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(54) Title: SUCTION PIPE INLET DEVICE FOR CENTRIFUGAL PUMP

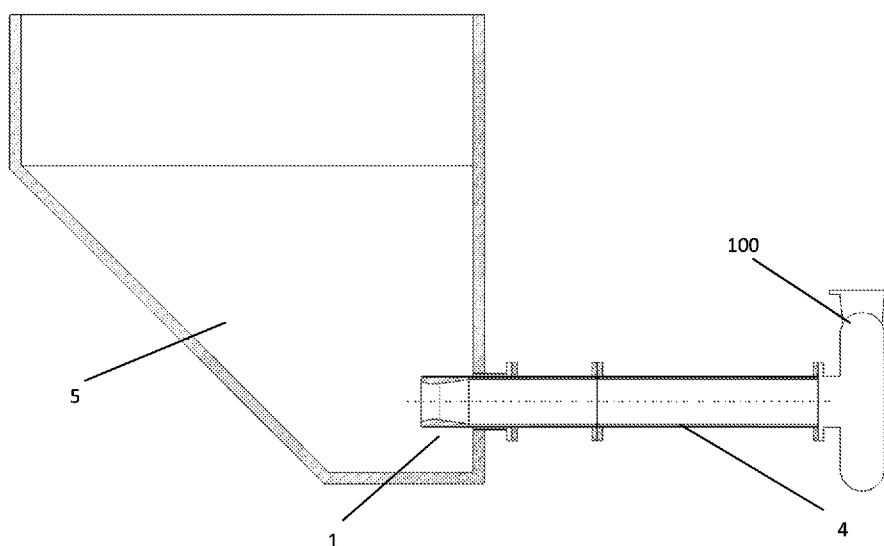


FIGURE 1

(57) Abstract: A suction pipe inlet device for a centrifugal pump, the device having a hollow tubular axisymmetric body along a longitudinal axis having an open first end adapted for fitting into or against a retention tank; an open second end adapted for fitting into or against an inflow end of a suction pipe having an outer pipe diameter and an inner pipe diameter; a converging section located closer to the retention tank; a diverging section located closer to the suction pipe; a throat located at the intersection point between the converging and diverging sections, the converging and diverging sections defining an interior converging-diverging geometry within the tubular axisymmetric body and the throat defining a minimum inner cross sectional area of the tubular axisymmetric body.

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 applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
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SUCTION PIPE INLET DEVICE FOR CENTRIFUGAL PUMP

FIELD OF THE INVENTION

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The present invention relates to a suction pipe inlet device for minimizing entrance losses in slurry systems involving centrifugal pumps used in the mining and other processing industries to transport mixtures of liquids and solids such as slurries.

BACKGROUND OF THE INVENTION

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Mixtures of liquids and solids, such as slurries in mining and mineral processing operations, are typically transported using centrifugal pumps. Examples of centrifugal pumps may be appreciated from U.S. Patent Nos. 5,921,748, 7,074,017 and U.S. Patent Application Publication No. 2014/0037440.

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Centrifugal pump performance can be negatively affected by a poor design of the channel that conducts the fluid, e.g. slurry, from the reservoir or sump to the suction nozzle of the pump, normally known as a suction pipe. Ideally the suction pipe should supply to the pump a steady flow of fluid with a uniform velocity profile while minimizing frictional losses in order to promote optimum pump performance, ensure throughput and system reliability, and maintain a reasonable energy consumption. Typical suction pipe designs used for handling slurry focus on safety and maintainability, usually incorporating simple pipe entrances at the sump, and as a consequence they tend to be inefficient due to e.g. friction losses at the suction inlet, high wear rates in the suction inlet due to non-uniform velocity and turbulence in the slurry, increasing the system head and therefore reducing production or increasing wear and energy consumption, this in addition to higher wear rates in the same suction pipe. . For example, while typical "straight" pipe suction inlet designs with square corners protrude into the sump and can be pulled straight out of the sump wall; such a "straight" design causes unnecessarily high entrance losses that affect negatively the capacity and or performance of the pumping system. The "straight" design also causes the suction pipe inlet to wear out faster due to non-axial velocity components and turbulence in the slurry from what is known as the "vena contracta" effect. By way of further example, typical "bell mouth" pipe suction inlet designs (e.g. as shown in US 2005/0229982) commonly used in water pump installations are difficult to use in sumps intended for slurry since the "bell mouth" design implies diameter dimensions that exceed the size of the suction pipe and therefore cannot be pulled out easily through the wall of

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the sump, making it difficult to maintain or replace. Instead, when a "bell mouth" design requires maintenance or replacement, the retention tank is required to be drained so that the pipe inlet can be pulled out through the top of the retention tank involving undesirable and potentially unsafe operations.

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OBJECT OF THE INVENTION

It is an object of the invention to overcome or at least alleviate one or more of the above problems and/or provide the consumer with a useful or commercial choice.

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SUMMARY OF THE INVENTION

A suction pipe inlet device for a centrifugal pump is provided. The suction pipe inlet device may comprise a hollow tubular axisymmetric body along a longitudinal axis having an open first end adapted for fitting into or against a retention tank; an open second end adapted for fitting into or against an inflow end of a suction pipe having an outer pipe diameter and an inner pipe diameter; a converging section located closer to the retention tank; a diverging section located closer to the suction pipe; a throat located at the intersection point between the converging and diverging sections, the converging and diverging sections defining an interior converging-diverging geometry within the tubular axisymmetric body and the throat defining a minimum inner cross sectional area of the tubular axisymmetric body.

In an exemplary embodiment, the open first end may comprise an inner cross sectional area located at or near the edge of open first end, wherein an area ratio between the inner cross sectional area of the open first end and the minimum inner cross sectional area of the tubular axisymmetric body is between approximately 0.36 and 0.81. In some embodiments, the area ratio is between approximately 0.55 and 0.74.

In an exemplary embodiment, the converging section may be shaped as an arcuate smooth contraction, e.g. it can be elliptical shaped, such that the elliptical aspect ratio between an ellipse major radius and ellipse minor radius is between 1- 6. In some embodiments, the aspect ratio (AR) may be between 2 - 4.

In an exemplary embodiment, the diverging section may be shaped such that an included angle of internal side walls increases from approximately 4 degrees in an area closer to

the converging section to approximately 30 degrees in an area closer to the suction pipe. In some embodiments, the angle may increase from approximately 10 degrees in the area closer to the converging section to approximately 12 degrees in the area closer to the suction pipe.

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In an exemplary embodiment, the suction pipe inlet device may be attached to the inflow end of a suction pipe by mechanical, adhesive or other forming means.

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In an exemplary embodiment, the suction pipe inlet device may be a single integral piece with the suction pipe.

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In an exemplary embodiment, the suction pipe inlet device may further comprise a plurality of spiral ribs or spiral grooves located on an interior portion of the converging section or diverging section for affecting fluid flow through the suction pipe inlet device.

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In an exemplary embodiment, the suction pipe may further comprise a liner with a predetermined thickness and wherein the suction pipe also has an inner pipe lined wet diameter. In some embodiments, the inner cross sectional area of converging section may reduce progressively to a minimum inner cross sectional area corresponding to a reduction in radii approximately 0.05 - 0.20 times the inner pipe lined wet diameter. In some embodiment, the reduction in radii may be approximately 0.07 - 0.13.

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In an exemplary embodiment, the outer pipe diameter of the suction pipe may be approximately equal to outer diameter of the hollow tubular axisymmetric body. Other details, objects, and advantages of the invention will become apparent as the following description of certain present exemplary embodiments thereof and certain present exemplary methods of practicing the same proceeds.

BRIEF DESCRIPTION OF THE FIGURES

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Embodiments of the invention, by way of example only, will be described with reference to the accompanying drawings in which:

Figure 1 shows an overview of an exemplary embodiment of the suction pipe inlet device, a retention tank or sump, a suction pipe and a centrifugal pump.

5 Figure 2 shows a close-up view of an exemplary embodiment of the suction pipe inlet device.

Figure 3 shows a Computational Fluid Dynamics (CFD) result displaying velocity of the slurry within the suction pipe having the suction pipe inlet device of Figure 2 compared to suction pipes having "straight" or "bell mouth" designs.

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Figure 4 shows a Computational Fluid Dynamics (CFD) result displaying turbulence of the flow within the suction pipe having the suction pipe inlet device of Figure 2 compared to suction pipes having "straight" or "bell mouth" designs.

15 Figure 5 shows computed entrance losses and calculated total dynamic head losses within the suction pipe having the suction pipe inlet device of Figure 2 compared to suction pipes having "straight" or "bell mouth" designs using Computational Fluid Dynamics (CFD).

DETAILED DESCRIPTION OF THE INVENTION

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Figure 1 shows an exemplary embodiment of the suction pipe inlet device 1, a suction pipe 4, a retention tank or sump 5 and a centrifugal pump 100. The suction pipe 4 connects the sump 5 with the suction nozzle of the centrifugal pump 100, and as shown the suction pipe inlet device 1 protrudes into or against the retention tank 5. The suction
25 pipe inlet device 1 may be attached to or integral with the suction pipe 4, e.g. it may be attached by mechanical, adhesive or other forming means.

Referring now to Figure 2, the suction pipe inlet device 1 has a hollow tubular axisymmetric body along a longitudinal axis (L). Generally, the suction pipe inlet device 1 has an open
30 first end 1a and an open second end 1b which is opposite the open first end 1a. The open first end 1a can protrude or project, at least partially, into the retention tank 5 or can be adapted such that the open first end 1a fits against an opening in the retention tank 5. The open second end 1b can protrude or project, at least partially, into an inflow end of a suction pipe 4 or can be adapted such that the open second end 1b fits against the inflow
35 end of a suction pipe 4. The suction pipe 4 has an outer pipe diameter (ODp) and an inside pipe diameter (IDp). The open first end 1a also has an inner cross sectional area

located at or near the edge or end of the open first end 1a. The suction pipe 4 may also have a thickness T, with or without a liner 7, resulting in a flow area which is defined herein as the pipe lined wet inner diameter IDw.

- 5 As further shown in Figure 2, the suction pipe inlet device has an internal profile and an external profile. In an exemplary embodiment, the outer diameter or outer surface of the suction pipe inlet device 1 is approximately equal to the outer pipe diameter of the suction pipe 4. In an exemplary embodiment, the outer diameter or outer surface of the suction pipe inlet device 1 is shaped such that the suction pipe inlet device can be extracted
10 through a generally circular hole or recess in the retention tank 5. In an exemplary embodiment the internal profile of the suction pipe inlet device 1 is designed such that there is an interior converging-diverging geometry within the tubular axisymmetric body and a throat 1c within the tubular axisymmetric body which defines a minimum inner cross sectional area of the tubular axisymmetric body. The throat 1c is located at the intersection
15 point between a converging section 10 which is located closer to the retention tank 5 and a diverging section 20 which is located closer to the suction pipe 4.

In an exemplary embodiment of the converging section 10, the area ratio between the inner cross sectional area of the open first end 1a and the minimum inner cross sectional area at the throat 1c of the tubular axisymmetric body is between approximately 0.36 and
20 0.81, and preferably between approximately 0.55 and 0.74. In other words, the internal profile of the converging section 10 reduces progressively the cross sectional area from the open first end 1a to a minimum at the throat 1c corresponding to a reduction in radii approximately by 0.05 to 0.20 times the pipe lined wet inner diameter IDw and preferably
25 by approximately 0.07 - 0.13.

In an exemplary embodiment of the converging section 10, the open first end 1a is shaped to define an arcuate smooth contraction, as for example an elliptical shape entrance, such that an elliptical aspect ratio AR between an ellipse major radius R1 and an ellipse minor radius R2 is between 1 and 6 and preferably between 2 and 4. As shown in Figure 2, the
30 ellipse major radius R1 is the length from the edge of the open first end 1a and the throat 1c and the ellipse minor radius R2 is the radial height or thickness of the converging section 10.

In an exemplary embodiment of the diverging section 20, the diverging section 20 is shaped such that an included angle $\bullet$ of internal side walls 23 increases from approximately 4 degrees in an area closer to the converging section 10 to approximately 30 degrees in an area closer to the suction pipe 4 and preferably from approximately 10 degrees in the area closer to the converging section 10 to approximately 12 degrees in the area closer to the suction pipe 4. In other words, the internal profile of the diverging section 20 is shaped to increase progressively its cross sectional area (from the throat 1c to the second open end 1b towards the side closer to the suction pipe 4) as for example linearly with an angle $\bullet$ between the internal side walls 23 that can be within 4 to 30 degrees and preferably within 10 to 12 degrees.

In some embodiments, the suction pipe inlet device 1 can be manufactured with a wear resistant material or the suction pipe inlet device 1 may be protected with a suitable wear resistant liner such as a hard metal or an elastomer. In some embodiments, it is envisaged that a plurality of spiral grooves or spiral ribs may be disposed on a slurry-side surface of the converging 10 or diverging 20 sections in order to produce a swirling motion in the slurry that helps to control problems associated with settling of solids along suction pipes when feeding centrifugal pumps 100.

As shown in Figures 3 and 4, CFD analysis was conducted on the suction pipe inlet device 1 contemplated here, on a typical "straight" design and on a typical "bell mouth" design indicating enhanced velocity patterns and less turbulence with the suction pipe inlet device 1 compared with the traditional "straight" entrance design, offering a solution that would perform closer to the "bell mouth" design.

As shown in Figure 5, using the CFD results (as shown in Figure 3), inlet entrance losses were calculated for the suction pipe inlet device 1 contemplated here, for a typical "straight" design and for a typical "bell mouth" design at exemplary conditions: slurry flow = 13,200 gpm (3,000 m³/h); Pipe inner diameter = 18 inches (0.457 m). The results indicate a significant suction head loss of 3.33 ft (1.02 m) with the conventional straight pipe entrance design due mostly to entrance losses, which can be controlled as shown in this example with a bell mouth entrance predicted to reduce losses by 78% or with the suction pipe inlet device 1 disclosed here and predicted to reduce losses by 62%.

There are numerous advantages to the suction pipe inlet device 1 described and claimed herein. For example, it is estimated that the suction pipe inlet device 1 will (i) cut suction inlet loss by 50-60% from the "straight" pipe design equating to a few feet in overall total dynamic head requirements; (ii) increase slurry flow as compared to the "straight" design; (iii) be longer lasting than the "straight" pipe design due to less turbulence; (iv) be interchangeable with the typical "straight" designs, meaning an increase in pump performance without changing the design of the sump and (v) be easier to maintain and replace than the "bell mouth" design due to the same diameter as the hole in the retention tank while at the same time being closer in function to the "bell mouth" design.

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It is to be understood that the form of this invention as shown is merely a preferred embodiment. Various changes may be made in the function and arrangement of parts; equivalent means may be substituted for those illustrated and described; and certain features may be used independently from others without departing from the spirit and scope of the invention as defined in the following claims.

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LIST OF COMPONENTS

	1	suction pipe inlet device
20	1a	open first end of suction pipe inlet device
	1b	open second end of suction pipe inlet device
	1c	throat
	4	suction pipe
	5	retention tank / sump
25	7	liner
	10	converging section
	20	diverging section
	23	internal side walls of diverging section
	100	centrifugal pump
30	L	longitudinal axis
	ODp	outer pipe diameter
	IDp	inner pipe diameter
	IDw	inner pipe lined wet diameter
	R1	ellipse major radius
35	R2	ellipse minor radius
	AR	elliptical aspect ratio

- T predetermined liner thickness
- angle of internal side walls of diverging section

CLAIMS

1. A suction pipe inlet device (1) for a centrifugal pump (100) comprising:
a hollow tubular axisymmetric body along a longitudinal axis (L) having an open
5 first end (1a) adapted for fitting into or against a retention tank (5); an open second end
(1b) adapted for fitting into or against an inflow end of a suction pipe (4) having an outer
pipe diameter (Odp) and an inner pipe diameter (Idp); a converging section (10) located
closer to the retention tank (5); a diverging section (20) located closer to the suction pipe
(4); a throat (1c) located at the intersection point between the converging and diverging
10 sections (10, 20), the converging and diverging sections (10, 20) defining an interior
converging-diverging geometry within the tubular axisymmetric body and the throat (1c)
defining a minimum inner cross sectional area of the tubular axisymmetric body.
2. The suction pipe inlet device (1) of claim 1, wherein the open first end (1a)
15 comprises an inner cross sectional area located at or near the edge of open first end and
wherein an area ratio between the inner cross sectional area of the open first end (1a) and
the minimum inner cross sectional area of the tubular axisymmetric body is between
approximately 0.36 and 0.81.
- 20 3. The suction pipe inlet device (1) of claim 2, wherein the area ratio is between
approximately 0.55 and 0.74.
4. The suction pipe inlet device (1) of claim 1, wherein the converging section (10) is
shaped as an arcuate smooth contraction, e.g. elliptical shaped, and wherein an elliptical
25 aspect ratio (AR) between an ellipse major radius (R1) and ellipse minor radius (R2) is
between 1- 6.
5. The suction pipe inlet device (1) of claim 4, wherein the aspect ratio (AR) is
between 2 - 4.
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6. The suction pipe inlet device (1) of claim 1, wherein the diverging section (20) is
shaped such that an included angle (•) of internal side walls (23) increases from
approximately 4 degrees in an area closer to the converging section (10) to approximately
30 degrees in an area closer to the suction pipe (4).
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7. The suction pipe inlet device (1) of claim 6, wherein the angle ($\bullet$) increases from approximately 10 degrees in the area closer to the converging section (10) to approximately 12 degrees in the area closer to the suction pipe (4).
- 5 8. The suction pipe inlet device (1) of claim 1, wherein the suction pipe inlet device (1) is attached to the inflow end of a suction pipe (4) by mechanical, adhesive or other forming means.
9. The suction pipe inlet device (1) of claim 1, wherein the suction pipe inlet device
10 (1) is a single integral piece with the suction pipe (4).
10. The suction pipe inlet device (1) of claim 1, further comprising a plurality of spiral ribs or spiral grooves located on an interior portion of the converging section (10) or diverging section (20) for affecting fluid flow through the suction pipe inlet device (1).
11. The suction pipe inlet device (1) of claim 1, wherein the suction pipe (4) further
15 comprises a liner (7) with a predetermined thickness (T) and wherein the suction pipe (4) also has an inner pipe lined wet diameter (Idw).
12. The suction pipe inlet device (1) of claim 11, wherein the inner cross sectional area of converging section (10) reduces progressively to a minimum inner cross sectional area corresponding to a reduction in radii approximately 0.05 - 0.20 times the inner pipe lined
20 wet diameter (Idw).
13. The suction pipe inlet device (1) of claim 12, wherein the reduction in radii is approximately 0.07 - 0.13.
14. The suction pipe inlet device (1) of claim 1, wherein the outer pipe diameter (Odp) of the suction pipe (4) is approximately equal to outer diameter of the hollow tubular
25 axisymmetric body.

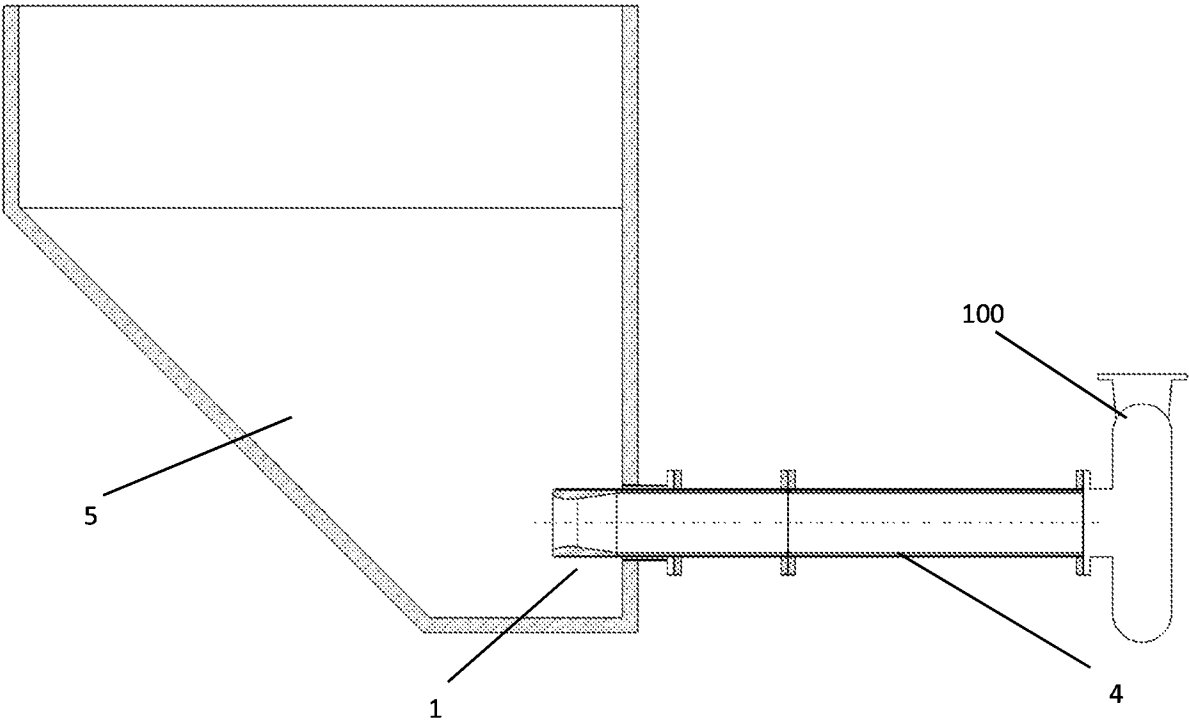


FIGURE 1

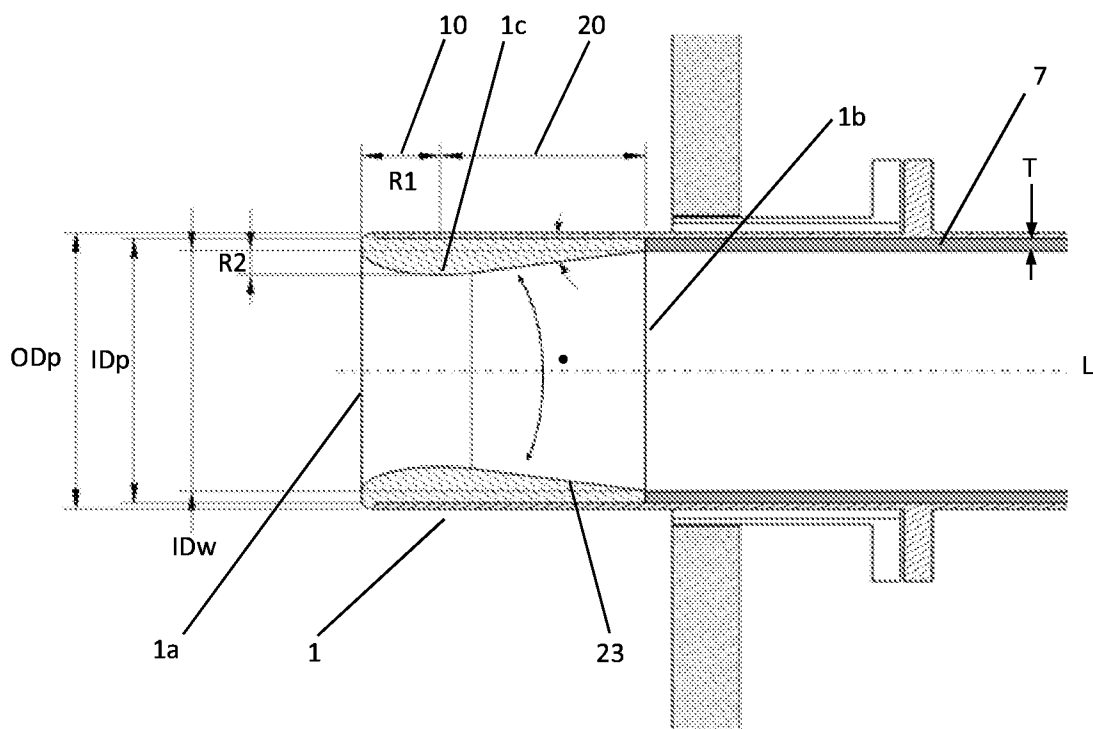


FIGURE 2

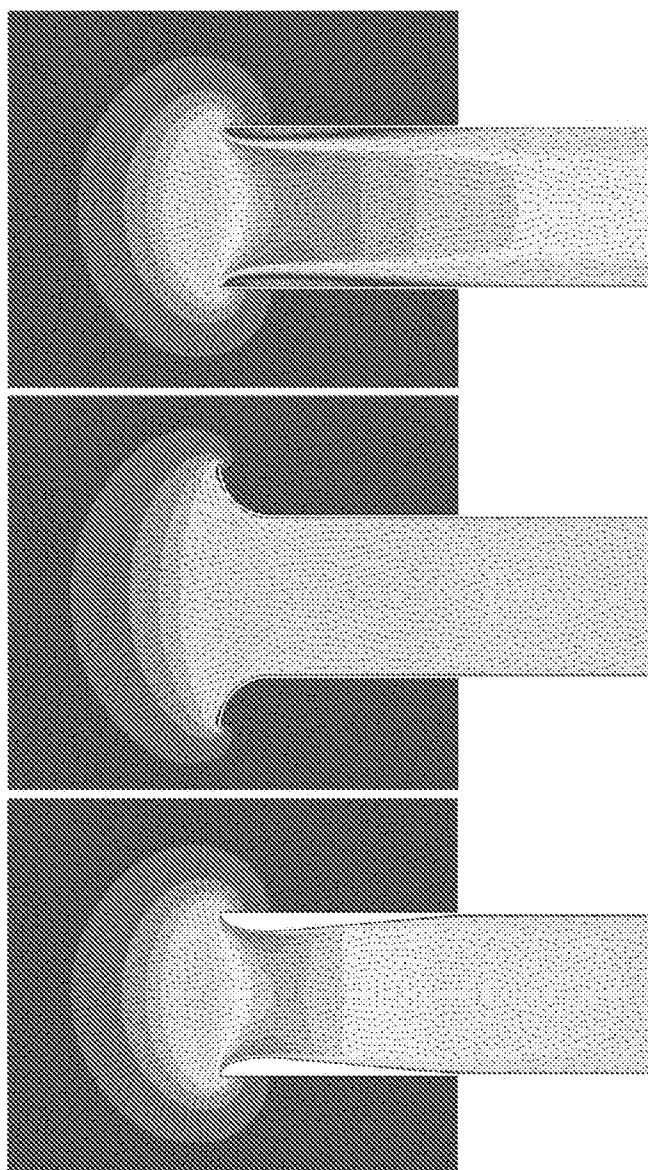


FIGURE 3

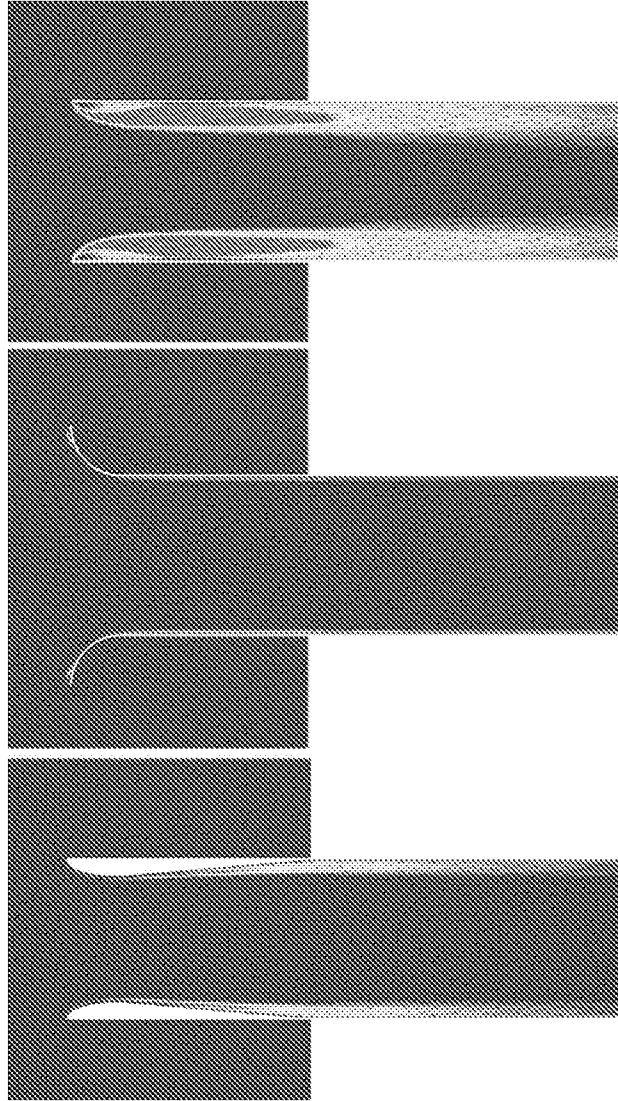
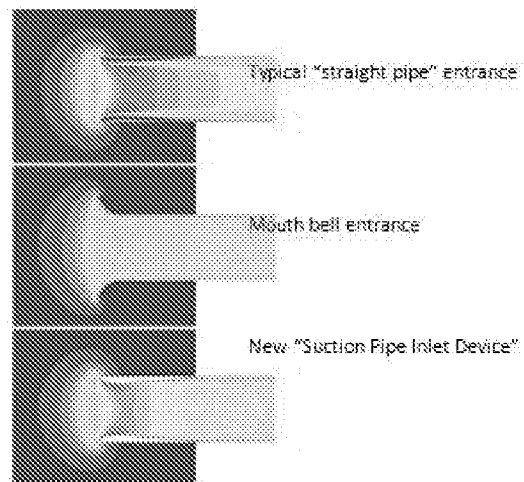


FIGURE 4



Example Flow = 13 200 gpm (3 000 m³/h)
 Fluid density = 1.0
 Pipe inner diameter = 18 inch (0.457 m)

	With straight pipe entrance	With bell mouth entrance	With new suction pipe inlet device
Suction pipe losses computed	3.33 ft (1.02 m)	0.73 ft (0.22 m)	1.25 ft (0.38 m)
Reduction in suction losses Vs. straight pipe entrance	0	-2.60 ft (-0.79 m)	-2.08 ft (-0.63 m)
		-78%	-62%

FIGURE 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/057963

A. CLASSIFICATION OF SUBJECT MATTER

INV. F04D29/70 F04D13/16 F04D29/42 F04D29/68 F15D1/02
F15D1/06

ADD.

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 F15D E03F F16L B65G G01F

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 33 38 610 A1 (GEN ELECTRIC [US]) 3 May 1984 (1984-05-03)	1-9, 11-14
Y	page 7, line 7 - line 16 page 8, line 7 - page 9, line 15 figures 1-3	10
X	----- WO 2008/080437 A1 (GARDNER DENVER DEUTDCHLAND GMB [DE]; DITTMAR RUDI [DE]; KOPF MARKUS [D] 10 July 2008 (2008-07-10)	1,8,9, 11,14
Y	page 1, line 23 - line 31 page 4, line 25 - page 5, line 18 page 10, line 20 - page 11, line 2 figures 1, 7 ----- -/-	10



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

8 March 2018

Date of mailing of the international search report

15/03/2018

Name and mailing address of the ISA/

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Oliveira, Damien

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/057963

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 301 764 A1 (COMMISSARIAT ENERGIE ATOMIQUE [FR]) 17 September 1976 (1976-09-17)	1-9, 11-14
Y	page 1, line 1 - line 6 page 6, line 8 - line 20 figures 2, 3 -----	10
Y	US 2005/229982 A1 (GONZALES PETER D [US]) 20 October 2005 (2005-10-20) cited in the application	10
A	paragraph [0034] - paragraph [0039] figures 1, 2, 5A-7D -----	1-9, 11-14
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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