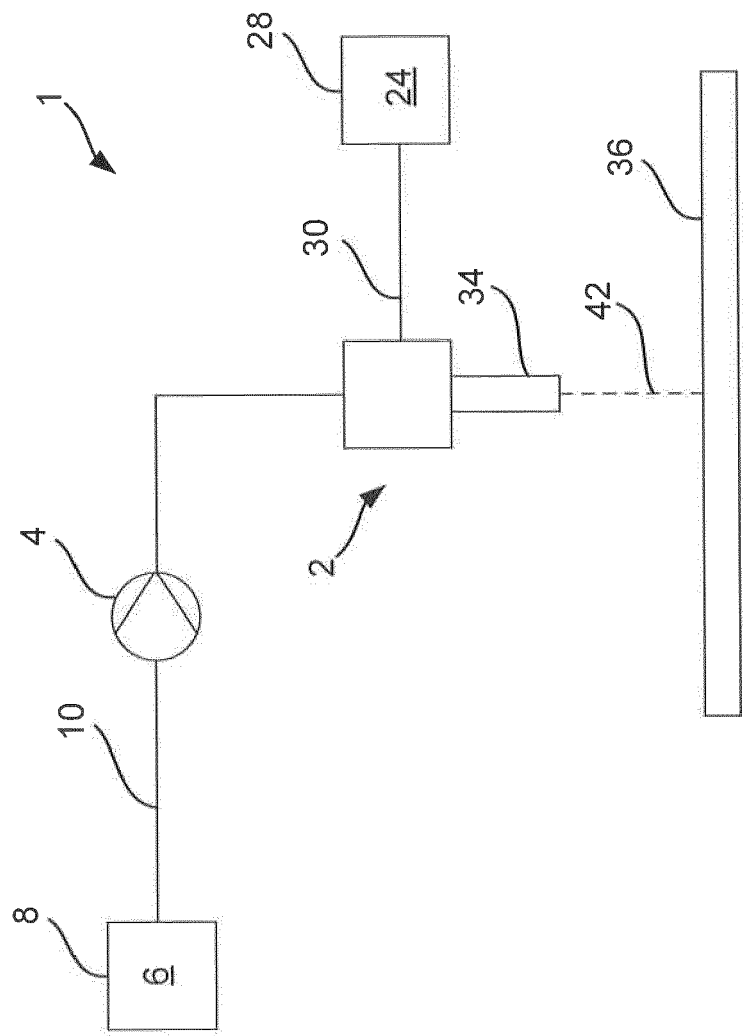


Fig. 1

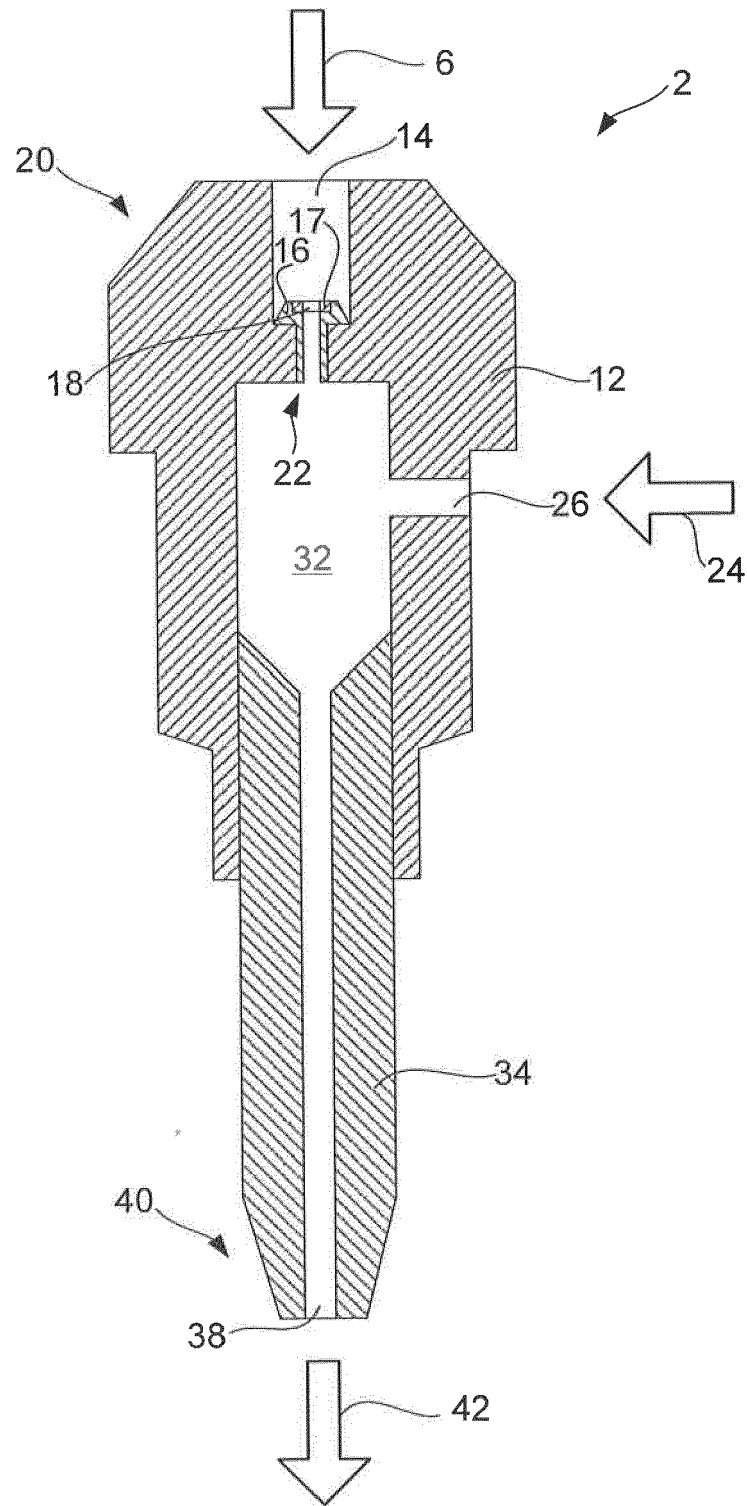


Fig. 2

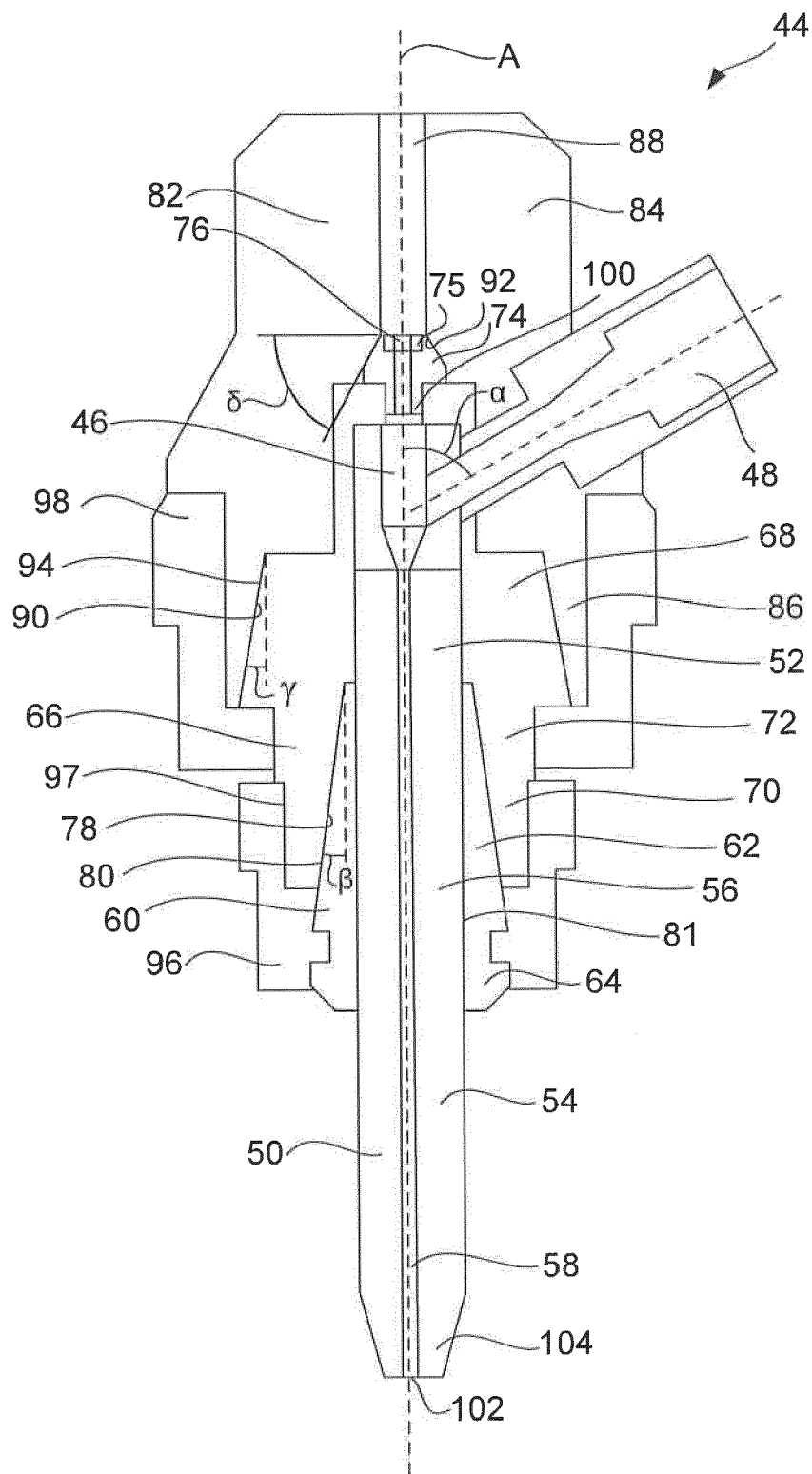


Fig. 3a

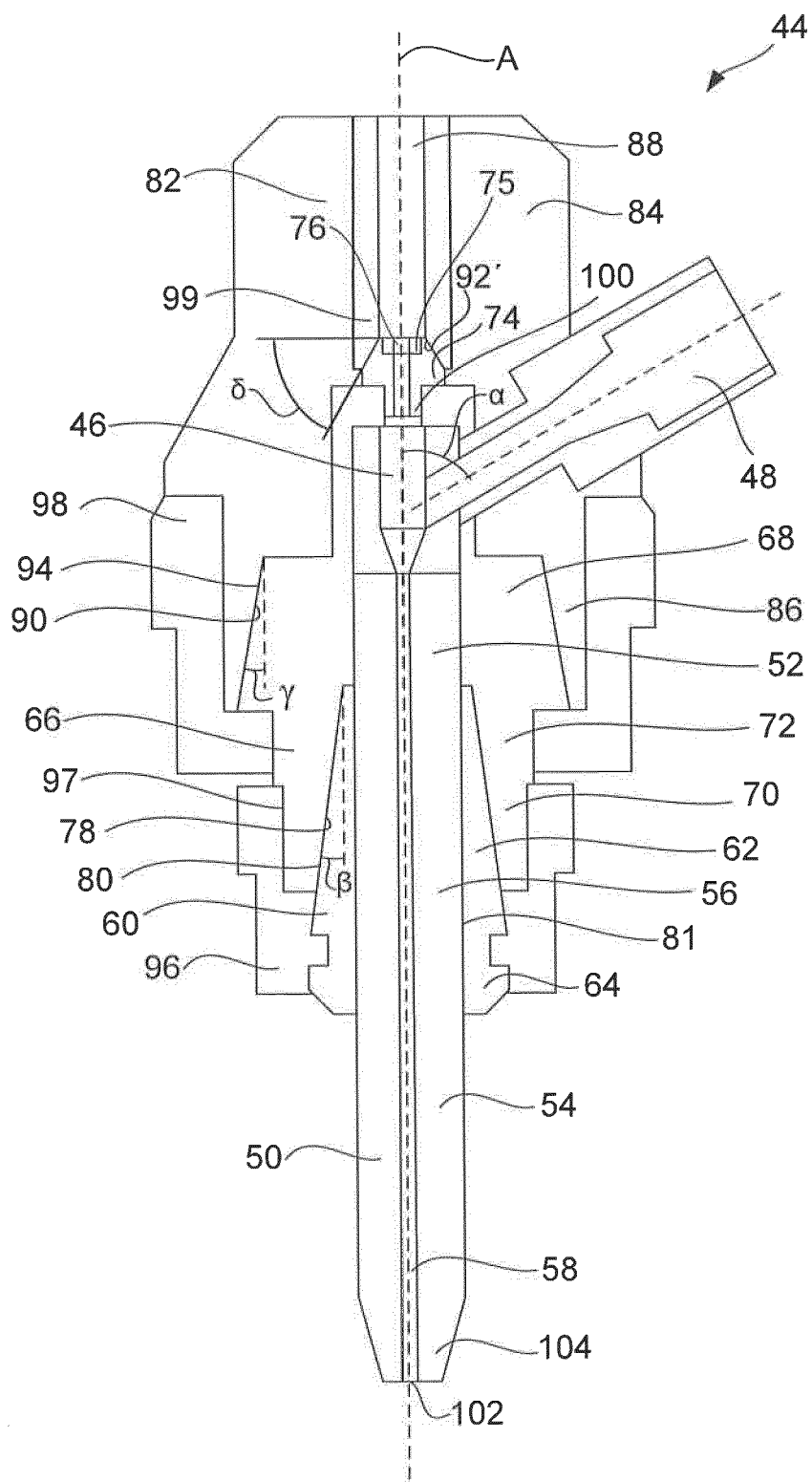


Fig. 3b



EUROPEAN SEARCH REPORT

Application Number
EP 13 18 6434

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DOCUMENTS CONSIDERED TO BE RELEVANT			
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 14 January 2014	Examiner Eder, Raimund
CATEGORY OF CITED DOCUMENTS		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	
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			

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 13 18 6434

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
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