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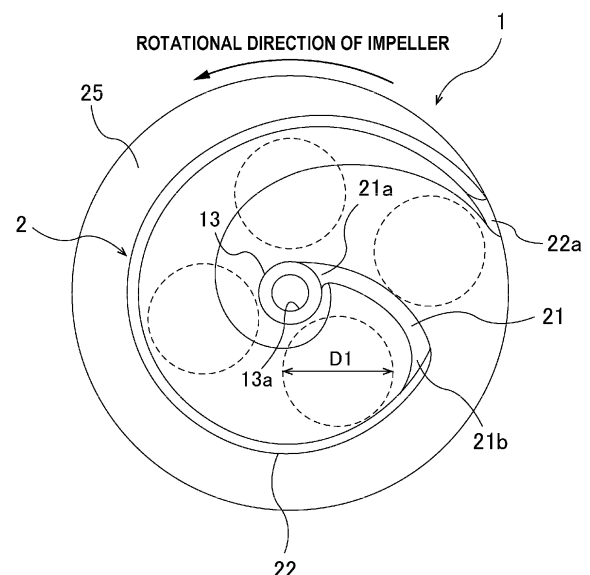
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(54) **PUMP**

(57) The present invention relates to a pump for delivering liquid, and more particularly to a pump for delivering liquid containing foreign object, such as string, fiber, or cloth. The pump includes an impeller (1) and an impeller casing (5) housing the impeller (1) therein. The impeller (1) has a hub (13), a single swept-back blade (2) coupled to the hub (13), and a shroud (25) to which the hub (13) and the swept-back blade (2) are coupled.

FIG. 2



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Description

Technical Field

[0001] The present invention relates to a pump for delivering liquid, and particularly to a pump for delivering liquid containing foreign object, such as a string, fiber, or cloth.

Background Art

[0002] Conventionally, a centrifugal pump has been used to deliver liquid, such as sewage, flowing through a sewer pipe. Such sewage may contain elongated foreign objects, such as strings, fibers, or cloth. Such elongated foreign objects tend to get caught in an impeller of the pump and may impede the rotation of the impeller. Therefore, in order to remove foreign object caught in the impeller, swept-back blades that are less likely to be clogged with foreign object are employed (see, for example, Patent Document 1).

Citation List

Patent Literature

[0003] Patent document 1: Japanese laid-open patent publication No. 2016-186284

Summary of Invention

Technical Problem

[0004] However, a conventional impeller has two or more swept-back blades. In a small sewage pump, the impeller itself is small in size, and a gap between the blades (hereinafter referred to as passage diameter) is also small. Such a sewage pump cannot have a passage diameter large enough to pass the foreign object. As a result, the impeller may be clogged with the foreign object.

[0005] Therefore, the present invention provides a pump that can prevent an impeller from being clogged with foreign object, such as string, fiber, or cloth.

Solution to Problem

[0006] In an embodiment, there is provided a pump for delivering liquid containing foreign object, comprising: an impeller; and an impeller casing that accommodates the impeller therein, the impeller including a hub, a single swept-back blade coupled to the hub, and a shroud to which the hub and the swept-back blade are coupled.

[0007] In an embodiment, the swept-back blade has a front edge extending radially outward from the hub, and a trailing edge extending spirally from the front edge in a direction opposite to a rotational direction of the impeller, and a winding angle of the swept-back blade from a

center of the front edge to a center of a rear end of the trailing edge is in a range of 320 to 410 degrees.

[0008] In an embodiment, an inner end of the front edge extends in a tangential direction of an outer circumferential surface of the hub.

[0009] In an embodiment, the impeller further includes a balance weight.

Advantageous Effects of Invention

[0010] Since the impeller has a single swept-back blade, the passage diameter within the impeller can be large. Therefore, a foreign object contained in a liquid can pass through the impeller without clogging the impeller.

Brief Description of Drawings

[0011]

[FIG. 1] FIG. 1 is a sectional view showing an embodiment of a pump;

[FIG. 2] FIG. 2 is a front view of an impeller as viewed from a direction indicated by arrow A in FIG. 1;

[FIG. 3] FIG. 3 is a perspective view of the impeller;

[FIG. 4] FIG. 4 is a front view of a conventional impeller having two swept-back blades;

[FIG. 5] FIG. 5 is a diagram illustrating a winding angle of a swept-back blade of the impeller shown in FIG. 2;

[FIG. 6] FIG. 6 is a graph showing an example of a relationship between the winding angle of the swept-back blade and impeller efficiency;

[FIG. 7] FIG. 7 is a meridional cross-sectional view of the impeller shown in FIG. 2;

[FIG. 8] FIG. 8 is a view of the impeller shown in FIG. 2 from its back side; and

[FIG. 9] FIG. 9 is a side view of the impeller shown in FIG. 2.

Description of Embodiments

[0012] Embodiments of the present invention will be described below with reference to the drawings.

[0013] FIG. 1 is a sectional view showing an embodiment of a pump. The pump shown in FIG. 1 is, for example, a centrifugal pump used to deliver liquid (e.g., sewage flowing through a sewer pipe) containing foreign object, such as string, fiber, or cloth.

[0014] As shown in FIG. 1, the pump includes a rotation shaft 11, an impeller 1 fixed to the rotation shaft 11, and an impeller casing 5 housing the impeller 1 therein. The rotation shaft 11 is coupled to a motor 12. The impeller 1 is rotated together with the rotation shaft 11 within the impeller casing 5 by the motor 12. A mechanical seal 15 is arranged between the motor 12 and the impeller 1. This mechanical seal 15 prevents liquid from entering the motor 12.

[0015] The impeller casing 5 has a casing body 6

disposed around the impeller 1 and a casing liner 8 coupled to the casing body 6. The impeller casing 5 has a suction port 3 and a discharge port 4. More specifically, the casing liner 8 has the cylindrical suction port 3, and the casing body 6 has the discharge port 4. The impeller casing 5 has a volute chamber (vortex chamber) 7 formed in the casing body 6, and the impeller 1 is arranged in the volute chamber 7. The volute chamber 7 has a shape surrounding the impeller 1. The suction port 3 and the discharge port 4 communicate with the volute chamber 7.

[0016] When the impeller 1 is rotated, liquid is sucked through the suction port 3. The liquid that had flowed through the suction port 3 is discharged into the volute chamber 7 in a circumferential direction by the rotation of the impeller 1. Velocity energy is imparted to the liquid by the rotation of the impeller 1. Furthermore, as the liquid flows through the volute chamber 7, the velocity energy is converted into pressure, so that the pressure of the liquid is increased. The pressurized liquid is discharged through the discharge port 4. A blade 2 of the impeller 1 faces an inner surface 8a of the casing liner 8 of the impeller casing 5 with a slight gap between the blade 2 and the inner surface 8a. This gap is, for example, in a range of 0.3 mm to 0.7 mm.

[0017] FIG. 2 is a front view of the impeller 1 as viewed from a direction indicated by arrow A in FIG. 1, and FIG. 3 is a perspective view of the impeller 1. The impeller 1 includes a single swept-back blade 2, a cylindrical hub 13, and a shroud 25 to which the swept-back blade 2 and the hub 13 are coupled. The hub 13 has a through-hole 13a into which an end of the rotation shaft 11 shown in FIG. 1 is inserted, so that the hub 13 is fixed to the end of the rotation shaft 11 with a fixing device (not shown). The impeller 1 is rotated by the motor 12 in a direction indicated by arrow.

[0018] The swept-back blade 2 has a front edge 21 extending radially outward from the hub 13, and a trailing edge 22 extending spirally from the front edge 21. The trailing edge 22 has a spiral shape extending from an outer end 21b of the front edge 21 in a direction opposite to the rotational direction of the impeller 1. A rear end 22a of the trailing edge 22 is located on an outer periphery of the shroud 25 and is coupled to the shroud 25. As shown in FIG. 3, the entire swept-back blade 2 is inclined with respect to an axis CL of the impeller 1.

[0019] As shown in FIG. 1, the front edge 21 is located in the suction port 3 of the impeller casing 5 and is exposed in the suction port 3. The trailing edge 22 faces the inner surface of the impeller casing 5 (more specifically, the inner surface 8a of the casing liner 8). A minute gap is formed between the trailing edge 22 and the inner surface 8a of the casing liner 8.

[0020] As shown in FIGS. 2 and 3, the shroud 25 is integral with the hub 13. The swept-back blade 2 is coupled to a front side of the shroud 25, and the swept-back blade 2, the hub 13, and the shroud 25 rotate together.

[0021] The front edge 21 extends radially outward from the hub 13 in an arc shape. More specifically, the front edge 21 is curved from the hub 13 in a direction opposite to the rotational direction of the impeller 1. Therefore, the outer end 21b of the front edge 21 is located more backward than the inner end 21a of the front edge 21 in the rotational direction of the rotation shaft 11. The trailing edge 22 extends spirally from the outer end 21b of the front edge 21.

[0022] The inner end 21a of the front edge 21 extends in a tangential direction of an outer circumferential surface of the hub 13 and is smoothly connected to the outer circumferential surface of the hub 13. Actual operations of the pump have confirmed the fact that such a shape of the front edge 21 causes foreign object in the liquid to move smoothly on the front edge 21 as the impeller 1 rotates, thus preventing clogging of the impeller 1.

[0023] In FIG. 2, symbol D1 represents a passage diameter through which a foreign object (e.g., string, fiber, or cloth) contained in the liquid can pass. Specifically, if the size of the foreign object is less than or equal to the passage diameter D1, the foreign object is expected to be able to pass through the impeller 1 together with the liquid without clogging the impeller 1.

[0024] FIG. 4 is a front view of a conventional impeller having two swept-back blades 100. In FIG. 4, symbol D2 represents a passage diameter through which a foreign object (e.g., string, fiber, or cloth) contained in liquid can pass. As can be seen from the comparison between FIG. 2 and FIG. 4, the impeller 1 of this embodiment has the single swept-back blade 2, and therefore the passage diameter D1 in the impeller 1 is larger than the passage diameter D2 in the conventional impeller of the two-blade type. Therefore, according to this embodiment, foreign object contained in the liquid can pass through the impeller 1 without clogging the impeller 1.

[0025] As described above, the single swept-back blade 2 can prevent the foreign object from clogging the impeller 1, but an impeller efficiency tends to decrease compared to the impeller with multiple swept-back blades. Therefore, in order to improve the impeller efficiency, as shown in FIG. 5, a winding angle θ of the swept-back blade 2 of this embodiment is in a range of 320 to 410 degrees, more preferably in a range of 330 to 390 degrees. The winding angle θ of the swept-back blade 2 is an angle from a start point to an end point of a camber line D of the swept-back blade 2, in other words, an angle from the center of the front edge 21 to the center of the rear end 22a of the trailing edge 22. More specifically, the winding angle θ of the swept-back blade 2 is defined by an angle between a straight line L1 extending from the center of the impeller 1 to the center of the front edge 21 and a straight line L2 extending from the center of the impeller 1 to the center of the rear end 22a of the trailing edge 22.

[0026] FIG. 6 is a graph showing an example of a relationship between the winding angle θ of the swept-back blade 2 and the impeller efficiency. As shown in FIG.

6, as the winding angle θ of the swept-back blade 2 increases, the impeller efficiency tends to improve. On the other hand, if the winding angle θ of the swept-back blades 2 is too large, the impeller efficiency will actually decrease. In addition, if the winding angle θ of the swept-back blade 2 is too large (particularly if the winding angle of the swept-back blade 2 exceeds 410 degrees), the passage diameter D1 described with reference to FIG. 2 becomes small. From these viewpoints, the winding angle θ of the swept-back blade 2 is in the range of 320 to 410 degrees, more preferably in the range of 330 to 390 degrees.

[0027] The impeller 1 having the single swept-back blade 2 and having the winding angle θ within the above-mentioned range can achieve high impeller efficiency while preventing foreign object from clogging the impeller 1.

[0028] FIG. 7 is a meridional cross-sectional view of the impeller 1 shown in FIG. 2, and FIG. 8 is a view of the impeller 1 shown in FIG. 2 viewed from its back side. Since the impeller 1 of this embodiment has one swept-back blade 2, the impeller 1 has a balance weight 30 in order to balance the rotation of the impeller 1. This balance weight 30 is provided on the back side of the shroud 25. The balance weight 30 may be integral with the shroud 25.

[0029] The balance weight 30 can prevent vibration of the impeller 1 when the impeller 1 is rotating at high speed and can prevent the impeller 1 from contacting the impeller casing 5.

[0030] FIG. 9 is a side view of the impeller 1 shown in FIG. 2. As shown in FIG. 9, the rear end 22a of the trailing edge 22 is connected diagonally to the shroud 25. Specifically, when viewed from a direction perpendicular to the axis CL of the impeller 1, the rear end 22a of the trailing edge 22 is inclined with respect to the axis CL of the impeller 1. A connection angle α between the rear end 22a of the trailing edge 22 and the shroud 25 is larger than 90 degrees. In other words, the connection angle α satisfies $90^\circ < \alpha < 180^\circ$.

[0031] The rear end 22a of the trailing edge 22 corresponds to an outlet of the swept-back blade 2. Such an oblique shape of the rear end 22a of the trailing edge 22 can reduce a radial load that the rotating impeller 1 receives from the liquid. As a result, the rotation of the impeller 1 is stabilized.

[0032] In one embodiment, the connection angle α between the rear end 22a of the trailing edge 22 and the shroud 25 may be 90 degrees or less than 90 degrees. In other words, the connection angle α satisfies $0^\circ < \alpha \leq 90^\circ$.

[0033] The previous description of embodiments is provided to enable a person skilled in the art to make and use the present invention. Moreover, various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles and specific examples defined herein may be applied to other embodiments. Therefore, the present invention is not

intended to be limited to the embodiments described herein but is to be accorded the widest scope as defined by limitation of the claims.

5 Industrial Applicability

[0034] The present invention is applicable to a pump for delivering liquid containing foreign object, such as a string, fiber, or cloth.

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Reference Signs List

[0035]

15	1	impeller
	2	swept-back blade
	3	suction port
	4	discharge port
	5	impeller casing
20	6	casing body
	7	volute chamber (vortex chamber)
	8	casing liner
	11	rotation shaft
	12	motor
25	13	hub
	15	mechanical seal
	21	front edge
	21a	inner end of front edge
	21b	outer end of front edge
30	22	trailing edge
	22a	rear end of trailing edge
	25	shroud
	30	balance weight

35 Claims

1. A pump for delivering liquid containing foreign object, comprising:

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an impeller; and
an impeller casing that accommodates the impeller therein,
the impeller including

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a hub,
a single swept-back blade coupled to the hub, and
a shroud to which the hub and the swept-back blade are coupled.

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2. The pump according to claim 1, wherein the swept-back blade has a front edge extending radially outward from the hub, and a trailing edge extending spirally from the front edge in a direction opposite to a rotational direction of the impeller, and a winding angle of the swept-back blade from a center of the front edge to a center of a rear end of the trailing edge is in a range of 320 to 410 degrees.

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3. The pump according to claim 1, wherein an inner end of the front edge extends in a tangential direction of an outer circumferential surface of the hub.
4. The pump according to claim 1, wherein the impeller further includes a balance weight.

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FIG. 1

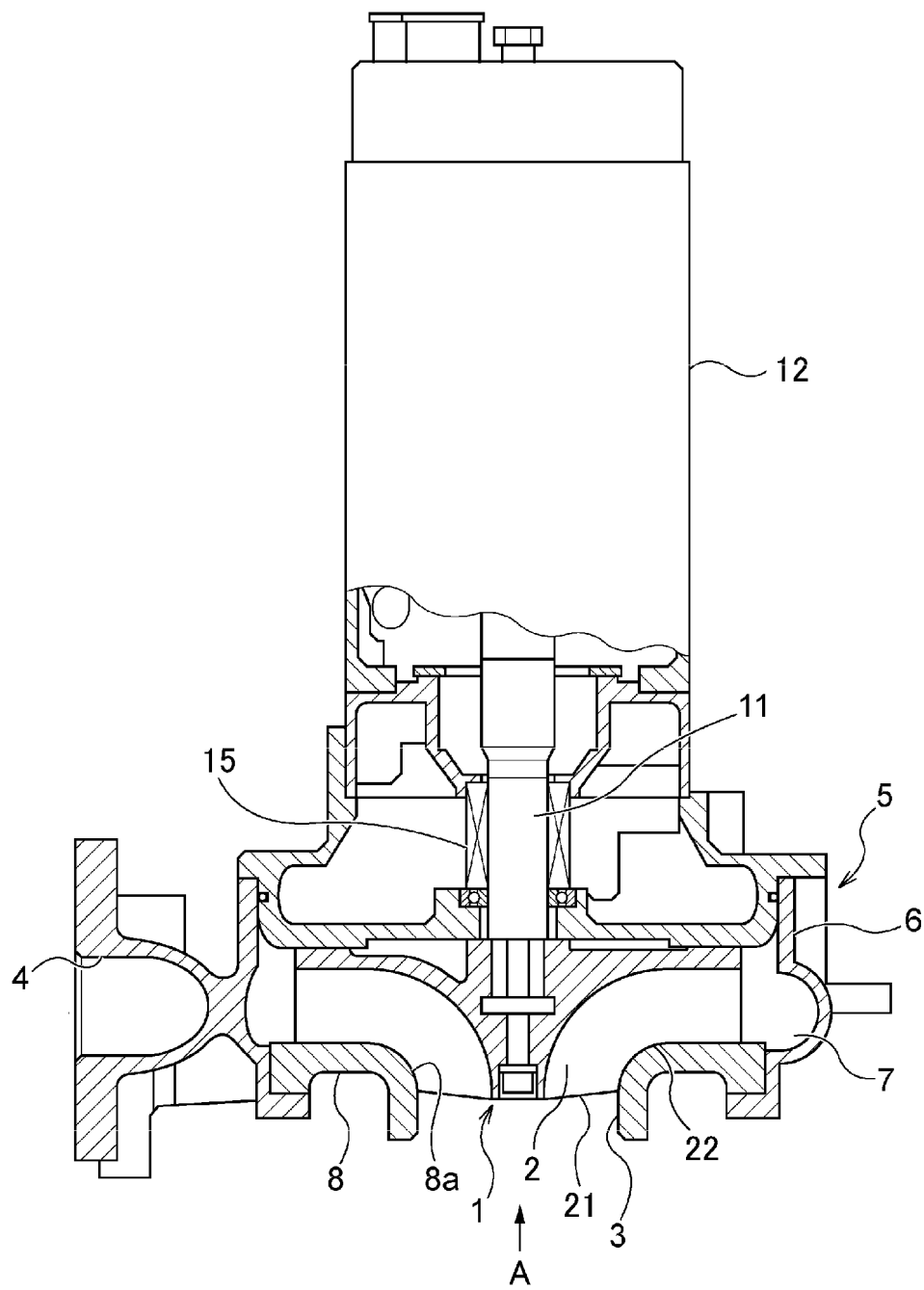


FIG. 2

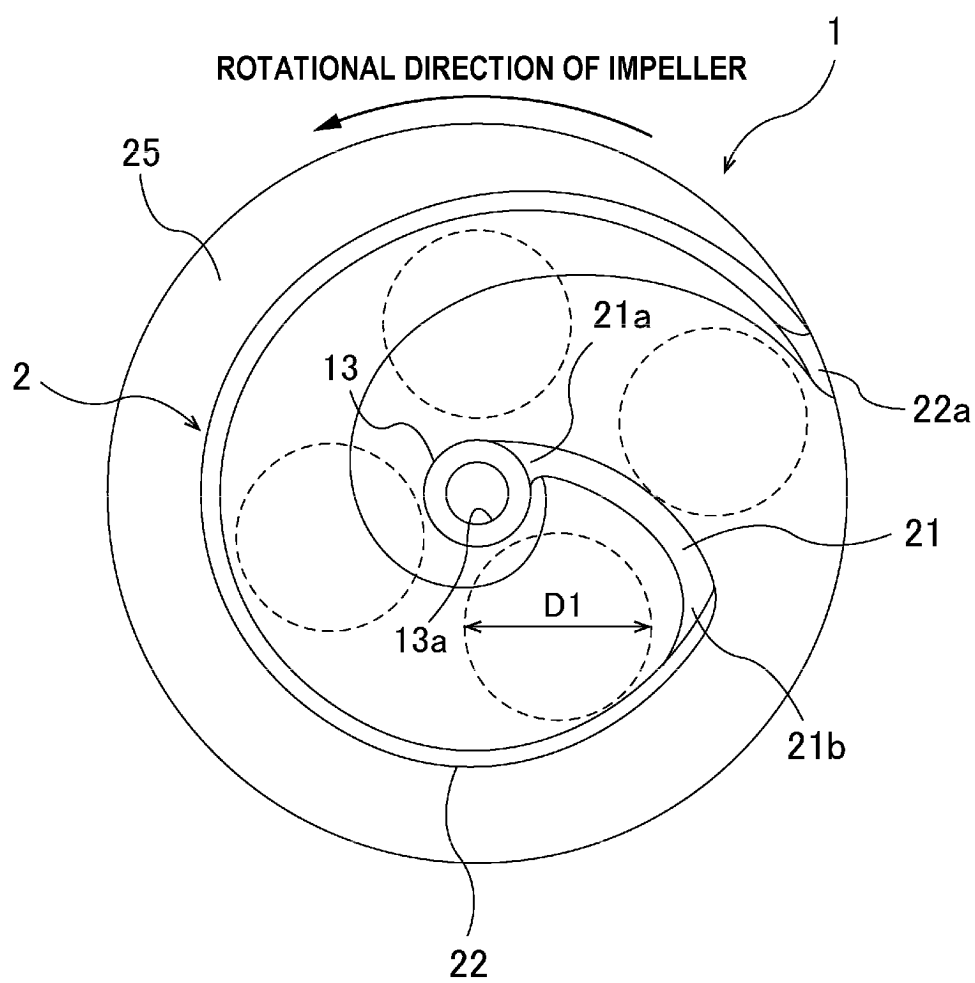


FIG. 3

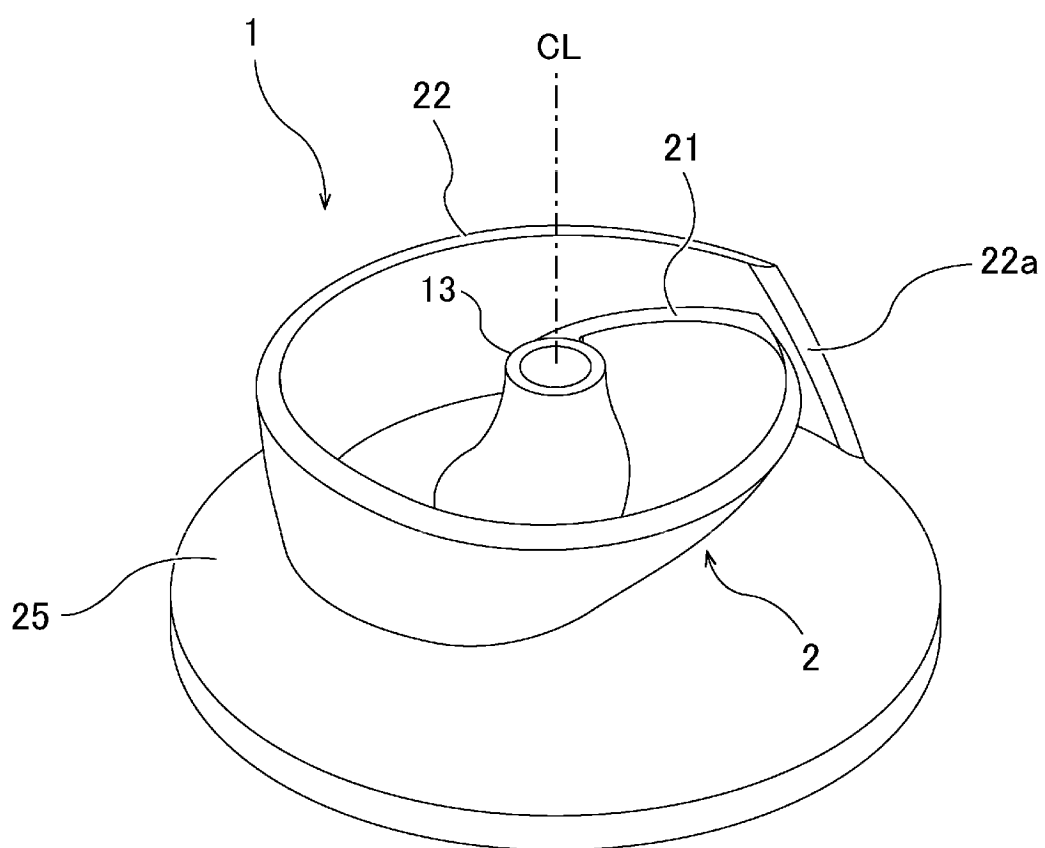


FIG. 4

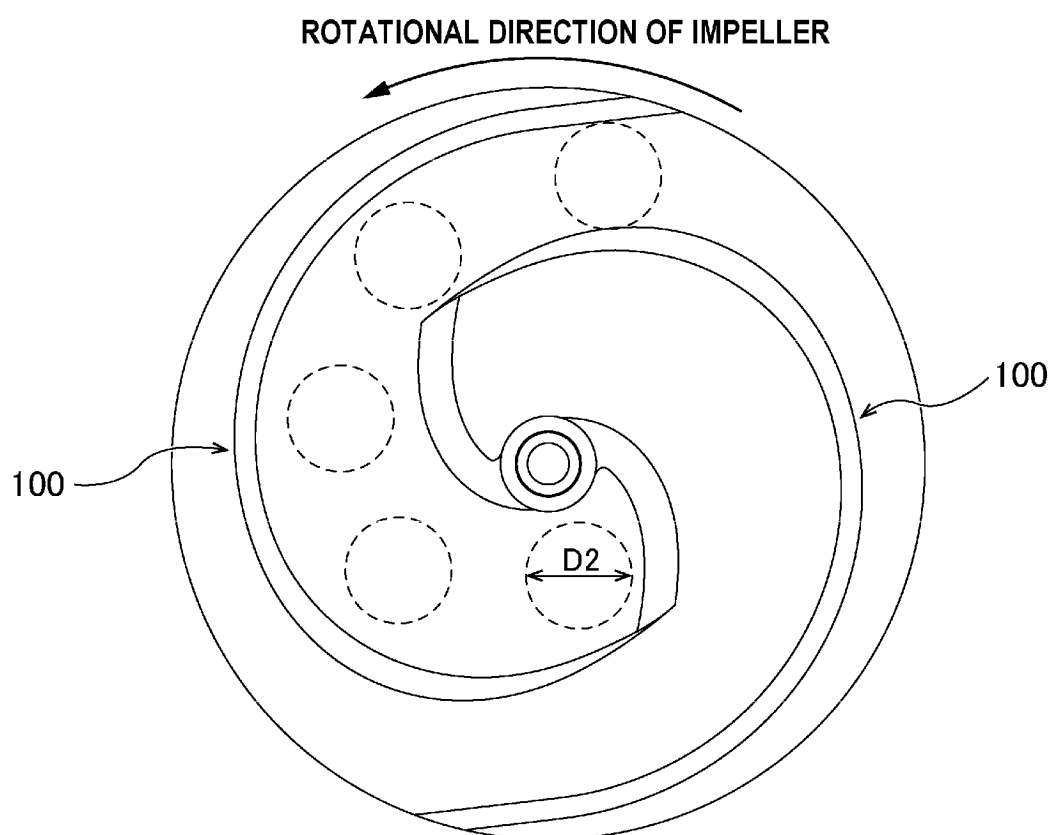


FIG. 5

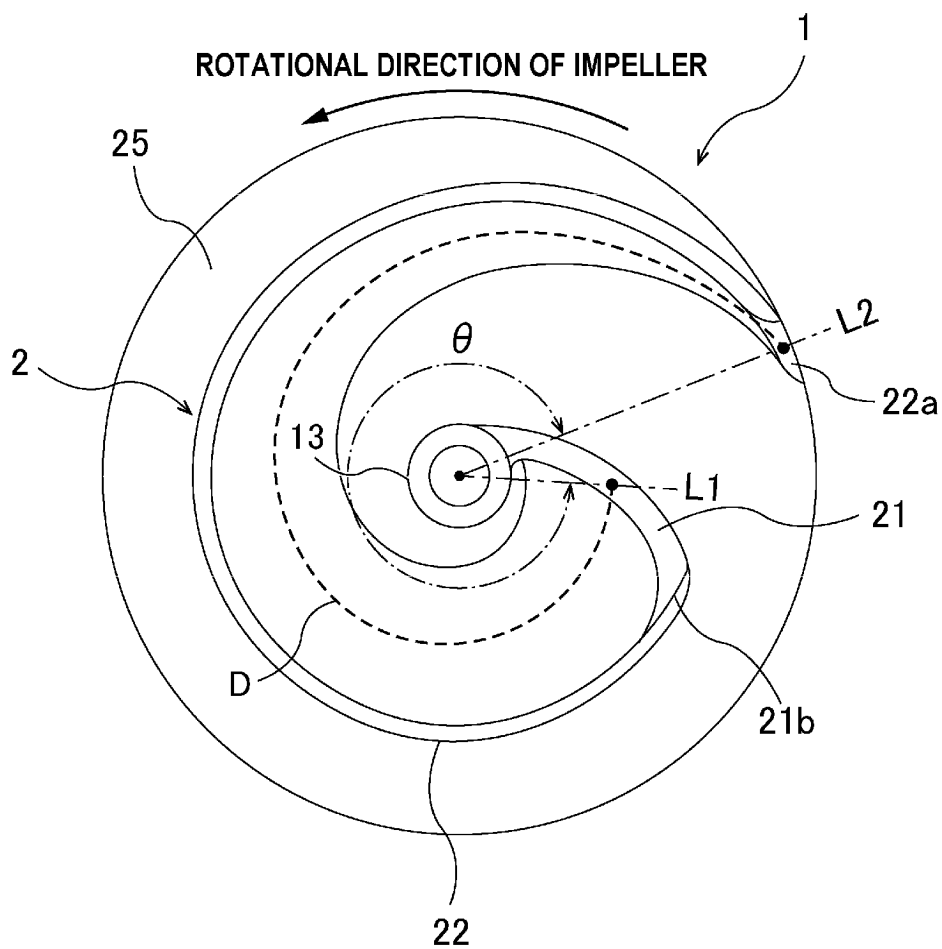


FIG. 6

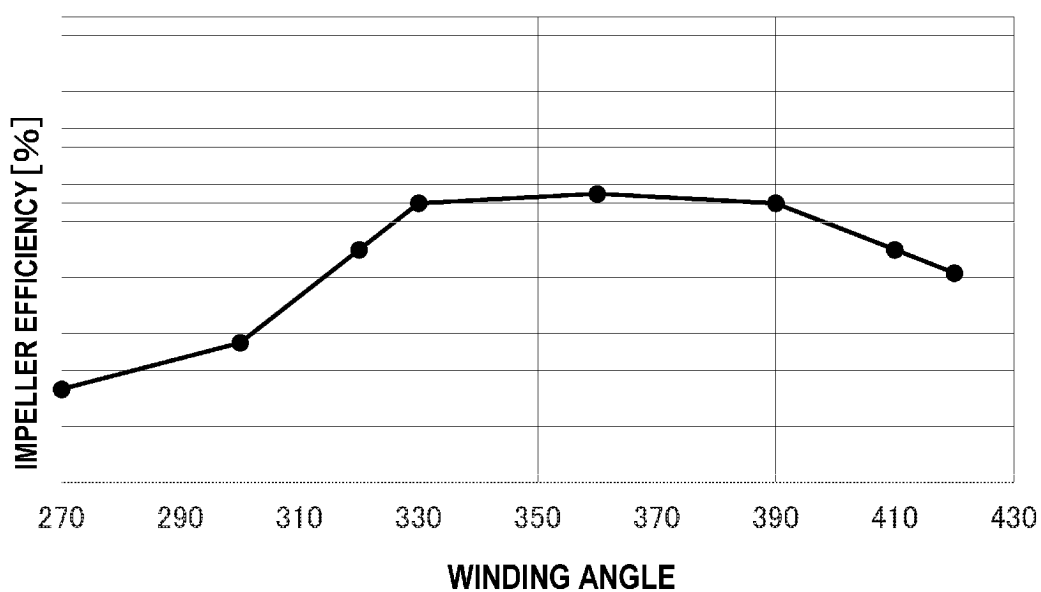


FIG. 7

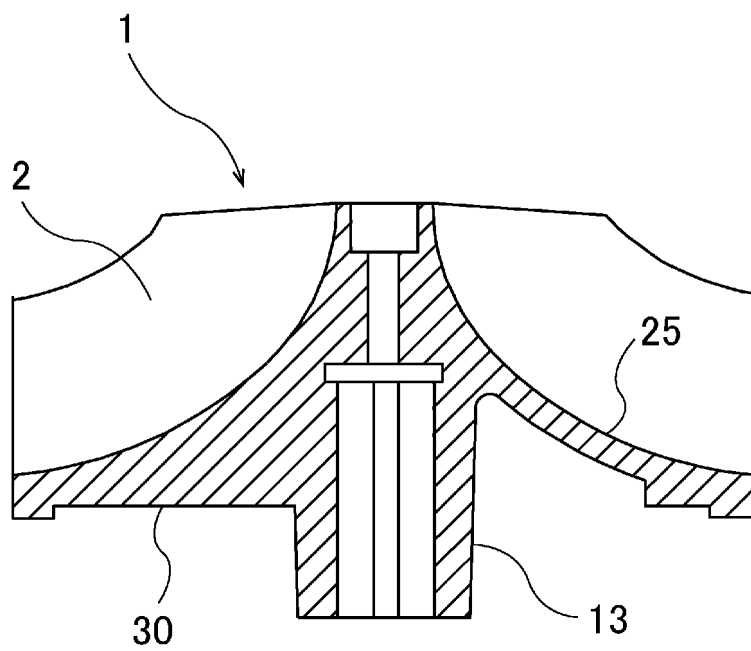


FIG. 8

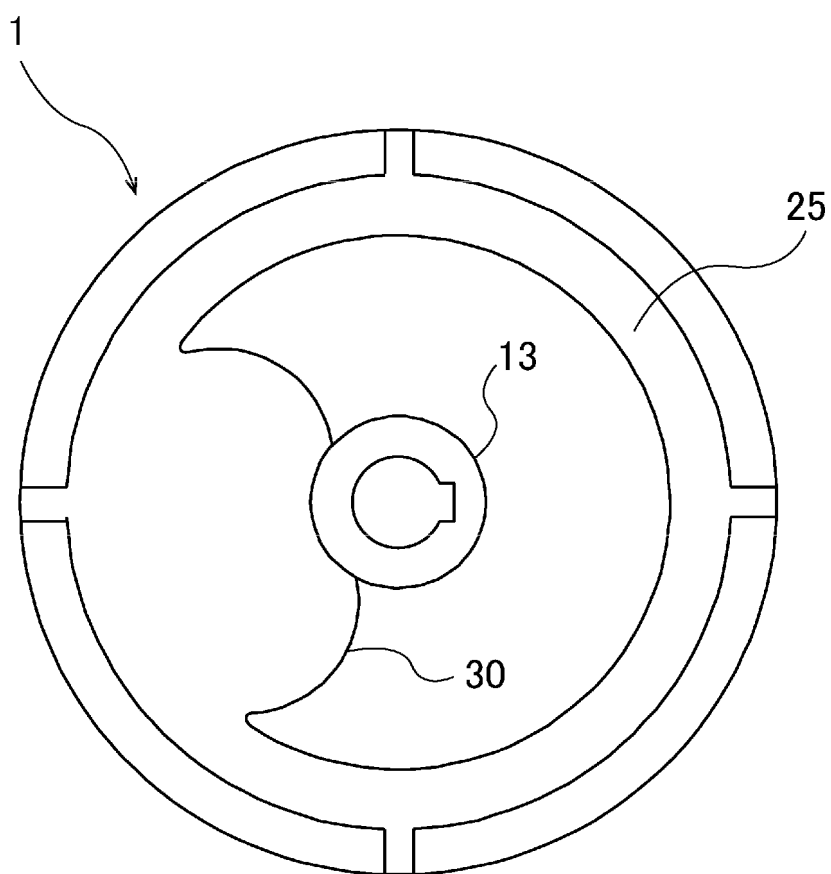
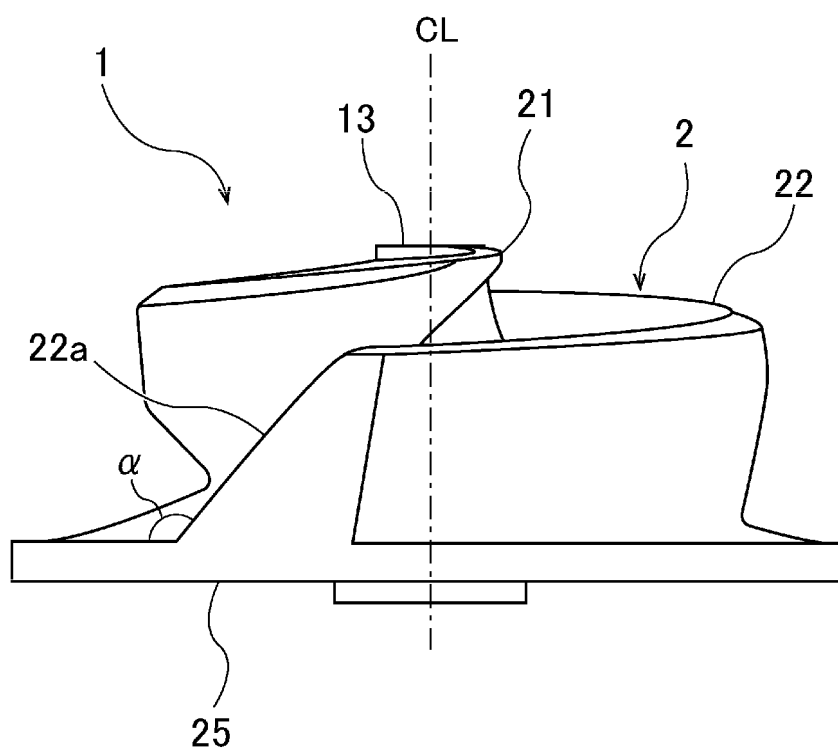


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/047062

A. CLASSIFICATION OF SUBJECT MATTER

F04D 29/24(2006.01)i

FI: F04D29/24 C; F04D29/24 B

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)

F04D29/24

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2023

Registered utility model specifications of Japan 1996-2023

Published registered utility model applications of Japan 1994-2023

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 11-6496 A (EBARA CORP) 12 January 1999 (1999-01-12) paragraphs [0001], [0011]-[0025], fig. 1-4	1-4
Y	JP 2010-174630 A (KUBOTA CORP) 12 August 2010 (2010-08-12) paragraphs [0001], [0016]-[0023], fig. 1-5	1-4
Y	JP 2022-1755 A (TSURUMIMANUFACTURING CO., LTD.) 06 January 2022 (2022-01-06) paragraphs [0016], [0046], [0048], [0083]	1-4
Y	JP 2016-188641 A (EBARA CORP) 04 November 2016 (2016-11-04) paragraph [0019]	2
Y	JP 50-403 A (HITACHI LTD) 07 January 1975 (1975-01-07) claims, p. 1, lower right column, lines 5-7, fig. 2	2, 4
Y	JP 2006-291938 A (SHIN MEIWA IND CO LTD) 26 October 2006 (2006-10-26) claims 3-5, paragraphs [0001], [0034], [0051]-[0053]	4

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

* Special categories of cited documents:

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Date of the actual completion of the international search

23 January 2023

Date of mailing of the international search report

07 February 2023

Name and mailing address of the ISA/JP

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/047062

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2014-34885 A (TSURUMIMANUFACTURING CO., LTD.) 24 February 2014 (2014-02-24) paragraphs [0033]-[0035], fig. 1-2	1-4
A	CN 102345630 A (KUBOTA CORP) 08 February 2012 (2012-02-08) entire text, all drawings	1-4

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2022/047062

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 11-6496 A	12 January 1999	(Family: none)	
JP 2010-174630 A	12 August 2010	(Family: none)	
JP 2022-1755 A	06 January 2022	WO 2021/260974 A1 paragraphs [0016], [0046], [0048], [0083]	
JP 2016-188641 A	04 November 2016	US 2018/0051708 A1 paragraph [0053] WO 2016/158666 A1 EP 3276177 A1 CN 107407284 A	
JP 50-403 A	07 January 1975	(Family: none)	
JP 2006-291938 A	26 October 2006	(Family: none)	
JP 2014-34885 A	24 February 2014	(Family: none)	
CN 102345630 A	08 February 2012	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2016186284 A [0003]