

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property

Organization

International Bureau

(43) International Publication Date

11 June 2020 (11.06.2020)



(10) International Publication Number

WO 2020/117258 A1

(51) International Patent Classification:

F04D 29/16 (2006.01) F16J 15/42 (2006.01)

F04D 13/08 (2006.01) B41J 2/175 (2006.01)

F04D 7/02 (2006.01)

Published:

— with international search report (Art. 21(3))

(21) International Application Number:

PCT/US2018/064381

(22) International Filing Date:

07 December 2018 (07.12.2018)

(25) Filing Language:

English

(26) Publication Language:

English

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(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to the identity of the inventor (Rule 4.17(i))
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

(54) Title: TURBOMACHINE WITH SEAL

(57) Abstract: Example implementations relate to transporting fluids. One example implementation includes a centrifugal pump having an impeller arranged to rotate within a casing in order to draw a fluid from an inlet of the impeller to a circumferential chamber of the casing. A seal is formed between an inner surface of the casing and a surface of the impeller. The seal has an annular recess in one of these surfaces and a plurality of blades on the other surface. The blades are arranged to rotate within the annular recess.



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TURBOMACHINE WITH SEAL

BACKGROUND

[0001] Centrifugal pumps are used to transport fluids and have many applications, including delivering printing fluid or ink within a digital printing press used for commercial printing. These pumps include rotating and static parts which have a gap between these parts in order to avoid wear and friction. However, such gaps allow unintended leaking of fluid between the parts which reduces the pump efficiency. Leaking may be reduced by using high tolerance parts so that the gap can be made very small, however pumps using high tolerance parts can be expensive and prone to malfunction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Various features of the present disclosure will be apparent from the detailed description which follows, taken in conjunction with the accompanying drawings, which together illustrate features of the present disclosure, and wherein:

[0003] Figure 1 is a cross-section of an example centrifugal pump which may make use of the present disclosure;

[0004] Figure 2 is a detail cross-section showing an example seal of the pump of figure 1;

[0005] Figure 3 is a partial cross-section of another example centrifugal pump;

[0006] Figure 4 is a plan view of one side of an impeller wall of the pump of figure 3;

[0007] Figure 5 is a plan view of the other side of the impeller wall of the pump of figure 4;

[0008] Figure 6 is a plan view of one side of another example impeller wall;

[0009] Figure 7 is a detail cross-section showing a seal using the impeller of figure 6;

[0010] Figure 8 is a block diagram of an example digital printing press which may incorporate a centrifugal pump including the features of one or more of figures 1-8;

[0011] Figure 9 is a section of the shroud of figure 1 showing blades;

[0012] Figure 10 is a partial plan view of an alternative shroud and blade arrangement; and

[0013] Figure 11 is a partial plan view of another alternative shroud and blade arrangement.

DETAILED DESCRIPTION

[0014] Figures 1 and 2 illustrate an example centrifugal pump which may be used for transporting printing or other fluids. The centrifugal pump 100 comprises an impeller 105 arranged to rotate within a casing 110 in order to draw fluid from an inlet 150 of the impeller to a circumferential chamber 145 of the casing, for example a volute. The impeller 105 has an annular wall 125 having a central orifice forming an inlet 150. The annular wall 125 in this example includes a shroud 132 extending towards the inlet port 155. The impeller also comprises a second wall 135 and a number of vanes 140 located between the walls in order to form a plurality of radially extending flow channels for transporting the fluid between the inlet 150 and the chamber 145, which radially encompasses the impeller.

[0015] The impeller 105 is coupled to a shaft 120 which is driven and rotated about an axis of rotation 115. Fluid enters the casing 110 at an inlet port 155 which is arranged to direct the fluid to the inlet 150 of the impeller 105. The flow of fluid from the inlet port 155, through the impeller 105 to the circumferential

chamber 145 can be seen from the lines with solid arrow heads. These also show a smaller flow of fluid leaking back from the chamber 145 to the inlet 150 between the impeller and casing. In order to limit this leakage or backflow, a seal 160 is provided between the static casing 110 and the rotating impeller 105.

[0016] The annular wall 125 of the impeller 105 has a first surface 129 facing an inner surface 112 of the casing 110. The annular wall 125 also has a second surface 127 on the other side of the wall, and on which the vanes are fixed or formed with. A seal 160 is arranged between the inner surface 112 of the casing 105 and the first surface 129 of the annular wall along the shroud 132.

[0017] Figure 2 shows a detailed section of the seal 160 which includes a number of blades 265 spaced apart around the first surface of the annular wall, in this example located along the shroud 132. The blades 265 are arranged to rotate within a corresponding annular recess 263 within the inner surface 212 of the casing 110. A gap 270 exists between the static parts of the casing and the rotating parts, including the blades, of the impeller.

[0018] A cross-section of the shroud and blades at the seal is shown in figure 9. The blades 265 extend perpendicular to the first surface 129 of the annular wall 125 at the shroud 132. The shroud and blades rotate about the axis of rotation 115, with the blades rotating within the recess 263. The blades in this example are straight and extend longitudinally along the shroud in a direction parallel to the axis of rotation. Figure 10 is a plan view of a section of a shroud 1032 according to another example in which the blades 1065 are angled with respect to the axis of rotation 115. A further example is shown in figure 11 which is also a plan view of a shroud 1132 in which the blades 1165 extend longitudinally but are curved.

[0019] Whilst in this example, the seal 160 does not provide a hermetic seal in order to completely eliminate the leakage, it does reduce backflow or leakage thereby providing some sealing effect.

[0020] When the blades 265, 1065, 1165 are rotating in the annular recess 263, drag forces are created on the leakage or backflow of fluid between the casing and impeller. These drag forces prevent or reduce this fluid flow effectively preventing the leakage. The drag forces create low pressure on the inlet side of

the blades and high pressure on the circumferential chamber side, effectively acting against any backflow to reduce this to provide a sealing function. This reduced leakage improves the efficiency of the pump.

[0021] The use of this seal arrangement 160 in the pump 100 can be used to improve the efficiency of the pump, and/or allow a larger gap 270 between the rotating parts and the static parts of the pump. By supporting a larger gap 270 between the impeller 105 and the casing 110, lower tolerance parts may be used. For example, 3D printed parts, die casting parts or sand casting parts may be used, without first machining to improve their tolerance. This can significantly reduce the cost of manufacturing the pumps. This may be further enhanced by using cheaper materials such as plastic. The constructed pump is therefore tolerant of lower accuracy parts, as well as some misalignment of the parts. Furthermore, the pump is more robust against external forces such as impact shocks. In addition, if abrasive material is to be transported through the pump, this example will allow the gap to increase due to wear without significantly limiting the pump efficiency. The example may also be used in applications for the transportation of fluids carrying hard particles with less filtration, for example oil pumps, sewer pumps, swamp pumps and similar implementations.

[0022] Figures 3, 4 and 5 illustrate a centrifugal pump according to another example. Figure 3 shows a cross-section similar to figure 1 of the first example, and figures 4 and 5 show plan views of different sides of an annular wall of an impeller. Parts corresponding to those of the first example have been numbered with the same last two digits.

[0023] The pump 300 includes an impeller generally indicated at 305 and which comprises an annular wall 325 being generally disk shaped or circular, and a second wall 335 also disk or circular shaped. The annular wall 325 includes a first surface 329 facing towards the input of the pump (left), and a second surface 327 facing in the other direction (right). The first surface 329 faces a corresponding inner surface 312 of a casing 310. Vanes 340 extend between the second surface of the annular wall and the second wall 335 to form radially extending flow channels 342 in order to transport fluid from an inlet 350 to a

circumferential chamber 445. The impeller 305 rotates within the casing 310, being driven by a shaft 320.

[0024] The pump 300 has a similar seal 360 to the pump 100, however the annular wall 325 does not include a shroud, and instead the seal 360 is located on an upper part of the annular wall closer to the circumferential chamber. The seal includes an annular recess 363 within the inner wall 312 of the casing 310. Blades from the first surface 329 of the annular wall are arranged to rotate within the annular recess 363. The blades 365 may be angled with respect to a radial line from the center of the annular wall as shown in figure 5. This figure also indicates the corresponding location of the annular recess 363 using dashed lines. In alternative arrangements, the blades may be aligned radially and/or may be curved instead of straight.

[0025] Figures 6 and 7 illustrate a further example centrifugal pump having two seals. This example is similar to the second example of figures 3-5, having blades 665 extending from a first surface 629 of an annular wall 625 of an impeller. The blades rotate in an annular recess 763, and in this example the blades 665 are radially aligned as shown. This first seal 760 is complemented by a second seal 785 which further assists leakage of backflow.

[0026] The second seal 785 comprises an annular channel 680 in the first surface 629 of the annular wall 625. The inner surface 712 of the casing 710 comprises a corresponding annular projection 682 which is arranged to rotate within the annular channel 680. The second seal is located between the first seal 760 and the inlet of the impeller.

[0027] The second seal 785 also introduces drag forces to any leakage or backflow of fluid, and therefore supplements the effect of the first seal 760 in reducing overall leakage, and/or allowing for the use of lower tolerance parts and accuracy in assembly these into the pump.

[0028] Various alternatives are available in other example pumps, for example the blades 265, 365, 665, 1065, 1165 may be fixed to the inner wall of the casing, with the annular wall including a corresponding annular recess which rotates about the blades. Similarly, if a second seal is used, the annular projection may extend from the annular wall, and the corresponding annular channel formed

in the casing. The annular recess and annular channel may be on the same or different surfaces.

[0029] The annular wall may include a radially extending section as well as a shroud extending at an angle, similar to the example of figure 1, however the seal may be located on the radially extending section. The radially extending section of an annular wall, with or without a shroud, may extend perpendicular to the axis of rotation or at an acute angle to this. The second surface of the annular wall may be parallel to the second wall similar to the example of figures 3, or it may extend at an acute angle to the parallel similar to the example of figure 1.

[0030] Figure 8 illustrates a digital printing press or commercial printer having a centrifugal pump according to one of the examples. These digital printing presses are typically used in commercial applications using high quality, high volume printing. They benefit from reliable, high rates of printing fluid or ink supply, which are provided by the example centrifugal pumps. The digital printing press 800 includes one or more printing fluid tanks 890 each having a predetermined color of printing fluid. The or each printing fluid tank 890 has immersed in it a pump 300, or 100, 600, which transports printing fluid in the tank to other parts of the digital printing press for delivery onto a substrate such as paper. The example pumps can be produced relatively cheaply, for example using 3D printed parts, and yet are robust given their tolerance of external shocks and less accurate parts and assembly.

[0031] A pump 100, 300, 600 may be incorporated in separately available parts which may be periodically replaced within the digital printing press. For example, replacement printing fluid tanks may be available and incorporate a pump according to an example together with printing fluid. Similarly, a replaceable return tank may incorporate an example pump.

[0032] Whilst the seal arrangement in the examples described above has been explained in the context of a centrifugal pump, this seal arrangement could be employed in other turbomachinery such as other pump types, blowers, turbines or compressors. Similarly, whilst the seal arrangement has been described in the context of transporting printer printing fluid, turbomachinery employing the seal arrangement could be used for transporting any fluid.

[0033] Whilst the pump examples have been described in the context of printing fluid printing, they may be employed in any turbomachinery application, for example well pumping, swamp pumping, sewer pumping, and machining oil pumps.

[0034] The preceding description has been presented to illustrate and describe examples of the principles described. This description is not intended to be exhaustive or to limit these principles to any precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is to be understood that any feature described in relation to any one example may be used alone, or in combination with other features described, and may also be used in combination with any features of any other of the examples, or any combination of any other of the examples.

CLAIMS

What is claimed is:

1. A centrifugal pump, comprising:
an impeller arranged to rotate within a casing in order to draw a fluid from an inlet of the impeller to a circumferential chamber of the casing;
a seal formed between an inner surface of the casing and a surface of the impeller, the seal having an annular recess in one said surface and a plurality of blades on the other surface, the blades arranged to rotate within the annular recess.
2. The pump of claim 1, wherein the plurality of blades are on the impeller and the annular recess is in the casing.
3. The pump of claim 2, further comprising a second seal between the inner surface of the casing and the impeller, the second seal having an annular channel in one said surface and an annular projection on the other surface, the annular projection arranged to rotate within the annular channel.
4. The pump of claim 4, wherein the annular recess and the annular channel are in the same surface.
5. The pump of claim 1, wherein the blades have one or more of the following shapes projected from the surface: curved; straight.
6. A turbomachine comprising:
an impeller rotatably housed within a casing;
the impeller having an annular wall with a first surface facing a corresponding inner surface of the casing, and a second surface having a plurality of vanes extending radially to form a plurality of radially extending flow channels between adjacent vanes;

a seal formed between the inner surface of the casing and the first surface of the annular wall, the seal having an annular recess in one said surface and a plurality of blades on the other surface, the blades arranged to rotate within the annular recess.

7. The turbomachine of claim 6, wherein the impeller further comprises a second wall extending perpendicular to an axis of rotation of the impeller such that the vanes are located between the annular and second walls, the casing further comprising a chamber radially encompassing the impeller.

8. The turbomachine of claim 7, wherein the annular wall includes a section extending substantially perpendicular to an axis of rotation of the impeller, and wherein the seal is located at said section.

9. The turbomachine of claim 8, wherein the blades are angled with respect to a radial line of the axis of rotation.

10. The turbomachine of claim 7, wherein the annular wall includes a shroud extending at an angle from an inner edge and wherein the seal is located at said shroud.

11. The turbomachine of claim 6, wherein the casing comprises an input port arranged to direct a fluid to an inlet of the impeller adjacent an axis of rotation, the impeller arranged to rotate in order to draw the fluid from adjacent the axis radially along the flow channels to the chamber.

12. The turbomachine of claim 6, configured as a centrifugal printing fluid pump.

13. A printing fluid tank for a printer; the printing fluid tank having a centrifugal pump arranged to supply printing fluid from the printing fluid tank, the centrifugal pump comprising:

an impeller arranged to rotate within a casing in order to draw the printing fluid from an inlet of the impeller to a circumferential chamber of the casing;

a seal formed between an inner surface of the casing and a surface of the impeller, the seal having an annular recess in one said surface and a plurality of blades on the other surface, the blades arranged to rotate within the annular recess.

14. The printing fluid tank of claim 12, wherein in use the centrifugal pump is submerged in printing fluid within the printing fluid tank.

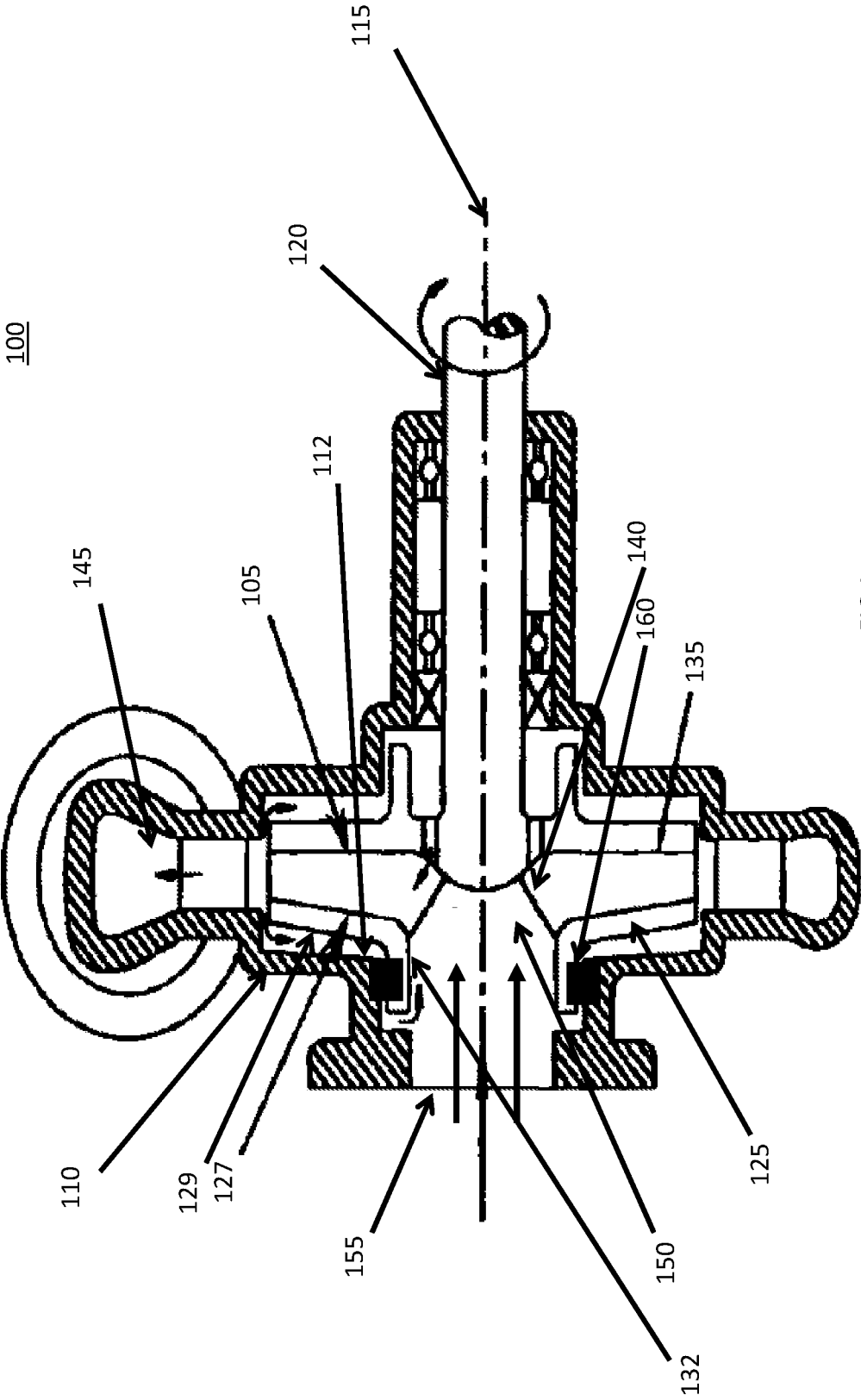


FIG 1

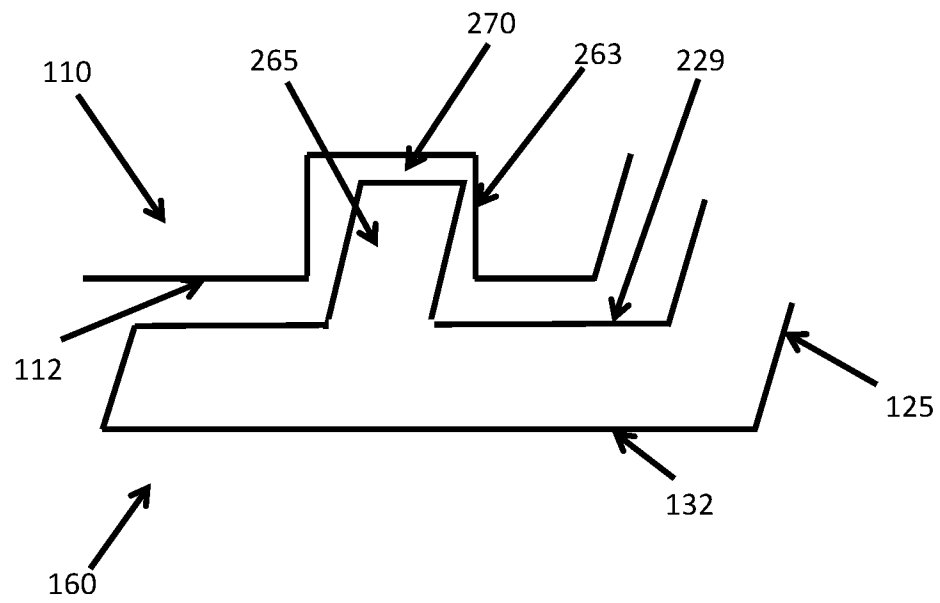


FIG 2

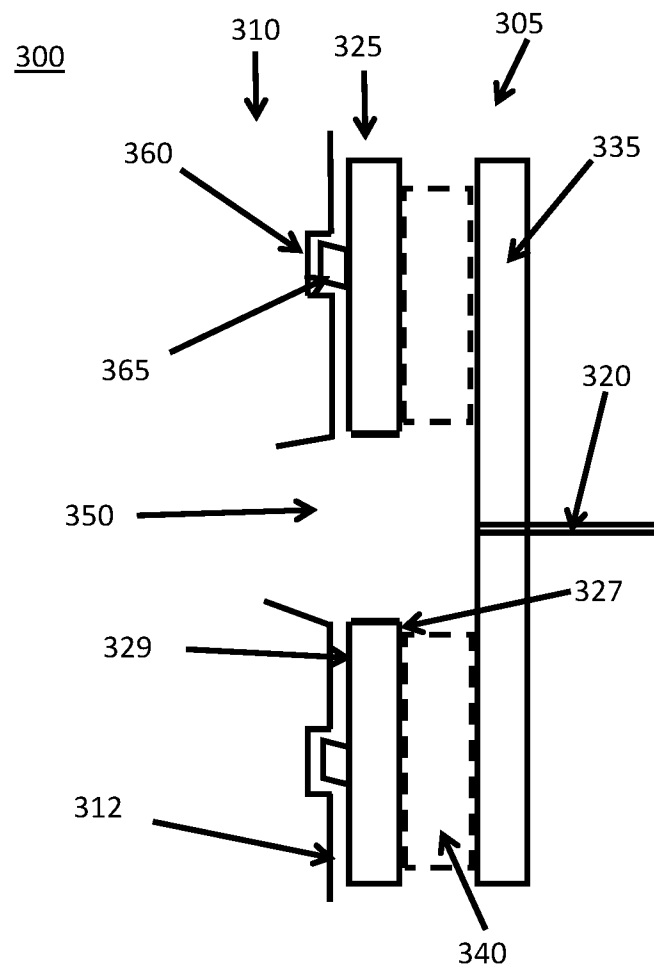


FIG 3

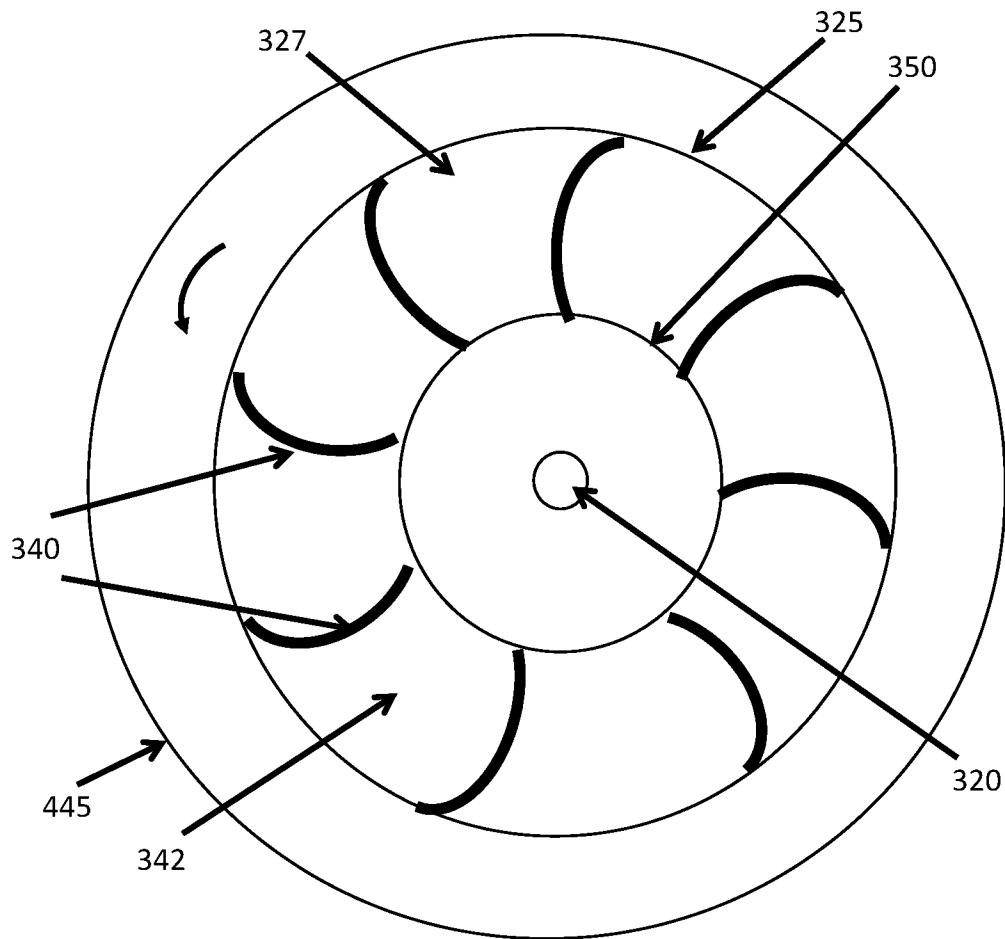


FIG 4

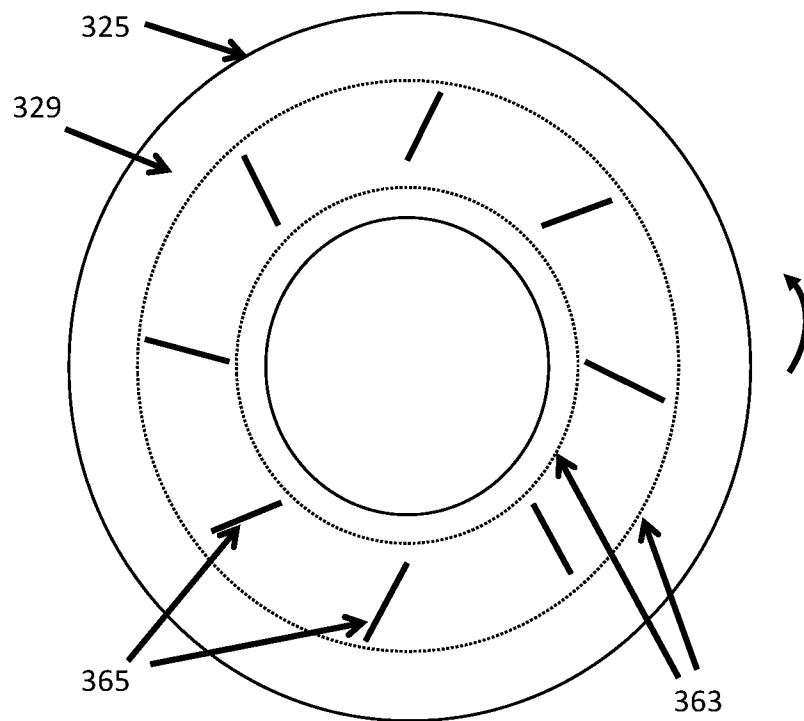


FIG 5

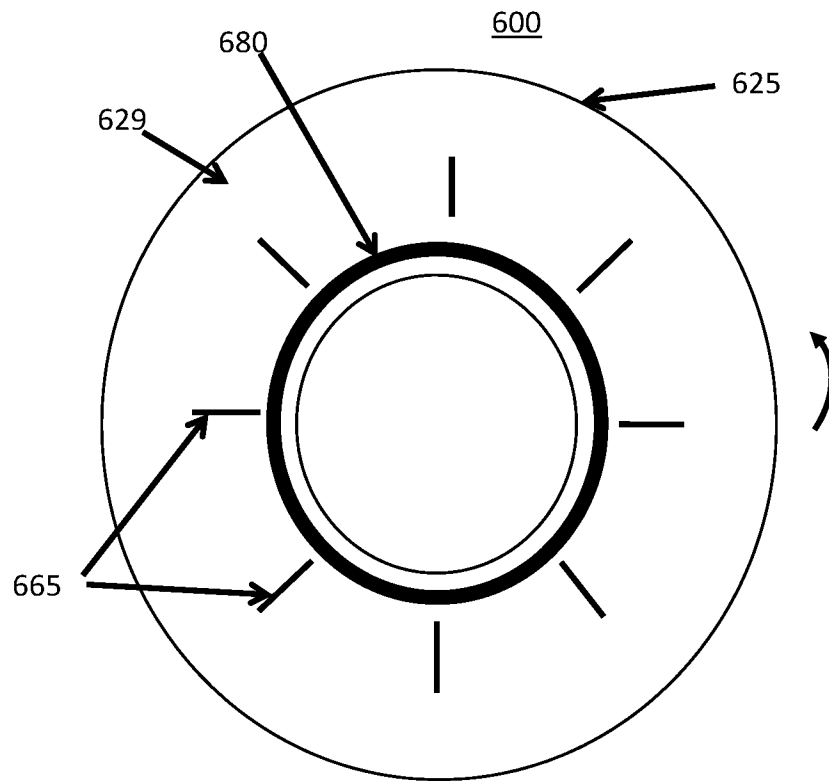


FIG 6

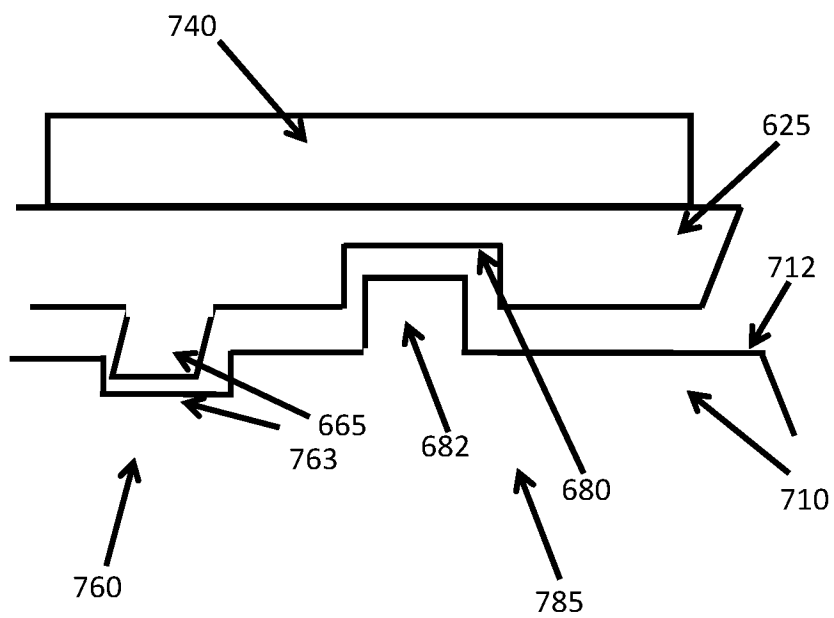


FIG 7

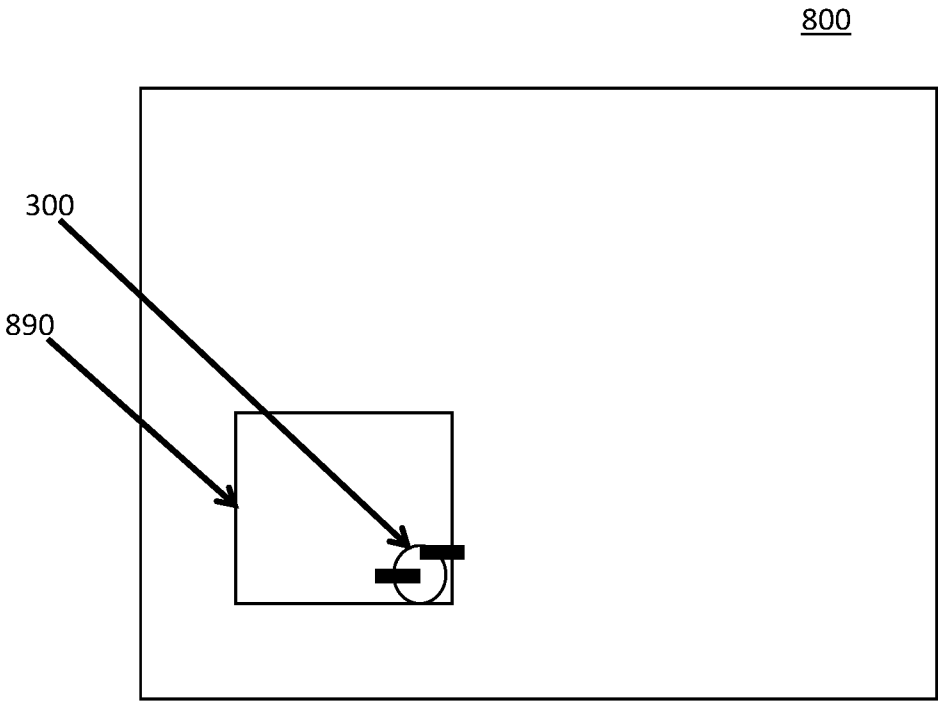


FIG 8

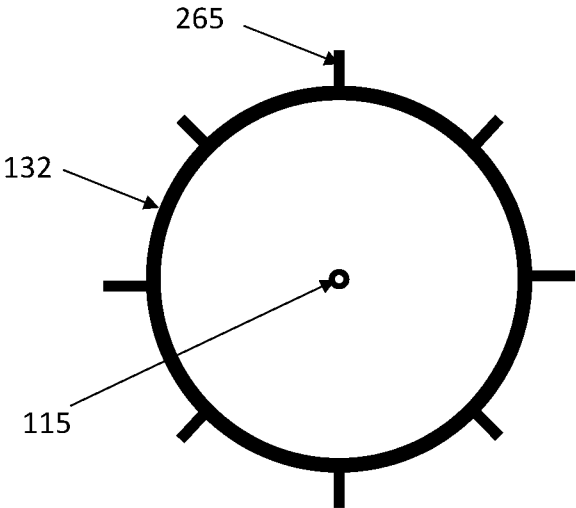


FIG 9

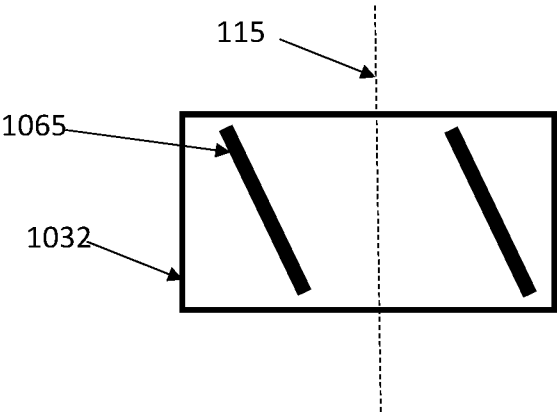


FIG 10

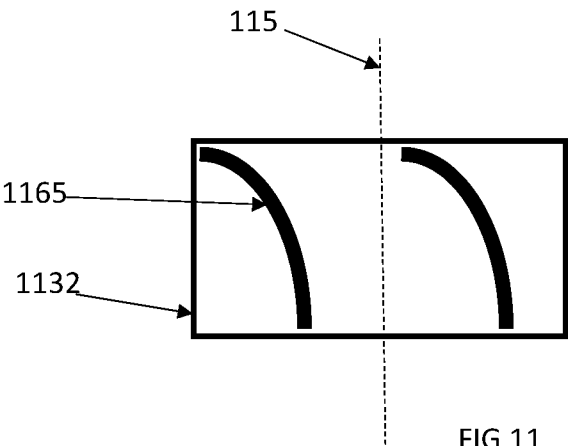


FIG 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2018/064381

A. CLASSIFICATION OF SUBJECT MATTER

F04D 29/16 (2006.01)**F04D 13/08** (2006.01)**F04D 7/02** (2006.01)**F16J 15/42** (2006.01)**B41J 2/175** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04D 29/00, 29/08, 29/16, 13/00, 13/06 -/08, 7/00, 7/02, F16J 15/00, 15/16, 15/40 - 15/42, B41J 2/00 -/015, 2/17 -/18, 31/02, F01D 11/00 -/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 1949429 A (FLUID SEAL CORPORATION) 06.03.1934, p.1 lines 1-3, p.2, lines 38-65, claim 1, fig.1, 2, c.3, lines 21-29, fig.5, 6	1-4, 6-8 5, 9-14
Y	US 7182444 B2 (FUJI PHOTO FILM CO LTD) 27.02.2007, claims1, 3, col.7, line 66 -col.8, line 12, col.8, lines 29-31, fig.1, 2, 7	11-14
Y	JPH 03177662 A (FUJI PHOTO FILM CO LTD) 01.08.1991, abstract, fig.1-3	5-9
Y	WO 2014/114373 A1 (SIEMENS AKTIENGESELLSCHAFT) 31.07.2014, p.23, lines 6 -13, p.20, line 34 -p.21, line 2, fig 5	10
A	RU 2037709 C1 (NAUCHNO-PROIZVODSTVENNOE OB EDINENIE ENERGETICHESKOGO MASHINOSTROENIYA IM. V.P. GLUSHKO) 19.06.1995	1-14

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

30 May 2019 (30.05.2019)

Date of mailing of the international search report

13 June 2019 (13.06.2019)

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