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(54) **CONTROLLED CAVITATION DEVICE**

(57) The present invention relates to a cavitation device (10) with a shaft (11), a housing (20), a rotor (30), a fluid inlet conduit (24) and a fluid outlet conduit (25). The inlet direction (B-B) of the inlet axis (B) of the fluid inlet conduit (24) is perpendicular to the axial direction (X-X) of the rotor axis (X) of the shaft (11), the outlet direction

(C-C) of the outlet axis (C) of the fluid outlet conduit (24) is perpendicular to the axial direction (X-X). The inlet and outlet ports (22, 23) of the housing (20) are positioned at an axial position spaced apart from the rotor (30), which is shaped as a conical frustum.

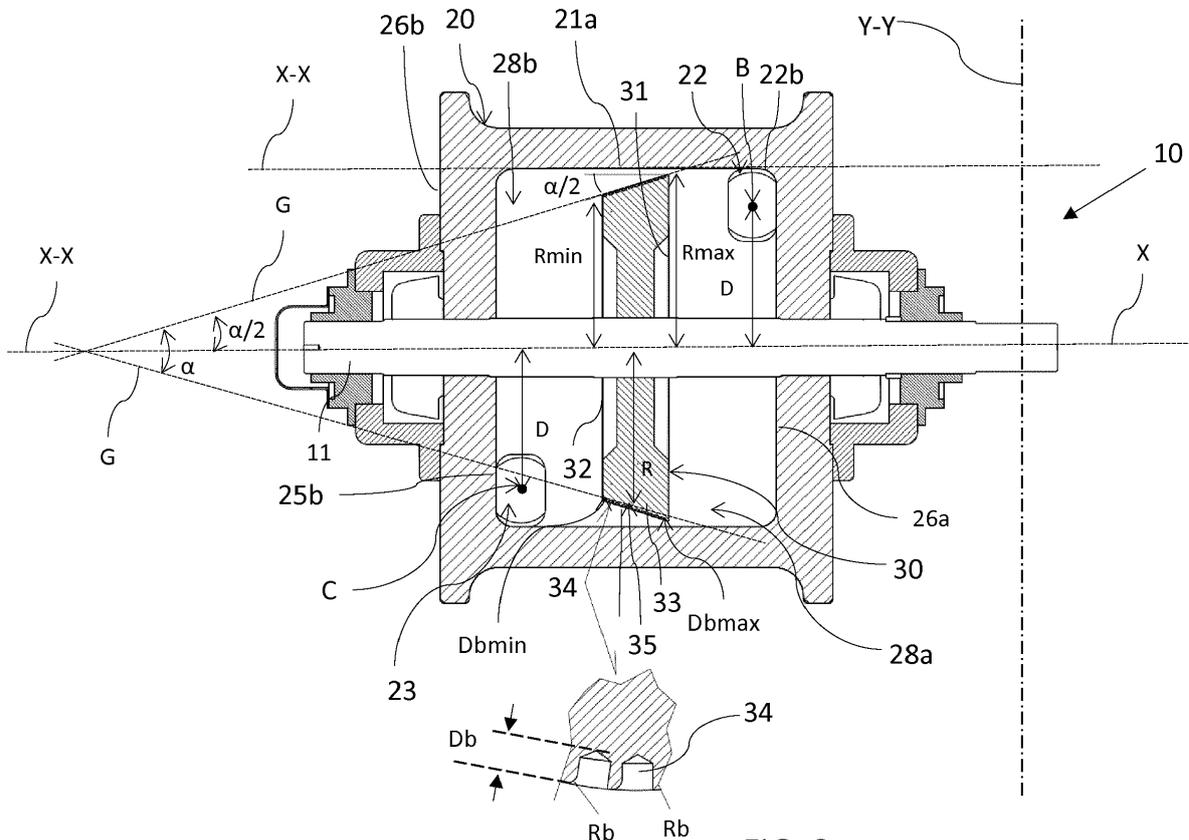


FIG. 3

Description

TECHNICAL FIELD

[0001] The present invention relates to a controlled cavitation device.

BACKGROUND OF THE INVENTION

[0002] A cavitation device is disclosed in EP 610914. This device comprises a housing defining a chamber formed by a cylindrical side wall and a pair of end plates, a shaft passing through an axis of the chamber and a rotor mounted on the shaft within the chamber so as to rotate with the shaft.

[0003] The rotor has a surface toward the side wall provided with uniformly-spaced inwardly-directed recesses or bores at a selected angle. These recesses produce turbulence of fluid within a cavitation zone defined between the rotor and the inner surface of the chamber.

[0004] This device comprises also an inlet port for the introduction of fluid into the space between the rotor and the inner surface of the chamber and an outlet port for the removal of treated fluid. A first and a second fluid connections are connected to the inlet and outlet ports which are oriented axially or radially in the two proposed embodiments.

[0005] A different cavitation device is disclosed in EP 1289638. In this device an inlet port is axially provided on either side of the housing in order to equalize the hydraulic pressure on the rotor and an outlet port is radially provided in the housing in the cylindrical wall of the housing to communicate with the cavitation zone in a region of the rotor intermediate or between the arrays of bores.

[0006] The position of the outlet port ensures that the entire volume of the gas/liquid mixture traverses at least one of the arrays of bores and thus moves through the cavitation zone prior to exiting the housing.

[0007] The cavitation devices mentioned above suffer of problem when treating abrasive fluids, such as biological fluid, manure, sewage, waste, mud any other fluid which incorporates solid particles that may create friction.

[0008] In fact, with the cavitation devices of the prior art, the fluid must vary suddenly its direction and speed when enters and/or exits the chamber of the housing. This change of the direction and speed of the fluid causes wear of the inlet and outlet ports.

[0009] A further cavitation device is disclosed in document EP 15169737 filed by the Applicant. This cavitation device comprises: a shaft, a housing, a cylindrical rotor comprising at least two arrays of bores realized on its lateral surface, a fluid inlet conduit and a fluid outlet conduit. The inlet direction of the inlet axis of the fluid inlet conduit is perpendicular to the axial direction of the rotor axis of the shaft. The outlet direction of the outlet axis of the fluid outlet conduit is perpendicular to the axial direction. The inlet and outlet ports of the housing are

positioned at an axial position spaced apart from the rotor.

[0010] In view of the above prior art, the object of the present invention is to provide a cavitation device which is more efficient with respect to the known cavitation devices. Another object of the present invention is to provide a cavitation device where the direction and speed of the fluid entering and exiting the chamber of the housing is controlled thereby preventing damage of the inlet and outlet ports.

SUMMARY OF THE INVENTION

[0011] According to the present invention, this purpose is fulfilled by a cavitation device according to claim 1.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The characteristics and advantages of the present invention will appear from the following detailed description of one practical embodiment, which is given as a non-limiting example with reference to the annexed drawings, in which:

- figure 1 shows a top view of a cavitation device according to the present invention,
- figure 2 shows a front view of the cavitation device of figure 1,
- figure 3 shows a section view of the cavitation device of figure 1 along the section line A-A,
- figure 4 shows a perspective view of the cavitation device of figure 1.

DETAILED DESCRIPTION

[0013] Referring to the appended figures, figure 1 shows a cavitation device 10 coupled with an electric motor 1 to define a cavitation apparatus 100.

[0014] The cavitation device 10 comprises a shaft 11, a housing 20 and a rotor 30.

[0015] The shaft 11 extends along an axial direction X-X and is configured to be coupled with the electric motor 1. In particular, the electric motor 1 comprises a driving shaft 2 coupled with the shaft 11 of the cavitation device 10 through transmission means 3 to put in rotation the shaft 11.

[0016] The housing 20 defines a cylindrical chamber 21 having an inner cylindrical surface 21a and has a fluid inlet port 22 and a fluid outlet port 23.

[0017] Preferably, the housing 20 has one single fluid inlet 22 and one single fluid outlet 23.

[0018] The rotor 30 is arranged within the cylindrical chamber 21 of the housing 20 and is mounted on the shaft 11 to rotate about a rotor axis X extending along the axial direction X-X.

[0019] A fluid inlet conduit 24 is coupled to the fluid inlet port 22 for supplying fluid into the cylindrical chamber 21 of the housing 20. This fluid inlet conduit 24 has an

inlet axis B extending along an inlet direction B-B.

[0020] A fluid outlet conduit 25 is coupled to the fluid outlet port 23 for receiving fluid from the cylindrical chamber 21 of the housing 20. This fluid outlet conduit 25 has an outlet axis C extending along an outlet direction C-C.

[0021] The housing 20 comprises a first side wall 26a and a second side wall 26b axially spaced from the first side wall 26a along the axial direction X-X.

[0022] The housing 20 comprises also a cylindrical body 27 extending axially between the first side wall 26a and the second side wall 26b and joining the first and second side walls 26a, 26b. The cylindrical body 27 and the first and second side walls 26a, 26b define the cylindrical chamber 21 of the housing 20.

[0023] The rotor 30 comprises a first side surface 31 and a second side surface 32 axially spaced from the first side surface 31 along the axial direction X-X.

[0024] The rotor 30 comprises also a peripheral surface 33 extending between the first side surface 31 and the second side surface 32 and joining the first and second side surfaces 31, 32. The rotor 30 is shaped as a conical frustum, which is a truncated cone of a right circular cone having a circular section and two opposite circular base surfaces, i.e., the first and second side surfaces 31, 32, which extend parallel to each other and perpendicular to the axial direction X-X of the rotor Xx. The peripheral surface 33 of the rotor 30 is shaped as a conical surface which extends in a tapered manner between the first and second side surfaces 31, 32. In other words, the first and second side surfaces 31, 32 are the two flat surfaces of the conical frustum, while the peripheral surface 33 is the lateral tapered surface of the conical frustum. The radial distance between rotor axis X and the peripheral surface 33 defines the rotor radius R of the rotor 30. The axial distance between the first side surface 31 and the second side surface 32 defines the axial extension of the rotor 30.

[0025] Preferably, the radius R of the conical frustum shaped rotor 30 decreases gradually along the axial direction X-X of the rotor axis X from the first side surface 31 to the second side surface 32, such that the radius R reaches a maximum value on the first side surface 31 and a minimum value on the second side surface 32. In particular, the maximum radius Rmax corresponds to the maximum radial distance between the rotor axis X and the peripheral surface 33 measured on the first side surface 31 of the rotor 30. While, the minimum radius Rmin corresponds to the minimum radial distance between the rotor axis X and the peripheral surface 33 measured on the second side surface 32 of the rotor 30. More preferably, the first side surface 31, which is the main surface of the conical frustum, faces the single fluid inlet 22, while the smaller second side surface 32 faces the single fluid outlet 23. Advantageously, the cavitation device having a conical frustum shaped rotor 30 provides a more efficient cavitation with respect to the known cavitation devices.

[0026] Preferably, the conical frustum shaped rotor 30

has an opening angle α ranging from 4° to 60° , more preferably ranging from 10° to 40° , even more preferably the opening angle α measures 20° . The opening angle α is the angle comprised between the two generatrix lines G of the peripheral surface 33 (i.e., lateral surface of the cone). In particular, the perimeter of the base of a cone, i.e., the first side surface 31, is the directrix, and each of the line segments between the directrix and the apex of the cone is a generatrix line G of the peripheral surface 33. The opening angle α , or otherwise named as the aperture of the right circular cone, is the maximum angle between two generatrix lines G (figure 3). It is worth noting that in the present case the aperture angle of the conical frustum corresponds to the opening angle α measured between two generatrix lines G at the virtual apex of the conical frustum (figure 3). Moreover, each generatrix line G makes an angle $\alpha/2$ (i.e., the half of the opening angle α) to the axial direction X-X of the rotor axis X (figure 3). Therefore, an alternative way for defining the conicity of the conical frustum would be to refer to the angle $\alpha/2$. In other words, the conical frustum shaped rotor 30 has a conicity ranging from 2° to 30° , more preferably ranging from 5° to 20° , even more preferably the conicity is 10° .

[0027] At least two arrays of bores 34 are formed in the peripheral surface 33. In the example shown in the figures, the rotor 30 comprises three arrays of bores. The bores 34 of each array of bores are arranged in a row extending around the peripheral surface 33.

[0028] Preferably, each bore 34 extends radially into the rotor 30 from the peripheral surface 33. Preferably, the bores of the at least two array of bores 34 extend radially into said rotor 30 from said peripheral surface 33 for a depth Db which decreases in adjacent arrays of bores 34 along said axial direction X-X of said rotor axis X from the first side surface 31 to the second side surface 32. In detail, each array of bores 34 comprises a predetermined number of radial bores 34 which have a predetermined diameter and depth Db. The depth Db is maximum Dbmax in the first array of bores 34 which is located on the peripheral surface 33 proximate to the first side surface 31, which is closer to the fluid inlet 22. Moving along the axial direction X-X of the rotor axis X, the depth Db decreases in the next arrays of bores 34 which are closer to the fluid outlet 23 until the last array of bores 34 that has the minimum depth Dbmin, and which is located on the peripheral surface 33 proximate to the second side surface 32, which is closer to the fluid outlet 23 (figure 3). Advantageously, this particular configuration of the bores 34 promotes cavitation inside the bores 34. In particular, cavitation occurs inside the volume defined by each bore 34 in an internal and/or recessed portion of the body of the rotor 30. The increased efficiency generated by the conical rotor 30 is consequent to the fact that the fluid velocity decreases subsequently to the first array of bores 34 due to the turbulence created by the first cavitation events. Consequently, cavitation will be less efficient in correspondence the last array of bores 34.

With the conical rotor 30 the speed loss of the fluid determined by the turbulence generated by the bores 34 subsequent to the first array of bores 34 is compensated by the acceleration of the fluid induced by the change (i.e., decrease) in diameter of the conical rotor 30. Therefore, the most preferable technical solution is to realize a conical frustum shaped rotor 30 having an opening angle α that allows fluid to maintain a constant speed. Hence, the optimum opening angle α can be calculated depending on the design of the rotor and of the power that expresses the same, in order to keep the fluid speed constant along the peripheral surface 33, from the fluid inlet to the fluid outlet.

[0029] Preferably, the bores 34 of each array of bores have a peripheral circular edge formed in the peripheral surface 33 which is at least partially rounded (figure 3). More preferably, the peripheral circular edge of the bores 34 of each array of bores can be entirely rounded. The peripheral circular edge of the bores 34 is rounded by a radius R_b (figure 3) which preferably ranges between 10% of the diameter of the bore 34 and 50% of the diameter of the bore 34, and more preferably the radius R_b measures 30% of the diameter of the bore 34. Advantageously, also this particular configuration of the bores 34 improves cavitation control inside the bores 34, especially if combined in a synergic manner with the above mentioned variable depth configuration of the adjacent arrays of bores 34.

[0030] A cavitation zone 35 is defined inside the bores 34.

[0031] Advantageously, the conical frustum configuration of the rotor 30, when combined in a synergic manner with the particular disposition of the arrays of bores 34 having variable depth D_b along the axial direction X-X, promotes and improves cavitation in the cavitation zone 35, especially if compared to the cavitation devices known in the state of the art.

[0032] Preferably, the bores 34 can be realized as holes and/or recesses and/or grooves which extend into the body of the rotor 30 from the peripheral surface 33. More preferably, the bores 34 can be shaped as bores or recesses with variable depth, and with different section profiles, such as circular, polygonal, rectangular, triangular, etc. In other words, the bores 34 can be realized with different shapes in order to improve cavitation inside the bores 34.

[0033] The cylindrical chamber 21 comprises an inlet cylindrical chamber 28a formed between the first side surface 31 and the first side wall 26a and an outlet cylindrical chamber 28b formed between the second side surface 32 and the second side wall 26b.

[0034] The fluid inlet port 22 is positioned in the housing 20 to introduce fluid into the inlet cylindrical chamber 28a at an axial position spaced apart from the first side surface 31 of the rotor 30.

[0035] The fluid outlet port 23 is positioned in the housing 20 to receive fluid from the outlet cylindrical chamber 28b at an axial position spaced apart from the second

side surface 32 of the rotor 30.

[0036] Preferably, the axial distance between the fluid inlet port 22 and the first side surface 31 of the rotor 30 is equal to or greater than the axial extension of the rotor 30.

[0037] Preferably, the axial distance between the fluid outlet port 23 and the second side surface 32 of the rotor 30 is equal to or greater than the axial extension of the rotor 30.

[0038] The inlet direction B-B of the inlet axis B is perpendicular to the axial direction X-X of the rotor axis X and the outlet direction C-C of the outlet axis C is perpendicular to the axial direction X-X of the rotor axis X.

[0039] Preferably, the fluid inlet conduit 24 and the fluid outlet conduit 25 are arranged on the stator 20 such that the fluid supplied through the fluid inlet port 22 and delivered through the fluid outlet port 23 follows within the cylindrical chamber 21 a helical path. The inlet axis B and the outlet axis C are substantially tangential to this helical path.

[0040] With this arrangement of the inlet and outlet axes B and C relative to the rotor axis X and thanks to the axial position of the fluid inlet and outlet ports 22, 23, it is possible to control the tangential speed of the fluid supplied into the housing 20 and received from the housing 20 reducing any effect of suction and delivery.

[0041] The inlet cylindrical chamber 28a and the outlet cylindrical chamber 28b make available two chambers so that, in use, the mass of fluid axially arranged before the rotor 30, in the inlet cylindrical chamber 28a, and after the rotor 30, in the outlet cylindrical chamber 28b, guarantee a rotational inertia which opposes the axial speed of the fluid, with respect to the radial and tangential speed set by the speed of the rotor 30.

[0042] As a consequence, the axial speed of the fluid is independent from the speed of the rotor 30 and the cavitation is thereby controlled.

[0043] This arrangement is extremely advantageous with abrasive fluids, however it can be used with benefit also with non-abrasive fluids and for mixing liquid-liquid, liquid-gas and liquid solid supplied through the fluid inlet conduit 24.

[0044] According to one embodiment, the inlet port 22 is positioned in the housing 20 to introduce fluid into the inlet cylindrical chamber 28a at an axial position adjacent to the first side wall 26a of the housing 20 and the outlet port 23 is positioned in the housing 20 to receive fluid from the outlet cylindrical chamber 28b at an axial position adjacent to the second side wall 26b of the housing 20.

[0045] According to a preferred embodiment, the fluid inlet conduit 24 and the fluid outlet conduit 25 are positioned such that the inlet axis B and the outlet axis C are parallel to and proximate to respective tangential directions to the peripheral surface 33 of the rotor 30 or to respective tangential directions to the inner cylindrical surface 21a of the cylindrical chamber 21 of the stator 20.

[0046] More preferably, the fluid inlet conduit 24 and the fluid outlet conduit 25 have respective first portions

24a, 25a facing a respective plane, in the example a same plane P', passing through the rotor axis X and parallel to the corresponding inlet axis B and outlet axis C and opposite second portions 24b, 25b. The second portions 24b, 25b of the fluid inlet conduit 24 and the fluid outlet conduit 25 join the stator 20 substantially tangentially to the inner cylindrical surface 21a of the cylindrical chamber 21 of the stator 20.

[0047] In the example shown in the figures, the inlet axis B and the outlet axis C are parallel.

[0048] According to one embodiment, the distance between the outlet axis C and the rotor axis X along a direction Y-Y perpendicular to the outlet axis C and the rotor axis X ranges between 70% and 100% the rotor maximum radius Rmax measured on the first side surface (31).

[0049] The same applies to the distance between the inlet axis B and the rotor axis X along a direction Y-Y perpendicular to the inlet axis C and the rotor axis X which ranges between 70% and 100% the rotor maximum radius Rmax measured on the first side surface (31).

[0050] In particular, the inlet axis B and the outlet axis C intersect a plane P passing through the rotor axis X and perpendicular to the inlet and outlet axes B, C at a distance D from the rotor axis X between 70% and 100% the rotor maximum radius Rmax measured on the first side surface (31).

[0051] Preferably, the housing 20 comprises two lateral portions 20a, 20b defined at opposite sides relative to the plane P passing through the rotor axis X and perpendicular to the inlet and outlet axes B, C.

[0052] In the example shown in the figures, the fluid inlet port 22 and the fluid outlet port 23 are positioned on one of the two lateral portions 20a, 20b, namely in the lateral portion 20a.

[0053] Those skilled in the art will obviously appreciate that a number of changes and variants may be made to the arrangements as described hereinbefore to meet incidental and specific needs.

[0054] For example, unless otherwise imposed by evident technical limitations, any feature described in a preferred embodiment may be clearly used in another embodiment, with appropriate adaptations.

All the changes will fall within the scope of the invention, as defined in the following claims.

Claims

1. A cavitation device (10) comprising:

- a shaft (11) configured to be coupled with motor means (1), said shaft (11) extending along an axial direction (X-X),
- a housing (20) defining a cylindrical chamber (21) having an inner cylindrical surface (21a), said housing having a fluid inlet port (22) and a fluid outlet port (23),

- a rotor (30) arranged within said cylindrical chamber (21) of said housing (20) and mounted on said shaft (11) to rotate about a rotor axis (X) extending along said axial direction (X-X), said rotor (30) comprises a first side surface (31) and a second side surface (32) axially spaced from said first side surface (31), said rotor (30) comprises a peripheral surface (33) extending between said first and second side surfaces (31, 32) and joining said first and second side surfaces (31, 32),

- a fluid inlet conduit (24) coupled to said fluid inlet port (22) for supplying fluid into said cylindrical chamber (21), said fluid inlet conduit (24) having an inlet axis (B) extending along an inlet direction (B-B),

- a fluid outlet conduit (25) coupled to said fluid outlet port (23) for receiving fluid from said cylindrical chamber (21), said fluid outlet conduit (23) having an outlet axis (C) extending along an outlet direction (C-C),

wherein:

- said housing (20) comprises:

- a first side wall (26a) and a second side wall (26b) axially spaced from said first side wall (26a),
- a cylindrical body (27) extending axially between said first and second side walls (26a, 26b) and joining said first and second side walls (26a, 26b),

- said cylindrical chamber (21) comprises an inlet cylindrical chamber (28a) formed between said first side surface (31) and said first side wall (26a) and an outlet cylindrical chamber (28b) formed between said second side surface (32) and said second side wall (26b),

- said inlet direction (B-B) of said inlet axis (B) is perpendicular to said axial direction (X-X) of said rotor axis (X),

- said outlet direction (C-C) of said outlet axis (C) is perpendicular to said axial direction (X-X) of said rotor axis (X),

- said inlet port (22) is positioned in said housing (20) to introduce fluid into said inlet cylindrical chamber (28a) at an axial position spaced apart from said first side surface (31) of the rotor (30),

- said outlet port (23) is positioned in said housing (20) to receive fluid from said outlet cylindrical chamber (28b) at an axial position spaced apart from said second side surface (32) of the rotor (30),

characterized in that:

- said rotor (30) is shaped as a conical frustum and said peripheral surface (33) is shaped as a conical surface which extends in a tapered manner between said first and second side surfaces (31, 32),
- at least two arrays of bores (34) formed in said peripheral surface (33), the bores (34) of each array of bores being arranged in a row extending around said peripheral surface (33), each bore (33) extending radially into said rotor (30) from said peripheral surface (33),
- a cavitation zone (35) is defined inside the bores 34.
2. The cavitation device (10) according to claim 1, wherein:
- said conical frustum shaped rotor (30) has an opening angle (α) ranging from 4° to 60°.
3. The cavitation device (10) according to any of claims 1 or 2, wherein:
- the radius (R) of said conical frustum shaped rotor (30) decreases gradually along said axial direction (X-X) of said rotor axis (X) from said first side surface (31) to said second side surface (32).
4. The cavitation device (10) according to claim 3, wherein:
- said bores of said at least two array of bores (34) extend radially into said rotor (30) from said peripheral surface (33) for a depth (Db) which decreases in adjacent arrays of bores 34 along said axial direction (X-X) from said first side surface (31) to said second side surface (32).
5. The cavitation device (10) according to any of the preceding claims, wherein:
- said bores (34) of each array of bores have a peripheral circular edge formed in said peripheral surface (33) which is at least partially rounded.
6. The cavitation device (10) according to any of the preceding claims, wherein:
- said inlet port (22) is positioned in said housing (20) to introduce fluid into said inlet cylindrical chamber (28a) at an axial position adjacent said first side wall (26a) of the housing (20),
- said outlet port (23) is positioned in said housing (23) to receive fluid from said outlet cylindrical chamber (28b) at an axial position adjacent said second side wall (26b) of the housing (20).
7. The cavitation device (10) according to any of the preceding claims, wherein:
- said fluid inlet conduit (24) and said fluid outlet conduit (25) are arranged on the stator (20) such that the fluid supplied through said fluid inlet port (22) and delivered through said fluid outlet port (23) follows within the cylindrical chamber (21) a helical path.
8. The cavitation device (10) according to claim 7, wherein:
- said inlet axis (B) and said outlet axis (C) are substantially tangential to said helical path.
9. The cavitation device (10) according to any of the preceding claims, wherein:
- said fluid inlet conduit (24) and said fluid outlet conduit (25) are positioned such that said inlet axis (B) and said outlet axis (C) are parallel to and proximate to respective tangential directions to said peripheral surface (33) of the rotor (30).
10. The cavitation device (10) according to any of the preceding claims, wherein:
- said fluid inlet conduit (24) and said fluid outlet conduit (25) are positioned such that said inlet axis (B) and said outlet axis (C) are parallel to and proximate to respective tangential directions to said inner cylindrical surface (21a) of the cylindrical chamber (21) of the housing (20).
11. The cavitation device (10) according to any of the preceding claims, wherein:
- said fluid inlet conduit (24) and said fluid outlet conduit (25) have respective first portions (24a, 25a) facing a respective plane passing through said rotor axis (X) and parallel to the corresponding inlet axis (B) and outlet axis (C) and opposite second portions (24b, 25b),
- said second portions (24b, 25b) of the fluid inlet conduit (24) and the fluid outlet conduit (25) join the stator (20) substantially tangentially to the inner cylindrical surface (21 a) of the cylindrical chamber (21) of the stator (20).
12. The cavitation device (10) according to any of the preceding claims, wherein:
- the distance (D) between the outlet axis (C) and the rotor axis (X) along a direction (Y-Y) perpendicular to said outlet axis (C) and said rotor axis (X) ranges between 70% and 100%

the maximum radial distance (Rmax) between said rotor axis (X) and said peripheral surface (33) measured on the first side surface (31) of the rotor (30),

- the distance (D) between the inlet axis (B) and the rotor axis (X) along a direction (Y-Y) perpendicular to said inlet axis (B) and said rotor axis (X) ranges between 70% and 100% the maximum radial distance (Rmax) between said rotor axis (X) and said peripheral surface (33) measured on the first side surface (31) of the rotor (30).

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13. The cavitation device (10) according to any of the preceding claims, wherein:

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- said inlet axis (B) intersects a plane (P) passing through said rotor axis (X) and perpendicular to said inlet and outlet axes (B, C) at a distance (D) from said rotor axis (X) between 70% and 100% the maximum radial distance (Rmax) between said rotor axis (X) and said peripheral surface (33) measured on the first side surface (31) of the rotor (30),

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- said outlet axis (C) intersects a plane (P) passing through said rotor axis (X) and perpendicular to said inlet and outlet axes (B, C) at a distance (D) from said rotor axis (X) between 70% and 100% the maximum radial distance (Rmax) between said rotor axis (X) and said peripheral surface (33) measured on the first side surface (31) of the rotor (30).

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14. The cavitation device (10) according to any of the preceding claims, wherein:

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- the axial distance between the fluid inlet port (22) and the first side surface (31) of the rotor (30) is equal to or greater than the axial distance between the first side surface (31) and the second side surface (32) of the rotor (30).

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15. The cavitation device (10) according to any of the preceding claims, wherein:

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- the axial distance between the fluid outlet port (23) and the second side surface (32) of the rotor (30) is equal to or greater than the axial distance between the first side surface (31) and the second side surface (32) of the rotor (30).

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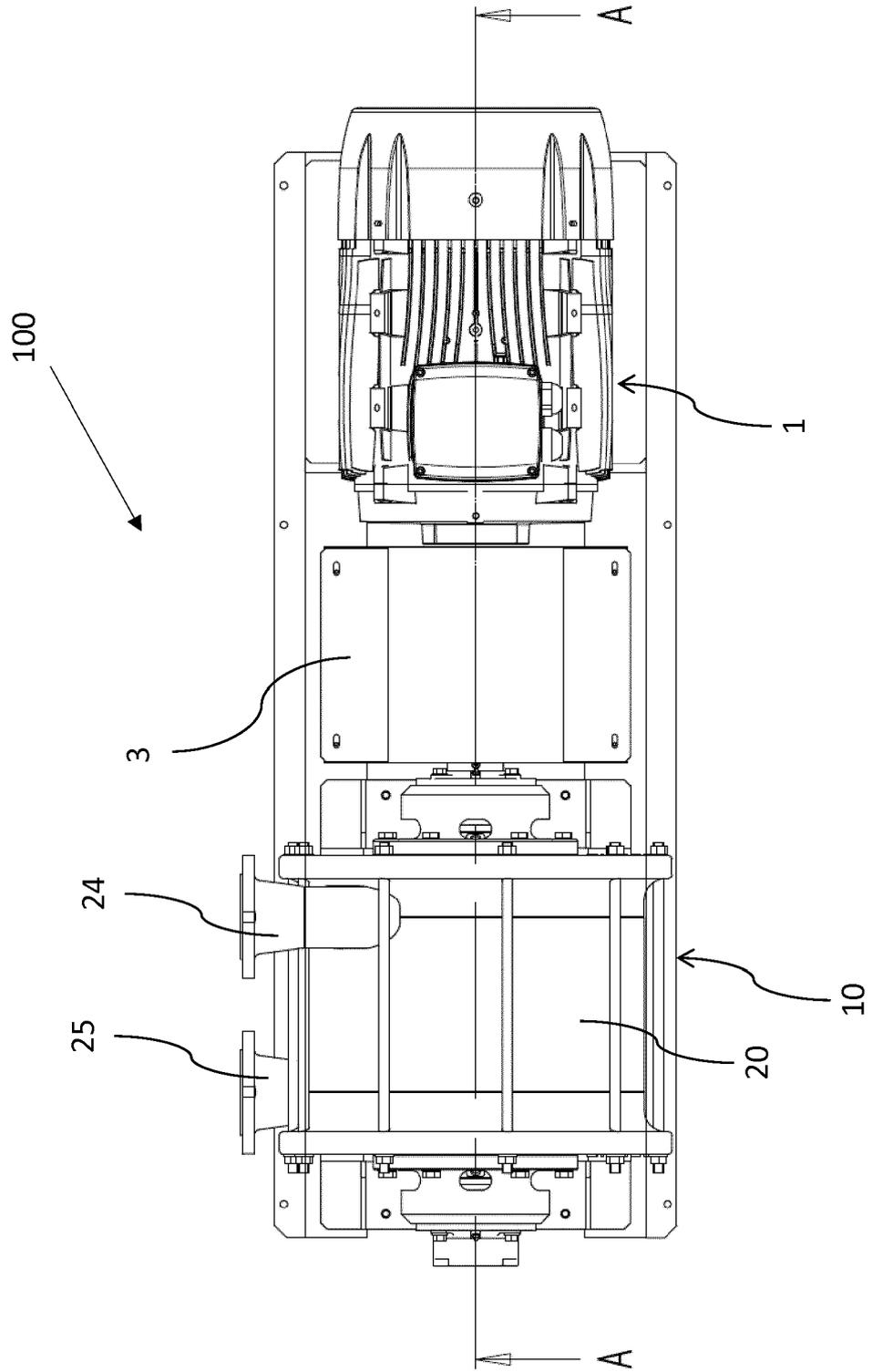


FIG. 1

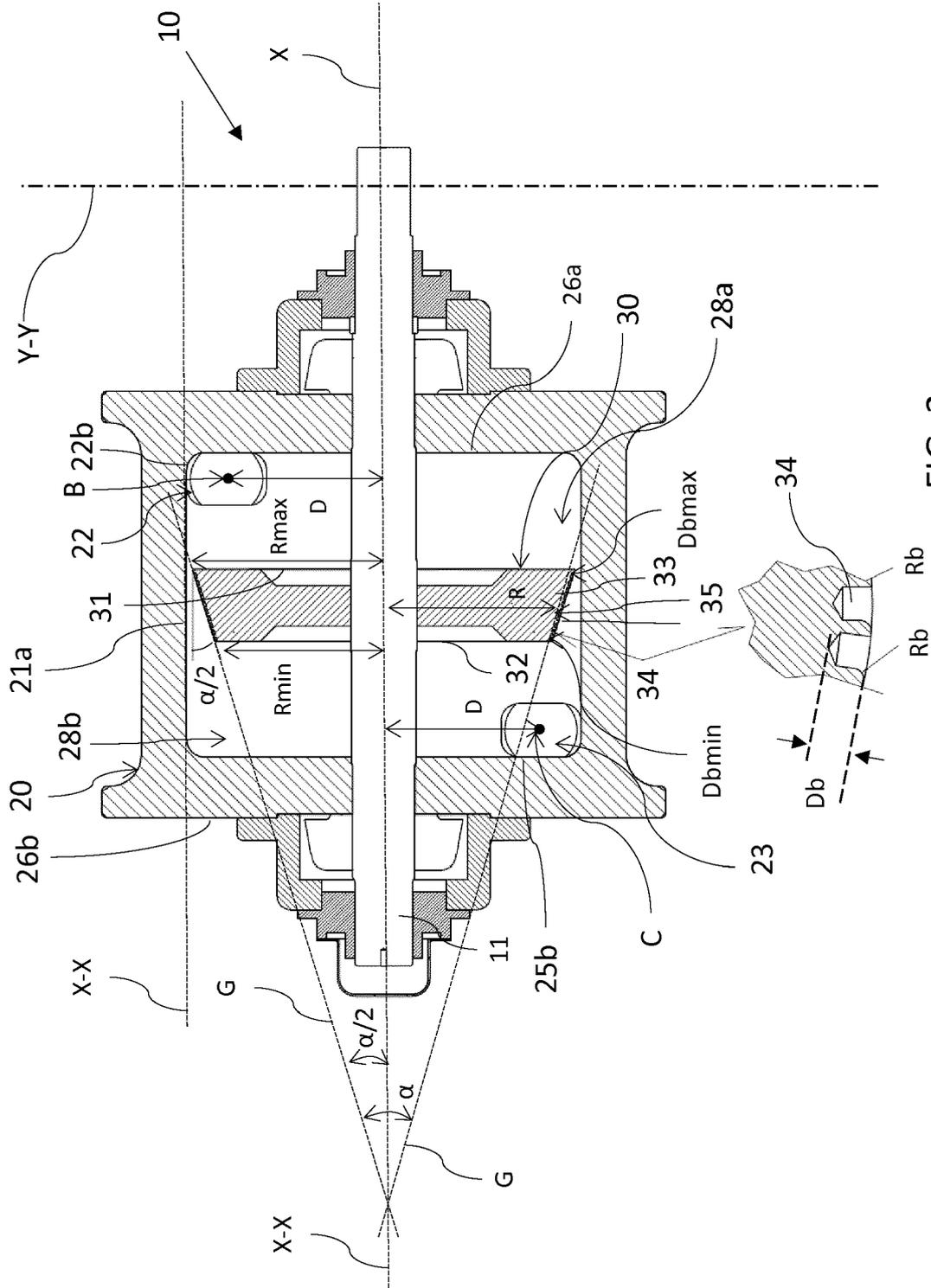


FIG. 3

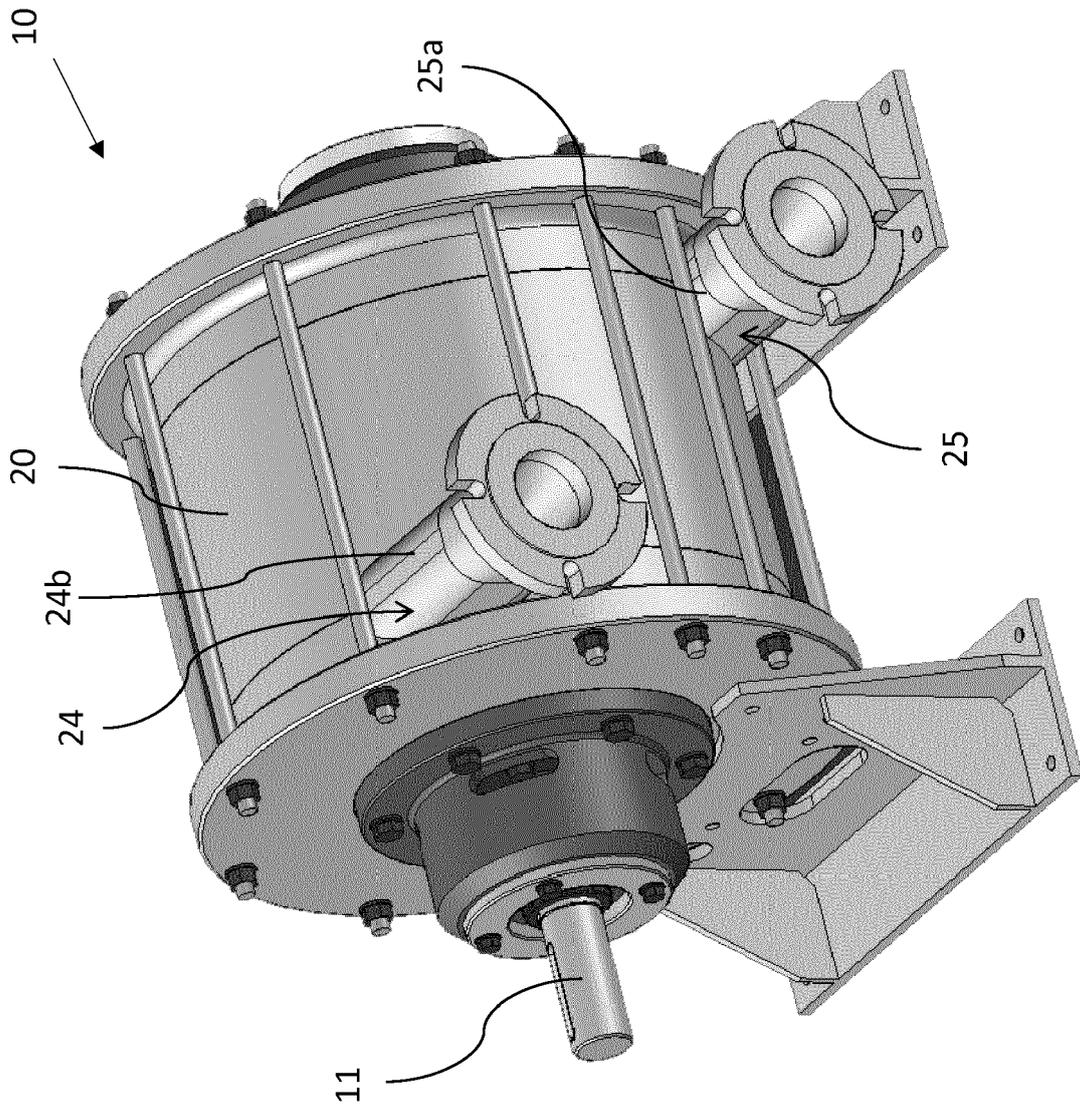


FIG. 4



EUROPEAN SEARCH REPORT

Application Number
EP 16 18 2624

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2011/081384 A1 (ARCHAMBEAU GREGORY J [US] ET AL) 7 April 2011 (2011-04-07)	1-3,5-15	INV. B01F7/00
A	* paragraphs [0204] - [0212], [0243] - [0246], [0255] - [0258] * * figures 4-11 *	4	
A	----- US 2005/259510 A1 (THOMA CHRISTIAN [GB]) 24 November 2005 (2005-11-24) * figures 1-5 * * abstract *	1-15	
A	----- US 2005/263607 A1 (THOMA CHRISTIAN [GB]) 1 December 2005 (2005-12-01) * figure 9 * * abstract *	1-15	
A	----- DE 33 27 137 A1 (KONISHIROKU PHOTO IND [JP]) 9 February 1984 (1984-02-09) * figure 4 * * page 4, line 4 - page 6, line 15 *	1-15	
A	----- US 2004/103855 A1 (THOMA CHRISTIAN HELMUT [GB]) 3 June 2004 (2004-06-03) * figures 7-9 * * abstract * * paragraphs [0042] - [0046] *	1-15	TECHNICAL FIELDS SEARCHED (IPC) B01F F24J
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 1 February 2017	Examiner Krasenbrink, B
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	

EPO FORM 1503 03.02 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT
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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.

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