(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 904 695 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
03.11.2021 Bulletin 2021/44

(51) Int Cl.:
***F04D 29/44** (2006.01)* ***F04D 1/06** (2006.01)*
***F04D 13/10** (2006.01)* ***F04D 29/42** (2006.01)*

(21) Application number: **20171820.2**

(22) Date of filing: **28.04.2020**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Xylem Europe GmbH**
8200 Schaffhausen (CH)

(72) Inventor: **ANDRÉ, Erik**
132 49 SALTSJÖ-BOO (SE)

(74) Representative: **Brann AB**
P.O. Box 3690
Drottninggatan 27
103 59 Stockholm (SE)

(54) BOWL PUMP AND VERTICAL BOWL PUMP ARRANGEMENT

(57) The invention relates to a bowl pump and a vertical bowl pump arrangement. The bowl pump (1) comprises a pump housing (10), a hub (14) and guide vanes (23) extending between the hub (14) and pump housing (10). The guide vanes (23) has a positive lean angle, i.e. a mean radial span vane angle determined as a mean value of a pressure side radial span (26) vane angle (a) and a suction side radial span (27) vane angle (β) is equal to or more than 30 degrees from 0,1 to 0,2 relative axial position of the guide vane (23).

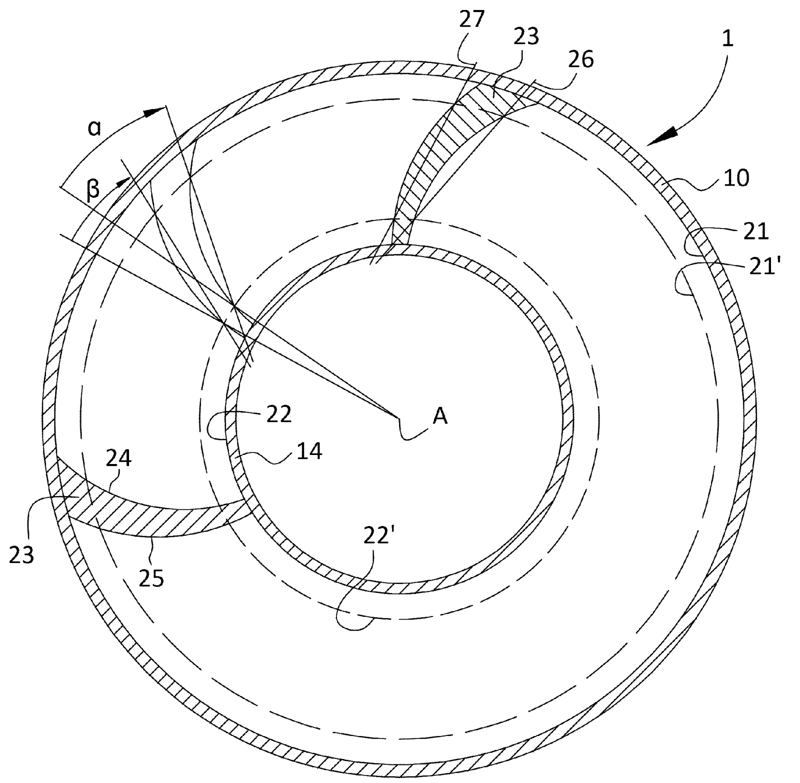

Fig. 4

EP 3 904 695 A1

Description

Technical field of the Invention

[0001] The present invention relates generally to the technical field of bowl pumps for pumping liquid, such as clean/drinking water, chemicals, etc. Bowl pumps are also known under the term vertical turbine pumps or multistage pumps. More precisely the present invention relates specifically to the technical field of guide vanes of such bowl pumps.

[0002] According to a first aspect the present invention relates to a bowl pump that comprises:

- an outer pump housing having an inlet, an outlet and an axial centre axis extending from said inlet to said outlet,
- a hub arrangement, wherein the hub arrangement comprises:
- a stationary hub located inside the pump housing, and
- an impeller that is suspended from the hub and located adjacent said inlet of the pump housing, the pump housing having an inner surface and an imaginary inner surface and the hub having an outer surface and an imaginary outer surface,

wherein the imaginary inner surface of the pump housing is offset radially inwards from said inner surface fifteen percent of the radial distance between the inner surface of the pump housing and outer surface of the hub, and wherein the imaginary outer surface of the hub is offset radially outwards from said outer surface fifteen percent of the radial distance between the inner surface of the pump housing and the outer surface of the hub.

[0003] The bowl pump further comprises a set of guide vanes, each guide vane extending in the radial direction between the outer surface of the hub and the inner surface of the pump housing, and extending in the axial direction from a start position located adjacent the impeller to an end position located downstream said start position, wherein each guide vane has a pressure side surface and a suction side surface, wherein said start position is defined as the radial plane through the bowl pump that is located closest to the inlet of the pump housing and that intersects the guide vane the full distance from the imaginary inner surface of the pump housing to the imaginary outer surface of the hub, wherein said end position is defined as the radial plane through the bowl pump that is located closest to the outlet of the pump housing and that intersects the guide vane the full distance from the imaginary inner surface of the pump housing to the imaginary outer surface of the hub, wherein each guide vane has a relative axial position along the axial centre axis starting from zero at the start position and ending at one at the end position, and wherein each guide vane in each radial plane through the bowl pump between the start position and the end position has a pressure side radial span, that extends between the intersection between the pressure side surface of the guide vane and the imaginary outer surface of the hub and the intersection between the pressure side surface of the guide vane and the imaginary inner surface of the pump housing, and has a suction side radial span, that extends between the intersection between the suction side surface of the guide vane and the imaginary outer surface of the hub and the intersection between the suction side surface of the guide vane and the imaginary inner surface of the pump housing.

[0004] According to a second aspect the present invention relates to a vertical bowl pump arrangement comprising a drive unit having a motor and a drive shaft, a column, a discharge connection connected to an upper end of said column, and at least one bowl pump connected to a lower end of said column.

Background of the Invention

[0005] Bowl pumps are designed to have the advantages of centrifugal pumps in terms of efficiency and pressure while allowing a discharge flow in the axial direction like axial/propeller pumps. Thus, the pump is designed to guide the liquid in an outward spiral in a mixture of radial/axial direction from the impeller towards the pump housing in order to increase the pressure by centrifugal action and thereafter guide vanes are used to redirect the liquid flow from rotating to axial in order to recover static pressure and to try to improve the flow profile leaving the pump housing to the next bowl pump. The inlet of the bowl pump and the outlet of the bowl pump are of the same dimension. Thus, the flow is the same through each bowl pump when having a multistage/stacked bowl pump arrangement, and at the same time the pressure/head is expected to increase in each stage/bowl pump.

[0006] In known bowl pumps, the guide vanes extending in the radial direction between the outer surface of the hub and the inner surface of the pump housing are shaped to have an essentially straight radial extension or a slightly negative lean angle, i.e. the guide vane is tilted towards the suction side of the guide vane, i.e. the suction side surface of the guide vane is facing the outer surface of the hub, at the beginning of the guide vane and/or at the crest of the hub. The conventional shape of the guide vanes are the consequence of a simplified design principle based on stream surfaces where the exchange of momentum perpendicular to the stream surface is limited. Thereto known casting methods limits the variation of the lean angle along the axial extension of the guide vane, identified by the inventors limits the maximum possible efficiency of the pump.

[0007] However, the inventors have identified that this conventional guide vane design entails low efficiency, flow separation downstream the crest of the hub and resulting in dynamic pressure losses, especially in a multistage/stacked bowl pump arrangement where insufficient control of the flow profile in the an upstream stage pump causes problems for the downstream stage pump.

Object of the Invention

[0008] The present invention aims at obviating the aforementioned disadvantages and failings of previously known bowl pumps, and at providing an improved bowl pump. A primary object of the present invention is to provide an improved bowl pump of the initially defined type wherein the guide vanes have a more optimal design/shape entailing a higher efficiency and less dynamic flow losses. It is another object of the present invention to provide a bowl pump, wherein the guide vanes guide the pumped liquid towards the hub in order to obtain higher efficiency and more optimal flow profile leaving the pump housing. It is another object of the present invention to provide a bowl pump, wherein the flow separation of the liquid at the hub after the crest is decreased or entirely eliminated.

Summary of the Invention

[0009] According to the invention at least the primary object is attained by means of the initially defined bowl pump having the features defined in the independent claims. Preferred embodiments of the present invention are further defined in the dependent claims.

[0010] According to a first aspect of the present invention, there is provided a bowl pump of the initially defined type, which is characterized in that each guide vane has a mean radial span vane angle (δ) determined as a mean value of:

- a pressure side radial span vane angle (α) between the pressure side radial span and a radial line extending from the axial centre axis through the intersection between the pressure side surface of the guide vane and the imaginary outer surface of the hub, wherein the pressure side radial span vane angle (α) is positive measured from said radial line and in the rotational direction from suction side to pressure side, and
- a suction side radial span vane angle (β) between the suction side radial span and a radial line extending from the axial centre axis through the intersection between the suction side surface of the guide vane and the imaginary outer surface of the hub, wherein the suction side radial span vane angle (β) is positive measured from said radial line and in the rotational direction from suction side to pressure side,

wherein at least one guide vane has a mean radial span vane angle (δ) that is equal to or more than 30 degrees from 0,1 to 0,2 relative axial position of the guide vane.

[0011] According to a second aspect of the present invention, there is provided a vertical bowl pump arrangement comprising an above-mentioned bowl pump, wherein the impeller of the bowl pump is connected to a drive shaft extending from said motor.

[0012] Thus, the present invention is based on the insight of shaping the guide vanes, before the crest and/or at the crest, to guide the liquid flow towards the hub instead of towards the pump housing of the bowl pump in order to obtain higher efficiency, less flow separation and more optimal flow profile leaving the pump housing. Thus, the guide vane is provided with positive lean angle at least before and/or at the crest of the hub, i.e. that the guide vanes are tilted towards the pressure side of the guide vane. Thus, the pressure side surface of the guide vane is facing the outer surface of the hub.

[0013] According to various embodiments of the present invention, the at least one guide vane has a mean radial span vane angle (δ) that is equal to or more than 30 degrees up to 0,3 relative axial position of the guide vane, preferably up to 0,5 relative axial position and most preferably up to 0,7 relative axial position. This means that the efficiency of the bowl pump is further enhanced, and the flow profile is even more optimal.

[0014] According to various embodiments, the at least one guide vane has a mean radial span vane angle (δ) that is equal to or more than 35 degrees from 0,1 to 0,2 relative axial position. This means that the efficiency of the bowl pump is further enhanced, and the flow profile is even more optimal.

[0015] According to various embodiments, the at least one guide vane has a mean radial span vane angle (δ) that is equal to or more than 40 degrees from 0,2 to 0,3 relative axial position. This means that the efficiency of the bowl pump is further enhanced, and the flow profile is even more optimal.

[0016] According to various embodiments, the crest of the hub is located upstream 0,3 relative axial position and located downstream 0,05 relative axial position.

[0017] Further advantages with and features of the invention will be apparent from the other dependent claims as well as from the following detailed description of preferred embodiments.

Brief description of the drawings

[0018] A more complete understanding of the abovementioned and other features and advantages of the present invention will be apparent from the following detailed description of preferred embodiments in conjunction with the appended drawings, wherein:

Fig. 1 is a schematic semi cross sectional side view of a vertical bowl pump arrangement,

Fig. 2 is a schematic perspective view from above of an inventive bowl pump,

Fig. 3 is a schematic cross-sectional side view of the bowl pump of figure 2,

Fig. 4 is a schematic cross-sectional view from above of a bowl pump highlighting the pressure side radial span vane angle (α) and the suction side radial span vane angle (β), and

Fig. 5a-f are schematic cross-sectional views from above at different relative axial position of the guide vanes.

Detailed description of preferred embodiments of the invention

[0019] The present invention relates to a bowl pump, generally designated 1, and a vertical bowl pump arrangement, generally designated 2. Reference are initially made to figures 1-3.

[0020] A vertical bowl pump arrangement 2 is used for pumping liquid, such as clean/drink water, chemicals, etc., at great flow and great geodetic head, for instance for lifting liquid from deep wells or the like reservoirs. Vertical bowl pump arrangements 2 comprises a drive unit 3 having a motor 4 and a drive shaft 5 extending from the motor 4 and driven in rotation by the motor 4. The vertical bowl pump arrangement 2 further comprises a column 6 and a discharge connection 7 connected to an upper end of the column 6. The column 6 has the function of a discharge/outlet pipe and the discharge connection 7 has the function of connecting the column 6 to outgoing piping or a tank (not disclosed). In the disclosed embodiment the discharge connection 7 redirects the liquid flow from vertical to horizontal. At the lower end of the column 6 one or more bowl pumps 1 are connected in series, i.e. stacked or multistage vertical bowl pump arrangement.

[0021] In the disclosed embodiment the vertical bowl pump arrangement 2 further comprises an inlet screen 8 or filter unit connected to the lowest bowl pump 1. The vertical bowl pump arrangement 2 also comprises a drive shaft sleeve 9 surrounding and protecting the drive shaft 5 and extending inside the column 6. In the disclosed embodiment the motor 4 is arranged outside the column 6, i.e. above the discharge connection 7. According to various alternative embodiments the motor 4 is arranged inside the column 6, i.e. below the discharge connection 7, or arranged inside the discharge connection 7. The drive shaft sleeve 9 may be constituted by several segments, especially smaller segments located between the bowl pumps 1. The column 6 may be constituted by several segments.

[0022] The bowl pump 1 comprises an outer pump housing 10 having an inlet 11 and an outlet 12. The bowl pump 1 comprises a center axis A extending from the inlet 11 to the outlet 12 and which is common with the center axis of the drive shaft 5, i.e. the center axis of the vertical bowl pump arrangement 2. The inlet 11 and the outlet 12 match each other in order to be stackable, i.e. several bowl pumps 1 connected in series. Thus, the inlet 11 and the outlet 12 have corresponding dimensions.

[0023] The bowl pump 1 further comprises a hub arrangement 13 located inside the pump housing 10, wherein the hub arrangement 13 comprises a stationary hub 14 and an impeller 15. The hub 14 is located entirely inside the pump housing 10. The impeller 15 is suspended from the hub 14 and located adjacent the inlet 11 of the pump housing 10. In the disclosed embodiment, the impeller 15 is located partly inside the pump housing 10 and partly outside the pump housing 10, i.e. protruding from the inlet 11. The impeller 15 is a socalled closed or channel type impeller having an axial inlet 16 and radial outlets 17. The impeller 15 comprises an upper cover disc 18 (cone shaped), a lower cover disc 19 (funnel shaped) and several spirally extending blades 20 extending between the lower cover disc 19 and the upper cover disc 18. The impeller 15 is connected to the drive shaft 5 and driven in rotation by the drive shaft 5. The hub 14 is onion shaped and the crest of the hub 14 is the location having the largest diameter. The pump housing 10 comprises an inner surface 21 and the hub 14 comprises an outer surface 22.

[0024] The bowl pump 1 further comprises a set of guide vanes 23, wherein each guide vane 23 extending in the radial direction between the outer surface 22 of the hub 14 and the inner surface 21 of the pump housing 10, and extending in the axial direction from a start position located adjacent the impeller 15 to an end position located downstream said start position. Each guide vane 23 has a pressure side surface 24 and a suction side surface 25.

[0025] Reference is now also made to figure 4, schematic and not disclosing all guide vanes.

[0026] The pump housing 10 has an imaginary inner surface 21' and the hub 14 has an imaginary outer surface 22' , wherein the imaginary inner surface 21' of the pump housing 10 is offset radially inwards from said inner surface 21 fifteen percent of the radial distance between the inner surface 21 of the pump housing 10 and outer surface 22 of the hub 14), and wherein the imaginary outer surface 22' of the hub 14 is offset radially outwards from said outer surface 22 fifteen percent of the radial distance between the inner surface 21 of the pump housing and the outer surface 22 of the hub. The imaginary outer surface 22' and the imaginary inner surface 21' are used in order not to be disturbed during measurement by possible extra material at the transitions from hub 14 to guide vane 23 and from guide vane 23 to pump housing 10.

[0027] Said start position of the guide vane 23 is defined as the radial plane through the bowl pump 1 that is located closest to the inlet 11 of the pump housing and that intersects the guide vane 23 the full distance from the imaginary inner surface 21' of the pump housing 10 to the imaginary outer surface 22' of the hub 14. Said end position of the guide vane 23 is defined as the radial plane through the bowl pump 1 that is located closest to the outlet 12 of the pump housing 10 and that intersects the guide vane 23 the full distance from the imaginary inner surface 21' of the pump housing 10 to the imaginary outer surface 22' of the hub 14. Thereto, each guide vane 23 has a relative axial position along the axial centre axis A starting from zero at the start position and ending at one at the end position.

[0028] Each guide vane 23 in each radial plane through the bowl pump 1 between the start position and the end position has a pressure side radial span 26, that extends between the intersection between the pressure side surface 24 of the guide vane 23 and the imaginary outer surface 22' of the hub 14 and the intersection between the pressure side surface 24 of the guide vane and the imaginary inner surface 21' of the pump housing, and has a suction side radial span 27, that extends between the intersection between the suction side surface 25 of the guide vane and the imaginary outer surface 22' of the hub and the intersection between the suction side surface 25 of the guide vane and the imaginary inner surface 21' of the pump housing.

[0029] Reference is now also made to figures 5a - 5f, disclosing six different radial planes or cross sections of the bowl pump 1. Figure 5a is taken at the start position of the guide vane 23 (i.e. at 0,0 relative axial position), figure 5b is taken at 0,2 relative axial position, figure 5c is taken at 0,3 relative axial position, figure 5d is taken at 0,5 relative axial position, figure 5e is taken at 0,8 relative axial position, figure 5f is taken at the end position of the guide vane 23 (i.e. at 1,0 relative axial position).

[0030] According to the invention each guide vane 23 has a mean radial span vane angle (δ) determined as a mean value of:

- a pressure side radial span vane angle (α) between the pressure side radial span 26 and a radial line extending from the axial centre axis A through the intersection between the pressure side surface 24 of the guide vane and the imaginary outer surface 22' of the hub, wherein the pressure side radial span vane angle (α) is positive measured from said radial line and in the rotational direction from suction side to pressure side, and
- a suction side radial span vane angle (β) between the suction side radial span 27 and a radial line extending from the axial centre axis through the intersection between the suction side surface 25 of the guide vane and the imaginary outer surface 22' of the hub, wherein the suction side radial span vane angle (β) is positive measured from said radial line and in the rotational direction from suction side to pressure side.

[0031] At least one guide vane 23 has a mean radial span vane angle (δ) that is equal to or more than 30 degrees from 0,1 to 0,2 relative axial position of the guide vane. Thus, in the stated range the guide vane has positive lean.

[0032] Thus, a positive mean radial span vane angle (δ) disclose that the guide vane is tilted in a direction that is opposite the rotational direction of the impeller, i.e. clockwise in figure 4.

[0033] The described definition of the mean radial span vane angle is chosen in order to simplify measurement, i.e. in a 3D-model or a real bowl pump it is easy to provide a radial cross section through the bowl pump 1 and measure the defined angles.

[0034] According to preferred embodiments the mean radial span vane angle (δ) is equal to or more than 30 degrees up to 0,3 relative axial position of the guide vane, preferably up to 0,5 relative axial position and most preferably up to 0,7 relative axial position. Thereto, the mean radial span vane angle (δ) is preferably equal to or more than 30 degrees from 0,05 relative axial position.

[0035] According to preferred embodiments the mean radial span vane angle (δ) is equal to or more than 35 degrees from 0,1 to 0,2 relative axial position, preferably up to 0,3 relative axial position, and most preferably up to 0,5 relative axial position.

[0036] According to preferred embodiments the mean radial span vane angle (δ) that is equal to or more than 40 degrees from 0,2 to 0,3 relative axial position, preferably up to 0,4 relative axial position.

[0037] According to preferred embodiments the mean radial span vane angle (δ) is equal to or more than 20 degrees from 0,1 to 1 relative axial position of the guide vane.

[0038] According to preferred embodiments the crest of the hub 14 is located upstream 0,3 relative axial position, and located downstream 0,05 relative axial position.

[0039] Thus, according to the invention and the preferred embodiments most guiding of the liquid flow inwards towards the hub 14 is performed before and/or at the crest of the hub 14, in order to reduce or entirely eliminate flow separation of the liquid at the outer surface 22 of the hub 14 downstream the crest. Thereto, the main redirection of the liquid flow from rotating to axial flow is performed downstream the crest of the hub 14. Thus, as little redirection as possible from rotating to axial at or about the crest of the hub, while the guide vanes 23 provide a reaction force inward towards the hub 14 at or about the crest. In order to reduce or entirely eliminate flow separation of the liquid at the outer surface 22 of the hub 14 downstream the crest.

[0040] Thanks to the inventive design of the guide vanes 23 the liquid flow profile at the outlet 12 of the pump housing 10 has a greater density at the center, i.e. adjacent the drive shaft sleeve 9, than prior art solutions. Thereby, the next/downstream bowl pump will be fed with a liquid flow having a more uniform flow profile and higher pressure at the center and thereby the next/downstream bowl pump will add more pressure to the liquid than prior art solutions and will thereto be starting at a higher pressure level thanks to the output from the first/upstream bowl pump 1, i.e. entailing a much higher efficiency than prior art bowl pump arrangements.

Feasible modifications of the Invention

[0041] The invention is not limited only to the embodiments described above and shown in the drawings, which primarily have an illustrative and exemplifying purpose. This patent application is intended to cover all adjustments and variants of the preferred embodiments described herein, thus the present invention is defined by the wording of the appended claims and the equivalents thereof. Thus, the equipment may be modified in all kinds of ways within the scope of the appended claims.

[0042] For instance, it shall be pointed out that the present invention also protects a bowl pump having the impeller temporarily disconnected from the hub, or having the impeller not yet installed in the bowl pump.

[0043] It shall also be pointed out that all information about/concerning terms such as above, under, upper, lower, etc., shall be interpreted/read having the equipment oriented according to the figures, having the drawings oriented such that the references can be properly read. Thus, such terms only indicate mutual relations in the shown embodiments, which relations may be changed if the inventive equipment is provided with another structure/design.

[0044] It shall also be pointed out that even thus it is not explicitly stated that features from a specific embodiment may be combined with features from another embodiment, the combination shall be considered obvious, if the combination is possible.

[0045] Throughout this specification and the claims which follows, unless the context requires otherwise, the word "comprise", and variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or steps or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

Claims

1. Bowl pump (1) for pumping liquid, comprising:

- an outer pump housing (10) having an inlet (11), an outlet (12) and an axial centre axis (A) extending from said inlet to said outlet,
- a hub arrangement (13), wherein the hub arrangement comprises:
- a stationary hub (14) located inside the pump housing (10), and
- an impeller (15) that is suspended from the hub (14) and located adjacent said inlet (11) of the pump housing,

the pump housing (10) having an inner surface (21) and an imaginary inner surface (21') and the hub (14) having an outer surface (22) and an imaginary outer surface (22'),
wherein the imaginary inner surface (21') of the pump housing is offset radially inwards from said inner surface (21) fifteen percent of the radial distance between the inner surface (21) of the pump housing (10) and outer surface (22) of the hub (14), and
wherein the imaginary outer surface (22') of the hub is offset radially outwards from said outer surface (22) fifteen percent of the radial distance between the inner surface of the pump housing and the outer surface of the hub,
the bowl pump further comprising:

- a set of guide vanes (23),
each guide vane (23) extending in the radial direction between the outer surface of the hub (14) and the inner surface of the pump housing (10), and extending in the axial direction from a start position located adjacent the impeller (15) to an end position located downstream said start position,
- wherein each guide vane (23) has a pressure side surface (24) and a suction side surface (25),
- wherein said start position is defined as the radial plane through the bowl pump that is located closest to the inlet (11) of the pump housing and that intersects the guide vane (23) the full distance from the imaginary inner surface (21') of the pump housing (10) to the imaginary outer surface (22') of the hub (14),
- wherein said end position is defined as the radial plane through the bowl pump that is located closest to the outlet (12) of the pump housing and that intersects the guide vane (23) the full distance from the imaginary inner surface (21') of the pump housing to the imaginary outer surface (22') of the hub,
- wherein each guide vane (23) has a relative axial position along the axial centre axis (A) starting from zero at the start position and ending at one at the end position,
- wherein each guide vane in each radial plane through the bowl pump between the start position and the end position has a pressure side radial span (26), that extends between the intersection between the pressure side surface (24) of the guide vane and the imaginary outer surface (22') of the hub and the intersection between the pressure side surface (24) of the guide vane and the imaginary inner surface (21') of the pump housing, and has a suction side radial span (27), that extends between the intersection between the suction side surface (25) of the guide vane and the imaginary outer surface (22') of the hub and the intersection between the suction side surface (27) of the guide vane and the imaginary inner surface (21') of the pump housing,
characterized in that each guide vane (23) has a mean radial span vane angle (δ) determined as a mean value of:
- a pressure side radial span vane angle (α) between the pressure side radial span (26) and a radial line extending from the axial centre axis (A) through the intersection between the pressure side surface (24) of the guide vane and the

imaginary outer surface (22') of the hub, wherein the pressure side radial span vane angle (α) is positive measured from said radial line and in the rotational direction from suction side to pressure side, and
- a suction side radial span vane angle (β) between the suction side radial span (27) and a radial line extending from the axial centre axis through the intersection between the suction side surface (25) of the guide vane and the imaginary outer surface (22') of the hub, wherein the suction side radial span vane angle (β) is positive measured from said radial line and in the rotational direction from suction side to pressure side,
wherein at least one guide vane (23) has a mean radial span vane angle (δ) that is equal to or more than 30 degrees from 0,1 to 0,2 relative axial position of the guide vane (23).

2. The bowl pump (1) according to claim 1, wherein said at least one guide vane (23) has a mean radial span vane angle (δ) that is equal to or more than 30 degrees up to 0,3 relative axial position of the guide vane, preferably up to 0,5 relative axial position and most preferably up to 0,7 relative axial position.

3. The bowl pump (1) according to claim 1 or 2, wherein said at least one guide vane (23) has a mean radial span vane angle (δ) that is equal to or more than 30 degrees from 0,05 relative axial position.

4. The bowl pump according to claim 1, wherein said at least one guide vane (23) has a mean radial span vane angle (δ) that is equal to or more than 35 degrees from 0,1 to 0,2 relative axial position.

5. The bowl pump according to claim 4, wherein said at least one guide vane (23) has a mean radial span vane angle (δ) that is equal to or more than 35 degrees up to 0,3 relative axial position, preferably up to 0,5 relative axial position.

6. The bowl pump according to claim 1, wherein said at least one guide vane (23) has a mean radial span vane angle (δ) that is equal to or more than 40 degrees from 0,2 to 0,3 relative axial position.

7. The bowl pump according to claim 4, wherein said at least one guide vane (23) has a mean radial span vane angle (δ) that is equal to or more than 40 degrees up to 0,4 relative axial position.

8. The bowl pump according to any preceding claim, wherein the crest of the hub (14) is located upstream 0,3 relative axial position.

9. The bowl pump according to any preceding claim, wherein the crest of the hub (14) is located downstream 0,05 relative axial position.

10. The bowl pump according to any preceding claim, wherein said at least one guide vane (23) has a mean radial span vane angle (δ) that is equal to or more than 20 degrees from 0,1 to 1 relative axial position of the guide vane.

11. A vertical bowl pump arrangement (2) for pumping liquid, comprising:

- a drive unit (3) having a motor (4) and a drive shaft (5),
- a column (6),
- a discharge connection (7) connected to an upper end of said column (6), and
- at least one bowl pump (1) connected to a lower end of said column (6),

characterized in that said at least one bowl pump (1) is constituted by a bowl pump (1) according to any of claims 1-10, wherein the impeller (15) of the bowl pump (1) is connected to the drive shaft (5) extending from said motor (4).

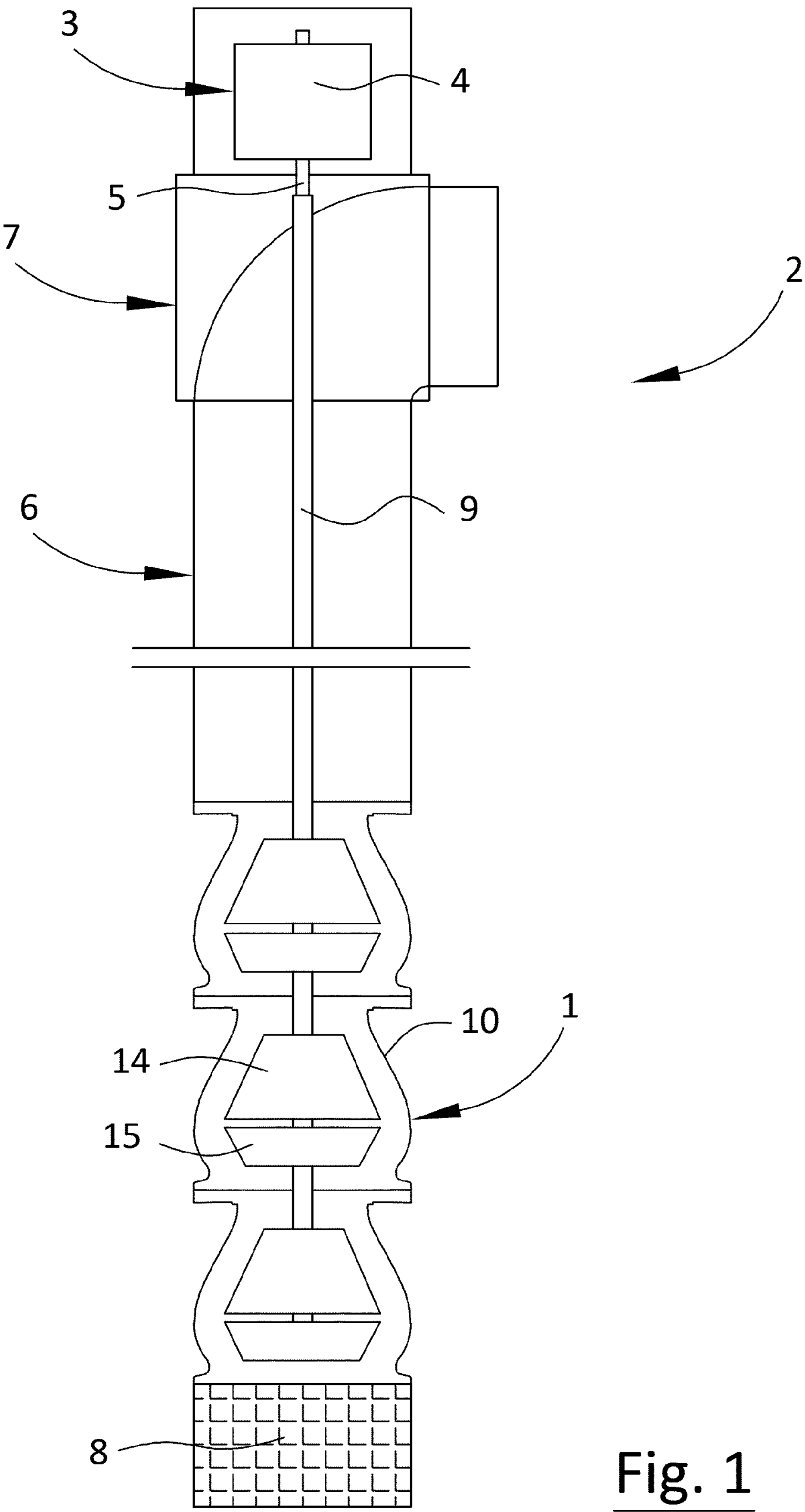

Fig. 1

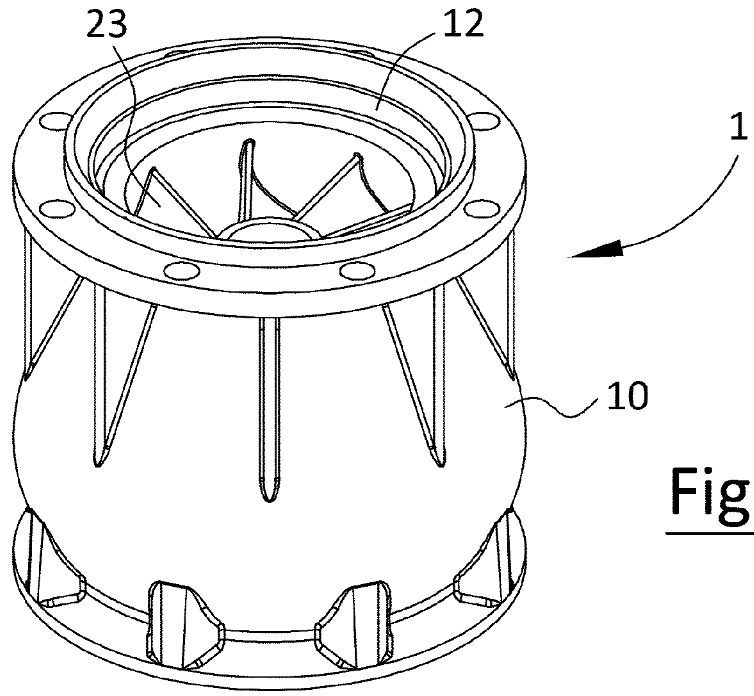

Fig. 2

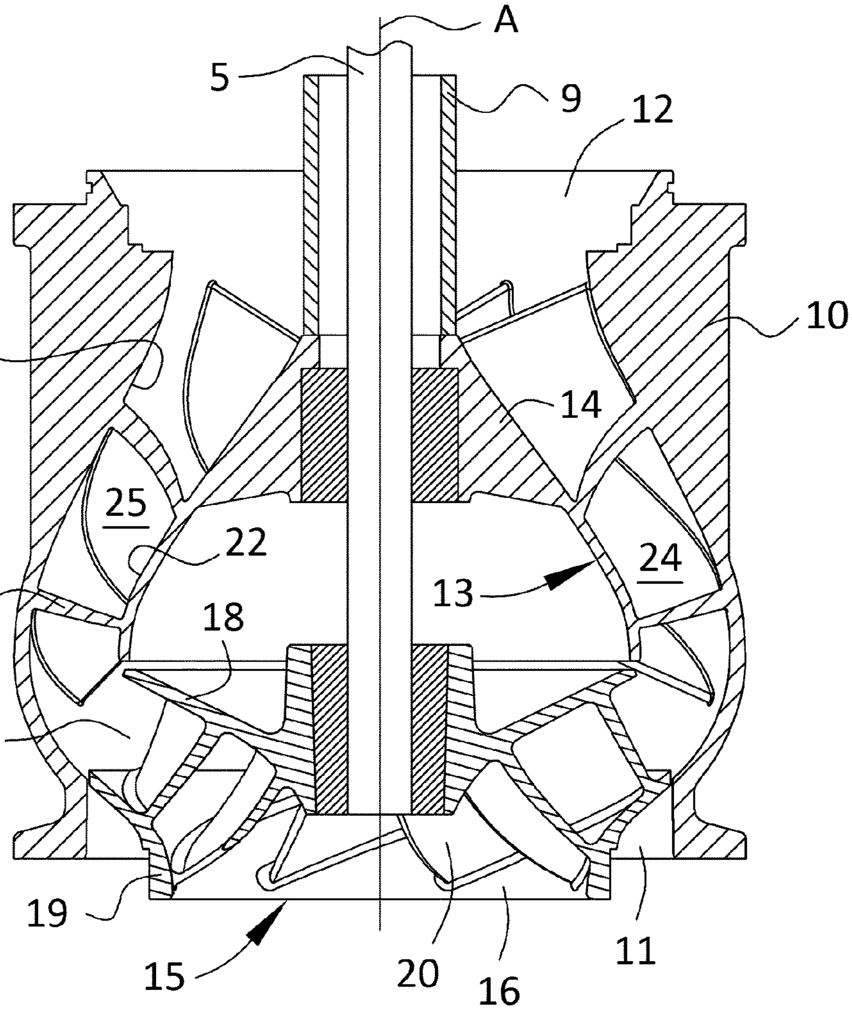

Fig. 3

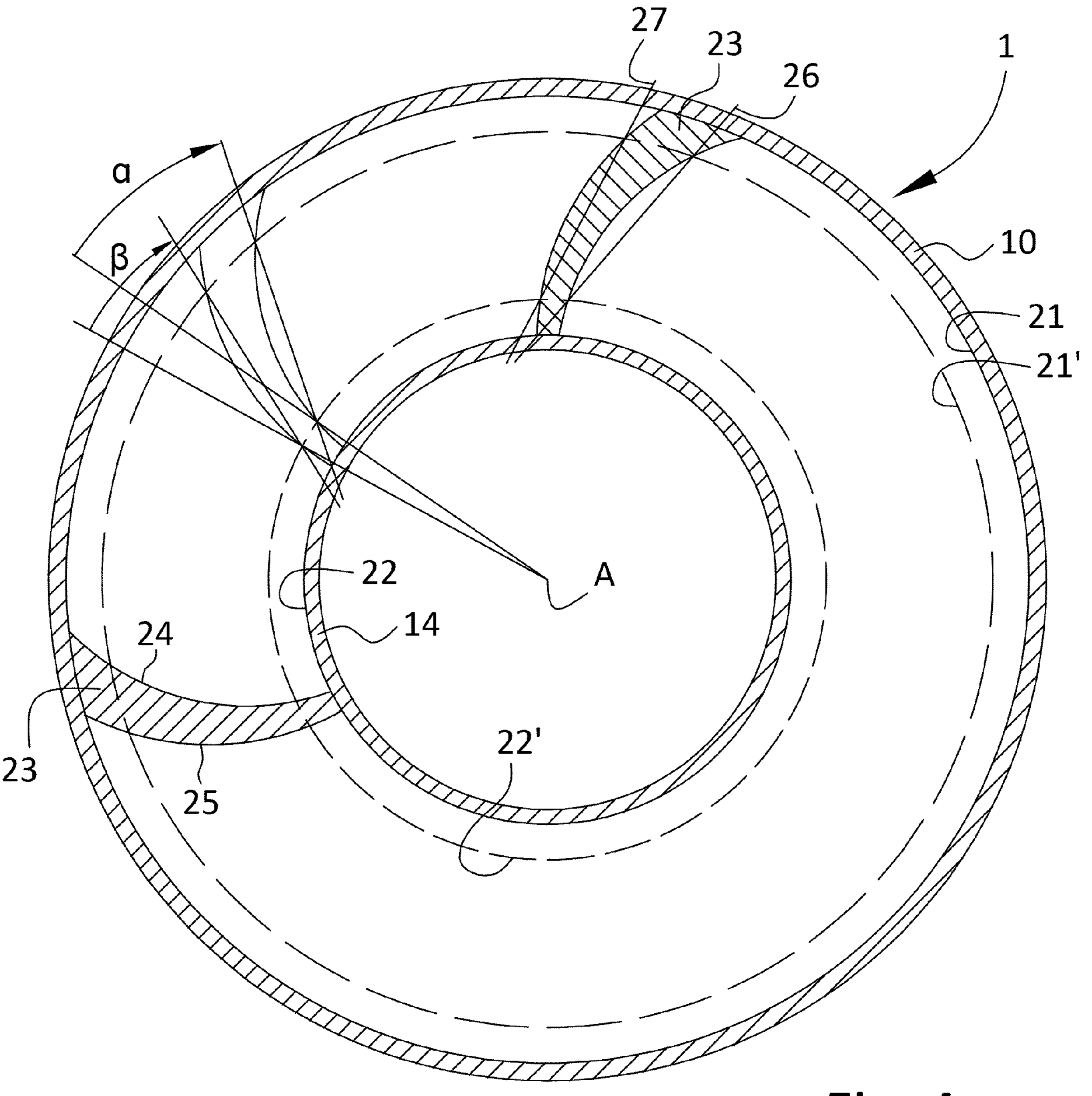

Fig. 4

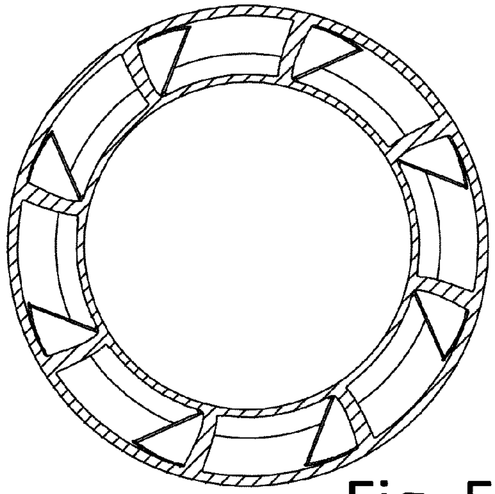

Fig. 5a

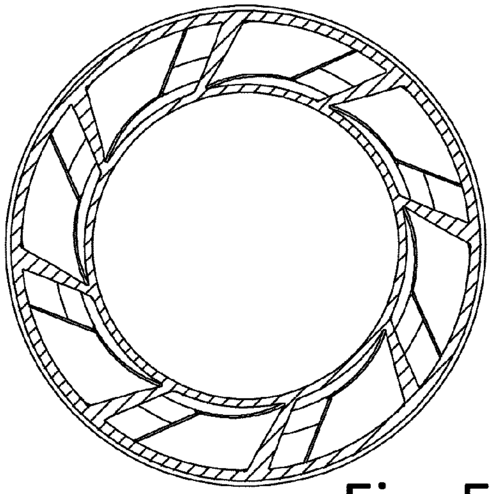

Fig. 5b

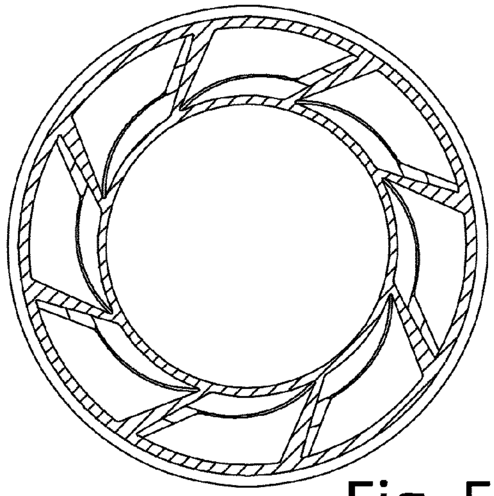

Fig. 5c

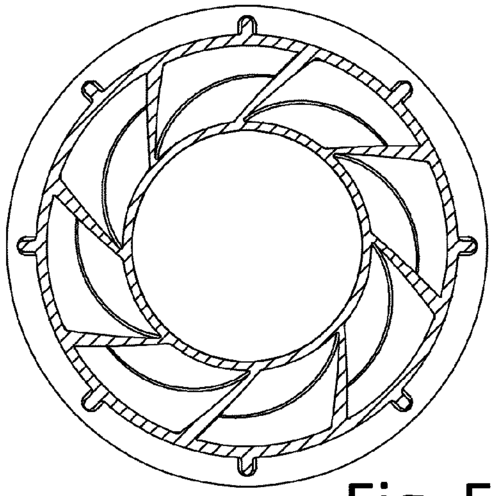

Fig. 5d

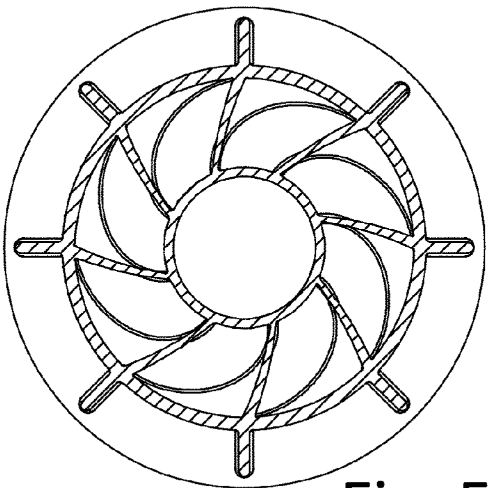

Fig. 5e

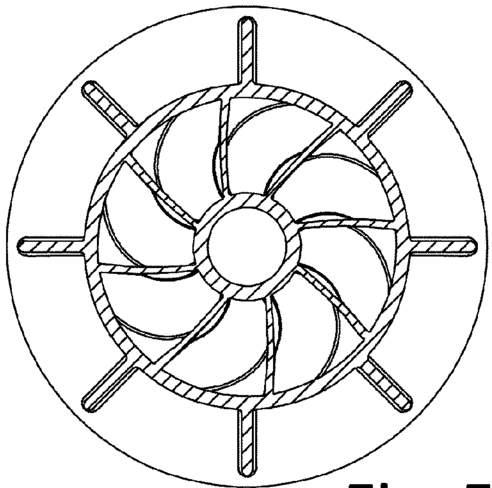

Fig. 5f

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 17 1820

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 2009/155064 A1 (BROWN DONN J [US] ET AL) 18 June 2009 (2009-06-18) * paragraphs [0028], [0029] * * figures 1, 2, 8 * -----	1-7,10, 11	INV. F04D29/44 F04D1/06 F04D13/10 F04D29/42
X	US 2014/178190 A1 (GAHLOT VISHAL [US] ET AL) 26 June 2014 (2014-06-26) * paragraphs [0037], [0038] * * figures 2, 16, 17 * -----	1-11	
X	US 2017/122333 A1 (GRAY DENNIS MICHAEL [US] ET AL) 4 May 2017 (2017-05-04) * paragraph [0026] * * figures 3, 4, 6 * -----	1-11	
X	US 3 776 664 A (KIMMEL A) 4 December 1973 (1973-12-04) * figures 1, 2, 2A, 11A, 11B * -----	1-11	

TECHNICAL FIELDS SEARCHED (IPC)

F04D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	6 October 2020	De Tobel, David

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 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 17 1820

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.

06-10-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009155064 A1	18-06-2009	CA 2708505 A1	18-06-2009
		US 2009155064 A1	18-06-2009
		WO 2009076596 A2	18-06-2009
US 2014178190 A1	26-06-2014	CA 2895715 A1	26-06-2014
		US 2014178190 A1	26-06-2014
		WO 2014099484 A1	26-06-2014
US 2017122333 A1	04-05-2017	CA 2945874 A1	30-04-2017
		RU 2016141401 A	23-04-2018
		US 2017122333 A1	04-05-2017
US 3776664 A	04-12-1973	NONE	

EPO FORM P0459

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