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(54) **Water jet cutting focusing tube, water jet cutting mixing chamber and water jet cutting focusing tube with integrated mixing chamber**

(57) The present invention relates to a water jet cutting focusing tube (44) comprising an elongated tubular body (46), having a generally circular cross section, with an upstream end (48) and a downstream end (50). The upstream end (48) comprises an inlet (52) and the downstream end (50) comprises an outlet (56). The elongated tubular body (46) comprises a flat outer surface (58) extending along a substantial portion of the length (L1) of the water jet cutting focusing tube (44). The present invention also relates to a water jet cutting mixing chamber (60) and a water jet cutting focusing tube with integrated mixing chamber (82).

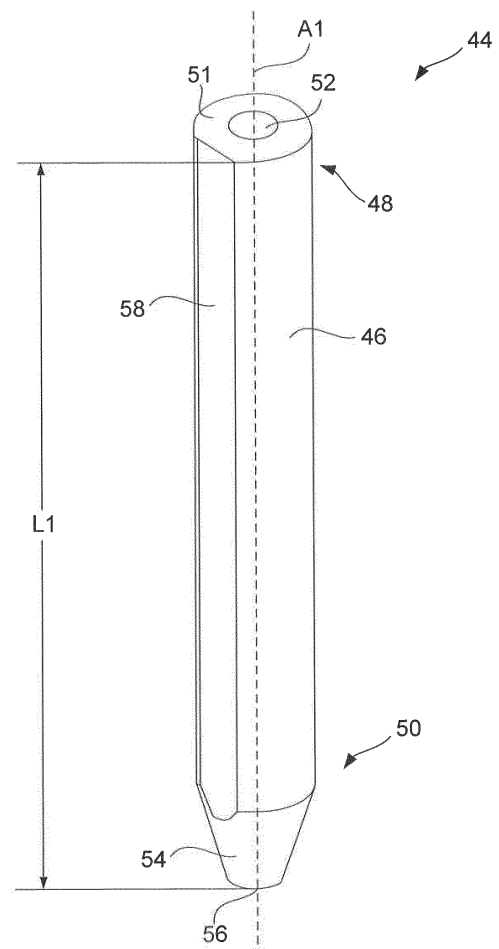


Fig. 3a

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## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to a water jet cutting focusing tube according to the preamble of claim 1. The invention also relates to a water jet cutting mixing chamber and a water jet cutting focusing tube with integrated mixing chamber.

### 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]** A water jet cutting machine comprises a water pump which increases the pressure of the water. It also comprises a 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. 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. 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. The mixing chamber can be a single component or it can be integrated in the focusing tube.

**[0004]** A focusing tube which does not comprise a mixing chamber, a mixing chamber which is not integrated in a focusing tube and a focusing tube with integrated mixing chamber are all removably insertable in the water jet cutting nozzle of the water jet cutting machine. It is common with mixing chambers and focusing tubes, with or without integrated mixing chambers, having circular cross sections because they are less expensive to produce compared to mixing chambers and focusing tubes having other cross sections. One problem with a focusing tube and a mixing chamber having circular cross sections is that it is hard to prevent the focusing tube and the mixing chamber to rotate about their longitudinal axis when inserted in a water jet cutting nozzle of a water jet cutting machine. Thereby it is hard to firmly affix a focusing tube and a mixing chamber in a water jet cutting nozzle. It is also hard to prevent relative movement between a focusing tube and a water jet cutting nozzle as well as

between a mixing chamber and a water jet cutting nozzle. Relative movement between a focusing tube and a water jet cutting nozzle or between a mixing chamber and a water jet cutting nozzle can lead to increased wear of components and machine failure. It is possible to prevent the focusing tube and the mixing chamber to rotate about their longitudinal axis by providing extra holding means, but that is an expensive and complicated solution.

**[0005]** A water jet cutting machine comprises a source of abrasive material with an outlet for abrasive material. A mixing chamber and a focusing tube with integrated mixing chamber each comprise an inlet for abrasive material. Another problem with a focusing tube with integrated mixing chamber and a mixing chamber with circular cross sections is that it is hard to fit the water jet cutting machines outlet for abrasive material to the focusing tube's inlet for abrasive material or to the mixing chamber's inlet for abrasive material.

**[0006]** The focusing tube and the mixing chamber are the most wearable parts in a water jet cutting machine and needs to be replaced depending on requested cutting quality requirements. Often a new focusing tube and a new mixing chamber, that will replace a worn out focusing tube and a worn out mixing chamber, are put on a workbench, or similar, before replacement. A focusing tube and a mixing chamber with circular cross sections can easily start rolling of the workbench, fall to the ground and get damaged. Focusing tubes and mixing chambers are also often made of ceramic materials, which are brittle. Thus a focusing tube and a mixing chamber made of ceramic material have an even higher risk to get damaged if falling to the ground.

**[0007]** An example of a known focusing tube with a circular cross section for a high pressure liquid jet abrasive cutting apparatus is shown in document US-5092085-A.

**[0008]** An example of a known focusing device comprising an elongated cylindrical body with flats formed at the upper end of the cylindrical body is shown in document US-2008032610-A. The focusing device may be sequentially incrementally positioned as to evenly distribute wear on the focusing device body to thereby prolong the useful life thereof. In addition, the focusing device can easily start rolling of the workbench, fall to the ground and get damaged.

**[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 water jet cutting focusing tube, an improved water jet cutting mixing chamber and an improved water jet cutting focusing tube with integrated mixing chamber which cannot easily roll on a flat surface, which are easy to firmly affix in a water jet cutting nozzle of a water jet cutting machine and which facilitates the water jet cutting machines outlet for abrasive material to fit to the inlet for abrasive material of a focusing tube with integrated mixing chamber or to fit the

mixing chamber's inlet for abrasive material.

**[0011]** There is also a need of an improved water jet cutting focusing tube, an improved water jet cutting mixing chamber and an improved water jet cutting focusing tube with integrated mixing chamber which prevent relative movement between the water jet cutting focusing tube and the water jet cutting nozzle, between the water jet cutting mixing chamber and the water jet cutting nozzle and between the focusing tube with integrated mixing chamber and the water jet cutting nozzle.

**[0012]** There is also a need of an improved water jet cutting focusing tube, an improved water jet cutting mixing chamber and an improved water jet cutting focusing tube with integrated mixing chamber that will allow for more efficient manufacturing processes and thereby lower manufacturing costs in industries using water jet cutting machines.

## SUMMARY OF THE INVENTION

**[0013]** The subject of the present invention is to eliminate the drawbacks according to prior art.

**[0014]** This subject has been fulfilled with the water jet cutting focusing tube, as well as the water jet cutting mixing chamber and the water jet cutting focusing tube with integrated mixing chamber according to the claims.

**[0015]** More specifically the water jet cutting focusing tube comprises an elongated tubular body, having a generally circular cross section, with an upstream end and a downstream end. The upstream end comprises an inlet and the downstream end comprises an outlet. The elongated tubular body comprises a flat outer surface extending along a substantial portion of the length of the water jet cutting focusing tube.

**[0016]** In another aspect of the invention the flat outer surface of the water jet cutting focusing tube is extending along at least 50 % of the length of the water jet cutting focusing tube.

**[0017]** In a further aspect of the invention the flat outer surface of the water jet cutting focusing tube is extending along at least 75 % of the length of the water jet cutting focusing tube.

**[0018]** In yet another aspect of the invention the flat outer surface of the water jet cutting focusing tube is extending from the upstream end to the downstream end.

**[0019]** The water jet cutting mixing chamber comprises a tubular body, having a generally circular cross section, with an upstream end and a downstream end. The upstream end comprises a first inlet and a second inlet. The downstream end comprises an outlet. The tubular body comprises a flat outer surface extending along a substantial portion of the length of the water jet cutting mixing chamber.

**[0020]** The water jet cutting focusing tube with integrated mixing chamber comprises an elongated tubular body, having a generally circular cross section, with an upstream end and a downstream end. The upstream end comprises a first inlet and a second inlet. The down-

stream end comprises an outlet. The elongated tubular body comprises a flat outer surface extending along a substantial portion of the length of the water jet cutting focusing tube with integrated mixing chamber.

**[0021]** In another aspect of the invention the flat outer surface of the water jet cutting focusing tube with integrated mixing chamber is extending along at least 50 % of the length of the water jet cutting focusing tube with integrated mixing chamber.

**[0022]** In a further aspect of the invention the flat outer surface of the water jet cutting focusing tube with integrated mixing chamber is extending along at least 75 % of the length of the water jet cutting focusing tube with integrated mixing chamber.

**[0023]** In yet another aspect of the invention the flat outer surface of the water jet cutting focusing tube with integrated mixing chamber is extending from the upstream end to the downstream end.

**[0024]** This results in a water jet cutting focusing tube, a water jet cutting mixing chamber and a water jet cutting focusing tube with integrated mixing chamber which cannot roll and which are easy to firmly affix in a water jet cutting nozzle of a water jet cutting machine. This also results in a water jet cutting mixing chamber having an inlet for abrasive material and a water jet cutting focusing tube with integrated mixing chamber having an inlet for abrasive material which are easy to fit to the water jet cutting machines outlet for abrasive material.

**[0025]** In this way is also achieved a water jet cutting focusing tube, a water jet cutting mixing chamber and a water jet cutting focusing tube with integrated mixing chamber which prevent relative movement between the water jet cutting focusing tube and the water jet cutting nozzle, between the water jet cutting mixing chamber and the water jet cutting nozzle and between the focusing tube with integrated mixing chamber and the water jet cutting nozzle.

**[0026]** The water jet cutting focusing tube, the water jet cutting mixing chamber and the water jet cutting focusing tube with integrated mixing chamber according to the invention will allow more efficient manufacturing processes and thereby lower manufacturing costs in industries using water jet cutting machines.

**[0027]** Other objectives, embodiments and advantages of the present invention are described in closer detail in the description and in the subsequent patent claims.

## DESCRIPTION OF THE DRAWINGS

**[0028]** 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 perspective view from above of the water jet cutting focusing tube according to the present invention,
- Fig. 3b shows a top view of the water jet cutting focusing tube according to the present invention,
- Fig. 4a shows a perspective view from above of the water jet cutting mixing chamber according to the present invention,
- Fig. 4b shows a perspective view from below of the water jet cutting mixing chamber according to the present invention,
- Fig. 4c shows a top view of the water jet cutting mixing chamber according to the present invention,
- Fig. 5a shows a perspective view from above of the water jet cutting focusing tube with integrated mixing chamber according to the invention, and
- Fig. 5b shows a perspective view from below of the water jet cutting focusing tube with integrated mixing chamber according to the invention.

#### DETAILED DESCRIPTION OF PRIOR ART AND THE INVENTION

**[0029]** 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.

**[0030]** 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.

**[0031]** The abrasive water jet cutting nozzle 2 comprises an inlet body 12. The inlet body 12 comprises a water inlet 14 at an upstream end 20 of the inlet body 12. The abrasive water jet cutting nozzle 2 further comprises a jewel element holder 16 comprising a jewel element 17 having a small diameter orifice 18. The jewel element 17 can for example comprise sapphire, ruby or diamond. 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.

**[0032]** 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.

**[0033]** 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 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 can for example comprise tungsten carbide or ceramic material.

**[0034]** Fig. 3a shows a perspective view from above of the water jet cutting focusing tube 44 (without an integrated mixing chamber) according to the present invention and fig. 3b shows a top view of the water jet cutting focusing tube 44 according to the present invention. The water jet cutting focusing tube 44 will be described with reference to both and fig. 3a and fig. 3b. The water jet cutting focusing tube 44 comprises an elongated tubular body 46 having a length L1. Usually the length L1 of the elongated tubular body 46 is in the range from a few centimetres to several decimetres. The elongated tubular body 46 may comprise for example ceramic material or any other suitable material with high resistance to abrasive wear. The elongated tubular body 46 has a generally circular cross section and comprises an upstream end 48 and an opposite downstream end 50. The elongated tubular body 46 is thus disposed about a longitudinal axis A1 between the upstream end 48 and the downstream end 50. The upstream end 48 comprises a flat top surface 51, extending transversally to the longitudinal axis A1, with an inlet 52. The downstream end 50 comprises a conical section 54 with an outlet 56. The inlet 52 and the outlet 56 are connected by a conduit 57 formed within

the water jet cutting focusing tube 44.

**[0035]** Preferably, water and abrasive material are supplied through the inlet 52. It is however possible for other liquids than water to be supplied through the inlet 52. The water jet cutting focusing tube 44 accelerates the jet and directs the jet toward the work piece being cut 36 (shown in fig. 1). The jet of water and abrasive material exits the water jet cutting focusing tube 44 through the outlet 56. The inlet 52 and the outlet 56 usually have different diameters. The diameter of the inlet 52 can for example be a few millimetres and the diameter of the outlet 56 can for example be in the range from a few hundredths of a millimetre to a few millimetres.

**[0036]** The elongated tubular body 46 further comprises a flat outer surface 58 extending along a substantial portion of the length L1 of the water jet cutting focusing tube 44. The flat outer surface 58 is thus extending parallel to the longitudinal axis A1 and transversally to the flat top surface 51. Preferably, the elongated tubular body 46 comprises one flat outer surface 58. It is however possible for the elongated tubular body 46 to comprise several flat outer surfaces 58. The flat outer surface 58 may be formed by for example forging or cutting. The flat outer surface 58 can for example be formed with a depth in the range from a few tenths of a millimetre to a few millimetres if a diameter D2 of the elongated tubular body 46 is about a few millimetres. Thus the difference between a diameter D1, which is the smallest diameter of the water jet cutting focusing tube 44, and the diameter D2, which is the largest diameter of the water jet cutting focusing tube 44, is in the range from a few tenths of a millimetre to a few millimetres.

**[0037]** Preferably, the flat outer surface 58 is extending from the upstream end 48 to the conical section 54 because the longer the flat outer surface 58 extends along the elongated tubular body 46, the more the water jet cutting focusing tube 44 is prevented from rolling when placed on a flat surface. It is however possible for the flat outer surface 58 to extend along a smaller portion of the length L1 of the water jet cutting focusing tube 44, for example at least 50 % or at least 75 % of the length L1 of the water jet cutting focusing tube 44. Preferably, if the flat outer surface 58 is not extending from the upstream end 48 to the conical section 54, the flat outer surface 58 extends from the upstream end 48. The flat outer surface 58 preferably extends from the upstream end 48 because, if the water jet cutting focusing tube 44 (without integrated mixing chamber) is connected to a mixing chamber with a flat outer surface, the water jet cutting focusing tube 44 is easy to firmly affix in a water jet cutting nozzle and relative movement between the water jet cutting focusing tube 44 and the water jet cutting nozzle is prevented.

**[0038]** Preferably, the downstream end 50 comprises a conical section 54. However, it is possible for the downstream end 50 to not comprise a conical section 54. In that case the downstream end 50 is cylindrical and comprises a flat bottom surface (not shown) of the same di-

ameters D1, D2 as the flat top surface 51 and parallel to the flat top surface 51. Preferably, if the downstream end 50 does not comprise a conical section 54, the flat outer surface 58 is extending from the flat top surface 51 to the flat bottom surface.

**[0039]** Fig. 4a shows a perspective view from above of the water jet cutting mixing chamber 60 according to the present invention, fig. 4b shows a perspective view from below of the water jet cutting mixing chamber 60 according to the present invention and fig. 4c shows a top view of the water jet cutting mixing chamber 60 according to the present invention. The water jet cutting mixing chamber 60 will be described with reference to fig. 4a-c.

**[0040]** The water jet cutting mixing chamber 60 comprises a tubular body 62 having a length L2. The length L2 of the tubular body 62 is usually in the range from a few millimetres to a few centimetres. The tubular body 62 can comprise for example ceramic material or any other suitable material with high resistance to abrasive wear. The tubular body 62 has a generally circular cross section and comprises an upstream end 64 and an opposite downstream end 66. The tubular body 62 is thus disposed about a longitudinal axis A2 between the upstream end 64 and the downstream end 66. The upstream end 64 comprises a flat top surface 68, extending transversally to the longitudinal axis A2, with a first inlet 70. The downstream end 66 comprises a flat bottom surface 72 with an outlet 74. The tubular body 62 comprises a circumferential surface 76, extending parallel to the longitudinal axis A2. The circumferential surface 76 comprises a second inlet 78. The first inlet 70, the second inlet 78 and the outlet 74 are in communication with each other within the water jet cutting mixing chamber 60.

**[0041]** Preferably, water 6 is supplied through the first inlet 70. It is however possible for other liquids than water 6 to be supplied through the first inlet 70. Preferably, abrasive material 24 is supplied through the second inlet 78. The abrasive material 24 is mixed with the water 6 in the water jet cutting mixing chamber 60. The water 6 and the abrasive material 24 exit the water jet cutting mixing chamber 60 through the outlet 74. The diameter of the first inlet 70 and the second inlet 78 can for example be about a few tenths of a millimetre and the diameter of the outlet 74 can for example be about a few millimetres.

**[0042]** The tubular body 62 further comprises a flat outer surface 80 extending along a substantial portion of the length L2 of the water jet cutting mixing chamber 60. The flat outer surface 80 is thus extending parallel to the longitudinal axis A2 and transversally to the flat top surface 68 and the flat bottom surface 72. Preferably, the tubular body 62 comprises one flat outer surface 80. It is however possible for the tubular body 62 to comprise several flat outer surfaces 80. The flat outer surface 80 may be formed by for example forging or cutting. The flat outer surface 80 can for example be formed with a depth in the range from a few tenths of a millimetre to a few millimetres if a diameter D2 of the tubular body 62 is about a few

millimetres. Thus the difference between a diameter D1, which is the smallest diameter of the water jet cutting mixing chamber 60, and the diameter D2, which is the largest diameter of the water jet cutting mixing chamber 60, is in the range from a few tenths of a millimetre to a few millimetres.

**[0043]** Preferably, the flat outer surface 80 is extending from the flat top surface 68 to the flat bottom surface 72 because the longer the flat outer surface 80 extends along the tubular body 62, the more the water jet cutting mixing chamber 60 is prevented from rolling when placed on a flat surface. It is however possible for the flat outer surface 80 to extend along a smaller portion of the length L2 of the water jet cutting mixing chamber 60, for example at least 50 % or at least 75 % of the length L2 of the water jet cutting mixing chamber 60. Preferably, if the flat outer surface 80 is not extending from the flat top surface 68 to the flat bottom surface 72, the flat outer surface 80 extends from the flat top surface 68. The flat outer surface 80 preferably extends from the flat top surface 68 because that results in that the water jet cutting mixing chamber 60 is easy to firmly affix in a water jet cutting nozzle, relative movement between the water jet cutting mixing chamber 60 and the water jet cutting nozzle is prevented and the second inlet 78 (for abrasive material 24) is easy to fit to the water jet cutting machines outlet for abrasive material.

**[0044]** As described above and shown in fig. 4b it is the circumferential surface 76 that comprises the second inlet 78. It is however possible for the flat outer surface 80 to comprise the second inlet 78. But preferably, it is the circumferential surface 76 that comprises the second inlet 78.

**[0045]** Fig. 5a shows a perspective view from above of the water jet cutting focusing tube with integrated mixing chamber 82 according to the invention. Fig. 5b shows a perspective view from below of the water jet cutting focusing tube with integrated mixing chamber 82 according to the invention. The water jet cutting focusing tube with integrated mixing chamber 82 will be described with reference to both and fig. 5a and fig. 5b.

**[0046]** The water jet cutting focusing tube with integrated mixing chamber 82 comprises an elongated tubular body 84 having a length L3. The length L3 of the elongated tubular body 84 can for example be in the range from about a few centimetres to several decimetres. The elongated tubular body 84 can comprise for example ceramic material or any other suitable material with high resistance to abrasive wear. The elongated tubular body 84 has a generally circular cross section and comprises an upstream end 86 and an opposite downstream end 88. The elongated tubular body 84 is thus disposed about a longitudinal axis A3 between the upstream end 86 and the downstream end 88. The upstream end 86 comprises a flat top surface 90, extending transversally to the longitudinal axis A3, with a first inlet 92. The downstream end 88 comprises a conical section 94 with an outlet 96.

**[0047]** The elongated tubular body 84 comprises a cir-

cumferential surface 98, extending parallel to the longitudinal axis A3. The circumferential surface 98 comprises a second inlet 100 at the upstream end 86. The first inlet 92, the second inlet 100 and the outlet 96 are in communication with each other within the water jet cutting focusing tube with integrated mixing chamber 82. Preferably, water 6 is supplied through the first inlet 92. It is however possible for other liquids than water 6 to be supplied through the first inlet 92. Preferably, abrasive material 24 is supplied through the second inlet 100.

**[0048]** Within the water jet cutting focusing tube with integrated mixing chamber 82 the abrasive material 24 is mixed with the water 6 and the jet (of water 6 and abrasive material 24) is accelerated and directed toward the work piece being cut 36 (shown in fig. 1). The water 6 and abrasive material 24 exits the water jet cutting focusing tube with integrated mixing chamber 82 through the outlet 96. Usually the diameter of the first inlet 92, the second inlet 100 and the outlet 96 is about a few tenths of a millimetre.

**[0049]** The elongated tubular body 84 further comprises a flat outer surface 102 extending along a substantial portion of the length L3 of the water jet cutting mixing focusing tube with integrated mixing chamber 82. The flat outer surface 102 is thus extending parallel to the longitudinal axis A3 and transversally to the flat top surface 90. Preferably, the elongated tubular body 84 comprises one flat outer surface 102. It is however possible for the elongated tubular body 84 to comprise several flat outer surfaces 102.

**[0050]** The flat outer surface 102 may be formed by for example forging or cutting. The flat outer surface 102 can for example be formed with a depth in the range from a few tenths of a millimetre to a few millimetres if a diameter D2 of the elongated tubular body 84 is about a few millimetres. Thus the difference between a diameter D1, which is the smallest diameter of the water jet cutting focusing tube with integrated mixing chamber 82, and the diameter D2, which is the largest diameter of the focusing tube with integrated mixing chamber 82, is in the range from a few tenths of a millimetre to a few millimetres. This is shown in and fig. 4c (the top view of the water jet cutting focusing tube with integrated mixing chamber 82 is the same as the top view of the water jet cutting mixing chamber 60).

**[0051]** Preferably, the flat outer surface 80 is extending from the flat top surface 90 to the conical section 94 because the longer the flat outer surface 102 extends along the elongated tubular body 84, the more the water jet cutting focusing tube with integrated mixing chamber 82 is prevented from rolling when placed on a flat surface. It is however possible for the flat outer surface 102 to extend along a smaller portion of the length L3 of the water jet focusing tube with integrated mixing chamber 82, for example at least 50 % or at least 75 % of the length L3 of the water jet cutting focusing tube with integrated mixing chamber 82. Preferably, if the flat outer surface 102 is not extending from the flat top surface 90

to the conical section 94, the flat outer surface 102 extends from the flat top surface 90. The flat outer surface 102 preferably extends from the flat top surface 90 because that results in that the water jet cutting focusing tube with integrated mixing chamber 82 is easy to firmly affix in the water jet cutting nozzle, relative movement between the water jet focusing tube with integrated mixing chamber 82 and the water jet cutting nozzle is prevented and the second inlet 100 (for abrasive material 24) is easy to fit to the water jet cutting machines outlet for abrasive material.

**[0052]** Preferably, the downstream end 88 comprises a conical section 94. However, it is possible for the downstream end 88 to not comprise a conical section 94. In that case the downstream end 88 is cylindrical and comprises a flat bottom surface (not shown) of the same diameters D1, D2 as the flat top surface 90 and parallel to the flat top surface 90. Preferably, if the downstream end 88 does not comprise a conical section 94, the flat outer surface 102 is extending from the flat top surface 90 to the flat bottom surface.

**[0053]** As described above and shown in fig. 5b it is the circumferential surface 98 that comprises the second inlet 100. It is however possible for the flat outer surface 102 to comprise the second inlet 100. But preferably, it is the circumferential surface 98 that comprises the second inlet 100.

**[0054]** 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.

**[0055]** The expression "flat surface" is mentioned above. In this context "flat surface" means a substantially even level surface.

**[0056]** 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. Water jet cutting focusing tube (44) comprising an elongated tubular body (46), having a generally circular cross section, with an upstream end (48) and a downstream end (50), wherein the upstream end (48) comprises an inlet (52) and the downstream end (50) comprises an outlet (56),  
**characterized in that**  
said elongated tubular body (46) comprises a flat outer surface (58) extending along a substantial portion of the length (L1) of the water jet cutting focusing tube (44).

2. The water jet cutting focusing tube according to claim 1, **characterized in that** the flat outer surface (58) is extending along at least 50 % of the length (L1) of the water jet cutting focusing tube (44).
3. The water jet cutting focusing tube according to claim 1 or 2, **characterized in that** the flat outer surface (58) is extending along at least 75 % of the length (L1) of the water jet cutting focusing tube (44).
4. The water jet cutting focusing tube according to claim 1, 2 or 3, **characterized in that** the flat outer surface (58) is extending from the upstream end (48) to the downstream end (50).
5. Water jet cutting mixing chamber (60) comprising a tubular body (62), having a generally circular cross section, with an upstream end (64) and a downstream end (66), wherein the upstream end (64) comprises a first inlet (70) and a second inlet (78), and wherein the downstream end (66) comprises an outlet (74),  
**characterized in that**  
said tubular body (62) comprises a flat outer surface (80) extending along a substantial portion of the length (L2) of the water jet cutting mixing chamber (60).
6. Water jet cutting focusing tube with integrated mixing chamber (82) comprising an elongated tubular body (84), having a generally circular cross section, with an upstream end (86) and a downstream end (88), wherein the upstream end (86) comprises a first inlet (92) and a second inlet (100), and wherein the downstream end (88) comprises an outlet (96), **characterized in that**  
said elongated tubular body (84) comprises a flat outer surface (102) extending along a substantial portion of the length (L3) of the water jet cutting focusing tube with integrated mixing chamber (82).
7. The water jet cutting focusing tube with integrated mixing chamber according to claim 6, **characterized in that** the flat outer surface (102) is extending along at least 50 % of the length (L3) of the water jet cutting focusing tube with integrated mixing chamber (82).
8. The water jet cutting focusing tube with integrated mixing chamber according to claim 6 or 7, **characterized in that** the flat outer surface (102) is extending along at least 75 % of the length (L3) of the water jet cutting focusing tube with integrated mixing chamber (82).
9. The water jet cutting focusing tube with integrated mixing chamber according to claim 6, 7 or 8, **characterized in that** the flat outer surface (102) is extending from the upstream end (86) to the downstream end (88).

stream end (88).

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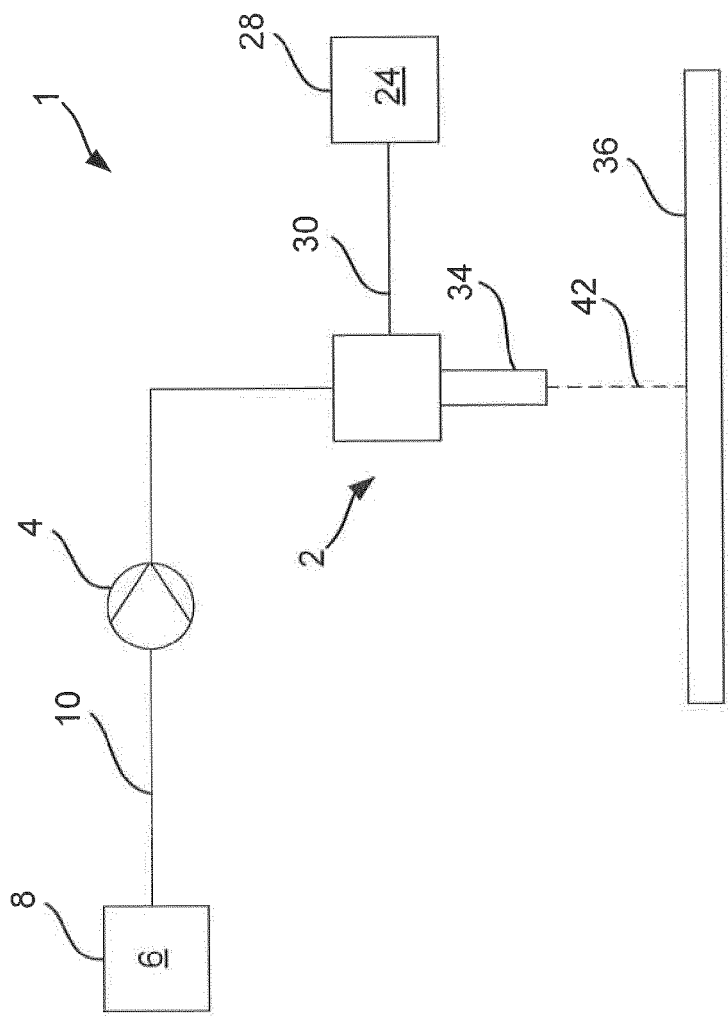


Fig. 1

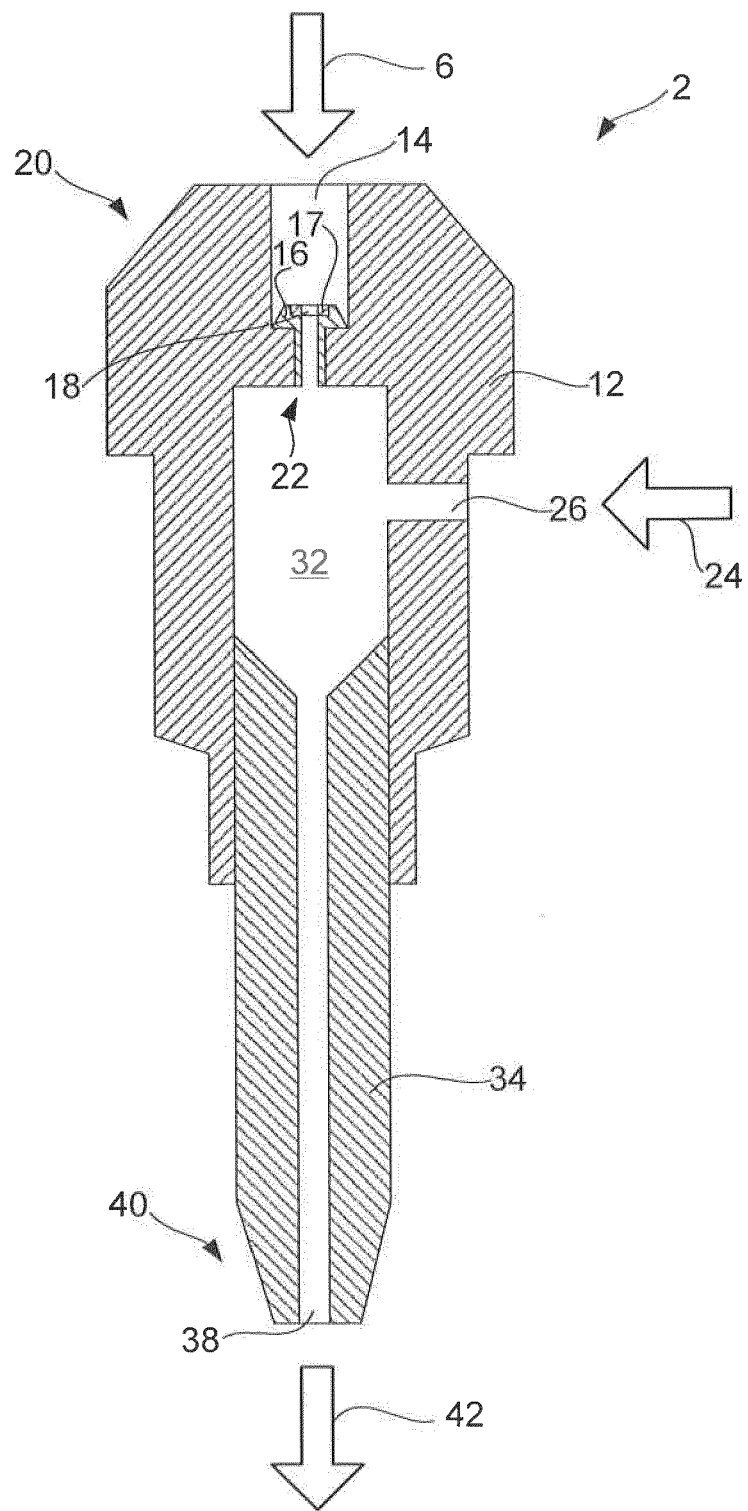
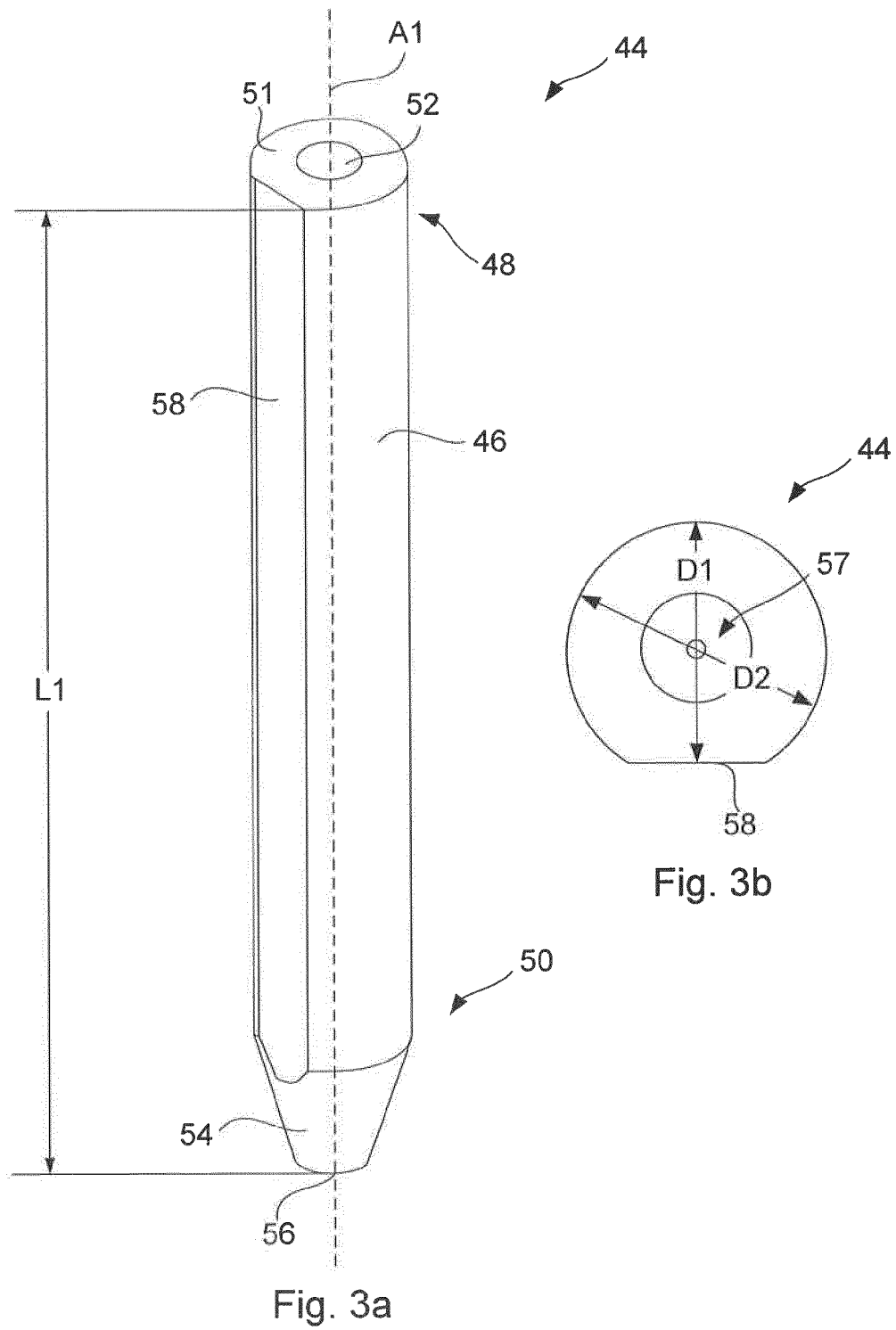


Fig. 2



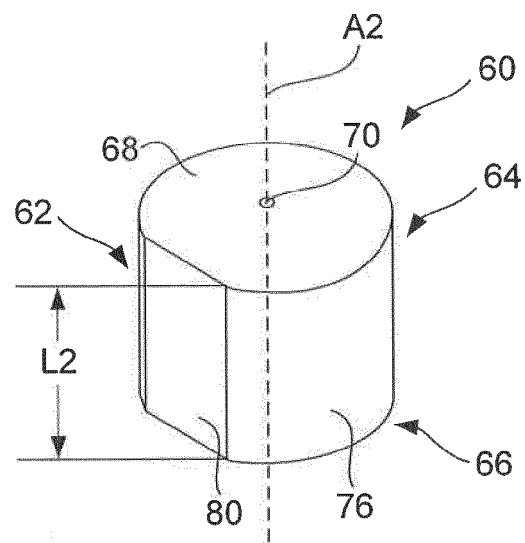


Fig. 4a

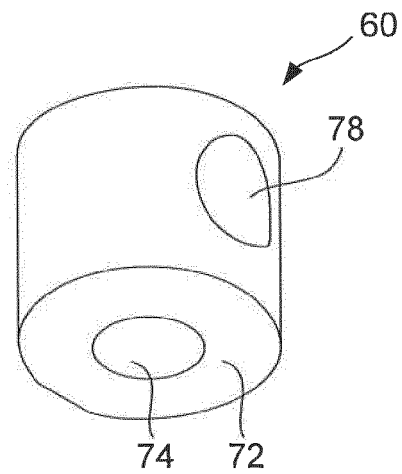


Fig. 4b

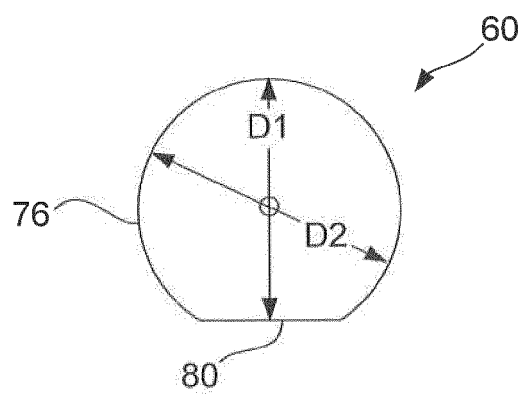
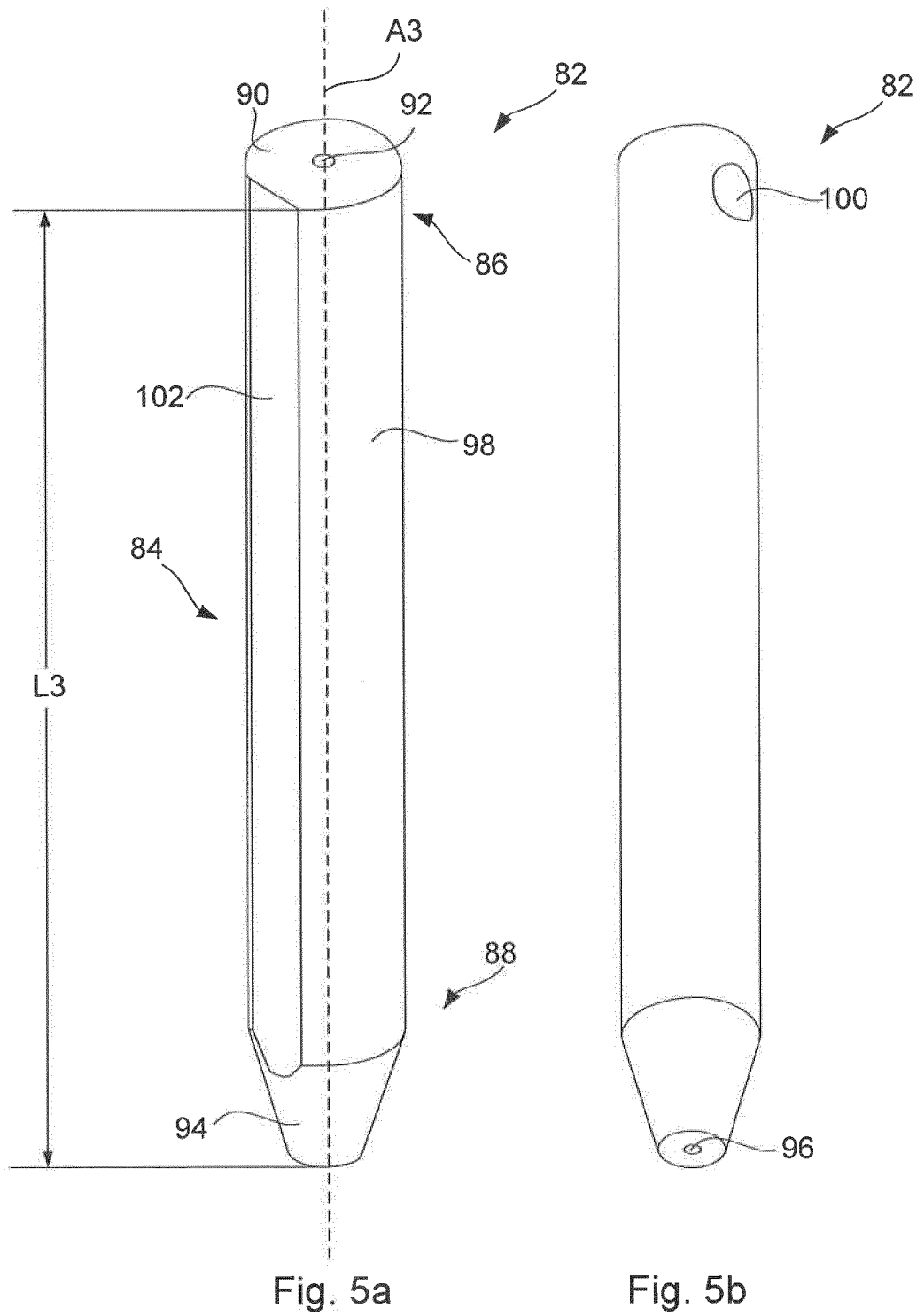


Fig. 4c





## EUROPEAN SEARCH REPORT

Application Number  
EP 13 18 6414

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| The present search report has been drawn up for all claims                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                          |                                                     |                                         |
| Place of search<br>Munich                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                          | Date of completion of the search<br>14 January 2014 | Examiner<br>Eder, Raimund               |
| <p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone<br/>Y : particularly relevant if combined with another document of the same category<br/>A : technological background<br/>O : non-written disclosure<br/>P : intermediate document</p> <p>T : theory or principle underlying the invention<br/>E : earlier patent document, but published on, or after the filing date<br/>D : document cited in the application<br/>L : document cited for other reasons<br/>.....<br/>&amp; : member of the same patent family, corresponding document</p> |                                                                                                                                                                          |                                                     |                                         |

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**ANNEX TO THE EUROPEAN SEARCH REPORT  
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