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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/261,361	10/03/2012	Reiner Liebing	103945-0127-301

CONFIRMATION NO. 3522

145006
White & Case, LLP
75 State St
Boston, MA 02109

POA ACCEPTANCE LETTER

OC000000090116679

Date Mailed: 03/24/2017

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 03/17/2017.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/nbekele/

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/261,361	10/03/2012	Reiner Liebing	103945-0127-301

CONFIRMATION NO. 3522

POWER OF ATTORNEY NOTICE

OC000000090116658

28120
ROPES & GRAY LLP
IPRM Docketing - Floor 43
PRUDENTIAL TOWER
800 BOYLSTON STREET
BOSTON, MA 02199-3600

Date Mailed: 03/24/2017

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 03/17/2017.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/nbekele/

PTO/SB/80 (11-08)
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I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(b).

I hereby appoint:

☑ Practitioners associated with the Customer Number: 145006

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

as attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignment documents attached to this form in accordance with 37 CFR 3.73(b).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(b) to:

☑ The address associated with Customer Number: 145006

OR

☐ Firm or Individual Name			
Address			
City		State	Zip
Country			
Telephone		Email	

Assignee Name and Address:

ECP ENTWICKLUNGSGESELLSCHAFT MBH
Neuenhofer Weg 3
52074 Aachen GERMANY

A copy of this form, together with a statement under 37 CFR 3.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature		Date	06.02.17
Name	Thorsten Siess	Telephone	6 February 2017
Title	Managing Director (Geschäftsführer), ECP ENTWICKLUNGSGESELLSCHAFT MBH		

Electronic Acknowledgement Receipt

EFS ID:	28657873
Application Number:	13261361
International Application Number:	
Confirmation Number:	3522
Title of Invention:	CONVEYING DEVICE FOR A FLUID USING AN OSCILLATING BODY ARRANGEMENT
First Named Inventor/Applicant Name:	Reiner Liebing
Customer Number:	28120
Filer:	Anne-Raphaelle Aubry/Regina Brickhouse
Filer Authorized By:	Anne-Raphaelle Aubry
Attorney Docket Number:	103945-0127-301
Receipt Date:	17-MAR-2017
Filing Date:	03-OCT-2012
Time Stamp:	09:18:58
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Assignee showing of ownership per 37 CFR 3.73	0127-373B-8814543.pdf	423170 6735060e886fd4432583111412df16fed3b032ba	no	2

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Information:					
2	Power of Attorney	ECP-POA.pdf	65878 2d2dc8b61518dc7926edef02a27df18a8957e297	no	1
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			Total Files Size (in bytes):	489048	

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National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
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STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: ECP ENTWICKLUNGSGESELLSCHAFT MBH

Application No./Patent No.: 8,814,543 Filed/Issue Date: August 26, 2014

Titled: CONVEYING DEVICE FOR A FLUID USING AN OSCILLATING BODY ARRANGEMENT

ECP ENTWICKLUNGSGESELLSCHAFT MBH , a corporation
(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.

states that it is:

1. [X] the assignee of the entire right, title, and interest in;

2. [ ] an assignee of less than the entire right, title, and interest in
(The extent (by percentage) of its ownership interest is ________ %); or

3. [ ] the assignee of an undivided interest in the entirety of (a complete assignment from one of the joint inventors was made)

the patent application/patent identified above, by virtue of either:

A. [X] An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 029669, Frame 0194, or for which a copy therefore is attached.

OR

B. [ ] A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: ________ To: ________
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2. From: ________ To: ________
The document was recorded in the United States Patent and Trademark Office at
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[ ] Additional documents in the chain of title are listed on a supplemental sheet(s).

[ ] As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Anne-Raphaelle Aubry/ Limited Recognition No. L0955 — 03/16/2017
Signature — Date

Anne-Raphaelle Aubry — Representative for Applicant
Printed or Typed Name — Title

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The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/261,361	10/03/2012	Reiner Liebing	

CONFIRMATION NO. 3522

POA ACCEPTANCE LETTER

OC000000077143182

28120
ROPES & GRAY LLP
IPRM Docketing - Floor 43
PRUDENTIAL TOWER
800 BOYLSTON STREET
BOSTON, MA 02199-3600

Date Mailed: 08/28/2015

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

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/dtvernon/

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/261,361	10/03/2012	Reiner Liebing	1-21942

CONFIRMATION NO. 3522

POWER OF ATTORNEY NOTICE

OC000000077143167

1678
MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

Date Mailed: 08/28/2015

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 08/25/2015.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/dtvernon/

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I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(b).

I hereby appoint:

[X] Practitioners associated with the Customer Number: 28120

OR

[ ] Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

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[X] The address associated with Customer Number: 28120

OR

[ ] Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

Assignee Name and Address:

ECP ENTWICKLUNGSGESELLSCHAFT MBH
Wiesenweg 10
Berlin, 12247
Germany

A copy of this form, together with a statement under 37 CFR 3.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	[signature]	Date	02/01/15
Name	Thorsten Siess	Telephone	
Title	Managing Director (Geschäftsführer), ECP ENTWICKLUNGSGESELLSCHAFT MBH		

51299624_1

STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: ECP ENTWICKLUNGSGESELLSCHAFT MBH

Application No./Patent No.: 8,814,543 Filed/Issue Date: August 26, 2014

Titled: CONVEYING DEVICE FOR A FLUID USING AN OSCILLATING BODY ARRANGEMENT

ECP ENTWICKLUNGSGESELLSCHAFT MBH, a Corporation
(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.

states that it is:

1. [x] the assignee of the entire right, title, and interest in;
2. [ ] an assignee of less than the entire right, title, and interest in
(The extent (by percentage) of its ownership interest is ______ %); or
3. [ ] the assignee of an undivided interest in the entirety of (a complete assignment from one of the joint inventors was made)

the patent application/patent identified above, by virtue of either:

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[ ] Additional documents in the chain of title are listed on a supplemental sheet(s).

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[NOTE: A separate copy (*i.e.,* a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Steven C. Obiajulu/ — August 25, 2015
Signature — Date

Steven C. Obiajulu — Agent for Applicant Registration No. 71,864
Printed or Typed Name — Title

Electronic Acknowledgement Receipt

EFS ID:	23301932
Application Number:	13261361
International Application Number:	
Confirmation Number:	3522
Title of Invention:	CONVEYING DEVICE FOR A FLUID USING AN OSCILLATING BODY ARRANGEMENT
First Named Inventor/Applicant Name:	Reiner Liebing
Customer Number:	1678
Filer:	Steven Chinedu Obiajulu/bridget mcauliffe
Filer Authorized By:	Steven Chinedu Obiajulu
Attorney Docket Number:	1-21942
Receipt Date:	25-AUG-2015
Filing Date:	03-OCT-2012
Time Stamp:	13:59:58
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	103945-0127-301_POA.pdf	57867 ad09349b1e6487083e058b266f11d1debe0a3ad1	no	1

Warnings:

Information:

2	Assignee showing of ownership per 37 CFR 3.73	103945-0127-301_373b.pdf	80635 e8056d7020f6519960f68946eb6a4260cde85176	no	1

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Information:

Total Files Size (in bytes):	138502

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
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New International Application Filed with the USPTO as a Receiving Office
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US008814543B2

(12) United States Patent
Liebing

(10) **Patent No.: US 8,814,543 B2**

(45) **Date of Patent: Aug. 26, 2014**

(54) **CONVEYING DEVICE FOR A FLUID USING AN OSCILLATING BODY ARRANGEMENT**

(75) Inventor: **Reiner Liebing**, Potsdam (DE)

(73) Assignee: **ECP Entwicklungsgesellschaft mbH**, Berlin (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/261,361**

(22) PCT Filed: **Jan. 27, 2011**

(86) PCT No.: **PCT/EP2011/000439**

§ 371 (c)(1), (2), (4) Date: **Oct. 3, 2012**

(87) PCT Pub. No.: **WO2011/092034**

PCT Pub. Date: **Aug. 4, 2011**

(65) **Prior Publication Data**

US 2013/0019968 A1 Jan. 24, 2013

Related U.S. Application Data

(60) Provisional application No. 61/298,581, filed on Jan. 27, 2010.

(51) **Int. Cl.**

F04D 33/00 (2006.01)
A61M 1/12 (2006.01)
A61M 1/10 (2006.01)

(52) **U.S. Cl.**

CPC ***A61M 1/12*** (2013.01); ***A61M 1/101*** (2013.01); ***F04D 33/00*** (2013.01); ***A61M 1/125*** (2013.01)

USPC **417/436**; 623/3.1

(58) **Field of Classification Search**

CPC F04D 33/00; A61M 1/12

USPC 417/436; 600/16, 17, 18; 137/565.01; 623/3.1, 3.22

See application file for complete search history.

(56) **References Cited**

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EP	2 194 278	A1	6/2010

(Continued)

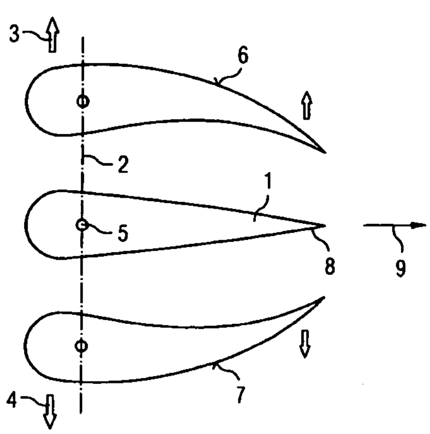
Primary Examiner — Nathan Zollinger

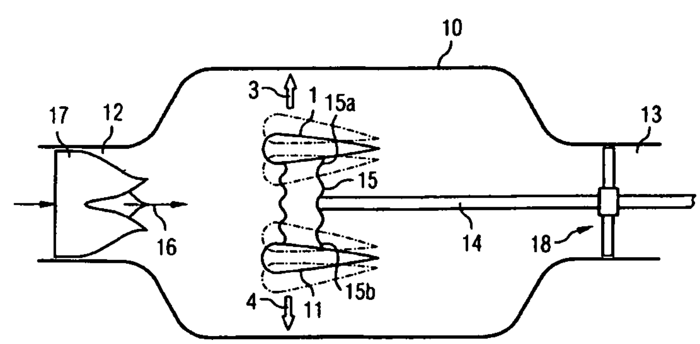
(74) *Attorney, Agent, or Firm* — Marshall & Melhorn, LLC

(57) **ABSTRACT**

The invention relates to a conveying device for conveying a fluid in a conveying direction having one or more drive bodies which can be driven in an oscillating manner by means of a drive system transversely to the conveying direction. An acceleration of the fluid is achieved by a corresponding movement in translation or by a partially pivoting movement of the drive bodies in the manner of the fin principle known from biology (e.g. aerodynamics and hydrodynamics).

19 Claims, 10 Drawing Sheets





(56) **References Cited**

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WO	WO 2006/038808 A1		4/2006
WO	WO 2009/157840 A1		12/2009

* cited by examiner

FIG 1

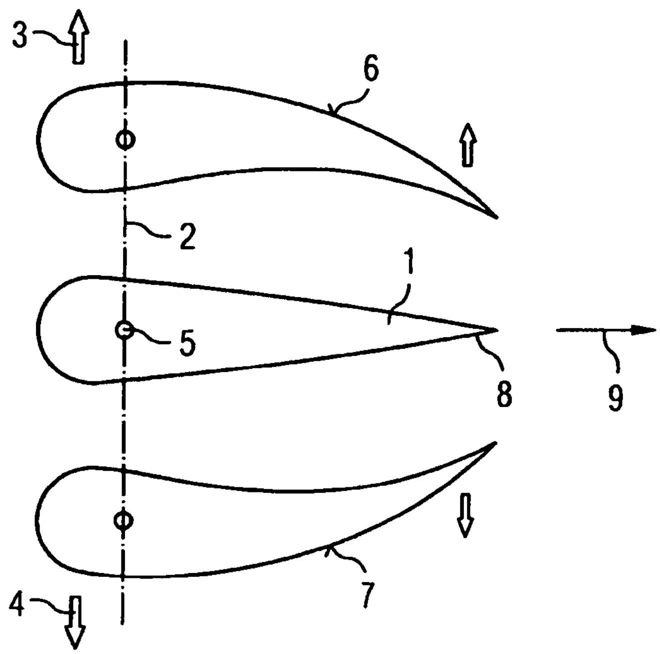


FIG 2

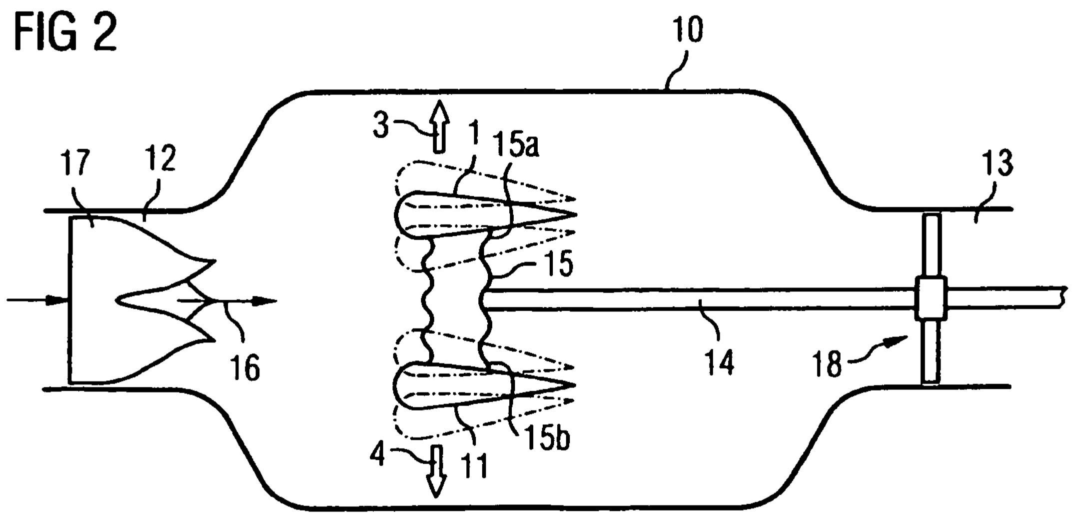


FIG 3

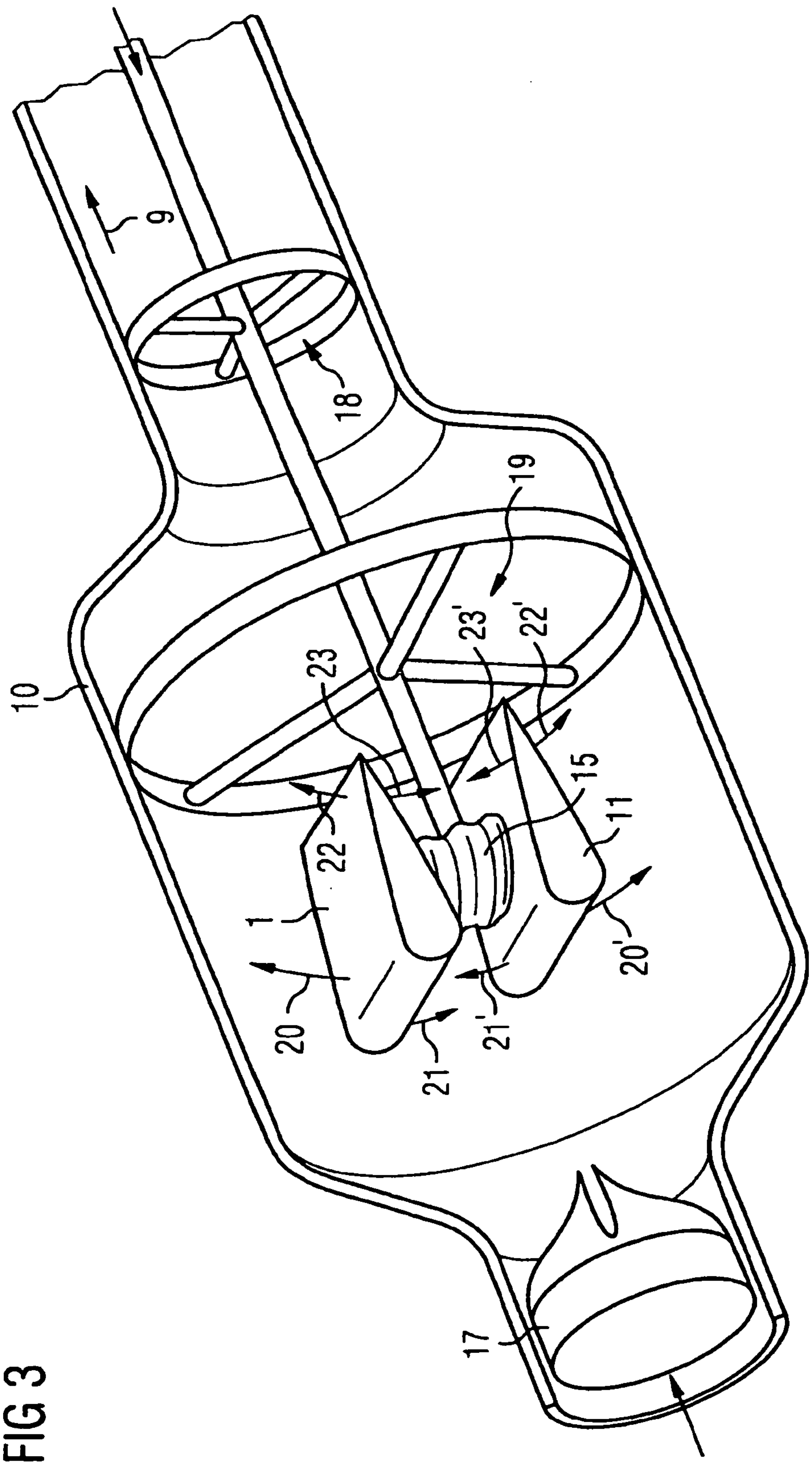


FIG 4

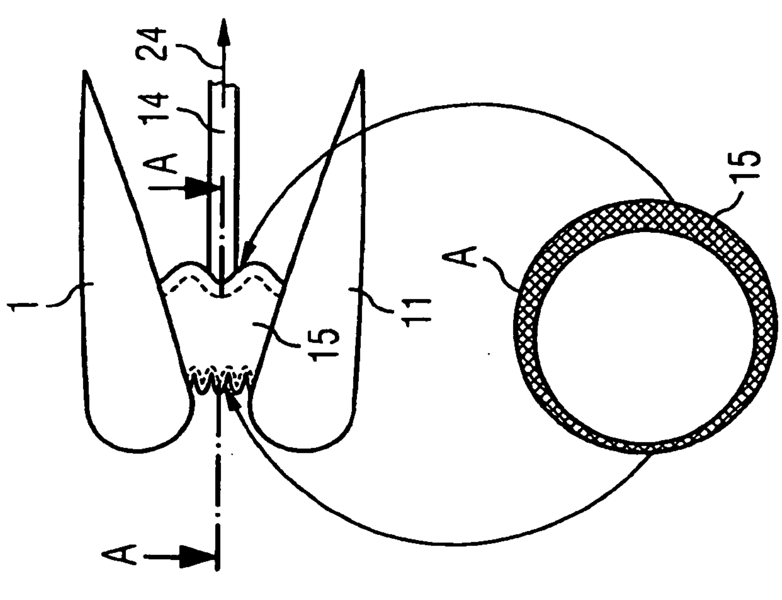


FIG 5

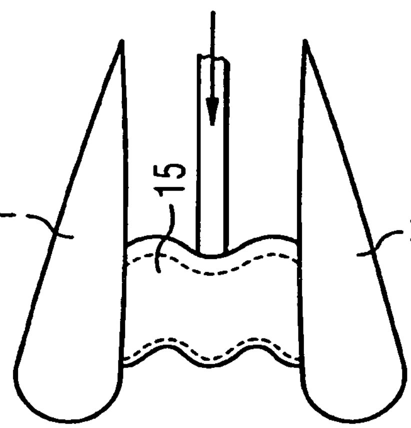


FIG 6

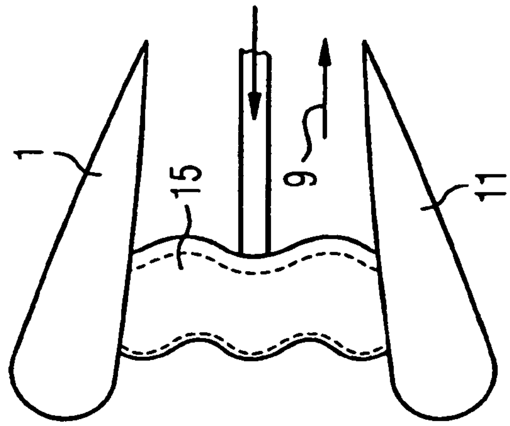


FIG 7

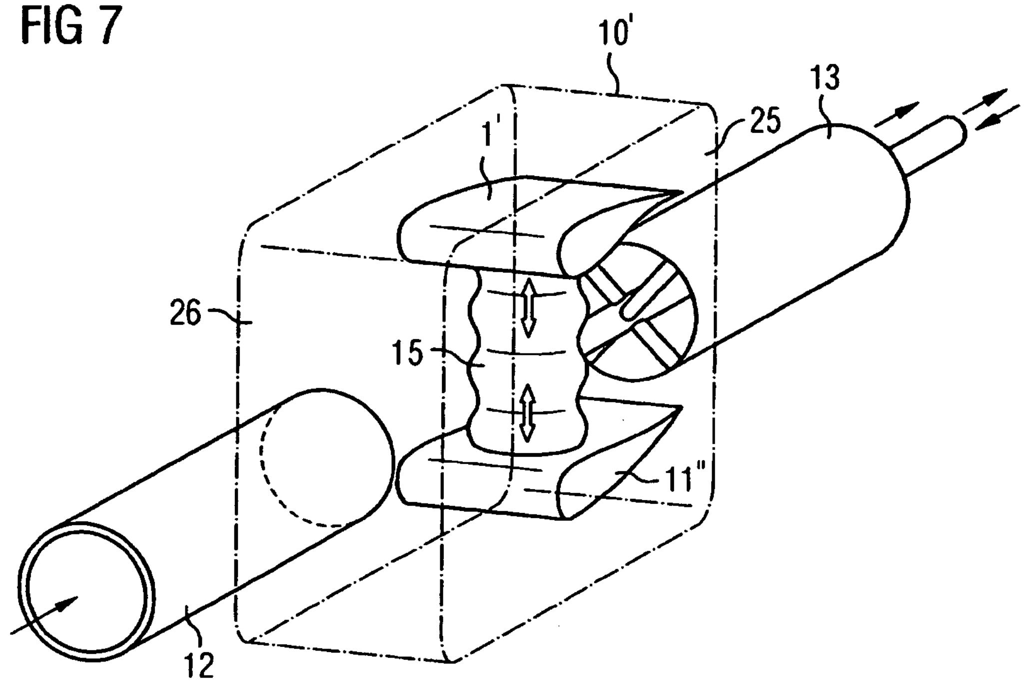


FIG 8

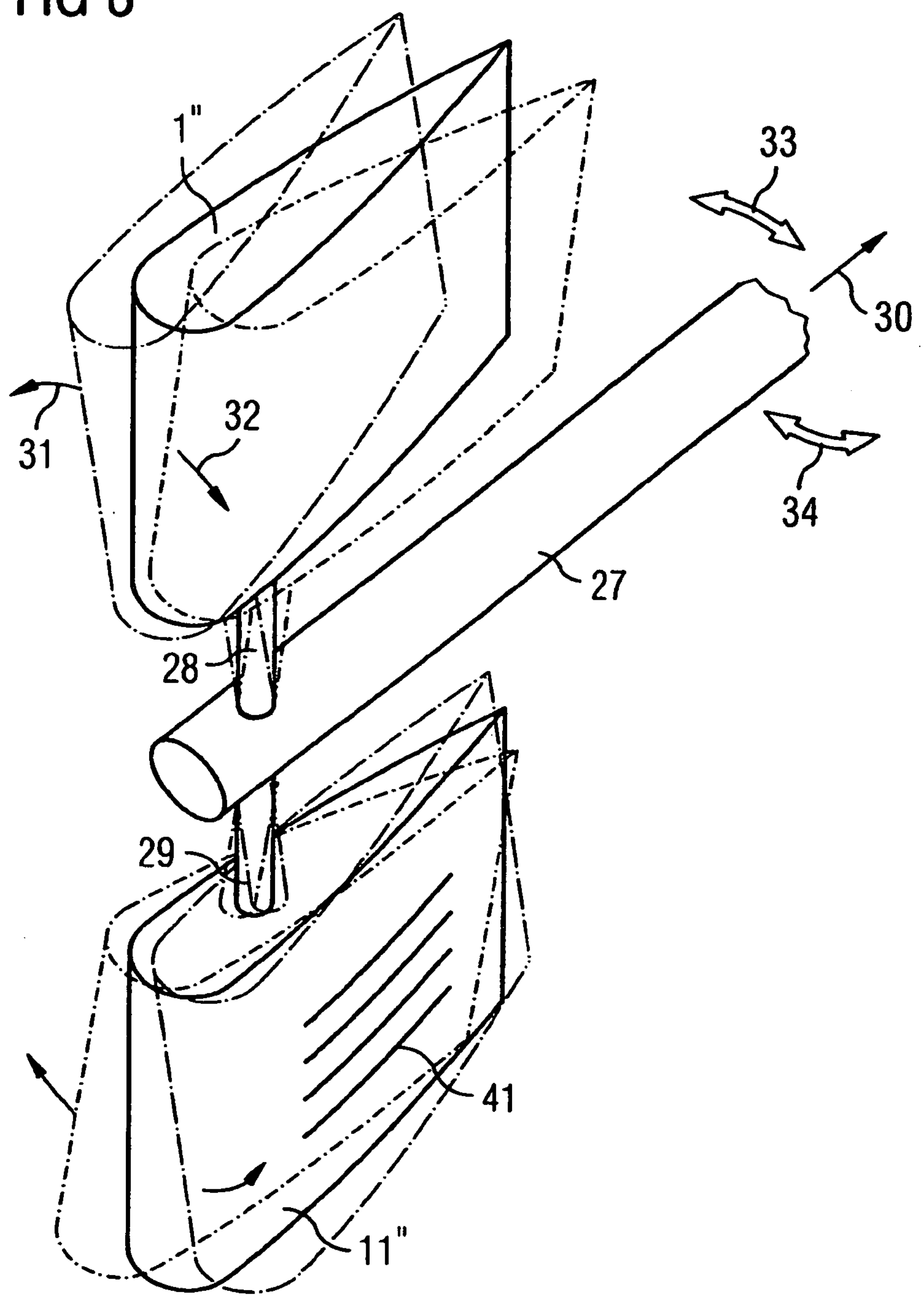


FIG 9

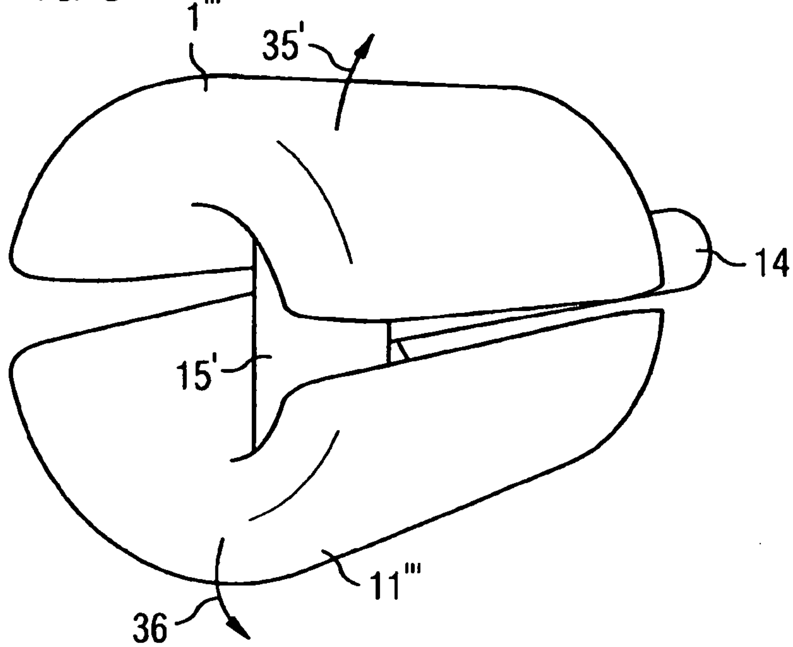
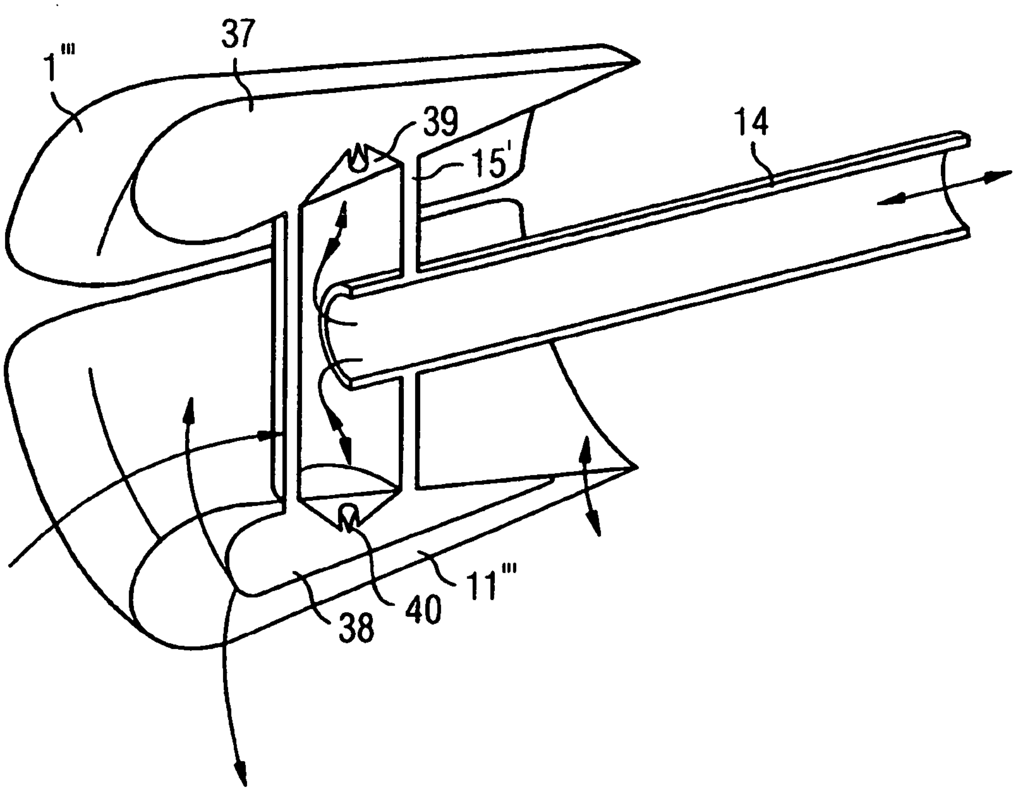


FIG 10



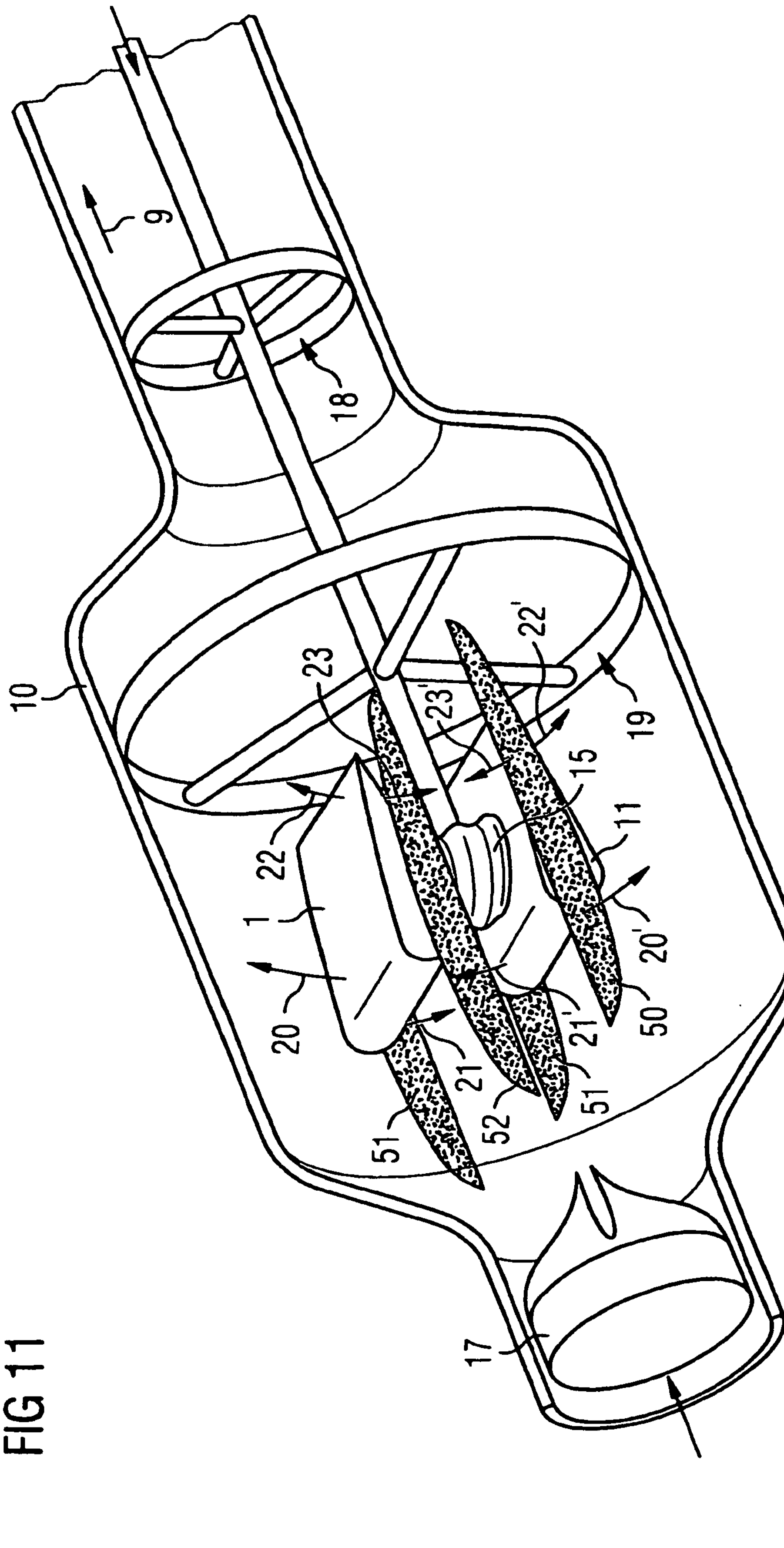


FIG 11

FIG 12

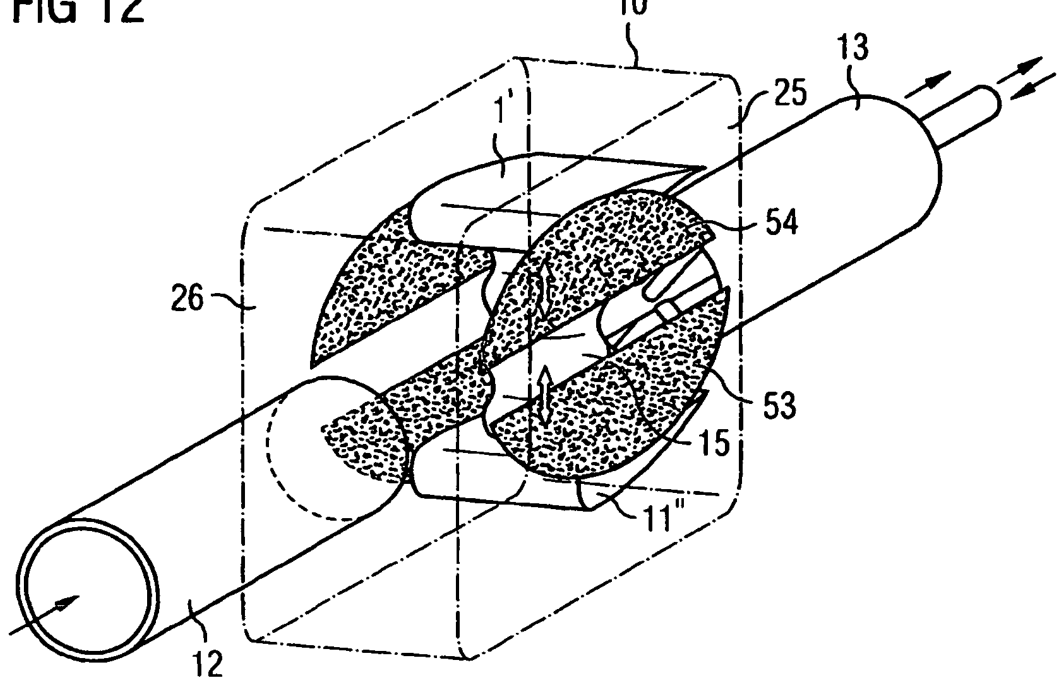


FIG 13

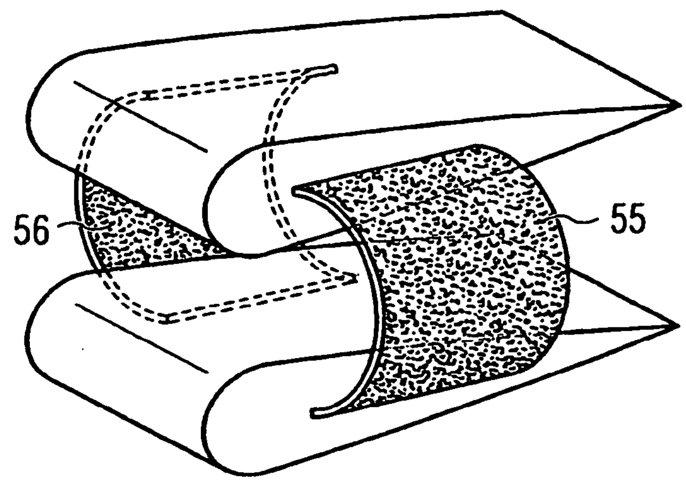


FIG 14

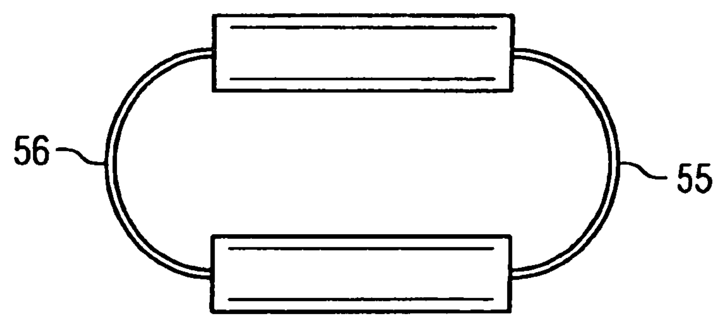


FIG 15

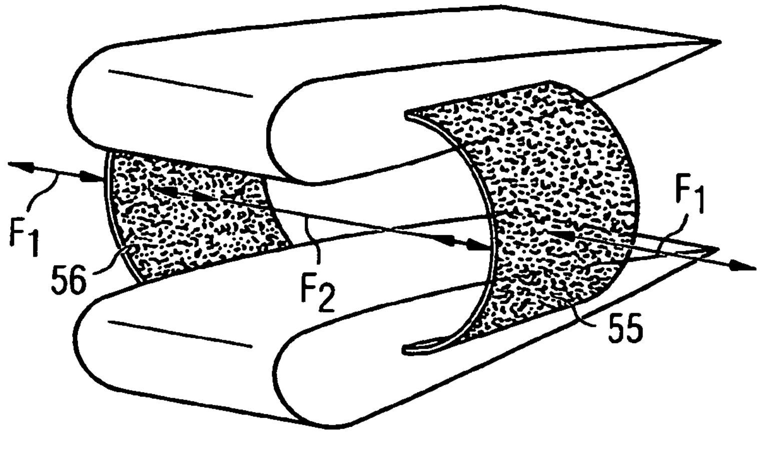


FIG 16

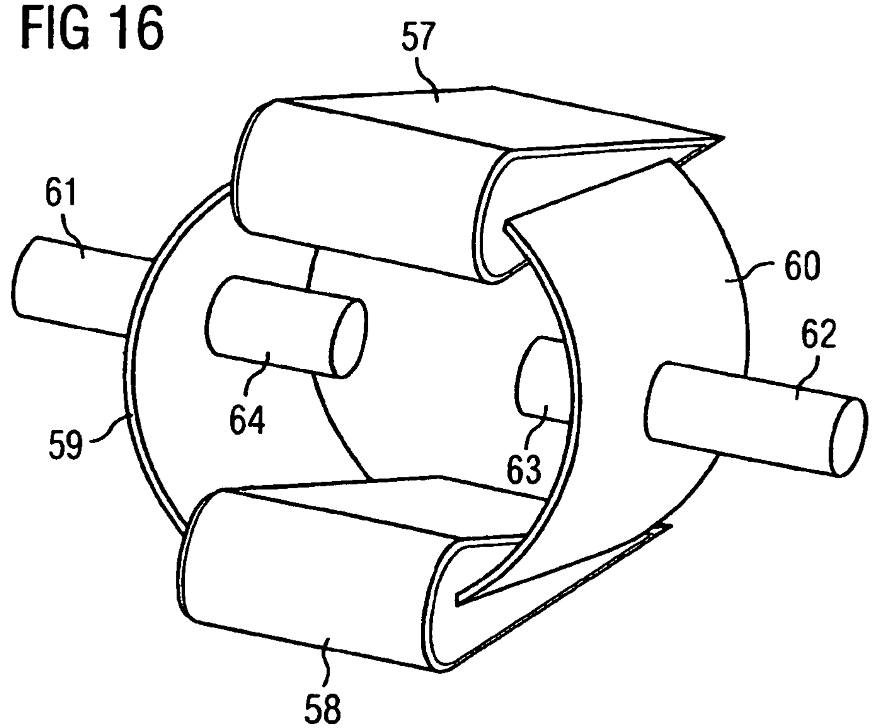


FIG 17

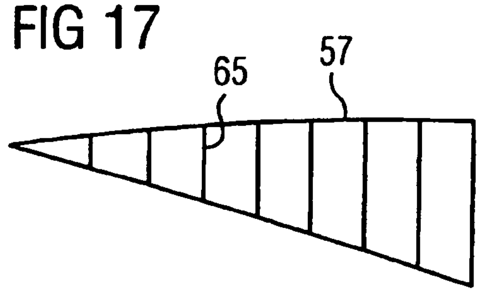
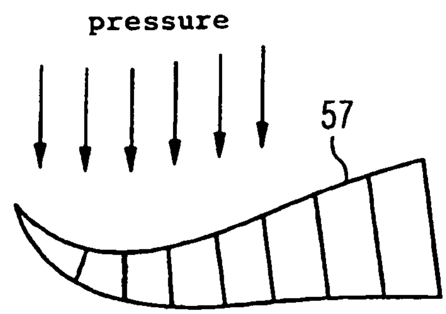


FIG 18



CONVEYING DEVICE FOR A FLUID USING AN OSCILLATING BODY ARRANGEMENT

The invention is in the field of mechanical engineering and relates to conveying devices for fluids, in particular for liquids.

Such conveying devices have become known in the form of different kinds of pumps in the most varied of embodiments. Pumps are of particular interest at this point which can be manufactured in such constructions that they can be used for more sensitive fluids, in particular fluids having macromolecules. A specific group among such pumps is represented by the fluid pumps which can be used for medical application purposes and which can be manufactured in small constructions. Such pumps can also be used in micro constructions, for example, for conveying the body's own fluids, or biocompatible fluids, for example as heart pumps for conveying blood.

In the conveying of such sensitive fluids such as blood which have large and sensitive molecules, for example, which satisfy biological functions and which therefore also may not be damaged at the microscopic level, care must be taken that the mechanical effect on the fluid by pressure maxima, shear forces and accelerations is limited as much as possible.

Axial flow pumps have in particular become known in this connection, for example, for the conveying of blood which have a rotor which rotates about a longitudinal axis, which has impeller blades and which continuously conveys blood in the axial direction.

Since a specific problem for the use of such pumps in the inside of the body comprises the fact of providing them, on the one hand, with sufficient conveying capacity, and, on the other hand, however, of configuring the construction size so that they can be introduced through a blood vessel, some of the challenges for such pumps comprise the fact of configuring them from a construction aspect so that they are radially compressible and expandable again for operation in the body.

A compressible rotor of this kind is known, for example, from U.S. Pat. No. 6,860,713. Another rotor is known from U.S. Pat. No. 7,393,181 B2. In the known solutions, the rotors are compressible and expandable either due to the elasticity and deformability of the material or on the basis of mechanically movable constructions.

It is unavoidable in this respect that a certain construction effort is exerted to ensure the compressibility of such a pump despite a corresponding reliability and conveying capacity. It must moreover be ensured that large shear forces which can damage sensitive fluids do not arise due to too high a rotational speed of the rotor or due to unfavorable geometrical shapes of impeller blades. In addition, care must be taken that pressure differences within the geometry of such a conveying device, on the one hand, and over the course of time, on the other hand, are kept within tight limits.

Under these conditions and against the background of the prior art, it is the underlying object of the present invention to provide a conveying device which can be manufactured with means which are simple from a construction aspect and which reliably and gently allow the conveying of a fluid.

The object is achieved in accordance with the invention by the features of claim **1**, alternatively by the features of claim **3** or claim **7**.

The conveying device in accordance with the invention, which serves to move a fluid in a conveying direction, for this purpose has a drive body which can be driven by means of a drive system and which can be driven in an oscillating manner transversely to the conveying direction.

The drive body is arranged in a channel or in a space in which the fluid should be conveyed in a preset conveying direction.

Known conveying mechanisms such as centrifugal pumps or the above-named axial flow pumps make use of rotating conveying elements for moving or accelerating a fluid. The likewise known piston pumps respectively have at least one piston which is substantially movable in translation and which conveys the medium in its direction of movement on its movement.

In contrast to this, in accordance with the present invention, the drive body is moved transversely to the conveying direction in the manner of a fin of a fish which is used in nature as a rule to generate a relative movement between the fin and a fluid. In the present invention, the fin-like element, the drive body, is in this respect substantially fixed in the conveying direction so that the relative movement results in a conveying movement of the fluid.

The movement of the drive body transversely to the conveying direction in this respect, for example, means that at least one part of the drive body is moved in translation or along a less curved path substantially perpendicular to the conveying direction and/or associated with a pivot movement about an axis which is substantially perpendicular to the conveying direction. In this respect, the deviation of the direction of extent of the axis to the perpendicular of the conveying direction should amount to a maximum of 45°. In this respect, movement patterns of fin-like bodies in fish and other creatures known from bionics should be reproduced.

The corresponding drive bodies can be adapted in shape and size to the available space. The relative movement of the drive body or of different parts of said drive body with respect to the fluid to be driven can be kept in a range with respect to the speed which prevents the creation of unpermitted shear forces. In this respect, the relative speed is to be coordinated with the viscosity of the medium to be conveyed and accordingly with possibly present compressibilities. The conveying principle described can be used particularly efficiently with substantially non-compressible and slightly liquid media such as blood. Corresponding drive movements can also be transmitted easily to a drive body to be moved in an oscillating manner. A rotatable journalling of a rotor does not necessarily have to be provided.

The drive body or bodies are flowed around by the fluid to be conveyed at multiple sides, in particular at all sides. In particular when two mutually opposite conveying surfaces are provided, they are each both in contact with the fluid to be conveyed.

The drive body or bodies are compressible together with a housing surrounding them in the radial direction with respect to the conveying direction. For this purpose, the drive bodies can be configured as foldable, as elastically compressible as foam or as inflatable. The housing can likewise be foldable and can comprise a membrane spanned over a support frame. The support frame can comprise a plastic or a metallic memory alloy, for example Nitinol or another superelastic material. The housing can also be configured as inflatable, in particular as a double-wall balloon body.

Since a certain periodicity of pressure fluctuations is to be expected due to the oscillatory movement of the drive body, with an occasional reversal of the flow direction not always being able to be precluded on such pressure fluctuations, the arrangement of a control valve for the flow to be generated in the conveying channel or in the space in which the drive body is located can also advantageously be considered. In this respect, the valve can either be controlled by an intelligent control synchronously with the movement of the drive body or it can be configured as an automatically acting check valve.

The conveying surface or a conveying surface of the drive body is advantageously aligned so that a partial force acts on the fluid in the conveying direction on a movement of the drive body. For this purpose, the direction of movement of the drive body and the direction of extent of the surfaces of the drive body at which a pressure increase arises are to be correspondingly coordinated with one another.

In this connection, at least two conveying surfaces can be provided, for example at a single drive body, which are aligned so that they each effect a conveying of the fluid in at least one of the directions of movement of the drive body. A conveying of the fluid in both drive movement directions or in a plurality of drive movement directions thus becomes possible. Two conveying surfaces can be provided at two different, mutually opposite outer surfaces of a drive body.

Provision can moreover advantageously be made that at least one drive body tapers in the conveying direction in the cross-section disposed parallel to its movement plane.

The drive body can, for example, be configured in the manner of a fin as a wedge-shaped body whose thickened end is arranged upstream with respect to the flow to be produced and whose tapered end is arranged downstream. The tapered end can converge acutely in the form of a blade edge, with the blade edge being able to extend perpendicular to the drive direction of the drive body. The drive body can also be widened toward its tapered end in the direction of extent of the cutting blade.

The conveying surfaces at both sides of such a wedge-shaped fin body can be either planar or convex or concave, viewed in the direction perpendicular to the movement plane or to the drive direction of the drive body.

The drive body can be stiff in one type of embodiment of the invention. In this case, the drive body can be pivotable about an axis which lies in the region of its thickened end. In addition, a superimposed movement in translation of the thickened end can be provided, for example in a straight manner or along a gate path. The movement portion in translation takes place in the same plane as the pivot movement in this respect.

Alternatively to this, provision can also be made that the drive body is so elastic that it can also be bent in operation in its end region by the fluid counterpressure by at least 5°, in particular also by at least 20°, with respect to the undistorted state.

The drive can in this case be configured in the same manner as with a stiff drive body, but the alignment of the conveying surfaces relative to the fluid to be conveyed in the respective phase of the drive movement can already be optimized and thus the efficiency of the drive increased by the elasticity and deformability of the drive body per se.

Such a drive body, whether stiff or elastic, can either be configured as symmetrically wedge-shaped, with planar, concave or convex conveying surfaces in the cross-section viewed perpendicular to the plane of the drive movement or a shape asymmetrical in the named cross-section can also be provided, for example with elements of an airfoil wing, to utilize additional flow effects. Such an airfoil section, for example, provides a convex shape on one side of the drive body and a convex or straight shape of the conveying surface on the opposite side.

On the use of such an asymmetrical design of a drive body, a further drive body can additionally be provided which is shaped and arranged in mirror form with respect to the first drive body and which is movably in synchronization with it in the same or opposite sense.

Provision can moreover be made to increase the efficiency of the drive that the drive body, in particular in the region of a conveying surface, has optimized surface structures.

In an advantageous embodiment of the invention, provision can moreover be made that the drive body has at least one hollow space. The provision of a hollow space reduces the mass of the drive body and thus the energy to be expended for its acceleration. In addition, the drive body can be configured as at least partially inflatable so that its outer dimensions in the non-inflated state can be smaller than in the inflated state. Such a drive body can then be brought more easily to its deployment site in the non-inflated state and inflated to the operating dimensions there. This is in particular advantageous when the conveying device should be manufactured in very small dimensions and moved within blood vessels.

The drive body can moreover advantageously comprise a foam, in particular polyurethane. The drive body can thus be manufactured as elastically deformable and as very light. The drive body can also comprise a hardenable material or generally a material whose deformability can be directly changed by physical influence, e.g. by irradiation, temperature change or by chemical reactions.

Provision can be made in the conveying device in accordance with the invention by providing a corresponding drive system that the drive body can be driven by means of a hydraulic or pneumatic device, in particular by means of a balloon body, but also by means of an electric and/or magnetic device.

Although one or more drive bodies in accordance with the invention can be moved simply by means of levers or similar mechanical devices, the drive movement can particularly easily be conducted to the conveying device by a hydraulic or pneumatic drive device. Corresponding pneumatic or hydraulic lines can be laid, for example, in the form of a hollow catheter or also within a hollow catheter, at the distal end of which the conveying device is provided, and can either act directly on a piston, bellows or balloon-like drive body in the region of the conveying device or can be converted into a lever movement there.

Possible drive movements of the drive body or bodies in this respect provide that at least one drive body is pivotable in an oscillating manner about an axis extending transversely to the conveying direction; and/or that one or more drive bodies are pivotable in an oscillating manner about an axis extending in the conveying direction, in particular outside the conveying bodies.

It is special about such an oscillatory movement that the pivot movement has a relatively small stroke so that a full rotation of the drive body does not take place in any case.

A rotation about larger angles can, however, also be provided on the rotation about an axis extending in the conveying direction.

To reduce unwanted pressure compensation procedures at the drive bodies, blocking bodies can be arranged on them between their conveying surfaces. Said blocking bodies should be flexible and can in this respect be configured as pliable or stiff, but bendable. The blocking bodies can also connect two respective blocking bodies to one another or one blocking body to a housing wall.

Provision can also be made that the driving force is transmitted to a drive body by means of a blocking body.

The described fin-like drive principle for fluids is novel in connection with the conveying of liquids and thus allows the realization of conveying characteristics which cannot be achieved with the already known conveying devices.

The invention will be shown and subsequently described in the following with reference to an embodiment in a drawing.

There are shown

FIG. **1** a drive body in three positions in cross-section;

FIG. **2** a conveying system for fluids having two drive bodies in a longitudinal section;

FIG. **3** a conveying system having two drive bodies in a three-dimensional view;

FIG. **4** two drive bodies in a first position with a drive system;

FIG. **5** the drive bodies from FIG. **4** in a second position;

FIG. **6** the drive bodies from FIGS. **4** and **5** in a third position;

FIG. **7** a drive system in a three-dimensional representation having a conveying space quadrangular in cross-section;

FIG. **8** two drive bodies which are rotated in an oscillating manner about an axis extending in the conveying direction;

FIG. **9** a drive system in a three-dimensional view having two partly cylindrical drive bodies;

FIG. **10** a section through the drive system of FIG. **9**;

FIG. **11** an embodiment as in FIG. **3** with additional blocking bodies;

FIG. **12** an embodiment similar to that of FIG. **7** with blocking bodies;

FIG. **13** a representation of two drive bodies which are connected by means of blocking bodies;

FIG. **14** the embodiment of FIG. **13** in a front view;

FIG. **15** a view of the embodiment of FIG. **13**, with the effect of a driving force on the blocking bodies being indicated;

FIG. **16** an arrangement in which the blocking bodies have a stiff, but bendable ring-strip shape;

FIG. **17** a drive body having fin-rays in the neutral state; and

FIG. **18** a drive body as in FIG. **17** in the loaded state.

FIG. **1** shows in the middle part a drive body **1** in section which substantially has a wedge shape which is modeled on the shape of a fin occurring in biology. The drive body **1** extends perpendicular to the plane of the drawing with an unchanging section, but can also widen perpendicular to the plane of the drawing toward its tapered end.

The drive body **1** can be moved in an oscillating manner along the dotted line **2** in the directions indicated by the arrows **3**, **4**. The region about the point of attack of the driving force is in this respect shown as a circle and is marked by **5**. The driving force engages at this point such that the drive body is moved substantially in translation along the line **2** and is thus not pivotable in a first variant to avoid an active fluid counterpressure.

A fluid counterpressure then results in operation, for example on the movement of the drive body within a liquid, on the side of the respectively acting conveying surface **6**, **7**, said fluid counterpressure resulting in a deformation of the end **8** of the drive body **1** remote from the drive, i.e. the tapered end, when this drive body is configured as elastic as in the example shown. A particularly efficient advance of the driven fluid in the conveying direction **9** results by this effect.

Alternatively, the drive of the drive body **1** can also be configured so that it is not driven strictly in translation in the sense of the directions **3**, **4**, but rather in a superimposed movement in translation and in a pivot movement. In this respect, for example simultaneously with the movement in the direction of the arrow **3**, a pivoting of the drive body takes place about the point of attack **5** clockwise about a specific angle, for example 10°, so that the drive body inclines at the end of the movement in a similar manner as under the effect of a fluid counterpressure. Optionally, the direction of rotation of the pivot movement can be reversed at the end of the movement in translation to beat with the fin. This driving principle can be combined both with stiff drive bodies and with flexible drive bodies.

A specific lever drive or a gate drive of the drive body can be provided for this purpose or it is conceivable to transmit the driving forces by means of a hydraulic or pneumatic apparatus.

FIG. **2** shows in a side view a housing **10** in which a conveying device in accordance with the invention having two drive bodies **1**, **11** is arranged. The housing **10** is set up rotationally symmetrically or elliptically in cross-section about the drive bodies **1**, **11** and has an inflow channel **12** as well as an outflow channel **13**. A fluid line **14** which is part of the drive system and which is connected to a drive bellows **15** projects through the outflow channel **13**. The drive bellows **15** can be connected via a pressure control device, not shown, via the fluid line **14** to an overpressure or to an underpressure so that said drive bellows can be inflated or deflated by the inflow of a fluid or the removal of the fluid.

One respective drive body **1**, **11** is fastened to the two ends **15***a*, **15***b* of the drive bellows **15** and runs through a drive movement in the direction of the arrows **3**, **4** by the volume changes of the drive bellows. The drive movement in translation of the drive bellows **15** can be translated into a more complex movement path of the drive bodies **1**, **11**, which can correspond to a superimposition of the movement in translation with a pivot movement, by a corresponding elastic configuration of the drive bellows **15** or by additional levers which connect the bellows to the drive bodies **1**, **11** or the drive bodies to a fixed point of the housing **10**.

Provision can, however, also be made that the movement of the drive bodies **1**, **11** substantially takes place in translation and said drive bodies are configured as elastic to carry out the elastically fin-like overall movement shown with reference to FIG. **1**.

If the pressure in the drive bellows **15** is changed periodically via the control of the fluid pressure in the fluid line **14**, for example several times per second, this is translated into an oscillatory movement of the drive bodies **1**, **11**. This results in an acceleration of the fluid located in the housing **10** in the direction of the arrow **16** which designates the conveying direction of the fluid. Since pressure fluctuations occur due to the periodicity of the movement, it may be meaningful to provide a check valve **17** in the inflow channel **12** which blocks the inflow channel **12** for the case that an overpressure arises within the housing **10** in front of the valve and closes it again as soon as an underpressure is generated there.

The fluid line **14** can be configured as a flexible hose line provided that the drive bellows **15** is held otherwise in the housing **10**. The drive line **14** can, however, also be configured as a rigid line in the form of a pipe in order simultaneously to conduct the fluid and to fix the drive bellows and the drive bodies **1**, **11**. The fluid line **14** can in every case be held and fixed in a holding star **18** or at a holding arm within the outflow channel **13**.

In the Figure, three positions are shown for each drive body **1**, **11**, with a middle neutral position being shown by solid lines and the extreme positions on the movement path of each individual drive body **1**, **11** being shown by broken lines.

FIG. **3** shows a similar arrangement to FIG. **2**, but in a three-dimensional view, with a second holding star **19** being provided in addition to the first holding star **18** in direct vicinity of the drive bellows **15** and of the drive bodies **1**, **11**.

Arrows **20**, **21** and **20'**, **21'** are drawn in which indicate the directions of movement of the respective thickened ends of the drive bodies **1**, **11** as are arrows **22**, **23** and **22'**, **23'** which indicate the movement of the tapered ends of the drive bodies

1, 11. The different lengths of the arrows shown should indicate that the thickened ends of the drive bodies 1, 11 facing the one-way valve 17 carry out a pivot movement whose amplitude is substantially larger than the movement of the tapered ends of the drive bodies. This is made possible, as will be shown in more detail with reference to FIGS. 4, 5 and 6, by a special construction of the drive bellows 15.

FIG. 4 shows in a side view in the upper part the two drive bodies 1, 11 as well as the drive bellows 15 in the deflated, i.e. compressed, form. The arrow 24 indicates that an underpressure is present in the fluid line 14 in this state to compress the drive bellows 15.

The drive bellows 15 itself has an asymmetrical structure, as can be seen more clearly from the lower part of FIG. 4. A cross-section through the drive bellows 15 along the dashed line A is shown there which makes clear that the drive bellows has a smaller wall thickness in its region facing the one-way valve 17 than in the outflow channel 13.

It is thereby achieved that the movement amplitude is larger in the front region facing the inflow channel 12 than in the rear region of the drive bellows facing the outflow channel 13. A pivot movement of the drive bodies 1, 11 therefore results on a pressure change in the drive bellows 15.

In FIG. 5, the arrangement of FIG. 4 with the drive bodies 1, 11 and a drive bellows 15 inflated further with respect to FIG. 4 is shown. The drive bodies are approximately in the straight position shown in FIG. 2.

FIG. 6 finally shows the state of the drive bodies 1, 11 in the fully inflated state of the drive bellows 15, with it also becoming clear that the thickened ends of the drive bodies 1, 11 have passed through a larger movement amplitude than the tapered ends so that a pivot movement of the drive bodies has taken place in addition to a movement in translation.

FIG. 7 shows in a three-dimensional view from a different perspective two drive bodies 1', 11' which are configured as asymmetrical in the manner of an aerodynamic airfoil section, but which may additionally also be configured as flexible and which can be driven by means of a drive bellows 15. The inflow channel 12 is shown in the foreground of the figure, the outflow channel 13 in the background. In contrast to the cylindrical housing 10 of the arrangement shown in FIG. 3, the housing 10' shown in FIG. 7 has a parallelepiped structure with a rectangular cross-section to implement the non-cylindrically symmetrical structure of the drive arrangement and of the drive bodies as efficiently as possible. Unlike the specific representation of FIG. 7, the transition from the housing 10' to the inflow and outflow channels 12, 13 can take place with conical or oblique transitions. Provision can advantageously be made that the drive bodies 1', 11' extend perpendicular to the plane of the drive movement up to as close as possible to the side walls 25, 26 of the housing 10'. Turbulence at the side surfaces of the drive bodies 1', 11' is thereby reduced.

The drive bodies 1', 11' can, just like the drive bodies 1, 11 shown further above, comprise a foam, in particular polyurethane, and can be inflatable. For this purpose, the bodies can have large and/or a plurality of small hollow spaces which can, for example, be inflated by the drive fluid via the fluid line 14 and which have check valves to be stabilized in the inflated state.

A good compressibility in the non-inflated state is hereby made possible so that the drive bodies can be radially compressed for transport to a deployment site together with the housing 10, 10' and can be expanded on site before they are put into operation.

FIG. 8 shows an arrangement in comparison with the Figures described further above having two drive bodies 1", 11" with another drive principle in which the drive bodies are connected via connection webs 28, 29 to a drive shaft 27 which extends in the conveying direction 30.

The drive shaft 27 can be rotated in an oscillating manner about the conveying direction 30, and indeed in each case, for example, at least by an amount of 5°, 10° or at least by 20° or 30°, in each direction, as indicated by the arrows 33, 34.

The longitudinal axes of the drive bodies 1" and 11" are aligned parallel to the shaft and undergo a movement quasi in translation in the peripheral direction of the shaft in the directions which are indicated by the arrows 31, 32 within the framework of this rotary movement, provided that the length of the connection webs 28, 29 is sufficient. In this manner, a corresponding approximately linear movement in translation of the drive bodies can be realized in a very simple manner by means of the drive shaft 27. In FIG. 8, a plurality of parallel microgrooves 41 are also shown by way of example at the lower drive body 11".

In FIG. 9, an arrangement is shown in a three-dimensional view which is as largely cylindrically symmetrical as possible of two drive bodies 1''' and 11''' which are connected by a drive bellows 15' and which can be moved substantially in the direction of the arrows 35, 36 in the radial direction with respect to the cylinder axis. The drive bellows 15' is connected to a pressure generation system by means of a fluid line 14. It is also conceivable to divide the cylindrically symmetrical arrangement into a higher number of cylinder segments, for example 4 or 8 or more and to move them radially in each case, with a movement pattern resulting which is similar to the manner of propagation of jellyfish.

A section through the arrangement of FIG. 9 is shown in FIG. 10 which makes the function clear. The drive body 1''' is shown by way of example with a hollow space 37, the drive body 11''' with a hollow space 38, with the hollow spaces only being indicated schematically.

Fluid is exchanged via the fluid line 14 with the interior of the drive bellows 15 and is pumped from there into the hollow spaces 37, 38, with the hollow spaces 37, 38 of the drive bodies 1''' and 11''' being connected to the hollow space of the drive bellows 15' by means of one-way valves 39, 40 so that the drive bodies are only inflated once and then thereafter maintain the increased fluid pressure to be stabilized in shape. Only the interior of the drive bellows 15' is inflated and deflated thereafter. The drive bodies 1''', 11''' thereby alternately move apart in the direction of the arrows 35, 36 and move together in the opposite direction, whereby a corresponding drive movement is realized.

The efficiency of the conveying device with respect to the non-cylindrically symmetrical arrangements which are shown in the aforesaid Figures is increased by the cylindrically symmetrical or approximately cylindrically symmetrical arrangement of the drive bodies.

FIG. 11 shows a cylindrical arrangement of a housing 10 having two drive bodies 11 which are each laterally provided with blocking bodies 50, 51, 52, 52 which are flexible and may also be connected to the wall of the housing 10 and which prevent or reduce a pressure equalization between the lower side and upper side or the high pressure side and low pressure side of each drive body during the drive movement.

FIG. 12 shows corresponding blocking bodies 53, 54 for a housing 10' with flattened side walls.

FIG. 13 shows two blocking bodies in the form of wide, flexible bands 55, 56 which connect two drive bodies to one another at both sides. This constellation is shown in a front view in FIG. 14.

FIG. 15 shows two blocking bodies 55, 56, as in FIG. 13, which connect two fin-like drive bodies to one another and act as an equalization block. The blocking bodies are configured as strips and can be configured as flexible or stiff and elastically pliable. In the latter case, a drive movement can be directly applied to the drive bodies by direct application of a mechanically, magnetically, pneumatically hydraulically or electrically generated driving force onto the blocking bodies from the outside, indicated by the arrows F_1 and F_1' or from the inside from the intermediate space of the drive bodies, indicated by the double arrow F_2.

Instead of the blocking bodies, similarly positioned coupling bodies in the form of a scaffold or frame can be provided to couple the drive movement into the sections.

The principle of the drive via the blocking bodies is additionally illustrated by way of example by FIG. **16**. Two drive bodies **57**, **58** are connected to one another there by two ring segments **59**, **60** of a ring strip in the form of a circular ring. The cylinders **61**, **62** symbolically indicate outwardly engaging driving forces which can apply a traction force or a compression force to the ring segments from the outside. Corresponding inwardly engaging forces are symbolically designated by **63**, **64**. A deformation of the ring segments effects a drive movement of the drive bodies **57**, **58**. They can be controlled in a suitable manner by a profiling of the ring segments **59**, **60** or by cut-outs in the ring segments.

In FIGS. **17** and **18**, a drive body is shown in a schematic plan view having so-called fin-rays **65** which have an influence on the flow of the fluid on the surface as web-like, groove-like or fin-like structures. They can be shaped and configured by their inner structure such that they effect a concave deformation and thus an increase in pressure on the pressure side on a movement of the drive body. This deformation against the pressure takes place automatically without any additional external energy supply and thus substantially differs from the deformation of customary beam structures which usually yield to a pressure increase on one side and evade the higher pressure.

The inner structure is formed by struts which preferably extend in the interior of a drive body from a drive surface to an oppositely disposed drive surface. The struts can in this respect be made as bars or also as plates, ribs or equivalent structures.

The conveying device for fluids in accordance with the invention allows an efficient configuration thanks to the use of an oscillatory movement transversely to the conveying direction of drive bodies, with the disadvantages of only rotating drive devices being avoided.

The invention claimed is:

1. A conveying device for the conveying of blood in a conveying direction having at least one drive body which can be driven by a drive system and which has a conveying surface, the drive body having a thickened upstream end and a tapered downstream, elastically deformable end, wherein the drive body can be driven in an oscillating, fin-like manner transversely to the conveying direction and is flowed around on a plurality of sides by blood to be conveyed, and wherein the drive body can be compressed together with a housing surrounding it.

2. The conveying device in accordance with claim **1**, wherein the drive body/bodies can be driven by a rotatable shaft.

3. The conveying device in accordance with claim **1**, wherein the at least one drive body is pivotable in an oscillating manner about an axis extending transversely to the conveying direction.

4. The conveying device in accordance with claim **1**, wherein the conveying surface of the at least one drive body is aligned such that a partial force acts on the blood in the conveying direction on movement of the at least one drive body.

5. The conveying device in accordance with claim **4**, wherein two conveying surfaces are aligned such that they effect a conveying of the blood in a respective movement direction of the at least one drive body.

6. The conveying device in accordance with claim **1**, wherein the at least one drive body tapers in the conveying direction in the cross-section disposed parallel to its movement plane.

7. The conveying device in accordance with claim **1**, wherein the at least one drive body is configured as stiff.

8. The conveying device in accordance with claim **1**, wherein the at least one drive body is configured as elastic such that it is bendable in its end region by the fluid counterpressure in operation by at least 5° with respect to the non-deformed state.

9. The conveying device in accordance with claim **8**, wherein the at least one drive body has microgrooves extending in the conveying direction.

10. The conveying device in accordance with claim **1**, wherein the at least one drive body has at least one hollow space.

11. The conveying device in accordance with claim **1**, wherein the at least one drive body comprises a foam.

12. The conveying device in accordance with claim **11**, wherein the at least one drive body is at least partly inflatable.

13. The conveying device in accordance with claim **1**, wherein the drive body/bodies is/are deformed in operation against the fluid pressure on the respective pressure side/sides.

14. The conveying device in accordance with claim **13**, wherein the deformation of the pressure side/sides takes place by inner struts of the drive body/bodies without any additional external energy supply.

15. The conveying device in accordance with claim **1**, wherein the deformation of a pressure side of the at least one drive body takes place by the so-called fin-ray effect.

16. The conveying device in accordance with claim **11**, wherein the at least one drive body comprises polyurethane.

17. A conveying device for the conveying of a fluid in a conveying direction having at least one drive body which can be driven by a drive system and which has a conveying surface, wherein the drive body can be driven in an oscillating manner transversely to the conveying direction, the conveying device also having blocks which are laterally fastened to the drive body and which form a barrier between different conveying surfaces of the drive body, the drive body having a thickened upstream end and a tapered downstream, elastically deformable end, and wherein the drive body can be compressed together with a housing surrounding it.

18. The conveying device in accordance with claim **17**, wherein at least one block is connected either to two drive bodies or to one drive body and the housing of the conveying device.

19. The conveying device in accordance with claim **18**, wherein a driving force is applied to the drive body/bodies by the blocks.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO.	: 8,814,543 B2
APPLICATION NO.	: 13/261361
DATED	: August 26, 2014
INVENTOR(S)	: Liebing

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Please delete patent 8814543 in its entirety and insert patent 8814543 in its entirety as shown on the attached pages.

Signed and Sealed this
Twenty-eighth Day of April, 2015

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office

(12) **United States Patent**
Liebing

(10) **Patent No.: US 8,814,543 B2**
(45) **Date of Patent: Aug. 26, 2014**

(54) **CONVEYING DEVICE FOR A FLUID USING AN OSCILLATING BODY ARRANGEMENT**

(75) Inventor: **Reiner Liebing**, Potsdam (DE)

(73) Assignee: **ECP Entwicklungsgesellschaft mbH**, Berlin (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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§ 371 (c)(1), (2), (4) Date: **Oct. 3, 2012**

(87) PCT Pub. No.: **WO2011/092034**
PCT Pub. Date: **Aug. 4, 2011**

(65) **Prior Publication Data**
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Related U.S. Application Data

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F04D 33/00 (2006.01)
A61M 1/12 (2006.01)
A61M 1/10 (2006.01)

(52) **U.S. Cl.**
CPC ***A61M 1/12*** (2013.01); ***A61M 1/101*** (2013.01); ***F04D 33/00*** (2013.01); ***A61M 1/125*** (2013.01)
USPC **417/436**; 623/3.1

(58) **Field of Classification Search**
CPC F04D 33/00; A61M 1/12
USPC 417/436; 600/16, 17, 18; 137/565.01; 623/3.1, 3.22
See application file for complete search history.

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Primary Examiner — Nathan Zollinger
(74) *Attorney, Agent, or Firm* — Marshall & Melhorn, LLC

(57) **ABSTRACT**

The invention relates to a conveying device for conveying a fluid in a conveying direction having one or more drive bodies which can be driven in an oscillating manner by means of a drive system transversely to the conveying direction. An acceleration of the fluid is achieved by a corresponding movement in translation or by a partially pivoting movement of the drive bodies in the manner of the fin principle known from biology (e.g. aerodynamics and hydrodynamics).

19 Claims, 10 Drawing Sheets

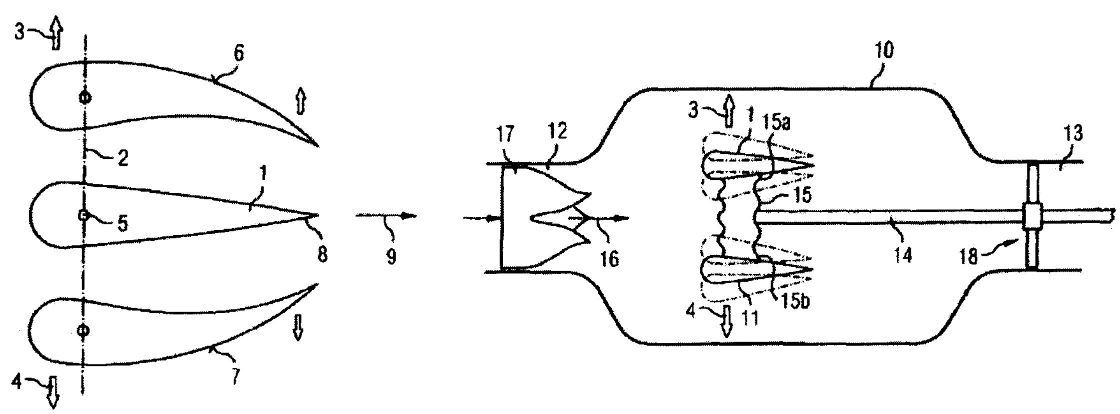

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FIG 1

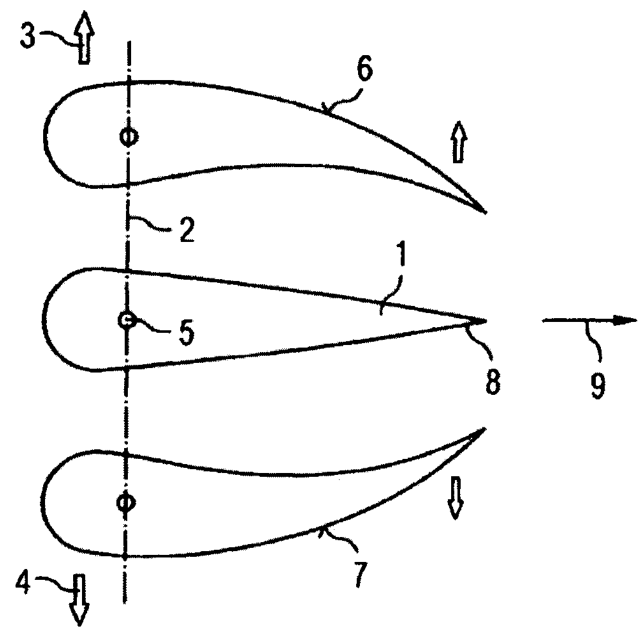
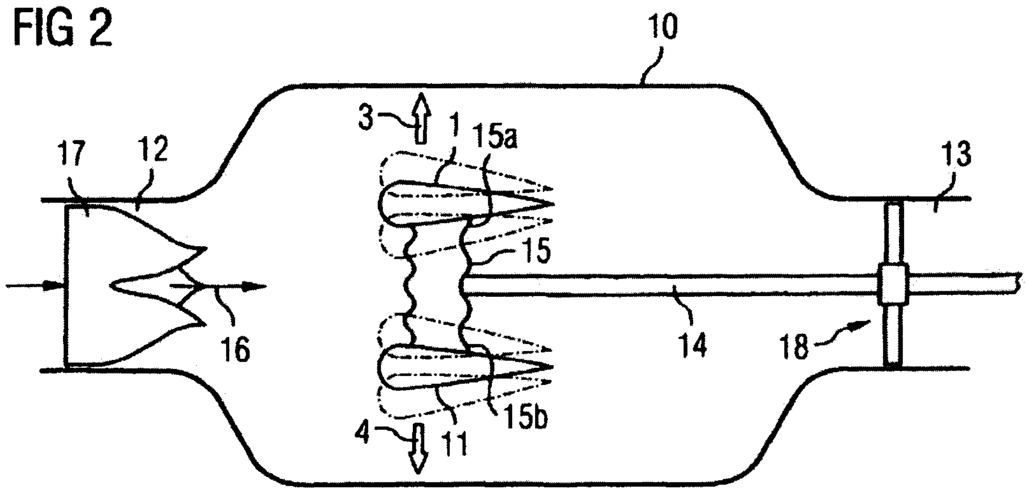


FIG 2



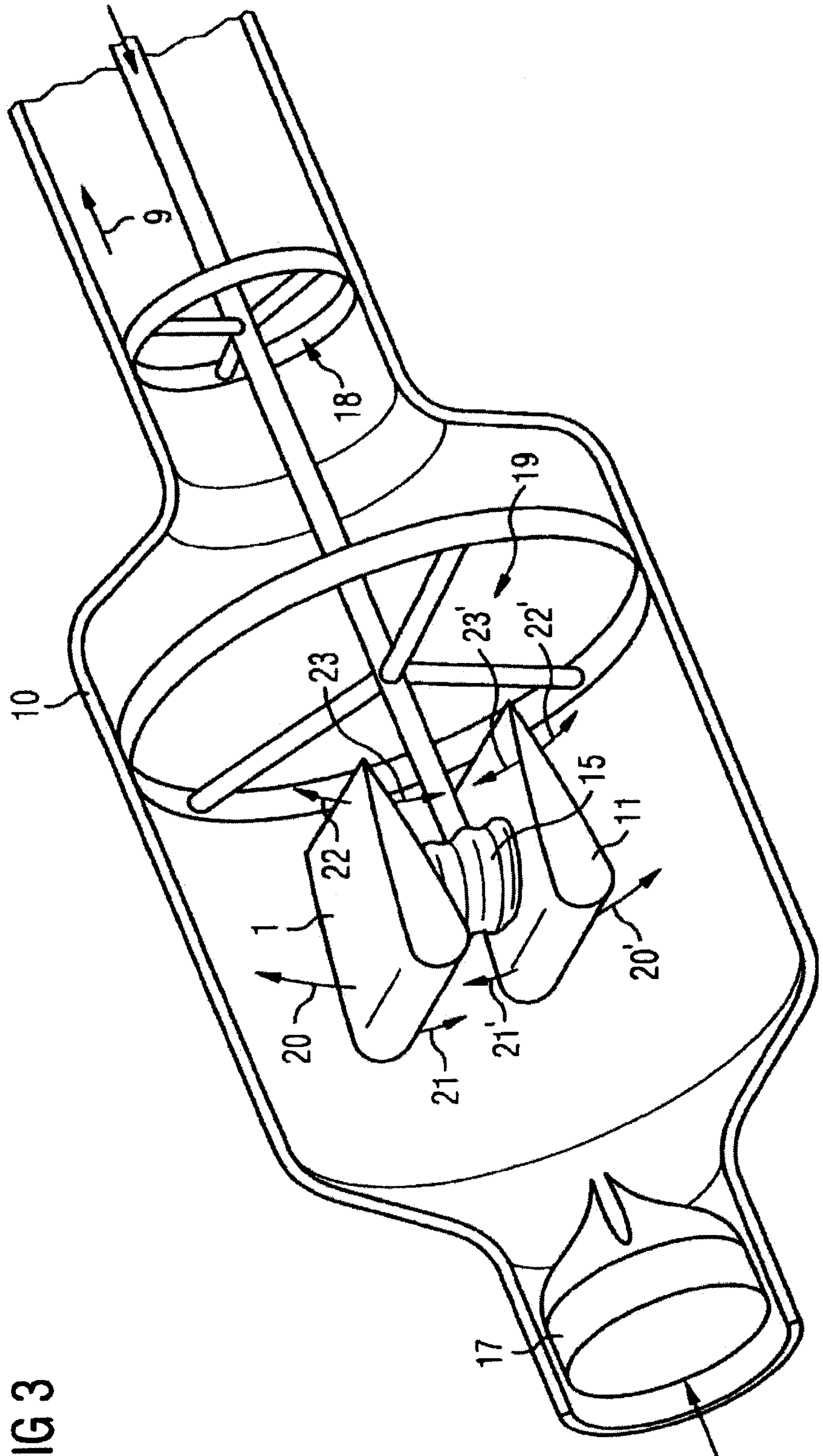


FIG 3

FIG 6

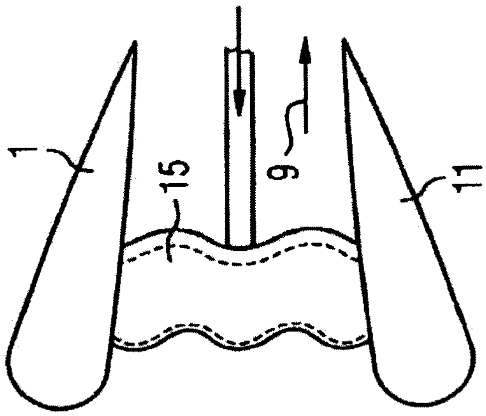


FIG 5

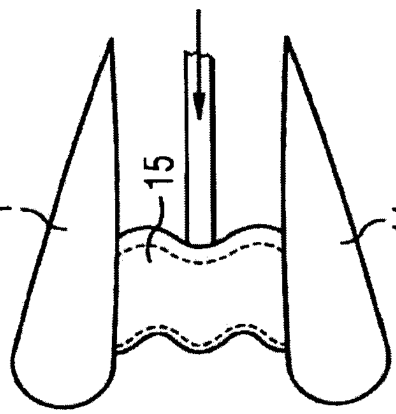


FIG 4

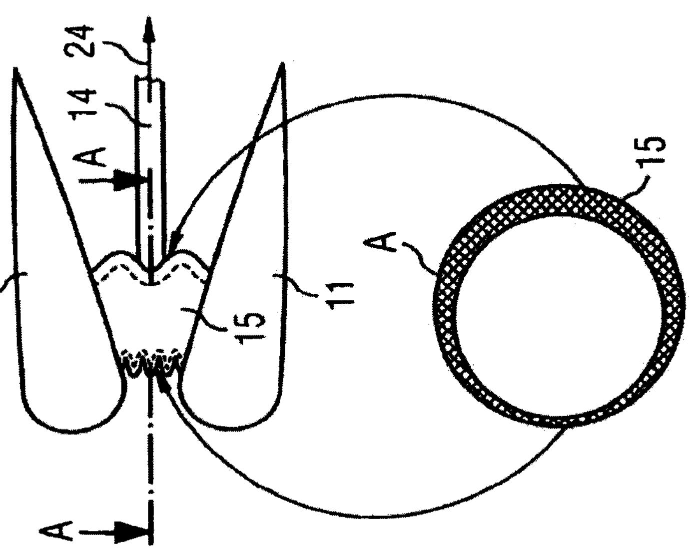


FIG 7

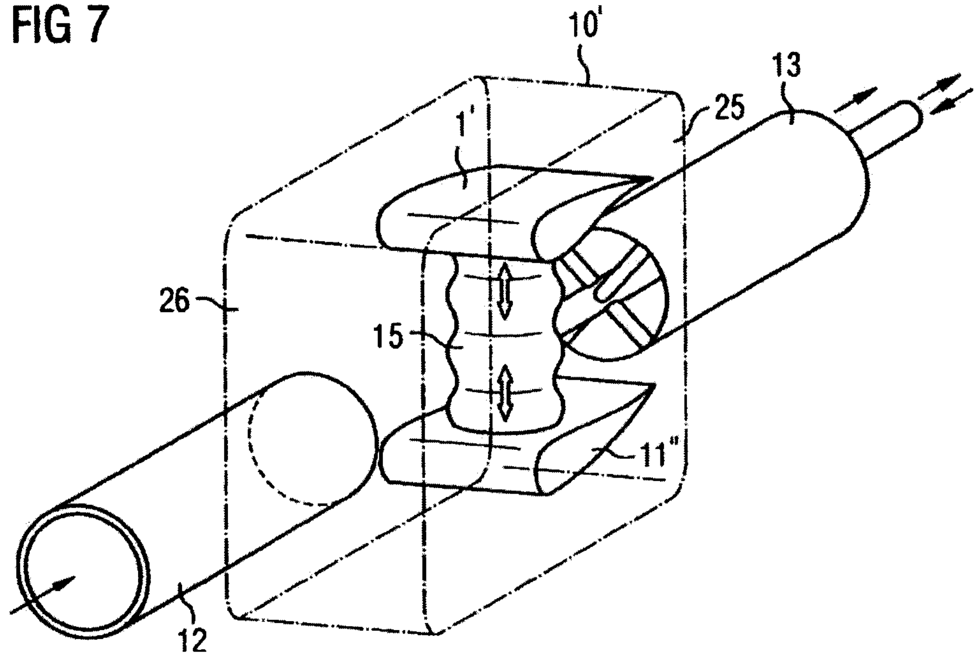


FIG 8

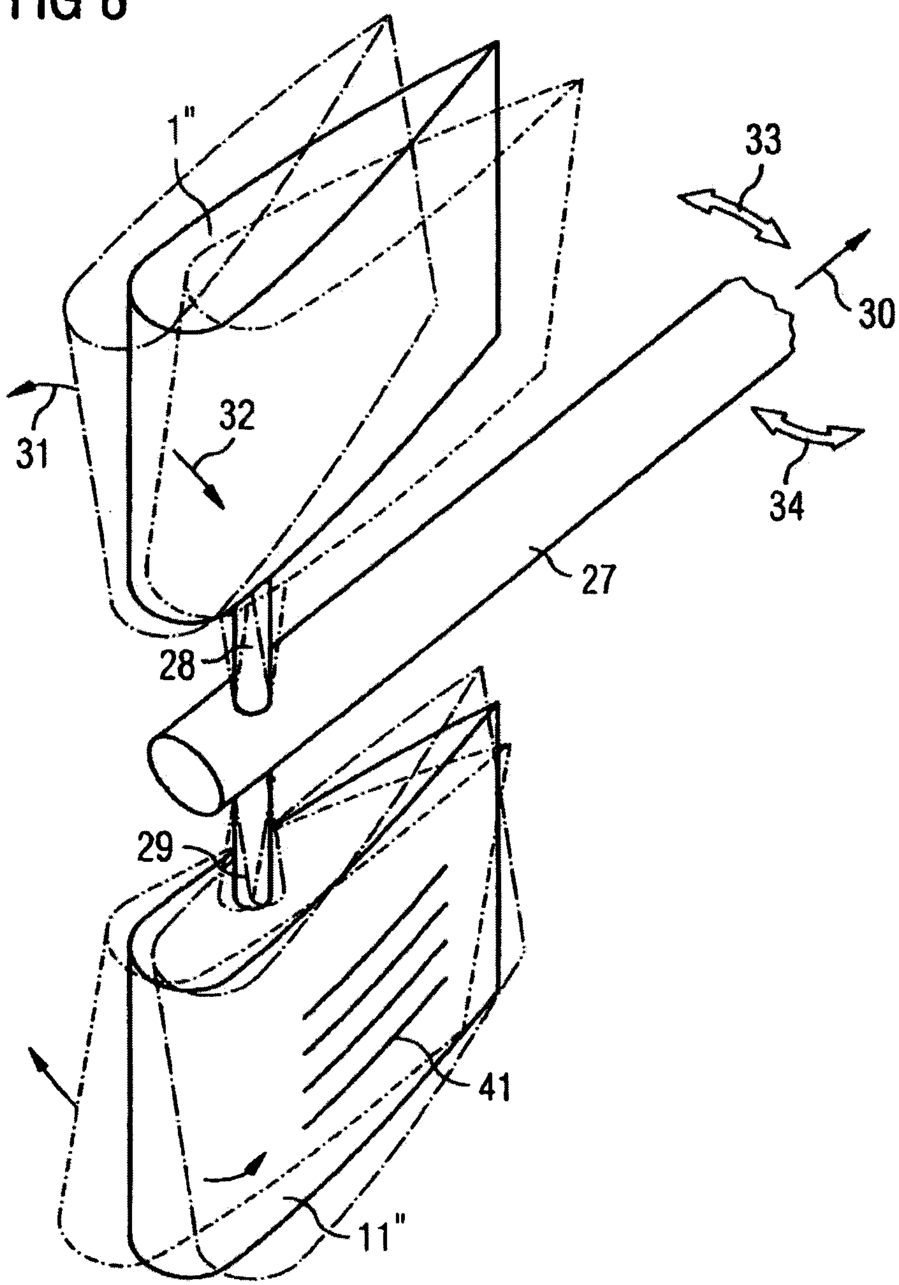


FIG 9

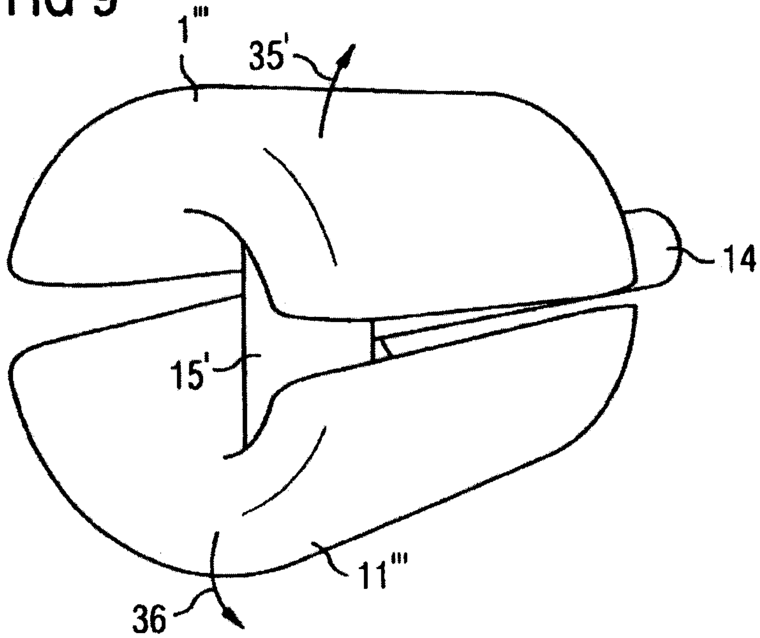
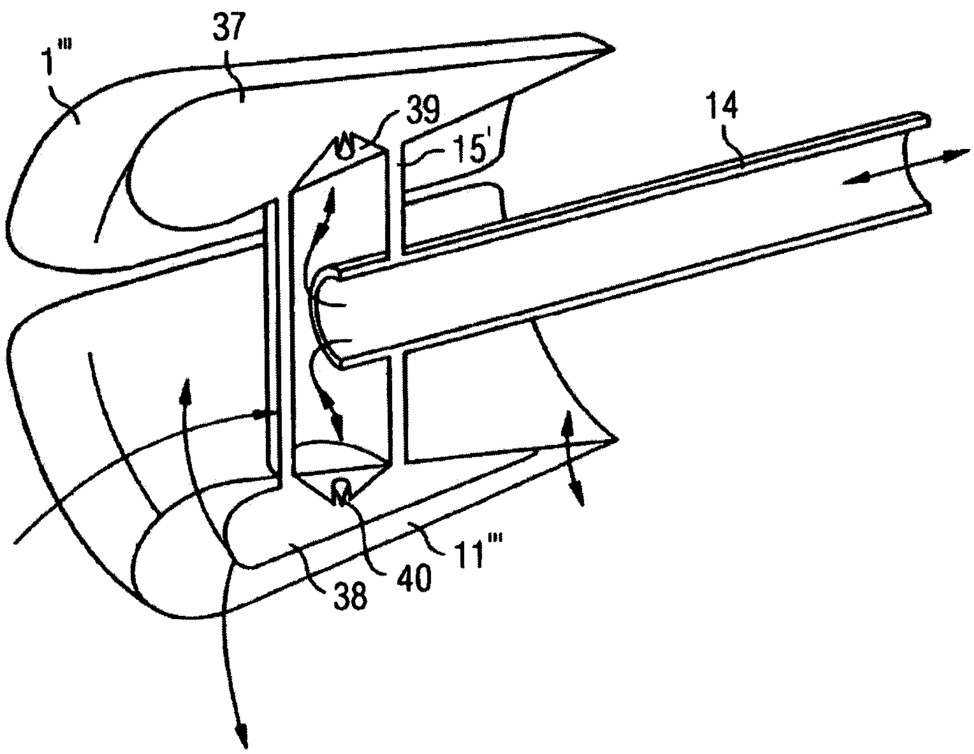


FIG 10



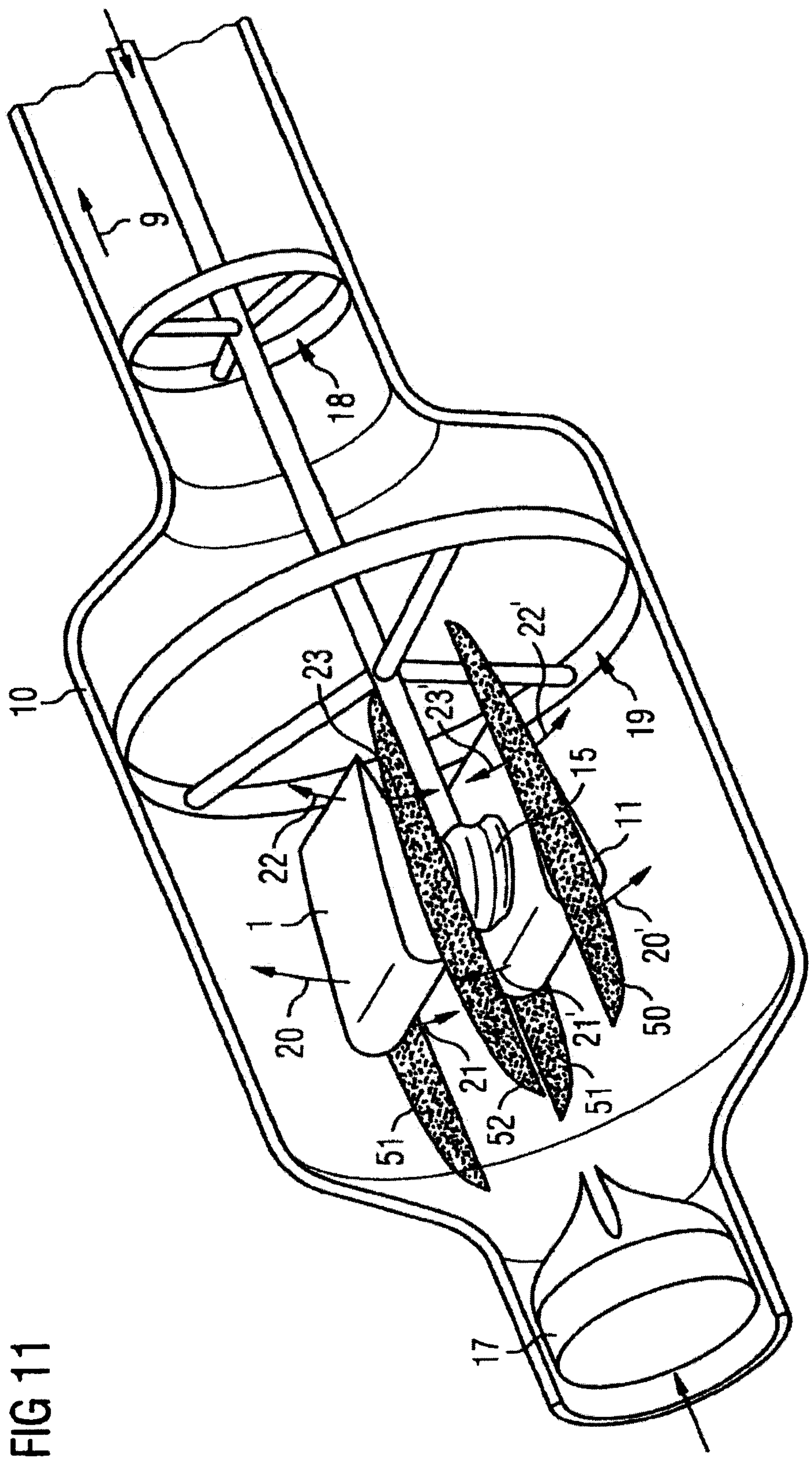


FIG 11

FIG 12

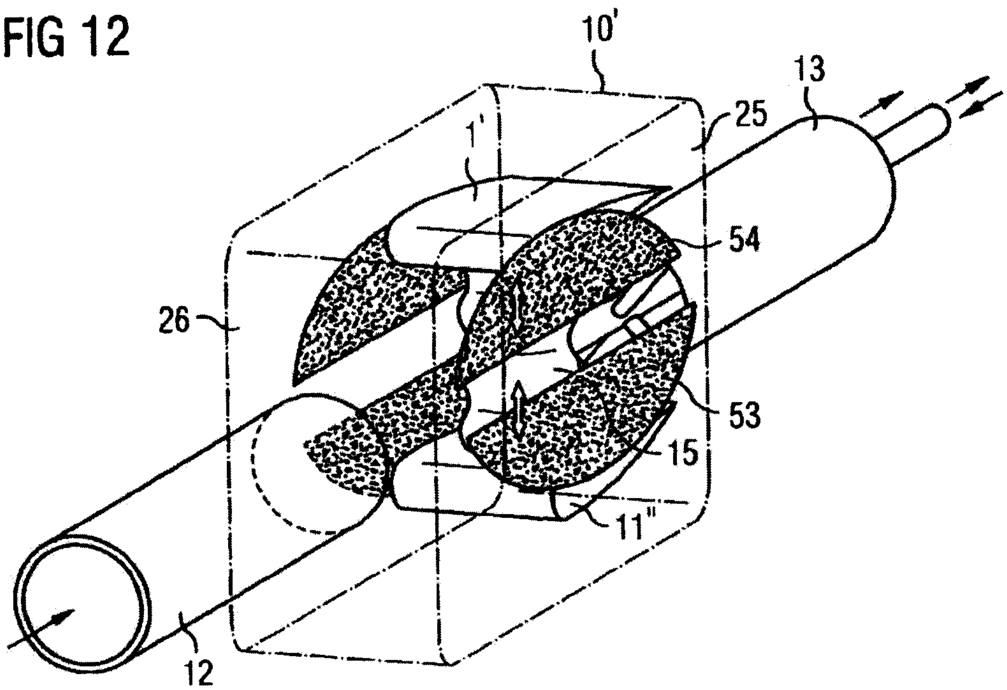


FIG 13

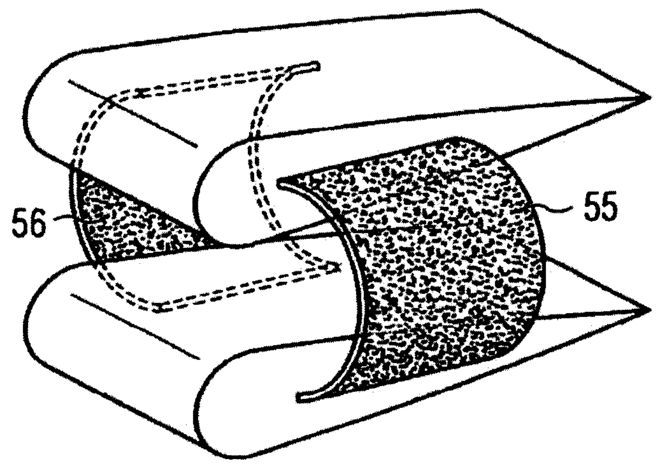


FIG 14

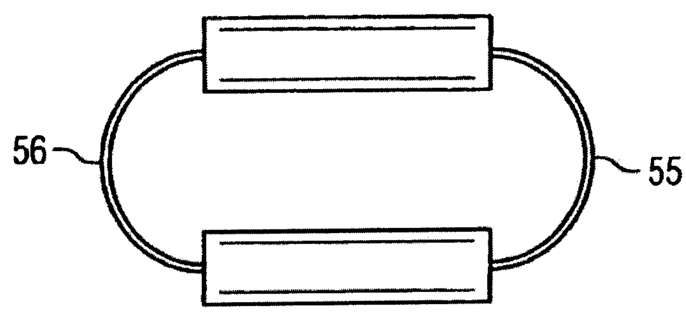


FIG 15

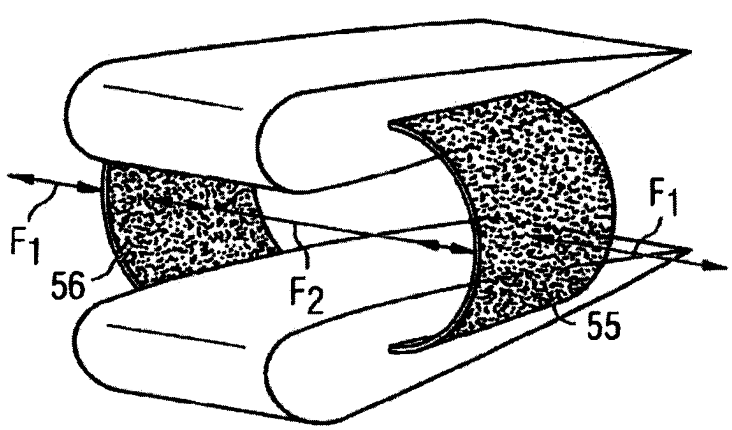


FIG 16

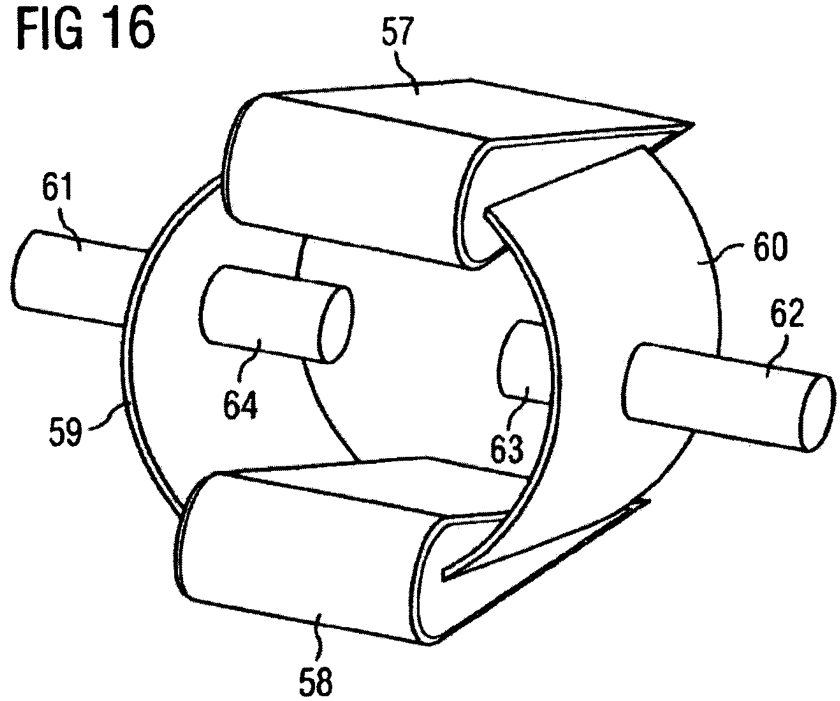


FIG 17

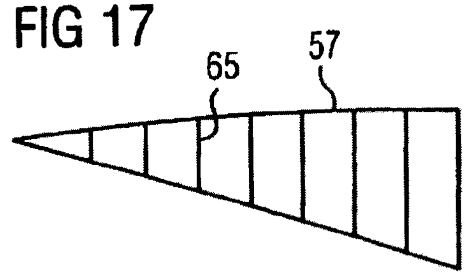
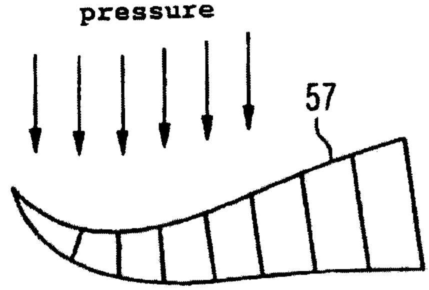


FIG 18



CONVEYING DEVICE FOR A FLUID USING AN OSCILLATING BODY ARRANGEMENT

BACKGROUND OF THE INVENTION

The invention is in the field of mechanical engineering and relates to conveying devices for fluids, in particular for liquids.

Such conveying devices have become known in the form of different kinds of pumps in the most varied of embodiments. Pumps are of particular interest at this point which can be manufactured in such constructions that they can be used for more sensitive fluids, in particular fluids having macromolecules. A specific group among such pumps is represented by the fluid pumps which can be used for medical application purposes and which can be manufactured in small constructions. Such pumps can also be used in micro constructions, for example, for conveying the body's own fluids, or biocompatible fluids, for example as heart pumps for conveying blood.

In the conveying of such sensitive fluids such as blood which have large and sensitive molecules, for example, which satisfy biological functions and which therefore also may not be damaged at the microscopic level, care must be taken that the mechanical effect on the fluid by pressure maxima, shear forces and accelerations is limited as much as possible.

Axial flow pumps have in particular become known in this connection, for example, for the conveying of blood which have a rotor which rotates about a longitudinal axis, which has impeller blades and which continuously conveys blood in the axial direction.

Since a specific problem for the use of such pumps in the inside of the body comprises the fact of providing them, on the one hand, with sufficient conveying capacity, and, on the other hand, however, of configuring the construction size so that they can be introduced through a blood vessel, some of the challenges for such pumps comprise the fact of configuring them from a construction aspect so that they are radially compressible and expandable again for operation in the body.

A compressible rotor of this kind is known, for example, from U.S. Pat. No. 6,860,713. Another rotor is known from U.S. Pat. No. 7,393,181 B2. In the known solutions, the rotors are compressible and expandable either due to the elasticity and deformability of the material or on the basis of mechanically movable constructions.

It is unavoidable in this respect that a certain construction effort is exerted to ensure the compressibility of such a pump despite a corresponding reliability and conveying capacity. It must moreover be ensured that large shear forces which can damage sensitive fluids do not arise due to too high a rotational speed of the rotor or due to unfavorable geometrical shapes of impeller blades. In addition, care must be taken that pressure differences within the geometry of such a conveying device, on the one hand, and over the course of time, on the other hand, are kept within tight limits.

BRIEF SUMMARY OF THE INVENTION

Under these conditions and against the background of the prior art, it is the underlying object of the present invention to provide a conveying device which can be manufactured with means which are simple from a construction aspect and which reliably and gently allow the conveying of a fluid.

The object is achieved in accordance with the invention by the features of claim 1, alternatively by the features of claim 3 or claim 7.

The conveying device in accordance with the invention, which serves to move a fluid in a conveying direction, for this

purpose has a drive body which can be driven by means of a drive system and which can be driven in an oscillating manner transversely to the conveying direction.

The drive body is arranged in a channel or in a space in which the fluid should be conveyed in a preset conveying direction.

Known conveying mechanisms such as centrifugal pumps or the above-named axial flow pumps make use of rotating conveying elements for moving or accelerating a fluid. The likewise known piston pumps respectively have at least one piston which is substantially movable in translation and which conveys the medium in its direction of movement on its movement.

In contrast to this, in accordance with the present invention, the drive body is moved transversely to the conveying direction in the manner of a fin of a fish which is used in nature as a rule to generate a relative movement between the fin and a fluid. In the present invention, the fin-like element, the drive body, is in this respect substantially fixed in the conveying direction so that the relative movement results in a conveying movement of the fluid.

The movement of the drive body transversely to the conveying direction in this respect, for example, means that at least one part of the drive body is moved in translation or along a less curved path substantially perpendicular to the conveying direction and/or associated with a pivot movement about an axis which is substantially perpendicular to the conveying direction. In this respect, the deviation of the direction of extent of the axis to the perpendicular of the conveying direction should amount to a maximum of 45°. In this respect, movement patterns of fin-like bodies in fish and other creatures known from bionics should be reproduced.

The corresponding drive bodies can be adapted in shape and size to the available space. The relative movement of the drive body or of different parts of said drive body with respect to the fluid to be driven can be kept in a range with respect to the speed which prevents the creation of unpermitted shear forces. In this respect, the relative speed is to be coordinated with the viscosity of the medium to be conveyed and accordingly with possibly present compressibilities. The conveying principle described can be used particularly efficiently with substantially non-compressible and slightly liquid media such as blood. Corresponding drive movements can also be transmitted easily to a drive body to be moved in an oscillating manner. A rotatable journalling of a rotor does not necessarily have to be provided.

The drive body or bodies are flowed around by the fluid to be conveyed at multiple sides, in particular at all sides. In particular when two mutually opposite conveying surfaces are provided, they are each both in contact with the fluid to be conveyed.

The drive body or bodies are compressible together with a housing surrounding them in the radial direction with respect to the conveying direction. For this purpose, the drive bodies can be configured as foldable, as elastically compressible as foam or as inflatable. The housing can likewise be foldable and can comprise a membrane spanned over a support frame. The support frame can comprise a plastic or a metallic memory alloy, for example Nitinol or another superelastic material. The housing can also be configured as inflatable, in particular as a double-wall balloon body.

Since a certain periodicity of pressure fluctuations is to be expected due to the oscillatory movement of the drive body, with an occasional reversal of the flow direction not always being able to be precluded on such pressure fluctuations, the arrangement of a control valve for the flow to be generated in the conveying channel or in the space in which the drive body is located can also advantageously be considered. In this respect, the valve can either be controlled by an intelligent control synchronously with the movement of the drive body or it can be configured as an automatically acting check valve.

The conveying surface or a conveying surface of the drive body is advantageously aligned so that a partial force acts on the fluid in the conveying direction on a movement of the drive body. For this purpose, the direction of movement of the drive body and the direction of extent of the surfaces of the drive body at which a pressure increase arises are to be correspondingly coordinated with one another.

In this connection, at least two conveying surfaces can be provided, for example at a single drive body, which are aligned so that they each effect a conveying of the fluid in at least one of the directions of movement of the drive body. A conveying of the fluid in both drive movement directions or in a plurality of drive movement directions thus becomes possible. Two conveying surfaces can be provided at two different, mutually opposite outer surfaces of a drive body.

Provision can moreover advantageously be made that at least one drive body tapers in the conveying direction in the cross-section disposed parallel to its movement plane.

The drive body can, for example, be configured in the manner of a fin as a wedge-shaped body whose thickened end is arranged upstream with respect to the flow to be produced and whose tapered end is arranged downstream. The tapered end can converge acutely in the form of a blade edge, with the blade edge being able to extend perpendicular to the drive direction of the drive body. The drive body can also be widened toward its tapered end in the direction of extent of the cutting blade.

The conveying surfaces at both sides of such a wedge-shaped fin body can be either planar or convex or concave, viewed in the direction perpendicular to the movement plane or to the drive direction of the drive body.

The drive body can be stiff in one type of embodiment of the invention. In this case, the drive body can be pivotable about an axis which lies in the region of its thickened end. In addition, a superimposed movement in translation of the thickened end can be provided, for example in a straight manner or along a gate path. The movement portion in translation takes place in the same plane as the pivot movement in this respect.

Alternatively to this, provision can also be made that the drive body is so elastic that it can also be bent in operation in its end region by the fluid counterpressure by at least 5°, in particular also by at least 20°, with respect to the undistorted state.

The drive can in this case be configured in the same manner as with a stiff drive body, but the alignment of the conveying surfaces relative to the fluid to be conveyed in the respective phase of the drive movement can already be optimized and thus the efficiency of the drive increased by the elasticity and deformability of the drive body per se.

Such a drive body, whether stiff or elastic, can either be configured as symmetrically wedge-shaped, with planar, concave or convex conveying surfaces in the cross-section viewed perpendicular to the plane of the drive movement or a shape asymmetrical in the named cross-section can also be provided, for example with elements of an airfoil wing, to utilize additional flow effects. Such an airfoil section, for example, provides a convex shape on one side of the drive body and a convex or straight shape of the conveying surface on the opposite side.

On the use of such an asymmetrical design of a drive body, a further drive body can additionally be provided which is

shaped and arranged in mirror form with respect to the first drive body and which is movably in synchronization with it in the same or opposite sense.

Provision can moreover be made to increase the efficiency of the drive that the drive body, in particular in the region of a conveying surface, has optimized surface structures.

In an advantageous embodiment of the invention, provision can moreover be made that the drive body has at least one hollow space. The provision of a hollow space reduces the mass of the drive body and thus the energy to be expended for its acceleration. In addition, the drive body can be configured as at least partially inflatable so that its outer dimensions in the non-inflated state can be smaller than in the inflated state. Such a drive body can then be brought more easily to its deployment site in the non-inflated state and inflated to the operating dimensions there. This is in particular advantageous when the conveying device should be manufactured in very small dimensions and moved within blood vessels.

The drive body can moreover advantageously comprise a foam, in particular polyurethane. The drive body can thus be manufactured as elastically deformable and as very light. The drive body can also comprise a hardenable material or generally a material whose deformability can be directly changed by physical influence, e.g. by irradiation, temperature change or by chemical reactions.

Provision can be made in the conveying device in accordance with the invention by providing a corresponding drive system that the drive body can be driven by means of a hydraulic or pneumatic device, in particular by means of a balloon body, but also by means of an electric and/or magnetic device.

Although one or more drive bodies in accordance with the invention can be moved simply by means of levers or similar mechanical devices, the drive movement can particularly easily be conducted to the conveying device by a hydraulic or pneumatic drive device. Corresponding pneumatic or hydraulic lines can be laid, for example, in the form of a hollow catheter or also within a hollow catheter, at the distal end of which the conveying device is provided, and can either act directly on a piston, bellows or balloon-like drive body in the region of the conveying device or can be converted into a lever movement there.

Possible drive movements of the drive body or bodies in this respect provide that at least one drive body is pivotable in an oscillating manner about an axis extending transversely to the conveying direction; and/or that one or more drive bodies are pivotable in an oscillating manner about an axis extending in the conveying direction, in particular outside the conveying bodies.

It is special about such an oscillatory movement that the pivot movement has a relatively small stroke so that a full rotation of the drive body does not take place in any case.

A rotation about larger angles can, however, also be provided on the rotation about an axis extending in the conveying direction.

To reduce unwanted pressure compensation procedures at the drive bodies, blocking bodies can be arranged on them between their conveying surfaces. Said blocking bodies should be flexible and can in this respect be configured as pliable or stiff, but bendable. The blocking bodies can also connect two respective blocking bodies to one another or one blocking body to a housing wall.

Provision can also be made that the driving force is transmitted to a drive body by means of a blocking body.

The described fin-like drive principle for fluids is novel in connection with the conveying of liquids and thus allows the realization of conveying characteristics which cannot be achieved with the already known conveying devices.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be shown and subsequently described in the following with reference to an embodiment in a drawing. There are shown

FIG. **1** a drive body in three positions in cross-section;

FIG. **2** a conveying system for fluids having two drive bodies in a longitudinal section;

FIG. **3** a conveying system having two drive bodies in a three-dimensional view;

FIG. **4** two drive bodies in a first position with a drive system;

FIG. **5** the drive bodies from FIG. **4** in a second position;

FIG. **6** the drive bodies from FIGS. **4** and **5** in a third position;

FIG. **7** a drive system in a three-dimensional representation having a conveying space quadrangular in cross-section;

FIG. **8** two drive bodies which are rotated in an oscillating manner about an axis extending in the conveying direction;

FIG. **9** a drive system in a three-dimensional view having two partly cylindrical drive bodies;

FIG. **10** a section through the drive system of FIG. **9**;

FIG. **11** an embodiment as in FIG. 3 with additional blocking bodies;

FIG. **12** an embodiment similar to that of FIG. 7 with blocking bodies;

FIG. **13** a representation of two drive bodies which are connected by means of blocking bodies;

FIG. **14** the embodiment of FIG. **13** in a front view;

FIG. **15** a view of the embodiment of FIG. 13, with the effect of a driving force on the blocking bodies being indicated;

FIG. **16** an arrangement in which the blocking bodies have a stiff, but bendable ring-strip shape;

FIG. **17** a drive body having fin-rays in the neutral state; and

FIG. **18** a drive body as in FIG. **17** in the loaded state.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** shows in the middle part a drive body **1** in section which substantially has a wedge shape which is modeled on the shape of a fin occurring in biology. The drive body **1** extends perpendicular to the plane of the drawing with an unchanging section, but can also widen perpendicular to the plane of the drawing toward its tapered end.

The drive body **1** can be moved in an oscillating manner along the dotted line **2** in the directions indicated by the arrows **3**, **4**. The region about the point of attack of the driving force is in this respect shown as a circle and is marked by **5**. The driving force engages at this point such that the drive body is moved substantially in translation along the line **2** and is thus not pivotable in a first variant to avoid an active fluid counterpressure.

A fluid counterpressure then results in operation, for example on the movement of the drive body within a liquid, on the side of the respectively acting conveying surface **6**, **7**, said fluid counterpressure resulting in a deformation of the end **8** of the drive body **1** remote from the drive, i.e. the tapered end, when this drive body is configured as elastic as in the example shown. A particularly efficient advance of the driven fluid in the conveying direction **9** results by this effect.

Alternatively, the drive of the drive body **1** can also be configured so that it is not driven strictly in translation in the sense of the directions **3**, **4**, but rather in a superimposed movement in translation and in a pivot movement. In this respect, for example simultaneously with the movement in the direction of the arrow **3**, a pivoting of the drive body takes place about the point of attack **5** clockwise about a specific angle, for example 10°, so that the drive body inclines at the end of the movement in a similar manner as under the effect of a fluid counterpressure. Optionally, the direction of rotation of the pivot movement can be reversed at the end of the movement in translation to beat with the fin. This driving principle can be combined both with stiff drive bodies and with flexible drive bodies.

A specific lever drive or a gate drive of the drive body can be provided for this purpose or it is conceivable to transmit the driving forces by means of a hydraulic or pneumatic apparatus.

FIG. **2** shows in a side view a housing **10** in which a conveying device in accordance with the invention having two drive bodies **1**, **11** is arranged. The housing **10** is set up rotationally symmetrically or elliptically in cross-section about the drive bodies **1**, **11** and has an inflow channel **12** as well as an outflow channel **13**. A fluid line **14** which is part of the drive system and which is connected to a drive bellows **15** projects through the outflow channel **13**. The drive bellows **15** can be connected via a pressure control device, not shown, via the fluid line **14** to an overpressure or to an underpressure so that said drive bellows can be inflated or deflated by the inflow of a fluid or the removal of the fluid.

One respective drive body **1**, **11** is fastened to the two ends **15***a*, **15***b* of the drive bellows **15** and runs through a drive movement in the direction of the arrows **3**, **4** by the volume changes of the drive bellows. The drive movement in translation of the drive bellows **15** can be translated into a more complex movement path of the drive bodies **1**, **11**, which can correspond to a superimposition of the movement in translation with a pivot movement, by a corresponding elastic configuration of the drive bellows **15** or by additional levers which connect the bellows to the drive bodies **1**, **11** or the drive bodies to a fixed point of the housing **10**.

Provision can, however, also be made that the movement of the drive bodies **1**, **11** substantially takes place in translation and said drive bodies are configured as elastic to carry out the elastically fin-like overall movement shown with reference to FIG. **1**.

If the pressure in the drive bellows **15** is changed periodically via the control of the fluid pressure in the fluid line **14**, for example several times per second, this is translated into an oscillatory movement of the drive bodies **1**, **11**. This results in an acceleration of the fluid located in the housing **10** in the direction of the arrow **16** which designates the conveying direction of the fluid. Since pressure fluctuations occur due to the periodicity of the movement, it may be meaningful to provide a check valve **17** in the inflow channel **12** which blocks the inflow channel **12** for the case that an overpressure arises within the housing **10** in front of the valve and closes it again as soon as an underpressure is generated there.

The fluid line **14** can be configured as a flexible hose line provided that the drive bellows **15** is held otherwise in the housing **10**. The drive line **14** can, however, also be configured as a rigid line in the form of a pipe in order simultaneously to conduct the fluid and to fix the drive bellows and the drive bodies **1**, **11**. The fluid line **14** can in every case be held and fixed in a holding star **18** or at a holding arm within the outflow channel **13**.

In the Figure, three positions are shown for each drive body **1**, **11**, with a middle neutral position being shown by solid lines and the extreme positions on the movement path of each individual drive body **1**, **11** being shown by broken lines.

FIG. **3** shows a similar arrangement to FIG. **2**, but in a three-dimensional view, with a second holding star **19** being provided in addition to the first holding star **18** in direct vicinity of the drive bellows **15** and of the drive bodies **1**, **11**.

Arrows **20**, **21** and **20'**, **21'** are drawn in which indicate the directions of movement of the respective thickened ends of the drive bodies **1**, **11** as are arrows **22**, **23** and **22'**, **23'** which indicate the movement of the tapered ends of the drive bodies **1**, **11**. The different lengths of the arrows shown should indicate that the thickened ends of the drive bodies **1**, **11** facing the one-way valve **17** carry out a pivot movement whose amplitude is substantially larger than the movement of the tapered ends of the drive bodies. This is made possible, as will be shown in more detail with reference to FIGS. **4**, **5** and **6**, by a special construction of the drive bellows **15**.

FIG. **4** shows in a side view in the upper part the two drive bodies **1**, **11** as well as the drive bellows **15** in the deflated, i.e. compressed, form. The arrow **24** indicates that an underpressure is present in the fluid line **14** in this state to compress the drive bellows **15**.

The drive bellows **15** itself has an asymmetrical structure, as can be seen more clearly from the lower part of FIG. **4**. A cross-section through the drive bellows **15** along the dashed line A is shown there which makes clear that the drive bellows has a smaller wall thickness in its region facing the one-way valve **17** than in the outflow channel **13**.

It is thereby achieved that the movement amplitude is larger in the front region facing the inflow channel **12** than in the rear region of the drive bellows facing the outflow channel **13**. A pivot movement of the drive bodies **1**, **11** therefore results on a pressure change in the drive bellows **15**.

In FIG. **5**, the arrangement of FIG. **4** with the drive bodies **1**, **11** and a drive bellows **15** inflated further with respect to FIG. **4** is shown. The drive bodies are approximately in the straight position shown in FIG. **2**.

FIG. **6** finally shows the state of the drive bodies **1**, **11** in the fully inflated state of the drive bellows **15**, with it also becoming clear that the thickened ends of the drive bodies **1**, **11** have passed through a larger movement amplitude than the tapered ends so that a pivot movement of the drive bodies has taken place in addition to a movement in translation.

FIG. **7** shows in a three-dimensional view from a different perspective two drive bodies **1'**, **11'** which are configured as asymmetrical in the manner of an aerodynamic airfoil section, but which may additionally also be configured as flexible and which can be driven by means of a drive bellows **15**. The inflow channel **12** is shown in the foreground of the figure, the outflow channel **13** in the background. In contrast to the cylindrical housing **10** of the arrangement shown in FIG. **3**, the housing **10'** shown in FIG. **7** has a parallelepiped structure with a rectangular cross-section to implement the non-cylindrically symmetrical structure of the drive arrangement and of the drive bodies as efficiently as possible. Unlike the specific representation of FIG. **7**, the transition from the housing **10'** to the inflow and outflow channels **12**, **13** can take place with conical or oblique transitions. Provision can advantageously be made that the drive bodies **1'**, **11'** extend perpendicular to the plane of the drive movement up to as close as possible to the side walls **25**, **26** of the housing **10'**. Turbulence at the side surfaces of the drive bodies **1'**, **11'** is thereby reduced.

The drive bodies **1'**, **11'** can, just like the drive bodies **1**, **11** shown further above, comprise a foam, in particular polyurethane, and can be inflatable. For this purpose, the bodies can have large and/or a plurality of small hollow spaces which can, for example, be inflated by the drive fluid via the fluid line **14** and which have check valves to be stabilized in the inflated state.

A good compressibility in the non-inflated state is hereby made possible so that the drive bodies can be radially compressed for transport to a deployment site together with the housing **10**, **10'** and can be expanded on site before they are put into operation.

FIG. **8** shows an arrangement in comparison with the Figures described further above having two drive bodies **1"**, **11"** with another drive principle in which the drive bodies are connected via connection webs **28**, **29** to a drive shaft **27** which extends in the conveying direction **30**.

The drive shaft **27** can be rotated in an oscillating manner about the conveying direction **30**, and indeed in each case, for example, at least by an amount of 5°, 10° or at least by 20° or 30°, in each direction, as indicated by the arrows **33**, **34**.

The longitudinal axes of the drive bodies **1"** and **11"** are aligned parallel to the shaft and undergo a movement quasi in translation in the peripheral direction of the shaft in the directions which are indicated by the arrows **31**, **32** within the framework of this rotary movement, provided that the length of the connection webs **28**, **29** is sufficient. In this manner, a corresponding approximately linear movement in translation of the drive bodies can be realized in a very simple manner by means of the drive shaft **27**. In FIG. **8**, a plurality of parallel microgrooves **41** are also shown by way of example at the lower drive body **11"**.

In FIG. **9**, an arrangement is shown in a three-dimensional view which is as largely cylindrically symmetrical as possible of two drive bodies **1'''** and **11'''** which are connected by a drive bellows **15'** and which can be moved substantially in the direction of the arrows **35**, **36** in the radial direction with respect to the cylinder axis. The drive bellows **15'** is connected to a pressure generation system by means of a fluid line **14**. It is also conceivable to divide the cylindrically symmetrical arrangement into a higher number of cylinder segments, for example 4 or 8 or more and to move them radially in each case, with a movement pattern resulting which is similar to the manner of propagation of jellyfish.

A section through the arrangement of FIG. **9** is shown in FIG. **10** which makes the function clear. The drive body **1'''** is shown by way of example with a hollow space **37**, the drive body **11'''** with a hollow space **38**, with the hollow spaces only being indicated schematically.

Fluid is exchanged via the fluid line **14** with the interior of the drive bellows **15** and is pumped from there into the hollow spaces **37**, **38**, with the hollow spaces **37**, **38** of the drive bodies **1'''** and **11'''** being connected to the hollow space of the drive bellows **15'** by means of one-way valves **39**, **40** so that the drive bodies are only inflated once and then thereafter maintain the increased fluid pressure to be stabilized in shape. Only the interior of the drive bellows **15'** is inflated and deflated thereafter. The drive bodies **1'''**, **11'''** thereby alternately move apart in the direction of the arrows **35**, **36** and move together in the opposite direction, whereby a corresponding drive movement is realized.

The efficiency of the conveying device with respect to the non-cylindrically symmetrical arrangements which are shown in the aforesaid Figures is increased by the cylindrically symmetrical or approximately cylindrically symmetrical arrangement of the drive bodies.

FIG. **11** shows a cylindrical arrangement of a housing **10** having two drive bodies **11** which are each laterally provided with blocking bodies **50**, **51**, **52**, **52** which are flexible and may also be connected to the wall of the housing **10** and which prevent or reduce a pressure equalization between the lower side and upper side or the high pressure side and low pressure side of each drive body during the drive movement.

FIG. **12** shows corresponding blocking bodies **53**, **54** for a housing **10'** with flattened side walls.

FIG. **13** shows two blocking bodies in the form of wide, flexible bands **55, 56** which connect two drive bodies to one another at both sides. This constellation is shown in a front view in FIG. **14**.

FIG. **15** shows two blocking bodies **55**, **56**, as in FIG. **13**, which connect two fin-like drive bodies to one another and act as an equalization block. The blocking bodies are configured as strips and can be configured as flexible or stiff and elastically pliable. In the latter case, a drive movement can be directly applied to the drive bodies by direct application of a mechanically, magnetically, pneumatically hydraulically or electrically generated driving force onto the blocking bodies from the outside, indicated by the arrows F_1 and F_1' or from the inside from the intermediate space of the drive bodies, indicated by the double arrow F_2.

Instead of the blocking bodies, similarly positioned coupling bodies in the form of a scaffold or frame can be provided to couple the drive movement into the sections.

The principle of the drive via the blocking bodies is additionally illustrated by way of example by FIG. **16**. Two drive bodies **57**, **58** are connected to one another there by two ring segments **59**, **60** of a ring strip in the form of a circular ring. The cylinders **61**, **62** symbolically indicate outwardly engaging driving forces which can apply a traction force or a compression force to the ring segments from the outside. Corresponding inwardly engaging forces are symbolically designated by **63**, **64**. A deformation of the ring segments effects a drive movement of the drive bodies **57**, **58**. They can be controlled in a suitable manner by a profiling of the ring segments **59**, **60** or by cut-outs in the ring segments.

In FIGS. **17** and **18**, a drive body is shown in a schematic plan view having so-called fin-rays **65** which have an influence on the flow of the fluid on the surface as web-like, groove-like or fin-like structures. They can be shaped and configured by their inner structure such that they effect a concave deformation and thus an increase in pressure on the pressure side on a movement of the drive body. This deformation against the pressure takes place automatically without any additional external energy supply and thus substantially differs from the deformation of customary beam structures which usually yield to a pressure increase on one side and evade the higher pressure.

The inner structure is formed by struts which preferably extend in the interior of a drive body from a drive surface to an oppositely disposed drive surface. The struts can in this respect be made as bars or also as plates, ribs or equivalent structures.

The conveying device for fluids in accordance with the invention allows an efficient configuration thanks to the use of an oscillatory movement transversely to the conveying direction of drive bodies, with the disadvantages of only rotating drive devices being avoided.

The invention claimed is:

1. A conveying device for the conveying of blood in a conveying direction having at least one drive body which can be driven by a drive system and which has a conveying surface, the drive body having a thickened upstream end and a tapered downstream, elastically deformable end, wherein the drive body can be driven in an oscillating, fin-like manner transversely to the conveying direction and is flowed around on a plurality of sides by blood to be conveyed, and wherein the drive body can be compressed together with a housing surrounding it.

2. The conveying device in accordance with claim **1**, wherein the drive body/bodies can be driven by a rotatable shaft.

3. The conveying device in accordance with claim **1**, wherein the at least one drive body is pivotable in an oscillating manner about an axis extending transversely to the conveying direction.

4. The conveying device in accordance with claim **1**, wherein the conveying surface of the at least one drive body is aligned such that a partial force acts on the blood in the conveying direction on movement of the at least one drive body.

5. The conveying device in accordance with claim **4**, wherein two conveying surfaces are aligned such that they effect a conveying of the blood in a respective movement direction of the at least one drive body.

6. The conveying device in accordance with claim **1**, wherein the at least one drive body tapers in the conveying direction in the cross-section disposed parallel to its movement plane.

7. The conveying device in accordance with claim **1**, wherein the at least one drive body is configured as stiff.

8. The conveying device in accordance with claim **1**, wherein the at least one drive body is configured as elastic such that it is bendable in its end region by the fluid counter-pressure in operation by at least 5° with respect to the non-deformed state.

9. The conveying device in accordance with claim **8**, wherein the at least one drive body has microgrooves extending in the conveying direction.

10. The conveying device in accordance with claim **1**, wherein the at least one drive body has at least one hollow space.

11. The conveying device in accordance with claim **1**, wherein the at least one drive body comprises a foam.

12. The conveying device in accordance with claim **11**, wherein the at least one drive body is at least partly inflatable.

13. The conveying device in accordance with claim **1**, wherein the drive body/bodies is/are deformed in operation against the fluid pressure on the respective pressure side/sides.

14. The conveying device in accordance with claim **13**, wherein the deformation of the pressure side/sides takes place by inner struts of the drive body/bodies without any additional external energy supply.

15. The conveying device in accordance with claim **1**, wherein the deformation of a pressure side of the at least one drive body takes place by the so-called fin-ray effect.

16. The conveying device in accordance with claim **11**, wherein the at least one drive body comprises polyurethane.

17. A conveying device for the conveying of a fluid in a conveying direction having at least one drive body which can be driven by a drive system and which has a conveying surface, wherein the drive body can be driven in an oscillating manner transversely to the conveying direction, the conveying device also having blocks which are laterally fastened to the drive body and which form a barrier between different conveying surfaces of the drive body, the drive body having a thickened upstream end and a tapered downstream, elastically deformable end, and wherein the drive body can be compressed together with a housing surrounding it.

18. The conveying device in accordance with claim **17**, wherein at least one block is connected either to two drive bodies or to one drive body and the housing of the conveying device.

19. The conveying device in accordance with claim **18**, wherein a driving force is applied to the drive body/bodies by the blocks.

* * * * *

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Alexandria, Virginia 22313-1450
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/261,361	10/03/2012	Reiner Liebing	1-21942	3522

1678 7590 11/19/2014

MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

EXAMINER
ZOLLINGER, NATHAN C

ART UNIT	PAPER NUMBER
3746	

MAIL DATE	DELIVERY MODE
11/19/2014	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
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Alexandria, VA 22313-1450
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In re Patent No. 8,814,543	:	
Issue Date: August 26, 2014	:	
Application No. 13/261,361	:	NOTICE
Filed: October 3, 2012	:	
Patentee(s): Reiner Liebing	:	

This is a Notice regarding the communication filed August 7, 2014, which is being treated as a request for acceptance of a fee deficiency submission under 37 CFR 1.28(c) filed August 7, 2014.

The Office no longer investigates or rejects original or reissue applications under 37 CFR 1.56. 1098 Off. Gaz. Pat. Office 502 (January 3, 1989). Therefore, nothing in this Notice is intended to imply that an investigation was done.

The fee deficiency submission under 37 CFR 1.28(c) is **ACCEPTED**. Accordingly, status as a small entity has been removed and any future fee(s) submitted must be paid at the large entity rate.

Inquiries related to this communication should be directed to the undersigned at (571) 272-3226.

/Andrea Smith/
Andrea Smith
Paralegal Specialist
Office of Petitions

Office of Petitions: Decision Count Sheet

Mailing Month: 11

Application No. 13261361

* 1 3 2 6 1 3 6 1 *

For US serial numbers: enter number only, no slashes or commas. Ex: 10123456
For PCT: enter "51+single digit of year of filing+last 5 numbers", Ex. for PCT/US05/12345, enter 51512345

Deciding Official: SMITH, ANDREA

Count (1) - Palm Credit 13/261,361

Decision: GRANT

FINANCE WORK NEEDED
☐ Select Check Box for YES

* G R A N T *

Decision Type: 321 - 37 CFR 1.28 TO MAKE ENTITY STATUS LARGE FRC

* 3 2 1 *

Notes:

Count (2)

Decision: n/a

FINANCE WORK NEEDED
☐ Select Check Box for YES

Decision Type: NONE

Notes:

Count (3)

Decision: n/a

FINANCE WORK NEEDED
☐ Select Check Box for YES

Decision Type: NONE

Notes:

Initials of Approving Official (if required)

If more than 3 decisions, attach 2nd count sheet & mark this box ☐

Printed on: *11/17/2014*

Office of Petitions: Routing Sheet

4700

Application No. 13/261,361

This application is being forwarded to your office for further processing. A decision has been rendered on a petition filed in this application.

[X] **GRANTED**

[ ] **DISMISSED**

[ ] **DENIED**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: REINER LIEBING	]]	Group Art Unit: 3746
Filing Under 35 USC 371 in DO/EO/ US of PCT/EP2011/000439 filed 27 January 2011	]]]]	Examiner: Zollinger, Nathan C.
Serial No.: 13/261,361	]]]	
Filed: 10/3/2012	]]	
For: CONVEYING DEVICE FOR A FLUID	]	Attorney Docket 1-21942

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SUBMISSION UNDER 37 CFR 1.28
& STATEMENT UNDER 37 CFR 1.27(G)(2)

Honorable Sir:

On July 17, 2014, the undersigned submitted an Issue Fee payment via EFS web in the above-captioned application. The small entity issue fee was paid in good faith. The undersigned was then subsequently informed by the applicant on July 23, 2014 that as of July 1, 2014 the applicant was no longer entitled to small entity status.

Applicant requests to be excused for payment of the small entity issue fee in accordance with 37 CFR 1.28.

Submitted herewith is the difference between the current fee amount for other than small entity on the date the deficiency is paid and the amount of the previous erroneous (small entity) fee payment. The difference is itemized below.

Small entity issue fee paid on July 17, 2014:	$480
Large entity issue fee due:	$960
Difference due:	$480

The undersigned requests that the $480 due be withdrawn from U.S. Deposit Account Number 13-1816 from which the undersigned is authorized to draw. Beside the issue fee, no other small entity fees were paid between the time the applicant transitioned from small entity to large entity.

In addition, in accordance with 37 CFR 1.27(G)(2) applicant hereby notifies the U.S. Patent and Trademark Office of its loss of entitlement to small entity status signed below by a party identified in 37 CFR 1.33(b).

No additional fees are believed due with this response. In the event that additional fees are due, please charge them to Deposit Account No. 13-1816. Kindly credit any overpayment to the same account. In either case, please associate P159600-21942001 with any credit or debit of the Deposit Account.

Please do not hesitate to contact the undersigned with any questions.

Respectfully submitted,

Stephen Evans

Stephen P. Evans
Registration No. 47,281

ATTORNEYS
Customer Number 00001678
MARSHALL & MELHORN, LLC
Four SeaGate - 8th Floor
Toledo, Ohio 43604
Phone: (419) 249-7138
Fax: (419) 249-7151
Email: evans@marshall-melhorn.com

Electronic Acknowledgement Receipt

EFS ID:	19803010
Application Number:	13261361
International Application Number:	
Confirmation Number:	3522
Title of Invention:	CONVEYING DEVICE FOR A FLUID USING AN OSCILLATING BODY ARRANGEMENT
First Named Inventor/Applicant Name:	Reiner Liebing
Customer Number:	1678
Filer:	Stephen P. Evans
Filer Authorized By:	
Attorney Docket Number:	1-21942
Receipt Date:	07-AUG-2014
Filing Date:	03-OCT-2012
Time Stamp:	14:06:56
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Notification of loss of entitlement to small entity status	SmallEntityStatusLossDifferencePayment.pdf	153085 790cd6295360f6380ec55defaa4fe7ce5206e76b	no	2

Warnings:

Information:

Total Files Size (in bytes):	153085

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: REINER LIEBING	]	Group Art Unit: 3746
Filing Under 35 USC 371 in DO/EO/ US of PCT/EP2011/000439 filed 27 January 2011	]	Examiner: Zollinger, Nathan C.
Serial No.: 13/261,361	]	
Filed: 10/3/2012	]	
For: CONVEYING DEVICE FOR A FLUID	]	Attorney Docket 1-21942

Commissioner for Patents
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SUBMISSION UNDER 37 CFR 1.28
& STATEMENT UNDER 37 CFR 1.27(G)(2)

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Submitted herewith is the difference between the current fee amount for other than small entity on the date the deficiency is paid and the amount of the previous erroneous (small entity) fee payment. The difference is itemized below.

08/12/2014 DALLEN 00000003 131816 13261361
01 FC:1461 400.00 DA

Small entity issue fee paid on July 17, 2014:	$480
Large entity issue fee due:	$960
Difference due:	$480

The undersigned requests that the $480 due be withdrawn from U.S. Deposit Account Number 13-1816 from which the undersigned is authorized to draw. Beside the issue fee, no other small entity fees were paid between the time the applicant transitioned from small entity to large entity.

In addition, in accordance with 37 CFR 1.27(G)(2) applicant hereby notifies the U.S. Patent and Trademark Office of its loss of entitlement to small entity status signed below by a party identified in 37 CFR 1.33(b).

No additional fees are believed due with this response. In the event that additional fees are due, please charge them to Deposit Account No. 13-1816. Kindly credit any overpayment to the same account. In either case, please associate P159600-21942001 with any credit or debit of the Deposit Account.

Please do not hesitate to contact the undersigned with any questions.

Respectfully submitted,

Stephen P. Evans
Registration No. 47,281

ATTORNEYS
Customer Number 00001678
MARSHALL & MELHORN, LLC
Four SeaGate - 8th Floor
Toledo, Ohio 43604
Phone: (419) 249-7138
Fax: (419) 249-7151
Email: evans@marshall-melhorn.com

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/261,361	08/26/2014	8814543	1-21942	3522

1678 7590 08/06/2014

MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Reiner Liebing, Potsdam, GERMANY;

In the Specification:

On page 1, line 2, between the title and the first paragraph, insert the following heading:

--BACKGROUND OF THE INVENTION--.

On page 3, line 10, insert the following heading:

--BRIEF SUMMARY OF THE INVENTION--.

Change(s) applied to document, /J.L.W./ 6/1/2014

On page ~~11~~ 10, above the first paragraph, insert the following heading:

--BRIEF DESCRIPTION OF THE DRAWINGS--.

On page ~~10~~ 11, line ~~12, line 28~~ 31, above the last paragraph, insert the following heading:

--DETAILED DESCRIPTION OF THE INVENTION--.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/261,361	10/03/2012	3746	745	1-21942	24	3

CONFIRMATION NO. 3522

CORRECTED FILING RECEIPT

OC000000069773888

1678
MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

Date Mailed: 07/23/2014

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Reiner Liebing, Potsdam, GERMANY;

Applicant(s)

Reiner Liebing, Potsdam, GERMANY;

Assignment For Published Patent Application

ECP ENTWICKLUNGSEGESELLSCHAFT MBH, BERLIN, GERMANY

Power of Attorney:

D Dolgorukov--26266
Donald Schurr--34247
Mark Hixon--44766
Stephen Evans--47281
Kristene Ragan--48611
Stephen Kimmet--52488
Mark Hamilton--56903
Jeanette Kuhn--66111

Domestic Priority data as claimed by applicant

This application is a 371 of PCT/EP2011/000439 01/27/2011
which claims benefit of 61/298,581 01/27/2010

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
EUROPEAN PATENT OFFICE (EPO) 10075043.9 01/27/2010

If Required, Foreign Filing License Granted: 10/11/2012

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/261,361**

Projected Publication Date: Not Applicable

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

CONVEYING DEVICE FOR A FLUID USING AN OSCILLATING BODY ARRANGEMENT

Preliminary Class

417

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

1678 7590 05/02/2014
MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/261,361	10/03/2012	Reiner Liebing	1-21942	3522

TITLE OF INVENTION: CONVEYING DEVICE FOR A FLUID

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0	$0	$480	08/04/2014

EXAMINER	ART UNIT	CLASS-SUBCLASS
ZOLLINGER, NATHAN C	3746	417-436000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   - ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   - ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
   (1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
   (2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
   1 Marshall & Melhorn, LLC
   2 ____
   3 ____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)
   PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.
   (A) NAME OF ASSIGNEE: ECP Entwicklungsgesellschaft mbH
   (B) RESIDENCE: (CITY and STATE OR COUNTRY): Berlin, Germany

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
- ☒ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies ____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number 131816 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ Applicant certifying micro entity status. See 37 CFR 1.29
- ☐ Applicant asserting small entity status. See 37 CFR 1.27
- ☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature Stephen Evans
Date 7-17-2014

Typed or printed name Stephen P. Evans
Registration No. 47281

Electronic Patent Application Fee Transmittal

Application Number:	13261361
Filing Date:	03-Oct-2012
Title of Invention:	CONVEYING DEVICE FOR A FLUID
First Named Inventor/Applicant Name:	Reiner Liebing
Filer:	Stephen P. Evans/Robin Hagemeyer
Attorney Docket Number:	1-21942

Filed as Small Entity

U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl Issue Fee	2501	1	480	480
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
		Total in USD ($)		**480**

Electronic Acknowledgement Receipt

EFS ID:	19609175
Application Number:	13261361
International Application Number:	
Confirmation Number:	3522
Title of Invention:	CONVEYING DEVICE FOR A FLUID
First Named Inventor/Applicant Name:	Reiner Liebing
Customer Number:	1678
Filer:	Stephen P. Evans/Robin Hagemeyer
Filer Authorized By:	Stephen P. Evans
Attorney Docket Number:	1-21942
Receipt Date:	17-JUL-2014
Filing Date:	03-OCT-2012
Time Stamp:	15:12:52
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$480
RAM confirmation Number	1425
Deposit Account	131816
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. 1.492 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	1-21942IssueFeeTransmittal.pdf	153296 68092b0a3c111555125ba2bd8683ddc496f69413	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30418 b33af4299aa061a788011f05ddf9fc24a53d08ef	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	183714	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

1678 7590 05/02/2014
MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

EXAMINER	
ZOLLINGER, NATHAN C	
ART UNIT	PAPER NUMBER
3746	

DATE MAILED: 05/02/2014

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/261,361	10/03/2012	Reiner Liebing	1-21942	3522

TITLE OF INVENTION: CONVEYING DEVICE FOR A FLUID

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0	$0	$480	08/04/2014

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

1678 7590 05/02/2014
MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/261,361	10/03/2012	Reiner Liebing	1-21942	3522

TITLE OF INVENTION: CONVEYING DEVICE FOR A FLUID

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0	$0	$480	08/04/2014

EXAMINER	ART UNIT	CLASS-SUBCLASS
ZOLLINGER, NATHAN C	3746	417-436000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   - ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   - ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
   (1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
   (2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

   1 ____________________
   2 ____________________
   3 ____________________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

   PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

   (A) NAME OF ASSIGNEE

   (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies ____________

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number ________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ❑ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature ____________________ Date ____________________

Typed or printed name ____________________ Registration No. ____________________

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/261,361	10/03/2012	Reiner Liebing	1-21942	3522

1678 7590 05/02/2014

MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

EXAMINER	
ZOLLINGER, NATHAN C	
ART UNIT	PAPER NUMBER
3746	

DATE MAILED: 05/02/2014

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)

(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Examiner-Initiated Interview Summary	**Application No.** 13/261,361	**Applicant(s)** LIEBING, REINER	
	Examiner NATHAN ZOLLINGER	**Art Unit** 3746	

All participants (applicant, applicant's representative, PTO personnel):

(1) NATHAN ZOLLINGER. (3)_____.

(2) Steve Evans. (4)_____.

Date of Interview: 23 April 2014.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☐112 ☐102 ☐103 ☐Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: 23-46.

Identification of prior art discussed: None.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

Discussed making minor changes to the claims to avoid antecedent basis issues and improvie clarity such as changing "a fluid" to "blood", deleting "means" language, etc. (see Examiner's amendment for a complete listing of changes agreed upon).

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/NATHAN ZOLLINGER/
Examiner, Art Unit 3746

Notice of Allowability	**Application No.** 13/261,361	**Applicant(s)** LIEBING, REINER	
	Examiner NATHAN ZOLLINGER	**Art Unit** 3746	**AIA (First Inventor to File) Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *an amendment filed on February 21, 2014*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on______.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *23-28,30-38,41-43 and 45*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☒ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. ______ .
   3. ☒ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☒ Interview Summary (PTO-413), Paper No./Mail Date *20140423* .
5. ☒ Examiner's Amendment/Comment
6. ☒ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/NATHAN ZOLLINGER/
Examiner, Art Unit 3746

Detailed Action

Response to Amendment

The amendment filed on February 21, 2014 has been entered. Claims 23, 25 and 43 have been amended and claims 39-40, 44 and 46 have been cancelled.

EXAMINER'S AMENDMENT

An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Steve Evans on April 23, 2014.

In claim 23, line 1, the phrase "a fluid" has been changed to –blood—

In claim 23, line 2, the phrase "means of" has been deleted

In claim 23, line 3, the phrase "said drive body" has been changed to –the drive body—

In claim 24, line 2, the phrase "means of" has been deleted

In claim 25, lines 2-3, the phrase "means of" has been deleted

In claim 25, lines 4-5, the phrase "characterized by" has been changed to –the conveying device also having—

In claim 25, line 5, the phrase "at least one" has been changed to –the—

In claim 25, line 6, the phrase “a drive body, said drive body" has been changed to –the drive body, the drive body—

In claim 25, line 7, the phrase “elastically deformable end" has been changed to –elastically deformable end, and wherein the drive body can be compressed together with a housing surrounding it—

In claim 26, line 3, the phrase “a housing" has been changed to –the housing—

In claim 27, lines 2-3, the phrase “drive bodies by means of the blocking body/bodies" has been changed to –drive body/bodies by the blocks—

In claim 28, line 2, the phrase “at least one drive body" has been changed to –the at least one drive body—

In claim 30, line 2, the phrase “at least one conveying surface" has been changed to –the conveying surface—

In claim 30, line 2, the phrase “at least one drive body" has been changed to –the at least one drive body—

In claim 30, line 3, the phrase “the fluid" has been changed to –the blood—

In claim 30, lines 3-4, the phrase “on a movement of the drive body" has been changed to –on movement of the at least one drive body—

In claim 31, line 3, the phrase “in a respective at least one movement direction of a drive body" has been changed to –in a respective movement direction of the at least one drive body—

In claim 31, line 3, the phrase “the fluid" has been changed to –the blood—

In claim 34, line 2, the phrase “the drive body" has been changed to –the at least one drive body—

In claim 35, lines 1-2, the phrase “the drive body" has been changed to –the at least one drive body—

In claim 41, line 2, the phrase “body or bodies" has been changed to –body/bodies—

In claim 41, line 3, the phrase “side" has been changed to –side/sides—

In claim 42, line 2, the phrase “side" has been changed to –side/sides—

In claim 42, lines 2-3, the phrase “the drive body" has been changed to –the drive body/bodies—

In claim 43, line 2, the phrase “the pressure side" has been changed to –a pressure side of the at least one drive body—

Claim 29 has been cancelled.

Election/Restrictions

Claims 23 and 25 are allowable. The restriction requirement among Species A1-D, as set forth in the Office action mailed on May 30, 2013, has been reconsidered in view of the allowability of claims to the elected invention pursuant to MPEP § 821.04(a). The restriction requirement is hereby withdrawn as to any claim that requires all the limitations of an allowable claim. Specifically, the restriction requirement of May 30, 2014 is partially withdrawn. Claims 35-36 and 43 are no longer withdrawn from consideration because the claim(s) requires all the limitations of an allowable claim.

In view of the above noted withdrawal of the restriction requirement, applicant is advised that if any claim presented in a continuation or divisional application is anticipated by, or includes all the limitations of, a claim that is allowable in the present application, such claim may be subject to provisional statutory and/or nonstatutory double patenting rejections over the claims of the instant application.

Once a restriction requirement is withdrawn, the provisions of 35 U.S.C. 121 are no longer applicable. See *In re Ziegler*, 443 F.2d 1211, 1215, 170 USPQ 129, 131-32 (CCPA 1971). See also MPEP § 804.01.

Allowable Subject Matter

Claims 23-28, 30-38, 41-43 and 45 are allowed.

The following is an examiner's statement of reasons for allowance:

Regarding claims 23 and 25, the prior art of record discloses or teaches in combination a conveying device for the conveying of a fluid/blood in a conveying direction having at least one drive body which can be driven by means of a drive system and which has a conveying surface, the drive body having a thickened upstream end and a tapered downstream, elastically deformable end, wherein the drive body can be driven in an oscillating, fin-like manner transversely to the conveying direction and is flowed around on a plurality of sides by fluid/blood to be conveyed, the conveying device also having blocks which are laterally fastened to the drive body and which form a barrier between different conveying surfaces of the drive body.

However, the prior art of record does not disclose or teach in combination that the drive body can be compressed together with a housing surrounding it.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled “Comments on Statement of Reasons for Allowance.”

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to NATHAN ZOLLINGER whose telephone number is (571)270-7815. The examiner can normally be reached on Monday - Thursday, 9 a.m. - 4 p.m. EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Devon Kramer can be reached on 571-272-7118. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/NATHAN ZOLLINGER/
Examiner, Art Unit 3746

Examiner-Initiated Interview Summary	**Application No.** 13/261,361	**Applicant(s)** LIEBING, REINER	
	Examiner NATHAN ZOLLINGER	**Art Unit** 3746	

All participants (applicant, applicant's representative, PTO personnel):

(1) NATHAN ZOLLINGER. (3)_____.

(2) Steve Evans. (4)_____.

Date of Interview: 23 April 2014.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☐112 ☐102 ☐103 ☐Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: 23-46.

Identification of prior art discussed: None.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

Discussed making minor changes to the claims to avoid antecedent basis issues and improvie clarity such as changing "a fluid" to "blood", deleting "means" language, etc. (see Examiner's amendment for a complete listing of changes agreed upon).

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/NATHAN ZOLLINGER/
Examiner, Art Unit 3746

Notice of References Cited	Application/Control No. 13/261,361	Applicant(s)/Patent Under Reexamination LIEBING, REINER	
	Examiner NATHAN ZOLLINGER	Art Unit 3746	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-6,659,740	12-2003	Drevet, Jean-Baptiste	417/436
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No. 13261361	Applicant(s)/Patent Under Reexamination LIEBING, REINER
	Examiner NATHAN ZOLLINGER	Art Unit 3746

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE									
Final	Original	05/29/2013	10/17/2013	04/30/2014							
	22	÷	✓	-							
1	23	÷	✓	=							
2	24	÷	✓	=							
17	25	÷	✓	=							
18	26	÷	✓	=							
19	27	÷	✓	=							
3	28	÷	✓	=							
	29	÷	N	-							
4	30	÷	✓	=							
5	31	÷	✓	=							
6	32	÷	✓	=							
7	33	÷	✓	=							
8	34	÷	✓	=							
9	35	÷	N	=							
10	36	÷	N	=							
11	37	÷	✓	=							
12	38	÷	✓	=							
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	40	÷	✓	-							
13	41	÷	✓	=							
14	42	÷	✓	=							
15	43	÷	N	=							
	44	÷	✓	-							
16	45	÷	✓	=							
	46	÷	✓	-							

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BIB DATA SHEET

CONFIRMATION NO. 3522

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/261,361	10/03/2012 **RULE**	417	3746	1-21942

APPLICANTS

INVENTORS
Reiner Liebing, Potsdam, GERMANY;

** **CONTINUING DATA** *************************
This application is a 371 of PCT/EP2011/000439 01/27/2011
which claims benefit of 61/298,581 01/27/2010

** **FOREIGN APPLICATIONS** *************************
EUROPEAN PATENT OFFICE (EPO) 10075043.9 01/27/2010

** **IF REQUIRED, FOREIGN FILING LICENSE GRANTED** ** ** SMALL ENTITY **
10/11/2012

		STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☑ Yes ☐ No 35 USC 119(a-d) conditions met ☑ Yes ☐ No Verified and Acknowledged /NATHAN C ZOLLINGER/ Examiner's Signature	☐ Met after Allowance Initials	GERMANY	10	24	3

ADDRESS

MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604
UNITED STATES

TITLE

CONVEYING DEVICE FOR A FLUID

FILING FEE RECEIVED		
745	FEES: Authority has been given in Paper No.____________ to charge/credit DEPOSIT ACCOUNT No.____________ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ________________ ☐ Credit

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13261361	LIEBING, REINER
	Examiner	**Art Unit**
	NATHAN ZOLLINGER	3746

CPC						
Symbol					**Type**	**Version**
A61M		1	/	101	I	2013-01-01
F04D		33	/	00	I	2013-01-01
A61M		1	/	12	F	2013-01-01
A61M		1	/	125	I	2014-02-04
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CPC Combination Sets								
Symbol					**Type**	**Set**	**Ranking**	**Version**
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			/					

		Total Claims Allowed:	
(Assistant Examiner)	(Date)	19	
/NATHAN ZOLLINGER/ Examiner.Art Unit 3746 (Primary Examiner)	04/30/2014 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1 and 2

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13261361	LIEBING, REINER
	Examiner	Art Unit
	NATHAN ZOLLINGER	3746

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS
417	436

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
623	3.1				

INTERNATIONAL CLASSIFICATION

CLAIMED					NON-CLAIMED
F	0	4	D	33 / 00 (2006.01.01)	
A	6	1	M	1 / 12 (2006.01.01)	

(Assistant Examiner)	(Date)	Total Claims Allowed: 19	
/NATHAN ZOLLINGER/ Examiner.Art Unit 3746 (Primary Examiner)	04/30/2014 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1 and 2

Issue Classification

Application/Control No.	Applicant(s)/Patent Under Reexamination
13261361	LIEBING, REINER
Examiner	**Art Unit**
NATHAN ZOLLINGER	3746

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
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1	23		39												
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7	33														
8	34														
9	35														
10	36														
11	37														

(Assistant Examiner)	(Date)	**Total Claims Allowed:** 19	
/NATHAN ZOLLINGER/ Examiner.Art Unit 3746 (Primary Examiner)	04/30/2014 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1 and 2

Search Notes	Application/Control No. 13261361	Applicant(s)/Patent Under Reexamination LIEBING, REINER
	Examiner NATHAN ZOLLINGER	Art Unit 3746

CPC- SEARCHED

Symbol	Date	Examiner
F04D33/00	4/30/2014	NZ
A61M1/12	4/30/2014	NZ

CPC COMBINATION SETS - SEARCHED

Symbol	Date	Examiner

US CLASSIFICATION SEARCHED

Class	Subclass	Date	Examiner
417	436	10/17/2013	NZ
600	16, 17, 18	10/17/2013	NZ
137	565.01	10/17/2013	NZ
623	3.1, 3.22	4/29/2014	NZ

SEARCH NOTES

Search Notes	Date	Examiner
East text, inventor name and forward/backward citation search	10/17/2013	NZ
Search assistance from Eric Bertram (600)	4/29/2014	NZ

INTERFERENCE SEARCH

US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
	Updated search	4/30/2014	NZ

/NATHAN ZOLLINGER/
Examiner.Art Unit 3746

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L3	1706	(600/16).CCLS.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/10/17 11:25
L4	55	L3 and foam	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2013/10/17 11:25
L5	33	US-2121942-$.DID. OR US-6860713-$.DID. OR US-7393181-$.DID. OR US-7927068-$.DID. OR WO-9818508-$.DID. OR US-5820542-$.DID. OR WO-2009157840-$.DID. OR EP-2194278-$.DID. OR US-1218663-$.DID. OR DE-10337804-$.DID. OR WO-20061038808-$.DID. OR US-7874882-$.DID. OR WO-20051003545-$.DID. OR EP-2353262-$.DID. OR US-3121942-$.DID. OR US-1219422-$.DID. OR WO-2006038808-$.DID. OR WO-2005003545-$.DID. OR US-6544216-$.DID. OR US-1800786-$.DID.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2013/10/17 11:36
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S23	199	(axial near flow) and pump.ab. and blood not impeller	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2013/10/16 21:30
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S32	78	S29 and pump.ab. and oscillat$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2013/10/16 21:49
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Bescheinigung

Die angehefteten Unterlagen stimmen mit der als ursprünglich eingereicht geltenden Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

Certificate

The attached documents are exact copies of the text in which the European patent application described on the following page is deemed to have been filed.

Attestation

Les documents joints à la présente attestation sont conformes au texte, considéré comme initialement déposé, de la demande de brevet européen qui est spécifiée à la page suivante.

Patentanmeldung Nr. **Patent application No.** **Demande de brevet n°**

10075043.9 / EP10075043

The organization code and number of your priority application, to be used for filing abroad under the Paris Convention, is EP10075043.

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le President de l'Office européen des brevets
p.o.

R.C. van Dijk

Anmeldung Nr:
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ECP Entwicklungsgesellschaft mbH
Wiesenweg 10
12247 Berlin/DE

Bezeichnung der Erfindung / Title of the invention / Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se référer à la description.)

Förderienrichtung für ein fluid

In Anspruch genommene Priorität(en) / Priority(Priorities) claimed / Priorité(s) revendiquée(s)
Staat/Tag/Aktenzeichen / State/Date/File no. / Pays/Date/Numéro de dépôt:

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ECP Entwicklungsgesellschaft mbH
097EP 1779

Fördereinrichtung für ein Fluid

Die Erfindung liegt auf dem Gebiet des Maschinenbaus und befasst sich mit Fördereinrichtungen für Fluide, insbesondere für Flüssigkeiten.

Solche Fördereinrichtungen sind in Form verschiedener Arten von Pumpen bereits in vielfältigsten Ausführungsformen bekannt geworden. Insbesondere interessant sind an dieser Stelle Pumpen, die in derartigen Bauformen hergestellt werden können, dass sie auch für sensiblere, insbesondere Fluide mit Makromolekülen eingesetzt werden können. Eine spezielle Gruppe unter derartigen Pumpen stellen die für medizinische Anwendungszwecke verwendbaren und in kleinen Bauformen herstellbaren Fluidpumpen dar. Solche Pumpen können in Mikrobauformen beispielsweise auch zur Förderung von körpereigenen oder bioverträglichen Flüssigkeiten eingesetzt werden, beispielsweise als Herzpumpen zur Förderung von Blut.

Bei der Förderung solcher sensibler Flüssigkeiten wie Blut, die beispielsweise große und empfindliche Moleküle aufweisen, die biologische Funktionen erfüllen und deshalb auch auf mikroskopischer Ebene nicht beschädigt werden dürfen, ist darauf zu achten, dass die mechanische Einwirkung auf die Flüssigkeit durch Druckmaxima, Scherkräfte und Beschleunigungen möglichst begrenzt wird .

Insbesondere zur Förderung von Blut sind in diesem Zusammenhang beispielsweise Axialpumpen bekannt geworden, die einen um eine Längsachse rotierenden Rotor mit Förderschaufeln aufweisen, der das Blut in Axialrichtung kontinuierlich fördert.

Da ein spezielles Problem für den Einsatz solcher Pumpen im Körperinneren darin besteht, diesen einerseits eine ausreichende Förderkapazität zu verleihen, andererseits aber die Baugröße so zu gestalten, dass sie durch ein Blutgefäß eingeführt werden können, liegen einige der Herausforderungen für solche Pumpen darin, sie konstruktiv so zu gestalten, dass sie radial komprimierbar und zum Betrieb im Körper wieder expandierbar sind.

Ein derartiger komprimierbarer Rotor ist beispielsweise aus der US 6 860 713 bekannt. Ein anderer Rotor ist aus der US 7 393 181 B2 bekannt. Bei den bekannten Lösungen sind die Rotoren entweder wegen der Elastizität und Verformbarkeit des Materials oder aufgrund von mechanisch beweglichen Konstruktionen komprimierbar und expandierbar.

Es ist dabei unvermeidlich, dass ein gewisser konstruktiver Aufwand getrieben wird, um die Komprimierbarkeit einer solchen Pumpe trotz entsprechender Zuverlässigkeit und Förderkapazität sicherzustellen. Zudem muss sichergestellt werden, dass nicht durch eine zu hohe Rotationsgeschwindigkeit des Rotors oder ungünstige geometrische Formen der Förderschaufeln zu große Scherkräfte entstehen, die sensible Flüssigkeiten schädigen können. Zudem ist darauf zu achten, dass Druckunterschiede innerhalb der Geometrie einer solchen Fördereinrichtung einerseits und im zeitlichen Ablauf andererseits in engen Grenzen gehalten werden.

Bei diesen Randbedingungen und vor dem Hintergrund des Standes der Technik liegt der vorliegenden Erfindung die Aufgabe zugrunde, eine Fördereinrichtung zu schaffen, die mit konstruktiv einfachen Mitteln herstellbar ist und zuverlässig und schonend die Förderung eines Fluids ermöglicht.

Die Aufgabe wird gemäß der Erfindung mit den Merkmalen des Patentanspruchs 1 gelöst.

Die erfindungsgemäße Fördereinrichtung, die dazu dient, ein Fluid in einer Förderrichtung zu bewegen, weist zu diesem Zweck einen mittels eines Antriebssystems antreibbaren Antriebskörper auf, der quer zur Förderrichtung oszillierend antreibbar ist.

Der Antriebskörper ist dazu in einem Kanal oder einem Raum angeordnet, in dem das Fluid in einer vorgegebenen Förderrichtung gefördert werden soll.

Bekannte Fördermechanismen wie beispielsweise Kreiselpumpen oder die oben genannten Axialpumpen bedienen sich rotierender Förderelemente zur Bewegung bzw. Beschleunigung eines Fluids. Die ebenfalls bekannten Kolbenpumpen weisen jeweils wenigstens einen Kolben auf, der im Wesentlichen translatorisch bewegbar ist und bei seiner Bewegung das Medium in seiner Bewegungsrichtung fördert.

Im Gegensatz dazu wird gemäß der vorliegenden Erfindung der Antriebskörper quer zur Förderrichtung nach Art einer Fischflosse bewegt, die in der Natur regelmäßig zur Erzeugung einer Relativbewegung zwischen der Flosse und einem Fluid eingesetzt wird. Bei der vorliegenden Erfindung steht dabei das flossenartige Element, der Antriebskörper in der Förderrichtung im Wesentlichen fest, so dass die Relativbewegung in einer Förderbewegung des Fluids resultiert.

Die Bewegung des Antriebskörpers quer zur Förderrichtung bedeutet dabei beispielsweise, dass wenigstens ein Teil des Antriebskörpers translatorisch oder entlang einer wenig gekrümmten Bahn im Wesentlichen senkrecht zur Förderrichtung und/oder verbunden mit einer Schwenkbewegung um eine Achse bewegt wird, die im Wesentlichen senkrecht zur Förderrichtung steht. Dabei sollte die Abweichung der Verlaufsrichtung der Achse zur Senkrechten der Förderrichtung maximal 45° betragen. Damit sollen die aus der Bionik bekannten Bewegungsmuster von flossenartigen Körpern bei Fischen und anderen Lebewesen nachgebildet werden.

Die entsprechenden Antriebskörper können in ihrer Form und Größe an den zur Verfügung stehenden Raum angepasst werden. Die Relativbewegung des Antriebskörpers bzw. verschiedener seiner Teile gegenüber dem anzutreibenden Fluid kann bezüglich der Geschwindigkeit in einem Bereich gehalten werden, der das Entstehen von unzulässigen Scherkräften verhindert. Dabei ist die Relativgeschwindigkeit auf die Viskosität des zu fördernden Mediums und entsprechend ggf. vorliegende Kompressibilitäten abzustimmen. Das beschriebene Förderprinzip ist bei im Wesentlichen inkompressiblen und leicht flüssigen Medien wie beispielsweise Blut besonders effizient einsetzbar. Auch entsprechende Antriebsbewegungen lassen sich zu einem oszillierend zu bewegenden Antriebskörper gut übertragen. Es muss nicht notwendig eine drehbare Lagerung eines Rotors vorgesehen werden.

Da durch die oszillatorische Bewegung des Antriebskörpers eine gewisse Periodizität von Druckschwankungen zu erwarten ist, bei denen eine zeitweise Umkehr der Strömungsrichtung nicht immer ausgeschlossen werden kann, kann vorteilhaft auch die Anordnung eines Steuerventils für die zu erzeugende Strömung im Förderkanal bzw. in dem Raum, in dem sich der Antriebskörper befindet, in Betracht gezogen werden. Dabei kann das Ventil entweder durch eine intelligente Steuerung synchron zur Bewegung des Antriebskörpers gesteuert oder als selbsttätig wirkendes Rückschlagventil ausgeführt werden.

Vorteilhaft wird die Förderfläche oder eine Förderfläche des Antriebskörpers derart ausgerichtet, dass bei einer Bewegung des Antriebskörpers auf das Fluid eine Teilkraft in der Förderrichtung wirkt. Hierzu sind die Bewegungsrichtung des Antriebskörpers und die Verlaufsrichtung der Flächen des Antriebskörpers, an denen eine Druckerhöhung entsteht, entsprechend aufeinander abzustimmen.

Es können in diesem Zusammenhang auch wenigstens zwei Förderflächen, beispielsweise an einem einzigen Antriebskörper, vorgesehen sein, die derart ausgerichtet sind, dass sie jeweils in wenigstens einer der Bewegungsrichtungen des Antriebskörpers eine Förderung des Fluids bewirken. Damit wird eine Förderung des Fluids in beiden oder mehreren Antriebsbewegungsrichtungen möglich.

Es kann außerdem vorteilhaft vorgesehen sein, dass wenigstens ein Antriebskörper sich in Förderrichtung in dem parallel zu seiner Bewegungsebene liegenden Querschnitt verjüngt.

Der Antriebskörper kann beispielsweise flossenartig als keilförmiger Körper ausgebildet sein, dessen verdicktes Ende bezüglich der zu erzeugenden Strömung stromaufwärts und dessen verjüngtes Ende stromabwärts angeordnet ist. Das verdjüngte Ende kann in Form einer Schneide spitz zulaufen, wobei die Schneide senkrecht zur Antriebsrichtung des Antriebskörpers verlaufen kann. Der Antriebskörper kann auch in der Verlaufsrichtung der Schneide zu seinem verjüngten Ende hin verbreitert sein.

Die Förderflächen zu beiden Seiten eines derart keilförmigen Flossenkörpers können entweder eben oder konvex oder konkav, in Richtung senkrecht zur Antriebsrichtung des Antriebskörpers gesehen, ausgebildet sein.

Der Antriebskörper kann in einer Ausführungsart der Erfindung steif ausgebildet sein. In diesem Fall kann der Antriebskörper um eine Achse, die im Bereich seines verdickten Endes liegt, schwenkbar sein. Zusätzlich kann eine überlagerte translatorische Bewegung des verdickten Endes, beispielsweise gerade oder entlang einer Kulissenbahn, vorgegeben sein. Der translatorische Bewegungsanteil findet dabei in derselben Ebene statt wie die Schwenkbewegung.

Alternativ dazu kann auch vorgesehen sein, dass der Antriebskörper derart elastisch ausgebildet ist, dass er durch den Fluidgegendruck im Betrieb in seinem Endbereich um wenigstens 5°, insbesondere auch wenigstens 20° gegenüber dem unverformten Zustand biegbar ist.

Der Antrieb kann in diesem Fall ebenso ausgebildet sein wie bei einem steifen Antriebskörper, jedoch wird durch die Elastizität und Verformbarkeit des Antriebskörpers an sich schon die Ausrichtung der Förderflächen relativ zum zu fördernden Fluid in der jeweiligen Phase der Antriebsbewegung optimiert und damit die Effizienz des Antriebs erhöht.

Ein derartiger Antriebskörper, gleich ob steif oder elastisch ausgebildet, kann in dem senkrecht zur Ebene der Antriebsbewegung betrachteten Querschnitt entweder symmetrisch keilförmig, mit ebenen, konkaven oder konvexen Förderflächen ausgebildet sein, oder es kann auch eine in dem genannten Querschnitt asymmetrische Form, beispielsweise mit Elementen eines Tragflügels vorgesehen sein, um zusätzliche Strömungseffekte zu nutzen. Ein derartiges Tragflügelprofil sieht beispielsweise auf einer Seite des Antriebskörpers eine konkave Form, auf der gegenüberliegenden Seite eine konvexe oder gerade Form der Förderfläche vor.

Bei Verwendung einer derart asymmetrischen Gestaltung eines Antriebskörpers kann ein weiterer Antriebskörper zusätzlich vorgesehen sein, der spiegelbildlich zu dem ersten Antriebskörper geformt und angeordnet ist und synchronisiert mit diesem gleichsinnig oder gegensinnig bewegbar ist.

Zur Erhöhung der Effizienz des Antriebs kann zudem vorgesehen sein, dass der Antriebskörper, insbesondere im Bereich einer Förderfläche, optimierte Oberflächenstrukturen aufweist.

In einer vorteilhaften Ausführungsform der Erfindung kann außerdem vorgesehen sein, dass der Antriebskörper wenigstens einen Hohlraum aufweist. Das Vorsehen eines Hohlraums verringert die Masse des Antriebskörpers und damit die aufzubringende Energie für seine Beschleunigung. Zudem kann der Antriebskörper wenigstens teilweise aufpumpbar gestaltet sein, so dass seine äußeren Abmaße im nicht aufgepumpten Zustand geringer sein können als im aufgepumpten Zustand. Ein derartiger Antriebskörper kann dann leichter im nicht aufgepumpten Zustand an einen Einsatzort gebracht und dort auf die Betriebsmaße aufgepumpt werden. Dies ist insbesondere dann vorteilhaft, wenn die Fördereinrichtung in kleinsten Abmaßen hergestellt und innerhalb von Blutgefäßen bewegt werden soll.

Der Antriebskörper kann vorteilhaft zudem aus einem Schaumstoff, insbesondere aus Polyurethan bestehen. Damit kann der Antriebskörper elastisch verformbar und sehr leicht hergestellt werden.

Durch Vorsehen eines entsprechenden Antriebssystems kann bei der erfindungsgemäßen Fördereinrichtung vorgesehen sein, dass der Antriebskörper mittels eines hydraulischen oder pneumatischen Einrichtung, insbesondere eines Ballonkörpers, jedoch auch mittels einer elektrischen und/oder magnetischen Einrichtung, antreibbar ist.

Obwohl einer oder mehrere Antriebskörper gemäß der Erfindung mittels Hebeln oder ähnlicher mechanischer Einrichtungen einfach bewegbar sind, kann durch eine hydraulische oder pneumatische Antriebseinrichtung die Antriebsbewegung besonders einfach zu der Fördereinrichtung geleitet werden. Entsprechende pneumatische oder hydraulische Leitungen können beispielsweise in Form eines Hohlkatheters oder auch innerhalb eines Hohlkatheters, an dessen distalem Ende die Fördereinrichtung vorgesehen ist, verlegt werden und im Bereich der Fördereinrichtung entweder direkt auf einen Kolben, Faltenbalg oder ballonartigen Antriebskörper wirken oder dort in eine Hebelbewegung umgesetzt werden.

Mögliche Antriebsbewegungen des oder der Antriebskörper sehen dabei vor, dass wenigstens ein Antriebskörper oszillierend um eine quer zur Förderrichtung verlaufende Achse schwenkbar ist und/oder dass einer oder mehrere Antriebskörper oszillierend um eine in Förderrichtung, insbesondere außerhalb der Förderkörper, verlaufende Achse schwenkbar sind.

Besonders an einer derartigen oszillatorischen Bewegung ist, dass die Schwenkbewegung einen relativen geringen Hub aufweist, so dass in keinem Fall eine volle Drehung des Antriebskörpers erfolgt.

Bei der Drehung um eine in Förderrichtung verlaufende Achse kann jedoch auch eine Drehung um größere Winkel vorgesehen sein.

Zur Verringerung von unerwünschten Druckausgleichsvorgängen an den Antriebskörpern können an diesen zwischen deren Förderflächen Sperrkörper angeordnet sein. Diese sollten flexibel sein, können dabei biegeschlaff oder steif, aber biegsam ausgebildet sein. Die Sperrkörper können auch jeweils zwei Sperrkörper miteinander oder einen Sperrkörper mit einer Gehäusewand verbinden.

Das beschriebene flossenartige Antriebsprinzip für Fluide ist im Zusammenhang mit der Förderung von Flüssigkeiten neu und erlaubt damit die Realisierung von Fördercharakteristiken, die mit den bereits bekannten Fördereinrichtungen nicht erreichbar sind.

Im Folgenden wird die Erfindung anhand eines Ausführungsbeispiels in einer Zeichnung gezeigt und anschließend beschrieben.
Dabei zeigt

Fig. 1 im Querschnitt einen Antriebskörper in drei Stellungen,

Fig. 2 in einem Längsschnitt ein Fördersystem für Fluide mit zwei Antriebskörpern,

Fig. 3 ein Fördersystem mit zwei Antriebskörpern in einer dreidimensionalen Ansicht,

Fig. 4 zwei Antriebskörper in einer ersten Stellung mit einem Antriebssystem,

Fig. 5 die Antriebskörper aus Fig. 4 in einer zweiten Stellung,

Fig. 6 die Antriebskörper aus den Fign. 4 und 5 in einer dritten Stellung,

Fig. 7 ein Antriebssystem in dreidimensionaler Darstellung mit einem im Querschnitt viereckigen Förderraum,

Fig. 8 zwei Antriebskörper, die oszillierend um eine in Förderrichtung verlaufende Achse gedreht werden,

Fig. 9 in dreidimensionaler Ansicht ein Antriebssystem mit zwei teilzylindrisch ausgebildeten Antriebskörpern,

Fig. 10 einen Schnitt durch das Antriebssystem aus Fig. 9,

Fig. 11 eine Ausführungsform wie Fig. 3 mit zusätzlichen Sperrkörpern,

Fig. 12 eine Ausführungsform ähnlich der aus Fig. 7 mit Sperrkörpern,

Fig. 13 eine Darstellung von zwei Antriebskörpern, die mittels Sperrkörpern verbunden sind,

Fig. 14 die Ausführungsform aus Fig. 13 in einer Frontansicht,

Fig. 15 eine Ansicht der Ausführungsform aus Fig. 13, wobei die Einwirkung einer Antriebskraft auf die Sperrkörper angedeutet ist,

Fig. 16 eine Anordnung, bei der die Sperrkörper eine steife, aber biegsame Ringstreifenform aufweisen,

Fig. 17 einen Antriebskörper mit fin-rays im neutralen Zustand sowie

Fig. 18 einen Antriebskörper wie in Fig. 17 im belasteten Zustand.

Fig. 1 zeigt im mittleren Teil einen Antriebskörper 1 im Profil, der im Wesentlichen eine Keilform aufweist, die der Form einer in der Biologie auftretenden Flosse nachgebildet ist. Der Antriebskörper 1 erstreckt sich senkrecht zur Zeichenebene mit gleichbleibendem Profil, kann sich allerdings zu seinem verjüngten Ende hin auch senkrecht zur Zeichenebene verbreitern.

Der Antriebskörper 1 kann entlang der gestrichelten Linie 2 in den durch die Pfeile 3, 4 angedeuteten Richtungen oszillierend bewegt werden. Dabei ist der Bereich um den Angriffspunkt der Antriebskraft als Kreis dargestellt und mit 5 bezeichnet. An diesem Punkt greift die Antriebskraft derart an, dass der Antriebskörper im Wesentlichen translatorisch entlang der Linie 2 bewegt wird und in einer ersten Variante somit nicht schwenkbar ist, um einem wirkenden Fluidgegendruck auszuweichen.

Es ergibt sich dann im Betrieb beispielsweise bei Bewegung des Antriebskörpers innerhalb einer Flüssigkeit auf der Seite der jeweils wirkenden Förderfläche 6, 7 ein Fluidgegendruck, der zu einer Deformation des antriebsfernen Endes 8 des Antriebskörpers 1, d. h. des verjüngten Endes, führt, wenn dieser Antriebskörper wie in dem gezeigten Beispiel elastisch ausgebildet ist. Durch diesen Effekt ergibt sich ein besonders effizienter Vortrieb des angetriebenen Fluids in der Förderrichtung 9.

Alternativ kann der Antrieb des Antriebskörpers 1 auch so ausgestaltet sein, dass dieser nicht streng translatorisch im Sinne der Richtungen 3, 4, sondern in einer überlagerten translatorischen Bewegung und Schwenkbewegung angetrieben wird. Dabei kann beispielsweise gleichzeitig mit der Bewegung in Richtung des Pfeils 3 ein Schwenken des Antriebskörpers um den Angriffspunkt 5 im Uhrzeigersinn um einen bestimmten Winkel, beispielsweise 10°, erfolgen, so dass der Antriebskörper sich ähnlich wie unter der Wirkung eines Fluidgegendrucks zum Ende der Bewegung hin neigt. Optional kann zum Ende der Translationsbewegung die Rotationsrichtung der Schwenkbewegung noch umgekehrt werden, um mit der Flosse zu schlagen. Dieses Antriebsprinzip kann sowohl mit steifen als auch mit flexiblen Antriebskörpern kombiniert werden.

Es kann zu diesem Zweck ein spezieller Hebelantrieb oder ein Kulissenantrieb des Antriebskörpers vorgesehen sein, oder es ist denkbar, mittels einer hydraulischen oder pneumatischen Vorrichtung die Antriebskräfte zu übertragen.

Fig. 2 zeigt in einer Seitenansicht ein Gehäuse 10, in dem eine erfindungsgemäße Fördereinrichtung mit zwei Antriebskörpern 1, 11 angeordnet ist. Das Gehäuse 10 ist rotationssymmetrisch oder im Querschnitt elliptisch um die Antriebskörper 1, 11 herum aufgebaut und weist einen Zulaufkanal 12 sowie einen Ablaufkanal 13 auf. Durch den Ablaufkanal 13 hindurch ragt eine Fluidleitung 14, die Teil des Antriebssystems ist und die mit einem Antriebsbalg 15 verbunden ist. Über eine nicht dargestellte Drucksteuereinrichtung kann über die Fluidleitung 14 der Antriebsbalg 15 mit einem Über- oder Unterdruck verbunden werden, so dass dieser durch Einströmen eines Fluids oder Abziehen des Fluids aufgepumpt bzw. geschrumpft werden kann.

An den beiden Enden 15a, 15b des Antriebsbalgs 15 ist je ein Antriebskörper 1, 11 befestigt, der durch die Volumenänderungen des Antriebsbalges eine Antriebsbewegung in Richtung der Pfeile 3, 4 durchläuft. Durch eine entsprechende elastische Ausgestaltung des Antriebsbalges 15 oder durch zusätzliche Hebel, die den Balg mit den Antriebskörpern 1, 11 oder die Antriebskörper mit einem festen Punkt des Gehäuses 10 verbinden, kann die translatorische Antriebsbewegung des Antriebsbalges 15 in eine komplexere Bewegungsbahn der Antriebskörper 1, 11 übersetzt werden, die einer Überlagerung der translatorischen Bewegung mit einer Schwenkbewegung entsprechen kann.

Es kann jedoch auch vorgesehen sein, dass die Bewegung der Antriebskörper 1, 11 im Wesentlichen translatorisch erfolgt und diese elastisch ausgebildet sind, um die anhand der Fig. 1 dargestellte elastisch flossenartige Gesamtbewegung auszuführen.

Wenn über die Steuerung des Fluiddrucks in der Fluidleitung 14 der Druck im Antriebsbalg 15 periodisch geändert wird, beispielsweise mehrmals pro Sekunde, so wird dies in eine oszillatorische Bewegung der Antriebskörper 1, 11 übersetzt. Dies resultiert in einer Beschleunigung des in dem Gehäuse 10 befindlichen Fluids in Richtung des Pfeils 16, der die Förderrichtung des Fluids bezeichnet. Da durch die Periodizität der Bewegung Druckschwankungen auftreten werden, kann es sinnvoll sein, ein Rückschlagventil 17 im Einlaufkanal 12 vorzusehen, das für den Fall, dass vor dem Ventil innerhalb des Gehäuses 10 ein Überdruck entsteht, den Einlaufkanal 12 sperrt und diesen wieder öffnet, sobald dort ein Unterdruck erzeugt ist.

Die Fluidleitung 14 kann als flexible Schlauchleitung ausgeführt werden, sofern der Antriebsbalg 15 anderweitig in dem Gehäuse 10 gehalten ist. Die Antriebsleitung 14 kann jedoch auch als starre Leitung in Form eines Rohres ausgebildet sein, um gleichzeitig das Fluid zu leiten und den Antriebsbalg sowie die Antriebskörper 1, 11 zu fixieren. In jedem Fall kann die Fluidleitung 14 in einem Haltestern 18 oder an einem Haltearm innerhalb des Ablaufkanals 13 gehalten und fixiert sein.

In der Figur sind für jeden Antriebskörper 1, 11 drei Positionen gezeigt, wobei eine mittlere neutrale Position mit durchgezogenen Linien dargestellt ist und die Extrempositionen auf der Bewegungsbahn jedes einzelnen Antriebskörpers 1, 11 gestrichelt dargestellt sind.

Die Fig. 3 zeigt eine ähnliche Anordnung wie Fig. 2, jedoch in dreidimensionaler Ansicht, wobei ein zweiter Haltestern 19 zusätzlich zu dem ersten Haltestern 18 in unmittelbarer Nachbarschaft des Antriebsbalges 15 und der Antriebskörper 1, 11 vorgesehen ist.

Es sind Pfeile 20, 21 und 20', 21' eingezeichnet, die die Bewegungsrichtungen der jeweils verdickten Enden der Antriebskörper 1, 11 andeuten, sowie Pfeile 22, 23 und 22', 23', die die Bewegung der verjüngten Enden der Antriebskörper 1, 11 andeuten. Die unterschiedliche Länge der dargestellten Pfeile soll andeuten, dass die verdickten, dem Einwegventil 17 zugewandten Enden der Antriebskörper 1, 11 eine Schwenkbewegung ausführen, deren Amplitude wesentlich größer ist als die Bewegung der verjüngten Enden der Antriebskörper. Dies wird, wie näher anhand der Fign.

4, 5 und 6 gezeigt wird, durch eine besondere Konstruktion des Antriebsbalges 15 ermöglicht.

Die Fig. 4 zeigt in einer Seitenansicht im oberen Teil die beiden Antriebskörper 1, 11 sowie den Antriebsbalg 15 in geschrumpfter, d.h. komprimierter Form. Der Pfeil 24 deutet an, dass in diesem Zustand ein Unterdruck in der Fluidleitung 14 besteht, um den Antriebsbalg 15 zu komprimieren.

Der Antriebsbalg 15 selbst ist asymmetrisch aufgebaut, wie aus dem unteren Teil der Fig. 4 genauer hervorgeht. Dort ist ein Querschnitt durch den Antriebsbalg 15 entlang der gestrichelten Linie A gezeigt, der ersichtlich macht, dass der Antriebsbalg in seinem dem Einwegventil 17 zugewandten Bereich eine geringere Wandstärke aufweist als in dem dem Abflusskanal 13 zugewandten Bereich.

Dadurch wird erreicht, dass die Bewegungsamplitude im vorderen, dem Zuflusskanal 12 zugewandten Bereich größer ist als im hinteren, dem Abflusskanal 13 zugewandten Bereich des Antriebsbalges. Dadurch ergibt sich eine Schwenkbewegung der Antriebskörper 1, 11 bei einer Druckänderung in dem Antriebsbalg 15.

In der Fig. 5 ist die Anordnung aus der Fig. 4 mit den Antriebskörpern 1, 11 und einem gegenüber der Fig. 4 weiter aufgepumpten Antriebsbalg 15 gezeigt. Die Antriebskörper befinden sich etwa in der in Fig. 2 dargestellten geraden Position.

Die Fig. 6 letztlich zeigt den Zustand der Antriebskörper 1, 11 im voll aufgepumpten Zustand des Antriebsbalges 15, wobei auch deutlich wird, dass die verdickten Enden der Antriebskörper 1, 11 eine größere Bewegungsamplitude durchlaufen haben als die verjüngten Enden, so dass zusätzlich zu einer translatorischen Bewegung eine Schwenkbewegung der Antriebskörper erfolgt ist.

Fig. 7 zeigt aus einer anderen Perspektive dreidimensional dargestellt zwei Antriebskörper 1', 11', die asymmetrisch nach Art eines aerodynamischen Tragflächenprofils ausgebildet sind, jedoch zusätzlich gegebenenfalls flexibel ausgeführt sein können und die mittels eines Antriebsbalgs 15 antreibbar sind. Im Vordergrund der Figur ist der Einlaufkanal 12, im Hintergrund der Auslaufkanal 13 dargestellt. Im Gegensatz zu dem in Fig. 3 dargestellten zylindrischen Gehäuse 10 der Anordnung ist das in der Fig. 7 dargestellte Gehäuse 10' quaderförmig mit rechteckigem Querschnitt aufgebaut, um den nicht zylindersymmetrischen Aufbau der Antriebsanordnung und der Antriebskörper möglichst effizient umzusetzen. Im Unterschied zu der konkreten Darstellung der Fig. 7 kann der Übergang von dem Gehäuse 10' zu den Einlauf- und Auslaufkanälen 12, 13 mit konischen oder schrägen Übergängen erfolgen. Es kann vorteilhaft vorgesehen sein, dass sich die Antriebskörper 1', 11' senkrecht zur Ebene der Antriebsbewegung bis möglichst nah an die Seitenwände 25, 26 des Gehäuses 10' erstrecken. Dadurch werden Verwirbelungen an den Seitenflächen der Antriebskörper 1', 11' reduziert.

Die Antriebskörper 1', 11' können ebenso wie die weiter oben dargestellten Antriebskörper 1, 11 aus einem Schaumstoff, insbesondere Polyurethan, bestehen und aufpumpbar sein. Dazu können die Körper große und/oder viele kleine Hohlräume aufweisen, die beispielsweise durch das Antriebsfluid über die Fluidleitung 14 aufgepumpt werden können und die über

Rückschlagventile verfügen, um im aufgepumpten Zustand stabilisiert zu sein.

Hierdurch wird eine gute Komprimierbarkeit im nicht aufgepumpten Zustand ermöglicht, so dass die Antriebskörper zum Transport an einen Einsatzort gemeinsam mit dem Gehäuse 10, 10' radial komprimiert und vor Ort expandiert werden können, bevor sie in Betrieb genommen werden.

Fig. 8 zeigt im Vergleich zu den weiter oben beschriebenen Figuren eine Anordnung mit zwei Antriebskörpern 1'', 11'' mit einem anderen Antriebsprinzip, bei dem die Antriebskörper über Verbindungsstege 28, 29 mit einer Antriebswelle 27 verbunden sind, welche in der Förderrichtung 30 verläuft.

Die Antriebswelle 27 kann um die Förderrichtung 30 herum oszillierend gedreht werden, und zwar jeweils beispielsweise mindestens um einen Betrag von 5°, 10° oder mindestens um 20° oder 30° in jede Richtung, wie durch die Pfeile 33, 34 angedeutet.

Die Antriebskörper 1'' und 11'' sind mit ihren Längsachsen parallel zur Welle ausgerichtet und durchlaufen im Rahmen dieser rotatorischen Bewegung, sofern die Länge der Verbindungsstege 28, 29 ausreichend ist, eine quasitranslatorische Bewegung in Umfangsrichtung der Welle in den Richtungen, die mit den Pfeilen 31, 32 angedeutet sind. Auf diese Weise lässt sich mittels der Antriebswelle 27 auf sehr einfache Weise eine entsprechende annähernd lineare translatorische Bewegung der Antriebskörper realisieren. In Figur 8 sind beispielhaft am unteren Antriebskörper 11'' auch eine Mehrzahl von parallelen Mikrorillen 41 dargestellt.

In der Fig. 9 ist in dreidimensionaler Ansicht eine möglichst weitgehend zylindersymmetrische Anordnung von zwei Antriebskörpern 1''' und 11''' dargestellt, die mit einem Antriebsbalg 15' verbunden sind und im Wesentlichen in Richtung der Pfeile 35, 36 in radialer Richtung bezüglich der Zylinderachse bewegt werden können. Der Antriebsbalg 15' ist mittels einer Fluidleitung 14 mit einem Druckerzeugungssystem verbunden. Es ist auch denkbar, die Zylindersymmetrische Anordnung in eine höhere Anzahl von beispielsweise 4 oder 8 oder mehr Zylindersegmenten zu unterteilen und diese jeweils radial zu bewegen, wobei sich ein Bewegungsmuster ergibt, das der Fortbewegungsart von Quallen ähnelt.

In Fig. 10 ist ein Schnitt durch die Anordnung aus Fig. 9 dargestellt, der die Funktion deutlich macht. Der Antriebskörper 1''' ist beispielhaft mit einem Hohlraum 37 dargestellt, der Antriebskörper 11''' mit einem Hohlraum 38, wobei die Hohlräume nur schematisch angedeutet sind.

Über die Fluidleitung 14 wird Fluid mit dem Inneren des Antriebsbalgs 15 ausgetauscht und von dort in die Hohlräume 37, 38 hineingepumpt, wobei die Hohlräume 37, 38 der Antriebskörper 1''' und 11''' mittels Einwegventilen 39, 40 mit dem Hohlraum des Antriebsbalgs 15' verbunden sind, so dass die Antriebskörper nur einmal aufgepumpt werden und danach den erhöhten Fluiddruck halten, um sich in der Form zu stabilisieren. Danach wird lediglich das Innere des Antriebsbalgs 15' aufgepumpt und geschrumpft. Dadurch bewegen sich die Antriebskörper 1''', 11''' abwechselnd in Richtung der Pfeile 35, 36 auseinander und in entgegengesetzter Richtung zusammen, wodurch eine entsprechende Antriebsbewegung realisiert wird.

Durch die zylindersymmetrische oder annähernd zylindersymmetrische Anordnung der Antriebskörper wird der Wirkungsgrad der Fördereinrichtung gegenüber den nicht zylindersymmetrischen Anordnungen, die in den oben genannten Figuren dargestellt sind, erhöht.

Fig. 11 zeigt eine zylindrische Anordnung eines Gehäuses 10 mit zwei Antriebskörpern 11, die seitlich jeweils mit Sperrkörpern 50, 51, 52, 52 versehen sind, die flexibel sind und auch mit der Wand des Gehäuses 10 verbunden sein können und die während der Antriebsbewegung einen Druckausgleich zwischen Unter- und Oberseite bzw. der Hochdruck- und Niederdruckseite jedes Antriebskörpers verhindern oder verringern.

Fig. 12 zeigt entsprechende Sperrkörper 53, 54 für ein Gehäuse 10' mit abgeflachten Seitenwänden.

Fig. 13 zeigt zwei Sperrkörper in Form von breiten, flexiblen Bändern 55, 56, die zwei Antriebskörper zu beiden Seiten miteinander verbinden. Diese Konstellation ist in Fig. 14 in einer Frontansicht gezeigt.

Fig. 15 zeigt zwei Sperrkörper 55, 56 wie in Fig. 13, die zwei flossenförmige Antriebskörper miteinander verbinden und als Ausgleichssperre wirken. Die Sperrkörper sind als Streifen ausgebildet und können biegeschlaff oder steif und elastisch biegbar ausgebildet sein. Im letzten Fall kann durch gezieltes Aufbringen einer mechanisch, magnetisch, pneumatisch, hydraulisch oder elektrisch erzeugten Antriebskraft auf die Sperrkörper von außen, angedeutet durch die Pfeile F_1 und F_1', oder von innen aus dem Zwischen-raum der Antriebskörper, angedeutet durch den Doppelpfeil F_2, eine Antriebsbewegung auf die Antriebskörper gezielt aufgebracht werden.

Anstelle der Sperrkörper können auch ähnlich positionierte Kopplungskörper in Form eines Gerüstes oder Rahmens zur Einkopplung der Antriebsbewegung in die Profile vorgesehen sein.

Das Prinzip des Antriebs über die Sperrkörper ist beispielhaft zusätzlich durch Fig. 16 verdeutlicht. Dort sind zwei Antriebskörper 57, 58 durch zwei Ringsegmente 59, 60 eines Ringstreifens in Form eines Kreisrings miteinander verbunden. Die Zylinder 61, 62 deuten symbolisch außen ansetzende Antriebskräfte an, die von außen auf die Ringsegmente eine Zug- oder Druckkraft aufbringen können. Mit 63, 64 sind symbolisch entsprechende, innen ansetzende Kräfte bezeichnet. Eine Verformung der Ringsegmente bewirkt eine Antriebsbewegung der Antriebskörper 57, 58. Diese kann in geeigneter Weise durch eine Profilierung der Ringsegmente 59, 60 oder durch Ausnehmungen in den Ringsegmenten gesteuert werden.

In Fig. 17 und 18 ist in einer schematischen Draufsicht ein Antriebskörper mit sogenannten fin-rays 65 gezeigt, die als steg-, nut- oder flossenähnliche Strukturen auf der Oberfläche einen Einfluss auf die Strömung des Fluids nehmen. Diese können derart geformt und gestaltet sein, dass sie bei Bewegung des Antriebskörpers auf der Druckseite eine konkave Verformung und damit eine Druckerhöhung bewirken.

Die erfindungsgemäße Fördereinrichtung für Fluide erlaubt durch den Einsatz einer oszillatorischen Bewegung quer zur Förderrichtung von Antriebskörpern eine effiziente Ausgestaltung, wobei die Nachteile von ausschließlich rotierenden Antriebseinrichtungen vermieden werden.

ECP Entwicklungsgesellschaft mbH
097EP 1779

Patentansprüche

1. Fördereinrichtung zur Förderung eines Fluids in einer Förderrichtung mit wenigstens einem mittels eines Antriebssystems antreibbaren Antriebskörper (1,1',1'',1''',11,11',11'',11'''), dadurch gekennzeichnet, dass der Antriebskörper quer zur Förderrichtung (9) oszillierend antreibbar ist.

2. Fördereinrichtung nach Anspruch 1, dadurch gekennzeichnet, dass wenigstens eine Förderfläche (6,7) wenigstens eines Antriebskörpers (1,1',1'',1''',11,11',11'',11''') derart ausgerichtet ist, dass bei Bewegung des Antriebskörpers auf das Fluid eine Teilkraft in der Förderrichtung (9) wirkt.

3. Fördereinrichtung nach Anspruch 2, dadurch gekennzeichnet, dass zwei Förderflächen (6,7) derart ausgerichtet sind, dass sie in jeweils wenigstens einer Bewegungsrichtung (3,4) eines Antriebskörpers (1,1',1'',1''',11,11',11'',11''') eine Förderung des Fluids bewirken.

4. Fördereinrichtung nach Anspruch 1, 2 oder 3, dadurch gekennzeichnet, dass wenigstens ein Antriebskörper (1,1',1'',1''',11,11',11'',11''') sich in Förderrichtung (9) in dem parallel zu seiner Bewegungsebene liegenden Querschnitt verjüngt.

5. Fördereinrichtung nach Anspruch 1 oder einem der folgenden, dadurch gekennzeichnet, dass der

wenigstens eine Antriebskörper (1,1',1'',1''',11,11',11'',11''') steif ausgebildet ist.

6. Födereinrichtung nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, dass der Antriebskörper (1,1',1'',1''',11,11',11'',11''') derart elastisch ausgebildet ist, dass er durch den Fluidgegendruck im Betrieb in seinem Endbereich um wenigstens 5° gegenüber dem unverformten Zustand biegbar ist.

7. Fördereinrichtung nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, dass der Antriebskörper in Förderrichtung (9) verlaufende Mikrorillen (41) aufweist.

8. Fördereinrichtung nach Anspruch 1 oder einem der folgenden, dadurch gekennzeichnet, dass der Antriebskörper(1,1',1'',1''',11,11',11'',11''') wenigstens einen Hohlraum (37,38) aufweist.

9. Fördereinrichtung nach Anspruch 8, dadurch gekennzeichnet, dass der Antriebskörper (1,1',1'',1''',11,11',11'',11''') aus einem Schaumstoff, insbesondere Polyurethan, besteht.

10. Fördereinrichtung nach Anspruch 8 oder 9, dadurch gekennzeichnet, dass der Antriebskörper wenigstens (1,1',1'',1''',11,11',11'',11''') teilweise aufpumpbar ist.

11. Fördereinrichtung nach Anspruch 1 oder einem der folgenden, dadurch gekennzeichnet, dass der Antriebskörper mittels einer hydraulischen oder pneumatischen Einrichtung (15,15'), insbesondere eines Ballonkörpers, antreibbar ist.

12. Fördereinrichtung nach einem der Ansprüche 1 bis 10, dadurch gekennzeichnet, dass der Antriebskörper mittels einer elektrischen und/oder magnetischen Einrichtung antreibbar ist.

13. Fördereinrichtung nach Anspruch 1 oder einem der folgenden, dadurch gekennzeichnet, dass wenigstens ein Antriebskörper (1,1',1'',1''',11,11',11'',11''') oszillierend um eine quer zur Förderrichtung (9) verlaufende Achse schwenkbar ist.

14. Fördereinrichtung nach einem der Ansprüche 1 bis 13, dadurch gekennzeichnet, dass der/die Antriebskörper (1'', 11'') oszillierend um eine in Förderrichtung (9), insbesondere außerhalb des/der Antriebskörper(s) verlaufende Achse schwenkbar sind.

15. Fördereinrichtung nach einem der Ansprüche 1 bis 14, gekennzeichnet durch seitlich an wenigstens einem Antriebskörper befestigten Sperren, die eine Barriere zwischen verschiedenen Förderflächen eines Antriebskörpers bilden.

16. Fördereinrichtung nach Anspruch 14, dadurch gekennzeichnet, dass wenigstens eine Sperre entweder mit zwei Antriebskörpern oder mit einem Antriebskörper und einem Gehäuse der Fördereinrichtung verbunden ist.

17. Fördereinrichtung nach Anspruch 15 oder 16, dadurch gekennzeichnet, dass die Antriebskraft auf die Antriebskörper mittels des/der Sperrkörper(s) aufgebracht wird.

Zusammenfassung

Fördereinrichtung für ein Fluid

Die Erfindung bezieht sich auf eine Fördereinrichtung zur Förderung eines Fluids in einer Förderrichtung (9) mit einem oder mehreren Antriebskörpern (1,1',1'',1''',11,11',11'',11'''), die mittels eines Antriebssystems (15,15') oszillierend quer zur Förderrichtung antreibbar sind. Durch entsprechende translatorische oder teils schwenkende Bewegung der Antriebskörper wird nach Art des aus der Biologie (z. B. Aerodynamik und Hydrodynamik) bekannten Flossenprinzips eine Beschleunigung des Fluids erreicht.

(Fig. 3)

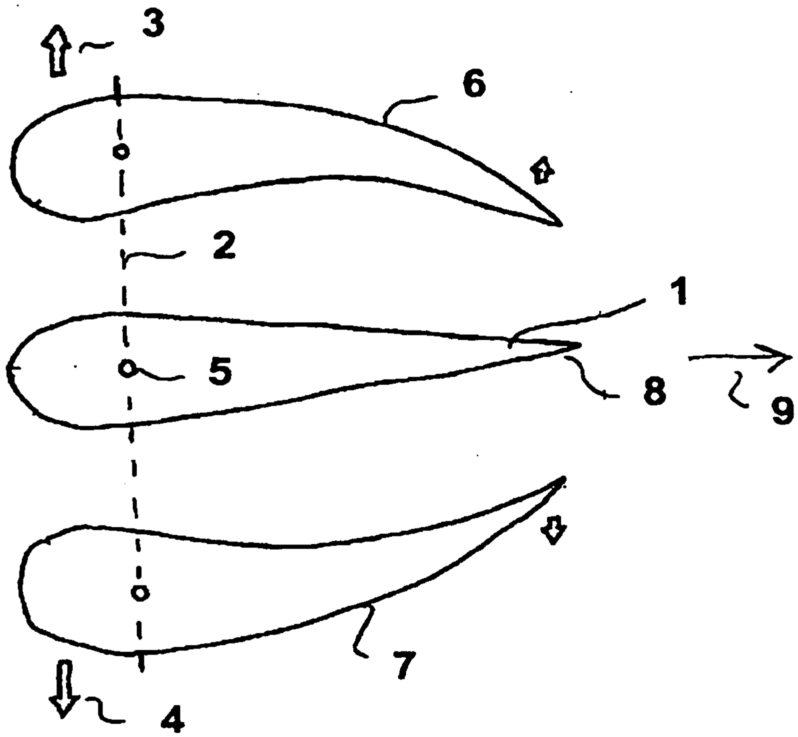


Fig. 1

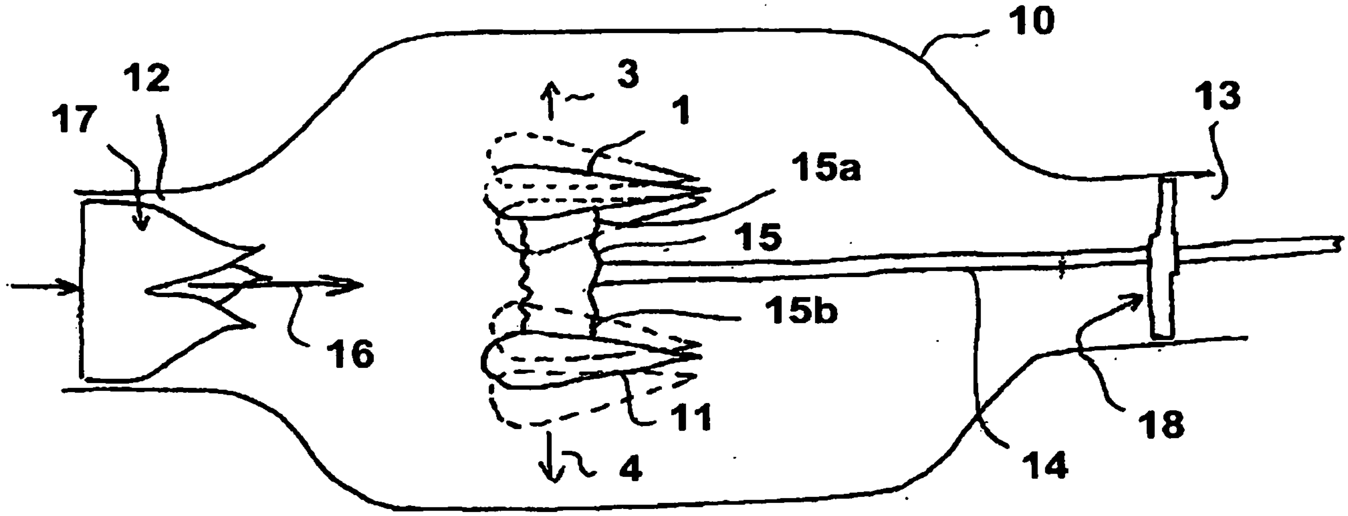


Fig. 2

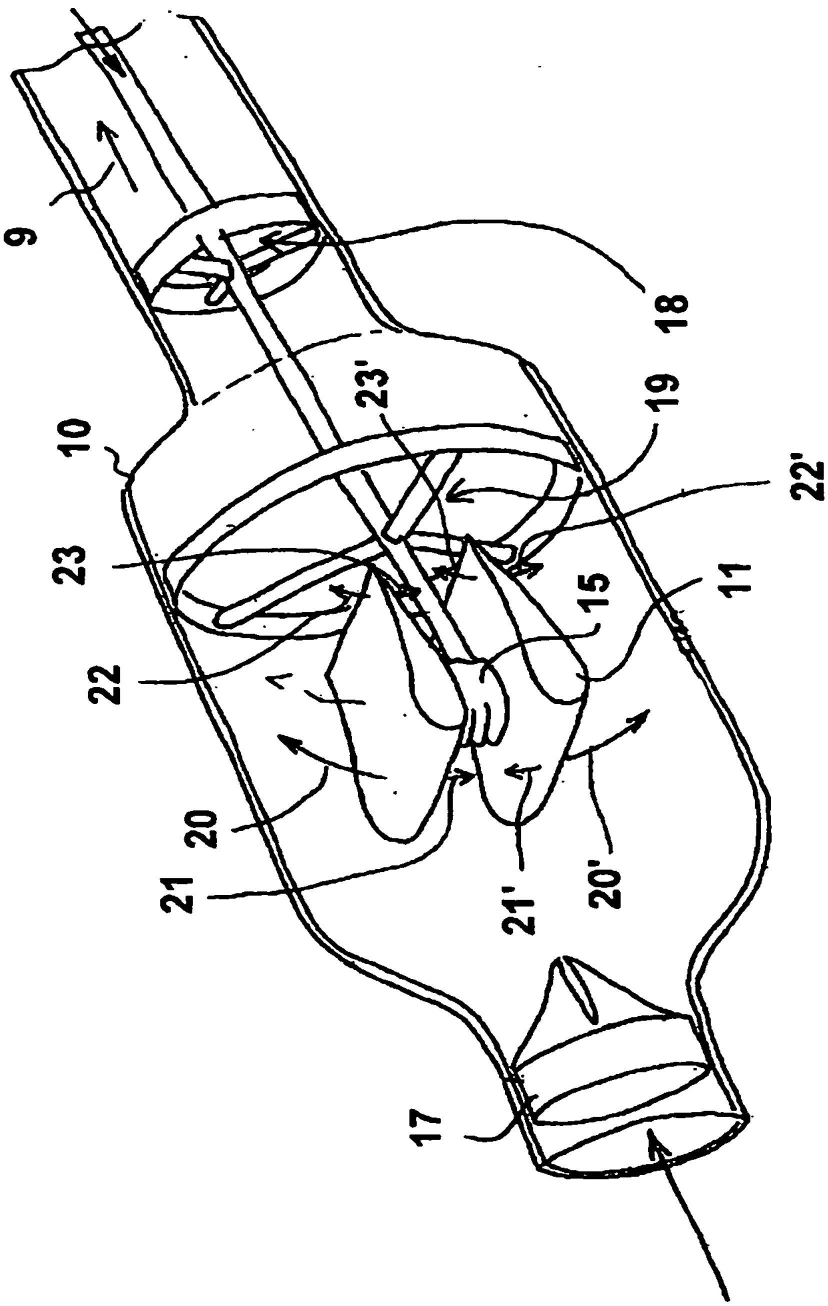


Fig. 3

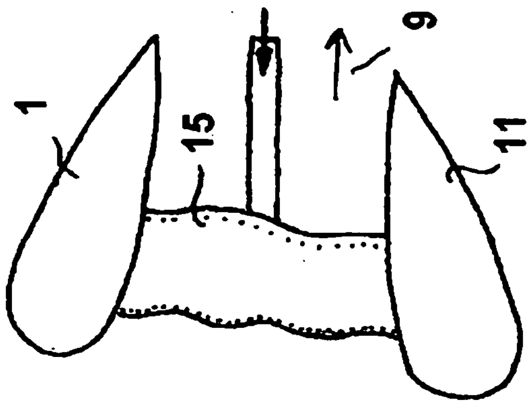


Fig. 6

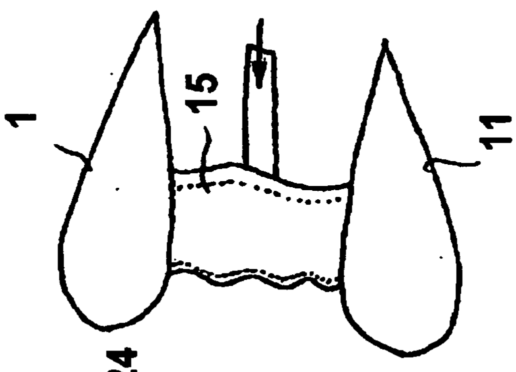


Fig. 5

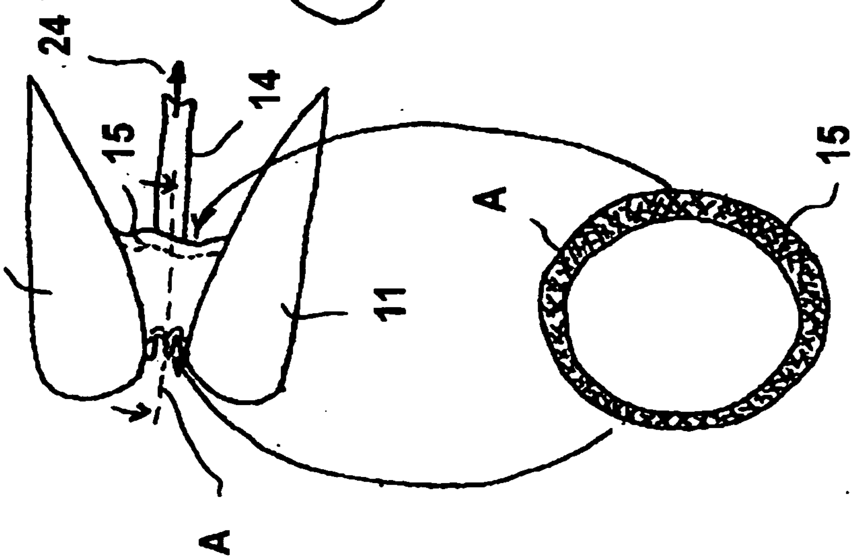


Fig. 4

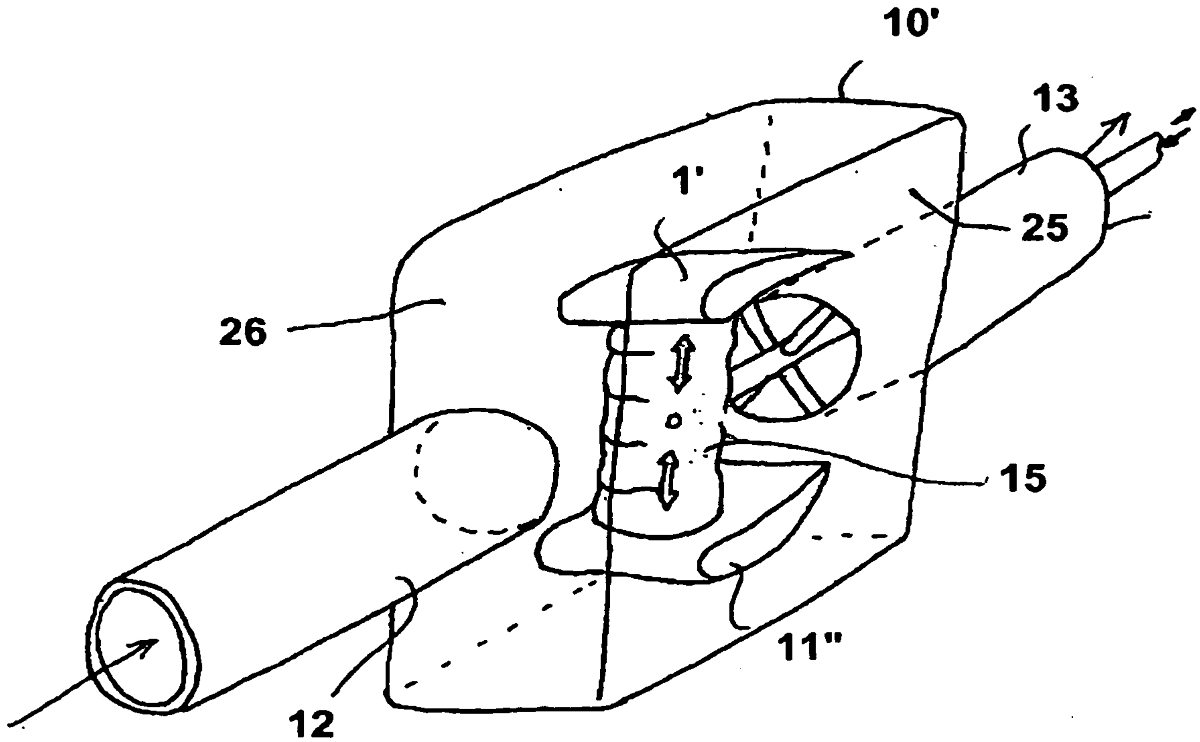


Fig. 7

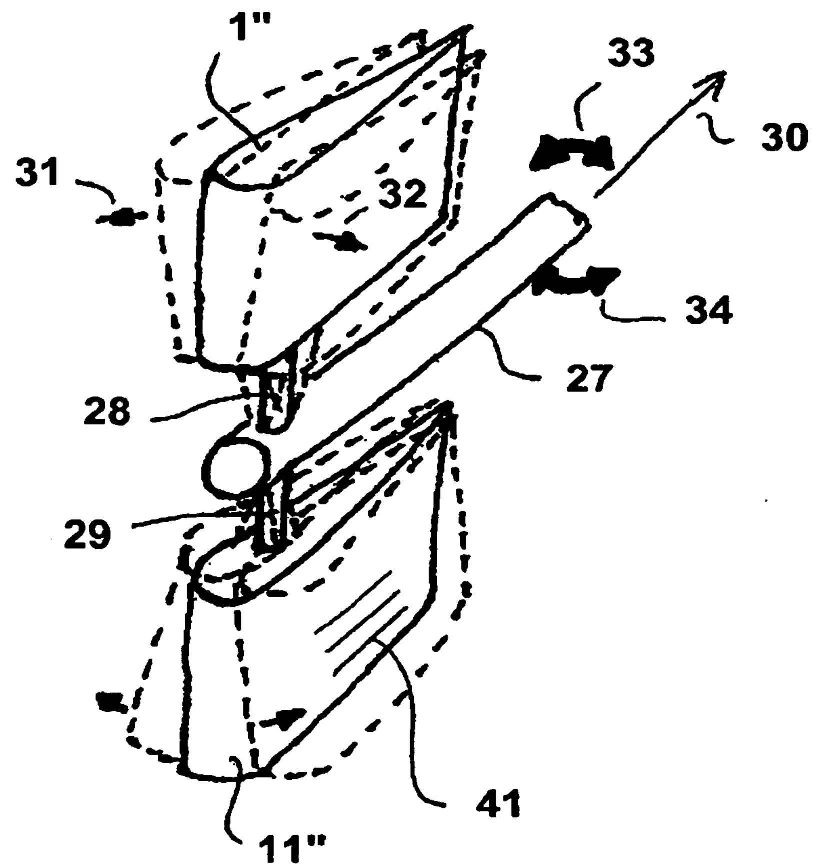


Fig. 8

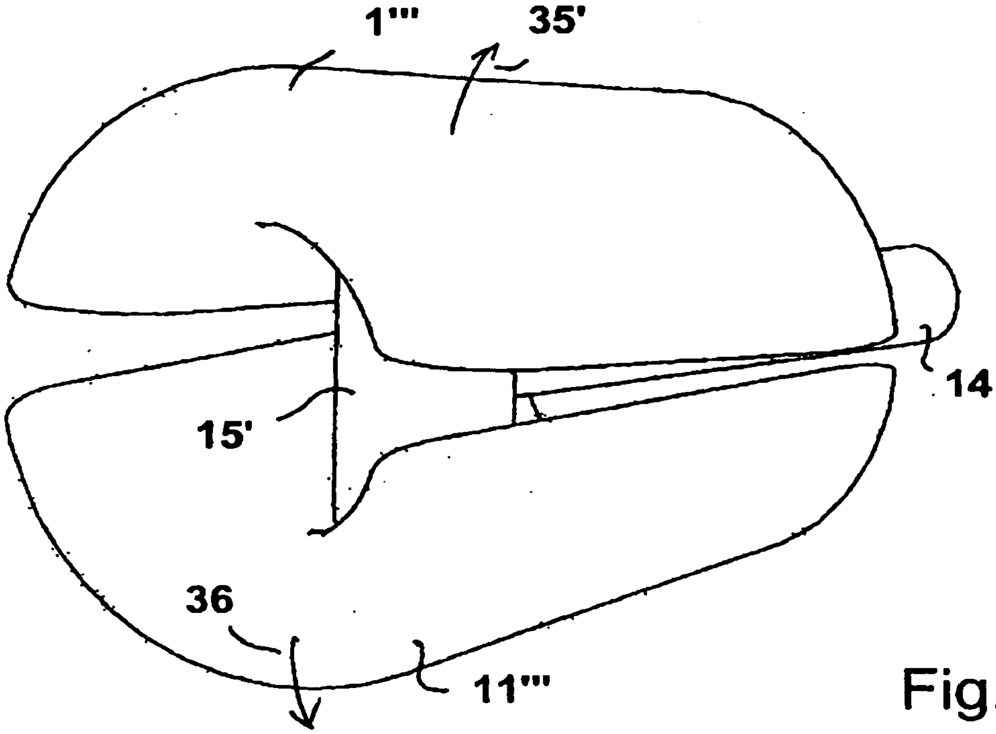


Fig. 9

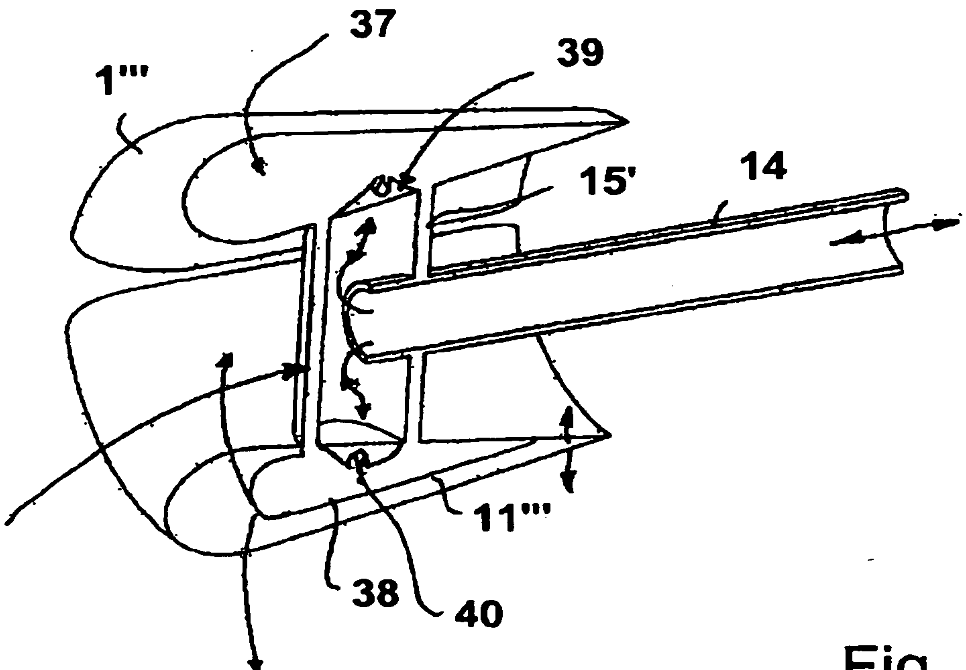
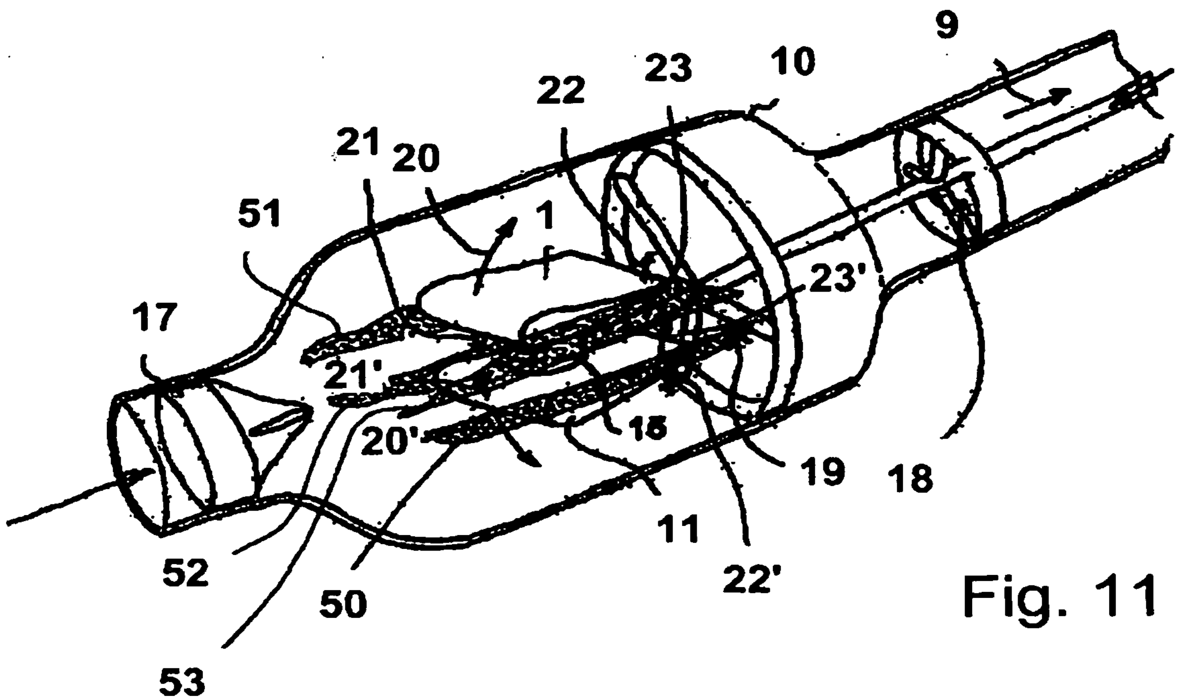


Fig. 10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23
10
22
21
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1
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53

Fig. 11

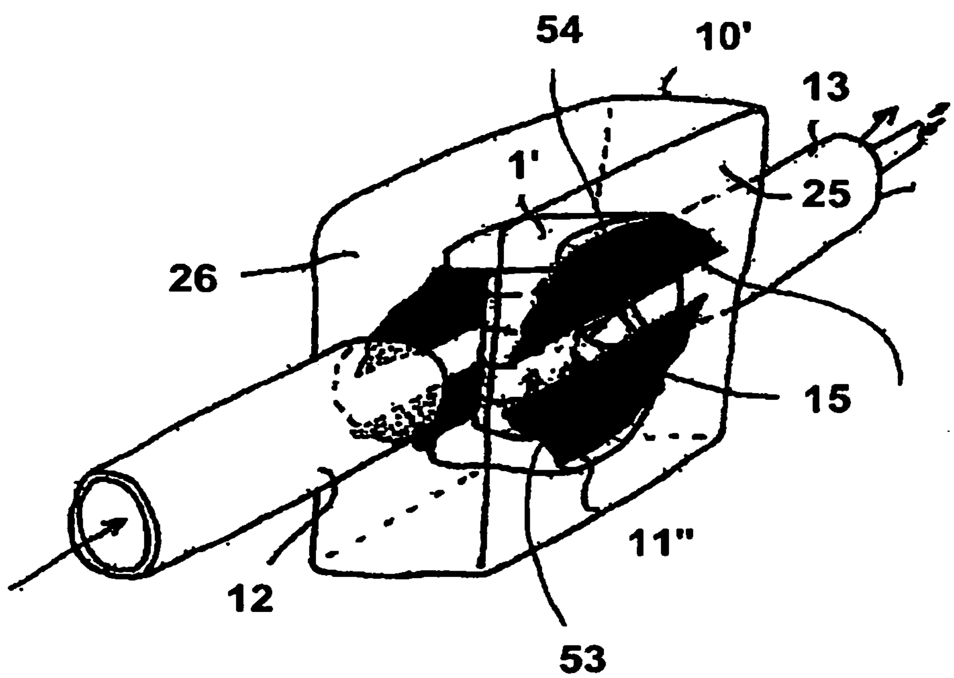
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Fig. 12

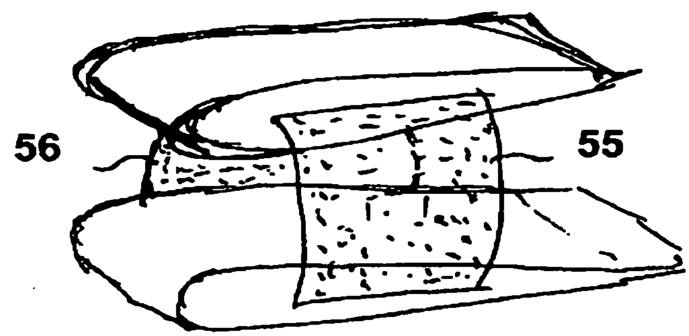

Fig. 13

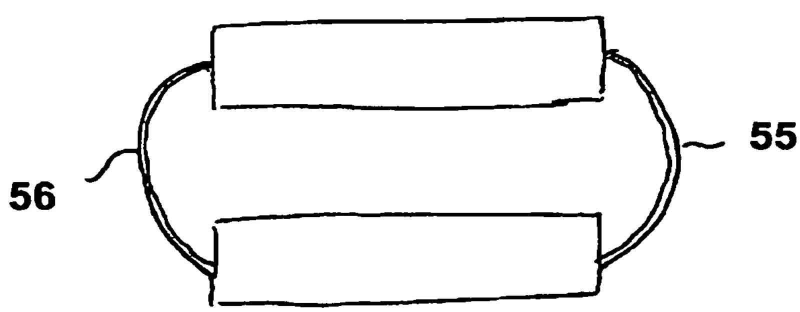

Fig. 14

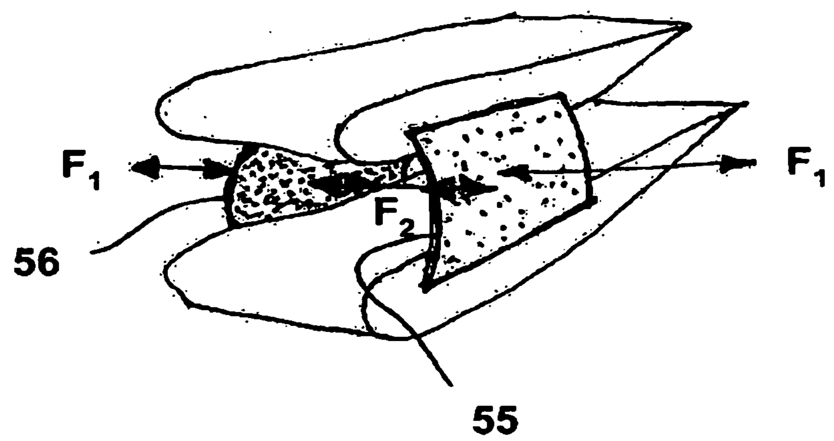

Fig. 15

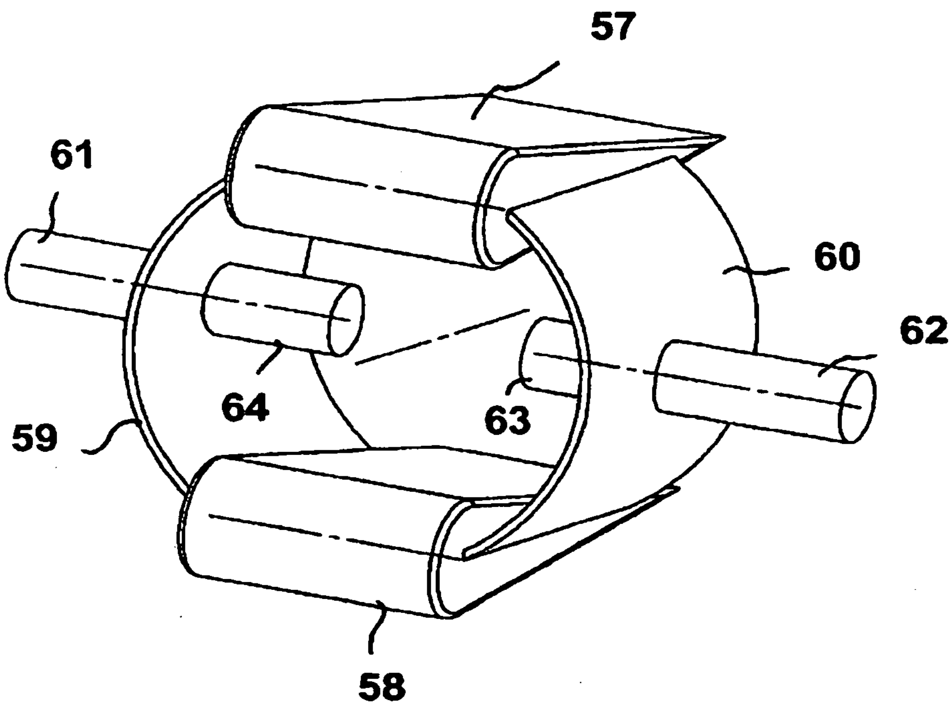

Fig. 16

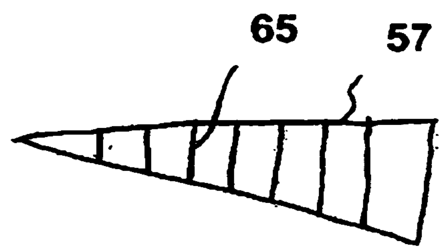

Fig. 17

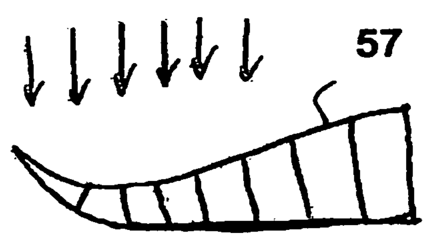

Fig. 18

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March 27, 2014

Robin M. Hagemeyer
(Name)

Robin M. Hagemeyer
(Signature)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: REINER LIEBING	]	Group Art Unit: 3746
Filing Under 35 USC 371 in DO/EO/ US of PCT/EP2011/000439 filed 27 January 2011	]	Examiner: Zollinger, Nathan C.
Serial No. 13/261,361	]	
Filed 10/3/2012	]	
For: CONVEYING DEVICE FOR A FLUID	]	Attorney Docket 1-21942

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL OF CERTIFIED COPY

Honorable Sir:

Attached hereto, please find the certified copy of the foreign application from which priority is claimed for this case:

Country: Europe
Applicant: ECP Entwicklungsgesellschaft mbH
Appl. No.: 10075043.9
Filed: January 27, 2010

Respectfully submitted,

Stephen P. Evans
Registration No. 47,281

ATTORNEYS
Customer Number 00001678
MARSHALL & MELHORN, LLC
Four SeaGate - 8th Floor
Toledo, Ohio 43604
Phone: (419) 249-7138
Fax: (419) 249-7151
Email: evans@marshall-melhorn.com

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: REINER LIEBING	]]	Group Art Unit: 3746
Filing Under 35 USC 371 in DO/EO/ US of PCT/EP2011/000439 filed 27 January 2011	]]]]	Examiner: Zollinger, Nathan C.
Serial No. 13/261,361	]]	
Filed 10/3/2012	]]	
For: CONVEYING DEVICE FOR A FLUID	]]	Attorney Docket 1-21942

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDMENT

Honorable Sir:

I. Introduction

In response to the Office Action mailed on October 21, 2013 in the above-captioned matter, applicant responds as follows. Specification amendments begin on page 2, claim amendments begin on page 3, and remarks begin on page 7.

II. Specification Amendment

Please replace the title with the following title:

CONVEYING DEVICE FOR A FLUID USING AN OSCILLATING BODY ARRANGMENT

III. Claim Amendments

Claims 1-22 (Cancelled).

23. (Currently Amended) A conveying device for the conveying of a fluid in a conveying direction having at least one drive body which can be driven by means of a drive system and which has a conveying surface, said drive body having a thickened upstream end and a tapered downstream, elastically deformable end, wherein the drive body can be driven in an oscillating, fin-like manner transversely to the conveying direction and is flowed around on a plurality of sides by blood ~~the fluid~~ to be conveyed, and wherein the drive body can be compressed together with a housing surrounding it.

24. (Previously Presented) The conveying device in accordance with claim 23, wherein the drive body/bodies can be driven by means of a rotatable shaft.

25. (Currently Amended) ~~The~~ A conveying device for the conveying of a fluid in a conveying direction having at least one drive body which can be driven by means of a drive system and which has a conveying surface, wherein the drive body can be driven in an oscillating manner transversely to the conveying direction, characterized by blocks which are laterally fastened to at least one drive body and which form a barrier between different conveying surfaces of a drive body, said drive body having a thickened upstream end and a tapered downstream, elastically deformable end.

26. (Previously Presented) The conveying device in accordance with claim 25, wherein at least one block is connected either to two drive bodies or to one drive body and a housing of the conveying device.

27. (Previously Presented) The conveying device in accordance with claim 26, wherein a driving force is applied to the drive bodies by means of the blocking body/bodies.

28. (Previously Presented) The conveying device in accordance with claim 23, wherein at least one drive body is pivotable in an oscillating manner about an axis extending transversely to the conveying direction.

29. (Withdrawn) A conveying device for the conveying of a fluid in a conveying direction having at least one drive body which can be driven by means of a drive system and which has a conveying surface, wherein the drive body can be driven in an oscillating manner transversely to the conveying direction, wherein the drive body/bodies is/are pivotable in an oscillating manner about an axis extending in the conveying direction, in particular outside the drive body/bodies.

30. (Previously Presented) The conveying device in accordance with claim 23, wherein at least one conveying surface of at least one drive body is aligned such that a partial force acts on the fluid in the conveying direction on a movement of the drive body.

31. (Previously Presented) The conveying device in accordance with claim 30, wherein two conveying surfaces are aligned such that they effect a conveying of fluid in a respective at least one movement direction of a drive body.

32. (Previously Presented) The conveying device in accordance with claim 23, wherein the at least one drive body tapers in the conveying direction in the cross-section disposed parallel to its movement plane.

33. (Previously Presented) The conveying device in accordance with claim 23, wherein the at least one drive body is configured as stiff.

34. (Previously Presented) The conveying device in accordance with claim 23, wherein the drive body is configured as elastic such that it is bendable in its end region by the fluid counterpressure in operation by at least 5° with respect to the non-deformed state.

35. (Withdrawn) The conveying device in accordance with claim 34, wherein the drive body has microgrooves extending in the conveying direction.

36. (Withdrawn) The conveying device in accordance with claim 23, wherein the at least one drive body has at least one hollow space.

37. (Previously Presented) The conveying device in accordance with claim 23, wherein the at least one drive body comprises a foam.

38. (Previously Presented) The conveying device in accordance with claim 37, wherein the at least one drive body is at least partly inflatable.

39. (Cancelled).

40. (Cancelled).

41. (Previously Presented) The conveying device in accordance with claim 23, wherein the drive body or bodies is/are deformed in operation against the fluid pressure on the respective pressure side.

42. (Previously Presented) The conveying device in accordance with claim 41, wherein the deformation of the pressure side takes place by inner struts of the drive body without any additional external energy supply.

43. (Currently Amended) The conveying device in accordance with claim 23 ~~20~~, wherein the deformation of the pressure side takes place by the so-called fin-ray effect.

44. (Cancelled).

45. (Previously Presented) The conveying device in accordance with claim 37, wherein the at least one drive body comprises polyurethane.

46. (Cancelled).

IV. Remarks

The October 21, 2013 Office Action indicated the withdrawal of claims 35-36 and 29 as being drawn to a nonelected species. Claim 43 was withdrawn by the Examiner since it depended from a cancelled claim. Claim 43 is amended herewith to change it dependency so it is now an active claim.

Applicant thanks the Examiner for the reminder regarding the certified copy of the 10075034.9 application. A certified copy will be submitted in due course.

The drawings were objected to for allegedly failing to show certain means in claims 39-40. Claims 39-40 have been cancelled so the objection is moot.

A new title for the application was required and Applicant thanks the Examiner for the suggested title which is requested to be utilized herewith.

Claim 25 and its dependent claims were objected to because claim 25 should be amended from "The conveying device" to "A conveying device". Claim 25 has been amended as suggested.

Claims 23-28, 30-34 and 41 are rejected under pre-AIA 102(b) as being anticipated by Shafer (US 2,728,298).

The Office Action indicates Shafer teaches that with respect to independent claim 23, the alleged drive body can be compressed together with a housing surrounding it in Shafer's Figs. 3-4 and via the Examiner's note that moving liquid within/around the housing during operation will exert compressive forces on the housing and drive body. Applicant respectfully disagrees.

Applicant respectfully submits that the Office Action, and Shafer, are silent on what the alleged housing might be. More particularly, the Action and the references do not identify the alleged housing with particularity – no reference number in the reference is used to identify the alleged housing, the figure in the reference was not annotated to depict the alleged housing and no portion of the written description of the reference was cited as describing the alleged housing.

For at least these reasons, the Office Action does not properly reject independent claim 23. "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." *Verdegaal Bros. v. Union Oil Co. of California*, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987); The identical invention must be shown in as complete detail as is contained in the ... claim." *Richardson v. Suzuki Motor Co.*, 868 F.2d 1226, 1236, 9 USPQ2d 1913, 1920 (Fed. Cir. 1989).

Independent claim 23 currently requires a drive body that can be compressed with a housing surrounding it. Both the drive body and the housing must be compressed so that both can fit within a person's body. More particularly, the housing and the drive body have to be compressed to fit within a blood vessel so the drive body can pump blood. See, for example, paras. 0002, 0005 and 0015 of applicant's published patent application.

The Shafer reference is silent on its alleged drive body, or its alleged housing, being compressible. In fact, one of the highly related embodiments in Shafer, shown in

Figs. 1 and 2, indicates that the alleged drive bodies are made of spring sheet metal. Spring sheet metal is not compressible the slightest amount unless subjected to extreme pressures and no such pressures are suggested or contemplated by Shafer, or the present invention.

Assuming, arguendo, that Shafer's structure 7 is the claimed compressible housing, there is nothing in Shafer to teach or suggest that structure 7 is compressed. In fact, it would be the opposite. If fluid were located between the two structure 7 walls, which is it required to be for Shafer's structure to work, the fluid would not compress structure 7, but rather it would expand it.

Independent claim 23 has also been amended to indicate that the fluid is blood. Shafer is entirely silent on blood. Further, it is clear by the crude design, dangerous moving parts and gears immersed in the alleged fluid that Shafer is not designed to be a blood conveying device. Applicant's disclosure discusses that blood must be carefully conveyed so that its large and sensitive molecules are not damaged. See, for example, paragraph 0003 of applicant's published application. And, Applicant's claimed blood conveying device accomplishes this goal. Thus, for at least this reason as well, Shafer's disclosure does not teach or suggest Applicant's independent claim 23 as now amended.

Independent claim 25 requires, among other limitations, "blocks which are laterally fastened to at least one drive body and which form a barrier between different conveying surfaces of a drive body…." The Office Action indicates that Shafer teaches blocks "upon 10 and 17". Applicant respectfully disagrees.

Shafer's Fig. 4 clearly shows that structures 10 and 17 are spindles to which the alleged fins (e.g.,8 are attached). The alleged blocks are the structures that attach the fins to the spindles. Fig. 4 shows the alleged blocks centered on each of the spindles, that the spindles extend through the alleged blocks and that the alleged blocks are only approximately double the width of the spindle. Fig. 4 also suggests that the alleged blocks are pivotally attached to the alleged drive bodies, such as through a hinge-type structure.

Based on the above, Shafer clearly does not depict the alleged blocks being laterally fastened to at least one drive body. Instead, Shafer shows the alleged drive bodies trailing behind each of the alleged blocks.

Further, Shafer's alleged blocks do not at all form a barrier between different conveying surfaces of the alleged drive bodies. As seen in Shafer's Figs. 3 and 4, the alleged blocks are centered both horizontally and vertically with the alleged drive bodies, they are only slightly thicker than the alleged drive bodies, and they connect with the alleged drive bodies with an unobtrusive hinge-like connection. Fluid is freely permitted to flow over and around the alleged blocks to any and all surfaces of the alleged drive body. Additionally, Shafer is silent the alleged blocks forming any kind of a barrier against any surface of the any drive body. It is therefore respectfully submitted that Shafer's alleged blocks do not form any barrier between different conveying surfaces of the alleged drive bodies.

Claims 23 and 41-42 are rejected under pre-AIA 35 USC 102(b) as being anticipated by Panthoefer (GB 2041447).

Independent claim 23 now requires, among other limitations, that the drive body has a thickened upstream end and a tapered downstream, elastically deformable end, where the drive body can be driven in an oscillating, fin-like manner, where the drive body is flowed around on a plurality of sides by blood.

The Panthoefer reference is silent on conveying blood. Instead, it indicates that it is used for aquaria (lines 8, 36). For at least this reason, the reference does not teach all the limitations of amended independent claim 23.

The alleged drive body in the reference is indicated at structure 6, 7, 8 in the Office Action. Alleged drive body 6, 7, 8 in the reference does not teach or suggest a thickened upstream end and tapered downstream, elastically deformable end. Instead, structure 6, 7, and 8, if it has an upstream end, is likely adjacent part 7. Part 7 appears in Fig. 1 to be the thinnest component of the alleged drive body 6, 7 and 8. Parts 6 and 8 are near the outlet 4, making them the downstream end. Parts 6 and 8 are clearly thicker than part 7. Thus, the reference does not teach or suggest that its alleged drive body 6, 7, 8 has a thickened upstream end and a tapered downstream end as now required by amended claim 23. In view of the fact that the reference does not teach or suggest all of the limitations of independent claim 23 as amended, it is requested that the rejection be removed.

Claims 23, 38-29, 44 and 46 were rejected under pre-AIA 35 USC 102(b) as being anticipated by Kung (GB 2041447).

Independent claim 23 has been amended to require that it has a drive body with a thickened upstream end and a tapered downstream, elastically deformable end, wherein the drive body can be driven in an oscillating, fin-like manner transversely to the conveying direction, among other limitations.

The Office Action indicates that Kung teaches a drive body at 102 and 104, including structure 122 or the side walls of 102.

Structures 104 or 122 do not drive fluid. Instead, structure 104 is the cannula in the reference. Structure 122 is merely a one way valve (column 6, line 35-37) where its flap is either pushed open or falls closed. There is no teaching or suggestion in the reference that either the cannula or the one way valve, together or separately, drive fluid. Thus, for at least this reason it is respectfully submitted that structures 104 or 122 are not drive bodies.

Independent claim 23 now requires that the drive body be driven in an oscillating, fin-like manner transversely to the conveying direction. None of the alleged drive bodies 102, 104, or 122 oscillate in a fin-like manner. As stated above, structure 104 is simply a cannula and structure 122 is an open/close valve. Structure 102 is taught to inflate and deflate, but the reference is silent on it doing anything other than that; the reference has no teaching or suggestion that that structure 102 oscillates in a fin-like manner.

Additionally, independent claim 23 requires that the alleged drive bodies 102, 104, or 122 move in a fin-like manner transversely to the conveying direction. Applicant respectfully submits that if the reference does not teach or suggest drive bodies moving in a fin like manner, it also does not teach or suggest that fin-like movement being transverse to the conveying direction.

Based on the foregoing, it is respectfully submitted that the amended independent claims and remarks define over the cited art. Since the independent claims are allowable, the claims which depend from them are allowable.

The fee for a one month extension of time is being submitted herewith. No additional fees are believed due with this response. In the event that additional fees are due, please charge them to Deposit Account No. 13-1816. Kindly credit any overpayment to the same account. In either case, please associate P159600-21942001 with any credit or debit of the Deposit Account.

Please do not hesitate to contact the undersigned with any questions.

Respectfully submitted,

Stephen Evans

Stephen P. Evans
Registration No. 47,281

ATTORNEYS
Customer Number 00001678
MARSHALL & MELHORN, LLC
Four SeaGate - 8th Floor
Toledo, Ohio 43604
Phone: (419) 249-7138
Fax: (419) 249-7151
Email: evans@marshall-melhorn.com

Electronic Patent Application Fee Transmittal

Application Number:	13261361
Filing Date:	03-Oct-2012
Title of Invention:	CONVEYING DEVICE FOR A FLUID
First Named Inventor/Applicant Name:	Reiner Liebing
Filer:	Stephen P. Evans
Attorney Docket Number:	1-21942

Filed as Small Entity

U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 1 month with $0 paid	2251	1	100	100

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
	Total in USD ($)			**100**

Electronic Acknowledgement Receipt

EFS ID:	18263205
Application Number:	13261361
International Application Number:	
Confirmation Number:	3522
Title of Invention:	CONVEYING DEVICE FOR A FLUID
First Named Inventor/Applicant Name:	Reiner Liebing
Customer Number:	1678
Filer:	Stephen P. Evans
Filer Authorized By:	
Attorney Docket Number:	1-21942
Receipt Date:	21-FEB-2014
Filing Date:	03-OCT-2012
Time Stamp:	11:43:31
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$100
RAM confirmation Number	8823
Deposit Account	131816
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. 1.492 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Extension of Time	Petition.pdf	112079 00b5c19f0c0eae252623ed6cd76411fb84b74e98	no	1

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2		Amendment.pdf	997267 503b52666cac24c006fd01a51359d9ab92d28303	yes	13

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment/Req. Reconsideration-After Non-Final Reject	1	1
Specification	2	2
Claims	3	6
Specification	7	13

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/AIA/22 (03-13)
Approved for use through 7/31/2016. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)	Docket Number (Optional) 1-21942
Application Number 13/261,361	Filed 10/03/2012
For Conveying Device for a Fluid	
Art Unit 3746	Examiner Zollinger

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above-identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	Fee	Small Entity Fee	Micro Entity Fee	
☑ One month (37 CFR 1.17(a)(1))	$200	$100	$50	$ 100.00
☐ Two months (37 CFR 1.17(a)(2))	$600	$300	$150	$
☐ Three months (37 CFR 1.17(a)(3))	$1,400	$700	$350	$
☐ Four months (37 CFR 1.17(a)(4))	$2,200	$1,100	$550	$
☐ Five months (37 CFR 1.17(a)(5))	$3,000	$1,500	$750	$

☑ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29.
Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☑ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 13-1816.

☑ Payment made via EFS-Web.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 47281.

☐ attorney or agent acting under 37 CFR 1.34. Registration number ______.

/Stephen Evans/	2/21/14
Signature	Date
Stephen Evans	419-249-7100
Typed or printed name	Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.

☐ * Total of 1 forms are submitted.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/261,361	Filing Date 10/03/2012	☐ To be Mailed

ENTITY: ☐ LARGE ☒ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)
02/21/2014	Total (37 CFR 1.16(i))	* 18	Minus	** 24	= 0	x $40 =	0
	Independent (37 CFR 1.16(h))	* 5	Minus	***5	= 0	x $210 =	0
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	**0**

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/PATSY ZIMMERMAN/

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/261,361	10/03/2012	Reiner Liebing	1-21942	3522

1678 7590 10/21/2013
MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

EXAMINER	
ZOLLINGER, NATHAN C	

ART UNIT	PAPER NUMBER
3746	

MAIL DATE	DELIVERY MODE
10/21/2013	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 13/261,361	Applicant(s) LIEBING, REINER	
	Examiner NATHAN ZOLLINGER	Art Unit 3746	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *6/20/13*.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) *23-46* is/are pending in the application.
5a) Of the above claim(s) *29,35,36 and 43* is/are withdrawn from consideration.
6)☐ Claim(s) _____ is/are allowed.
7)☒ Claim(s) *23-28,30-34,37-42,45 and 46* is/are rejected.
8)☐ Claim(s) _____ is/are objected to.
9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☒ The specification is objected to by the Examiner.
11)☒ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☒ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some * c)☒ None of the:
1.☐ Certified copies of the priority documents have been received.
2.☐ Certified copies of the priority documents have been received in Application No. _____.
3.☒ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *20120713*.
3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
4) ☐ Other: _____.

Detailed Action

Election/Restrictions

Claims 35-36 withdrawn from further consideration pursuant to 37 CFR 1.142(b) as being drawn to a nonelected species, there being no allowable generic or linking claim. Claim 29 is also withdrawn as it applies to a nonelected species C. Claim 43 has also been withdrawn as it depends on a cancelled claim. Election was made **without** traverse in the reply filed on June 20, 2013.

Priority

Acknowledgment is made of applicant's claim for foreign priority based on an application filed 1/27/2010. It is noted, however, that applicant has not filed a certified copy of the 10075043.9 application as required by 37 CFR 1.55.

Drawings

The drawings are objected to under 37 CFR 1.83(a). The drawings must show every feature of the invention specified in the claims. Therefore, the hydraulic/pneumatic/electric/magnetic means of claims 39-40 and balloon body of claim 46 for operating the drive body must be shown or the feature(s) canceled from the claim(s). No new matter should be entered.

Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as “amended.” If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either “Replacement Sheet” or “New Sheet” pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Specification

The title of the invention is not descriptive. A new title is required that is clearly indicative of the invention to which the claims are directed.

The following title is suggested: Conveying device for a fluid using an oscillating drive body arrangement.

Claim Objections

Claim 25 and its dependents are objected to because of the following informalities: in claim 25, line 1, the phrase “The conveying device” should be changed to “A conveying device”. Appropriate correction is required.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of pre-AIA 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 23-28, 30-34 and 41 are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Shafer (US 2,728,298).

Claim 23: Shafer discloses a conveying device for the conveying of a fluid in a conveying direction (Figs. 3-4) having at least one drive body (8, 9, 10, etc.) which can be driven by means of a drive system (5/6/13/20/21) and which has a conveying surface (note top/bottom surface of 8, 8, 10, etc.), wherein the drive body can be driven in an oscillating manner transversely to the conveying direction and is flowed around on a plurality of sides by the fluid to be conveyed (Figs. 3-4), and wherein the drive body can be compressed together with a housing surrounding it (Figs. 3-4, Examiner noting that during operation, the moving liquid pressures involved within/around the housing during pump operation will exert compressive forces on the housing and drive body;

alternatively, when the device is submerged in liquid, a slight compressive force will be exerted upon all the submerged components).

Claim 24: Shafer further discloses that the drive body/bodies can be driven by means of a rotatable shaft (Figs. 3-4, Examiner noting any of the shafts for 5, 6, 10, 21).

28. (new) The conveying device in accordance with claim 23, wherein at least one drive body is pivotable in an oscillating manner about an axis extending transversely to the conveying direction.

Claim 25: Shafer discloses a conveying device for the conveying of a fluid in a conveying direction (Figs. 3-4) having at least one drive body (8, 9, 10, etc.) which can be driven by means of a drive system (5/6/13/20/21) and which has a conveying surface (note top/bottom surface of 8, 8, 10, etc.), wherein the drive body can be driven in an oscillating manner transversely to the conveying direction (Figs. 3-4), characterized by blocks (note blocks upon 10 and 17) which are laterally fastened to at least one drive body and which form a barrier between different conveying surfaces of a drive body (Examiner notes that these blocks can act to stop flow from between the two sides of a drive body).

Claim 26: Shafer further discloses that that at least one block is connected either to two drive bodies or to one drive body and a housing of the conveying device (Figs. 3-4).

Claim 27: Shafer further discloses that a driving force is applied to the drive bodies by means of the blocking body/bodies (Figs. 3-4).

<u>Claim 28:</u> Shafer further discloses that at least one drive body is pivotable in an oscillating manner about an axis extending transversely to the conveying direction (Figs. 3-4).

<u>Claim 30:</u> Shafer further discloses that at least one conveying surface of at least one drive body is aligned such that a partial force acts on the fluid in the conveying direction on a movement of the drive body (Figs. 3-4).

<u>Claim 31:</u> Shafer further discloses that two conveying surfaces are aligned such that they effect a conveying of fluid in a respective at least one movement direction of a drive body (Figs.3-4).

<u>Claim 32:</u> Shafer further discloses that the at least one drive body tapers in the conveying direction in the cross-section disposed parallel to its movement plane (Figs. 3-4).

<u>Claim 33:</u> Shafer further discloses that the at least one drive body is configured as stiff (Figs. 3-4, col. 2, line 30).

<u>Claim 34:</u> Shafer further discloses that the drive body is configured as elastic (Figs. 3-4, col. 2, line 30) such that it is bendable in its end region by the fluid counterpressure in operation by at least 5° with respect to the non-deformed state (Examiner notes bended drive bodies in Fig. 3, which exhibit more than a 5° bend).

<u>Claim 41:</u> Shafer further discloses that the drive body or bodies is/are deformed in operation against the fluid pressure on the respective pressure side (Figs. 3-4, Examiner noting this result when a more flexible material is used per col. 2, line 30).

Claims 23, 40 and 44 are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Riepe (US 4,063,826).

Claim 23: Shafer discloses a conveying device for the conveying of a fluid in a conveying direction (Figs. 1-2) having at least one drive body (9) which can be driven by means of a drive system (8/10) and which has a conveying surface (note top/bottom surface of 9), wherein the drive body can be driven in an oscillating manner transversely to the conveying direction and is flowed around on a plurality of sides by the fluid to be conveyed (Figs. 1-2), and wherein the drive body can be compressed together with a housing surrounding it (Figs. 3-4, Examiner noting that during operation, the moving liquid pressures involved within the housing during pump operation will exert compressing forces on the housing and drive body; alternatively, if the device is submerged in liquid, a slight compressive force will be exerted upon all the submerged components).

Claim 40: Shafer further discloses that the drive body can be driven by means of an electric and/or magnetic device (8/10).

Claim 44: Shafer further discloses that the conveying device can convey liquid. While Shafer does not explicitly recite conveying blood; such omission is immaterial since it has been held that the recitation with respect to the matter in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus satisfying the claimed structural limitations. *Ex part Masham*, 2 USPQ2d 1647 (1987).

Claims 23 and 41-42 are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Panthoefer (GB 2041447).

<u>Claim 23:</u> Panthoefer discloses a conveying device for the conveying of a fluid in a conveying direction (Figs.1-2 direction by 4) having at least one drive body (6, 7, 8) which can be driven by means of a drive system (3) and which has a conveying surface (note top/bottom surface of 8), wherein the drive body can be driven in an oscillating manner transversely to the conveying direction and is flowed around on a plurality of sides by the fluid to be conveyed (Figs. 1-2), and wherein the drive body can be compressed together with a housing surrounding it (Figs. 1-2, Examiner noting that during operation, the moving liquid pressures involved within/around the housing during pump operation will exert compressive forces on the housing and drive body; alternatively, when the device is submerged in liquid, a slight compressive force will be exerted upon all the submerged components).

<u>Claim 41:</u> Panthoefer further discloses that the drive body or bodies is/are deformed in operation against the fluid pressure on the respective pressure side (Fig. 1, Examiner noting the deformed direction indicated by 9).

<u>Claim 42:</u> Panthoefer further discloses that the deformation of the pressure side takes place by inner struts (Examiner notes that the spring can be viewed as having different “Strut” portions indicated at 13, 14, 7 and 12 which bears most of the deformation) of the drive body without any additional external energy supply.

Claims 23, 38-39, 44 and 46 are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Kung (GB 2041447).

Claim 23: Kung discloses a conveying device for the conveying of a fluid in a conveying direction (Figs. 1A, 1B) having at least one drive body (Examiner notes elements of 102 and 104, including 122 or side walls of 102) which can be driven by means of a drive system (106) and which has a conveying surface (Examiner notes conveying side wall surfaces of 102 as well as the valve portions 122, which open to allow conveyance of fluid), wherein the drive body can be driven in an oscillating manner transversely to the conveying direction (Examiner notes that the valves and side walls oscillate in a general side to side direction) and is flowed around on a plurality of sides by the fluid to be conveyed (Figs. 1A-1B), and wherein the drive body can be compressed together with a housing surrounding it (Figs. 1A-1B).

Claim 38: Kung further discloses that the at least one drive body is at least partly inflatable (elements of 104/102 are inflatable).

Claim 39: Kung further discloses that the drive body can be driven by means of a hydraulic or pneumatic device (106).

Claim 44: Kung further discloses that the conveying device can convey blood (Title).

Claim 46: Kung further discloses that the at least one drive body can be driven by a balloon body (102).

Claim Rejections - 35 USC § 103

The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 37 and 45 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Kung (GB 2041447) in view of Lichtenstein (US 20060253193).

Claim 37: Kung discloses the limitations of claim 23, discussed previously. Kung discloses using polyurethane for the drive body (col. 7, line 23) but is not explicit about it being a foam. Lichtenstein teaches an expandable body which uses a foam as it provides good elasticity (paragraph 26). It would have been obvious at the time the invention was made to a person having ordinary skill in the art to employ a foam as taught by Lichtenstein into the apparatus of Kung because it will offer good elastic properties for the drive body to inflate/deflate.

Claim 45: Kung and Lichtenstein teach the limitations of claim 37, discussed previously. Kung further discloses that the at least one drive body comprises polyurethane (col. 7, line 23).

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to NATHAN ZOLLINGER whose telephone number is (571)270-7815. The examiner can normally be reached on Monday - Thursday, 9 a.m. - 4 p.m. EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Devon Kramer can be reached on 571-272-7118. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/NATHAN ZOLLINGER/
Examiner, Art Unit 3746

Notice of References Cited	Application/Control No. 13/261,361	Applicant(s)/Patent Under Reexamination LIEBING, REINER	
	Examiner NATHAN ZOLLINGER	Art Unit 3746	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2006/0253193	11-2006	Lichtenstein et al.	623/003.1
*	B	US-2,728,298	12-1955	SHAFER HOMER J	417/343
*	C	US-7,914,436	03-2011	Kung, Robert T. V.	600/18
*	D	US-4,063,826	12-1977	Riepe, Waldemar	417/410.1
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	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N	GB 2041447 A	09-1980	United Kingdom		
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NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
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	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No. 13261361	Applicant(s)/Patent Under Reexamination LIEBING, REINER
	Examiner NATHAN ZOLLINGER	Art Unit 3746

CPC- SEARCHED

Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED

Symbol	Date	Examiner

US CLASSIFICATION SEARCHED

Class	Subclass	Date	Examiner
417	436	10/17/2013	NZ
600	16	10/17/2013	NZ
137	565.01	10/17/2013	NZ

SEARCH NOTES

Search Notes	Date	Examiner
East text, inventor name and forward/backward citation search	10/17/2013	NZ

INTERFERENCE SEARCH

US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

/NATHAN ZOLLINGER/ Examiner.Art Unit 3746	

Receipt date: 07/13/2012

IAP01Rec'd PCT 13 JUL 2012 13261361 - GAU: 3746

PTO/SB/08a (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	13/261361
Filing Date	
First Named Inventor	Reiner LIEBING
Art Unit	
Examiner Name	
Attorney Docket Number	1-21942

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US- 2011/0034874 A1	02-10-2011	Reitan et al	
		US- 2011/0236210 A1	09-29-2011	McBride et al	
		US- 2011/0275884 A1	11-10-2011	Scheckel	
		US- 2011/0282128 A1	11-17-2011	Reitan et al	
		US- 5,820,542 B1	10-13-1998	Dobak, III et al	
		US- 6,544,216 B1	04-08-2003	Sammler et al	
		US- 6,860,713 B2	03-01-2005	Hoover	
		US- 7,393,181 B2	07-01-2008	McBride et al	
		US- 7,874,882 B2	01-25-2011	Sagov	
		US- 7,927,068 B2	04-19-2011	McBride et al	
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FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] -Number[4] -Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
		DE 103 37 804 A1	03-24-2005	Franzke		
		FR 1 218 663 A	05-12-1960	Kuettner		
		EP 2 194 278 A1	06-09-2010	Scheckel		
		WO 98/18508 A1	05-07-1998	Dobak et al		
		WO 2005/003545 A1	01-13-2005	Robinson		
		WO 2006/038808 A1	04-13-2006	Sagov		

Examiner Signature	/Nathan Zollinger/	Date Considered	10/18/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6]Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /N.Z./

Receipt date: 07/13/2012

13261361 - GAU: 3746

IAP01Rec'd PCT 13 JUL 2012

PTO/SB/08a (07-09)

Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 2 of 2

Complete if Known	
Application Number	13/261361
Filing Date	
First Named Inventor	Reiner LIEBING
Art Unit	
Examiner Name	
Attorney Docket Number	1-21942

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
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FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] -Number[4] -Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
		WO 2009/157840 A1	12-30-2009	Reitan et al		

Examiner Signature	/Nathan Zollinger/	Date Considered	10/18/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3]Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4]For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6]Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /N.Z./

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BIB DATA SHEET

CONFIRMATION NO. 3522

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/261,361	10/03/2012 **RULE**	417	3746	1-21942

APPLICANTS
Reiner Liebing, Potsdam, GERMANY;

** **CONTINUING DATA** *************************
This application is a 371 of PCT/EP2011/000439 01/27/2011
which claims benefit of 61/298,581 01/27/2010

** **FOREIGN APPLICATIONS** *************************
EUROPEAN PATENT OFFICE (EPO) 10075043.9 01/27/2010

** **IF REQUIRED, FOREIGN FILING LICENSE GRANTED** ** ** SMALL ENTITY **
10/11/2012

		STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☑ Yes ☐ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /NATHAN C ZOLLINGER/ Examiner's Signature	☐ Met after Allowance Initials	GERMANY	10	24	3

ADDRESS
MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604
UNITED STATES

TITLE
CONVEYING DEVICE FOR A FLUID

FILING FEE RECEIVED		
745	FEES: Authority has been given in Paper No.____________ to charge/credit DEPOSIT ACCOUNT No.____________ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ________________ ☐ Credit

(12) UK Patent Application (19) GB (11) 2 041 447 A

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F1C 1D
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None
(58) Field of search
F1C
(71) Applicant
Tetra Werke Dr Rer Nat Ulrich Baensch GmbH
Herrenteich
4520 Melle
Federal Republic of Germany
(72) Inventor
Rudolf Panthoefer
(74) Agents
Potts Kerr & Co

(54) Oscillating armature pump for liquids

(57) The pump has a housing defining a pump cavity 1 having alternating current operating coils mounted laterally of the cavity on block 3. The oscillating armature 6 is mounted on a plate spring 7 which is secured to the pump housing, and the armature is also provided with a resiliently flexible plate 8 for executing the pumping movement.

The plate spring 7 is substantially 'U' or Omega-shape so that it takes up the minimum space, and also provides a favourable transition between the active oscillating end 11 of the spring plate and the static end 13 of the spring plate 7 secured to the housing.

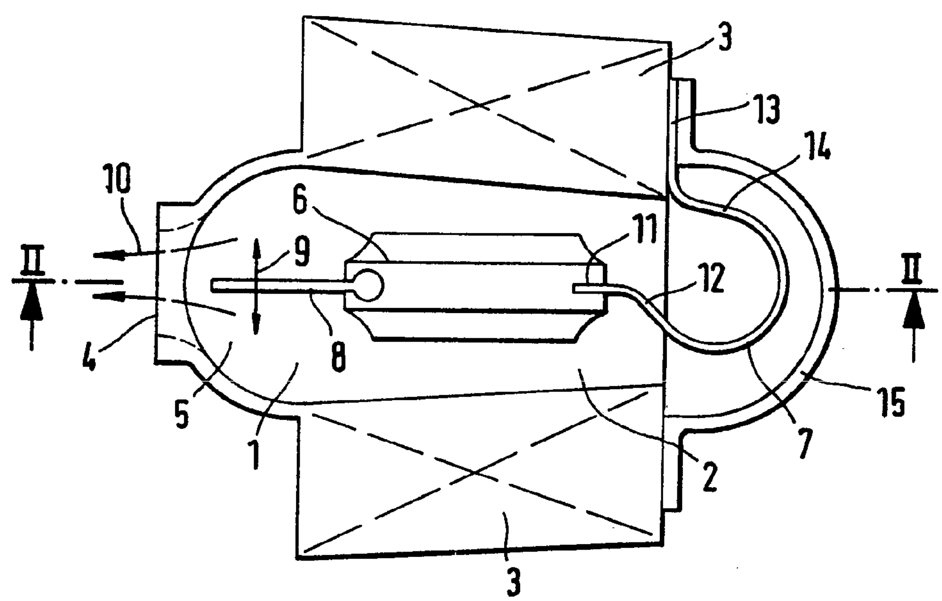

FIG. 1

The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

GB 2 041 447 A

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1/1

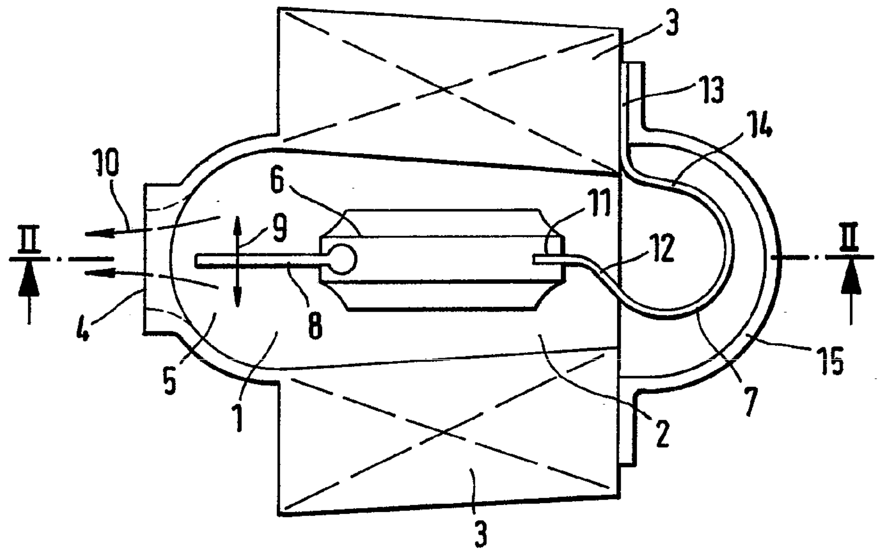
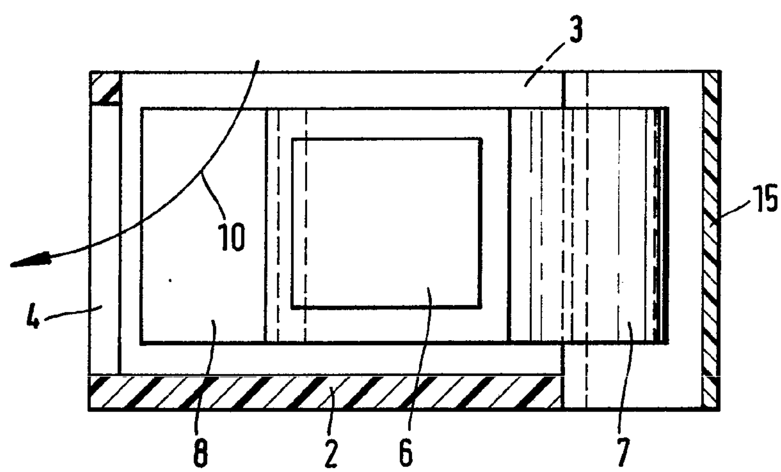


FIG. 1

FIG. 2



SPECIFICATION

Oscillating armature pump

The present invention relates to an oscillating armature pump operated by alternating current, more especially a circulating pump for aquaria, in which the armature is secured to a plate spring which is provided with a thin plate made of rubber or rubber-like plastics material and which for carrying out the pumping movement is reciprocatable in the manner of a fishtail.

In known pumps of this kind, an elongate plate spring is provided in the form of a flat plate which is clamped at one end and at its free end supports the armature. Since, in these springs, a high specific continuous loadability is required, a predetermined minimum cross-sectional dimension is required. As a result of this, however, the rigidity of the spring can be obtained only by varying the length of the spring if the amplitude and hence that of the said plate is to be increased. Such a step, however, in small pumps causes difficulties.

The object of the invention is based on increasing the active length of the plate spring without having to substantially modify the dimensions of the pump housing. At the same time the aim is to obtain a simplified clamping of the plate spring on the pump housing.

According to the present invention there is provided an oscillating armature pump operated with alternating current, more especially a circulating pump for aquaria, in which an armature is secured to a plate spring, the armature being provided with a resiliently flexible thin plate, which, for carrying out a pumping movement, is reciprocated in the manner of a fishtail, wherein the plate spring is substantially U-shaped. It is also possible to provide a fishhook shape or omega-shape.

In these embodiments one end of the plate spring is connected to the pump housing and the other end is connected to the armature, which in known manner may be produced by clamping, screwing thereon or the like. For the purpose of improved securing the shanks may also be provided with small bends, if for securing reasons this leads to a simplification.

The present invention will be described further, by way of example, with reference to the accompanying drawings in which:

Figure 1 shows a plan view of a circulating pump for aquaria; and

Figure 2 shows a section taken on the line II–II of Fig. 1.

The pump housing is a plastics material body having a pump cavity 1 defined by a rigid base plate 2 and by side blocks 3, which are used to receive, preferably moulded-in, alternating current coils (not shown in detail). At the front end of the pump cavity 1 there is the outlet 4 at the end of a taper or constriction 5. The pump housing is open at its upper side.

Between the two blocks 3, or the alternating current coils located there, an armature 6 is arranged, which is secured to a plate spring 7 of steel or the like, and at its front end the armature supports a thin rubber plate 8.

This rubber plate 8 is reciprocated in the manner of a fishtail in accordance with the double arrow 9, in order so to draw in aquarium water via the open top side of the pump housing and to eject it through the outlet 4, (see arrows 10). It is, however, also possible for a proportion of the inflow to occur also via the rear end of the pump cavity 1.

The plate spring 7 is arcuate, and thus substantially U-shaped, with one end 11 of one shank 12 secured to the armature 6 and one end 13 of the other shank 14 secured to one of the blocks 3. Whilst the end 11 is retained by clamping in a slot in the armature 6, the end 13 is preferably secured to the block 3 by screwing or riveting. The rear end of the pump cavity 1 may also be provided with a yoke 15, the ends of which are also connected to the blocks 3, to provide a rear closure of the pump cavity 1.

The pre-shaped plate spring 7 not only permits a predetermined spring characteristic in the narrowest space to be obtained, but moreover, from a strength point of view, provides a favourable transition between the active, oscillating part of the plate spring 7 and the securing point or the part of the plate spring 7 (end 13), which is constantly at rest. Thus, a substantial increase of service life of the dynamically highly-stressed plate spring 7 is attained. Furthermore, the mounting of the clamped plate spring end is simplified. The said shaping of the plate spring 7 provides end portions of this spring (ends 11, 13) which assume right angles relative to one another.

CLAIMS

1. An oscillating armature pump operated with alternating current, more especially a circulating pump for aquaria, in which an armature is secured to a plate spring, the armature being provided with a resiliently flexible thin plate, which, for carrying out a pumping movement, is reciprocated in the manner of a fishtail, wherein the plate spring is substantially U-shaped.

2. A pump according to claim 1, in which the plate spring is substantially omega-shaped.

3. A pump according to claim 1, in which the plate spring is substantially shaped in the manner of a fishhook.

4. A pump according to claim 1, in which the shanks of the plate spring or the ends thereof extend at least at right angles to one another.

5. A pump according to claim 1, in which

one end of the plate spring is secured to the rear end face of the pump housing, which extends substantially at right angles to the longitudinal extension of the armature of the thin plate supported thereby.

6. A pump according to claim 1, in which the plate spring projects arcuately to the rear beyond the pump housing.

7. A pump according to claim 1, in which the pump cavity hollow space towards the rear is closed by a yoke enclosing the plate spring.

8. A pump according to claims 1 and 7, in which an end of the yoke and an end of the plate spring are mutually secured to the pump housing.

9. A pump as claimed in any preceding claim in which the resiliently flexible thin plate is made of rubber or rubber-like plastics material.

10. An oscillating armature pump for liquids substantially as herein described with reference to and as illustrated in the accompanying drawings.

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Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L3	1706	(600/16).CCLS.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/10/17 11:25
L4	55	L3 and foam	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2013/10/17 11:25
L5	33	US-2121942-$.DID. OR US-6860713-$.DID. OR US-7393181-$.DID. OR US-7927068-$.DID. OR WO-9818508-$.DID. OR US-5820542-$.DID. OR WO-2009157840-$.DID. OR EP-2194278-$.DID. OR US-1218663-$.DID. OR DE-10337804-$.DID. OR WO-20061038808-$.DID. OR US-7874882-$.DID. OR WO-20051003545-$.DID. OR EP-2353262-$.DID. OR US-3121942-$.DID. OR US-1219422-$.DID. OR WO-2006038808-$.DID. OR WO-2005003545-$.DID. OR US-6544216-$.DID. OR US-1800786-$.DID.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2013/10/17 11:36
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L10	13	"2041447"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2013/10/17 12:49
L11	8	((REINER) near2 (LIEBING)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2013/10/17 12:51
L12	0	(137/565/01).CCLS.	US-PGPUB; USPAT; USOCR;	OR	OFF	2013/10/17 12:53

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S3	3	((REINER) near2 (LIEBING)).INV.	EPO; JPO; DERWENT	OR	ON	2013/10/09 08:25
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S14	53	("3902365" | "4144790" | "4178526" | "4205267" | "4472654" | "4498851" | "4697116").PN. OR ("4780062").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2013/10/09 09:34
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S19	5	("2152243").URPN.	USPAT	OR	ON	2013/10/09 09:51
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S22	675	(axial near flow) and pump and blood not impeller	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2013/10/16 21:29
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10/17/2013 1:01:29 PM
C:\Users\nzollinger\Documents\EAST\Workspaces\13261361.wsp

Index of Claims

Application/Control No.	Applicant(s)/Patent Under Reexamination
13261361	LIEBING, REINER
Examiner	**Art Unit**
NATHAN ZOLLINGER	3746

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	05/29/2013	10/17/2013							
	22	÷	✓							
	23	÷	✓							
	24	÷	✓							
	25	÷	✓							
	26	÷	✓							
	27	÷	✓							
	28	÷	✓							
	29	÷	N							
	30	÷	✓							
	31	÷	✓							
	32	÷	✓							
	33	÷	✓							
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	36	÷	N							
	37	÷	✓							
	38	÷	✓							
	39	÷	✓							
	40	÷	✓							
	41	÷	✓							
	42	÷	✓							
	43	÷	N							
	44	÷	✓							
	45	÷	✓							
	46	÷	✓							

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: REINER LIEBING	]	Group Art Unit: 3746
Filing Under 35 USC 371 in DO/EO/ US of PCT/EP2011/000439 filed 27 January 2011	]	Examiner: Zollinger, Nathan C.
Serial No. 13/261,361	]	
Filed 10/3/2012	]	
For: CONVEYING DEVICE FOR A FLUID	]	Attorney Docket 1-21942

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

RESPONSE TO ELECTION REQUIREMENT

Honorable Sir:

In response to the Office Action dated May 30, 2013, it is respectfully requested that the following remarks be considered in the above-captioned application. Claims 22-46 are pending in the application and these claims are subject to restriction.

The Examiner indicated that the application contains claims directed to the following patentably distinct species:

Species A1: Figs. 1-6, 11, 17-18

Species A2: Figs. 1-6, 13-15, 17-18

Species A3: Figs. 1-6, 16, 17-18

Species B1: Figs. 7, 12, 17-18

Species B2: Figs. 7, 13-15, 17-18

Species B3: Figs 7, 16, 17-18

Species C: Fig. 8

Species D: Figs. 9-10

The Examiner indicated that Applicant is required under 37 CFR 1.475 et al to elect a single species for prosecution on the merits to which the claims shall be restricted if no generic claim is finally held to be allowable. The Examiner indicated that currently no claim is generic. The Examiner also required Applicant to identify the claims encompassing the elected species.

Applicant elects without traverse Species A1 drawn to Figs. 1-6, 11, 17-18. The claims which read on the elected species comprise 23-34, and 37-46. Applicant has made the above election to comply with 37 CFR 1.475 et al for the sole purpose of prosecution on the merits. Applicant's election should not be construed in any way to limit the scope or spirit of any of the embodiments of the present invention disclosed in the application. Applicant reserves the right to file any divisional or continuation application as necessary on any nonelected species.

No fees are believed due with this response. In the event that additional fees are due, please charge them to Deposit Account No. 13-1816. Kindly credit any overpayment to the same account. In either case, please associate P159600-21942001 with any credit or debit of the Deposit Account.

Please do not hesitate to contact the undersigned with any questions.

Respectfully submitted,

Stephen P. Evans
Registration No. 47,281

ATTORNEYS
Customer Number 00001678
MARSHALL & MELHORN, LLC
Four SeaGate - 8th Floor
Toledo, Ohio 43604

Phone: (419) 249-7138
Fax: (419) 249-7151
Email: evans@marshall-melhorn.com

Electronic Acknowledgement Receipt

EFS ID:	16093690
Application Number:	13261361
International Application Number:	
Confirmation Number:	3522
Title of Invention:	CONVEYING DEVICE FOR A FLUID
First Named Inventor/Applicant Name:	Reiner Liebing
Customer Number:	1678
Filer:	Stephen P. Evans
Filer Authorized By:	
Attorney Docket Number:	1-21942
Receipt Date:	20-JUN-2013
Filing Date:	03-OCT-2012
Time Stamp:	12:02:38
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Response to Election / Restriction Filed	USPTOElectionResponse.pdf	175426 c070699940fc8fa2a46a090f2732b9cf1eb08401	no	3

Warnings:

Information:

Total Files Size (in bytes):	175426

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/261,361	10/03/2012	Reiner Liebing	1-21942	3522

1678 7590 05/30/2013
MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

EXAMINER	
ZOLLINGER, NATHAN C	
ART UNIT	**PAPER NUMBER**
3746	

MAIL DATE	DELIVERY MODE
05/30/2013	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 13/261,361	Applicant(s) LIEBING, REINER	
	Examiner NATHAN ZOLLINGER	**Art Unit** 3746	**AIA (First Inventor to File) Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *1* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) *22-46* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☐ Claim(s) _____ is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☒ Claim(s) *22-46* are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some * c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Interim copies:

a)☐ All b)☐ Some c)☐ None of the: Interim copies of the priority documents have been received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

Detailed Action

Election/Restrictions

This application contains claims directed to more than one species of the generic invention. These species are deemed to lack unity of invention because they are not so linked as to form a single general inventive concept under PCT Rule 13.1.

The species are as follows:

Species A1: Figures 1-6, 11, 17-18

Species A2: Figures 1-6, 13-15, 17-18

Species A3: Figures 1-6, 16, 17-18

Species B1: Figures 7, 12, 17-18

Species B2: Figures 7, 13-15, 17-18

Species B3: Figures 7, 16, 17-18

Species C: Figure 8

Species D: Figures 9-10

Applicant is required, in reply to this action, to elect a single species to which the claims shall be restricted if no generic claim is finally held to be allowable. The reply must also identify the claims readable on the elected species, including any claims subsequently added. An argument that a claim is allowable or that all claims are generic is considered non-responsive unless accompanied by an election.

Upon the allowance of a generic claim, applicant will be entitled to consideration of claims to additional species which are written in dependent form or otherwise require all the limitations of an allowed generic claim. Currently, none of the claim(s) are generic.

REQUIREMENT FOR UNITY OF INVENTION

As provided in 37 CFR 1.475(a), a national stage application shall relate to one invention only or to a group of inventions so linked as to form a single general inventive concept (“requirement of unity of invention”). Where a group of inventions is claimed in a national stage application, the requirement of unity of invention shall be fulfilled only when there is a technical relationship among those inventions involving one or more of the same or corresponding special technical features. The expression “special technical features” shall mean those technical features that define a contribution which each of the claimed inventions, considered as a whole, makes over the prior art.

The determination whether a group of inventions is so linked as to form a single general inventive concept shall be made without regard to whether the inventions are claimed in separate claims or as alternatives within a single claim. See 37 CFR 1.475(e).

WHEN CLAIMS ARE DIRECTED TO MULTIPLE CATEGORIES OF INVENTIONS

As provided in 37 CFR 1.475(b), a national stage application containing claims to different categories of invention will be considered to have unity of invention if the claims are drawn only to one of the following combinations of categories:

(1) A product and a process specially adapted for the manufacture of said product; or

(2) A product and process of use of said product; or

(3) A product, a process specially adapted for the manufacture of the said product, and a use of the said product; or

(4) A process and an apparatus or means specifically designed for carrying out the said process; or

(5) A product, a process specially adapted for the manufacture of the said product, and an apparatus or means specifically designed for carrying out the said process.

Otherwise, unity of invention might not be present. See 37 CFR 1.475(c).

Applicant is advised that the reply to this requirement to be complete must include (i) an election of a species or a grouping of patentably indistinct species to be examined even though the requirement may be traversed (37 CFR 1.143) and (ii) identification of the claims encompassing the elected species or grouping of patentably indistinct species, including any claims subsequently added. An argument that a claim is allowable or that all claims are generic is considered nonresponsive unless accompanied by an election.

The election may be made with or without traverse. To preserve a right to petition, the election must be made with traverse. If the reply does not distinctly and specifically point out supposed errors in the election of species requirement, the election shall be treated as an election without traverse. Traversal must be presented at the time of election in order to be considered timely. Failure to timely traverse the requirement will result in the loss of right to petition under 37 CFR 1.144. If claims are added after the election, applicant must indicate which of these claims are readable on the elected species or grouping of patentably indistinct species.

Should applicant traverse on the ground that the species, or groupings of patentably indistinct species from which election is required, are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing them to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the species unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C. 103(a) of the other species.

Upon the allowance of a generic claim, applicant will be entitled to consideration of claims to additional species which depend from or otherwise require all the limitations of an allowable generic claim as provided by 37 CFR 1.141.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to NATHAN ZOLLINGER whose telephone number is (571)270-7815. The examiner can normally be reached on Monday - Thursday, 9 a.m. - 4 p.m. EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Devon Kramer can be reached on 571-272-7118. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/NATHAN ZOLLINGER/
Examiner, Art Unit 3746

Index of Claims

Application/Control No.	Applicant(s)/Patent Under Reexamination
13261361	LIEBING, REINER
Examiner	**Art Unit**
NATHAN ZOLLINGER	3746

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	05/29/2013								
	22	÷								
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/261,361	10/03/2012	Reiner Liebing	1-21942

CONFIRMATION NO. 3522

PUBLICATION NOTICE

OC000000058841108

1678
MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

Title:CONVEYING DEVICE FOR A FLUID

Publication No.US-2013-0019968-A1
Publication Date:01/24/2013

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

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U.S. APPLICATION NUMBER NO.	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
13/261,361	Reiner Liebing	1-21942

1678
MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

INTERNATIONAL APPLICATION NO.	
PCT/EP2011/000439	
I.A. FILING DATE	PRIORITY DATE
01/27/2011	01/27/2010

CONFIRMATION NO. 3522
371 ACCEPTANCE LETTER

OC000000057015780

Date Mailed: 10/12/2012

NOTICE OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C 371 AND 37 CFR 1.495

The applicant is hereby advised that the United States Patent and Trademark Office in its capacity as a Designated / Elected Office (37 CFR 1.495), has determined that the above identified international application has met the requirements of 35 U.S.C. 371, and is ACCEPTED for national patentability examination in the United States Patent and Trademark Office.

The United States Application Number assigned to the application is shown above and the relevant dates are:

10/03/2012	10/03/2012
DATE OF RECEIPT OF 35 U.S.C. 371(c)(1), (c)(2) and (c)(4) REQUIREMENTS	DATE OF COMPLETION OF ALL 35 U.S.C. 371 REQUIREMENTS

A Filing Receipt (PTO-103X) will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE " FILING DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371 (c)(1), (c)(2) and (c)(4) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN ABOVE.** *The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363).* Once the Filing Receipt has been received, send all correspondence to the Group Art Unit designated thereon.

The following items have been received:

- Indication of Small Entity Status
- Copy of the International Application filed on 07/13/2012
- Copy of the International Search Report filed on 07/13/2012
- Copy of IPE Report filed on 07/13/2012
- Preliminary Amendments filed on 07/13/2012
- Information Disclosure Statements filed on 07/13/2012
- Oath or Declaration filed on 10/03/2012
- Request for Immediate Examination filed on 07/13/2012
- U.S. Basic National Fees filed on 07/13/2012
- Specification filed on 07/13/2012
- Claims filed on 07/13/2012
- Abstracts filed on 07/13/2012
- Drawings filed on 07/13/2012

FORM PCT/DO/EO/903 (371 Acceptance Notice)

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

RODERICK M JONES

Telephone: (571) 272-9083

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/261,361	10/03/2012		745	1-21942	24	3

CONFIRMATION NO. 3522

1678
MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

FILING RECEIPT

OC000000057015779

Date Mailed: 10/12/2012

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Reiner Liebing, Potsdam, GERMANY;

Applicant(s)

Reiner Liebing, Potsdam, GERMANY;

Assignment For Published Patent Application

ECP ENTWICKLUNGSEGESELLSCHAFT MBH, BERLIN, GERMANY

Power of Attorney:

D Dolgorukov--26266
Donald Schurr--34247
Mark Hixon--44766
Stephen Evans--47281
Kristene Ragan--48611
Stephen Kimmet--52488
Mark Hamilton--56903
Jeanette Kuhn--66111

Domestic Priority data as claimed by applicant

This application is a 371 of PCT/EP2011/000439 01/27/2011
which claims benefit of 61/298,581 01/27/2010

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
EUROPEAN PATENT OFFICE (EPO) 10075043.9 01/27/2010

If Required, Foreign Filing License Granted: 10/11/2012

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/261,361**

Projected Publication Date: 01/24/2013

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

CONVEYING DEVICE FOR A FLUID

Preliminary Class

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

PATENT APPLICATION FEE DETERMINATION RECORD
Substitute for Form PTO-875

Application or Docket Number
13/261,361

APPLICATION AS FILED - PART I

FOR	NUMBER FILED (Column 1)		NUMBER EXTRA (Column 2)	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A		N/A	N/A	195		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A		N/A	N/A	250		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A		N/A	N/A	125		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	24	minus 20 =	* 4	x 31 =	124	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3	minus 3 =	*	x 125 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					0.00			
				TOTAL	694		TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED - PART II

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

IAP03Rec'd PCT 03 OCT 2012

PTO-1390 (09-11)
Approved for use through ... 0651-0021
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371	ATTORNEY'S DOCKET NUMBER 1-21942 U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 13/261,361
INTERNATIONAL APPLICATION NO. PCT/EP2011/000439 / INTERNATIONAL FILING DATE 27 January 2011 (27.01.2011)	PRIORITY DATE CLAIMED 27 January 2010 (27.01.2010)

TITLE OF INVENTION
CONVEYING DEVICE FOR A FLUID

APPLICANT(S) FOR DO/EO/US
Reiner LIEBING

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☐ This is a **FIRST** submission of items concerning a submission under 35 U.S.C. 371.
2. ☑ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a submission under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected (Article 31).
5. ☐ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☑ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A preliminary amendment.
14. ☐ An Application Data Sheet under 37 CFR 1.76.
15. ☐ A substitute specification.
16. ☑ A power of attorney and/or change of address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.3 and 37 CFR 1.821- 1.825.
18. ☐ A second copy of the published International Application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
13/261,361	PCT/EP2011/000439	1-21942

20. Other items or information:
Express mail certificate; return card; Response to Notification of Missing Requirements under 35 USC 371 w/copy of 371 Formalities Letter; and pursuant to 37 CFR 1.78(a)(5)(iv) copies of the "Response to Letter re Non-English Language Application Papers in a Provisional Application", Verification Statement for Translation and English translation of Provisional Application No. 61/298,581 which were filed in prior-filed provisional application.

The following fees have been submitted	CALCULATIONS	PTO USE ONLY
21. ☐ Basic national fee (37 CFR 1.492(a)) $380	$ -	
22. ☐ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) .... $0 All other situations $250	$ -	
23. ☐ Search fee (37 CFR 1.492(b)) If the written opinion of the ISA/US or the International preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) .... $0 Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority .... $120 International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB .... $490 All other situations $620	$ -	
TOTAL OF 21, 22 and 23 =	-	
☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)). The fee is **$310** for each additional 50 sheets of paper or fraction thereof.		

Total Sheets	Extra Sheets	Number of each additional 50 or fraction thereof (round **up** to a whole number)	RATE	CALCULATIONS
- 100 =	/50 =		x $310	$ -

	CALCULATIONS	PTO USE ONLY
Surcharge of **$130.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).	$ 130	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	- 20 =		x $ 60	$-	
Independent claims	- 3 =		x $250	$-	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $450	$ -	
TOTAL OF ABOVE CALCULATIONS =				$130	
☑ Applicant claims small entity status. See 37 CFR 1.27. Fees above are reduced by ½.				65	
SUBTOTAL =				$ 65	
Processing fee of **$130.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). +				$ -	
TOTAL NATIONAL FEE =				$ 65	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ -	
TOTAL FEES ENCLOSED =				$ 65	
				Amount to be refunded:	$
				Amount to be charged	$

10/05/2012 LLANDGRA 00000012 13261361
01 FC:2617 65.00 OP

a. ☑ A check in the amount of $ 65.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. ________ in the amount of $ ________ to cover the above fees.

c. ☑ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 13-1816.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038. The PTO-2038 should only be mailed or faxed to the USPTO. However, when paying the basic national fee, the PTO-2038 may NOT be faxed to the USPTO.

ADVISORY: If filing by EFS-Web, do **NOT** attach the PTO-2038 form as a PDF along with your EFS-Web submission. Please be advised that this is **not** recommended and by doing so your **credit card information may be displayed via PAIR**. To protect your information, it is recommended paying fees online by using the electronic payment method.

NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

SEND ALL CORRESPONDENCE TO:

Customer Number 00001678
Marshall & Melhorn, LLC
Four SeaGate - 8th Floor
Toledo, Ohio 43604

Phone: 419-249-7138
Fax: 419-249-7151

Stephen Evans
SIGNATURE

Stephen P. Evans
NAME

47,281
REGISTRATION NUMBER

COPY

PTO-1390 (09-11)
Approved for use through 4/30/2013. OMB 0651-0021
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371		ATTORNEY'S DOCKET NUMBER 1-21942 U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 13/261,361
INTERNATIONAL APPLICATION NO. PCT/EP2011/000439	INTERNATIONAL FILING DATE 27 January 2011 (27.01.2011)	PRIORITY DATE CLAIMED 27 January 2010 (27.01.2010)
TITLE OF INVENTION CONVEYING DEVICE FOR A FLUID		
APPLICANT(S) FOR DO/EO/US Reiner LIEBING		

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☐ This is a **FIRST** submission of items concerning a submission under 35 U.S.C. 371.
2. ☑ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a submission under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected (Article 31).
5. ☐ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   - a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   - b. ☐ has been communicated by the International Bureau.
   - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   - a. ☐ is attached hereto.
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7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   - b. ☐ have been communicated by the International Bureau.
   - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
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8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☑ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
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Items 11 to 20 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A preliminary amendment.
14. ☐ An Application Data Sheet under 37 CFR 1.76.
15. ☐ A substitute specification.
16. ☑ A power of attorney and/or change of address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.3 and 37 CFR 1.821- 1.825.
18. ☐ A second copy of the published International Application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

COPY

PTO-1390 (09-11)
Approved for use through 4/30/2013. OMB 0651-0021
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
13/261,361	PCT/EP2011/000439	1-21942

20. Other items or information:
Express mail certificate; return card; Response to Notification of Missing Requirements under 35 USC 371 w/copy of 371 Formalities Letter; and pursuant to 37 CFR 1.78(a)(5)(iv) copies of the "Response to Letter re Non-English Language Application Papers in a Provisional Application", Verification Statement for Translation and English translation of Provisional Application No. 61/298,581 which were filed in prior-filed provisional application.

The following fees have been submitted	CALCULATIONS	PTO USE ONLY
21. ☐ Basic national fee (37 CFR 1.492(a))........ $380	$ -	
22. ☐ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4)........ $0 All other situations........ $250	$ -	
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TOTAL OF 21, 22 and 23 =	-	
☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)). The fee is **$310** for each additional 50 sheets of paper or fraction thereof.		

Total Sheets	Extra Sheets	Number of each additional 50 or fraction thereof (round **up** to a whole number)	RATE	
- 100 =	/50 =		x **$310**	$ -

Surcharge of **$130.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).	$ 130	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	- 20 =		x $ **60**	$-	
Independent claims	- 3 =		x **$250**	$-	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$450**	$ -	
			TOTAL OF ABOVE CALCULATIONS =	$130	
☑ Applicant claims small entity status. See 37 CFR 1.27. Fees above are reduced by ½.				65	
			SUBTOTAL =	$ 65	

Processing fee of **$130.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). +	$ -	
TOTAL NATIONAL FEE =	$ 65	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +	$ -	
TOTAL FEES ENCLOSED =	$ 65	
	Amount to be refunded:	$
	Amount to be charged	$

a. ☑ A check in the amount of $ 65.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. __________ in the amount of $ __________ to cover the above fees.

c. ☑ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 13-1816.

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NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

SEND ALL CORRESPONDENCE TO:

Customer Number 00001678
Marshall & Melhorn, LLC
Four SeaGate - 8th Floor
Toledo, Ohio 43604

Phone: 419-249-7138
Fax: 419-249-7151

Stephen Evans
SIGNATURE

Stephen P. Evans
NAME

47,281
REGISTRATION NUMBER

CERTIFICATE UNDER 37 CFR 1.10 OF MAILING BY "EXPRESS MAIL"

"Express Mail" Label Number EM 476467105 US

Date of Deposit October 3, 2012

I hereby certify that this correspondence is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Kathleen J. Moore

Signature of person mailing correspondence

Kathleen J. Moore

Typed name of person mailing correspondence

RESPONSE TO NOTIFICATION OF MISSING REQUIREMENTS UNDER 35 USC 371

Application No. 13/261,361

International Appln. No. PCT/EP2011/000439 filed 27 January 2011

Earliest Claimed Priority: 27 January 2010 (27.01.2010)

Title: CONVEYING DEVICE FOR A FLUID

Inventor: Reiner LIEBING

Assignee: ECP Entwicklungsgesellshaft mbH

Attorneys: Marshall & Melhorn, LLC
Customer Number 00001678

Attorney Docket No: 1-21942

Enclosures

Transmittal Letter PTO-1390 Concerning Submission under 35 USC 371 (3 pgs) with copy of same (3 pgs)

Response to Notification of Missing Requirements under 35 USC 371 (2 pgs) with copy of the 371 Formalities Letter (2 pgs)

Executed Combined Declaration and Power of Attorney Document (2 pgs)

Copy of the Response to Letter re Non-English Language Application Papers in the prior-filed provisional application, Verification Statement for Translation of Provisional Application and English translation of prior-filed Provisional Application No. 61/298,581 pursuant to 37 CFR 1.78(a)(5)(iv) (38 pgs)

Check

"Express Mail" Label Number EM 576467105US

I hereby certify that this correspondence is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on October 3, 2012 and is addressed to Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Kathleen J. Moore
(Signature of person mailing correspondence)
Kathleen J. Moore
(Typed name of person mailing correspondence)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: REINER LIEBING	Group Art Unit:
Application No. 13/261,361 Filing Under 35 USC 371 in DO/EO/ US of PCT/EP2011/000439 filed 27 January 2011	Examiner:
For: CONVEYING DEVICE FOR A FLUID	Attorney Docket 1-21942

October 3, 2012

Mail Stop PCT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

RESPONSE TO NOTIFICATION OF MISSING REQUIREMENTS UNDER 35 USC 371

Honorable Sir:

In response to the "Notification of Missing Requirements Under 35 U.S.C. 371 in the United States Designated/Elected Office (DO/EO/US)" dated August 7, 2012, (copy attached), enclosed is the fully executed Combined Declaration and Power of Attorney document to complete the requirements for acceptance under 35 USC 371, in the above-captioned application.

Also enclosed, pursuant to 37 CFR 1.78(a)(5)(iv), are copies of the "Response to Letter re Non-English Language Application Papers in a Provisional Application", the "Verification Statement for Translation U.S. Provisional Patent Application 61/298,581", and the English translation of U.S. Provisional Application No. 61/298,581, priority of which is claimed, confirming that the English translation and verified statement of translation were filed in the U.S. Patent and Trademark Office in the prior-filed provisional application on October 2, 2012.

A check in the amount of $65.00 is enclosed to cover the surcharge for late filing of the executed Declaration for small entity.

Please charge any additional fees due or credit any overpayment to Deposit Account No. 13-1816.

Respectfully submitted,

Stephen P. Evans

Stephen P. Evans
Registration No. 47,281

ATTORNEYS
Customer Number 00001678
MARSHALL & MELHORN, LLC
Four SeaGate - 8th Floor
Toledo, Ohio 43604

Phone: (419) 249-7138
Fax: (419) 249-7151
Email: evans@marshall-melhorn.com

1-21942

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

U.S. APPLICATION NUMBER NO.	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
13/261,361	Reiner Liebing	1-21942

1678
MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

INTERNATIONAL APPLICATION NO.	
PCT/EP2011/000439	
I.A. FILING DATE	PRIORITY DATE
01/27/2011	01/27/2010

CONFIRMATION NO. 3522
371 FORMALITIES LETTER

OC000000055802373

Date Mailed: 08/07/2012

NOTIFICATION OF MISSING REQUIREMENTS UNDER 35 U.S.C. 371 IN THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)

The following items have been submitted by the applicant or the IB to the United States Patent and Trademark Office as an Elected Office (37 CFR 1.495):

- Indication of Small Entity Status
- Priority Document
- Copy of the International Application filed on 07/13/2012
- Copy of the International Search Report filed on 07/13/2012
- Copy of IPE Report filed on 07/13/2012
- Preliminary Amendments filed on 07/13/2012
- Information Disclosure Statements filed on 07/13/2012
- Oath or Declaration filed on 07/13/2012
- Request for Immediate Examination filed on 07/13/2012
- U.S. Basic National Fees filed on 07/13/2012
- Specification filed on 07/13/2012
- Claims filed on 07/13/2012
- Abstracts filed on 07/13/2012
- Drawings filed on 07/13/2012

The applicant needs to satisfy supplemental fees problems indicated below.

The following items **MUST** be furnished within the period set forth below in order to complete the requirements for acceptance under 35 U.S.C. 371:

- Oath or declaration of the inventors, in compliance with 37 CFR 1.497(a) and (b), identifying the application by the International application number and international filing date. The current oath or declaration does not comply with 37 CFR 1.497(a) and (b) in that it:
  - is not executed in accordance with either 37 CFR 1.66 or 37 CFR 1.68.
- To avoid abandonment, a surcharge (for late submission of filing fee, search fee, examination fee or oath or declaration) as set forth in 37 CFR 1.492(h) of $65 for a small entity in compliance with 37 CFR 1.27, must be submitted with the missing items identified in this letter.

SUMMARY OF FEES DUE:

Total additional fees required for this application is **$65** for a Small Entity:
- **$65** Surcharge.

RECEIVED
AUG 10 2012

FORM PCT/DO/EO/905 (371 Formalities Notice)

ALL OF THE ITEMS SET FORTH ABOVE MUST BE SUBMITTED WITHIN TWO (2) MONTHS FROM THE DATE OF THIS NOTICE OR BY 32 MONTHS FROM THE PRIORITY DATE FOR THE APPLICATION, WHICHEVER IS LATER. FAILURE TO PROPERLY RESPOND WILL RESULT IN ABANDONMENT.

The time period set above may be extended by filing a petition and fee for extension of time under the provisions of 37 CFR 1.136(a).

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web.
https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at **1-866-217-9197** or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

RODERICK M JONES

Telephone: (571) 272-9083

Docket No. 1-21942

COMBINED DECLARATION AND POWER OF ATTORNEY IN ORIGINAL APPLICATION (CONCERNING A FILING UNDER 35 USC 371)

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name,

I believe that I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled ____ CONVEYING DEVICE FOR A FLUID ____

the specification of which

_X_ is a filing under 35 USC 371 of PCT International Application No. PCT/EP2011/000439 filed 27 January 2011 (27.01.2011); and

____ is attached hereto;

_X_ was filed on July 13, 2012 under 35 USC 371, assigned U.S. Application Number 13/261,361 and was amended on July 13, 2012 .

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information, which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56,

_X_ and which is material to the examination of this application, namely, information where there is a substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent;

____ if this is a continuation-in-part application, information that occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application, in accordance with 37 CFR 1.63(e);

_X_ in compliance with this duty, there is attached an information disclosure statement, in accordance with 37 CFR 1.98.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-art applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent, inventor's or plant breeder's certificate(s), or any PCT international application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application

(Number)	(Country)	(Day/Month/Year Filed)	Priority Claimed Yes	No
10 075 043.9	Europe	27 January 2010	X	

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith with full power of substitution and revocation: Stephen P. Evans, Reg. No. 47,281; Donald A. Schurr, Reg. No. 34,247; Mark A. Hixon, Reg. No. 44,766; Mark M. Hamilton, Reg. No. 56,903; D. Edward Dolgorukov, Reg. No. 26,266; Stephen G. Kimmet, Reg. No. 52,488; Kristene M. Ragan, Reg. No. 48,611; and Jeanette M. Kuhn, Reg. No. 66,111. Address all telephone calls to Stephen P. Evans at telephone number 419-249-7138. Address all correspondence to Customer Number 001678: MARSHALL & MELHORN, LLC, Four Seagate - 8th Floor, Toledo, Ohio 43604, Attention: Stephen P. Evans.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor Reiner LIEBING

Inventor's signature [signature] Date 2012 09 21

Residence Schmiedegasse 43, 14469 Potsdam, Germany

Citizenship Germany Post Office Address Same as above

Certificate of Mailing under 37 CFR 1.8
I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on October 2, 2012.

Kathleen J. Moore
Signature

Kathleen J. Moore
Typed or printed name of person signing Certificate

COPY

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: REINER LIEBING	Group Art Unit:
Application No. 61/298,581 Filed January 27, 2010	Examiner:
For: CONVEYING DEVICE FOR A FLUID	Attorney Docket 1-21942

October 2, 2012

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

RESPONSE TO LETTER RE NON-ENGLISH LANGUAGE APPLICATION PAPERS IN A PROVISIONAL APPLICATION

Honorable Sir:

In response to the "Letter re Non-English Language Application Papers in a Provisional Application" dated March 2, 2010, and pursuant to 37 CFR 1.78(a)(5)(iv), enclosed is a "Verification Statement for Translation U.S. Provisional Patent Application No. 61/298,581" along with the English translation of U.S. Provisional Application No. 61/298,581.

Any additional fees due should be charged to Deposit Account No. 13-1816.

Respectfully submitted,

Stephen Evans

Stephen P. Evans
Registration No. 47,281

ATTORNEYS
Customer Number 00001678
MARSHALL & MELHORN, LLC
Four SeaGate - 8th Floor
Toledo, Ohio 43604
Phone: (419) 249-7138
Fax: (419) 249-7151

VERIFICATION STATEMENT FOR TRANSLATION

U.S. Provisional Patent Application 61/298,581

I, Dr. Stefan Golkowsky, of Joachimstaler Strasse 12, D-10719 Berlin, Germany, do hereby certify that I am conversant with the German and English languages and that I am the translator of the document attached hereto and certify that to the best of my knowledge and belief the following is a true and correct English translation of the U.S. provisional patent application No. 61/298,581 filed on January 27, 2010.

Signed this 20 day of September, 2012

Dr. Stefan Golkowsky

61/298,581
ECP Entwicklungsgesellschaft mbH
097P 1780 / ECP 20 US

Conveying device for a fluid

The invention is in the field of mechanical engineering and relates to conveying devices for fluids, in particular for liquids.

Such conveying devices have become known in the form of different kinds of pumps in the most varied of embodiments. Pumps are of particular interest at this point which can be manufactured in such constructions that they can be used for more sensitive fluids, in particular fluids having macromolecules. A specific group among such pumps is represented by the fluid pumps which can be used for medical application purposes and which can be manufactured in small constructions. Such pumps can also be used in micro constructions, for example, for conveying the body's own fluids, or biocompatible fluids, for example as heart pumps for conveying blood.

In the conveying of such sensitive fluids such as blood which have large and sensitive molecules, for example, which satisfy biological functions and which therefore also may not be damaged at the microscopic level, care must be taken that the mechanical effect on the fluid by pressure maxima, shear forces and accelerations is limited as much as possible.

Axial flow pumps have in particular become known in this connection, for example, for the conveying of blood which have a rotor which rotates about a longitudinal axis, which has impeller blades and which continuously conveys blood in the axial direction.

Since a specific problem for the use of such pumps in the inside of the body comprises the fact of providing them, on the one hand, with sufficient conveying capacity, and, on the other hand, however, of configuring the construction size so that they can be introduced through a blood vessel, some of the challenges for such pumps comprise the fact of configuring them from a construction aspect so that they are radially compressible and expandable again for operation in the body.

A compressible rotor of this kind is known, for example, from US 6,860,713. Another rotor is known from US 7,393,181 B2. In the known solutions, the rotors are compressible and expandable either due to the elasticity and deformability of the material or on the basis of mechanically movable constructions.

It is unavoidable in this respect that a certain construction effort is exerted to ensure the compressibility of such a pump despite a

corresponding reliability and conveying capacity. It must moreover be ensured that large shear forces which can damage sensitive fluids do not arise due to too high a rotational speed of the rotor or due to unfavorable geometrical shapes of impeller blades. In addition, care must be taken that pressure differences within the geometry of such a conveying device, on the one hand, and over the course of time, on the other hand, are kept within tight limits.

Under these conditions and against the background of the prior art, it is the underlying object of the present invention to provide a conveying device which can be manufactured with means which are simple from a construction aspect and which reliably and gently allow the conveying of a fluid.

The object is achieved in accordance with the invention by the features of claim 1.

The conveying device in accordance with the invention, which serves to move a fluid in a conveying direction, for this purpose has a drive body which can be driven by means of a drive system and which can be driven in an oscillating manner transversely to the conveying direction.

The drive body is arranged in a channel or in a space in which the fluid should be conveyed in a preset conveying direction.

Known conveying mechanisms such as centrifugal pumps or the above-named axial flow pumps make use of rotating conveying elements for moving or accelerating a fluid. The likewise known piston pumps respectively have at least one piston which is substantially movable in translation and which conveys the medium in its direction of movement on its movement.

In contrast to this, in accordance with the present invention, the drive body is moved transversely to the conveying direction in the manner of a fin of a fish which is used in nature as a rule to generate a relative movement between the fin and a fluid. In the present invention, the fin-like element, the drive body, is in this respect substantially fixed in the conveying direction so that the relative movement results in a conveying movement of the fluid.

The movement of the drive body transversely to the conveying direction in this respect, for example, means that at least one part of the drive body is moved in translation or along a less curved path substantially perpendicular to the conveying direction and/or associated with a pivot movement about an axis which is substantially perpendicular to the conveying direction. In this respect, the deviation of the direction of extent of the axis to the perpendicular of the conveying direction should amount to a maximum of 45°. In this respect, movement patterns of fin-like bodies in fish and other creatures known from bionics should be reproduced.

The corresponding drive bodies can be adapted in shape and size to the available space. The relative movement of the drive body or of different parts of said drive body with respect to the fluid to be driven can be kept in a range with respect to the speed which prevents the creation of unpermitted shear forces. In this respect, the relative speed is to be coordinated with the viscosity of the medium to be conveyed and accordingly with possibly present compressibilities. The conveying principle described can be used particularly efficiently with substantially non-compressible and slightly liquid media such as blood. Corresponding drive movements can also be transmitted easily to a drive body to be moved in an oscillating manner. A rotatable journalling of a rotor does not necessarily have to be provided.

Since a certain periodicity of pressure fluctuations is to be expected due to the oscillatory movement of the drive body, with an occasional reversal of the flow direction not always being able to be precluded on such pressure fluctuations, the arrangement of a control valve for the flow to be generated in the conveying channel or in the space in which the drive body is located can also advantageously be considered. In this respect, the valve can either be controlled by an intelligent control synchronously with the movement of the drive body or it can be configured as an automatically acting check valve.

The conveying surface or a conveying surface of the drive body is advantageously aligned so that a partial force acts on the fluid in the conveying direction on a movement of the drive body. For this purpose, the direction of movement of the drive body and the direction of extent of the surfaces of the drive body at which a pressure increase arises are to be correspondingly coordinated with one another.

In this connection, at least two conveying surfaces can be provided, for example at a single drive body, which are aligned so that they each effect a conveying of the fluid in at least one of the directions of movement of the drive body. A conveying of the fluid in both drive movement directions or in a plurality of drive movement directions thus becomes possible.

Provision can moreover advantageously be made that at least one drive body tapers in the conveying direction in the cross-section disposed parallel to its movement plane.

The drive body can, for example, be configured in the manner of a fin as a wedge-shaped body whose thickened end is arranged upstream with respect to the flow to be produced and whose tapered end is arranged downstream. The tapered end can converge acutely in the form of a blade edge, with the blade edge being able to extend perpendicular to the drive direction of the drive body. The drive body can also be widened toward its tapered end in the direction of extent of the cutting blade.

The conveying surfaces at both sides of such a wedge-shaped fin body can be either planar or convex or concave, viewed in the direction perpendicular to the drive direction of the drive body.

The drive body can be stiff in one type of embodiment of the invention. In this case, the drive body can be pivotable about an axis which lies in the region of its thickened end. In addition, a superimposed movement in translation of the thickened end can be provided, for example in a straight manner or along a gate path. The movement portion in translation takes place in the same plane as the pivot movement in this respect.

Alternatively to this, provision can also be made that the drive body is so elastic that it can also be bent in operation in its end region by the fluid counterpressure by at least 5°, in particular also by at least 20°, with respect to the undistorted state.

The drive can in this case be configured in the same manner as with a stiff drive body, but the alignment of the conveying surfaces relative to the fluid to be conveyed in the respective phase of the drive movement can already be optimized and thus the efficiency of the drive increased by the elasticity and deformability of the drive body per se.

Such a drive body, whether stiff or elastic, can either be configured as symmetrically wedge-shaped, with planar, concave or convex conveying surfaces in the cross-section viewed perpendicular to the plane of the drive movement or a shape asymmetrical in the named cross-section can also be provided, for example with elements of an airfoil wing, to utilize additional flow effects. Such an airfoil section, for example, provides a convex shape on one side of the drive body and a convex or straight shape of the conveying surface on the opposite side.

On the use of such an asymmetrical design of a drive body, a further drive body can additionally be provided which is shaped and arranged in mirror form with respect to the first drive body and which is movably in synchronization with it in the same or opposite sense.

Provision can moreover be made to increase the efficiency of the drive that the drive body, in particular in the region of a conveying surface, has optimized surface structures.

In an advantageous embodiment of the invention, provision can moreover be made that the drive body has at least one hollow space. The provision of a hollow space reduces the mass of the drive body and thus the energy to be expended for its acceleration. In addition, the drive body can be configured as at least partially inflatable so that its outer dimensions in the non-inflated state can be smaller than in the inflated state. Such a drive body can then be brought more easily to its deployment site in the non-inflated state and inflated to the operating dimensions there. This is in particular advantageous when the conveying device should be manufactured in very small dimensions and moved within blood vessels.

The drive body can moreover advantageously comprise a foam, in particular polyurethane. The drive body can thus be manufactured as elastically deformable and as very light.

Provision can be made in the conveying device in accordance with the invention by providing a corresponding drive system that the drive body can be driven by means of a hydraulic or pneumatic device, in particular by means of a balloon body, but also by means of an electric and/or magnetic device.

Although one or more drive bodies in accordance with the invention can be moved simply by means of levers or similar mechanical devices, the drive movement can particularly easily be conducted to the conveying device by a hydraulic or pneumatic drive device. Corresponding pneumatic or hydraulic lines can be laid, for example, in the form of a hollow catheter or also within a hollow catheter, at the distal end of which the conveying device is provided, and can either act directly on a piston, bellows or balloon-like drive body in the region of the conveying device or can be converted into a lever movement there.

Possible drive movements of the drive body or bodies in this respect provide that at least one drive body is pivotable in an oscillating manner about an axis extending transversely to the conveying direction; and/or that one or more drive bodies are pivotable in an oscillating manner about an axis extending in the conveying direction, in particular outside the conveying bodies.

It is special about such an oscillatory movement that the pivot movement has a relatively small stroke so that a full rotation of the drive body does not take place in any case.

A rotation about larger angles can, however, also be provided on the rotation about an axis extending in the conveying direction.

To reduce unwanted pressure compensation procedures at the drive bodies, blocking bodies can be arranged on them between their conveying surfaces. Said blocking bodies should be flexible and can in this respect be configured as pliable or stiff, but bendable. The blocking bodies can also connect two respective blocking bodies to one another or one blocking body to a housing wall.

The described fin-like drive principle for fluids is novel in connection with the conveying of liquids and thus allows the realization of conveying characteristics which cannot be achieved with the already known conveying devices.

The invention will be shown and subsequently described in the following with reference to an embodiment in a drawing.
There are shown in

Fig. 1 a drive body in three positions in cross-section;

Fig. 2 a conveying system for fluids having two drive bodies in a longitudinal section;

Fig. 3 a conveying system having two drive bodies in a three-dimensional view;

Fig. 4 two drive bodies in a first position with a drive system;

Fig. 5 the drive bodies from Fig. 4 in a second position;

Fig. 6 the drive bodies from Figs. 4 and 5 in a third position;

Fig. 7 a drive system in a three-dimensional representation having a conveying space quadrangular in cross-section;

Fig. 8 two drive bodies which are rotated in an oscillating manner about an axis extending in the conveying direction;

Fig. 9 a drive system in a three-dimensional view having two partly cylindrical drive bodies;

Fig. 10 a section through the drive system of Fig. 9;

Fig. 11 an embodiment as in Fig. 3 with additional blocking bodies;

Fig. 12 an embodiment similar to that of Fig. 7 with blocking bodies;

Fig. 13 a representation of two drive bodies which are connected by means of blocking bodies;

Fig. 14 the embodiment of Fig. 13 in a front view;

Fig. 15 a view of the embodiment of Fig. 13, with the effect of a driving force on the blocking bodies being indicated;

Fig. 16 an arrangement in which the blocking bodies have a stiff, but bendable ring-strip shape;

Fig. 17 a drive body having fin-rays in the neutral state; and

Fig. 18 a drive body as in Fig. 17 in the loaded state.

Fig. 1 shows in the middle part a drive body 1 in section which substantially has a wedge shape which is modeled on the shape of a fin occurring in biology. The drive body 1 extends perpendicular to the plane of the drawing with an unchanging section, but can also widen perpendicular to the plane of the drawing toward its tapered end.

The drive body 1 can be moved in an oscillating manner along the dotted line 2 in the directions indicated by the arrows 3, 4. The region about the point of attack of the driving force is in this respect shown as a circle and is marked by 5. The driving force engages at this point such that the drive body is moved substantially in translation along the line 2 and is thus not pivotable in a first variant to avoid an active fluid counterpressure.

A fluid counterpressure then results in operation, for example on the movement of the drive body within a liquid, on the side of the respectively acting conveying surface 6, 7, said fluid counterpressure resulting in a deformation of the end 8 of the drive body 1 remote from the drive, i.e. the tapered end, when this drive body is configured as elastic as in the example shown. A particularly efficient advance of the driven fluid in the conveying direction 9 results by this effect.

Alternatively, the drive of the drive body 1 can also be configured so that it is not driven strictly in translation in the sense of the directions 3, 4, but rather in a superimposed movement in translation and in a pivot movement. In this respect, for example simultaneously with the movement in the direction of the arrow 3, a pivoting of the drive body takes place about the point of attack 5 clockwise about a specific angle, for example 10°, so that the drive body inclines at the end of the movement in a similar manner as under the effect of a fluid counter-pressure. Optionally, the direction of rotation of the pivot movement can be reversed at the end of the movement in translation to beat with the fin. This driving principle can be combined both with stiff drive bodies and with flexible drive bodies.

A specific lever drive or a gate drive of the drive body can be provided for this purpose or it is conceivable to transmit the driving forces by means of a hydraulic or pneumatic apparatus.

Fig. 2 shows in a side view a housing 10 in which a conveying device in accordance with the invention having two drive bodies 1, 11 is arranged. The housing 10 is set up rotationally symmetrically or elliptically in cross-section about the drive bodies 1, 11 and has an inflow channel 12 as well as an outflow channel 13. A fluid line 14 which is part of the drive system and which is connected to a drive bellows 15 projects through the outflow channel 13. The drive bellows 15 can be connected via a pressure control device, not shown, via the fluid line 14 to an overpressure or to an underpressure so that said drive bellows can be inflated or deflated by the inflow of a fluid or the removal of the fluid.

One respective drive body 1, 11 is fastened to the two ends 15a, 15b of the drive bellows 15 and runs through a drive movement in the direction of the arrows 3, 4 by the volume changes of the drive bellows. The drive movement in translation of the drive bellows 15 can be translated into a more complex movement path of the drive bodies 1, 11, which can correspond to a superimposition of the movement in translation with a pivot movement, by a corresponding elastic configuration of the drive bellows 15 or by additional levers which connect the bellows to the drive bodies 1, 11 or the drive bodies to a fixed point of the housing 10.

Provision can, however, also be made that the movement of the drive bodies 1, 11 substantially takes place in translation and said drive bodies are configured as elastic to carry out the elastically fin-like overall movement shown with reference to Fig. 1.

If the pressure in the drive bellows 15 is changed periodically via the control of the fluid pressure in the fluid line 14, for example several times per second, this is translated into an oscillatory movement of the drive bodies 1, 11. This results in an acceleration of the fluid located in the housing 10 in the direction of the arrow 16 which designates the conveying direction of the fluid. Since pressure fluctuations occur due to the periodicity of the movement, it may be meaningful to provide a check valve 17 in the inflow channel 12 which blocks the inflow channel 12 for the case that an overpressure arises within the housing 10 in front of the valve and closes it again as soon as an underpressure is generated there.

The fluid line 14 can be configured as a flexible hose line provided that the drive bellows 15 is held otherwise in the housing 10. The drive line 14 can, however, also be configured as a rigid line in the form of a pipe in order simultaneously to conduct the fluid and to fix the drive bellows and the drive bodies 1, 11. The fluid line 14 can in every case be held and fixed in a holding star 18 or at a holding arm within the outflow channel 13.

In the Figure, three positions are shown for each drive body 1, 11, with a middle neutral position being shown by solid lines and the extreme positions on the movement path of each individual drive body 1, 11 being shown by broken lines.

Fig. 3 shows a similar arrangement to Fig. 2, but in a three-dimensional view, with a second holding star 19 being provided in addition to the first holding star 18 in direct vicinity of the drive bellows 15 and of the drive bodies 1, 11.

Arrows 20, 21 and 20', 21' are drawn in which indicate the directions of movement of the respective thickened ends of the drive bodies 1, 11 as are arrows 22, 23 and 22', 23' which indicate the movement of the tapered ends of the drive bodies 1, 11. The different lengths of the arrows shown should indicate that the thickened ends of the drive bodies 1, 11 facing the one-way valve 17 carry out a pivot movement whose amplitude is substantially larger than the movement of the tapered ends of the drive bodies. This is made possible, as will be shown in more detail with reference to Figs. 4, 5 and 6, by a special construction of the drive bellows 15.

Fig. 4 shows in a side view in the upper part the two drive bodies 1, 11 as well as the drive bellows 15 in the deflated, i.e. compressed, form. The arrow 24 indicates that an underpressure is present in the fluid line 14 in this state to compress the drive bellows 15.

The drive bellows 15 itself has an asymmetrical structure, as can be seen more clearly from the lower part of Fig. 4. A cross-section through the drive bellows 15 along the dashed line A is shown there which makes clear that the drive bellows has a smaller wall thickness in its region facing the one-way valve 17 than in the outflow channel 13.

It is thereby achieved that the movement amplitude is larger in the front region facing the inflow channel 12 than in the rear region of the drive bellows facing the outflow channel 13. A pivot movement of the drive bodies 1, 11 therefore results on a pressure change in the drive bellows 15.

In Fig. 5, the arrangement of Fig. 4 with the drive bodies 1, 11 and a drive bellows 15 inflated further with respect to Fig. 4 is shown. The drive bodies are approximately in the straight position shown in Fig. 2.

Fig. 6 finally shows the state of the drive bodies 1, 11 in the fully inflated state of the drive bellows 15, with it also becoming clear that the thickened ends of the drive bodies 1, 11 have passed through a larger movement amplitude than the tapered ends so that a pivot movement of the drive bodies has taken place in addition to a movement in translation.

Fig. 7 shows in a three-dimensional view from a different perspective two drive bodies 1', 11' which are configured as asymmetrical in the manner of an aerodynamic airfoil section, but which may additionally also be configured as flexible and which can be driven by means of a drive bellows 15. The inflow channel 12 is shown in the foreground of the figure, the outflow channel 13 in the background. In contrast to the cylindrical housing 10 of the arrangement shown in Fig. 3, the housing 10' shown in

Fig. 7 has a parallelepiped structure with a rectangular cross-section to implement the non-cylindrically symmetrical structure of the drive arrangement and of the drive bodies as efficiently as possible. Unlike the specific representation of Fig. 7, the transition from the housing 10' to the inflow and outflow channels 12, 13 can take place with conical or oblique transitions. Provision can advantageously be made that the drive bodies 1', 11' extend perpendicular to the plane of the drive movement up to as close as possible to the side walls 25, 26 of the housing 10'. Turbulence at the side surfaces of the drive bodies 1', 11' is thereby reduced.

The drive bodies 1', 11' can, just like the drive bodies 1, 11 shown further above, comprise a foam, in particular polyurethane, and can be inflatable. For this purpose, the bodies can have large and/or a plurality of small hollow spaces which can, for example, be inflated by the drive fluid via the fluid line 14 and which have check valves to be stabilized in the inflated state.

A good compressibility in the non-inflated state is hereby made possible so that the drive bodies can be radially compressed for transport to a deployment site together with the housing 10, 10' and can be expanded on site before they are put into operation.

Fig. 8 shows an arrangement in comparison with the Figures described further above having two drive bodies 1", 11" with another drive principle in which the drive bodies are connected via connection webs 28, 29 to a drive shaft 27 which extends in the conveying direction 30.

The drive shaft 27 can be rotated in an oscillating manner about the conveying direction 30, and indeed in each case, for example, at least by an amount of 5°, 10° or at least by 20° or 30°, in each direction, as indicated by the arrows 33, 34.

The longitudinal axes of the drive bodies 1" and 11" are aligned parallel to the shaft and undergo a movement quasi in translation in the peripheral direction of the shaft in the directions which are indicated by the arrows 31, 32 within the framework of this rotary movement, provided that the length of the connection webs 28, 29 is sufficient. In this manner, a corresponding approximately linear movement in translation of the drive bodies can be realized in a very simple manner by means of the drive shaft 27. In Figure 8, a plurality of parallel microgrooves 41 are also shown by way of example at the lower drive body 11".

In Fig. 9, an arrangement is shown in a three-dimensional view which is as largely cylindrically symmetrical as possible of two drive bodies 1''' and 11''' which are connected by a drive bellows 15' and which can be moved substantially in the direction of the arrows 35, 36 in the radial direction with respect to the cylinder axis. The drive bellows 15' is connected to a pressure generation system by means of a fluid line 14. It is also conceivable to divide the cylindrically symmetrical arrangement into a higher number of cylinder segments, for example 4 or 8 or more and to move them radially in each case, with a movement pattern resulting which is similar to the manner of propagation of jellyfish.

A section through the arrangement of Fig. 9 is shown in Fig. 10 which makes the function clear. The drive body 1''' is shown by way of example with a hollow space 37, the drive body 11''' with a hollow space 38, with the hollow spaces only being indicated schematically.

Fluid is exchanged via the fluid line 14 with the interior of the drive bellows 15 and is pumped from there into the hollow spaces 37, 38, with the hollow spaces 37, 38 of the drive bodies 1''' and 11''' being connected to the hollow space of the drive bellows 15' by means of one-way valves 39, 40 so that the drive bodies are only inflated once and then thereafter maintain the increased fluid pressure to be stabilized in shape. Only the interior of the drive bellows 15' is inflated and deflated thereafter. The drive bodies 1''', 11''' thereby alternately move apart in the direction of the arrows 35, 36 and move together in the opposite direction, whereby a corresponding drive movement is realized.

The efficiency of the conveying device with respect to the non-cylindrically symmetrical arrangements which are shown in the aforesaid Figures is increased by the cylindrically symmetrical or approximately cylindrically symmetrical arrangement of the drive bodies.

Fig. 11 shows a cylindrical arrangement of a housing 10 having two drive bodies 11 which are each laterally provided with blocking bodies 50, 51, 52, 52 which are flexible and may also be connected to the wall of the housing 10 and which prevent or reduce a pressure equalization between the lower side and upper side or the high pressure side and low

pressure side of each drive body during the drive movement.

Fig. 12 shows corresponding blocking bodies 53, 54 for a housing 10' with flattened side walls.

Fig. 13 shows two blocking bodies in the form of wide, flexible bands 55, 56 which connect two drive bodies to one another at both sides. This constellation is shown in a front view in Fig. 14.

Fig. 15 shows two blocking bodies 55, 56, as in Fig. 13, which connect two fin-like drive bodies to one another and act as an equalization block. The blocking bodies are configured as strips and can be configured as flexible or stiff and elastically pliable. In the latter case, a drive movement can be directly applied to the drive bodies by direct application of a mechanically, magnetically, pneumatically hydraulically or electrically generated driving force onto the blocking bodies from the outside, indicated by the arrows F_1 and F_1' or from the inside from the intermediate space of the drive bodies, indicated by the double arrow F_2.

Instead of the blocking bodies, similarly positioned coupling bodies in the form of a scaffold or frame can be provided to couple the drive movement into the sections.

The principle of the drive via the blocking bodies is additionally illustrated by way of example by Fig. 16. Two drive bodies 57, 58 are connected to one another there by two ring segments 59, 60 of a ring strip in the form of a circular ring. The cylinders 61, 62 symbolically indicate outwardly engaging

driving forces which can apply a traction force or a compression force to the ring segments from the outside. Corresponding inwardly engaging forces are symbolically designated by 63, 64. A deformation of the ring segments effects a drive movement of the drive bodies 57, 58. They can be controlled in a suitable manner by a profiling of the ring segments 59, 60 or by cut-outs in the ring segments.

In Figs. 17 and 18, a drive body is shown in a schematic plan view having so-called fin-rays 65 which have an influence on the flow of the fluid as web-like, groove-like or fin-like structures on the surface. They can be shaped and configured such that they effect a concave deformation and thus an increase in pressure on the pressure side on a movement of the drive body.

The conveying device for fluids in accordance with the invention allows an efficient configuration thanks to the use of an oscillatory movement transversely to the conveying direction of drive bodies, with the disadvantages of only rotating drive devices being avoided.

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Claims

1. A conveying device for the conveying of a fluid in a conveying direction having at least one drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) which can be driven by means of a drive system, characterized in that the drive body can be driven in an oscillating manner transversely to the conveying direction (9).

2. A conveying device in accordance with claim 1, characterized in that at least one conveying surface (6, 7) of at least one drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) is aligned such that a partial force acts on the fluid in the conveying direction (9) on a movement of the drive body.

3. A conveying device in accordance with claim 2, characterized in that two conveying surfaces (6, 7) are aligned such that they effect a conveying of fluid in a respective at least one movement direction (3, 4) of a drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′).

4. A conveying device in accordance with one of the claims 1, 2 or 3, characterized in that at least one drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) tapers in the conveying direction (9) in the cross-section disposed parallel to its movement plane.

5. A conveying device in accordance with claim 1 or one of the following claims, characterized in that the at least one drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) is configured as stiff.

6. A conveying device in accordance with one of the claims 1 to 4, characterized in that the drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) is configured as elastic such that it is bendable in its end region by the fluid counterpressure in operation by at least 5° with respect to the non-deformed state.

7. A conveying device in accordance with one of the claims 1 to 6, characterized in that the drive body has microgrooves (41) extending in the conveying direction (9).

8. A conveying device in accordance with claim 1 or one of the following claims, characterized in that the drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) has at least one hollow space (37, 38).

9. A conveying device in accordance with claim 8, characterized in that the drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) comprises a foam, in particular polyurethane.

10. A conveying device in accordance with either of claims 8 or 9, characterized in that the drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) is at least partly inflatable.

11. A conveying device in accordance with claim 1 or one of the following claims, characterized in that the drive body can be driven by means of a

hydraulic or pneumatic device (15, 15'), in particular by means of a balloon body.

12. A conveying device in accordance with one of the claims 1 to 10, characterized in that the drive body can be driven by means of an electric and/or magnetic device.

13. A conveying device in accordance with claim 1 or one of the following claims, characterized in that at least one drive body (1, 1', 1'', 1''', 11, 11', 11'', 11''') is pivotable in an oscillating manner about an axis extending transversely to the conveying direction (9).

14. A conveying device in accordance with one of the claims 1 to 13, characterized in that the drive body/bodies (1'', 11'') is/are pivotable in an oscillating manner about an axis extending in the conveying direction (9), in particular outside the drive body/bodies.

15. A conveying device in accordance with one of the claims 1 to 14, characterized by blocks which are laterally fastened to at least one drive body and which form a barrier between different conveying surfaces of a drive body.

16. A conveying device in accordance with claim 14, characterized in that at least one block is connected either to two drive bodies or to one drive body and a housing of the conveying device.

17. A conveying device in accordance with either of claims 15 or 16, characterized in that the driving force is applied to the drive bodies by means of the blocking body/bodies.

Abstract

A conveying device for a fluid

The invention relates to a conveying device for conveying a fluid in a conveying direction (9) having one or more drive bodies (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) which can be driven in an oscillating manner by means of a drive system (15, 15') transversely to the conveying direction. An acceleration of the fluid is achieved by a corresponding movement in translation or by a partially pivoting movement of the drive bodies in the manner of the fin principle known from biology (e.g. aerodynamics and hydrodynamics).

(Fig. 3)

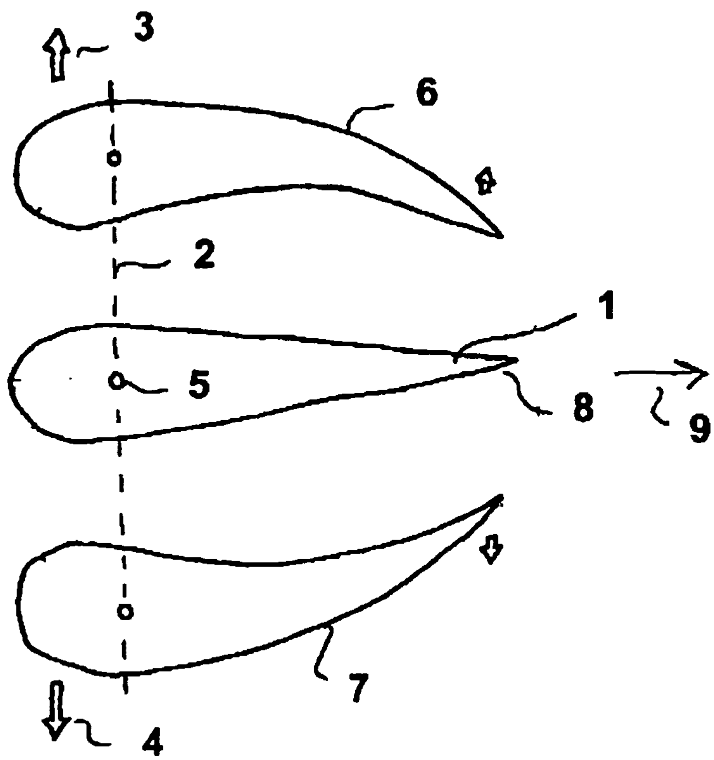


Fig. 1

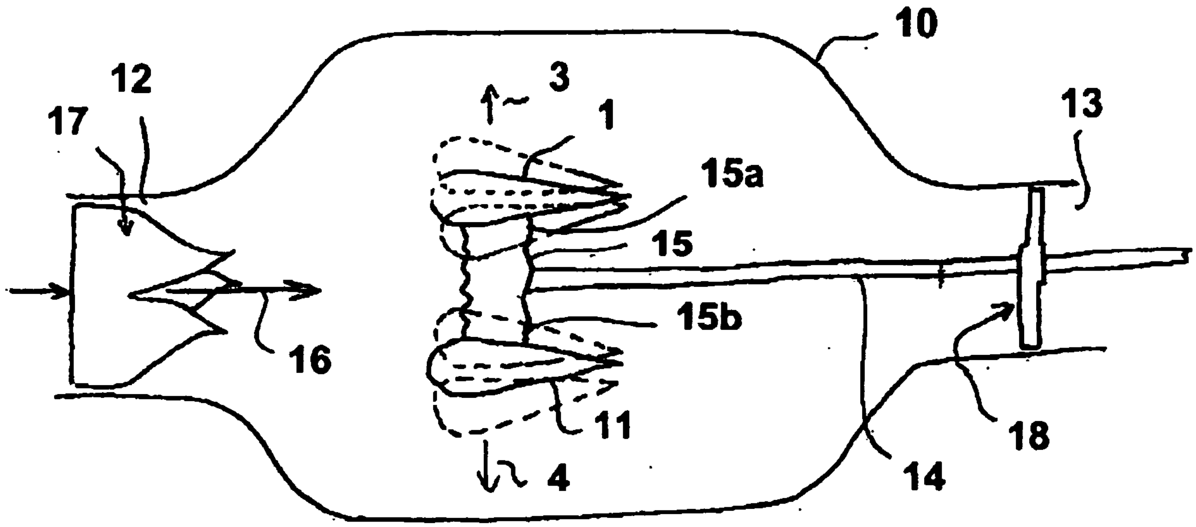


Fig. 2

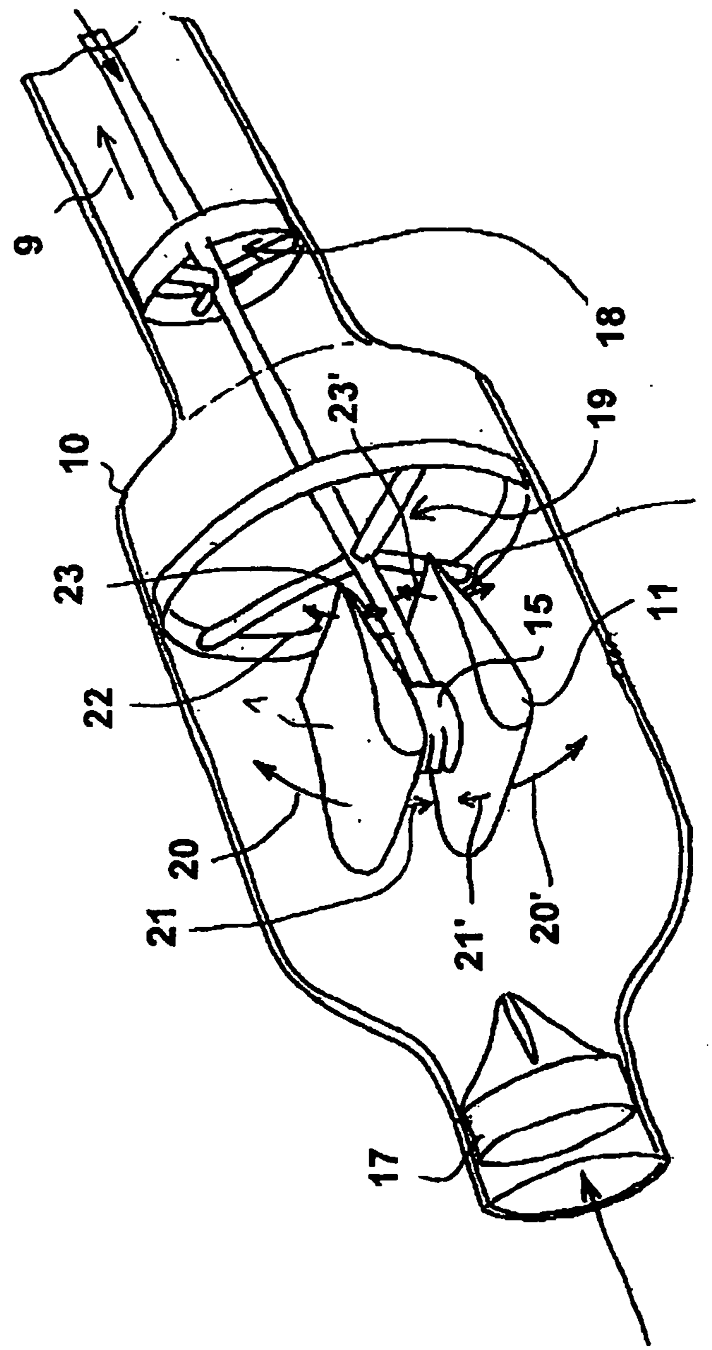


Fig. 3

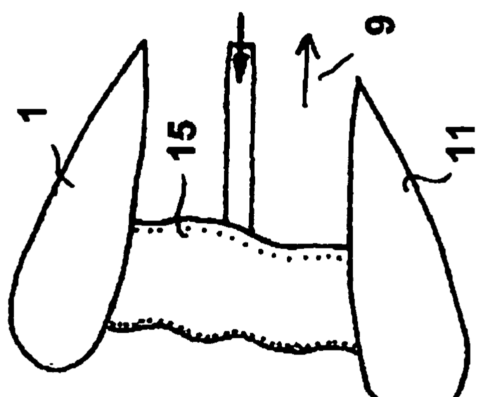


Fig. 6

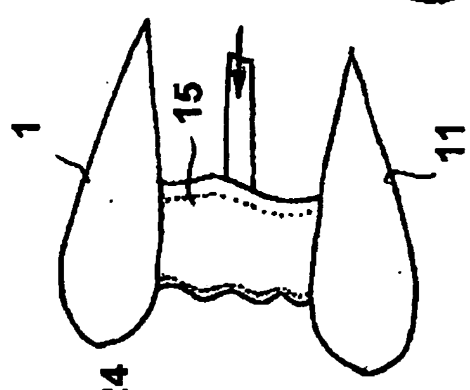


Fig. 5

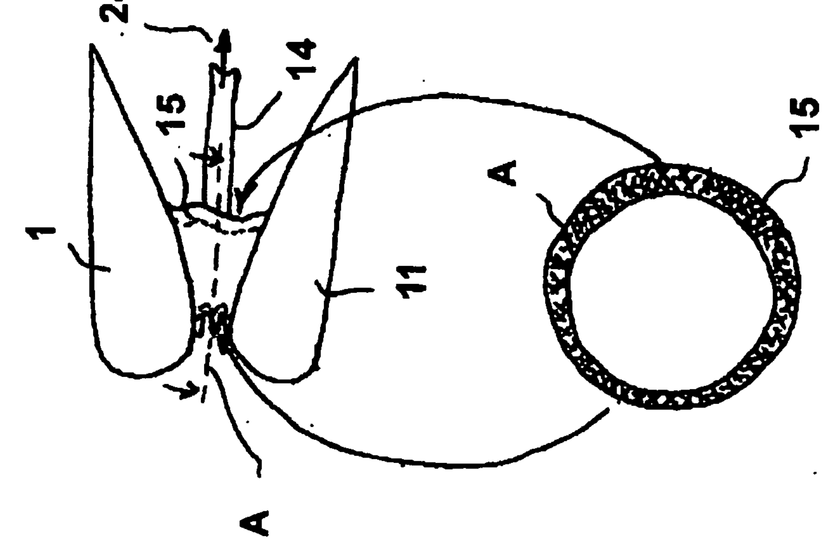


Fig. 4

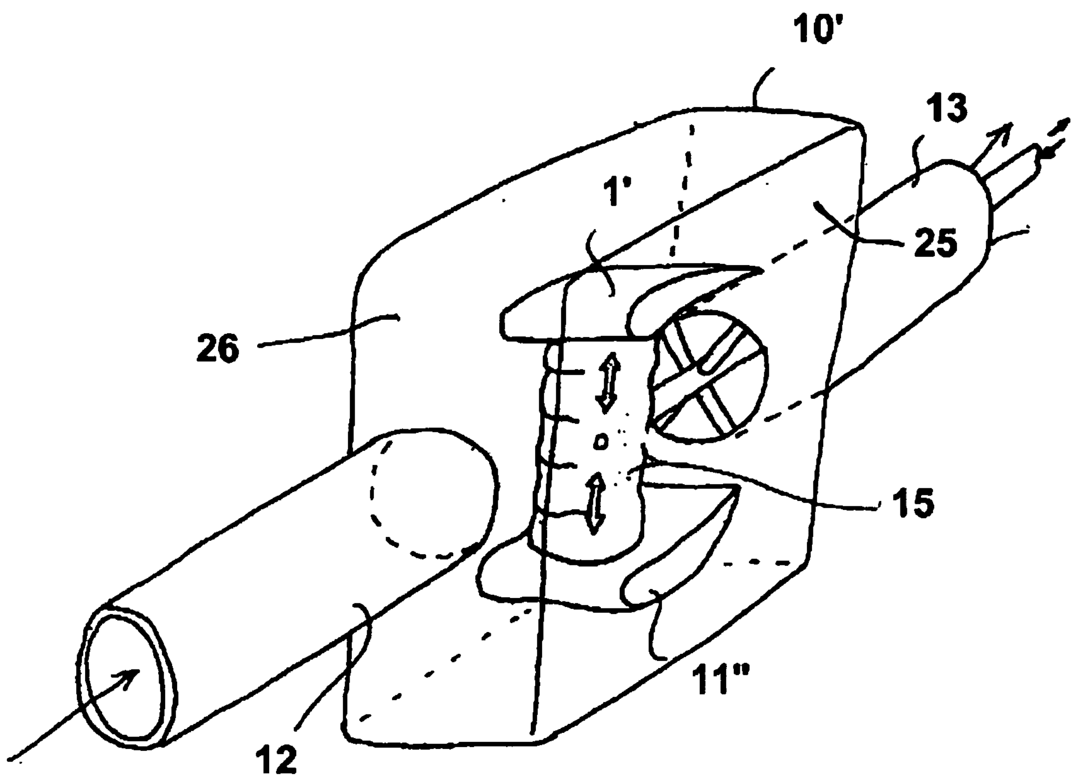


Fig. 7

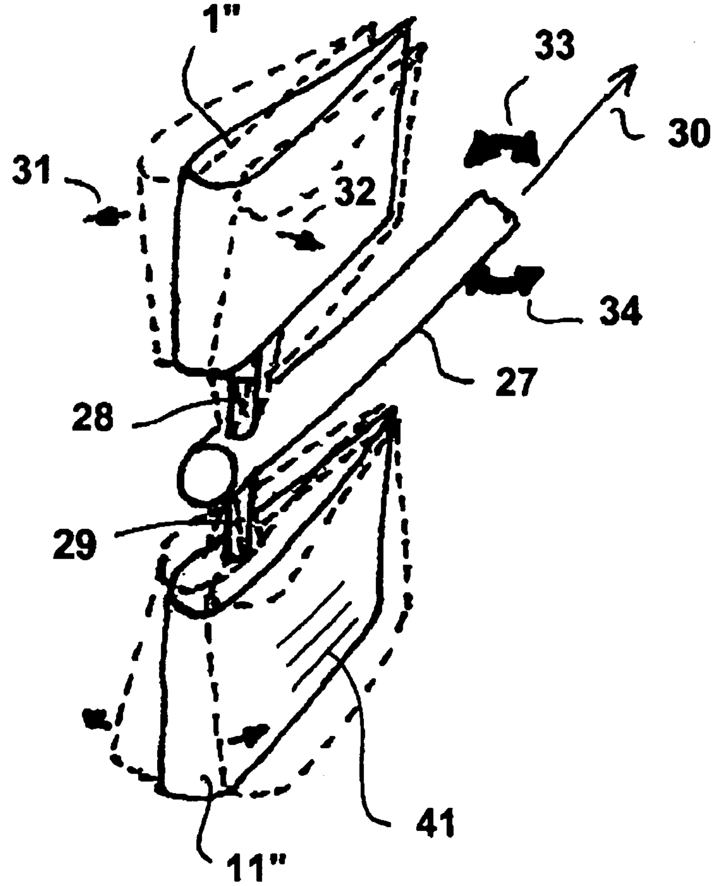


Fig. 8

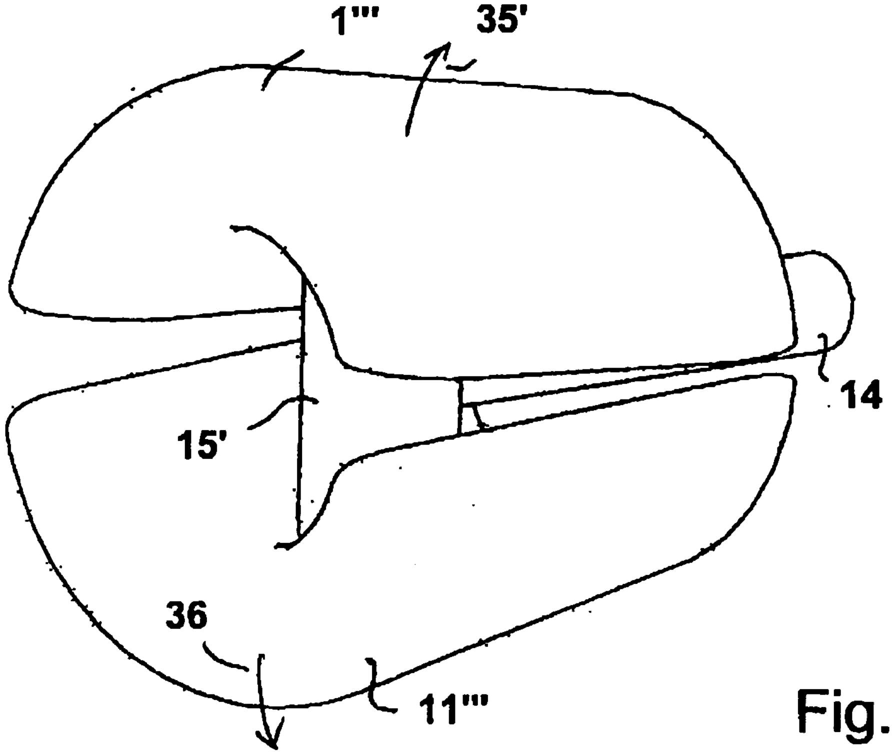


Fig. 9

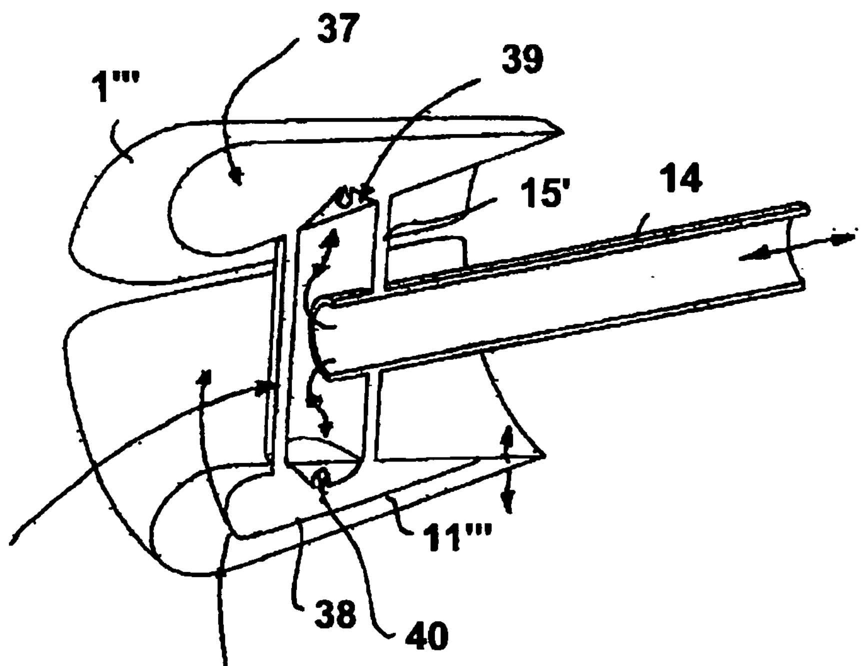
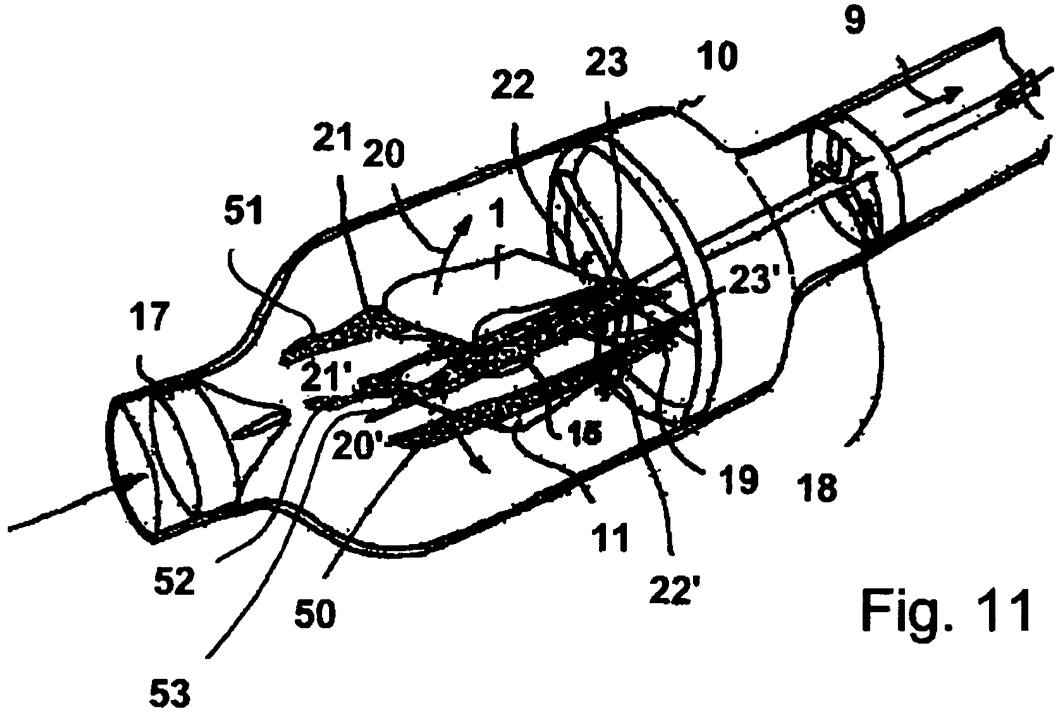


Fig. 10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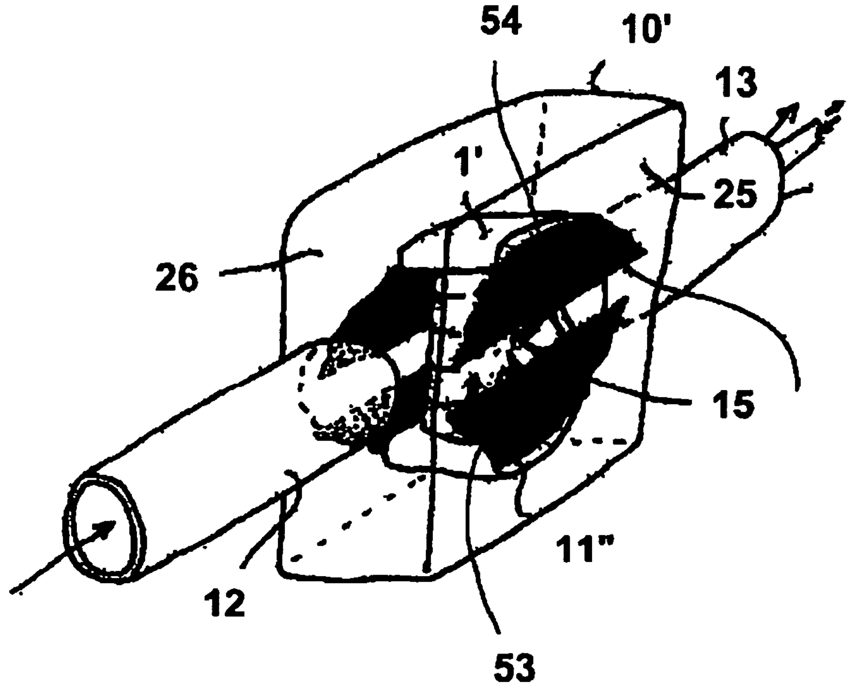
53

Fig. 11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12
53

Fig. 12

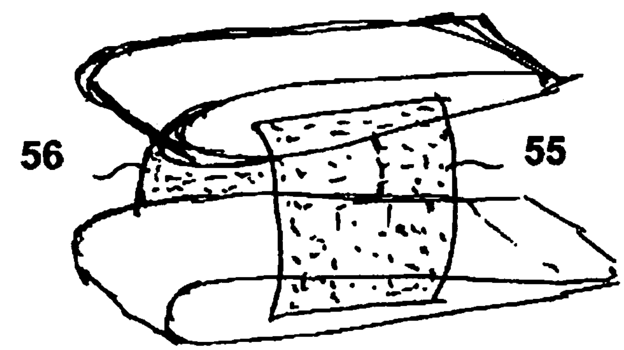

Fig. 13

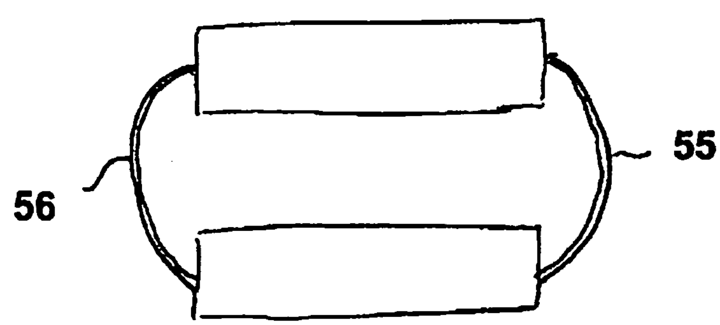

Fig. 14

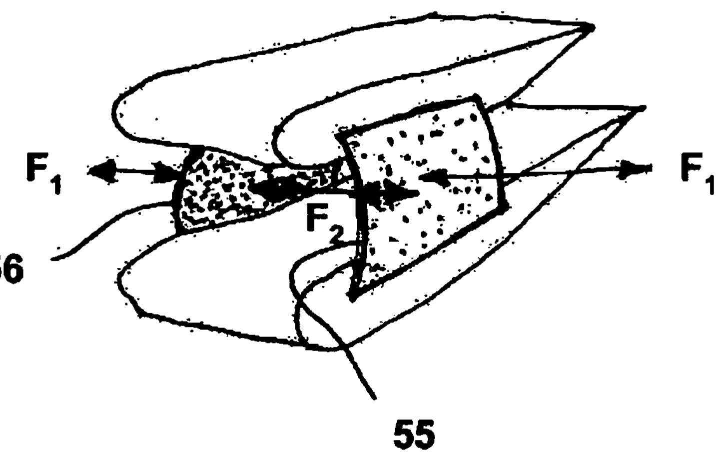

Fig. 15

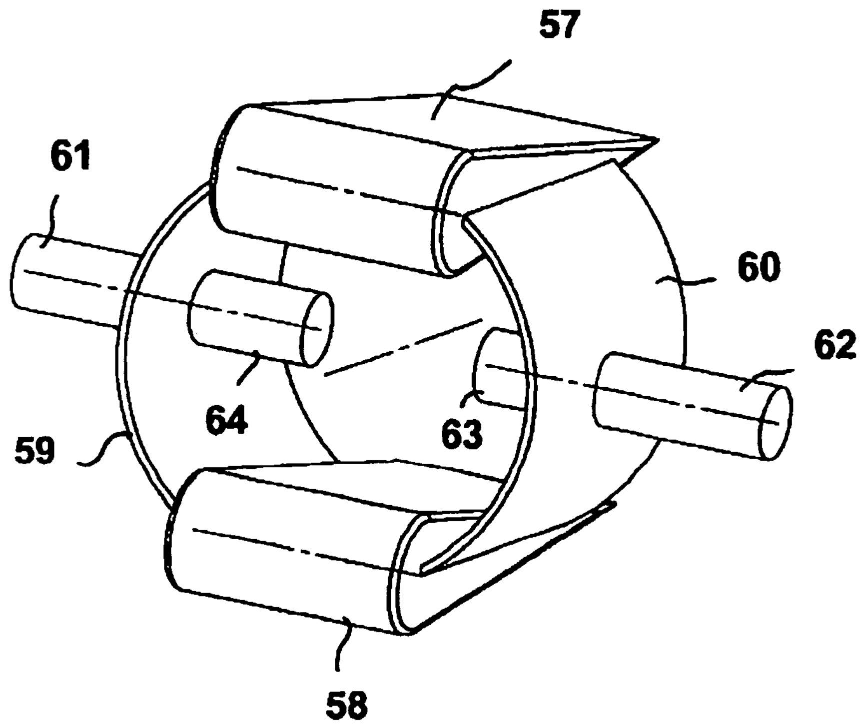

Fig. 16

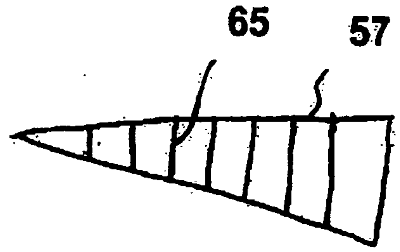

Fig. 17

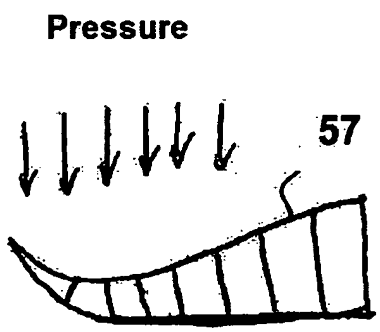

Fig. 18

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		Arrival at Unit	October 04, 2012, 7:33 am	DULLES, VA 20102	
		Processed through USPS Sort Facility	October 04, 2012, 7:14 am	DULLES, VA 20102	
		Depart USPS Sort Facility	October 03, 2012	TOLEDO, OH 43601	
		Processed through USPS Sort Facility	October 03, 2012, 6:32 pm	TOLEDO, OH 43601	

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U.S. APPLICATION NUMBER NO.	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
13/261,361	Reiner Liebing	1-21942

1678
MARSHALL & MELHORN, LLC
FOUR SEAGATE - EIGHTH FLOOR
TOLEDO, OH 43604

INTERNATIONAL APPLICATION NO.	
PCT/EP2011/000439	
I.A. FILING DATE	PRIORITY DATE
01/27/2011	01/27/2010

CONFIRMATION NO. 3522
371 FORMALITIES LETTER

OC000000055802373

Date Mailed: 08/07/2012

NOTIFICATION OF MISSING REQUIREMENTS UNDER 35 U.S.C. 371 IN THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)

The following items have been submitted by the applicant or the IB to the United States Patent and Trademark Office as an Elected Office (37 CFR 1.495):

- Indication of Small Entity Status
- Priority Document
- Copy of the International Application filed on 07/13/2012
- Copy of the International Search Report filed on 07/13/2012
- Copy of IPE Report filed on 07/13/2012
- Preliminary Amendments filed on 07/13/2012
- Information Disclosure Statements filed on 07/13/2012
- Oath or Declaration filed on 07/13/2012
- Request for Immediate Examination filed on 07/13/2012
- U.S. Basic National Fees filed on 07/13/2012
- Specification filed on 07/13/2012
- Claims filed on 07/13/2012
- Abstracts filed on 07/13/2012
- Drawings filed on 07/13/2012

The applicant needs to satisfy supplemental fees problems indicated below.

The following items **MUST** be furnished within the period set forth below in order to complete the requirements for acceptance under 35 U.S.C. 371:

- Oath or declaration of the inventors, in compliance with 37 CFR 1.497(a) and (b), identifying the application by the International application number and international filing date. The current oath or declaration does not comply with 37 CFR 1.497(a) and (b) in that it:
  - is not executed in accordance with either 37 CFR 1.66 or 37 CFR 1.68.
- To avoid abandonment, a surcharge (for late submission of filing fee, search fee, examination fee or oath or declaration) as set forth in 37 CFR 1.492(h) of $65 for a small entity in compliance with 37 CFR 1.27, must be submitted with the missing items identified in this letter.

SUMMARY OF FEES DUE:

Total additional fees required for this application is $**65** for a Small Entity:

- $**65** Surcharge.

FORM PCT/DO/EO/905 (371 Formalities Notice)

ALL OF THE ITEMS SET FORTH ABOVE MUST BE SUBMITTED WITHIN TWO (2) MONTHS FROM THE DATE OF THIS NOTICE OR BY 32 MONTHS FROM THE PRIORITY DATE FOR THE APPLICATION, WHICHEVER IS LATER. FAILURE TO PROPERLY RESPOND WILL RESULT IN ABANDONMENT.

The time period set above may be extended by filing a petition and fee for extension of time under the provisions of 37 CFR 1.136(a).

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web.
https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at **1-866-217-9197** or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

RODERICK M JONES

Telephone: (571) 272-9083

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number
13/261,361

APPLICATION AS FILED - PART I

FOR	NUMBER FILED (Column 1)		NUMBER EXTRA (Column 2)	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A		N/A	N/A	190		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A		N/A	N/A	245		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A		N/A	N/A	125		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	24	minus 20 =	* 4	x 30 =	120	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3	minus 3 =	*	x 125 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					0.00			
				TOTAL	680		TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED - PART II

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

IAP01Rec'd PCT 13 JUL 2012

PTO-1390 (09-11)

Approved for use through 4/30/2013. OMB 0651-0021

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371		ATTORNEY'S DOCKET NUMBER 1-21942 U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 13/261361
INTERNATIONAL APPLICATION NO. PCT/EP2011/000439	INTERNATIONAL FILING DATE 27 January 2011 (27.01.2011)	PRIORITY DATE CLAIMED 27 January 2010 (27.01.2010)
TITLE OF INVENTION CONVEYING DEVICE FOR A FLUID		
APPLICANT(S) FOR DO/EO/US Reiner LIEBING		

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☑ This is a **FIRST** submission of items concerning a submission under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a submission under 35 U.S.C. 371.
3. ☑ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☑ The US has been elected (Article 31).
5. ☑ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   - a. ☑ is attached hereto (required only if not communicated by the International Bureau).
   - b. ☐ has been communicated by the International Bureau.
   - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   - a. ☐ is attached hereto.
   - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   - b. ☐ have been communicated by the International Bureau.
   - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   - d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☑ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☑ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☑ A preliminary amendment.
14. ☑ An Application Data Sheet under 37 CFR 1.76.
15. ☐ A substitute specification.
16. ☑ A power of attorney and/or change of address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.3 and 37 CFR 1.821- 1.825.
18. ☐ A second copy of the published International Application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

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U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
13/261361	PCT/EP2011/000439	1-21942

20. Other items or information:
Express mail certificate; return card; copies of IB/304 Transmittal Priority Document, IB/308 (Second and Supplementary Notice) Communication of International Appln to Designated Offices, ISA/210 International Search Rpt with Written Opinion; and the published International Application; IDS Form SB/08A, cover page earliest claimed EP priority with EPO Search Rpt, detailed citation list, ISA/210 Intl Search Report, and copies of cited foreign documents

The following fees have been submitted	CALCULATIONS	PTO USE ONLY
21. ☑ Basic national fee (37 CFR 1.492(a)) $380	$ 380	
22. ☑ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) .... $0 All other situations $250	$ 250	
23. ☑ Search fee (37 CFR 1.492(b)) If the written opinion of the ISA/US or the International preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) .... $0 Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority .... $120 International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB .... $490 All other situations $620	$ 490	
TOTAL OF 21, 22 and 23 =	$1,120	
☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)). The fee is **$310** for each additional 50 sheets of paper or fraction thereof.		

Total Sheets	Extra Sheets	Number of each additional 50 or fraction thereof (round **up** to a whole number)	RATE	
- 100 =	/50 =		x $310	$-

Surcharge of **$130.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).	$ -	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	24 - 20 =	4	x $ 60	$240	
Independent claims	3 - 3 =	0	x $250	$-	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $450	$ -	
TOTAL OF ABOVE CALCULATIONS =				$1,360	
☑ Applicant claims small entity status. See 37 CFR 1.27. Fees above are reduced by ½.				680	
SUBTOTAL =				$ 680	
Processing fee of **$130.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). +				$ -	
TOTAL NATIONAL FEE =				$ 680	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ -	
TOTAL FEES ENCLOSED =				$ 680	
				Amount to be refunded:	$
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a. ☑ A check in the amount of $ 680.00 to cover the above fees is enclosed.

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c. ☑ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 13-1816.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038. The PTO-2038 should only be mailed or faxed to the USPTO. However, when paying the basic national fee, the PTO-2038 may NOT be faxed to the USPTO.

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NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

SEND ALL CORRESPONDENCE TO:

Customer Number 00001678
Marshall & Melhorn, LLC
Four SeaGate - 8th Floor
Toledo, Ohio 43604

Phone: 419-249-7138
Fax: 419-249-7151

Stephen Evans
SIGNATURE

STEPHEN P. EVANS
NAME

47,281
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The following fees have been submitted	CALCULATIONS	PTO USE ONLY
21. ☑ Basic national fee (37 CFR 1.492(a)) **$380**	$ 380	
22. ☑ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4).......... **$0** All other situations.......... **$250**	$ 250	
23. ☑ Search fee (37 CFR 1.492(b)) If the written opinion of the ISA/US or the International preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4).......... **$0** Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority.......... **$120** International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB.......... **$490** All other situations.......... **$620**	$ 490	
TOTAL OF 21, 22 and 23 =	$1,120	
☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)). The fee is **$310** for each additional 50 sheets of paper or fraction thereof.		

Total Sheets	Extra Sheets	Number of each additional 50 or fraction thereof (round up to a whole number)	RATE	
- 100 =	/50 =		x $310	$-

Surcharge of **$130.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).	$ -	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	24 - 20 =	4	x $ **60**	$240	
Independent claims	3 - 3 =	0	x **$250**	$-	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$450**	$ -	

TOTAL OF ABOVE CALCULATIONS =	$1,360	
☑ Applicant claims small entity status. See 37 CFR 1.27. Fees above are reduced by ½.	680	
SUBTOTAL =	$ 680	
Processing fee of **$130.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). +	$ -	
TOTAL NATIONAL FEE =	$ 680	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +	$ -	
TOTAL FEES ENCLOSED =	$ 680	
	Amount to be refunded:	$
	Amount to be charged	$

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a. ☑ A check in the amount of $ 680.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. __________ in the amount of $ __________ to cover the above fees.

c. ☑ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 13-1816.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038. The PTO-2038 should only be mailed or faxed to the USPTO. However, when paying the basic national fee, the PTO-2038 may NOT be faxed to the USPTO.

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NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

SEND ALL CORRESPONDENCE TO:

Customer Number 00001678
Marshall & Melhorn, LLC
Four SeaGate - 8th Floor
Toledo, Ohio 43604

Phone: 419-249-7138
Fax: 419-249-7151

Stephen Evans
SIGNATURE

STEPHEN P. EVANS
NAME

47,281
REGISTRATION NUMBER

13/261361

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PTO/SB/14 (11-08)
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	1-21942
		Application Number	
Title of Invention	CONVEYING DEVICE FOR A FLUID		

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Applicant Information:

Applicant 1

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	**Given Name**	**Middle Name**	**Family Name**	**Suffix**
	REINER		LIEBING	

Residence Information (Select One) ○ US Residency ◉ Non US Residency ○ Active US Military Service

City	POTSDAM	**Country Of Residence** i	DE
Citizenship under 37 CFR 1.41(b) i	DE		
Mailing Address of Applicant:			
Address 1	SCHMIEDEGASSE 43		
Address 2			
City	POTSDAM	**State/Province**	
Postal Code	14469	**Country** i	DE

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	000001678	
Email Address	evans@marshall-melhorn.com	Add Email Remove Email

Application Information:

Title of the Invention	CONVEYING DEVICE FOR A FLUID		
Attorney Docket Number	1-21942	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		**Sub Class (if any)**	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	10	**Suggested Figure for Publication (if any)**	

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	1-21942
	Application Number	
Title of Invention	CONVEYING DEVICE FOR A FLUID	

Publication Information:

☐	Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐	**Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S. C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	◯ US Patent Practitioner	◯ Limited Recognition (37 CFR 11.9)
Customer Number	000001678		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

Prior Application Status		Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	a 371 of international	PCT/EP2011/000439	2011-01-27
Prior Application Status		Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/298581	2010-01-27

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

		Remove	
Application Number	Country[i]	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
10 075 043.9	EP	2010-01-27	◉ Yes ◯ No

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	1-21942
	Application Number	
Title of Invention	CONVEYING DEVICE FOR A FLUID	

Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.

Assignee 1

If the Assignee is an Organization check here. ☒

Organization Name	ECP ENTWICKLUNGSGESELLSCHAFT MBH		
Mailing Address Information:			
Address 1	WIESENWEG 10		
Address 2			
City	BERLIN	**State/Province**	
Country	DE	Postal Code	12247
Phone Number		Fax Number	
Email Address			

Additional Assignee Data may be generated within this form by selecting the **Add** button.

Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	Stephen Evans			Date (YYYY-MM-DD)	2012-07-13
First Name	STEPHEN	Last Name	EVANS	Registration Number	47281

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Kathleen J. Moore
(Signature of person mailing correspondence)
Kathleen J. Moore
(Typed name of person mailing correspondence)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: REINER LIEBING	]	Group Art Unit:
Filing Under 35 USC 371 in DO/EO/ US of PCT/EP2011/000439 filed 27 January 2011	]	Examiner:
For: CONVEYING DEVICE FOR A FLUID	]	Attorney Docket 1-21942

July 13, 2012

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INFORMATION DISCLOSURE STATEMENT

Honorable Sir:

Pursuant to Section 1.97 of Title 37 of the Code of Federal Regulations, and prior to the issuance of a first office action, record is hereby made of information the United States Patent and Trademark Office may wish to consider during examination of the above-entitled application which is being filed concurrently herewith under 35 U.S.C. 371.

No representation is made or intended that a prior art search was conducted, or that no better art than that listed is available. As this Information Disclosure Statement is being submitted prior to a first Office Action on the merits, it is respectfully submitted that no fee is required for consideration of this IDS.

The following documents were cited in the present specification, which serves as a statement of relevance for any of the non-English references, as well as in the specifications of the earliest claimed European and US priorities:

US 6,860,713 B2; and

US 7,393,181 B2 (related to Cont. US 7,927,068 and Cont. US 2011/0236210A1).

The following documents were cited in the International Search Report and Written Opinion of the corresponding international application, priority of which is claimed:

WO 98/18508A1 (corresponds to US 5,820,542);

WO 2009/157840A1 (corresponds to US 2011/0282128A1 and 2011/0034874A1);

EP 2 194 278 A1 (corresponds to US 2011/0275884A1);

FR 1 218 663 A;

DE 103 37 804 A1;

WO 2006/038808 A1 (corresponds to US 7,874,882); and

WO 2005/003545 A1.

Copies of the International Search Report with Written Opinion, as well as the cover page of the earliest claimed European priority along with the European Search Report and a detailed citation list, are attached hereto for the Examiner's convenience, and serve as statements of relevance for any of the non-English references.

The following documents were cited in earliest claimed US priority (61/298,581) and European priority EP 10 075 043.9 (now EP 2 353 262 A1):

1. US 61/297,858

   Specification

   US 6,860,713 and US 7,393,181 (also cited in the subject specification).

2. <u>EP 10 075 043.9 (now EP 2 353 262 A1)</u>:

   <u>Specification</u>:

   US 6,860,713 and US 7,393,181 (also cited in the subject specification).

   <u>EPO Search Report</u> (also cited in the International Search Report of the corresponding international application):

   DE 103 37 804 A1;
   WO 2006/038808 A1 (corresponds to US 7,874,882);
   WO 98/18508 A1 (corresponds to US 5,820,542);
   FR 1 218 663 A;
   WO 2005/003545 A1; and
   US 6,544,216 B1.

Copies of the cover page of the earliest claimed Euopean priority, the European Search Report and detailed citation listing are attached hereto for the Examiner's convenience and serves as a statement of relevance for any of the non-English references.

Copies of the above-noted foreign documents are enclosed herewith, along with IDS Forms SB/08A. It is requested that the cited references be fully considered and made of record in this case.

Respectfully submitted,

Stephen P. Evans
Registration No. 47,281

<u>ATTORNEYS</u>
Customer Number 00001678
MARSHALL & MELHORN, LLC
Four SeaGate - 8th Floor
Toledo, Ohio 43604

Phone: (419) 249-7138
Fax: (419) 249-7151
Email: evans@marshall-melhorn.com

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	13/261361
Filing Date	
First Named Inventor	Reiner LIEBING
Art Unit	
Examiner Name	
Attorney Docket Number	1-21942

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US- 2011/0034874 A1	02-10-2011	Reitan et al	
		US- 2011/0236210 A1	09-29-2011	McBride et al	
		US- 2011/0275884 A1	11-10-2011	Scheckel	
		US- 2011/0282128 A1	11-17-2011	Reitan et al	
		US- 5,820,542 B1	10-13-1998	Dobak, III et al	
		US- 6,544,216 B1	04-08-2003	Sammler et al	
		US- 6,860,713 B2	03-01-2005	Hoover	
		US- 7,393,181 B2	07-01-2008	McBride et al	
		US- 7,874,882 B2	01-25-2011	Sagov	
		US- 7,927,068 B2	04-19-2011	McBride et al	
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FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
		DE 103 37 804 A1	03-24-2005	Franzke		
		FR 1 218 663 A	05-12-1960	Kuettner		
		EP 2 194 278 A1	06-09-2010	Scheckel		
		WO 98/18508 A1	05-07-1998	Dobak et al		
		WO 2005/003545 A1	01-13-2005	Robinson		
		WO 2006/038808 A1	04-13-2006	Sagov		

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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Sheet 2 of 2

Complete if Known	
Application Number	13/261361
Filing Date	
First Named Inventor	Reiner LIEBING
Art Unit	
Examiner Name	
Attorney Docket Number	1-21942

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-			
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FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
		WO 2009/157840 A1	12-30-2009	Reitan et al		

Examiner Signature		Date Considered	

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This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Espacenet

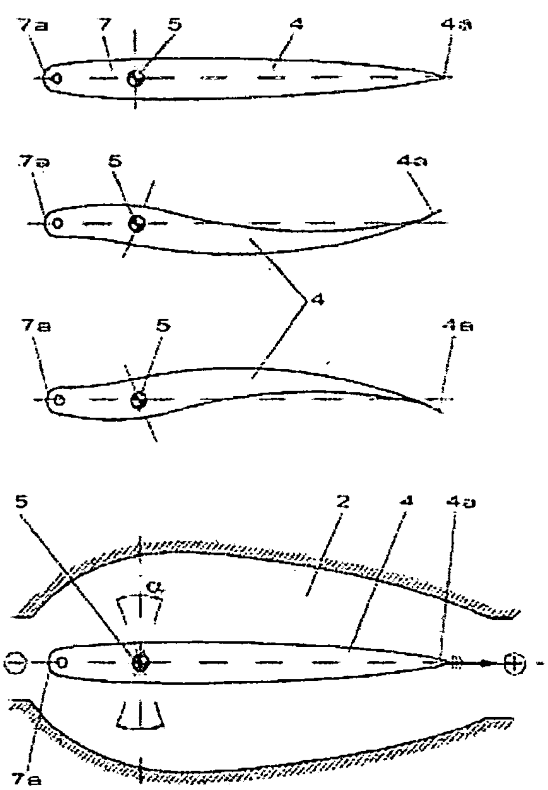
Bibliographic data: DE10337804 (A1) — 2005-03-24

Device for feed of fluid such as water has feed element with feed surface with free movement end in direction of feed by which oscillating back and forth movement is executed

Inventor(s):	FRANZKE GUENTER [DE] + (FRANZKE, GUENTER)	
Applicant(s):	WILO AG [DE] + (WILO AG, ; WILO SE)	
Classification:	**- international:**	***F04D33/00;*** (IPC1-7): F04D33/00
	- European:	F04D33/00
Application number:	DE20031037804 20030814	
Priority number(s):	DE20031037804 20030814	
Also published as:	DE10337804 (B4)	

Abstract of DE10337804 (A1)

The device for the feed of a fluid has a feed chamber (2) which has at least one flow inlet opening, an outlet opening, and a feed element (4). The feed element has a feed surface with free movement end (4a) in the direction of the feed by which an oscillating back and forth movement is executed. The free movement end of the feed element executes travel perpendicular to the direction of feed, especially through which the feed surface is driven to operate around an axis (5).



(19) Bundesrepublik Deutschland
Deutsches Patent- und Markenamt

(10) **DE 103 37 804 A1** 2005.03.24

(12) # Offenlegungsschrift

(21) Aktenzeichen: **103 37 804.9**
(22) Anmeldetag: **14.08.2003**
(43) Offenlegungstag: **24.03.2005**

(51) Int Cl.⁷: **F04D 33/00**

(71) Anmelder:
WILO AG, 44263 Dortmund, DE

(74) Vertreter:
COHAUSZ DAWIDOWICZ HANNIG & PARTNER, 40237 Düsseldorf

(72) Erfinder:
Franzke, Günter, 06862 Hundeluft, DE

(56) Für die Beurteilung der Patentfähigkeit in Betracht zu ziehende Druckschriften:

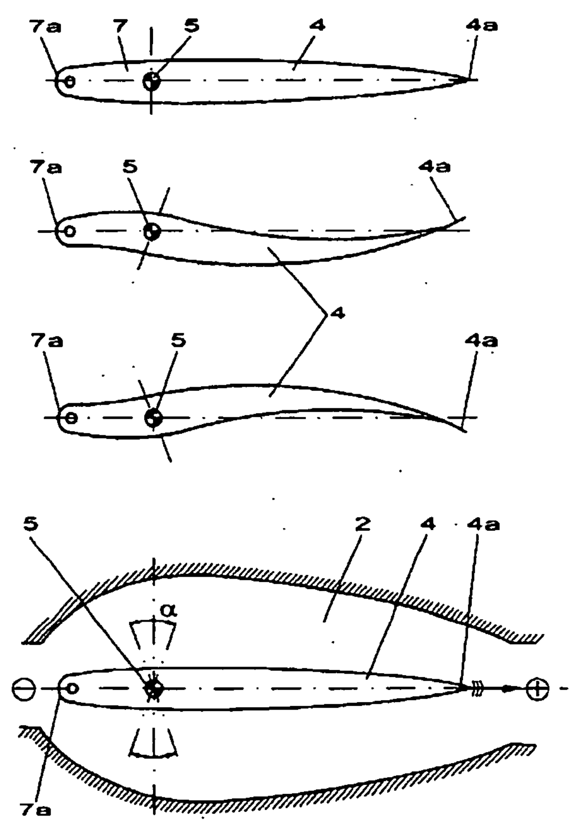
DE	27 01 595 A1
DE	25 22 309 A1
DD	32 489
GB	22 10 414 A
GB	21 21 111 A
EP	00 50 169 A1

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

Rechercheantrag gemäß § 43 Abs. 1 Satz 1 PatG ist gestellt.

(54) Bezeichnung: **Vorrichtung zur Föderung eines Fluids mit einem oszillierenden Förderelement**

(57) Zusammenfassung: Die Erfindung betrifft eine Vorrichtung zur Förderung eines Fluids mit einem Förderraum (2), der wenigstens eine Zustromöffnung (3a), eine Abstromöffnung (3b) und ein Förderelement (4) aufweist, wobei das Förderelement (4) eine Förderfläche mit einem in Förderrichtung (6) bewegungsfreien Ende (4a) aufweist, mit dem eine ozillierende Hin- und Herbewegung ausführbar ist.



Beschreibung

[0001] Die Erfindung betrifft eine Vorrichtung zur Förderung eines Fluids mit einem Förderraum, der wenigstens eine Zustromöffnung, eine Abstromöffnung und ein Förderelement aufweist.

Stand der Technik

[0002] Derartige Vorrichtungen sind allgemein als Pumpen zur Förderung beliebiger Fluide bekannt, wobei oftmals, beispielsweise in der Heizungstechnik, eine Kreiselpumpe zur Förderung von Wasser eingesetzt wird, bei der das Förderelement als rotierendes Laufrad ausgebildet ist.

[0003] Derartige gattungsgemäße Pumpen wie beispielsweise auch Kreiselpumpen haben jedoch erhebliche Nachteile, gerade wenn eine definierte Durchströmung eines hydraulischen Verbrauchers mit niedrigen Widerstand und bei geringsten Förderströmen gewünscht ist, da bei diesen Anforderungen die verwendeten Pumpen nur kleinste Wellenleistungen und Drehmomente aufweisen und somit beispielsweise nach einem Stillstand einer solchen Pumpe sich Probleme mit einem sicheren Neuanlaufen einstellen können. Auch ist ein lautloser Betrieb derartiger gattungsgemäßer Pumpen über längere Zeit in herkömmlicher Bauart nicht möglich.

[0004] In der Heizungstechnik ist es zwischenzeitig bekannt, an Heizkörpern beispielsweise eine übliche Thermostatregelung dadurch zu ersetzen, dass das bekannte Thermotatventil in Entfall kommt und direkt am Heizkörper stattdessen eine Pumpe eangeordnet wird, die in Verbindung mit einer Raumthermostatisierung beispielsweise von einem elektronischen Raumregler oder durch andere Art und Weise geregelt wird, so dass bei einer Heizanforderung der Heizkörper durch die jeweils unmittelbar an ihm angeordnete Pumpe mit Heißwasser beaufschlagt wird.

[0005] Hierbei kann beispielsweise die eingesetzte Pumpe das Heizwasser einem differenzdrucklosen System (hydraulische Weiche) entnehmen. Da der für die Funktion des bislang eingesetzten Thermostatventils notwendige Differenzdruckanteil entfällt muss diese Pumpe lediglich den hydraulischen Widerstand des Heizkörpers überwinden, der bei derartigen Anforderungen sehr klein ist.

Aufgabenstellung

[0006] Um insbesondere bei dieser genannten Anwendung oder auch anderen beliebigen Anwendungen die oben genannten Nachteile herkömmlicher Pumpen zu überwinden, ist es Aufgabe der Erfindung eine Vorrichtung zur Förderung eines Fluids bereit zu stellen, die den Transport eines Fluids wie z.B. Wasser ohne ein rotierendes Laufrad ermöglicht, einen lautlosen Betrieb gewährleistet, ausfallsicher, robust und überlastsicher ist und darüber hinaus einen sicheren Anlauf nach einem Stillstand sicherstellt.

[0007] Die Aufgabe wird erfindungsgemäß dadurch gelöst, dass das Förderelement eine Förderfläche mit einem in Förderrichtung bewegungsfreien Ende aufweist, mit dem eine oszillierende Hin- und Herbewegung ausführbar ist.

[0008] Wesentliches Merkmal der Erfindung ist es somit, dass die Erzeugung des Transportes eines Fluids wie beispielsweise Wasser durch einen oszillierenden Körper erfolgt, der im einfachsten Fall einer Förderfläche entspricht, die oszilliert und hierbei einen Wassertransport in Richtung der gewünschten Förderrichtung hervorruft, wofür sich bei der Oszillation bzw. Hin- und Herbewegung der Förderfläche eine Kraftkomponente auf ein hinter/unter der Förderfläche liegendes Fluidvolumen jeweils in der gewünschten Förderrichtung einstellt, so dass dieses Fluidvolumen durch die Bewegung verschoben wird.

[0009] Bevorzugt kann eine Förderung des Fluids dadurch erreicht werden, dass das in Förderrichtung bewegungsfreie Ende der Förderfläche einen Hub im wesentlichen senkrecht zur Förderrichtung durchführt, d.h. dass dieser Hub zumindest eine wesentliche Bewegungskomponente senkrecht zu dieser Förderrichtung aufweist. Beispielsweise kann die Förderfläche um eine Drehachse oszillierend angetrieben sein, insbesondere wobei die Ebene der Förderfläche in radialer Richtung angeordnet ist, so dass das von der Drehachse weiter entfernte Ende der Forderfläche einen größeren Hub ausführt, als das näher an der Drehachse angeordnete Ende. Hierbei kann die Bewegung der Förderfläche so orientiert sein, dass sich bei der Bewegung immer eine auf das Fluid wirkende Kraftkomponente in Förderrichtung ergibt.

[0010] Ein erfindungsgemäß oszillierendes Förderelement kann in seiner Ausführung sowohl als starre Förderfläche als auch in einer besonders bevorzugten Ausführung als ein elastischer sich in Förderrichtung erstreckender Körper ausgebildet sein, wobei wenigstens dessen in Strömungsrichtung liegendes Ende die Förderfläche bildet. Hierbei ist in einer bevorzugten Ausführung der elastische Körper zumindest teilweise, insbesondere am Endbereich flossenförmig ausgebildet.

[0011] Dieser besonderen Ausführungsform liegt im wesentlichen die Schwimmbewegung eines Fisches in einem ruhigen aber auch im entgegenströmenden Wasser zugrunde, die dadurch entsteht, dass der Fisch seine Körperachse verwindet und hieraus ein oszillierendes Schlagen der Schwanzflosse entsteht. Diese bewirkt eine Wasserverwirbelung im an sich trägen Wasser, wodurch sich die Vortriebskraft des

Fisches ergibt.

[0012] Die erfindungsgemäß bevorzugte Ausführung beruht im wesentlichen auf einer Umkehrung des genannten Prinzips, wobei im vorliegenden Fall das oszillierende Förderelement aus einem elastischen Körper z.B. in fischähnlicher Form ausgeführt ist und im Förderraum fixiert angeordnet ist. Führt nun dieser elastische Körper eine oszillierende Bewegung durch, die sich insbesondere in das in Strömungsrichtung liegende Ende des Körpers quasi wellenförmig fortpflanzt und so die zumindest am Körperende ausgebildete Förderfläche in eine Oszillationsbewegung antreibt, so wird das Fluid im Förderraum in die gewünschte Fließrichtung in Bewegung versetzt.

[0013] Bevorzugt wird der elastische Körper derart ausgebildet, das er einen Anfangsbereich aufweist, der im Förderraum ortsfest angeordnet ist und dass er um eine in Förderrichtung hinter dem Anfangsbereich angeordnete Drehachse/Torsionsachse oszillierend drehbar/tordierbar ist, um im elastischen Körper eine in Förderrichtung wandernde Welle derart auszubilden, dass mit einem hinteren bewegungsfreien Ende des elastischen Körpers eine oszillierende Hin- und Herbewegung ausführbar ist.

[0014] Um bei dem Bild des Fisches zu bleiben kann hier der oszillierende Körper in fischähnlicher Form ausgebildet sein, wobei dieser an einem Fixpunkt, der hier dem Fischkopf entspricht ortsfest im Strömungskanal angeordnet wird und um den Drehpunkt herum, der beim Fischkörper etwa dem Brusttlossenbereich entspräche oszillierend verwindungsfähig ist.

[0015] Für eine optimale Förderung eines Fluids in der gewünschten Förderrichtung kann es hierbei bevorzugt vorgesehen sein, dass der elastische Körper in Förderrichtung einen Querschnitt aufweist, der sich von der Drehachse bis zum hinteren Bereich verjüngt, insbesondere derart, dass der Querschnitt etwa fischförmig ist.

[0016] Hierbei kann der Körper beispielsweise aus einem alterungsbeständigen und hochflexiblen Kunststoff, bevorzugt mit einer Textileinlage bestehen, um auch in unterschiedlichen Temperatur- und Druckbereichen wie beispielsweise in Heizwasser eingesetzt werden zu können. Bei der oszillierenden Hin- und Herbewegung des elastischen z.B. etwa fischförmigen Körpers ergibt sich über das elastische Körpermaterial hinweg zusätzlich eine wandemde Welle, die das umliegende Wasser mitträgt und hierdurch die Förderung unterstützt.

[0017] Bei der konkreten Ausgestaltung einer Fördervorrichtung kann der Förderraum einen Strömungskanal ausbilden, der um den elastischen Körper hin erweitert ist und sich insbesondere in Strömungsrichtung verjüngt, so dass der elastische Körper und der Förderraum einander im wesentlichen angepasste Querschnitte aufweisen. Hierdurch ergeben sich im Gesamtsystem ausgesprochen gute hydrodynamische Eigenschaften, die ein lautloses Strömen des Fluids ermöglichen.

[0018] Bevorzugt kann es vorgesehen sein, dass die oszillierende Drehachse/Torsionsachse von einem elektromagnetischen Schwingersystem angetrieben ist. Zum Antrieb kann es vorgesehen sein, dass senkrecht zur Drehachse ein sich wenigstens einseitig, bevorzugt zweiseitig der Drehachse erstreckender magnetischer Anker angeordnet ist, wobei das jeweilige Ende des Ankers über einem Doppelspulensystem angeordnet ist. So können in einer bevorzugten Ausführung die beiden Spulen eines Doppelspulensystems in einem Takt derart elektrisch umsteuerbar sein, dass das Ankerende eine oszillierende Hin- und Herbewegung ausführt, die sich auf die Drehachse/Torsionsachse und somit auf den elastischen Körper überträgt.

Ausführungsbeispiel

[0019] Ein Ausführungsbeispiel der Erfindung ist in den nachfolgenden Figuren dargestellt. Es zeigen:

[0020] **Fig.** 1: eine Vorrichtung zur Förderung eines Fluids, wobei das Förderelement als Förderfläche ausgebildet ist, welches eine oszillierende Hin- und Herbewegung ausführt;

[0021] **Fig.** 2: eine Vorrichtung, bei der das Förderelement als ein elastischer sich etwa fischförmiger erstreckender Körper ausgebildet ist, dessen in Strömungsrichtung liegendes Ende die Förderfläche bildet;

[0022] **Fig.** 3: einen Antriebsmechanismus zum Antrieb des elastischen Körpers gemäß **Fig.** 2.

[0023] Die **Fig.** 1 zeigt eine Vorrichtung **1** zur Förderung eines Fluids umfassend einen Förderraum **2**, mit einer Zustromöffnung **3a** und einer Abstromöffnung **3b**, wobei der Förderraum **2** ein Förderelement aufweist, welches eine Förderfläche **4** umfasst mit einem in Förderrichtung bewegungsfreien Ende **4a**, mit dem eine oszillierende Hin- und Herbewegung, hier mit Bezug auf den oberen Teil der **Fig.** 1 als Auf- und Abbewegung durchführbar ist.

[0024] Die oszillierende Bewegung erfolgt um eine Achse **5**, die z.B. hin- und herdreht oder tordiert, was beispielsweise durch eine jeweils teilweise Drehung oder eine Torsionsbewegung realisierbar ist. Über Abstandselemente **6** ist in dieser Ausführung die Förderfläche **4** mit der Drehachse **5** verbunden, so dass durch einen entsprechenden Antrieb das Auf- und

Abschwingen der Förderfläche **4** initiiert werden kann.

[0025] Mit Bezug auf den oberen Teil der **Fig.** 1 und hier die untere gestrichelte Darstellung ist ersichtlich, dass bei einer Aufbewegung der Förderfläche **4** sich ein Kräfteparallelogramm ergibt, welches auch eine resultierende Kraftrichtung in die Förderrichtung des Pfeiles **6** ergibt. Aus diesem Grunde wird mit diesem höchst einfachen Mechanismus eine geringste Fördermenge in der gewünschten Richtung **6** erreicht.

[0026] In der Ausführung gemäß **Fig.** 1 können die Förderfläche 4 sowie auch die Verbindungselemente **6** aus einem starren sowie auch aus einem elastischen Material hergestellt sein. Insbesondere bei der Ausbildung aus einem elastischen Material ergibt sich durch die elastische Verbiegung der Förderfläche **4** aufgrund der Trägheit des umliegenden Wassers eine größere Kraftkomponente in Richtung der Förderrichtung **6**.

[0027] Die **Fig.** 2 zeigt eine bevorzugte Ausführung, bei der das Förderelement als ein elastischer sich in Förderrichtung erstreckender Körper **7** ausgebildet ist, dessen in Strömungsrichtung liegender Teil die Förderfläche **4** und dessen Ende das schwingende bewegungsfreie Ende **4a** der Fläche **4** bildet. Hierbei kann der elastische Körper **7** zumindest teilweise insbesondere an dem in Strömungsrichtung liegenden Ende **4a** flossenförmig ausgebildet sein, wie es beispielsweise von Fischen her bekannt ist.

[0028] Der elastische Körper **7** weist hier einen Anfangsbereich **7a** auf, der im Förderraum ortsfest angeordnet ist, wobei dann der Körper um eine in Förderrichtung hinter dem Anfangsbereich **7a** angeordnete Achse **5** oszillierend drehbar oder tordierbar ist, um so in dem elastischen Körper **7**, insbesondere in dessen hinterem Bereich **4** eine in Förderrichtung wandernde Welle derart auszubilden, dass mit einem bewegungsfreien Bereich **4a** am Ende des elastischen Körpers **7** die oszillierende Hin- und Herbewegung ausführbar ist, die dem Schlagen der Schwanzflosse eines Fisches ähnelt.

[0029] Dieser elastische etwa fischförmig ausgebildete Körper **7** wird durch den Antrieb im wesentlichen die Schwimmbewegung eines Fisches vollziehen, wobei jedoch aufgrund der ortsfesten Fixierung des Anfangsbereiches **7a** des elastischen Körpers **7** sich nicht dieser Körper **7** im Fluid fortbewegt, sondern vielmehr das Fluid um den Körper **7** herum in Strömungsrichtung **6** gefördert wird.

[0030] Die untere Darstellung der **Fig.** 2 zeigt eine Gesamtübersicht einer beispielhaften Konstruktion einer erfindungsgemäßen Fördervorrichtung, wobei sowohl der elastische Körper **7** als auch der Förderraum der hier einen Strömungskanal ausbildet in ihrem jeweiligen Querschnitt etwa einander angepasst sind um besonders gute hydrodynamische Eigenschaften zu erreichen.

[0031] Im unteren Teil der **Fig.** 2 ist darüber hinaus dargestellt, dass die Achse **5** etwa um den Winkelbereich α gedreht oder tordiert wird und so wie es in der gestrichelten Darstellung angedeutet ist der oszillierende Körper innerhalb des Strömungsraumes **2** hin- und herschwingt und das Fluid durch die sich einstellende wandernde Welle im hinteren Teil **4** und das Schlagen des Endes **4a** der Förderfläche **4** mitträgt.

[0032] Die **Fig.** 3 zeigt in ihren oberen und unteren Bereichen im wesentlichen den Antrieb, wie er beispielsweise für einen derartigen elastischen Körper **7** vorgesehen sein kann. Beispielsweise kann hier senkrecht zur Achse **5** ein hier bevorzugt zweiseitig sich zur Achse erstreckender magnetischer Anker **8** angeordnet sein, wobei das jeweilige Ende **9** des Ankers **8** über einem Doppelspulensystem **10** angeordnet ist. Die beiden Spulen **10a** und **10b** bzw. **10c** und **10d** des jeweiligen Doppelspulensystems können in einem Takt derart elektrisch umgesteuert werden, dass die Ankerenden **9** eine oszillierende Hin- und Herbewegung ausführen, wobei diese Hin- und Herbewegung über die Achse **5**, an der der elastische Körper **7** befestigt ist, auf diesen übertragen wird und so zur schwingenden Bewegung des elastischen Körpers führt.

[0033] Hierbei kann es zum einen vorgesehen sein, dass die Drehachse **5** im Förderraum mittels Lager angeordnet ist, um eine freie Drehung der Achse zu ermöglichen, andererseits kann es ebenso vorgesehen sein, dass die Achse **5** selbst aus einem elastischen Material besteht und über Drehpunkte im Förderraum befestigt ist, die ihrerseits auf Torsion beansprucht werden.

[0034] In der **Fig.** 3 unten zeigt es sich, dass ein magnetischer Anker **8** beispielsweise einen Ferritflachkern umfassen kann und fest mit dem oszillierenden Körper **7** verbunden ist. Das Doppelspulensystem **10** wird entsprechend einer Taktfrequenz umgesteuert, wofür abwechselnd die Spulen **10a** und **10c** sowie **10b** und **10d** angesteuert werden. Der Boden auf dem die Spulen montiert sind kann bevorzugt eine Ferritgrundplatte umfassen, so dass der magnetische Fluss dementsprechend abwechselnd durch die Spule **10a** – Boden – **10c** – magnetischer Anker und dann Spule **10b** – Boden – Spule **10d** – magnetischer Anker geht.

[0035] Somit führt der Anker **8** dementsprechend um die Achse **5** die Schwingbewegung aus. Hier kann es bevorzugt vorgesehen sein, dass die dargestellten Spulen **10** gekapselt, beispielsweise vergossen, ausgeführt sind, um den Einsatz in einem nassen Medium wie z.B. Wasser, zu ermöglichen. Die hier wirkenden Kräfte im Schwingsystem bewirken die Bewegung des etwa fischförmig ausgebildeten elastischen Körpers, wobei durch die Eigenelastizität dieser Körper bei keiner Ansteuerung des Schwingsystems in die gerade Nullstellung zurückgeht, sondern jeweils wellenförmig derart ausgebildet ist, dass sich über den elastischen Körper 7 eine wandernde Welle ausbildet, die aufgrund der sich dadurch einstellenden Hin- und Herbewegung des das Förderelement bildenden Endbereiches die Förderung des Fluids in die gewünschte Richtung bewirkt.

[0036] Mit einer darartigen Fördervorrichtung z.B. als Pumpe für Wasser können kleinste Fördermengen realisiert werden, wobei nach einem Stillstand ein sicheres Anlaufen der Vorrichtung gewährleistet ist.

Patentansprüche

1. Vorrichtung zur Förderung eines Fluids mit einem Förderraum (2), der wenigstens eine Zuströmöffnung (3a), eine Abströmöffnung (3b) und ein Förderelement (4) aufweist, **dadurch gekennzeichnet**, dass das Förderelement (4) eine Förderfläche mit einem in Förderrichtung (6) bewegungsfreien Ende (4a) aufweist, mit dem eine ozillierende Hin- und Herbewegung ausführbar ist.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, dass das in Förderrichtung (6) bewegungsfreie Ende (4a) der Förderfläche (4) einen Hub senkrecht zur Förderrichtung (6) durchführt, insbesondere dadurch, dass die Förderfläche (4) um eine Achse (5) oszillierend antreibbar ist.

3. Vorrichtung nach einem der vorherigen Ansprüche, dadurch gekennzeichnet, dass das Förderelement (4) als elastischer sich in Förderrichtung (6) erstreckender Körper (7) ausgebildet ist, dessen in Förderrichtung (6) liegendes Ende die Förderfläche (4) bildet.

4. Vorrichtung nach Anspruch 3, dadurch gekennzeichnet, dass der elastische Körper (7) zumindest teilweise flossenförmig ausgebildet ist.

5. Vorrichtung nach einem der vorherigen Ansprüche, dadurch gekennzeichnet, dass der elastische Körper (7) einen Anfangsbereich (7a) aufweist, der im Förderraum (2) ortsfest angeordnet ist und um eine in Förderrichtung hinter dem Anfangsbereich angeordnete Achse (5) oszillierend drehbar/tordierbar ist, um im elastischen Körper (7) eine in Förderrichtung (6) wandernde Welle derart auszubilden, dass mit einem hinteren bewegungsfreien Bereich (4a) des elastischen Körpers (7) eine oszillierende Hin- und Herbewegung ausführbar ist.

6. Vorrichtung nach einem der vorherigen Ansprüche, dadurch gekennzeichnet, dass der elastische Körper (7) in Förderrichtung (6) einen Querschnitt aufweist, der sich von der Achse (5) bis zum hinteren Bereich (4) verjüngt, insbesondere derart, dass der Querschnitt fischförmig ist.

7. Vorrichtung nach einem der vorherigen Ansprüche, dadurch gekennzeichnet, dass der Förderraum (2) einen Strömungskanal ausbildet, der um den eleastischen Körper (7) bauchig erweitert ist, und sich insbesondere in Förderrichtungrichtung (6) verjüngt, so dass der elastische Körper (7) und der Förderraum (2) im wesentlichen aneinander angepasste Querschnitte aufweisen.

8. Vorrichtung nach einem der vorherigen Ansprüche, dadurch gekennzeichnet, dass Achse (5) von einem elektromagnetischen Schwingersystem oszillierend angetrieben ist.

9. Vorrichtung nach Anspruch 8, dadurch gekennzeichnet, dass senkrecht zur Achse (5) ein sich wenigstens einseitig, bevorzugt zweiseitig der Achse (5) erstreckender magnetischer Anker (8) angeordnet ist, wobei das jeweilige Ende (9) eines Ankers über je einem Doppelspulensystem (10) angeordnet ist.

10. Vorrichtung nach Anspruch 9, dadurch gekennzeichnet, dass die beiden Spulen (**10a**, **10b** bzw. **10c**, **10d**) eines Doppelspulensystems (10) in einem Takt derart elektrisch umsteuerbar sind, dass das Ankerende (9) eine ozillierende Hin- und Herbewegung ausführt.

Es folgen 3 Blatt Zeichnungen

Anhängende Zeichnungen

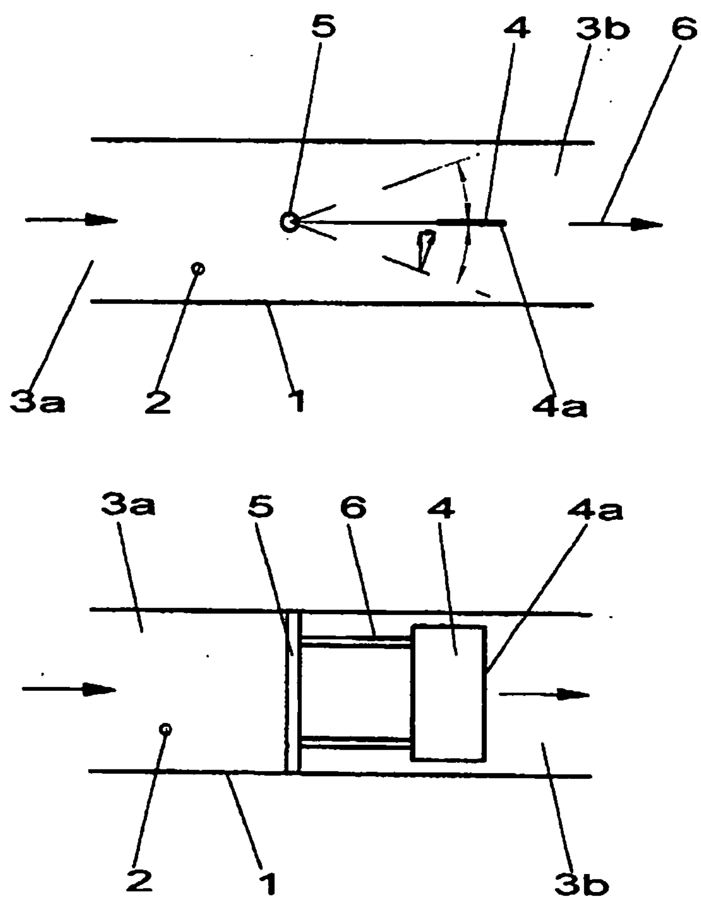


Fig. 1

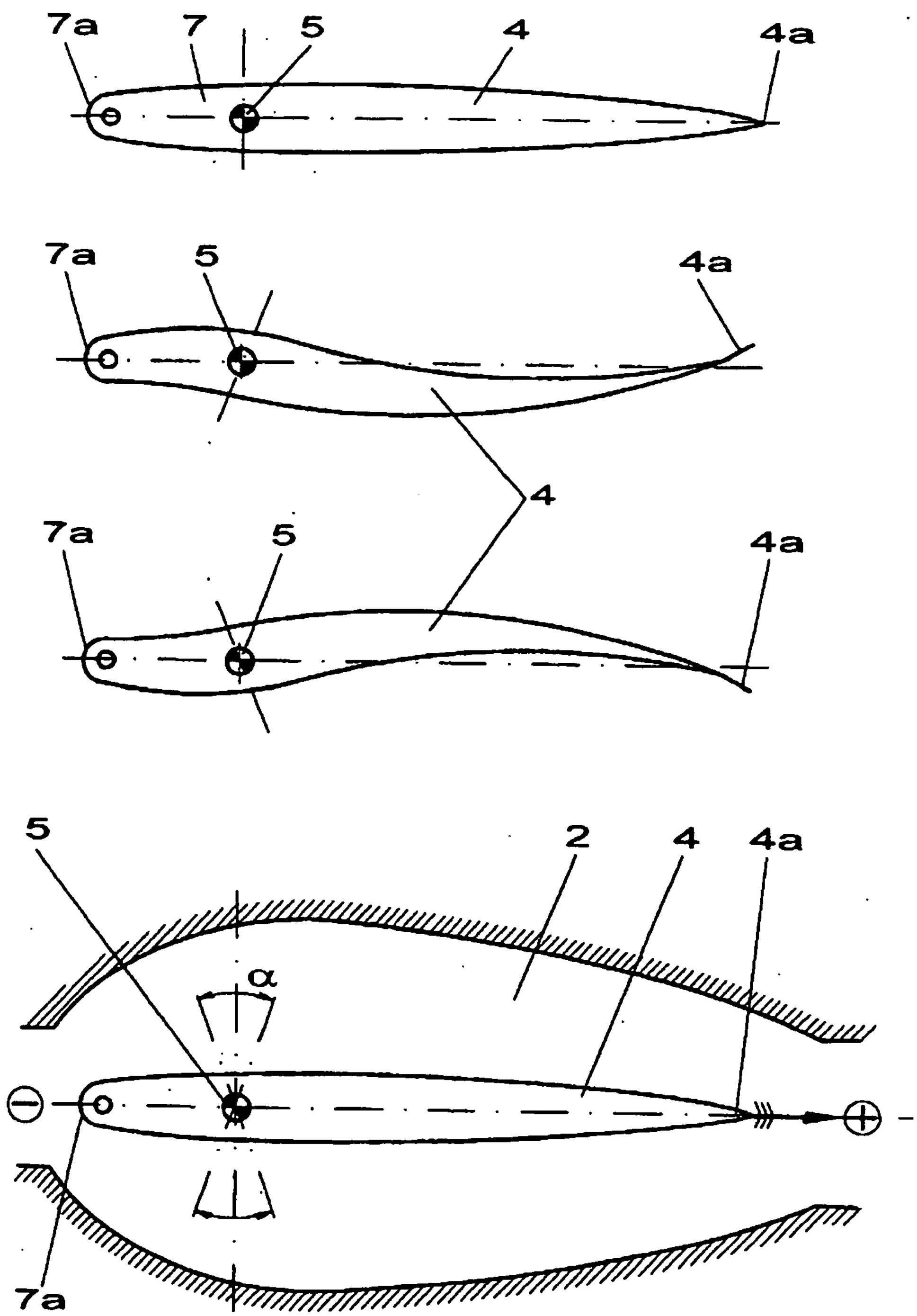


Fig. 2

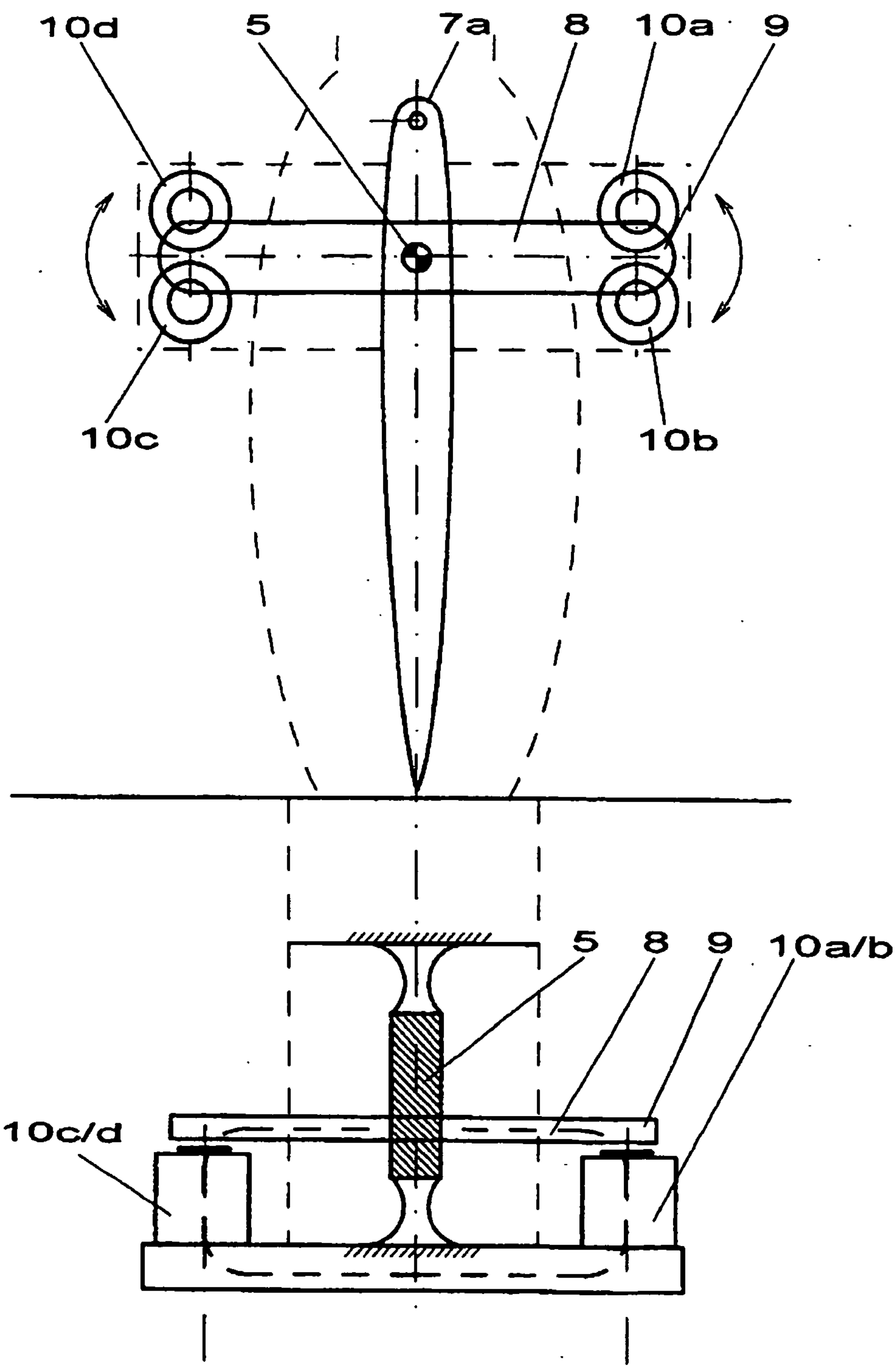


Fig. 3

Espacenet

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Pompe de refoulement oscillante

Inventor(s):	KUETTNER HUGO ± (KUETTNER HUGO)	
Applicant(s):		
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MINISTÈRE DE L'INDUSTRIE

SERVICE
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Pompe de refoulement oscillante.

M. Hugo KÜTTNER résidant en Autriche.

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Pour refouler des fluides liquides, semi-liquides ou gazeux, on connaît déjà des pompes ou des ventilateurs de divers types qui présentent comme organes de refoulement des pistons ou des pièces rotatives. Les grosses impuretés du fluide refoulé, telles que sable, gravier, morceaux de bois, etc., se manifestent souvent désagréablement dans ces pompes et donnent lieu à une forte usure des pièces mises mécaniquement en mouvement. Dans les pompes à pistons, la matière transportée peut aussi donner lieu à un déplacement des sièges des soupapes.

On connaît déjà une pompe de refoulement oscillante qui présente comme organe de refoulement une lame de ressort oscillante maintenue serrée d'un côté et disposée dans un canal fermé de tous côtés. L'endroit de serrage de la lame de ressort se trouve à proximité de l'entrée du fluide à refouler dans le canal. Pour mettre le ressort en oscillation, on a déjà proposé de disposer des deux côtés de ce ressort des aimants qui sont excités alternativement pour imprimer les impulsions nécessaires au ressort. L'invention vise à perfectionner essentiellement le rendement hydraulique d'une pompe refoulante oscillante de ce genre et obtient ce résultat du fait que le ressort oscillant est fixé à un arbre qui est disposé transversalement dans le canal et qui peut être mis en oscillations rotatives rythmiques, le nombre d'impulsions étant choisi égal ou presque égal à la fréquence d'oscillation propre du ressort oscillant. Il est ainsi possible, par un choix approprié de la fréquence propre d'oscillation, qui dépend en général de la masse et de la longueur du ressort oscillant, de fixer la vitesse de passage du courant du fluide refoulé. Ceci est particulièrement important en ce qui concerne le refoulement de boue épaisse, parce que, avec cette boue, les parties plus liquides se séparent dans le cas d'une trop grande vitesse de refoulement, ce qui pourrait conduire à un épaississement de la boue et, le cas échéant, à un bouchage de la pompe.

L'invention est expliquée avec plus de détail dans ce qui suit.

La fig. 1 est une coupe longitudinale schématique de la pompe de refoulement oscillante.

La fig. 2 est une coupe transversale de la pompe suivant la ligne II-II de la fig. 1.

Le carter à canal de la pompe est constitué par une pièce médiane allongée 1 qui comporte à l'avant et à l'arrière deux ouvertures cylindriques 2, 3 pour le passage du fluide à refouler. La pièce médiane 1 est percée des deux côtés entre les deux ouvertures cylindriques et est fermée par deux plaques de recouvrement 4, 5, de sorte qu'un canal complètement fermé est formé. A proximité de l'ouverture d'entrée 2, le canal présente un élargissement cylindrique 6 dans lequel est disposé un arbre de commande 7 pour le ressort oscillant 8 constitué sous forme de lame. Les deux plaques latérales 4, 5 servent de paliers. L'une des deux plaques est traversée par l'arbre 7 et se termine en une fusée 9 sur laquelle un levier 10 est fixé, par exemple claveté. Il est évident que des manchons ou roulements à billes peuvent être prévus pour le support de l'arbre 7 et que l'on peut, en outre, disposer des pièces d'étanchéité appropriées sur les paliers pour empêcher la sortie du fluide à refouler de la pompe en ces endroits.

Le levier 10 est relié par une bielle 11 à une manivelle 11' et on peut ainsi lui imprimer un mouvement de va-et-vient. Ce mouvement se fait à la cadence de la fréquence d'oscillation propre du ressort oscillant.

Le ressort 8, fixé dans une fente 12 de l'arbre 7, est constitué, de préférence, sous la forme d'un corps composite à plusieurs couches; il est, par exemple, composé d'un corps central élastique pouvant être soumis à de grands efforts, par exemple de l'acier, qui est entouré par une matière élastique flexible, notamment du caoutchouc vulcanisé sur lui. Le ressort présente une section allant en s'amincissant dans le sens de la longueur. Suivant une forme de réalisation particulière, le ressort est constitué par une pièce médiane allongée sur les deux côtés de laquelle sont disposés des ressorts-lames plus courts.

Au lieu de la commande à manivelle, on peut aussi prévoir une commande oscillante. A cet effet, un corps rotatif, dont le centre de gravité massique est à l'extérieur de son axe de rotation, est placé sur le levier 10 à une certaine distance radiale de l'arbre 7. Ce corps rotatif peut être mis en rotation de façon quelconque, par exemple au moyen d'une commande à courroie ou par un arbre entraîné à la cardan. Dès que ce corps est mis en rotation, il exécute un mouvement oscillant autour de l'axe de l'arbre 7 et met, par suite, également le ressort oscillant 8 en oscillations rythmiques par l'intermédiaire de cet arbre 7.

Pour produire de plus hautes pressions, on peut disposer plusieurs ressorts oscillants 8 en série dans le canal.

Diverses modifications peuvent d'ailleurs être apportées à la forme de réalisation, représentée et décrite en détail, sans sortir du cadre de l'invention.

RÉSUMÉ

Pompe de refoulement oscillante comportant comme organe de refoulement un ressort, essentiellement en forme de lame, maintenu serré d'un côté et oscillant dans un canal fermé, remarquable notamment par les caractéristiques suivantes, considérées séparément ou en combinaison :

a. Le ressort oscillant est fixé sur un arbre qui est disposé transversalement dans le canal et qui peut être mis en oscillations rotatives rythmiques, le nombre d'impulsions étant choisi égal ou presque égal à la fréquence propre d'oscillation du ressort;

b. Le ressort oscillant est constitué sous la forme d'un corps composite comprenant un noyau en acier ou matière analogue qui est revêtu par une matière élastique flexible, par exemple du caoutchouc vulcanisé sur lui;

c. Le ressort oscillant est constitué par une lame centrale sur les deux côtés de laquelle sont placées de plus courtes lames de ressort;

d. La section du ressort oscillant va en rétrécissant en partant de l'endroit de serrage dans le sens de la longueur;

e. Le ressort oscillant est muni d'un levier de commande relié à une manivelle;

f. Le levier du ressort oscillant présente, à une certaine distance radiale de l'arbre oscillant, un corps rotatif déséquilibré (balourd) dont le nombre de tours est égal à la fréquence propre d'oscillation du ressort;

g. Plusieurs ressorts oscillants sont disposés en série dans le canal.

Hugo KÜTTNER

Par procuration :
René MADEUF

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FIG. 1

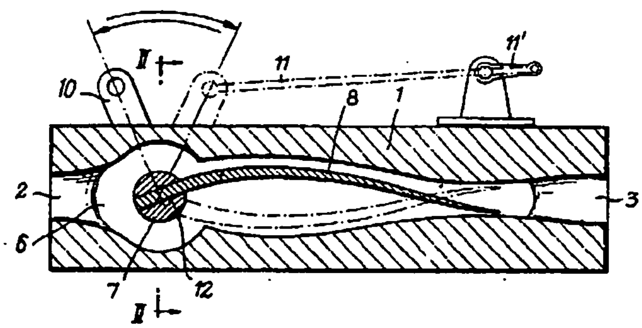
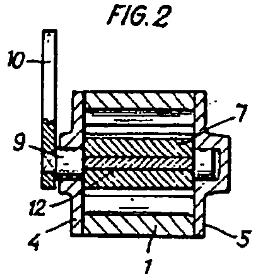


FIG. 2



Espacenet

Bibliographic data: EP2194278 (A1) — 2010-06-09

Fluid pump with a rotor

Inventor(s):	SCHECKEL MARIO [DE] + (SCHECKEL, MARIO)
Applicant(s):	ECP ENTWICKLUNGSGMBH [DE] + (ECP ENTWICKLUNGSGESELLSCHAFT MBH)
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Abstract of EP2194278 (A1)

The fluid pump has a rotor (18) with rotor blades (20,21) for supplying fluid. A diameter of a rotor is changed between a compressed condition and another expanded condition. The rotor blades are deformed between the compressed condition and expanded condition by a fluid counter pressure (23) with a rotation of the rotor in the pumping operation. An independent claim is also included for a method for operating a fluid pump.

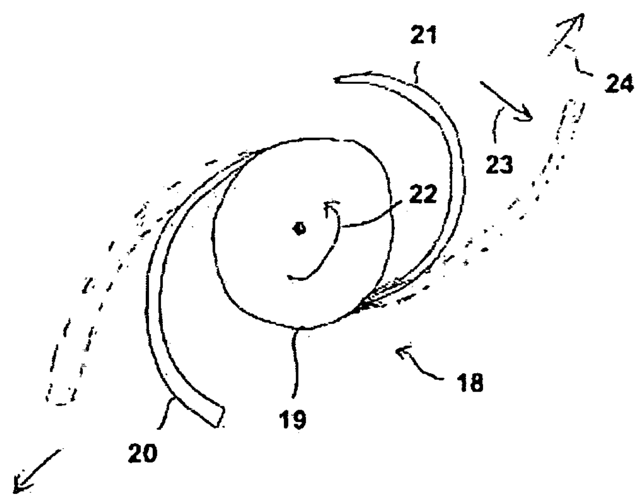

Fig. 3

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(71) Anmelder: **ECP Entwicklungsgesellschaft mbH
12247 Berlin (DE)**

(72) Erfinder: **Scheckel, Mario
13187 Berlin (DE)**

(74) Vertreter: **Pfenning, Meinig & Partner GbR
Patent- und Rechtsanwälte
Joachimstaler Strasse 10-12
10719 Berlin (DE)**

(54) **Fluidpumpe mit einem rotor**

(57) Die Erfindung bezieht sich auf eine Fluidpumpe, insbesondere auf eine Flüssigkeitspumpe mit einem Rotor (18) mit wenigstens einem Rotorblatt (20, 21) zur Förderung des Fluids, wobei der Rotor bezüglich seines Durchmessers zwischen einem ersten, komprimierten Zustand und einem zweiten, expandierten Zustand veränderbar ist. Zur Realisierung einer einfachen Komprimierbarkeit und Expandierbarkeit des Rotors der Pumpe ist gemäß der Erfindung vorgesehen, dass das wenigstens eine Rotorblatt zwischen einem ersten Zustand, den es im komprimierten Zustand des Rotors einnimmt, und einem zweiten Zustand, den es im expandierten Zustand des Rotors einnimmt, durch einen Fluidgegendruck (23) bei einer Rotation des Rotors im Pumpbetrieb verformbar ist.

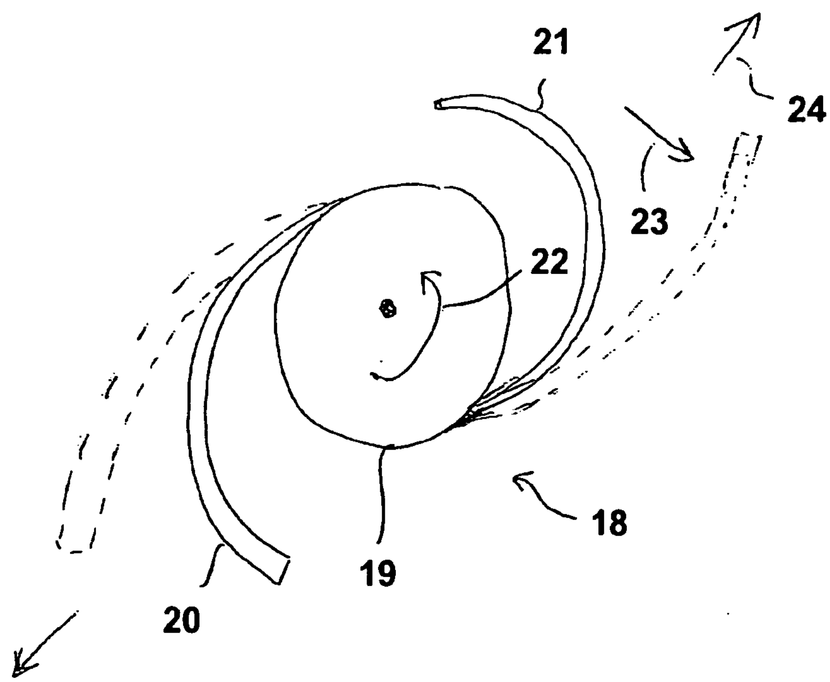

Fig. 3

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Beschreibung

[0001] Die Erfindung liegt auf dem Gebiet der Fluidpumpen und betrifft eine Pumpe, die bezüglich ihres Rotordurchmessers veränderbar ist, um beispielsweise durch enge Öffnungen, wie Röhren, insbesondere Blutgefäße, durchgeführt und nach der Durchführung in expandiertem Zustand betrieben werden zu können.

[0002] Die Anwendung kann somit einerseits im medizinischen Bereich, beispielsweise als Blutpumpe zur Herzunterstützung, in minimalinvasiver Weise vorgesehen sein, andererseits ist jedoch auch ein Einsatz in Rührwerken oder als Vortriebselement für Schiffe denkbar.

[0003] Besondere Vorteile kann die Erfindung durch die mögliche Miniaturisierung im medizinischen Bereich entfalten.

[0004] Dort kann, nach Einführung der Fluidpumpe durch ein großes Blutgefäß bis in die Herzkammer und nachfolgende Inbetriebnahme nach Expansion des Rotors, die Pumpleistung eines Herzens beispielsweise beim Menschen erheblich unterstützt oder teilweise ersetzt werden. Der therapeutische Vorteil solcher Anwendungen liegt in einer zumindest teilweisen Entlastung des Herzmuskels.

[0005] Derartige expandierbare Fluidpumpen sind aus dem Stand der Technik bereits bekannt. Beispielsweise geht aus der DE 10 059 714 C1 eine Pumpe hervor, die mitsamt dem Pumpenantrieb durch ein Blutgefäß geschoben werden kann. Das Blut fließt dort durch eine Kanüle, deren Durchmesser zur Veränderung der Strömungsverhältnisse expandierbar und komprimierbar ist.

[0006] Aus der WO 03/103745 A2 ist eine Blutpumpe bekannt, deren Rotor radial komprimierbar und expandierbar ist, wobei dort verschiedene Konstruktionen zur Erreichung der Expandierbarkeit vorgeschlagen werden. Beispielsweise kann durch verschiedene gegeneinander verschiebbare Teile des Katheters nach der Einführung eine Stauchung des Pumpengehäuses und damit verbunden eine radiale Aufweitung erfolgen. Andererseits ist die Möglichkeit offenbart, durch Drehung einer Antriebswelle gegenüber einem in dem Katheter befindlichen Draht eine Helixstruktur des Drahtes zu erzeugen, wobei der Draht zudem eine Membran trägt, die nach Annahme der Helixstruktur eine Rotorschaufel bildet.

[0007] Zudem ist aus dem Dokument eine Rotorstruktur mit einer Mehrzahl von in sich steifen, schwenkbar an einem zentralen Teil angelenkten Schaufeln bekannt, die sich im Betrieb aufstellen und damit einen Fluiddruck erzeugen.

[0008] Aus der EP 0 768 900 B1 ist eine Pumpe bekannt, bei der innerhalb eines Pumpengehäuses an eine Welle Rotorblätter derart angelenkt sind, dass sie im Ruhezustand an die Welle angeklappt und im Betrieb senkrecht zur Welle aufgestellt werden können, um das Fluid zu fördern.

[0009] Dem bekannten Stand der Technik ist gemein, dass Rotorblätter einer Pumpe zur Expansion entweder mittels eines Schwenkmechanismus aufgeschwenkt werden oder durch eine mechanische Vorrichtung nach Art eines Bowdenzuges oder ähnlich erst zur Expansion der Pumpe gebildet werden.

[0010] Der vorliegenden Erfindung liegt vor dem Hintergrund des Standes der Technik die Aufgabe zugrunde, eine Fluidpumpe mit einem bezüglich seines Durchmessers komprimierbaren Rotor zu schaffen, der konstruktiv möglichst einfach aufgebaut ist, der vorzugsweise wie das ihn umgebende Pumpengehäuse aus biokompatiblen Materialien besteht, dessen Expansion und Kompression möglichst einfach bewerkstelligt werden können und der im Betrieb die notwendige Zuverlässigkeit aufweist.

[0011] Die Aufgabe wird gemäß der Erfindung mit den Merkmalen des Patentanspruchs 1 gelöst.

[0012] Zudem bezieht sich die Erfindung auf Verfahren zum Betrieb der erfindungsgemäßen Fluidpumpe gemäß den Ansprüchen 16, 17 oder 18.

[0013] Der Erfindung liegt die Erkenntnis zugrunde, dass eine möglichst einfache Struktur der Fluidpumpe durch eine Verformbarkeit eines Rotorblattes selbst zu realisieren ist. Der Rotor der Fluidpumpe weist dazu wenigstens ein Rotorblatt auf, das sich in einem ersten Zustand befindet, so lange der Rotor einen ersten, komprimierten Zustand einnimmt, wobei das Rotorblatt bei Übergang des Rotors in einem expandierten Zustand durch Verformung einen zweiten Zustand einnimmt.

[0014] Dabei wird das Rotorblatt von dem ersten Zustand in den zweiten Zustand durch den Fluidgegendruck überführt, der bei der Rotation des Rotors im Pumpbetrieb auftritt.

[0015] Ein besonderer Vorteil der Erfindung liegt darin, dass keine Betätigungselemente zur Expansion des Rotors außer dem eigentlichen Antrieb der Pumpe vorgesehen werden müssen und dass durch die Verformbarkeit des/der Rotorblätter in sich auch keine schwenkbare Anlenkung von Rotorblättern an anderen Teilen der Pumpe vorgesehen werden muss.

[0016] Es tritt auch bei der Durchführung der Fluidpumpe durch eine Röhre, beispielsweise ein Blutgefäß, kein Bestreben des Rotors auf, ohne äußere Einflüsse zu expandieren. Ein derartiges Bestreben wäre bei medizinischem Einsatz nicht wünschenswert, da die Wände der Blutgefäße durch die die Pumpe durchgeführt wird, geschont werden sollen. Bei der Applikation durch einen röhrenförmigen künstlichen Zugang (Schleuse) würden die beschriebenen Rückstellkräfte eine besondere Schwierigkeit darstellen, da hierdurch hohe Reibungskräfte an der Wand der künstlichen Röhre entstünden und erhebliche Kräfte zum Vorschieben der Fluidpumpe in das Körperinnere erzeugt werden müssten.

[0017] Solange die Pumpe nicht betrieben, d.h. an der Pumpwelle nicht gedreht wird, bleibt der Rotor in dem komprimierten Zustand und kann durch das Blutgefäß vorgeschoben werden.

[0018] Wird die Pumpe an Ort und Stelle in Betrieb genommen, so wird der Rotor in Förderrichtung angetrieben und das/die Rotorblätter werden durch den Fluidgegendruck verformt und somit aufgestellt, wodurch die eigentliche, vollumfängliche Förderung in Gang kommt. Dabei ist es vorteilhaft, wenn die Verformung des/der Rotorblätter elastisch ist, da in vielen Anwendungsfällen die Fluidpumpe nach der Anwendung wieder komprimiert werden muss, um entfernt zu werden.

[0019] In diesem Fall nimmt das Rotorblatt/nehmen die Rotorblätter nach Einstellen des Pumpbetriebs und Stillsetzung des Rotors wieder ihren ersten Zustand ein, in dem der Rotor komprimiert ist.

[0020] Vorteilhaft ist ebenfalls, wenn die Verformbarkeit des wenigstens einen Rotorblatts durch Materialeigenschaften und/oder im konstruktiven Aufbau des Rotorblatts begrenzt ist.

[0021] Dabei soll die Grenze vorteilhaft dort liegen, wo durch die Verformung eine Form des Rotors angenommen wird, die die optimale Förderleistung erlaubt.

[0022] Dies kann gemäß der Erfindung vorteilhaft dadurch erreicht werden, dass das wenigstens eine Rotorblatt eine bei Förderbetrieb in Bewegungsrichtung vorlaufende und eine nachlaufende Seite aufweist, die verschieden gestaltet sind.

[0023] Üblicherweise wird die im Betrieb vorlaufende Seite des Rotorblattes vorwiegend auf Zug beansprucht, während die nachlaufende Seite einer Druckbeanspruchung unterliegt. Dabei kann die Trennfläche zwischen der vorlaufenden und der nachlaufenden Seite dort gedacht werden, wo eine neutrale Beanspruchung im Pumpbetrieb vorliegt. Diese Trennfläche muss entsprechende Schub- und Scherspannungen aufnehmen.

[0024] Es kann beispielsweise vorgesehen sein, dass die vorlaufende Seite und die nachlaufende Seite des Rotorblattes im Bereich der Trennfläche miteinander verklebt oder durch andere Fügetechniken miteinander verbunden sind.

[0025] Die für die Erfindung vorteilhaften Eigenschaften des Rotorblattes können beispielsweise dadurch erreicht werden, dass die vorlaufende Seite des wenigstens einen Rotorblatts aus einem ersten Material und die nachlaufende Seite aus einem zweiten, von dem ersten verschiedenen Material besteht.

[0026] Als vorteilhaft erweist es sich, wenn das erste Material dehnbarer ist als das zweite Material.

[0027] Das erste Material sollte dabei eine Dehngrenze aufweisen, so dass bei der Verformung des Rotorblattes im Pumpbetrieb eine möglichst genau definierte Grenze erreicht wird und sich eine definierte Form des Rotorblattes im Betrieb einstellt. Eine solche Dehngrenze ist beispielsweise durch einen nicht linearen Bereich der Elastizitätskoeffizienten des Materials gegeben, so dass die zur Dehnung notwendige Kraft ab einer bestimmten Dehngrenze überproportional ansteigt und die Form sich hierdurch stabilisiert. Diese Eigenschaft kann dem ersten Material eigen sein, sie kann jedoch dadurch unterstützt oder im Wesentlichen realisiert sein, dass in das erste Material dehnfeste Fasern eingebettet sind, die wesentlich dehnfester sind als das erste Material selbst und die im ersten Zustand des Rotorblattes ungestreckt, im zweiten Zustand in gestreckter Form in dem ersten Material vorliegen. Solche Fasern können beispielsweise durch hochfeste Kunststoffe oder durch Glas oder durch Kohlenstofffasern gebildet sein.

[0028] Das zweite Material auf der nachlaufenden Seite der Rotorblätter kann inkompressibel oder nur bis zu einer bestimmten Kompressibilitätsgrenze verformbar sein. Vorteilhaft ist die Verformbarkeit elastisch. Die Kompressionsgrenze kann beispielsweise durch eine Nichtlinearität der Kompressionskoeffizienten gebildet sein, indem die zur Kompression notwendige Kraft von einem bestimmten Kompressionsgrad an überproportional ansteigt.

[0029] Es kann auch vorteilhaft vorgesehen sein, dass das wenigstens eine Rotorblatt auf der nachlaufenden Seite Formelemente aufweist, die im ersten Zustand voneinander beabstandet sind und die im zweiten Zustand aneinander anliegen.

[0030] Diese Formelemente können im ersten Zustand durch Schlitze voneinander getrennt oder auch in ein komprimierbares Material eingebettet sein. Jedenfalls begrenzen sie, indem sie in dem zweiten Zustand aneinander anliegen, eine weitere Verformbarkeit des Rotorblattes.

[0031] Eine weitere vorteilhafte Ausgestaltung der Erfindung sieht vor, dass wenigstens ein Anschlagselement auf einer Seite des wenigstens einen Rotorblatts befestigt ist, welches die Trennfläche zwischen der vorlaufenden Seite und der nachlaufenden Seite durchsetzt und auf der anderen Seite des Rotorblatts in einer Ausnehmung begrenzt beweglich ist.

[0032] Das Anschlagselement ist vorteilhaft aus einem Material hergestellt, das annähernd so inkompressibel oder genauso inkompressibel ist wie das Material aus dem die nachlaufende Seite des Rotorblattes besteht, um eine definierte Anschlagsposition zu erzielen. Das Anschlagselement kann beispielsweise aus einem Metall oder einem harten Kunststoff bestehen.

[0033] Die Erfindung bezieht sich außer auf eine Fluidpumpe zudem auf ein Verfahren zum Betrieb einer Fluidpumpe der beschriebenen Form, wobei die Pumpe durch Rotation des Rotors in Betriebsrichtung gestartet und der Rotor durch den Fluidgegendruck expandiert wird.

[0034] Es kann zudem auch vorgesehen sein, dass zur Verringerung des Rotordurchmessers der Rotor in der der Betriebsrichtung entgegengesetzten Richtung angetrieben wird.

[0035] Es ist damit durch die Erfindung ermöglicht, dass der Rotor während des Durchführens der Pumpe durch eine Öffnung, insbesondere ein Blutgefäß in der der Betriebsrichtung entgegengesetzten Richtung angetrieben und damit komprimiert wird.

[0036] Die Erfindung wird nachfolgend anhand eines Ausführungsbeispiels in einer Zeichnung gezeigt und anschließend erläutert.

[0037] Dabei zeigt

Fig. 1 schematisch die Anwendung einer Fluidpumpe in einem Herz zur Förderung von Blut,

Fig. 2 schematisch einen Pumpenkopf im Längsschnitt mit radialer Anströmung,

Fig. 2a schematisch einen Pumpenkopf im Längsschnitt mit axialer Anströmung,

Fig. 3 schematisch einen Rotor mit zwei Rotorblättern in einer Draufsicht,

Fig. 4 einen Rotor in einer seitlichen Ansicht,

Fig. 5 einen Schnitt durch einen Teil eines Rotorblattes,

Fig. 6 einen Schnitt durch einen Teil eines Rotorblattes in einer anderen Ausgestaltung,

Fig. 7 einen Schnitt durch einen Teil eines Rotorblattes,

Fig. 8 eine Ausschnittvergrößerung des in der Fig. 7 mit VIII bezeichneten Details,

Fig. 9 einen Schnitt durch ein Rotorblatt in einer weiteren Ausführungsform,

Fig. 10 eine Ausführungsform eines Rotors mit einem helixförmigen Rotorblatt, das durch Formelemente gestützt ist,

Fig. 11 einen Rotor, dessen helixförmiges Blatt durch eine schraubenförmige Wicklung gestützt ist, und

Fig. 12 einen Rotor, dessen helixförmiges Rotorblatt durch eine Kulissenführung gestützt ist.

[0038] Die Fig. 1 zeigt schematisch im Querschnitt ein Herz 1, bei dem in eine Herzkammer 2 der Kopf 3 einer Fluidpumpe hineinragt. Der Pumpenkopf 3 ist am Ende einer Kanüle 4 angeordnet und weist ein vorn abgerundetes Pumpengehäuse 5 auf.

[0039] Der Antrieb der Pumpe erfolgt über eine Antriebswelle 6, die längs durch die Kanüle 4 verläuft und außen mit einem Motor 7 verbunden ist.

[0040] Der Motor 7 kann in beiden Richtungen 8, 9 angetrieben werden, wobei nur in einer Drehrichtung tatsächlich eine Förderung von Fluid stattfindet.

[0041] In der Fig. 2 ist schematisch im Längsschnitt der Pumpenkopf 3 mit dem Pumpengehäuse 5 gezeigt sowie die Antriebswelle 6. Diese ist am vorderen Ende des Pumpenkopfes 3 in einem Lagerbock 10 mittels eines Lagers 11 drehbar gelagert.

[0042] Die Fig. 2 zeigt den Pumpenkopf in einer expandierten Form, d.h. mit vergrößertem Radius gegenüber der Darstellung der Fig. 1.

[0043] Zur Einführung des Pumpenkopfes 3 durch ein Blutgefäß 12 in das Herz wird der Pumpenkopf 3 durch Lockerlassen der Welle oder durch Axialdruck auf die Welle radial komprimiert, d. h. in den Zustand seiner geringstmöglichen radialen Ausdehnung gebracht.

[0044] Ist der Pumpenkopf an dem gewünschten Ort angekommen, so kann das Pumpengehäuse durch Aufbringen eines Zuges in Richtung des Pfeils 13 axial zusammengezogen und dadurch radial aufgebläht werden, wie durch die Pfeile 14, 15 angedeutet.

[0045] Denkbar ist auch das Komprimieren und Aufblähen des Gehäuses durch Verformung des Gehäuses mittels Nutzung von Formgedächtniswerkstoffen. Hierbei wird das Sprungverhalten von Formgedächtniswerkstoffen bei bestimmten Temperaturen ausgenutzt. Durch die Schlitze 16, 17, die in axialer Richtung der Welle 6 verlaufen, kann durch das Pumpengehäuse 5 hindurch Fluid, also im vorliegenden Fall Blut, zu dem Rotor 18 der Pumpe gelangen und durch diesen weiter befördert werden, beispielsweise axial durch die Kanüle 4. In Fig. 2 ist die Anströmung des Rotors radial ausgeführt. In Fig. 2a ist schematisch eine Ausführung mit axialer An- und Abströmung dargestellt.

[0046] Der Rotor weist einen Rotorblattträger 19 sowie Rotorblätter 20, 21 auf, wobei die Rotorblätter 20, 21 im Pumpbetrieb, d.h. im expandierten Zustand des Rotors aufgeklappt sind.

[0047] Der Radius des Rotors im Betrieb ist auf den Innendurchmesser des Pumpgehäuses in dessen aufgeblähtem Zustand abgestimmt.

[0048] Soll der Pumpenkopf aus dem Herz 1 entfernt werden, so wird der Pumpbetrieb eingestellt und die Rotorblätter 20, 21 legen sich an den Rotorblattträger 19 zur Verringerung des Radius des Rotors 18 an. Dies wird vorteilhaft durch eine Rotation des Rotors 18 in der dem Pumpbetrieb entgegengesetzten Drehrichtung unterstützt.

[0049] Wird dann die Welle 16 zum Pumpenkopf 3 nach Art eines Bowdenzuges verschoben, so nimmt der Pumpenkopf wieder seine komprimierte Form ein und kann durch das Blutgefäß 12 entfernt werden.

[0050] Die Fig. 3 zeigt im Detail eine Draufsicht auf den Rotor 18 mit dem Rotorblattträger 19 und den Rotorblättern 20, 21, wobei diese in durchgezogener Form in ihrem ersten Zustand, d.h. dem komprimierten Zustand des Rotors, dargestellt sind. Die Rotorblätter können in dem ersten Zustand auch noch enger an dem Rotorblattträger 19 anliegen.

[0051] Wichtig ist, dass bei Aufnahme des Pumpbetriebes und Drehung des Rotors 18 in der zum Förderbetrieb notwendigen Drehrichtung 22 ein Fluidgegendruck in Richtung des Pfeils 23 gegen die Rotorblätter entsteht und diese unter Aufweitung des Radius des Rotors 18 aufgebogen werden. Ist die Pumpe als Radialpumpe ausgelegt, so wird das Fluid radial nach außen in Richtung des Pfeils 24 verdrängt und damit gefördert.

[0052] Sind die Rotorblätter 20, 21 in Axialrichtung profiliert, so kann das Fluid auch in der Axialrichtung gefördert werden, wie in Fig. 4 durch die Pfeile 25, 26 angedeutet.

[0053] Wird der Rotor in einer der zur Förderung notwendigen Drehrichtung 22 entgegengesetzten Drehrichtung betrieben, so entsteht auf die Rotorblätter 20, 21 ein Fluidgegendruck, der der Richtung 23 entgegengesetzt ist und der zum Anklappen der Rotorblätter an den Rotorblattträger 19 und zu einer entsprechenden Reduzierung des Rotordurchmessers führt. In diesem Zustand kann der Rotor mit entsprechend komprimiertem Pumpengehäuse 5 aus dem Herzen durch die Blutbahn entfernt werden.

[0054] Durch die Wahl der Drehrichtung und der Drehzahl kann somit einerseits der Durchmesser des Rotors gezielt verändert werden, andererseits die Förderleistung der Pumpe wunschgemäß eingestellt werden.

[0055] Die Fig. 5 zeigt beispielhaft ein Rotorblatt 21 mit einer im Pumpenbetrieb vorlaufenden Seite 27 sowie einer nachlaufenden Seite 28, wobei das Rotorblatt entlang einer Trennfläche 29 auf deren beiden Seiten unterschiedliche Beschaffenheiten aufweist. Im Betrieb wirkt auf das Rotorblatt ein Fluidgegendruck in Richtung des Pfeils 23 und verformt dieses in den zweiten Zustand in dem der Rotor expandiert ist. Hierzu muss die vorlaufende Seite 27 in einem gewissen Maß dehnbar sein und die entsprechende erste Materialschicht 30 weist aus diesem Grunde Membraneigenschaften auf. Es kann sich bei dieser ersten Materialschicht beispielsweise um Gummi oder ein elastisches Kunststoffmaterial handeln, das bis zu einer Dehngrenze elastisch verformbar ist und sich möglichst danach einer weiteren Dehnung widersetzt.

[0056] Auf der nachlaufenden Seite 21 besteht die zweite Materialschicht 31 aus einem druckfesten Material, das beispielsweise so hart gestaltet ist, dass es sich bei den im Betrieb wirkenden Kräften nur minimal verformt, so dass die Biegung des Rotorblattes ausschließlich über die Dehnung der ersten Materialschicht 30 realisiert wird.

[0057] Es kann jedoch eine gewisse Kompressibilität der zweiten Materialschicht 31 vorgesehen sein.

[0058] Die Fig. 6 zeigt ein weiteres Beispiel zur Gestaltung eines Rotorblattes, bei dem in der zweiten Materialschicht 31 Einkerbungen 32 vorgesehen sind, die die Kompression und Biegung der nachlaufenden Seite erlauben, bis dass die Kerben 32 geschlossen sind und die verschiedenen zwischen den Kerben 32 gebildeten Stege formschlüssig aneinanderstoßen. In diesem Zustand würde eine weitere Biegung des Rotorblattes gestoppt.

[0059] Das Material der ersten Materialschicht 31 kann in diesem Fall ebenfalls ein harter Kunststoff sein, aus dem Teile ausgeschnitten oder in einen Guss- oder Prägevorgang ausgespart werden.

[0060] Auch in diesem Fall besteht das Material der ersten Materialschicht 30 aus einem begrenzt dehnbaren Stoff.

[0061] In der Fig. 7 ist ein Rotorblatt im Querschnitt dargestellt, wobei die Einzelheit VIII in der Fig. 8 detaillierter gezeigt ist. Die Einzelheit VIII zeigt dabei die druckfeste zweite Materialschicht 31a, die ihrerseits mehrschichtig aufgebaut ist nach Art einer Sandwichstruktur, wobei diese aus zug- und/oder druckfesten Außenschichten 33, 34 35, 36 sowie einer Volumenschicht 37 besteht. Die Außenschichten 35, 36 können beispielsweise gewebeverstärkt sein.

[0062] Damit wird auf der nachlaufenden Seite eine sehr druckfeste Schicht gebildet, so dass die Verformbarkeit des Rotorblattes im Wesentlichen durch die Dehnbarkeit der vorlaufenden Seite 27 bestimmt ist.

[0063] In der Fig. 9 ist eine Variante dargestellt, bei der ein Anschlagselement 38 in der ersten Schicht 30 befestigt ist, beispielsweise mittels einer eingelassenen Schraube 39, wobei das Anschlagselement 38 in eine Öffnung 40 der zweiten Schicht 31 hineinragt.

[0064] Wird das Rotorblatt 21 verformt, so wird sich die Öffnung 40 in der zweiten Materialschicht 31 tendenziell verkleinern und verschieben, bis die Ränder der Öffnung 40 an das Anschlagselement 38 anschlagen. Das Anschlagselement besteht aus einem harten Material, ebenso wie die zweite Materialschicht 31, so dass nach dem Anschlagen keine weitere Kompression auf der nachlaufenden Seite möglich ist und das Schaufelblatt sich gegen weitere Verformung versteift.

[0065] Fig. 10 zeigt ein helixförmiges Rotorblatt, bei dem eine Reihe von Formelementen 41, 42 auf der nachlaufenden Seite des Blattes mit diesem verbunden, beispielsweise aufgeklebt oder mit anderen Fügeverfahren aufgebracht ist. Im komprimierten Zustand des Rotors ist zwischen den Formelementen jeweils Abstand. Beim Betrieb der Pumpe und nach Aufrichten des Blattes liegen die Formelemente aneinander an und versteifen sich als durchgehender Steg, der die als Membran wirkenden Flächenteile des Blattes stützt und eine weitere Verformung verhindert. Mehrere solche Reihen von Formelementen können entlang der Antriebswelle 6 axial und azimutal versetzt angeordnet sein.

[0066] Eine ähnliche Konstruktion ist in Fig. 11 gezeigt, wo der Steg zur Verfestigung des Rotorblattes durch eine aus Windungen bestehende Wicklung, beispielsweise bestehend aus einem Kunststoff, einem Federdraht oder aus einem Schlauch gebildet ist. Die einzelnen Windungen bilden je ein Formelement und sind einzeln mit der membranartigen Fläche des Rotorblattes durch Kleben verbunden. Beim Komprimieren des Rotors öffnen sich die Zwickel zwischen den Windungen, und diese schließen sich beim Aufrichten des Blattes. Um die Wicklung zu stabilisieren, ist innerhalb dieser ein durchgehender Kern vorgesehen, der flexibel sein kann.

[0067] Die Fig. 12 zeigt die Stützung eines Rotorblattes durch eine feste Schiene/Kulisse 45, in der ein Anschlagselement begrenzt beweglich ist. Das Anschlagselement ist mit dem Rotorblatt verbunden.

[0068] Die Schiene/Kulisse 45 kann bezogen auf die zu erwartenden angreifenden Kräfte und Momente als knickfestes und druckfestes Bauteil ausgeführt sein. Durch die Biegung entstehen bei dieser Ausführung geringe zusätzliche Rückstellkräfte. Durch die geringe Materialstärke werden absolut gesehen wenig Rückstellkräfte erzeugt.

[0069] In Fig. 12 befindet sich das Anschlagselement in der unteren Position. Ein Verbiegen bis zum Knickfall würde für diese Position durch die geringe Länge zwischen Kulissenaufnahme an der Welle 6 und Position des Führungsstiftes in der Schiene/Kulisse 45 hohe angreifende Kräfte erfordern.

[0070] Die genannten und beschriebenen Konstruktionen von Rotorblättern sind Beispiele dafür, wie durch unterschiedliche Gestaltung der verschiedenen Seiten der Rotorblätter eine begrenzte Verformbarkeit durch den Fluidgegendruck im Betrieb erreicht werden kann.

[0071] Bei einer Rotation des Rotors in einer der Betriebsrichtung entgegengesetzten Richtung wird die Verformung der Rotorblätter rückgängig gemacht, und diese legen sich an den Rotor an, nehmen einen ersten Zustand an und definieren damit den komprimierten Zustand des Rotors, in dem dieser durch eine enge Öffnung, beispielsweise ein Blutgefäß oder einen röhrenförmigen künstlichen Zugang (Schleuse)), komfortabel bewegt werden kann.

[0072] Damit erlaubt die Erfindung in konstruktiv besonders einfacher Weise die Realisierung eines in seinem Durchmesser veränderbaren Rotors für verschiedene Anwendungen, besonders vorteilhaft jedoch für den medizinischen Bereich.

Patentansprüche

1. Fluidpumpe, insbesondere Flüssigkeitspumpe mit einem Rotor (18) mit wenigstens einem Rotorblatt (20, 21) zur Förderung des Fluids, wobei der Rotor bezüglich seines Durchmessers zwischen einem ersten, komprimierten Zustand, und einem zweiten, expandierten Zustand veränderbar ist,
dadurch gekennzeichnet,
dass das wenigstens eine Rotorblatt (20, 21) zwischen einem ersten Zustand, den es im komprimierten Zustand des Rotors einnimmt, und einem zweiten Zustand, den es im expandierten Zustand des Rotors einnimmt, durch einen Fluidgegendruck (23) bei einer Rotation des Rotors im Pumpbetrieb verformbar ist.

2. Fluidpumpe nach Anspruch 1, **dadurch gekennzeichnet, dass** das wenigstens eine Rotorblatt (20, 21) durch den Fluidgegendruck (23) elastisch verformbar ist.

3. Fluidpumpe nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Verformbarkeit des wenigstens einen Rotorblatts (20, 21) durch Materialeigenschaften und/oder den konstruktiven Aufbau des Rotorblattes begrenzt ist.

4. Fluidpumpe nach Anspruch 3, **dadurch gekennzeichnet, dass** die Verformbarkeit des wenigstens einen Rotorblatts (20, 21) derart begrenzt ist, dass die Verformung nicht über die Form hinausgeht, bei der der Rotor den größtmöglichen Fluidgegendruck erzeugt.

5. Fluidpumpe nach Anspruch 1 oder einem der folgenden, **dadurch gekennzeichnet, dass** das wenigstens eine Rotorblatt (20, 21) eine bei Förderbetrieb in Bewegungsrichtung vorlaufende (27) und eine nachlaufende Seite (28) aufweist, die verschieden gestaltet sind.

6. Fluidpumpe nach Anspruch 5, **dadurch gekennzeichnet, dass** die vorlaufende Seite (27) des wenigstens einen Rotorblatts (20, 21) aus einem ersten Material und die nachlaufende Seite (28) aus einem zweiten, von dem ersten verschiedenen Material besteht.

7. Fluidpumpe nach Anspruch 5 oder 6, **dadurch gekennzeichnet, dass** das erste Material dehnbarer ist als das zweite Material.

8. Fluidpumpe nach Anspruch 7, **dadurch gekennzeichnet, dass** das erste Material eine Dehngrenze aufweist.

9. Fluidpumpe nach Anspruch 7 oder 8, **dadurch gekennzeichnet, dass** in das erste Material Fasern eingebettet sind, die wesentlich dehnfester sind als das erste Material.

10. Fluidpumpe nach Anspruch 5 oder einem der folgenden, **dadurch gekennzeichnet, dass** das zweite Material inkompressibel ist.

11. Fluidpumpe nach einem der Ansprüche 5 bis 9, **dadurch gekennzeichnet, dass** das zweite Material elastisch bis zu einer Kompressionsgrenze komprimierbar ist.

12. Fluidpumpe nach Anspruch 5 oder einem der folgenden, **dadurch gekennzeichnet, dass** das wenigstens eine Rotorblatt (20, 21) auf der nachlaufenden Seite (28) Formelemente (31, 41, 42, 43, 44) aufweist oder mit Formelementen verbunden ist, die im ersten Zustand voneinander beabstandet sind und die im zweiten Zustand aneinander anliegen.

13. Fluidpumpe nach Anspruch 12, **dadurch gekennzeichnet, dass** die Formelemente (31, 41, 42, 43, 44) im ersten Zustand durch Schlitze (32) voneinander getrennt sind.

14. Fluidpumpe nach Anspruch 12 oder 13, **dadurch gekennzeichnet, dass** die Formelemente (41, 42) auf eine Seite, insbesondere die nachlaufende Seite eines Rotorblattes aufgeklebt oder mit einem anderen Fügeverfahren aufgebracht sind.

15. Fluidpumpe nach Anspruch 12, 13 oder 14, **dadurch gekennzeichnet, dass** die Formelemente (43, 44) durch je eine Windung einer Wicklung gebildet sind.

16. Fluidpumpe nach Anspruch 12 oder einem der folgenden, **dadurch gekennzeichnet, dass** die Formelemente (31, 41, 42, 43, 44) in ein komprimierbares Material eingebettet sind.

17. Fluidpumpe nach Anspruch 5 oder einem der folgenden, **dadurch gekennzeichnet, dass** wenigstens ein Anschlagselement (38, 39) auf einer Seite des wenigstens einen Rotorblatts befestigt ist, welches die Trennfläche (29) zwischen der vorlaufenden Seite und der nachlaufenden Seite durchsetzt und auf der anderen Seite des Rotorblattes in einer Ausnehmung begrenzt beweglich ist.

18. Verfahren zum Betrieb einer Fluidpumpe nach einem der Ansprüche 1 bis 17, **dadurch gekennzeichnet, dass** die Pumpe durch Rotation des Rotors (18) in Betriebsrichtung gestartet und der Rotor durch den Fluidgegendruck (23) expandiert wird.

19. Verfahren zum Betrieb einer Fluidpumpe nach einem der Ansprüche 1 bis 15, **dadurch gekennzeichnet, dass** zur Verringerung des Rotordurchmessers dieser in der der Betriebsrichtung (22) entgegengesetzten Richtung angetrieben wird.

20. Verfahren zum Betrieb einer Fluidpumpe nach einem der Ansprüche 1 bis 15, **dadurch gekennzeichnet, dass** der Rotor (18) während des Durchführens der Pumpe durch eine Öffnung, insbesondere ein Blutgefäß oder ein röhrenförmiger künstlicher Zugang, in der der Betriebsrichtung entgegengesetzten Richtung (22) angetrieben wird.

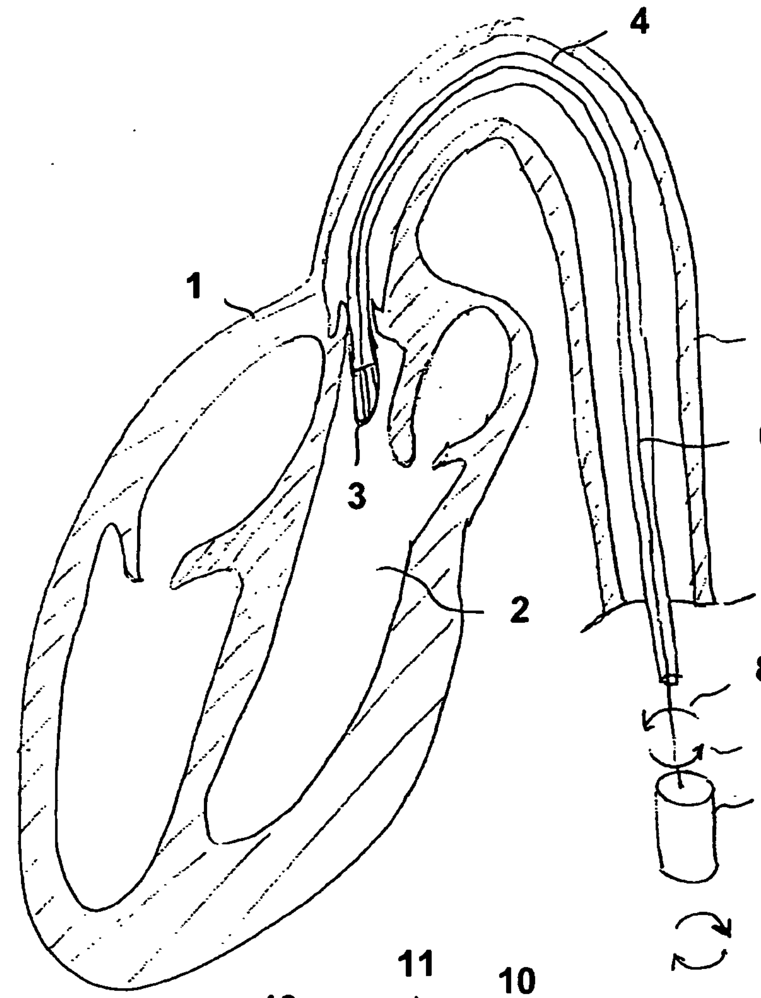

Fig. 1

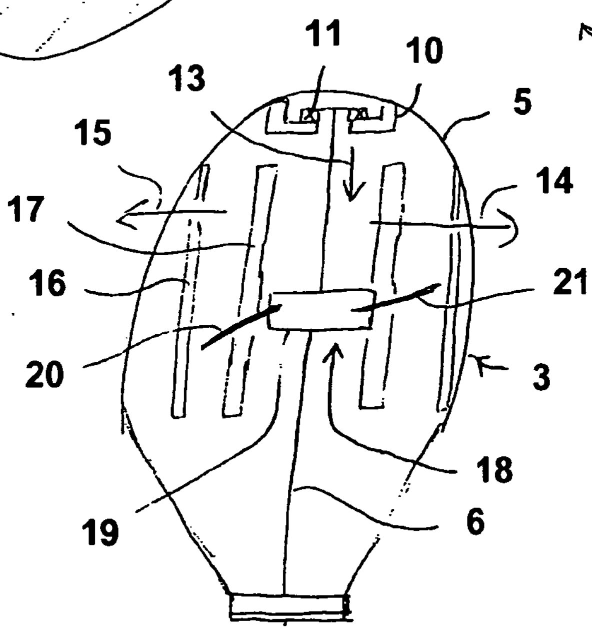

Fig. 2

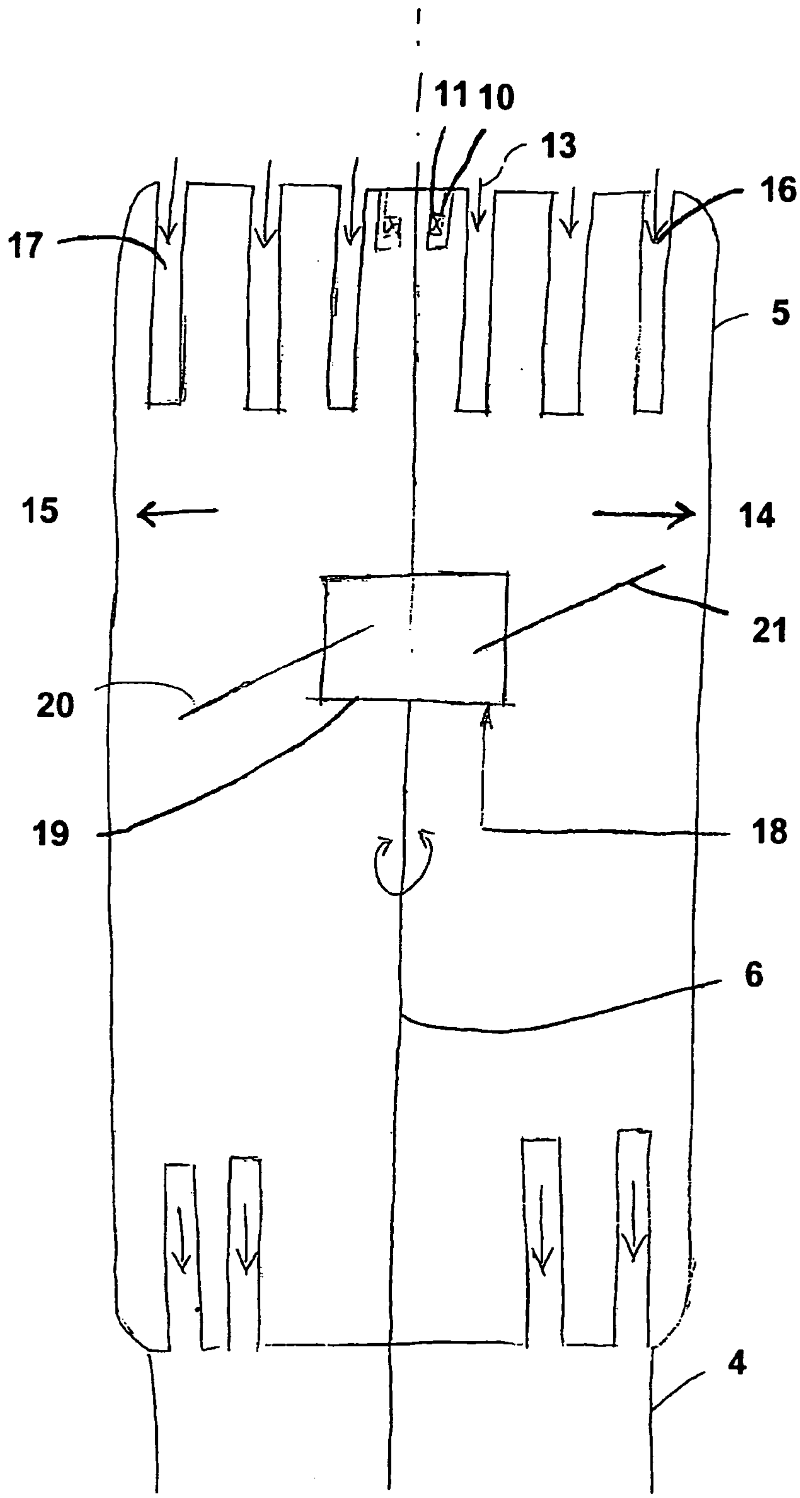

Fig. 2a

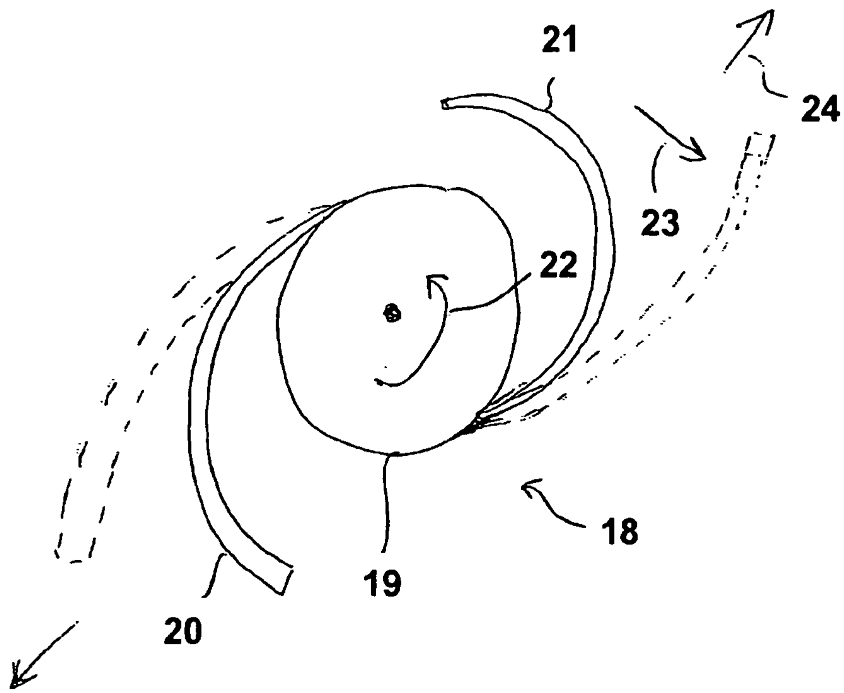

Fig. 3

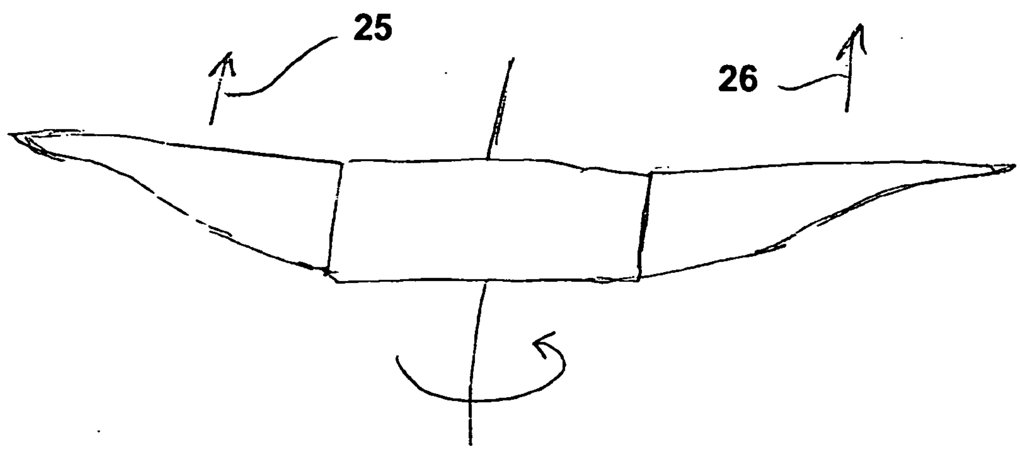

Fig. 4

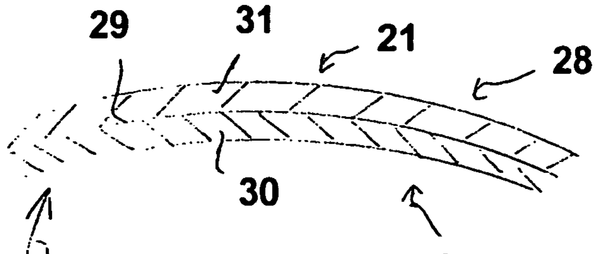

Fig. 5

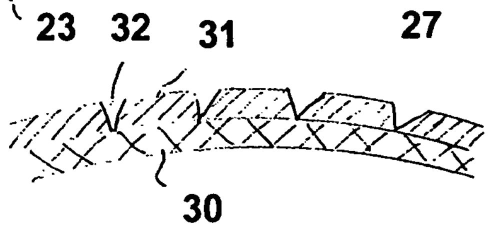

Fig. 6

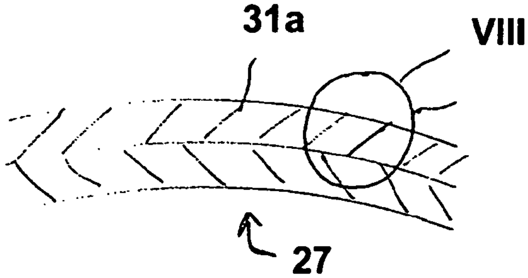

Fig. 7

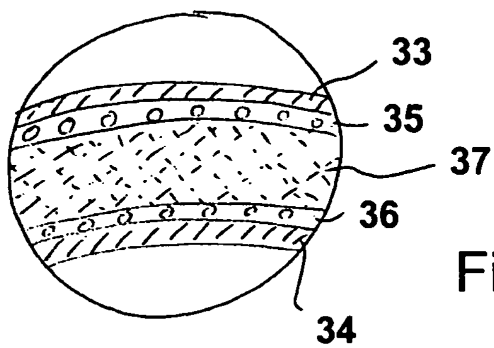

Fig. 8

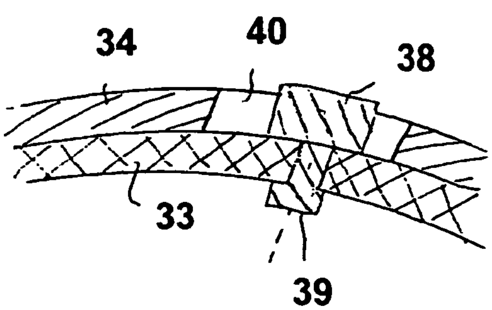

Fig. 9

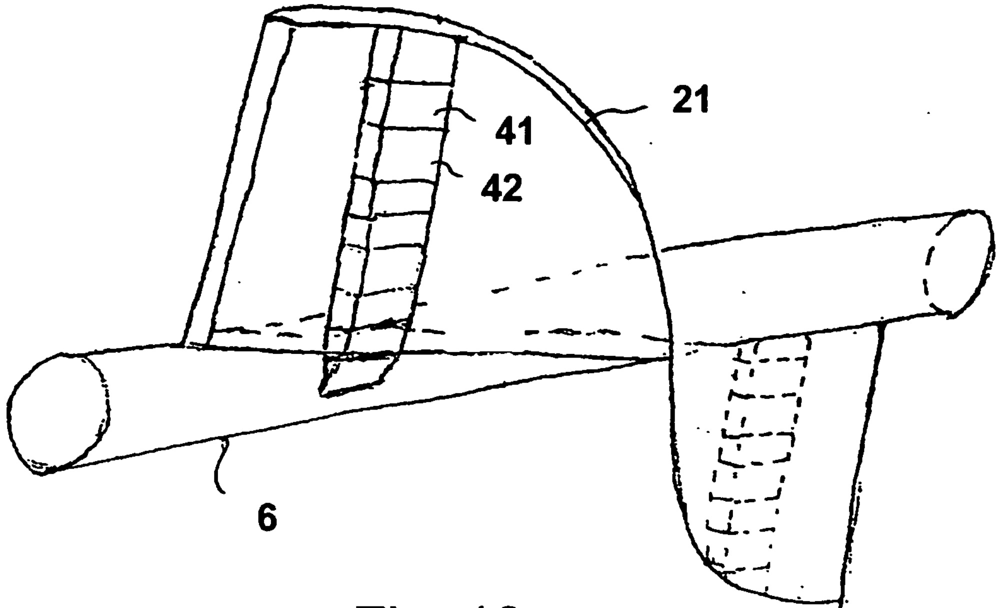

Fig. 10

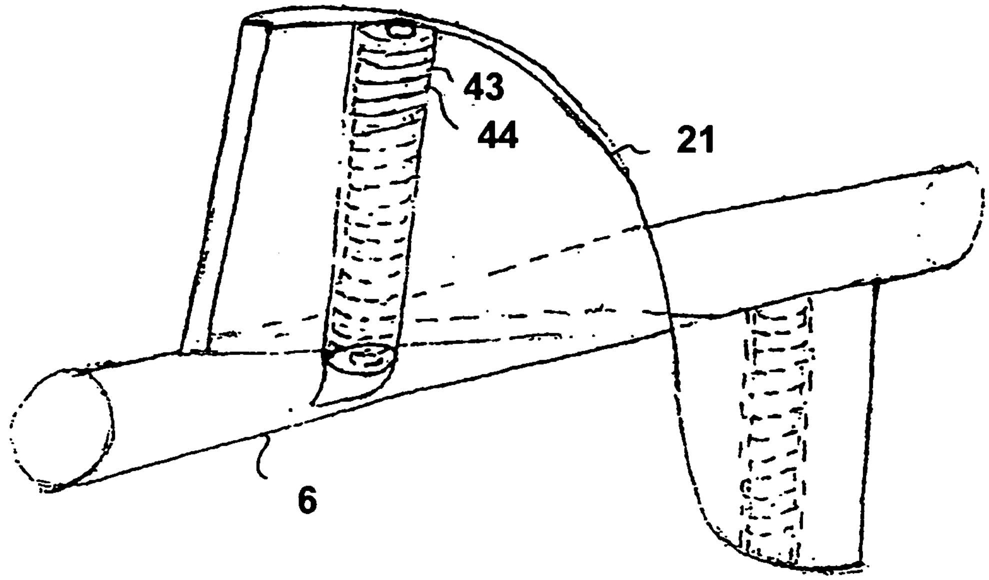

Fig. 11

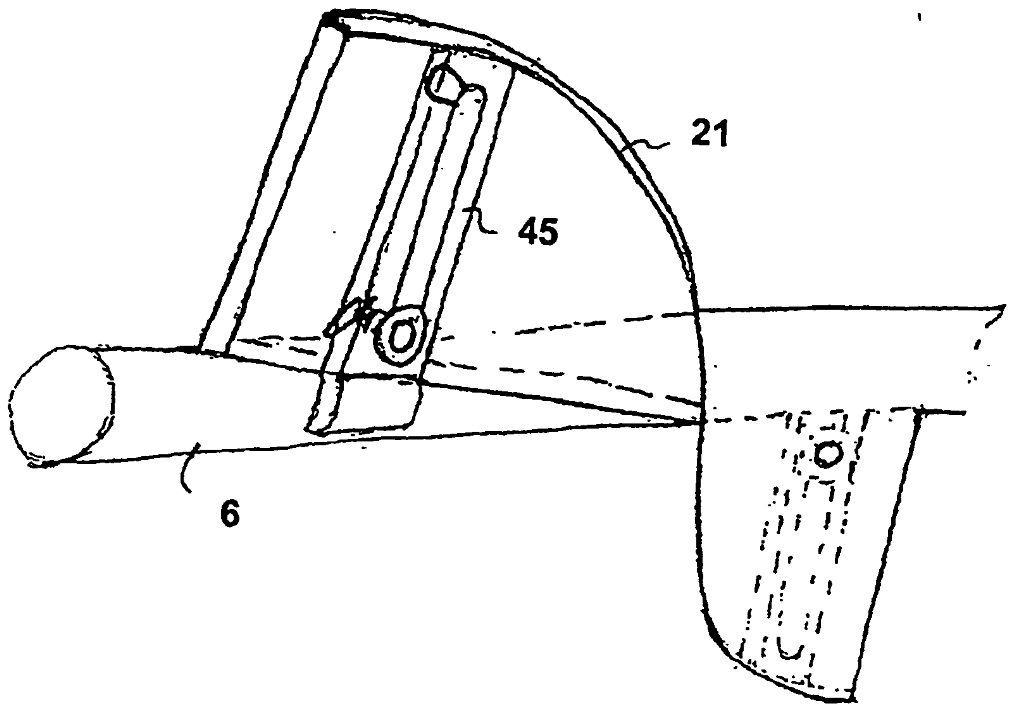

Fig. 12

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EUROPÄISCHER RECHERCHENBERICHT

Nummer der Anmeldung
EP 08 07 5923

Kategorie	EINSCHLÄGIGE DOKUMENTE Kennzeichnung des Dokuments mit Angabe, soweit erforderlich, der maßgeblichen Teile	Betrifft Anspruch	KLASSIFIKATION DER ANMELDUNG (IPC)
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Der vorliegende Recherchenbericht wurde für alle Patentansprüche erstellt

Recherchenort	Abschlußdatum der Recherche	Prüfer
München	22. April 2009	de Martino, Marcello

KATEGORIE DER GENANNTEN DOKUMENTE

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EPO FORM 1503 03.82 (P04C03)

ANHANG ZUM EUROPÄISCHEN RECHERCHENBERICHT ÜBER DIE EUROPÄISCHE PATENTANMELDUNG NR.

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Für nähere Einzelheiten zu diesem Anhang : siehe Amtsblatt des Europäischen Patentamts, Nr.12/82

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In der Beschreibung aufgeführte Patentdokumente

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- WO 03103745 A2 **[0006]**
- EP 0768900 B1 **[0008]**

Espacenet

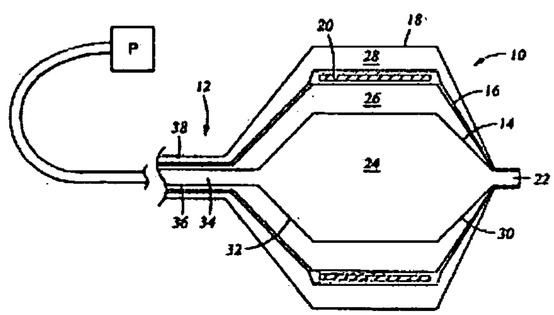
Bibliographic data: WO9818508 (A1) — 1998-05-07

MODIFIED CIRCULATORY ASSIST DEVICE

Inventor(s):	DOBAK JOHN D III [US]; GHAERZADEH KAMBIZ [US] + (DOBAK, JOHN, D., III, ; GHAERZADEH, KAMBIZ)	
Applicant(s):	DOBAK JOHN D III [US]; GHAERZADEH KAMBIZ [US] + (DOBAK, JOHN, D., III, ; GHAERZADEH, KAMBIZ)	
Classification:	**- international:**	***A61M1/10; A61M1/12;*** (IPC1-7): A61M1/00
	- European:	A61M1/10E; A61M1/10E51D
Application number:	WO1997US19412 19971028	
Priority number (s):	US19960740657 19961031; US19970891545 19970711	
Also published as:	US5820542 (A) EP1017430 (A1) EP1017430 (A4) AU5000597 (A)	

Abstract of WO9818508 (A1)

This invention is a circulatory assist device having a housing (16) and a pumping membrane (14), with a control chamber (26) and a pumping chamber (28). The device is mounted on a catheter and collapsed to a sufficiently small diameter to allow insertion into the vascular system of a patient. An expansion mechanism (20) in the device, such as a stent, can be expanded to hold the housing in an expanded, substantially rigid state, while control fluid is pumped into and evacuated from the control chamber to repeatedly deflect the pumping membrane. At least one opening (22) is formed in the device, to allow vascular fluid to enter and exit the pumping chamber as the pumping membrane deflects. Introduction and evacuation of control fluid can be synchronized with the heart cycle of the patient. After use, the housing is contracted to a smaller diameter to allow withdrawal from the vascular system.



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08/891,545 11 July 1997 (11.07.97) US

(71)(72) Applicants and Inventors: DOBAK, John, D., III. [US/US]; 2707 Camino Del Mar, Del Mar, CA 92014 (US). GHAERZADEH, Kambiz [US/US]; Unit 303, 6116 Calle Mariselda, San Diego, CA 92124 (US).

(74) Agent: SPINKS, Gerald, W.; P.O. Box 10158, College Station, TX 77842-0158 (US).

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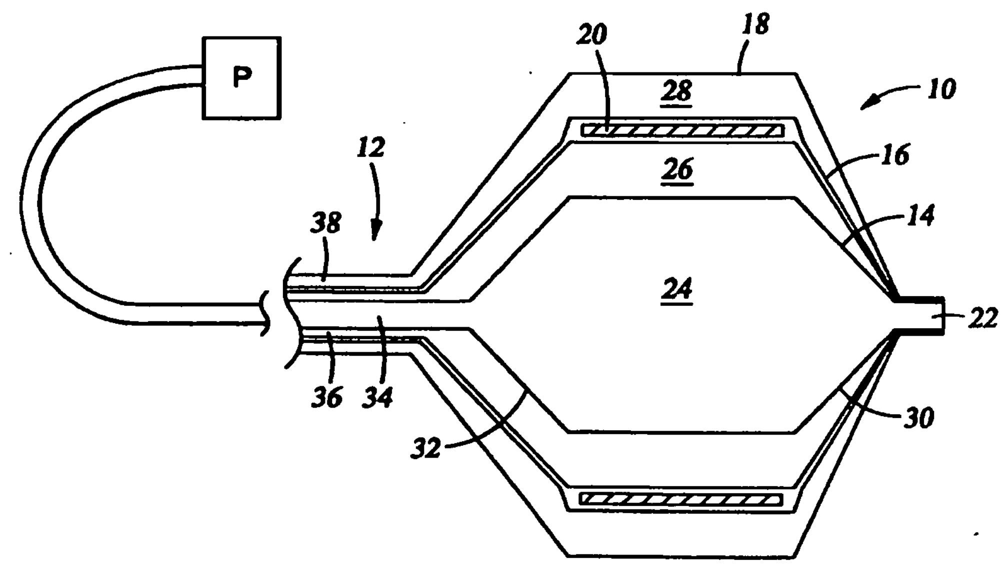
(54) Title: MODIFIED CIRCULATORY ASSIST DEVICE



(57) Abstract

This invention is a circulatory assist device having a housing (16) and a pumping membrane (14), with a control chamber (26) and a pumping chamber (28). The device is mounted on a catheter and collapsed to a sufficiently small diameter to allow insertion into the vascular system of a patient. An expansion mechanism (20) in the device, such as a stent, can be expanded to hold the housing in an expanded, substantially rigid state, while control fluid is pumped into and evacuated from the control chamber to repeatedly deflect the pumping membrane. At least one opening (22) is formed in the device, to allow vascular fluid to enter and exit the pumping chamber as the pumping membrane deflects. Introduction and evacuation of control fluid can be synchronized with the heart cycle of the patient. After use, the housing is contracted to a smaller diameter to allow withdrawal from the vascular system.

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YU	Yugoslavia
ZW	Zimbabwe

TITLE OF THE INVENTION

Modified Circulatory Assist Device

BACKGROUND OF THE INVENTION

This invention is in the field of devices used to augment or replace the pumping capacity or other flow capabilities of a vascular system, such as the cardiovascular system. In particular, the present invention is in the field of devices which can be inserted percutaneously into a vascular system to augment the pumping capabilities of the system.

There are a number of conditions which can seriously impair the ability of a vascular system to maintain its required fluid flow rate. Different vascular systems are subject to different disorders which can impair the flow of vascular fluid. In particular, in the cardiovascular system, the heart is in some circumstances unable to maintain adequate circulation of blood. Some of the conditions which can impair the ability of the heart to maintain the flow rate are myocardial infarction, physical trauma to the heart, cardiomyopathy, and infectious disease. The heart may fibrillate, or it may stop beating altogether, known as asystole, with either condition resulting in the inability to provide any flow. In addition, the performance of some surgical procedures, such as coronary artery bypass, may require that the heart be artificially arrested for the duration of the procedure.

There are also conditions in which blood flow to a single organ may be reduced. In such a case, it may be desirable to selectively perfuse the organ, applying a higher pressure than that which can be provided by the circulatory system. An example of such a condition is atherosclerotic disease of the coronary arteries. In such a condition, the lumens of one or more coronary arteries are restricted by atheroma or atherosclerotic plaque. This results in a reduction in the blood flow rate to the heart muscle distal to the restricted section of artery. This reduction in blood flow rate can result in damage to the heart muscle, or to the tissues of any other organ which is so affected, caused by a reduction of the oxygen supply to the organ. Such a condition can be alleviated, at least temporarily, by increasing the blood pressure in the artery proximal to the restriction, to increase perfusion of the organ. Theoretically, an increase in the blood pressure provided by the circulatory system can be achieved by the administration of heart stimulants, or by the administration of blood transfusions. Unfortunately, these therapies also increase the work load on the heart, thereby increasing the oxygen demand of the heart, resulting in a cancellation of the effect of the additional oxygen being supplied, where the organ being perfused is the heart. The increased demand can even exceed the additional oxygen being supplied.

Regardless of the exact nature of the reduction of flow, whether a reduction of cardiac output, a localized circulatory reduction, or a complete circulatory failure, it is desirable to be able to provide circulation of the blood with an artificial device. Such devices are commonly called circulatory assist devices. Heart failure, fibrillation, and asystole often require emergency care, because of the limited time during which remedial actions must be taken in order to be effective. In order for a circulatory assist device to be useful in the emergency care situation, the device must be quickly and easily insertable to the desired vascular location where the circulatory assistance is most effectively applied. Percutaneous application is the most advantageous procedure, because physical trauma to the patient is limited in such a procedure, and because emergency medical personnel are familiar with percutaneous insertion of various types of devices.

It is also highly desirable for a circulatory assist device to possess several other attributes. It should be capable of providing a flow rate of at least 2.5 liters per minute, while maintaining an average arterial pressure of 90 mm of Hg. It is preferable that this flow be pulsatile, rather than continuous. Natural blood flow is pulsatile, and data shows that recovery is better when flow is pulsatile. The device should also be able to pump in synchrony with various points of the heart cycle or ECG, should a patient have some baseline function.

The outside diameter of the device and its delivery catheter should be limited to no greater than 4 mm. This will minimize any damage to the blood vessel through which it passes. Further, this limited diameter will limit ischemia of the tissues distal of the insertion site during long periods of use. The circulatory assist device should have as few moving parts as possible, in order to minimize the chance of mechanical failure, and to limit the fabrication cost. The device should also be constructed so as to inflict as little damage as possible to blood cells. Finally, the device should be constructed so as to minimize the opportunity for coagulation within the device.

It is the object of the present invention to provide a circulatory assist device which can be mounted to a catheter for percutaneous insertion into the vascular system and for advancement to the treatment area, where increased flow is to be provided, with the diameter of the device being small enough to cause minimal trauma to the vascular system. It is a further object of the present invention to provide the circulatory assist device with a means for expanding to an operating volume, once located in the treatment area, with the operating volume being sufficiently large to provide an adequate flow rate of vascular fluid. It is a still further object of the present invention to provide the circulatory assist device with a pumping mechanism which has a minimum of moving parts, and which will cause minimal trauma to the cells of the vascular fluid.

BRIEF SUMMARY OF THE INVENTION

The present invention comprises a circulatory assist device, which, by way of example, incorporates an expandable housing, which can incorporate an expansion mechanism, mounted to a catheter. The housing can incorporate an inflatable membrane, or it can be simply a relatively open fluid container, open on one end, or even tubular. An inner pumping membrane is mounted within the expansion mechanism and housing. The pumping membrane can be an enclosure, encompassing either a pumping chamber or a control chamber, or it can constitute just one wall of a control chamber. Where the pumping membrane is an enclosure encompassing a pumping chamber or a control chamber, vascular fluid is moved by expansion and collapse of the pumping membrane. Where the pumping membrane constitutes one wall of a control chamber, vascular fluid is moved by inward and outward flexing of the pumping membrane.

Importantly, the expanded housing of the present invention provides an enclosure which will not expand further when the control chamber is expanded, to provide a space within which efficient pumping can take place. It is known to insert a balloon into the thoracic aorta and repeatedly expand and collapse the balloon to augment blood flow. It has been noted, however, that if a balloon is expanded and contracted within a pliable enclosure, such as an artery or a heart chamber, the artery or heart chamber will expand with each expansion of the balloon. This expansion of the "pumping enclosure" prevents efficient expulsion of the vascular fluid from the space between the balloon and the artery wall. Therefore, it is significant that the present invention incorporates a housing which will not further expand when the control chamber is pressurized. It has been found that this can increase the pumping output by a factor of two (2), or more.

If the pumping membrane of the present invention is designed to encompass a pumping chamber, it has at least one port through its wall, with the construction of the circulatory assist device being such that the port can be exposed to vascular fluid. If the pumping membrane is designed to encompass a control chamber, it encompasses at least one control fluid port through the catheter wall, with the construction of the circulatory assist device being such that control fluid can be delivered to the control fluid port to effect expansion and collapse of the pumping membrane. In either case, the pumping membrane is expanded and collapsed to cause vascular fluid, such as blood, to flow through the circulatory assist device as the pumping membrane expands and collapses.

If the pumping membrane is designed to form one wall of a control chamber, it has one side which can be exposed to vascular fluid. The other side of the pumping membrane is exposed to at least one control fluid port in the catheter wall, with the construction of the circulatory assist device being such that control fluid can be delivered to the control fluid port to effect inward and outward flexing of the pumping membrane. In this design, the pumping membrane is flexed inwardly and outwardly to cause vascular fluid, such as blood, to flow through the circulatory assist device as the pumping membrane flexes.

A single vascular fluid port can be provided in the circulatory assist device to allow vascular fluid to flow into and out of the device through the same port. This single port reciprocating type of flow can be used where the device is positioned within the left ventricle of the heart, for instance, making use of the unidirectional flow characteristics of the mitral valve and the aortic valve. Alternatively, instead of using a single port, two or more ports can be used to control the direction of flow of the fluid. For instance, the ports can be fitted with one way valves to cause the vascular fluid to enter the circulatory assist device through the appropriate port, and to exit the circulatory assist device through the appropriate port, flowing in the desired direction. Further, a flow through type of housing can be utilized, being essentially open on both ends. Either the multiple-port or the flow-through unidirectional type of flow can be used where the device is positioned within the aorta. Additionally, in the multiple port type of device, either the inlet port or the outlet port can be fitted with an external tube to draw fluid from a smaller diameter vessel, or to inject fluid into a smaller diameter vessel. This latter method could be used to provide blood flow into the feeding artery of a selected organ, such as a coronary artery.

Expansion and collapse, or flexing, of the pumping membrane is enabled by first creating a rigid or semi-rigid housing or enclosure having a substantially constant inner space within which the pumping membrane can be repetitively flexed, or expanded and collapsed. This constant inner space between the housing and the pumping membrane can be a control space, if it is used to provide control of the size or shape of the pumping membrane, in which case the other side of the pumping membrane serves as the vascular fluid space. Conversely, the constant inner space within the housing can be a vascular fluid space, in which case the inside of the pumping membrane encompasses a control space, which is used to provide control of the size of the pumping membrane.

First, the housing and the pumping membrane are introduced percutaneously into the vascular system while maintained at a first, relatively small, diameter. The housing and the pumping membrane, still in a collapsed condition, are advanced to the treatment area, such as the left ventricle of the heart. Then, the housing is expanded to a selected, relatively larger, diameter, the size of which depends upon the size of the treatment area. Along with the housing, an expansion mechanism is expanded to this selected larger diameter. The expansion mechanism and the housing constitute a rigid or semi-rigid enclosure for the control space.

The expansion mechanism is designed to maintain the larger diameter until it is reshaped to a smaller diameter for eventual withdrawal from the vascular system. The expansion mechanism can either provide the expansion force itself, or it can be expanded by fluid pressure or other forces. The expansion mechanism is located near the housing; it can be positioned inside the housing, or outside the housing, or it can be incorporated in the wall of the housing. The expansion mechanism can also be attached to the housing, for instance if it is positioned outside the housing. It can be an expandable stent, which is expanded by fluid pressure inside the housing, if the housing incorporates an inflatable outer membrane. This hydraulically expandable type of stent requires a protective membrane outside the outer membrane, which can be pressurized to return the stent to its smaller diameter. Alternatively, the expandable stent can be made of a thermally expandable material, such as a nickel titanium alloy. Such a thermally expandable stent can be expanded to the larger diameter by being exposed to a first temperature, such as a relatively higher temperature, and returned to the smaller diameter by being exposed to a second temperature, such as a relatively lower temperature. Exposure of the thermally expandable stent to the vascular fluid can cause it to expand, or a control fluid at the appropriate temperature can be used for this purpose. In either case, a control fluid at the desired second temperature can be used to return the thermally expandable stent to the smaller diameter.

The expansion mechanism can also take other forms. A self-expanding element can be used, such as an outwardly biased cylindrical cage or a plurality of outwardly biased flexible prongs. The self-expanding element can be retained at a smaller diameter by a retention sheath, until positioned in the treatment area. Then, the self-expanding element can be expelled from the retention sheath to allow the self-expanding element to expand to a larger diameter, thereby expanding the housing along with it. The outward bias of the self-expanding element would maintain the housing at the larger diameter, functioning as the rigid or semi-rigid enclosure, to maintain the space within which the inner membrane operates.

Further, the expansion mechanism can take the form of a helical spring which has a larger diameter associated with a shorter length, and which has a smaller diameter associated with a longer length. The spring can be biased toward either the shorter length or the longer length. Selectively changing the length of the spring transforms its diameter accordingly. If the spring is biased toward the shorter length, it can be held under tension until positioned in the treatment area, at which time the tension can be released, allowing the spring to transform to the larger diameter. Conversely, if the spring is biased toward the longer length, it can be placed under compression once in the treatment area, transforming the spring to the shorter length and the larger diameter. In either case, reversing the process transforms the spring to the smaller diameter for withdrawal from the vascular system, once the pumping has been completed.

Regardless of the type of expansion mechanism used, a constant inner space is created inside the housing, between the housing and the pumping membrane. Control fluid can be repeatedly pumped into, and evacuated from, this constant inner space, where the constant space is utilized as a control space. When control fluid is pumped into the control space, the pumping membrane collapses, or flexes outwardly, expelling any vascular fluid which may be inside the device. When the control fluid is evacuated from the control space, the pumping membrane expands, or flexes inwardly, drawing in vascular fluid. Repetition of this process provides the necessary flow of vascular fluid.

Alternatively, where the pumping membrane encompasses a control chamber, control fluid can be repeatedly pumped into, and evacuated from, the space within the pumping membrane. When control fluid is pumped into the control space, the pumping membrane expands, expelling any vascular fluid which may be in the constant inner space between the housing and the pumping membrane. When the control fluid is evacuated from the control space, the pumping membrane collapses, drawing vascular fluid into the constant inner space between the housing and the pumping membrane. Repetition of this process provides the necessary flow of vascular fluid.

If the heart has some baseline, albeit diminished, pumping activity, the pumping of fluid into the control space must be timed with the cardiac cycle. If the pump is placed in the aorta, then the pumping should be synchronized with diastole. If it is placed in the ventricle, it should be synchronized with systole.

The novel features of this invention, as well as the invention itself, will be best understood from the attached drawings, taken along with the following description, in which similar reference characters refer to similar parts, and in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a section view of a first embodiment of the apparatus of the present invention;

Figure 2 is a section view of a second embodiment of the apparatus of the present invention, without a protective membrane;

Figure 3 is a section view of a third embodiment of the apparatus of the present invention, with a first type of self-expanding element;

Figure 4 is a section view of a fourth embodiment of the apparatus of the present invention, with a second type of self-expanding element;

Figure 5 is a section view of a fifth embodiment of the apparatus of the present invention, with ports in the proximal cone;

Figure 6 is a section view of a sixth embodiment of the apparatus of the present invention, with an enlarged port;

Figure 7 is a section view of a seventh embodiment of the apparatus of the present invention with a full discharge inner membrane;

Figure 8 is a section view of an eighth embodiment of the apparatus of the present invention, with a helical spring expansion mechanism, and with the membranes in the contracted state;

Figure 9 is a section view of the embodiment shown in Figure 8, in the expanded state;

Figure 10 is a section view of a ninth embodiment of the apparatus of the present invention, with a stiffening mandrel passing through the inner membrane, and with the membranes in the contracted state;

Figure 11 is a section view of the embodiment shown in Figure 10, in the expanded state;

Figure 12 is a section view of a tenth embodiment of the apparatus of the present invention, with a stiffening mandrel passing outside the inner membrane, and with the membranes in the contracted state;

Figure 13 is a section view of the embodiment shown in Figure 12, in the expanded state;

Figure 14 is a section view of an eleventh embodiment of the apparatus of the present invention, with one variety of a non-inflatable container-type housing;

Figure 15 is a section view of the apparatus of the present invention, showing one means of expanding the housing of the embodiment shown in Figure 14 with a cylindrical stent;

Figure 16 is a section view of a twelfth embodiment of the apparatus of the present invention, with a second variety of non-inflatable container-type housing, and showing expansion of the housing with a tapered stent;

Figure 17 is a section view of a thirteenth embodiment of the apparatus of the present invention, with one variety of inflatable membrane-type housing, and showing an inwardly and outwardly flexing pumping membrane; and

Figure 18 is a section view of a fourteenth embodiment of the apparatus of the present invention, with a third variety of non-inflatable container-type housing having a flow-through design.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is a circulatory assist device which consists primarily of a pumping mechanism utilizing a housing and a pumping membrane mounted on a catheter. The housing, which can be equipped with an expansion mechanism, provides an enclosure within which the pumping membrane can flex, or expand and collapse, to take in and expel a vascular fluid. The space between the pumping membrane and the housing can be repeatedly evacuated and then pressurized with a control fluid, to flex or expand and collapse the pumping membrane. Alternatively, a space enclosed within the pumping membrane can be repeatedly evacuated and then pressurized with a control fluid, to expand and collapse the pumping membrane.

As seen in the embodiment shown in Figure 1, the circulatory assist device (CAD) 10 of the present invention is mounted on a catheter 12. The CAD 10 includes a flexible inner pumping membrane 14, and a flexible housing 16 surrounding the pumping membrane 14. Depending upon the means by which the expansion of the CAD 10 is achieved, the CAD 10 can also be fitted with a flexible protective membrane 18, surrounding the housing 16. In some embodiments, a protective membrane 18 is not required. The housing 16 and the membranes 14, 18 can be made of a flexible material which can expand up to a desired size, or diameter, after which the material essentially does not expand further, even if the pressure inside the housing or membrane is increased further. Such materials, and the processes used in their fabrication, are widely used in the manufacture of balloons for angioplasty.

An expansion mechanism, such as a substantially cylindrical expandable stent 20, can be mounted in the CAD 10, near the housing 16. The stent 20 can be incorporated in the wall of the housing 16, or the housing 16 could consist of two laminated membranes, with the stent 20 captured therebetween. Alternatively, as will be illustrated below, the stent 20, or another similar expansion mechanism, could be located inside the housing 16, or outside the housing 16. Various other embodiments of the expansion mechanism can be used in place of the stent 20, but the stent 20 will generally be described herein, with the understanding that other embodiments could also be used. In any case, the expansion mechanism is positioned relative to, or attached to, the housing 16 in such a way that the housing 16 will expand with the expansion mechanism.

The stent 20 is an expandable, substantially cylindrical, lattice of elongated elements of plastic or metal. It can be similar to cardiovascular stents known in the art. The stent 20 is assembled in the CAD 10 while at a smaller diameter, substantially the diameter of the catheter 12. When the CAD 10 is positioned in the treatment area, fluid pressure can be introduced inside the stent 20 and the housing 16, to expand the stent 20 to a larger diameter. When the internal pressure is released, the stent 20 will retain its larger diameter, until it is eventually compressed by the application of fluid pressure to the outer surface of the stent 20. In some other embodiments, the expansion mechanism itself provides the expanding force, such as stents made of a nickel-titanium alloy, such as nitinol, which expands upon exposure to a higher temperature. Other stents can be mechanically biased toward a larger or smaller diameter, and physically manipulated to achieve the desired diameter. In all embodiments, once expanded, the purpose of the expansion mechanism is to hold the housing 16 in the expanded state.

Figure 1 shows the CAD 10 in its expanded state, wherein the housing 16, the membranes 14, 18, and the stent 20 are all expanded to a diameter which is relatively larger than the diameter of the catheter 12. This expanded diameter provides sufficient room for adequate pumping capacity. For use in the cardiovascular system of an adult patient, an expanded diameter of 35 mm. might be used. The housing 16, the membranes 14, 18, and the stent 20 are also collapsible to a relatively smaller diameter, in the range of 2.5 to 4 mm., at which the CAD 10 is essentially the same diameter as the catheter 12. This contracted diameter makes the CAD 10 small enough to be easily inserted percutaneously and advanced through the vascular system of the patient.

A port 22 for the flow of blood or other vascular fluid is formed in the distal end of the pumping membrane 14, extending through the housing 16 and the protective membrane 18. When the CAD 10 is positioned within a vascular system, such as the cardiovascular system, of a patient, the CAD 10 is positioned so that the port 22 is exposed to the blood in the system, at the treatment area, where circulatory assist is required. For example, depending upon the particular embodiment of the invention in use, the location of the CAD 10 could be in the left ventricle of the heart, or it could be in the aortic arch.

When the pumping membrane 14 is in the expanded state, a pumping chamber 24 within the pumping membrane 14 is expanded to its largest volume. The expansion of the pumping chamber 24 draws in the vascular fluid through the port 22. Subsequent collapse of the pumping chamber 24 expels the vascular fluid through the port 22. The size of the pumping chamber 24 can be designed to achieve the desired flow rate, given a selected pulse rate. For instance, if the CAD 10 is to be used in the cardiovascular system, it has been found that pulsatile flow at the frequency of the heartbeat is most beneficial. A pulse rate of 100 cycles per minute would be reasonable. In the cardiovascular system, it can be desirable to achieve a flow rate of up to 5 liters per minute. Therefore, if these parameters are assumed, the pumping chamber 24 should have a volume of 50 cc. to achieve the desired flow rate.

When the housing 16 is in the expanded state, a control chamber 26 is created between the housing 16 and the pumping membrane 14. This control chamber 26 is repetitively evacuated and pressurized with a control fluid, to achieve the expansion and collapse of the pumping membrane 14. While the housing 16 is held in the expanded state by the stent 20, the total volume enclosed by the housing 16 remains essentially constant, but the volume of the control chamber 26 decreases and increases as the pumping membrane 14 expands and collapses. Pressurization of the control chamber 26 collapses the pumping membrane 14, rather than further expanding the outer balloon 16, because the stent 20 and the housing 16 have been expanded to their greatest possible diameter. Evacuation of the control chamber 26 expands the pumping membrane 14, rather than collapsing the housing 16, because the stent 20 retains its expanded diameter. This requires that the external to internal pressure differential across the housing 16 during evacuation of the control chamber 26 be kept below the pressure differential required to compress the stent 20.

It should be noted that, in the particular embodiment discussed here, with a stent 20 which is expandable and compressible by the application of internal and external fluid pressure, the control chamber 26 is initially pressurized with a control fluid to expand the stent 20 and the housing 16. Once this expansion of the stent 20 has been achieved, the control chamber 26 can then be evacuated and repressurized to achieve the pumping discussed above. When the expansion mechanism is the type which is compressed by external fluid pressure, a second control space 28 is provided between the protective membrane 18 and the housing 16. The second control space 28 can be pressurized with a control fluid to compress the stent 20 and the housing 16 to a smaller diameter, to allow for removal of the CAD 10 from the vascular system. Alternatively, if the thermally expandable stent 20 is used, control fluid at the desired temperature can be introduced into either of the control spaces 26, 28 to control the diameter of the stent 20 and, consequently, the housing 16.

The shape of the pumping membrane 14 shown here is a substantially cylindrical body, with a tapered distal end cone 30 and a tapered proximal end cone 32. The housing 16 and the protective membrane 18 have similar shapes. Other shapes could also be used without departing from the spirit of the present invention.

The catheter 12 has its proximal end connected to a control fluid flow device such as a pump P. The control fluid flow device must be capable of applying a fluid pressure and drawing a vacuum. A syringe could also be used in some of the embodiments. The catheter 12 shown in Figure 1 is a multi-lumen catheter, but some of the embodiments can be used with single-lumen catheters. A first lumen 34 can be provided in the catheter 12, to allow flow of the vascular fluid into or out of the pumping membrane 14. The first lumen 34 could be used for sampling of the vascular fluid or to direct the vascular fluid from one location to another. Additional ports (not shown) could be provided proximal to the CAD 10, to allow flow of vascular fluid into or out of the first lumen 34. A second lumen 36 is provided in the catheter 12, to allow the flow of control fluid between the control fluid flow device P and the control chamber 26. The second lumen 36 is used to hydraulically or thermally expand the stent 20 and the housing 16, and to pressurize and evacuate the control chamber 26 for pumping purposes. A third lumen 38 is provided in the catheter 12, to allow the flow of control fluid between the control fluid flow device P and the second control space 28. The third lumen 38 is used to thermally expand the stent 20 to create a pump housing for the pumping membrane 14, or to hydraulically or thermally compress the stent 20 and the housing 16 to a smaller diameter for withdrawal from the vascular system.

Figure 2 shows a second embodiment of the present invention with a few variations from the embodiment shown in Figure 1. The stent 20 used in this embodiment is the thermally expanding stent 20 made of a material such as nitinol. A control fluid at a relatively higher temperature can be introduced into the control chamber 26 through the second lumen 36, to expand the stent 20. Alternatively, the vascular fluid in which the CAD 10 is immersed, such as blood, can be at a sufficiently high temperature to expand the stent 20. Compression of the stent 20 can then be achieved by introducing a control fluid at a relatively lower temperature into the control chamber 26. This embodiment also exhibits a one-way inlet valve 40 in the port 22, and a one-way outlet valve 42 in the first lumen 34, to control the direction of flow of the vascular fluid. The arrangement of the one-way valves 40, 42 would allow the CAD 10 to draw in blood, for instance, at the aortic arch, and direct the flow of blood to a particular artery, to perfuse a selected organ. Other arrangements of one-way valves could be used to control the direction of flow as desired for any particular application.

Figure 3 shows an embodiment of the CAD 10 which has a self-expanding stent 20. The self-expanding stent 20 shown here is an outwardly biased cage shaped element. The stent 20 can be retained within the retention sheath 44, which is a part of the catheter 12, during insertion of the CAD 10 into the vascular system. Once the CAD 10 is positioned in the treatment area, a positioner 46 can be used to push the stent 20 beyond the distal end 48 of the retention sheath 44, allowing the stent 20 to expand to its larger diameter. Conversely, the positioner 46 can be used to pull the stent 20 back within the retention sheath 44, to reduce the diameter of the CAD 10 for withdrawal from the patient. A protective membrane 18, as shown in Figure 1, could also be used with the self-expanding stent 20, to allow external pressurization of the stent 20 to hydraulically compress the stent 20 to its smaller diameter. Finally, the thermally expandable stent 20 could be used in the embodiment shown in Figure 3. Ejection of the thermally expandable stent 20 from the retention sheath 44 would expose the stent 20 to the temperature of the blood, to cause the stent 20 to expand. Control fluid at a lower temperature could then be pumped into the control chamber 26, to return the stent 20 to its smaller diameter.

Figure 4 shows a second type of the self-expanding expansion mechanism in the form of a plurality of flexible, outwardly biased prongs 21. The prongs 21 can be retained within the retention sheath 44, during insertion of the CAD 10 into the vascular system. Once the CAD 10 is positioned in the treatment area, the positioner 46 can be used to push the prongs 21 beyond the distal end 48 of the retention sheath 44, allowing the prongs 21 to expand outwardly, to stretch the housing 16 to its larger diameter. Subsequently, the positioner 46 can be used to pull the prongs 21 back within the retention sheath 44, to reduce the diameter of the CAD 10 for withdrawal from the patient. . A protective membrane 18, as shown in Figure 1, could also be used with the self-expanding prongs 21, to allow pressurization of the second control space 28, to achieve hydraulic compression of the prongs 21, to return the expansion mechanism to its smaller diameter.

Figure 5 shows an embodiment of the invention in which the vascular fluid enters and exits the pumping chamber 24 through ports 23 located in the proximal cone 32 of the pumping membrane 14. The proximal cones of the housing 16 and the protective membrane 18 are bonded to the proximal cone 32 of the pumping membrane 14. The catheter 12 used with this embodiment is a double-lumen tube. Pressurization and evacuation of the first control chamber 26 are achieved through the first control fluid lumen 36 and the inner control fluid port 37. Pressurization and evacuation of the second control space 28 are achieved through the second control fluid lumen 38 and the outer control fluid port 39. An outer plug 50 seals the distal end of the CAD 10, and an inner plug 52 seals the distal end of the housing 16. This embodiment is particularly useful when it is desirable to direct the flow of vascular fluid proximally. For instance, the CAD 10 can be positioned in the left ventricle, with the ports 23 placed close to, and directed toward, the aortic valve. This would direct the flow of blood through the aortic valve, to assist the action of the ventricle. Depending upon the type of expansion mechanism used with this embodiment, such as the thermally expandable stent 20, the protective membrane 18 may be eliminated.

Figure 6 shows another embodiment, which is a variation of the embodiment shown in Figure 5. In this embodiment, the proximal cones of the housing 16 and the membranes 14, 18 are not attached to the catheter 12, and the port 23 is open all around the catheter 12. This significantly increases the cross-sectional flow area through the port 23.

In applications where it is necessary to maximize the flow of vascular fluid in each pulse, the embodiments shown in Figures 5 and 6 have a disadvantage in that the bonding together of the proximal cones of the housing 16 and the membranes 14, 18 can prevent the complete collapse of the pumping membrane 14. This can be remedied as shown in Figure 7, where an expansion fold 54 of material is formed in the pumping membrane 14. The expansion fold 54 will fold up when the pumping membrane 14 experiences expansion into the housing 16, and the expansion fold 54 will distend when the pumping membrane 14 collapses, allowing the pumping membrane 14 to fully collapse and completely expel the vascular fluid from the pumping chamber 24.

Figures 8 and 9 show another embodiment which incorporates a self-expanding mechanism in the form of a helical spring 25. The helical spring 25 has two configurations. One configuration is shown in Figure 8, where the length of the spring 25 is extended, and its diameter is reduced. The other configuration is shown in Figure 9, where the length of the spring 25 is reduced, and its diameter is expanded. The distal end of the spring 25 is anchored to the distal end of the CAD 10. A spring controller 56 is attached to the proximal end of the spring 25, for transforming the spring 25 from one of these configurations to the other. Two types of spring 25 could be used.

One type of spring 25 would be biased toward the shortened configuration shown in Figure 9, with the expanded diameter. In such a spring, it would be necessary to place the spring 25 under tension with the spring controller 56, to hold the spring 25 in the lengthened configuration, with the reduced diameter, during insertion or withdrawal of the CAD 10 through the vascular system. Then, the tension could be released to allow the spring 25 to transform to its expanded diameter to hold the housing 16 in the expanded state. With this type of spring, the spring controller 56 could be either a relatively stiff member or a cable.

Another type of spring 25 would be biased toward the lengthened configuration shown in Figure 8, with the reduced diameter. In such a spring, it would be necessary to place the spring 25 under compression with the spring controller 56, to transform the spring 25 to the shortened configuration, with the expanded diameter, to hold the housing 16 in the expanded state. The spring 25 could be allowed to take its natural, lengthened, configuration during insertion or withdrawal of the CAD 10 through the vascular system. With this type of spring, the spring controller 56 must be a relatively stiff member.

When using a helical spring 25 as the expansion mechanism, it may be detrimental to rely entirely on the tensile or compressive strength of the housing 16 and the pumping membrane 14 to resist the force in the spring 25. For instance, with the short-biased type of spring 25, the housing 16 and the pumping membrane 14 may not have sufficient compressive strength to resist the tension placed in the spring 25 by the spring controller 56 to hold the spring in the configuration shown in Figure 8. In such a case, the housing 16 and the pumping membrane 14 would tend to bunch up, and the spring 25 could not be transformed to its reduced diameter for passage through the vascular system. Similarly, with the long-biased type of spring 25, the housing 16 and the pumping membrane 14 may not have sufficient tensile strength to resist the compression placed in the spring 25 by the spring controller 56 to transform the spring 25 to the configuration shown in Figure 9. In such a case, the housing 16 and the pumping membrane 14 would tend to extend axially when compression of the spring 25 is attempted, and the spring 25 could not be transformed to its expanded diameter to hold the housing 16 in the expanded state.

The embodiments shown in Figures 10 through 13 can be used to alleviate this problem. Figures 10 and 11 show a mandrel 58 passing through the center of the pumping membrane 14, and anchored to the CAD 10 at its distal end. The penetration of the mandrel 58 through the pumping membrane 14 must be sealed. The mandrel 58 holds the distal ends of the housing 16 and the pumping membrane 14 in place during application of tension or compression by the spring controller 56. If the short-biased type of spring 25 is used, the mandrel 58 must be a relatively stiff member to resist compression. If the long-biased type of spring 25 is used, the mandrel 58 can actually be very flexible, like a wire or cable. More than one mandrel 58 can be used in each CAD 10, if required for the necessary tensile or compressive strength. Figures 12 and 13 show a mandrel 58 passing outside the pumping membrane 14, and inside the spring 25, and anchored to the CAD 10 at its distal end. This eliminates the necessity for penetrating the pumping membrane 14, but the pumping membrane 14 must be constructed with longitudinal folds or creases, to allow it to expand around the mandrel 58, as shown in Figure 13.

Figure 14 shows yet another embodiment of the CAD 10, having a housing 16 and a pumping membrane 14 mounted on a catheter 12. In this embodiment, the housing 16 constitutes an open container type of enclosure, rather than an inflatable membrane type of enclosure, being open at its proximal end. The pumping membrane 14 encompasses a control chamber 26, while the space between the housing 16 and the pumping membrane 14 constitutes a pumping chamber 24 for moving vascular fluid in and out of the CAD 10, as shown by the arrow VF.

The housing 16 can be expanded to the condition shown by use of any of the previously described non-inflating mechanisms, such as the expandable stent, the expandable spring, or the expandable prongs. A control fluid port 60 is formed in the wall of the catheter 12, allowing the pressurization of the control chamber 26 with control fluid. As the control chamber 26 is pressurized with control fluid, the pumping membrane expands, forcing vascular fluid out of the pumping chamber 24. Evacuation of control fluid from the control chamber 26 collapses the pumping membrane 14, drawing vascular fluid into the pumping chamber 24.

Figure 15 shows how a stent 20 can be imbedded within the wall of the housing 16, to hold the housing 16 in its expanded state to form a pumping enclosure for the pumping membrane 14. Regardless of what type of mechanism is used to hold the housing 16 in its expanded state, the housing gives a non-expanding enclosure which increases the pumping capacity of the CAD 10 beyond the capacity which would be available by simply expanding and contracting a pumping membrane in an expandable enclosure, such as an artery.

Figure 16 shows another embodiment of the present invention, with a tapered stent 20 imbedded within the wall of the non-inflatable housing 16, to hold the housing 16 in its expanded state to form a pumping enclosure for the pumping membrane 14.

Figure 17 shows an embodiment of the CAD 10 having an inflatable housing 16, with a stent 20 imbedded in the wall of the housing 16. This embodiment also shows a flat pumping membrane 14, attached between the end of the housing 16 and the catheter 12. Rather than being flat, the pumping membrane 14 could have any other shape which allows it to flex inwardly and outwardly, as will be described. A control fluid port 60 is provided in the wall of the catheter 12, between the housing 16 and the pumping membrane 14. Further, an inflation port 62 is provided within the housing 16, and partition membrane 64 is attached to the housing 16 and the catheter 12, between the control port 60 and the inflation port 62. The catheter is constructed with multiple lumens as previously discussed, to provide control fluid to the control port 60, and to provide inflation fluid to the inflation port 62.

Pressurization of the interior of the housing 16 with inflation fluid via the inflation port 62 causes the housing 16 to expand. This creates a control chamber 26 between the partition membrane 64 and the pumping membrane 14. A pumping chamber 24 exists on the opposite side of the pumping membrane 14 from the control chamber 26. The pumping chamber 24 is shown relative to the inwardly flexed pumping membrane 14 as indicated by the dashed line 14A. The pumping membrane 14 is flexed inwardly to the approximate position indicated by the inner dashed line 14A by evacuation of the control chamber 26 via the control port 60, thereby drawing vascular fluid into the pumping chamber 24 of the CAD 10. Pressurization of the control chamber 26 with control fluid via the control port 60 causes the pumping membrane 14 to flex outwardly to the approximate vicinity of the outer dashed line 14B, thereby expelling vascular fluid from the pumping chamber 24. When the control chamber 26 is pressurized, the partition membrane 64 might tend to deflect toward the housing 16. When the control chamber 26 is evacuated, the partition membrane 64 might tend to deflect toward the pumping membrane 14.

Figure 18 shows an embodiment of the CAD 10 incorporating a flow through type of housing 16. The housing 16 of this embodiment can consist essentially of an expandable stent 20 incorporating a membrane to form a substantially tubular fluid container. Expansion of the stent 20 can be achieved by any of the non-inflatable means discussed above. Once expanded, the housing 16 will not expand further during pumping cycles, thereby providing an efficient pumping enclosure for the pumping membrane 14. The housing 16 can be tethered to the catheter 12 such as by a plurality of sutures 66 or other attachment means. The housing 16 is open on both ends, thereby allowing flow of vascular fluid through the CAD 10. Pressurization of the control chamber 26 within the pumping membrane 14 ejects vascular fluid from the pumping chamber 24. Such an embodiment would be particularly useful in the aorta, for augmentation of the aortic flow produced by the heart. The control chamber 26 would be evacuated during systole of the cardiac cycle, allowing the left ventricle to eject its load unimpeded. The control chamber 26 would be pressurized with control fluid via the control port 60 during diastole of the cardiac cycle, thereby pumping an additional load of blood through the aorta, in between systolic pulses.

OPERATION

The CAD 10 is arranged in its contracted, or collapsed, state, with its smallest diameter. The CAD 10 is then inserted into and through the vascular system, such as through a guide catheter, or over a wire, as is well known in the art. When the CAD 10 has been advanced to the area where circulatory assist is to be provided, the expansion mechanism, such as the stent 20, if present, is expanded along with the housing 16. This expansion can be achieved hydraulically, thermally, or by manipulation of one of the forms of self-expanding elements. The expansion mechanism then holds the housing 16 in the expanded state to form a pumping enclosure around the pumping membrane 14. The control chamber 26 is then evacuated to move the pumping membrane 14 in a first direction and draw vascular fluid into the pumping chamber 24. Control fluid is then introduced into the control chamber 26 to move the pumping membrane 14 in a second direction and expel vascular fluid from the pumping chamber 24. Introduction and evacuation of control fluid into and from the control chamber 26 may be synchronized to the systole or diastole of the heart cycle, using the ECG signal from the patient's heart. Upon completion of pumping, the expansion mechanism is compressed, or otherwise returned to its smaller diameter, and the CAD 10 is withdrawn from the vascular system.

While the particular invention as herein shown and disclosed in detail is fully capable of obtaining the objects and providing the advantages hereinbefore stated, it is to be understood that this disclosure is merely illustrative of the presently preferred embodiments of the invention and that no limitations are intended other than as described in the appended claims.

CLAIMS

We claim:

1. A circulatory assist device, comprising:

a flexible tubular catheter, said catheter being sized for insertion into a vascular system of a patient;

a selectively expandable inner membrane attached to said catheter, said inner membrane being disposable in the vascular system of the patient, with said catheter;

a selectively expandable outer membrane attached to said catheter, said outer membrane substantially surrounding said inner membrane, said outer membrane being selectively maintainable in an expanded state;

a control fluid flow device connected in flow communication with a control space adjacent said inner membrane, said control fluid flow device being capable of selectively introducing a control fluid into, and removing a control fluid from, said control space, to cause said inner membrane to expand and collapse; and

at least one port exposable to vascular fluid, said port being capable of allowing flow of vascular fluid into, and allowing flow of vascular fluid out of, said circulatory assist device, when said inner membrane expands and collapses.

2. A circulatory assist device as recited in claim 1, wherein:

said control space is between said inner membrane and said outer membrane, causing said inner membrane to collapse upon introduction of said control fluid into said control space, and causing said inner membrane to expand upon removal of said control fluid from said control space; and

said port is in said inner membrane, to allow flow of vascular fluid into and out of said inner membrane, as said inner membrane expands and collapses.

3. A circulatory assist device as recited in claim 1, wherein:

said control space is within said inner membrane, causing said inner membrane to expand upon introduction of said control fluid into said control space, and causing said inner membrane to collapse upon removal of said control fluid from said control space; and

said port is in said outer membrane, to allow flow of vascular fluid into and out of a pumping space between said inner membrane and said outer membrane, as said inner membrane expands and collapses.

4. A circulatory assist device, comprising:

a catheter;

a housing attached to said catheter, said housing being selectively expandable from a first, smaller, volume to a substantially rigid state having a second, larger, volume, said housing being selectively maintainable in said expanded state;

a selectively deflectable pumping membrane attached to said catheter, said pumping membrane being disposed substantially within said housing to divide said housing into a control chamber and a pumping chamber;

a control fluid flow device connected in flow communication with said control chamber, said control fluid flow device being capable of selectively evacuating said control chamber, to cause said pumping membrane to deflect in a first direction, said control fluid flow device being capable of selectively introducing a control fluid into said control chamber, to cause said pumping membrane to deflect in a second direction; and

an opening in said pumping chamber exposable to vascular fluid, whereby deflection of said pumping membrane in said first direction draws vascular fluid into said pumping chamber, and deflection of said pumping membrane in said second direction ejects vascular fluid from said pumping chamber.

5. A circulatory assist device as recited in claim 4, wherein said control fluid flow device is capable of synchronization with the heart cycle of a patient.

6. A circulatory assist device as recited in claim 4, further comprising an expansion mechanism attached to said housing.

7. A circulatory assist device as recited in claim 6, wherein said expansion mechanism is disposed within said housing.

8. A circulatory assist device as recited in claim 6, wherein said expansion mechanism is incorporated in a wall of said housing.

9. A circulatory assist device as recited in claim 6, wherein said expansion mechanism comprises an expandable stent, said stent being expandable from a first relatively smaller diameter to a second relatively larger diameter.

10. A circulatory assist device as recited in claim 6, wherein said expansion mechanism comprises a self-expanding element, said self-expanding element being expandable from a first relatively smaller diameter to a second relatively larger diameter.

11. A circulatory assist device as recited in claim 4, wherein:

said pumping membrane comprises an inflatable balloon mounted on said catheter;

said control chamber is between said pumping membrane and said housing;

said pumping chamber is within said pumping membrane;

said vascular fluid opening is in said pumping membrane;

said pumping membrane collapses upon introduction of said control fluid into said control chamber; and

said pumping membrane expands upon evacuation of said control fluid from said control chamber.

12. A circulatory assist device as recited in claim 4, wherein:

said pumping membrane comprises an inflatable balloon mounted on said catheter;

said control chamber is within said pumping membrane;

said pumping chamber is between said pumping membrane and said housing;

said vascular fluid opening is in said housing;

said pumping membrane expands upon introduction of said control fluid into said control chamber; and

said pumping membrane collapses upon evacuation of said control fluid from said control chamber.

13. A circulatory assist device as recited in claim 4, wherein:

said pumping membrane comprises a substantially flat wall attached to said housing and to said catheter;

said control chamber is on a first side of said pumping membrane, between said pumping membrane and said housing;

said pumping chamber is on a second side of said pumping membrane opposite said first side;

said vascular fluid opening is in said housing;

said pumping membrane flexes inwardly into said housing upon evacuation of said control fluid from said control chamber; and

said pumping membrane flexes outwardly from said housing upon introduction of said control fluid into said control chamber.

14. A circulatory assist device as recited in claim 4, wherein:

said pumping membrane comprises an inflatable balloon mounted on said catheter;

said housing comprises a tubular member;

said control chamber is within said pumping membrane;

said pumping chamber is between said pumping membrane and said tubular housing;

a first said vascular fluid opening is in a first end of said tubular housing;

a second said vascular fluid opening is in a second end of said tubular housing;

said pumping membrane expands upon introduction of said control fluid into said control chamber; and

said pumping membrane collapses upon evacuation of said control fluid from said control chamber.

15. A method of assisting circulation of a vascular fluid, comprising:

providing a catheter mounted circulation device having an inner membrane and an outer membrane, with a control space adjacent said inner membrane, said outer membrane also being mechanically fixable in an expanded state, said circulation device having at least one vascular fluid flow port;

inserting said circulation device through a vascular system of a patient, to a desired location where said at least one vascular fluid flow port is exposed to vascular fluid;

expanding said outer membrane;

holding said outer membrane in said expanded state;

alternatingly introducing a control fluid into said control space and evacuating control fluid from said control space to alternatingly expand and collapse said inner membrane, thereby drawing vascular fluid into, and expelling vascular fluid from, said circulation device.

16. A method of assisting circulation of a vascular fluid as recited in claim 15, wherein:

said control space is between said inner membrane and said outer membrane;

said at least one vascular fluid flow port is in said inner membrane;

said introduction of said control fluid into said control space collapses said inner membrane, thereby expelling said vascular fluid from said inner membrane; and

said evacuation of said control fluid from said control space expands said inner membrane, thereby drawing said vascular fluid into said inner membrane.

17. A method of assisting circulation of a vascular fluid, comprising:

providing a catheter mounted circulation device having a housing and a pumping membrane, with said pumping membrane dividing said housing into a control chamber and a pumping chamber;

inserting said circulation device through a vascular system of a patient, to a desired location where at least one opening of said pumping chamber is exposed to vascular fluid;

expanding said housing;

holding said housing in said expanded state;

evacuating said control chamber to deflect said pumping membrane in a first direction, thereby drawing vascular fluid into said pumping chamber; and

introducing a control fluid into said control chamber to deflect said pumping membrane in a second direction, thereby expelling vascular fluid from said pumping chamber.

18. A method of assisting circulation of a vascular fluid as recited in claim 17, further comprising synchronization of introduction and evacuation of control fluid with the heart cycle of the patient.

19. A method of assisting circulation of a vascular fluid as recited in claim 17, wherein:

said pumping membrane comprises an inflatable balloon mounted on said catheter;

said control chamber is between said pumping membrane and said housing;

said pumping chamber is within said pumping membrane;

said at least one vascular fluid flow port is in said pumping membrane;

said evacuation of said control fluid from said control chamber expands said pumping membrane, thereby drawing said vascular fluid into said pumping chamber; and

said introduction of said control fluid into said control chamber collapses said pumping membrane, thereby expelling said vascular fluid from said pumping chamber.

20. A method of assisting circulation of a vascular fluid as recited in claim 17, wherein:

said pumping membrane comprises an inflatable balloon mounted on said catheter;

said pumping chamber is between said pumping membrane and said housing;

said control chamber is within said pumping membrane;

said at least one vascular fluid flow port is in said housing;

said evacuation of said control fluid from said control chamber expands said pumping membrane, thereby drawing said vascular fluid into said pumping chamber; and

said introduction of said control fluid into said control chamber expands said pumping membrane, thereby expelling said vascular fluid from said pumping chamber.

21. A method of assisting circulation of a vascular fluid as recited in claim 17, wherein:

said pumping membrane comprises a substantially flat wall attached to said housing and to said catheter;

said control chamber is on a first side of said pumping membrane, between said pumping membrane and said housing;

said pumping chamber is on a second side of said pumping membrane opposite said first side;

said vascular fluid opening is in said housing;

said evacuation of said control fluid from said control chamber flexes said pumping membrane inwardly into said housing, thereby drawing said vascular fluid into said pumping chamber; and

said introduction of said control fluid into said control chamber flexes said pumping membrane outwardly from said housing, thereby expelling said vascular fluid from said pumping chamber.

22. A method of assisting circulation of a vascular fluid as recited in claim 17, wherein:

said pumping membrane comprises an inflatable balloon mounted on said catheter;

said housing comprises a tubular member;

said control chamber is within said pumping membrane;

said pumping chamber is between said pumping membrane and said tubular housing;

a first said vascular fluid opening is in a first end of said tubular housing;

a second said vascular fluid opening is in a second end of said tubular housing;

said evacuation of said control fluid from said control chamber collapses said pumping membrane, thereby drawing said vascular fluid into said pumping chamber; and

said introduction of said control fluid into said control chamber expands said pumping membrane, thereby expelling said vascular fluid from said pumping chamber.

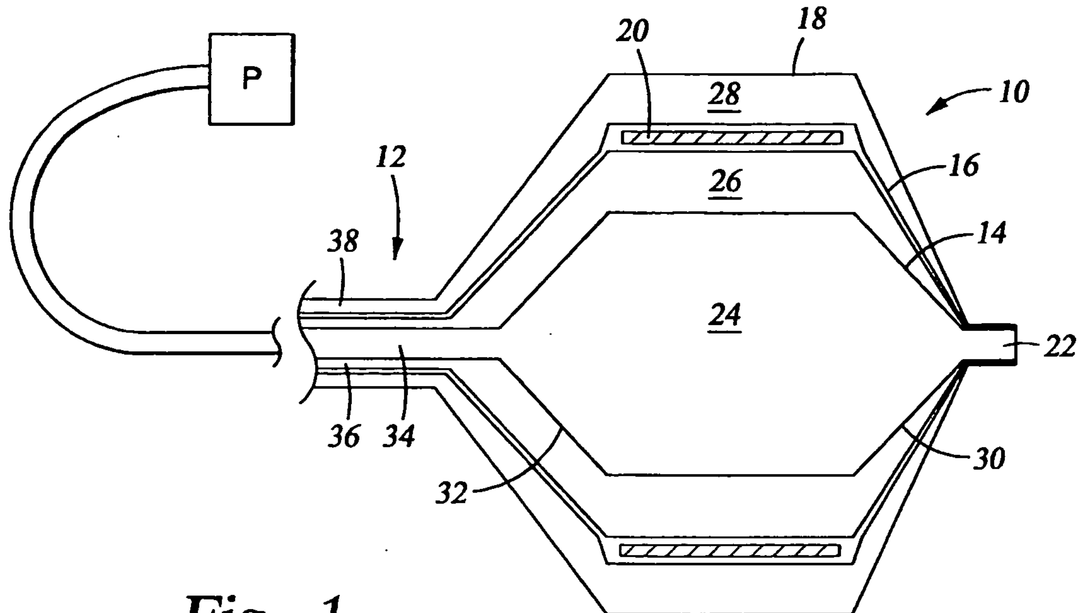
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Fig. 1

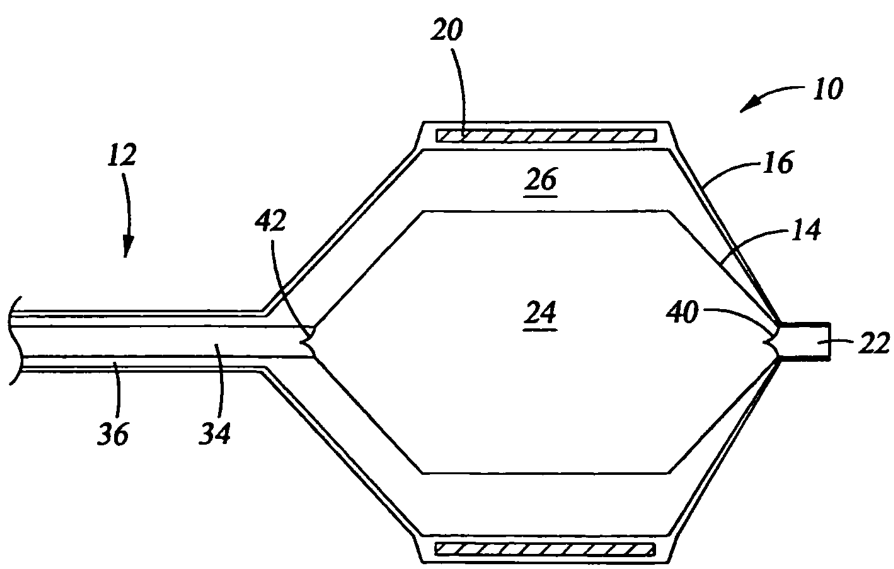
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Fig. 2

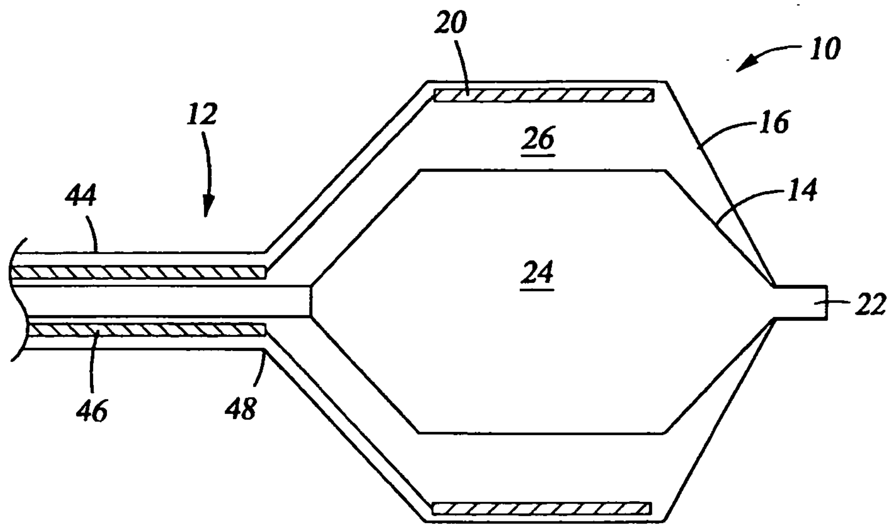

Fig. 3

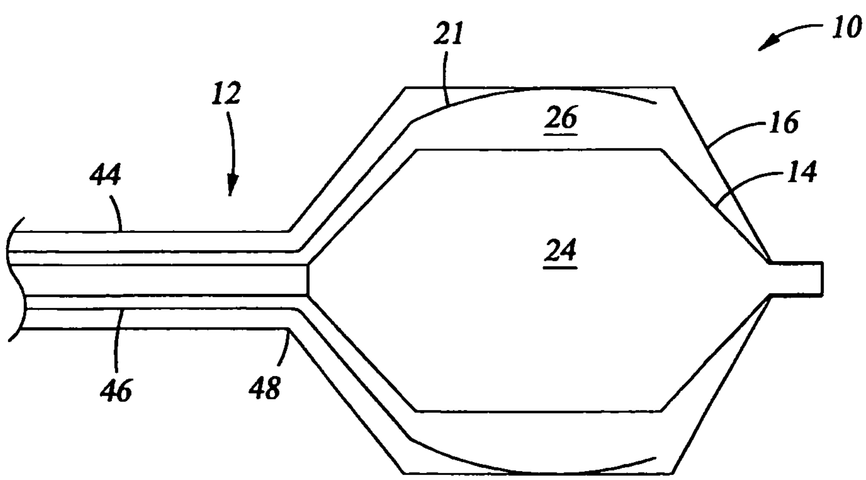

Fig. 4

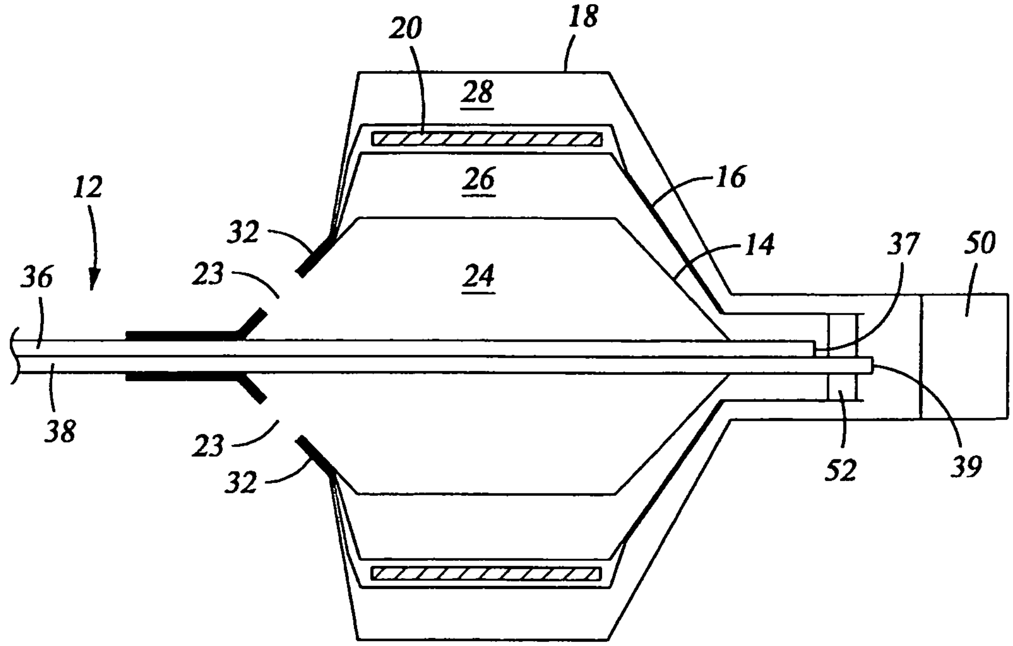
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Fig. 5

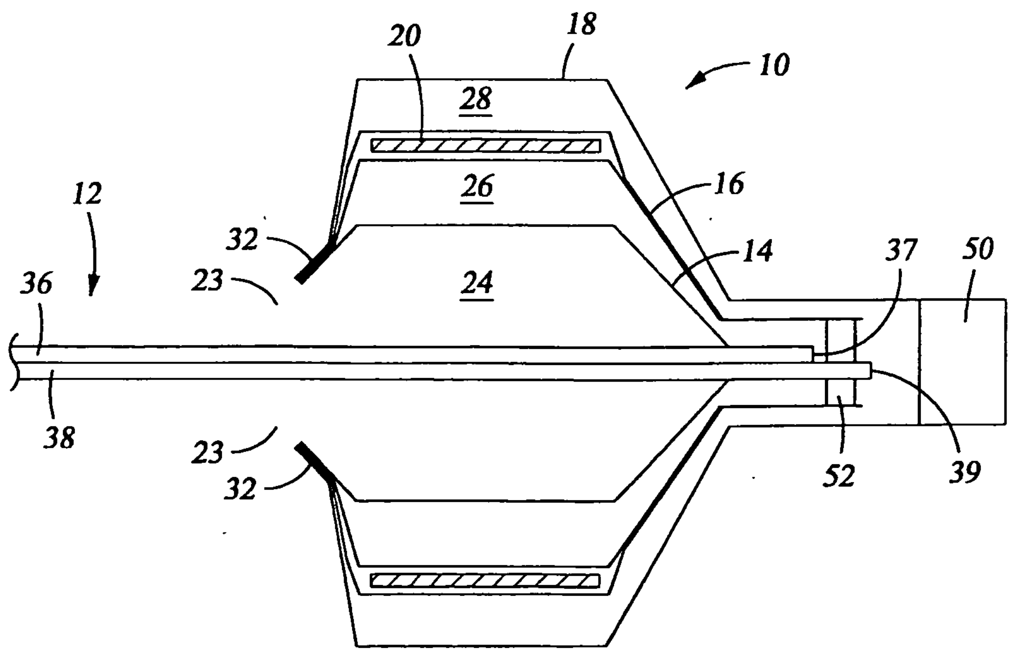
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Fig. 6

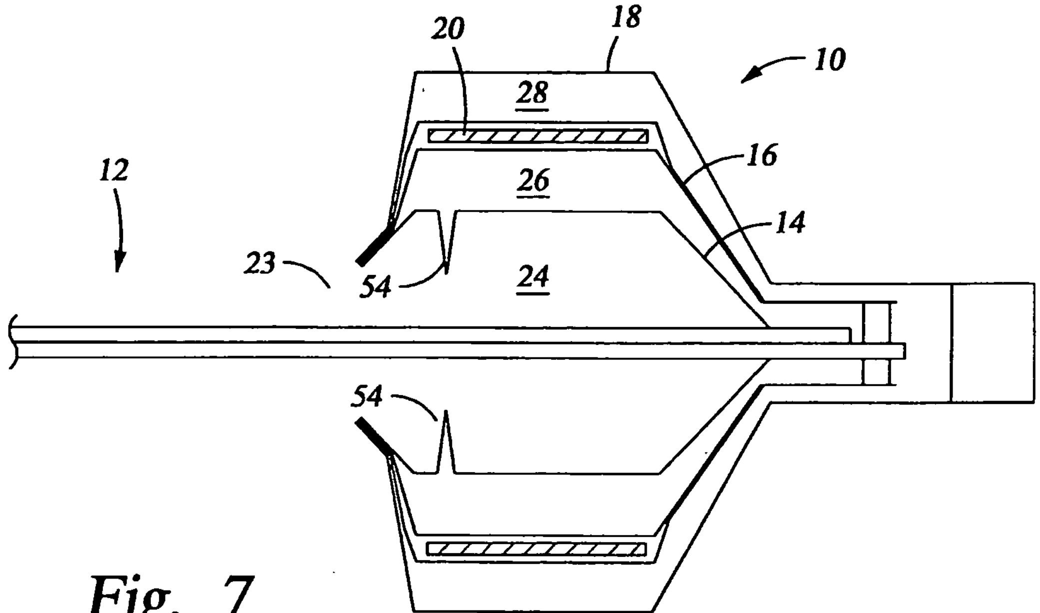

Fig. 7

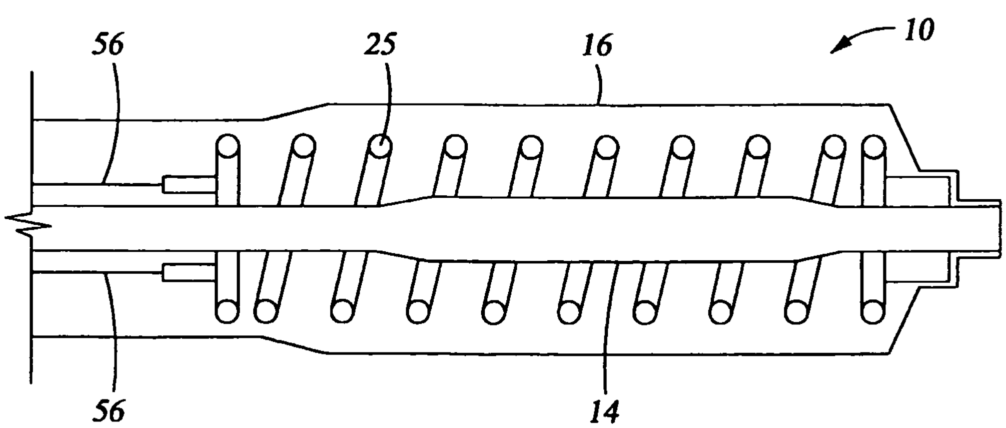

Fig. 8

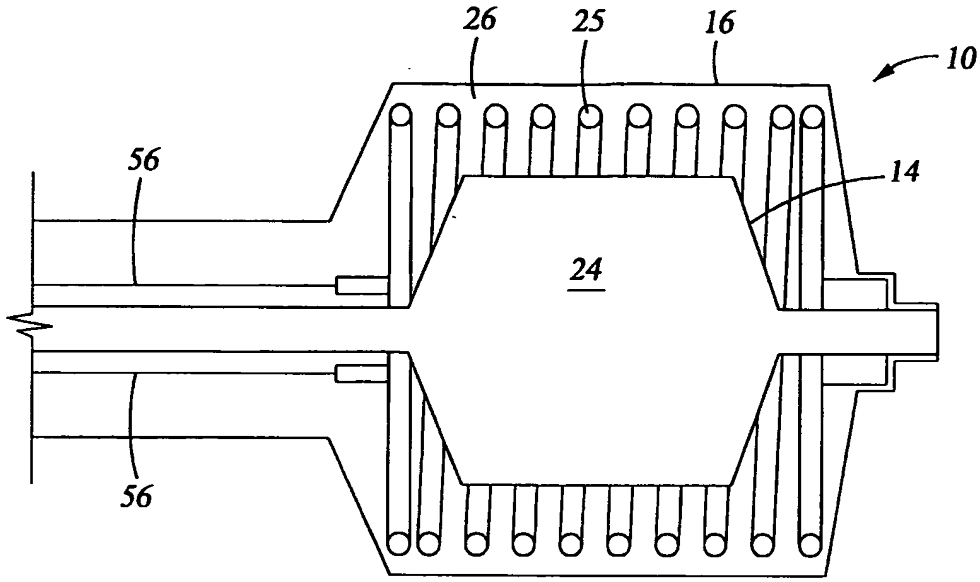

Fig. 9

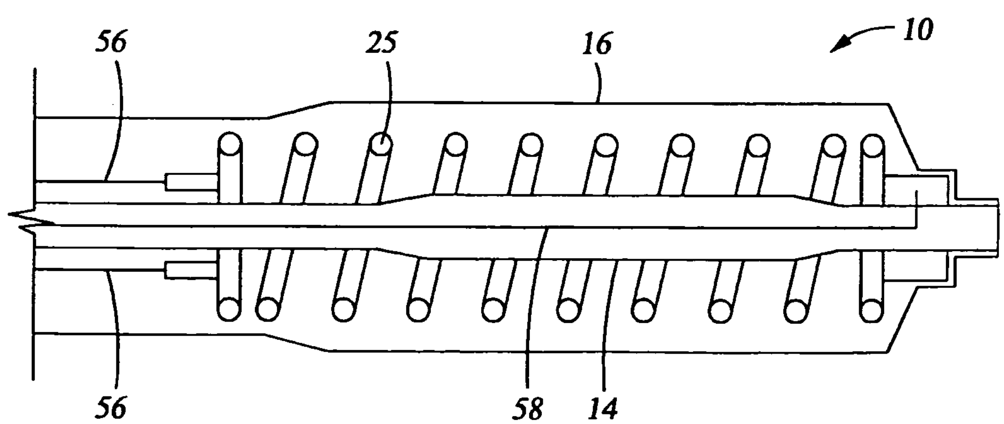

Fig. 10

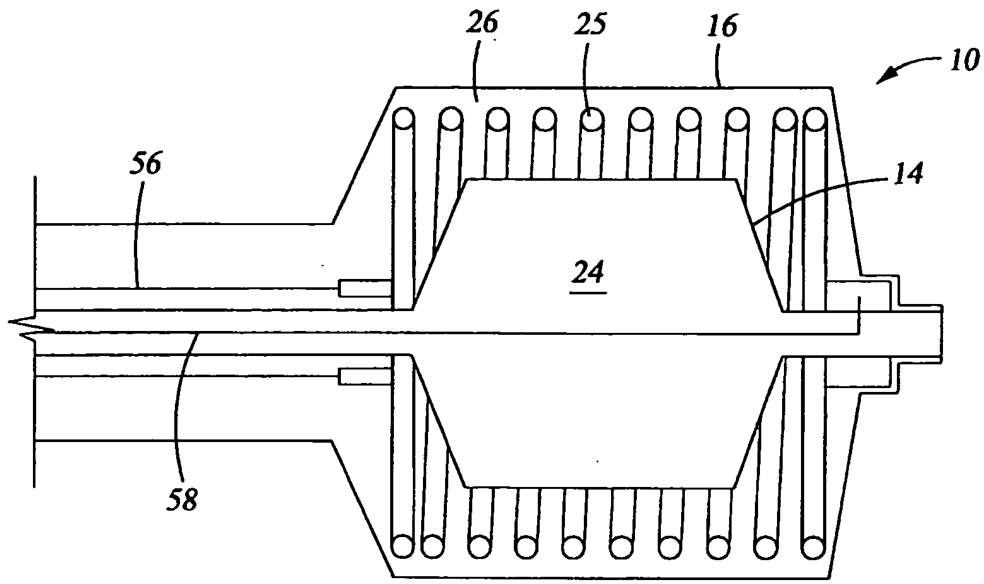

Fig. 11

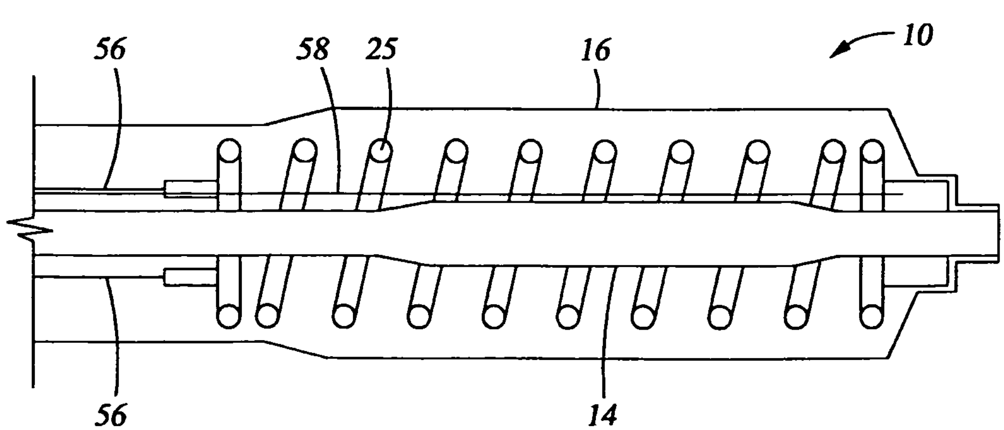

Fig. 12

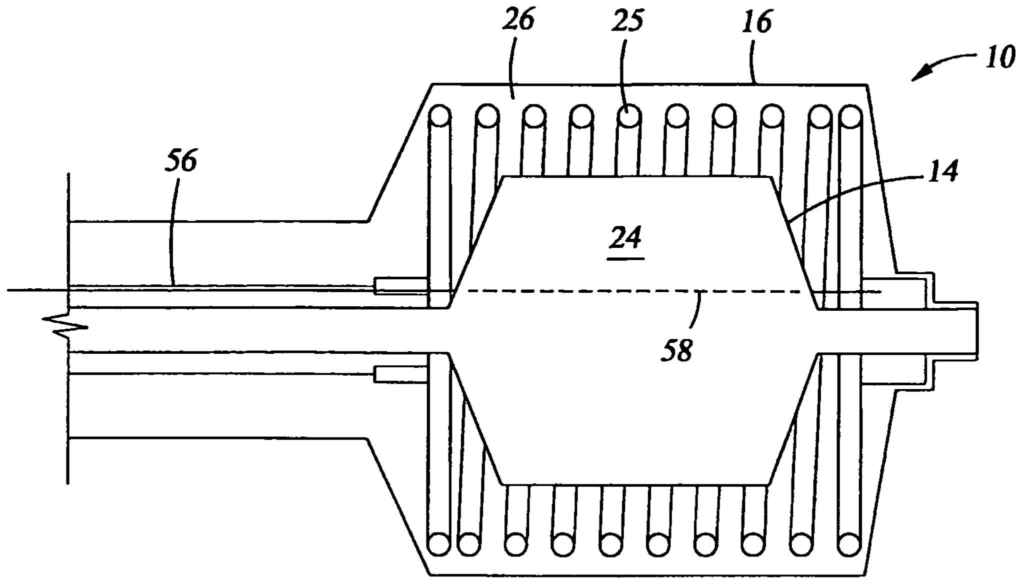

Fig. 13

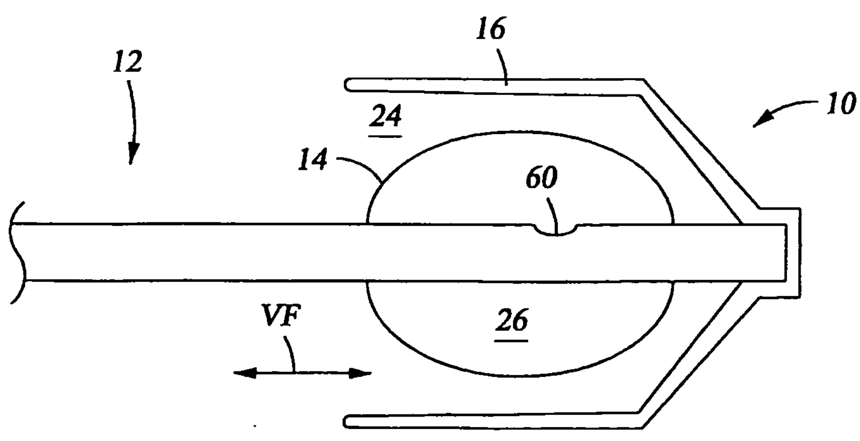

Fig. 14

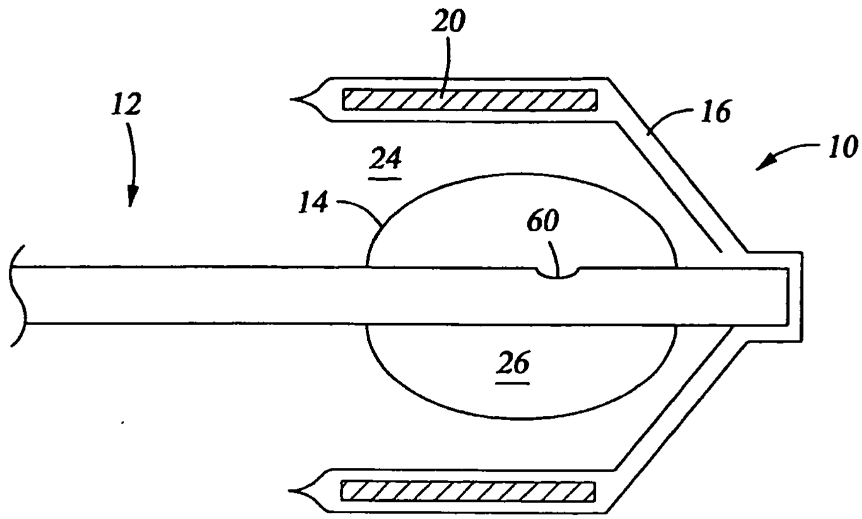

Fig. 15

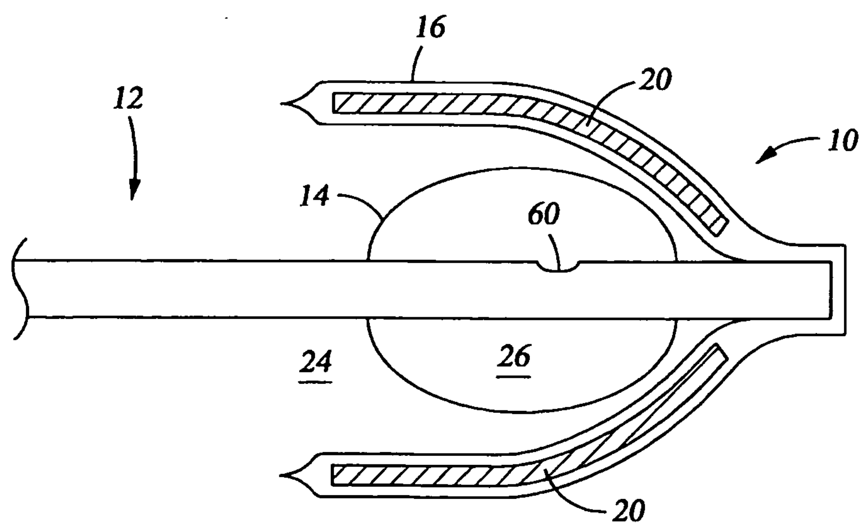

Fig. 16

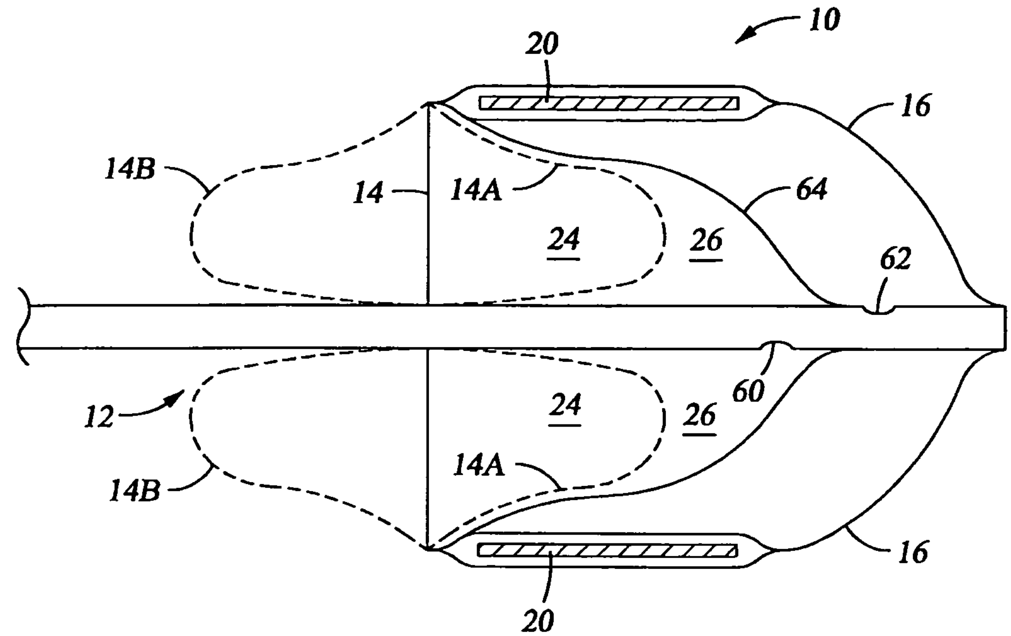
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Fig. 17

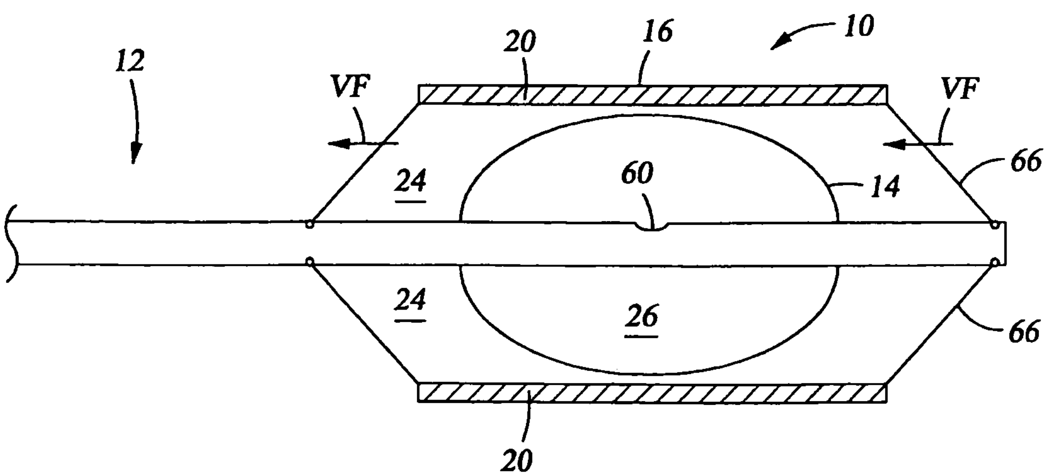
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Fig. 18

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/19412

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A61M 1/00
US CL :600/016
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)

U.S. : 600/016-018; 604/4-6, 65-67, 150-152, 891.1; 606/192, 193, 198; 623/003

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,569,184 A (CROCKER et al.) 29 October 1996, see Fig. 3.	1

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
22 DECEMBER 1997

Date of mailing of the international search report
03 FEB 1998

Name and mailing address of the ISA/US
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Box PCT
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Facsimile No. (703) 305-3230

Authorized officer
JEFFREY R. JASTRZAB
Telephone No. (703) 308-2097

Espacenet

Bibliographic data: WO2005003545 (A1) — 2005-01-13

PROPULSION SYSTEM

Inventor(s): ROBINSON NICHOLAS PAUL [GB] + (ROBINSON, NICHOLAS, PAUL)

Applicant(s): ROBINSON NICHOLAS PAUL [GB] + (ROBINSON, NICHOLAS, PAUL)

Classification:

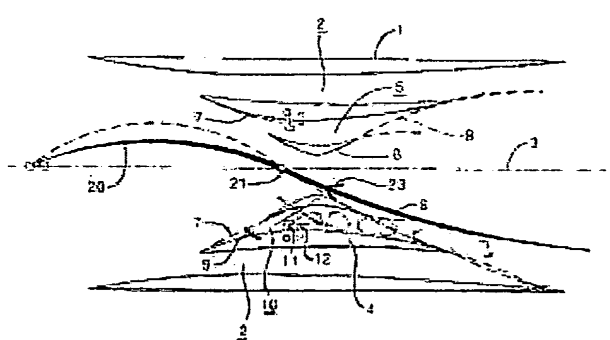
- **international:** ***F02B27/00; F02B29/02; F02B33/00; F02B33/32; F02K7/00; F02K7/06; F04D33/00; F04F7/00;*** (IPC1-7): F02K7/00; F02K7/02; F02K7/06
- **European:** F02B27/00; F02B29/02; F02B33/00; F02B33/32; F02K7/00; F02K7/06; F04D33/00; F04F7/00

Application number: WO2003GB02837 20030702

Priority number (s): WO2003GB02837 20030702

Also published as: AU2003304285 (A1)

Abstract of WO2005003545 (A1)



A universal jet propulsion device featuring a longitudinally mounted flipper-fin housed in a laminar baffle manifold with flap valves provides environmentally friendly operation when deployed as an aerospace propulsion system or a fluid pump. It is able to extend the flight envelope when deployed in an airborne system by using its ultra-low turbulence full-wave action and extensible manifold geometry to maintain inlet overpressure in thin air near sub-space. By deploying the action of manifolded fuel-air combustion against alternate sides sequentially to cause the flexing of the flipper, powerful thrusts can be achieved in water and air.

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(71) Applicant and
(72) Inventor: ROBINSON, Nicholas, Paul [GB/GB]; 17 West End Road, Cottingham HU16 5PL (GB).

(74) Agent: HOWE, Steven; Lloyd Wise, Commonwealth House, 1-19 New Oxford Street, London WC1A 1LW (GB).

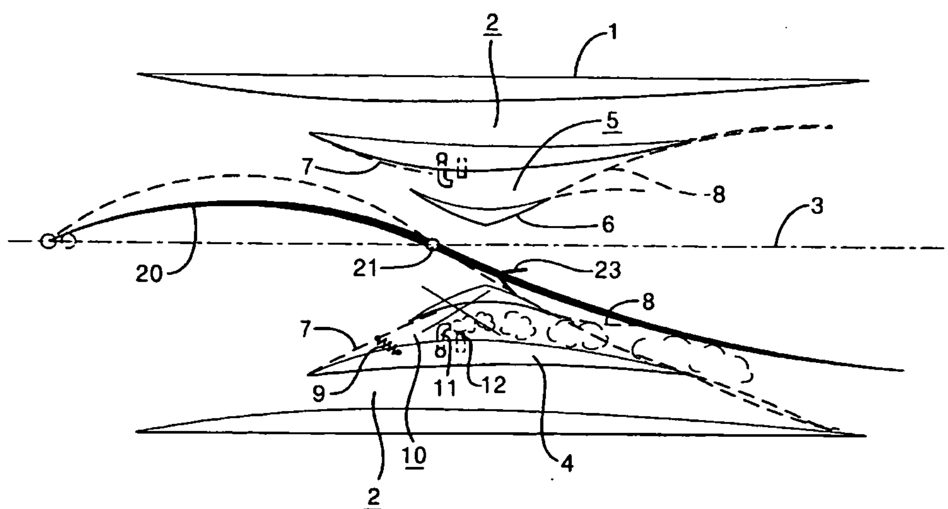
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: PROPULSION SYSTEM



(57) Abstract: A universal jet propulsion device featuring a longitudinally mounted flipper-fin housed in a laminar baffle manifold with flap valves provides environmentally friendly operation when deployed as an aerospace propulsion system or a fluid pump. It is able to extend the flight envelope when deployed in an airborne system by using its ultra-low turbulence full-wave action and extensible manifold geometry to maintain inlet overpressure in thin air near sub-space. By deploying the action of manifolded fuel-air combustion against alternate sides sequentially to cause the flexing of the flipper, powerful thrusts can be achieved in water and air.

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PROPULSION SYSTEM

The present invention relates to a propulsion system, and in particular to a system for propelling fluid. Such a propulsion system may be used to pump fluid, or for generating thrust for moving an object to which the propulsion system is attached.

Various pumps for pumping fluid are known. Most of these are based on a rotating armature. However, for small volumes, other types of pump or motor may be used, such as a piezoelectric pump, peristaltic pump or ion motor. There are limitations with the use of such pumps. Rotating armature pumps require lubrication and are liable to cause turbulence. High power densities are also difficult to implement at a small scale. Piezoelectric pumps and ion motors may overcome some of these problems, but conversely cannot be implemented on a larger scale.

Various systems are known for moving vehicles using a propulsion system. Conventionally, propellers have been used both for marine applications and aircraft. In the marine environment, conventional propellers systems are limited to the power and speed available under load to 60% at the onset of cavitation. Flipper propulsion systems have been proposed which have been found more efficient than conventional propellers systems.

For aircraft, jet engines are known. With the jet engine, compressed gas is introduced into the engine, and the compressed gas is expanded rapidly by combustion of fuel within the compressed gas. The rapidly expanding gas is then used to drive a turbine. It is known to couple the turbine to an inlet fan to enhance the input of gas into the engine, in a turbofan arrangement. RAM jet engines are also known. Whilst each of these types of engine have advantages in certain circumstances, they also cause disadvantages in other circumstances. For example, conventional jet engines are complex, requiring many parts to be moved at high speeds whilst under high stress. This means that such engines are expensive to manufacture, and are liable to catastrophic failure. Conventional jet engines are limited to operation up to 60,000 ft. due to the turbulent nature of the thrust generation and high venturi temperatures, pressures and speeds. RAM jet engines require a very high inlet velocity in order to start, and therefore their use in a "single stage" propulsion system is limited.

According to a first aspect of the present invention, a jet engine comprising an inner manifold include an inlet portion and an outlet portion and a flipper, one end of which is pivotally mounted towards the inlet portion of the manifold, and an intermediate part of which is pivotally mounted within the manifold, the pivots lying substantially centrally with respect to the manifold, the flipper being operable in a scoop-swallow-wallop cycle to scoop and compress fluid into an inlet manifold via an inlet valve, the flipper being pivoted in the opposite direction to allow the compressed fluid from the inlet manifold though the outlet to produce a jet of fluid.

The jet engine according to this aspect of the present invention has been found to be more efficient than other known jet engines in a greater range of environmental conditions.

Advantageously, an ignition means is provided to ignite the compressed fluid in the inlet manifold, causing this to expand thermodynamically to jet the fluid from the outlet. A fuel injection means may also be provided for injecting fuel into the inlet manifold for combustion of the compressed fluid. In this case, the expansion of the compressed fluid within the inlet manifold causes the pivoting of the flipper in the opposite direction. Alternatively, steam can be injected into the compressed fluid to cause its expansion.

Advantageously, the inlet valve is biased towards a closed position, thereby opening only when the pressure of compressed fluid from the flipper reaches a predetermined level. In this case, the bias of the inlet valve is advantageously adjustable.

The engine advantageously includes an outer manifold around the inner manifold, the outer manifold being defined by outer manifold side walls. This can help enhance the ram effect to enhance the efficiency of the jet. In this case, the tail of the flipper is preferably arranged to be able to close the outer manifold.

To control the efficiency of the engine, for example at different ambient conditions, the size of the inner and/or the outer manifold is variable by movement of the inner and/or outer manifold walls. This may be achieved by providing the inner and/or the outer manifold side walls on a scissors mechanism for movement with respect to the centre of the manifold.

In an alternative example, the jet engine further comprising a means for moving the flipper between opposite positions. The means may be a motor which could be connected to one of the pivots of the flipper to move the flipper between its opposite positions. With this arrangement, no combustion of the fluid is required within the manifold. This means that the engine can operate in fluid that is not combustible, for example in water.

According to a second aspect of the present invention, a turbojet compressor for providing compressed gas to an internal combustion engine, comprises an inner manifold include an inlet portion and an outlet portion, a flipper, one end of which is pivotally mounted towards the inlet portion of the manifold, and an intermediate part of which is pivotally mounted within the manifold, the pivots lying substantially centrally with respect to the manifold, and an internal combustion engine including a piston cylinder, the flipper being operable in a scoop-swallow-wallop cycle to scoop and compress fluid into the piston cylinder via an inlet valve, the fluid being combusted within the piston cylinder to drive a crank shaft of the engine.

The internal combustion engine may be a twin-cylinder engine.

Advantageously, the crank shaft of the internal combustion engine is coupled to move the flipper between opposed positions. This provided the force for movement of the flipper. The crank shaft may be connected to at least one of the pivots.

The fluid is advantageously supplied to the piston cylinder via an inlet manifold, the inlet manifold being in the form of a funnel to compress the fluid as this is supplied to the piston cylinder. The inlet manifold may be angled with respect to the centre line of the compressor to assist with the collection of fluid when moving through the fluid.

Advantageously, at least one of the pivots, preferably the leading pivot, is a floating head pivot. This assists the movement of the leading section of the flipper between its extreme positions.

The flipper may be formed of a resilient material, such as spring steel, or a nicromat alloy. Alternatively, the flipper may be formed in a number of segments which are connected together with a resilient means to give the required flexibility of the flipper. In this case, the resilience of the resilient means is preferably adjustable depending upon the application of the engine, the fluid in which this is being used and other similar factors.

The flipper may include an anti-oxide coating.

Cooling means are preferably provided to cool the flipper in use. The cooling means may comprise channels for cooling fluid which can be formed on or in the flipper, and which may carry a cooling fluid such as liquid sodium or water.

According to a third aspect of the present invention, an engine comprises a manifold, a flipper pivotally mounted for movement between a first position and a second position within the manifold to jet fluid out of the manifold, and a means for moving the flipper between the first and the second position, in which the side walls of the manifold include at least one one-way valve for allowing fluid to enter the manifold through the at least one valve, whilst preventing the flow of fluid from the manifold through the manifold side wall.

Advantageously, a plurality of valves are provided on each side wall of the manifold to assist with the inlet of fluid into the manifold. The or each valve may be flap valves.

According to a fourth aspect of the present invention, a pump comprises a channel along which fluid is to be pumped, and a flipper mounted within the channel, the flipper including a fixed end and a free tail extending downstream within the channel, and a means to move the tail of the flipper between a first position substantially adjacent one side of the channel and a second position substantially adjacent the other side of the channel to pump fluid along the channel.

Advantageously, the flipper is arranged to ripple along its length, thereby propelling fluid along the channel.

The device can be assembled from three Si wafers bonded together in a vertical planar, wafer-bonded sandwich using known techniques. The flipper is made by etching from the central component using standard methods used in MEMs technology, coated by either a magnetic or piezoelectric layer on either or both sides.

The flipper preferably includes at least two layers of different material or differently doped material, such that the application of a current across the flipper causes the flipper to move between the first and second positions. For example, the flipper may be formed with a n-type core and p-type layers on either side of the core, or with a p-type core and n-type layers on either side of the core.

The flipper may be moved or rippled using a piezoelectric effect, magnetism or in other ways.

According to a fifth aspect of the present invention, a gated charge pump provides for switched flow in two alternate directions. The flipper has a ripple flex action which pumps fluid through the device in metered quantities by counting the number of ripple flexions. The ripple-flex action is induced by piezoelectric flipper actuation as described, but at a frequency above its natural resonance in the propelled fluid, i.e. above its "S" point, creating an eel-like motion or ripple action. This rippling action is reinforced by electromagnetic fields acting on the collector wire and tail wafers produced by the embedded printed circuit coil "stator" in the manifold walls. When the device switches to the alternative gate for selective pumping, the electromagnetic field is reverse-biased, i.e. a DC offset component added or subtracted to the AC current causing the assisted ripple flexing. This causes the tail to vector its thrust and point it towards the alternative gate.

By providing a magnetic field around the tail end of the flipper, for example using at least one electromagnet arranged near the tail end of the flipper to generate the magnetic field, the movement of the flipper can be controlled.

Various features associated with different aspects of this invention may usefully be combined.

The present invention will be described with respect to the accompanying drawings, in which:

Figure 1 shows a sectional view through a jet engine according to a first aspect of the invention;

Figure 2 shows a sectional view of an alternative example of a jet engine according to the present invention;

Figures 3a and 3b show alternative manifold positions;

Figure 3c shows an arrangement of multiple engines;

Figure 4 shows a sectional view of a turbojet compressor;

Figure 5 shows a sectional view of a turbojet compressor;

Figures 6a-c shows a perspective view of a pump;

Figures 7a and 7b show sectional views of a flipper;

Figure 8 shows a gated charge pump;

Figure 9 shows a sectional view of a flipper pump;

Figure 10 shows a sectional view through an aqua-jet motor; and

Figure 11 shows a sectional view of a pump for arrangement in a blood vessel.

The present invention relies on the flexing of a flipper member to propel fluid along an opening or manifold in which the flipper member is provided. The flexing of the flipper member is achieved by various stimuli, dependent upon the application of the propulsion device.

A first example of a propulsion system according to the present invention will be described with respect to a jet engine as shown in Figures 1 to 3. In this case, the flexing of the flipper is achieved by the rapid expansion of compressed gas when this is combusted in a combustion chamber, assisting the jetting of gas from the rear of the device. This jet of gas produces thrust.

The engine comprises an outer manifold side wall 1 defining an outer manifold 2 having a central axis 3, and an inner manifold side wall 4 defining an inner manifold 5. Inner manifold throat baffles 6 are provided within the inner manifold 5. The arrangement of the manifolds is generally symmetrical along the central axis 3. The opposite sides of the axis 3 will be referred to the left side (below the axis as shown in Figure 1) and the right side (above the axis as shown in Figure 1). However, this notation should not be construed as limiting the orientation of the device. First valve members 7, in the example shown in the form of a flap valve, are mounted towards the leading edge of the left and right sides of the inner manifold side wall 4, and are biased to close against the respective inner manifold throat baffle 6 by biasing means 9 such as a spring. The spring bias may be adjustable. However, the valve will typically close when the pressure within the combustion chamber is equal to or greater than that in the inner manifold inlet. Each inner manifold side wall 4, and respective first valve member 7 and inner manifold throat baffle 6 define a respective combustion chamber 10 to be described below. A fuel injector 11 and ignition means 12 are directed into the combustion chamber 10. An optional second valve member 8, in the example shown a second flap valve, is mounted on the trailing end of the inner manifold throat baffle 6.

The system also includes a flipper 20, for example formed of a material such as nicromat alloy. The alloy may be precision cast, and may include an aluminium anti-oxide coating. To allow cooling of the flipper, this may include cooling tubes which are preferably internally cast. The cooling tubes may contain a cooling medium such as liquid sodium or water. The flipper 20 is pivotally mounted within the system by a pivot 21 provided on the central axis 3 of the inner and outer manifolds, the pivot 21 lying generally perpendicular to the central axis 3. The leading edge of the flipper 9 is also pivotally mounted on the central axis 3 with a floating head pivot 22 perpendicular to, and able to move along, the central axis 3. Where the second valve member 8 is omitted, a sealing member 23 is provided on the flipper 20 to seal the flipper 20 against the inner surface of the inner manifold throat baffle 6 as described below. The sealing member may be included where the second valve member 8 is retained.

In use, as shown in dotted lines in Figure 1, the trailing end of the flipper 20 closes the rear of the left combustion chamber 10 between the left inner manifold throat baffle 6 and the left inner manifold side wall 4. The trailing end of the flipper 20 also engages the left outer manifold side wall 1, thereby sealing the left outer manifold 2. At the same time, the left first flap valve 7 is closed by the combination of the biasing means 9 and a higher pressure within the left combustion chamber 10 than in the inlet left inner manifold 5. The gas within the combustion chamber 10 is thereby compressed. Fuel is then injected into the left combustion chamber 10 though the fuel inlet 11, and the resulting mixture of fuel and gas is ignited within the combustion chamber 10, causing the rapid expansion of this gas. This is illustrated in dotted lines in Figure 1 which shows the progressive expansion of the gas as this is exhausted from the manifold 5. The exhaust gas may be at temperatures in excess of 1000°C, typically of around 1200°C. The increase in pressure of the gas within the combustion chamber 10 as this is forced though the trailing end of the combustion chamber 10, causes flexing the trailing end of the flipper 20 away from the rear end of the left combustion chamber 10. A seal 23, which is shown in the form of a barb, between the flipper 20 and the inner surface of the left inner manifold throat baffle 6 prevents the expanded gas passing between the flipper 20 and an inner surface of the left inner manifold throat baffle 6, and accordingly all of the gas is forced out of the rear of the manifold, creating forward thrust. Where a second valve member 8 is provided, the may close against the flipper to create a seal. The force applied to the trailing end of the flipper 20 by the rapid expansion of the gas in the combustion chamber 10 causes the trailing end of the flipper 20 to whip across the inner manifold 5 about the pivot 21, closing the rear of the right combustion chamber 10 on the opposite side of the central axis 3 and compressing the gas within the right combustion chamber 10 to repeat the process.

During the flipping of the trailing end of the flipper 20 from the left side to the right side, the leading end of the flipper 20 flexes about the pivots 21 and 22 in the opposite direction. Particularly, the leading end of the flipper 20 moves from the right side to the left side, and in doing so straightens initially, causing the floating head pivot 22 to move forward. As the leading end of the flipper 20 passes the central axis 3, this bends, causing the floating head pivot 22 to move rearwards. By limiting the sliding movement of the floating head pivot 22, the degree of flexing of the flipper 20 can be regulated. This movement causes a reduction in the pressure in the right inlet manifold in the region of the right first flap valve 7 of the right combustion chamber 10 which, in combination with the action of the biasing means 9 causes the right first flap valve 7 to close, enabling the compression of the gas in the right combustion chamber 10.

At the same time, the pressure in the inner manifold 5 around the left first flap valve 7 of the left combustion chamber 10 is increased, causing the left first flap valve 7 to open against the bias of the biasing means 9. This assists with the exhaust of gas from the left combustion chamber 10. Also, the leading portion of the flipper 20 scoops gas and forces this into the left combustion chamber 10 so that this gas can be compressed by the action of the trailing end of the flipper 20 when the movement of the flipper 20 is reversed.

Further, the flow of gas through the left inner manifold will help cool this, reducing thermal stress.

The action of the leading end of the flipper 20 in flexing to force fluid toward the combustion chamber is referred to as the "scoop" phase. This is followed by a "swallow" phase preceding the combustion of gas in the opposed chamber, during which fluid flows through the inner and outer manifolds. The phase when the gas is combusted, causing the tail of the flipper to whip to the opposite side of the manifold is referred to as the "wallop" or "stroke" phase. Accordingly, the complete action of the flipper is referred to as "scoop-swallow-wallop" cycle.

It will be appreciated that the gas is alternately compressed and combusted in the opposite sides of the inner manifold 5, giving a reciprocating action.

With this arrangement, the outer manifold 2 functions to increase the thrust generated by the engine by increasing inlet ram airflow collection, exhaust gas compression and inlet-to-outlet gas flow with bypass mixing and cooling. As described above, the flipper 20 partially closes the trailing edge of the outer manifold 2 during the "swallow" phase, as the exhaust gases are exhausted from the inner manifold. This optimises rearward thrust generation. It also acts to maximise the pressure differential between the combustion chamber and the inlet inner manifold around the first valve 7, and thereby assists with the efficient opening and closing of the valve member. This is especially important at high inlet airspeed to maximise inlet air collection in thin air and to keep drag low.

An alternative arrangement is shown in Figure 2, in which like parts are given the same reference as in Figure 1. In this example, the outer manifold side walls 1 are adjustable, for example including a variable geometry scissors mechanism 30, adjustable by an actuator 32. By adjustment of the position of the outer manifold side walls 1, the thrust may be controlled dependent upon the environmental conditions. For example, where the engine is used for an aircraft, this can provide low speed thrust for takeoff and landing, and maintain thrust in thin air by expansion of the outer manifold 5 by outward movement of the outer manifold side walls to a position 1' as shown in Figure 2. The position of the inner manifold side walls may similarly be adjusted. The engine according to this aspect of the invention is able to operate at a lower manifold pressure compared to a conventional jet engine turbine, but with a larger aperture. This results in lower venturi speeds and lower operating temperatures. In turn, this leads to a reduction in stress on the components, and thereby a reduction in cost.

The scissors geometry manifold is shown in more detail in Figures 3a and 3b. In Figure 3a, the manifold is open to its maximum extent, causing the maximum amount of air to be collected into the manifold. This helps maintain the required overpressure and hence thrust in thin air. With this arrangement, a large displacement of the flipper is required as this moves from one side to the other. In this case, variable geometry wings 40 of an aircraft are shown extended for high altitude flying to maintain lift in thin air. Figure 3b shows the manifold in a narrow condition. This is suited to low altitude applications, including aircraft takeoff and landing, or when operating at high velocity, for example on re-entry to the atmosphere. In this example, the wings 40 are shown non-extended.

It is important that the engine components are sufficiently cooled. This may be achieved by airflow cooling of the inner manifold side walls by airflow passing through the outer manifold. The flipper may be cooled by internal tubes or coils within the flipper containing a cooling medium, or by cooling fluid extending along the flipper, for example from the main pivot.

Figure 3c shows an end view of an arrangement of multiple propulsion devices arranged in a stacked configuration. The multiple devices may be operated with different phase cycles. This produces a more continuous level of thrust. Also, the cycle time, and in particular the "swallow" phase, can be increased, thereby aiding cooling. Components may be shared with this arrangement, for example each of the flippers may share a commonly geared central pivot and manifold footprint.

Rather than injecting fuel into the combustion chamber and igniting the resulting mixture, steam can be injected into the compressed fluid causing the expansion of this.

To operate at maximum output, which is limited by the full wave resonant frequency of the flipper-manifold system, the resonant frequency should not be exceeded, otherwise the flipper will exceed its "S" point and will resonate at harmonics. This can be overcome by including adjustable stiffeners in the flipper as shown in Figure 10.

In another example, generally similar to that shown in Figures 1 to 3, the flipper is driven between its two positions by an engine, for example a twin cylinder opposed four-stroke reciprocating piston engine. The engine can be mounted to share its crank axle with the main pivot axle of the flipper. In this arrangement, the combustion features may be omitted. As no combustion of compressed fluid is required, this arrangement is suited to use with non-combustible fluids, such as water. In this case, the flipper is preferably formed of a spring steel sandwich composite, preferably with incorporated cooling means, such as cooling coils. Many of the features of the first embodiment may be used with this example, including the floating head pivot and features of the flipper and adjustable manifolds.

As the engine causes the flipper to move from one extreme position to the other extreme position, the leading end of the flipper will flex about the two pivots from its concave position to its convex position, "scooping" fluid and forcing this into an inlet manifold. By variation of the diameter of the manifold between inlet and exhaust, suitable compression and jetting can be achieved. The inlet manifold is connected to an exhaust manifold on the opposite side, which is closed by the tail of the flipper. Accordingly, fluid will be introduced into and compressed within the manifold. When the tail of the flipper is moved by the engine, the compressed fluid will be propelled from the exhaust manifold. In typical conditions, the fluid may be at a temperature of around 600°C. At the same time, the tail of the flipper will seal the opposite exhaust manifold, whilst the movement of the leading end of the flipper will scoop fluid into the opposed inlet manifold. During the "swallow" phase of the movement of the flipper, namely the phase between movement of the flipper between the two extreme positions, substantially uncompressed fluid will flow around the exhaust manifold, assisting in the cooling of the flipper and manifold. This helps reduce heat stress. This example acting as a compressor provides enhanced aspiration for the coupled IC piston engine for providing improved mechanical shaft output and/or thrust generation.

A further example of the use of the present invention, as shown in Figures 4 and 5, is as a turbo-jet compressor. Such a compressor may be used to enhance gas flow, such as air, into an internal combustion engine, and for thermodynamically expanding the exhaust gas of the engine through opposite cylinders with this arrangement, the flipper is driven between its extreme positions. Advantageously, part of the internal combustion engine's crank motive power is used to drive the compressor. Features of the previous examples including the floating head pivot, features of the flipper, and the adjustable manifolds may also be used in this example. With this arrangement, the combustion occurs within a cylinder as opposed to being within the manifold. This improves cooling and the generation of shaft power, and increases the inlet air compression ratio and combustion efficiency, whilst reducing the heat stress on the flipper.

A twin cylinder implementation is described with alternate flipper air cooling cycles.

As shown in Figure 4, there is provided an inlet manifold 204 for an internal combustion engine. A flipper is provided that may move from a first extreme position shown in solid lines with reference 202 to a second extreme position shown in dotted lines with reference 209. Scooped ram air 201 or other fluid is compressed by the leading end of the flipper as this is flexed from a concave to a convex orientation with respect to the left hand side of the system. The compressed air is accelerated through the inlet manifold 204 which has a reducing diameter 205, and into the cylinder cavity 206 of the internal combustion engine, passing through an inlet valve 210. The compressed air is thought to remain at a constant pressure as this is forced through the manifold. As the flipper is moved in the opposite direction, air is compressed and accelerated into the opposite inlet manifold.

The air within the cylinder is compressed further within the cylinder by the piston in its compression stroke, during which the inlet valve 210 is closed.

As shown best in Figure 5, the compressed air within the cylinder is ignited, causing its rapid expansion, which drives the piston in the internal combustion engine 225, rotating a crank shaft 230 connected to the piston in the normal manner. In the example shown in Figure 5, the crank shaft is used to drive the flipper between its two extreme positions, thereby scooping and compressing air into the piston chambers of the internal combustion engine.

Exhaust gas from the piston chamber is exhausted through an outlet valve, though an outlet manifold 224 and out of the rear of the system as exhaust gas 229. This exhaust of gas is aided by the flow of gas over the flipper.

In this example, the inlet manifolds are angled rearwards to ensure that the maximum amount of air is scooped into the manifolds. The position and angle of the manifolds may depend upon the velocity of the air flow into the inlet manifold of the system.

The "scoop-swallow-wallop" cycles of the flipper cap to a four-stroke compression-power-exhaust-induction cycle of the internal combustion engine as set out below:

IC Engine: Stroke count/ crank rotation angle (degrees)	IC Engine: Left Cylinder 1	IC Engine: Right Cylinder 2	Flipper: Left inlet	Flipper: Right inlet	Flipper: Left outlet	Flipper: Right outlet
1/ 0-180	Compression	Power	Scoop	Swallow	+ Left cylinder exhaust	Wallop
2/ 180-360	Power	Exhaust	Swallow	Scoop	Wallop	+ right cylinder exhaust
3/ 360-540	Exhaust	Induction	Scoop	Swallow	+ left cylinder exhaust	No wallop
4/ 540-720	Induction	Compression	Swallow	Scoop	No wallop	Cooling inlet air only
1/ 0-180	Compression	Power	Scoop	Swallow	Cooling inlet air only	Wallop
2/ 180-360	Power	Exhaust	Swallow	Scoop	Wallop + left cyl exhaust	Cooling inlet air only

It will be appreciated that rather than using the drive from the crank shaft, the exhaust gas from the system may be used as a jet of fluid for the propulsion of a device.

Another example of the present invention is shown in Figures 6 and 7.

In this example, a flipper 119 is mounted in a channel 112. The leading end 116 of the flipper 119 is fixed, whilst the trailing end or tail of the flipper 119 is free. In use, the tail of the flipper 119 is flexed to propel fluid along the channel 112.

The pump or motor according to this aspect of the present invention is especially suited to miniaturisation. In this case, as shown in Figure 6, the device may be formed from a semiconductor wafer 111 into which a flow channel 112 is formed, for example by etching. The tapered flipper 119 is formed within the channel 112. In a preferred example, the flipper 119 is formed from the semiconductor wafer during the etching of the channel 112, with the tail of the flipper 119 being undercut from the wafer by burning, lasering, etching or other means. The flipper 119 is tapered from the fixed leading end 116 to the tail 119. However, the flipper 119 may be formed from three layers bonded together using standard wafer bonding technique. The flipper may be coated with piezoelectric or magnetic layers.

The flipper 119 has a p-type doped core 113 sandwiched by outer n-type doped skins 114, 115 acting as cathodic outer skins, as shown in the cross-section of Figure 7b. The doping of the core 113 and the skins 114, 115 may be reversed. An anode 118 is provided at the tail end of the flipper 119, connected to a collector wire 121.

Rather than the p-n-p or n-p-n structure, a simple p-n structure formed from two rather than three layers may be used.

As shown in Figure 7a, due to the piezoelectric effect caused by the different doping of the core 113 and skins 114, 115, when the flipper 119 is flexed, it is believed electrons (-) and/or holes (+) will migrate along the rippling surface wave to the end of the flipper 119 where they are collected by the anode 118. The application of a lateral alternating current to the outer surface skins 114, 115 of the flipper 119, for example being applied to the outer skins of the flipper 119 at the fixed leading end 116 will cause the flipper 119 to flex. This flexing of the flipper 119 acts to pump fluid in the channel 112.

The propulsion of fluid may be controlled. The piezoelectric effect may be enhanced, or the propagation of holes and electrons controlled, by the application of a magnetic field across the channel 112. As shown in Figure 6, an electromagnetic field may be applied across the channel 112 by the use of coils on the side walls of the channel 112, for example through printed circuit coils. The advancing wave front of the flipper 119 (as shown by the arrow 101 in Figure 7) is thought to react against the electrostatic field, propelling electron concentrations and/or holes rearwards (in accordance with Fleming's Hand Rule).

Preferably, the flipper 119 is made to ripple along its length, rather than merely flap. This is achieved by a short wavelength deformation of the flipper 119.

As shown in Figure 8, the device may be used in a gated charge pump. In this case, there are provided two outlet paths, 131 and 132. The flipper 119 is able to be moved by an alternating power 137 applied to the skins 114, 115 of the flipper 119, with an anode voltage offset provided by a battery 138. In this case, as the tail end of the flipper 119 contacts the walls 135, 136 of the outlet, charge is collected from the exposed anode 118 on the tail of the flipper 119.

Other mechanism for movement of the flipper may include use of the Hall effect, or remote magnetic actuation by a stator containing field coils 130, 140 which enhance piezoelectric charge cluster propagation along the flexing flipper.

Ideally, the flipper of this pump is provided with a leading end that is moved opposite to the tail, as described with the earlier aspects of the invention. This provides the "ripple-flexing" action to improve the propulsion of fluid. The switch 131, 132 provides a DC offset to the stator coil 130 to move the ripple-flexing flipper to alternating gates 131, 132. Flap valve 135 pivot to guide fluid flow, and can snap shut to prevent flow reversal.

Small pumps of this type have many applications, including medical applications.

As shown in the sectional view of Figure 6b, three wafers are stacked above a chip substrate. The flipper is etched out of the middle section using MEMs techniques, leaving a channel. In this figure, the dotted line shows the direction of flipper flexion. Figure 6c shows a plan view of the planar bonded water assembly.

A semiconductor wafer actuated by a piezoelectric force causes ripple flexing when placed in a fluid and operated above its resonant frequency which is believed to cause charge migration along its rippling surface to be collected at its tail.

Another embodiment of the present invention is for a "short engine" comprising a valve-manifolded flipper that operates a "swallow-wallop" cycle.

The short engine comprises a middle section "throat" with a short inlet manifold and a rear end in which a pivoting flipper operates a swallow-wallop cycle.

The short engine lends itself to macro-scale marine applications, where the fluid to be propelled is not required to be highly pressurised or is not compressible.

As shown in Figure 9, an outlet 501 with flap valves in its delta side walls 505 that open 504 on retreating sweep strokes of the flipper 503 and close on advancing strokes of said flipper 502, creates reactive manifold thrust 506 whilst presenting a low-drag surface to passing water 507 on alternate sides of it main axis X-X. The pivot of the flipper 508 is placed ahead of the throat or neck of the manifold 509 at or about its apex. As the flipper advances to one side, it forms a valve with the throat and manifold wall 510, compressing fluid rearward to create thrust 506. As the flipper retreats, the throat valve and the manifold wall valves open to allow fluid to fill the opening cavity 511. This is the swallow stroke. The wallop stroke is performed on opposite sides of the flipper in sequence to provide thrust. The wallop stroke is the counterpart of the swallow stroke, occurring simultaneously on opposite sides of the flipper. As the water speed increases, the ram effect against the sides of the outlet manifold 512 forces more water through at overpressure to increase efficiency and reduce drag 507.

The motor contains a middle section with a main powered flipper pivot and a short inlet manifold 509 (the throat) through a small quantity of rapidly-moving ram-inlet water 513 flows along alternate sides along the flipper. The flipper may be powered by any suitable source.

Figure 10 shows the motor in a marine twin-hulled "aqua-jet" application with a remote IC engine and gearbox 551, a reciprocating main pivot gearhead 554, fixed and/or variable manifold wall geometry 552, manifold wall-pivoting adjustment mechanisms 555 and an adjustable flipper spring stiffener mechanism 553. As inlet water speed increases 556, the manifold wall displacement and flipper displacement can be fixed or vary with flipper frequency.

A final example of the present invention is described with respect to Figure 11 which shows a pump for pumping blood. In this example, propulsion system acting as a blood pump are mounted at various locations within the patients circulatory system to aid circulation and prevent blood pressure anomalies causing plaque detachment, clots, arterial collapse and blood pooling. In addition, it can be used outside the patient's body to act as a blood pump for open heart surgery to replace the function of the "ro-ro" peristaltic pump, a portable dialysis machine or for patient controlled drug administration. The unit derives its power from opposing muscle groups inside the body squeezing the manifold and flipper against its valves, expansion of the upper torso during breathing and/or from joint flexing. It can be worn around a limb or the torso or located deep inside the brain by remote insertion through the carotid arteries (like an angioplasty for example) to provide protection from stroke caused by blood pressure anomalies.

For implantation to treat pre-stroke victims, the unit is based on the "short engine" example as described for the marine application. The flipper is powered remotely by actuator coils implanted in the patient's head via keyhole surgery. By remote actuation (through the walls of the blood vessel), the requirement to cut through vulnerable blood vessels deep inside the brain is avoided. The unit "flaps" in normal blood flow and this is detected by the "normally-off" field coils. When blood flow ceases, the coils are energised.

The flipper is analogous to a "moving-magnet" armature in brushless electric motor with field coils acting as the "stator". Control circuitry is not shown but it is of the existing type associated with brushless motors. Having no rotating parts eliminates the requirement for lubricants and joint wear.

For use outside of and/or attached to the body, the units outlet manifold walls containing flap valves are made flexible to deform with changing limb or torso curvature and circumference. Increasing circumference forces the nearest manifold against the central flipper closing its valves and pumping blood as described. Releasing internal pressure causes the manifold walls to spring back open, inducing fresh blood into the opening cavities through opening flap valves.

Figure 11 shows the blood bags pumping on an expanding body belt. The action of a single blood pump 101 is described first. Like a concertina bellows, the bag contains an outlet manifold which can be pressed from the inside by the wearer to fold its sprung bellows towards the body belt, which acts as the stationary flipper in a pivoting manifold 104. Blood is pumped through this squeezing action caused by the inhalation of the wearer for example 105. The inlet pressure builds up forcing the valves on the far side 107 to open into the expanding cavity 108 and vice versa on contraction caused for example by the exhalation of the wearer. The output of the first bag 110 is coupled to the inlet of the next blood pump bag 111 and so on in cascade.

Blood is induced from natural blood pressure through inlet valve 111. Blood emerges pumped from valve 112 to be returned to the body.

Filtering and other blood treatments can be carried out en route through the body belt. As an implant, one or more blood bag pumps can be inserted between opposing muscle groups in the limbs which on contraction and/or relaxation and/or co-contraction can administer a patient controlled drug intravenously (PCD).

CLAIMS

1. A jet engine comprising an inner manifold include an inlet portion and an outlet portion and a flipper, one end of which is pivotally mounted towards the inlet portion of the manifold, and an intermediate part of which is pivotally mounted within the manifold, the pivots lying substantially centrally with respect to the manifold, the flipper being operable in a scoop-swallow-wallop cycle to scoop and compress fluid into an inlet manifold via an inlet valve, the flipper being pivoted in the opposite direction to allow the compressed fluid from the inlet manifold though the outlet to produce a jet of fluid.

2. A jet engine according to Claim 1, in which an ignition means is provided to ignite the compressed fluid in the inlet manifold, causing this to thermodynamically expand to jet the fluid from the outlet.

3. A jet engine according to Claim 2, including a fuel injection means for injecting fuel into the inlet manifold for combustion of the compressed fluid.

4. A jet engine according to Claim 2 or Claim 3, in which the expansion of the compressed fluid within the inlet manifold causes the pivoting of the flipper in the opposite direction.

5. A jet engine according to any one of the preceding claims, in which the inlet manifold is defined by an inner manifold side wall and an inner throat baffle, and the inlet valve, and is closed by the tail end of the flipper.

6. A jet engine according to Claim 5, further comprising an outlet valve.

7. A jet engine according to any one of the preceding claims, in which the inlet valve is biased towards a closed position.

8. A jet engine according to Claim 7, in which the bias of the inlet valve is adjustable.

9. A jet engine according to any one of the preceding claims, in which the inlet and/or the outlet valve is a flap valve.

10. A jet engine according to Claim 5 or any claim dependent thereon, in which the tail of the flipper includes a seal for sealing against the inner throat baffle.

11. A jet engine according to any one of the preceding claims, further comprising an outer manifold around the inner manifold, the outer manifold being defined by outer manifold side walls.

12. A jet engine according to Claim 11, in which the tail of the flipper is arranged to be able to close the outer manifold.

13. A jet engine according to any one of the preceding claims, in which the size of the inner and/or the outer manifold is variable by movement of the inner and/or outer manifold walls.

14. A jet engine according to Claim 13, in which the inner and/or the outer manifold side walls are mounted on a scissors mechanism for movement with respect to the centre of the manifold.

15. A jet engine according to Claim 1, further comprising a means for moving the flipper between opposite positions.

16. A jet engine according to Claim 15, in which a motor is connected to one of the pivots of the flipper to move the flipper between its opposite positions.

17. A jet engine according to Claim 15 or Claim 16, in which the fluid is a liquid, such as water.

18. A jet engine according to any one of the preceding claims, in which at least one of the pivots is a floating head pivot.

19. A jet engine according to Claim 18, in which the pivot mounting the end of the flipper towards the inlet of manifold is a floating head pivot.

20. A jet engine according to any one of the preceding claims, in which the flipper is formed of a resilient material, such as spring steel, or a nicromat alloy.

21. A jet engine according to any one of the preceding claims, in which the flipper includes an anti-oxide coating.

22. A jet engine according to any one of the preceding claims, in which the flipper is a cast flipper.

23. A jet engine according to any one of the preceding claims, in which the flipper includes cooling means to cool the flipper in use.

24. A jet engine according to Claim 23, in which the cooling means comprises channels for cooling fluid.

25. A jet engine according to Claim 24, in which the channels are formed within the flipper.

26. A jet engine according to Claim 24, in which the channels are formed on the surface of the flipper.

27. A jet engine according to any one of Claims 24 to 26, in which the cooling fluid is liquid sodium or water.

28. A turbojet compressor for providing compressed gas to an internal combustion engine, comprising: an inner manifold include an inlet portion and an outlet portion;a flipper, one end of which is pivotally mounted towards the inlet portion of the manifold, and an intermediate part of which is pivotally mounted within the manifold, the pivots lying substantially centrally with respect to the manifold; and,an internal combustion engine including a piston cylinder, the flipper being operable in a scoop-swallow-wallop cycle to scoop and compress fluid into the piston cylinder via an inlet valve, the fluid being combusted within the piston cylinder to drive a crank shaft of the engine.

29. A turbojet compressor according to Claim 28, in which the internal combustion engine is a multi-cylinder engine, for example a twin-cylinder engine.

30. A turbojet compressor according to Claim 28 or Claim 29, in which the crank shaft of the internal combustion engine is coupled to at least one of the pivots to move the flipper between opposed positions.

31. A turbojet compressor according to any one of Claims 28 to 30, in which the fluid is supplied to the piston cylinder via an inlet manifold, the inlet manifold being in the form of a funnel to compress the fluid as this is supplied to the piston cylinder.

32. A turbojet compressor according to any one of Claims 28 to 31, in which the fluid is supplied to the piston cylinder via an inlet manifold that is angled with respect to the centre line of the compressor.

33. A turbojet compressor according to any one of Claims 28 to 32, in which at least one of the pivots is a floating head pivot.

34. A turbojet compressor according to Claim 33, in which the pivot mounting the end of the flipper towards the inlet of manifold is a floating head pivot.

35. A turbojet compressor according to any one of Claims 28 to 34, in which the flipper is formed of a resilient material, such as spring steel, or a nicromat alloy.

36. A turbojet compressor according to any one of Claims 28 to 35, in which the flipper includes an anti-oxide coating.

37. A turbojet compressor according to any one of Claims 28 to 36, in which the flipper is a cast flipper.

38. A turbojet compressor according to any one of Claims 28 to 37, in which the flipper includes cooling means to cool the flipper in use.

39. A turbojet compressor according to Claim 38, in which the cooling means comprises channels for cooling fluid.

40. A turbojet compressor according to Claim 38, in which the channels are formed within the flipper.

41. A turbojet compressor according to Claim 38, in which the channels are formed on the surface of the flipper.

42. A turbojet compressor according to any one of Claims 38 to 41, in which the cooling fluid is liquid sodium or water.

43. An engine comprising a manifold, a flipper pivotally mounted for movement between a first position and a second position within the manifold to jet fluid out of the manifold, and a means for moving the flipper between the first and the second position, in which the side walls of the manifold include at least one one-way valve for allowing fluid to enter the manifold through the at least one valve, whilst preventing the flow of fluid from the manifold through the manifold side wall.

44. An engine according to Claim 43, in which a plurality of valves are provided on each side wall of the manifold.

45. An engine according to Claim 43 or Claim 44, in which the or each valve are flap valves.

46. An engine according to any one of Claims 43 to 45, arranged to propel a boat.

47. An engine according to any one of Claims 43 to 45, arranged to operate in a blood vessel to pump blood along the vessel.

48. A pump comprising a channel along which fluid is to be pumped, and a flipper mounted within the channel, the flipper including a fixed end and a free tail extending downstream within the channel, and a means to move the tail of the flipper between a first position substantially adjacent one side of the channel and a second position substantially adjacent the other side of the channel to pump fluid along the channel.

49. A pump according to Claim 48, in which the channel is formed in a substrate, for example by burning, micromachining, etching or lasering.

50. A pump according to Claim 49, in which the flipper is formed from a sandwich of three wafers bonded above the substrate, for example by burning, micromachining, etching or lasering.

51. A pump according to Claim 49 or Claim 50, in which substrate is a semi-conductor wafer.

52. A pump according to any one of Claims 48 to 51, in which the flipper includes at least two layers of different material or differently doped material, such that the application of a current across the flipper causes the flipper to move between the first and second positions.

53. A pump according to Claim 52, in which the flipper is formed with a n-type core and p-type layers on either side of the core.

54. A pump according to Claim 52, in which the flipper is formed with a p-type core and n-type layers on either side of the core.

55. A pump according to any one of Claims 48 to 54, further comprising an electrode to act as an anode or cathode charge collector at the tail end of the flipper.

56. A pump according to any one of Claims 48 to 55, further comprising a generally vertical or horizontal modulated magnetic field around the tail end of the flipper.

57. A pump according to Claim 56, including at least one electromagnet arranged near the tail end of the flipper to generate the magnetic field.

58. A pump according to Claim 57, in which the electromagnet comprises one or more coils provided in or adjacent the sides of the channel.

59. A pump according to any one of Claims 48 to 58, in which the flipper is mounted on a chip in a vertical planar bonded assembly of three wafers.

60. A gated charge pump including a pump according to any one of Claims 48 to 59.

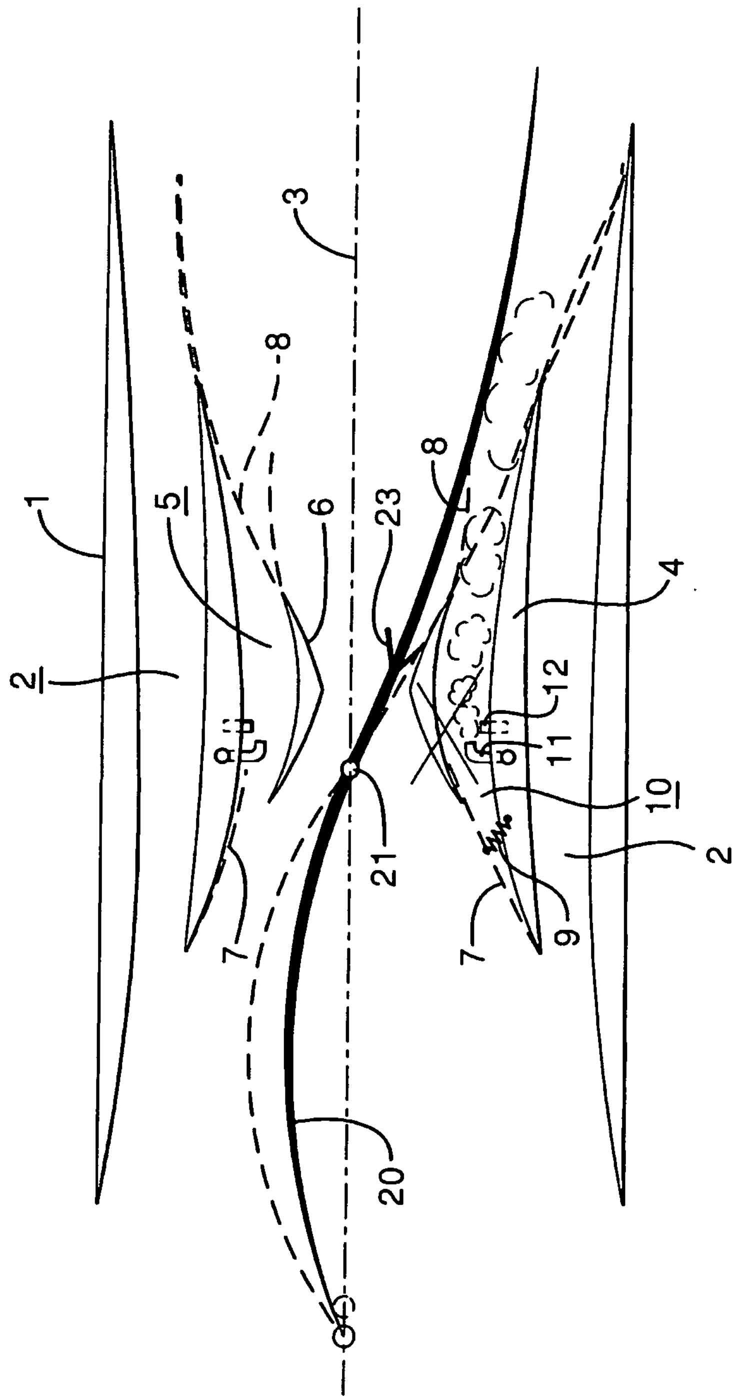
61. A jet engine comprising a centrally-pivoted flipper located within an air or water inlet and outlet manifold whereby the front end of the flipper is also pivoted with a floating head, both pivots lie in the same axial line within the engine, the flipper operates a scoop swallow wallop cycle in which air or water is initially scooped towards the middle section of the engine by the front end of the flipper, the air or water passes through a valve operated by the pressure

of the air or water, the flipper then pivoting in the opposite direction forces the air or water rearwards towards the outlet by the action of the rear end of the flipper moving towards the air of water which is trapped by the closure of the valve.

62. A jet engine according to Claim 1 or Claim 60, in which steam is injected into the inner manifold to create power.

63. A jet engine according to any one of Claims 1 to 27, or a turbocompressor according to any one of Claims 28 to 42, or an engine according to any one of Claims 43 to 47, in which a the flipper includes a variable stiffener to vary the resonant frequency.

Fig.1



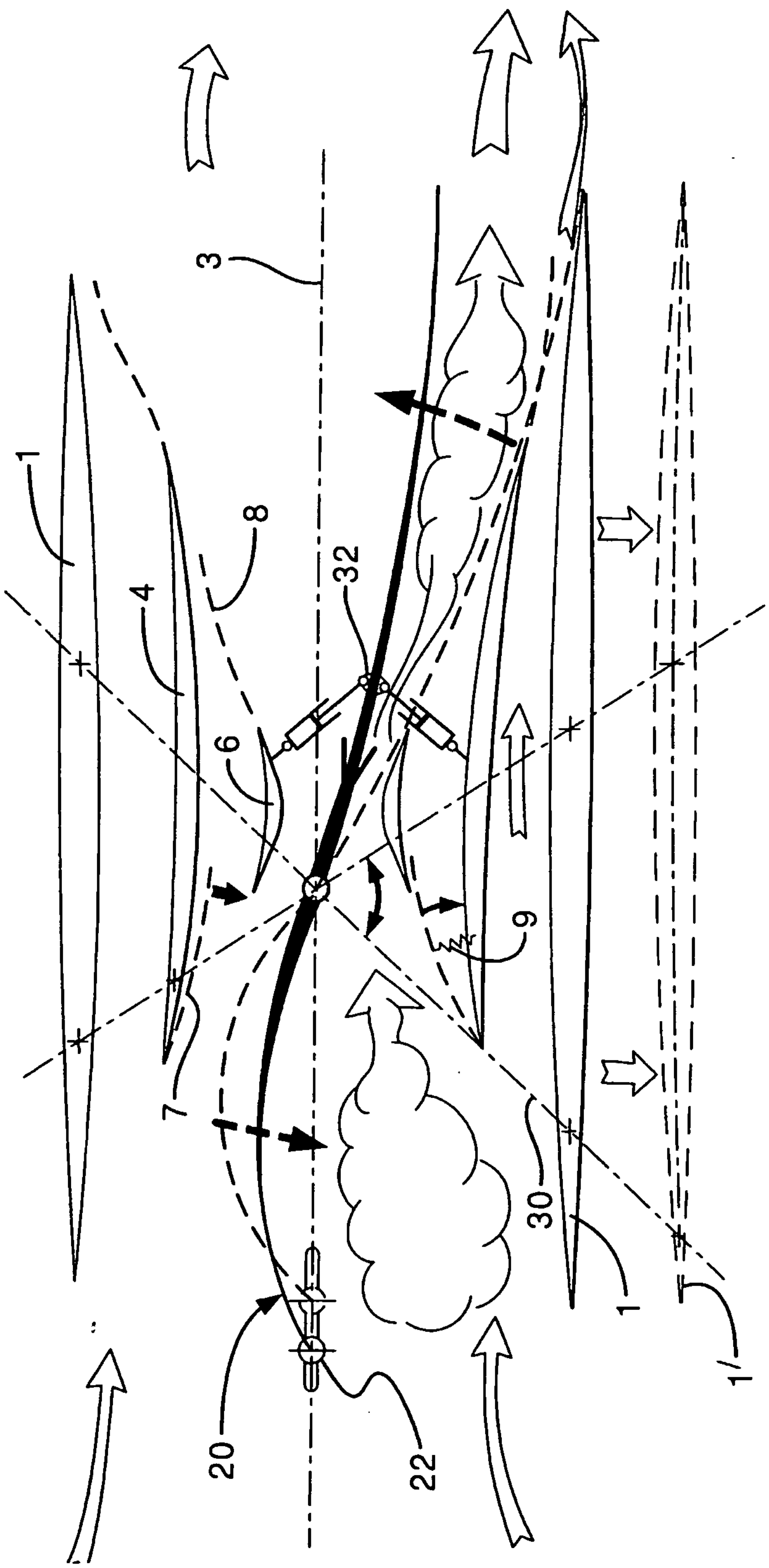


Fig.2

Fig.3c

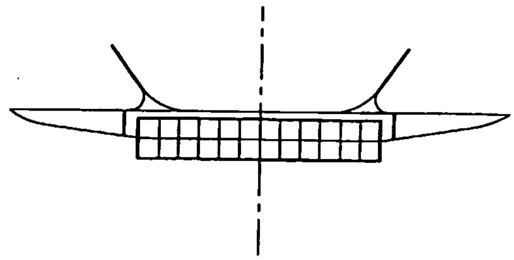


Fig.3b

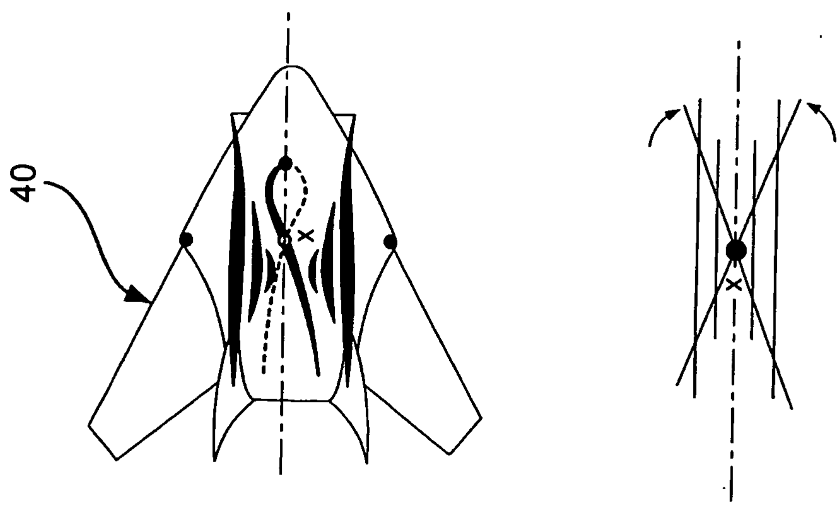
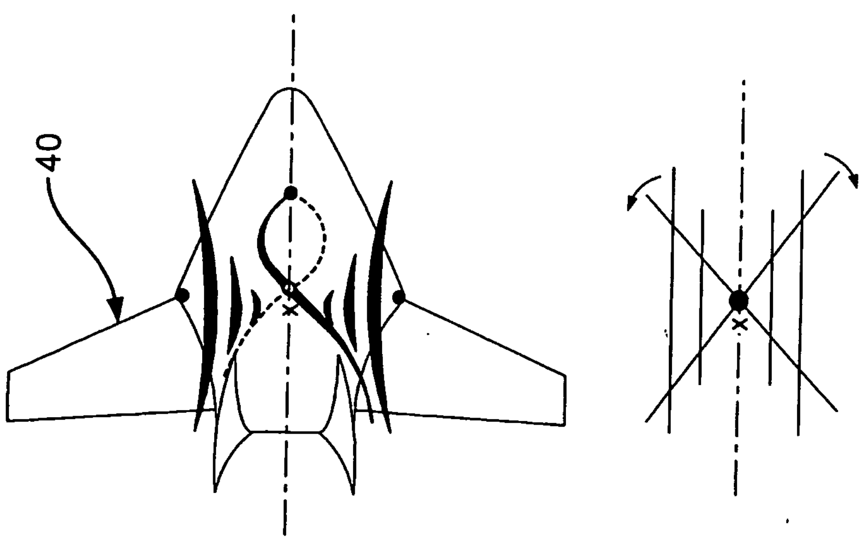


Fig.3a



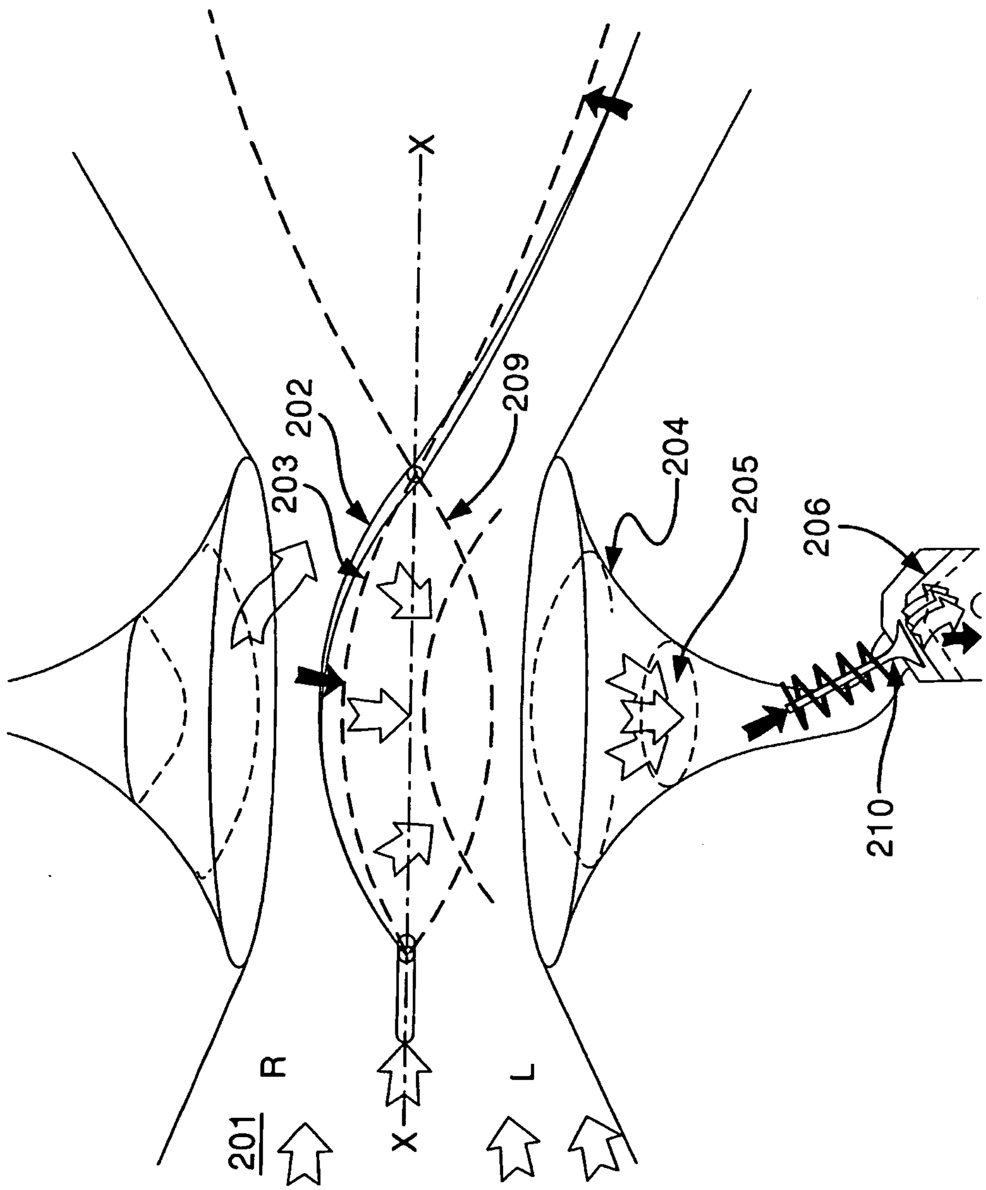
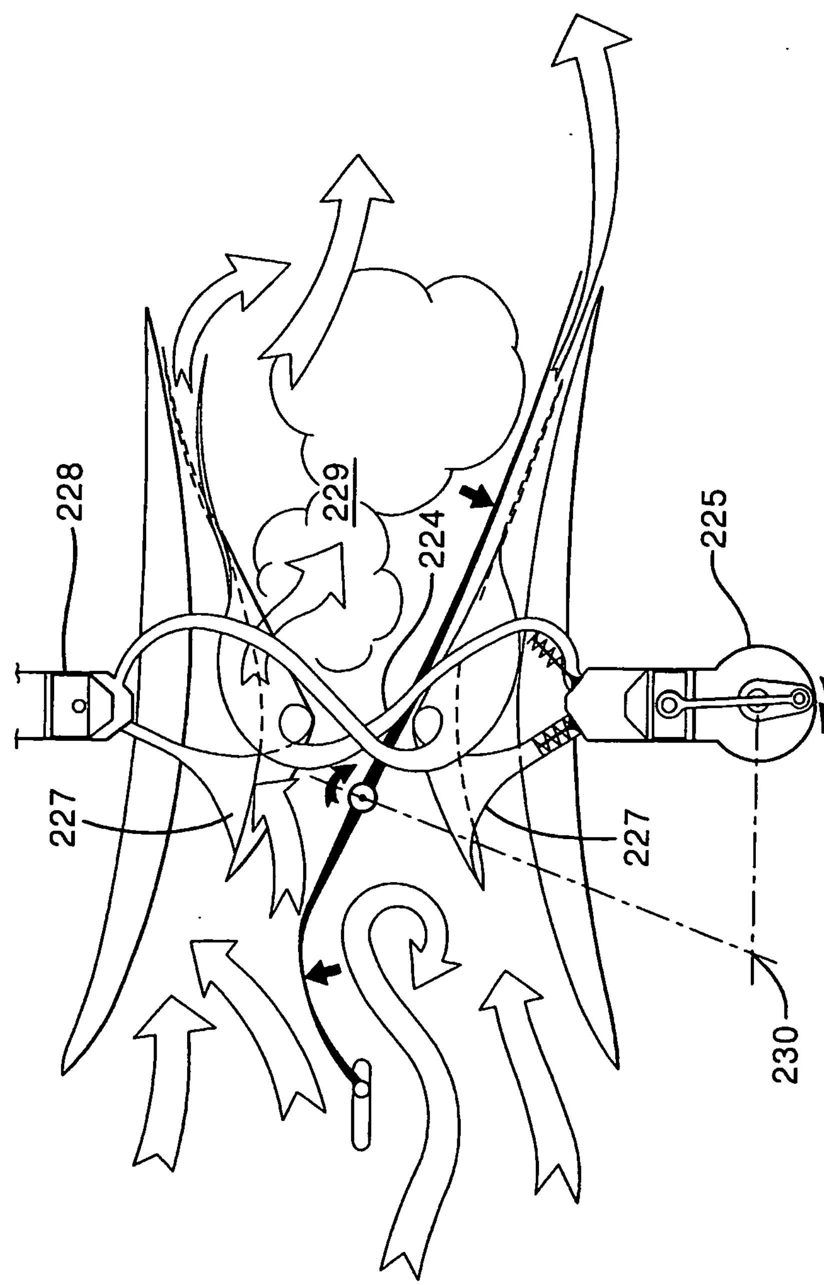


Fig.4

Fig.5



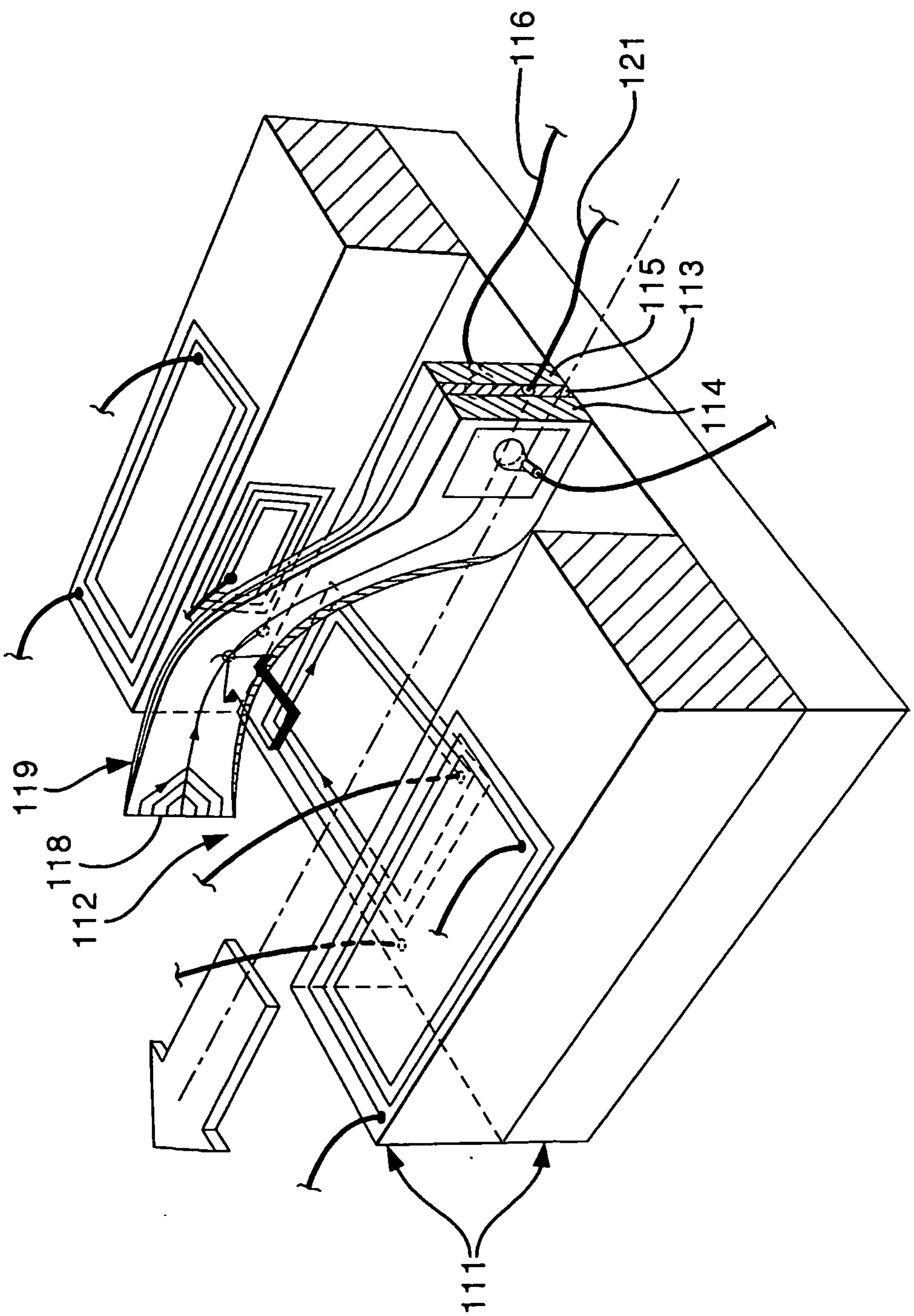


Fig.6a

Fig.6b

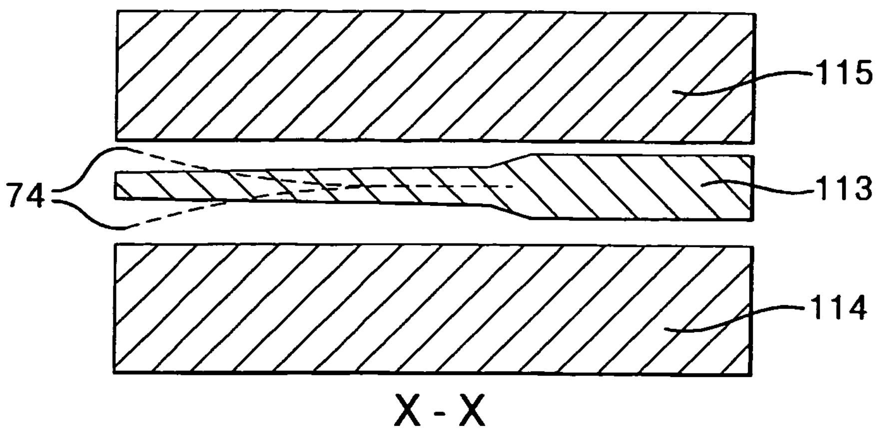


Fig.6c

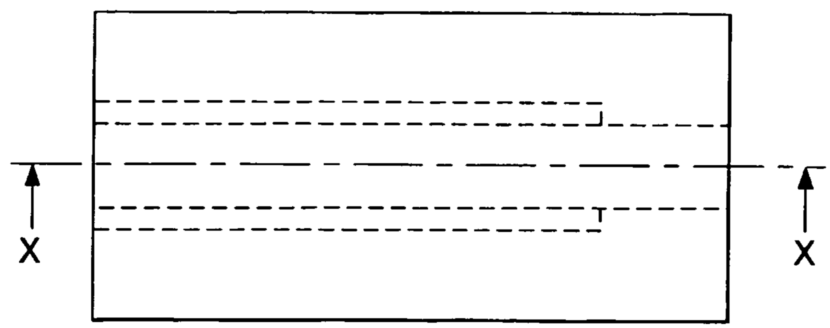


Fig.7a

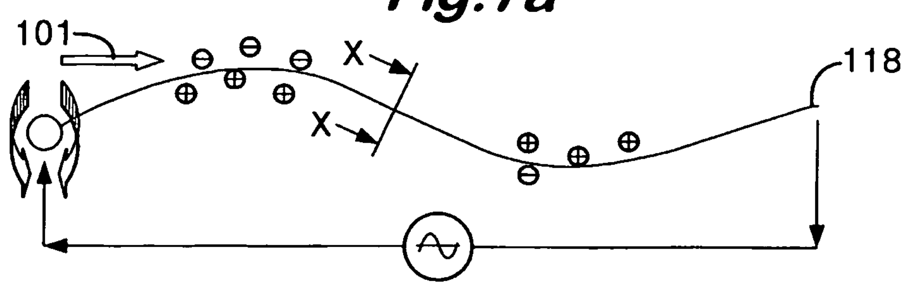


Fig.7b

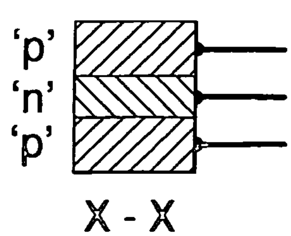


Fig.8

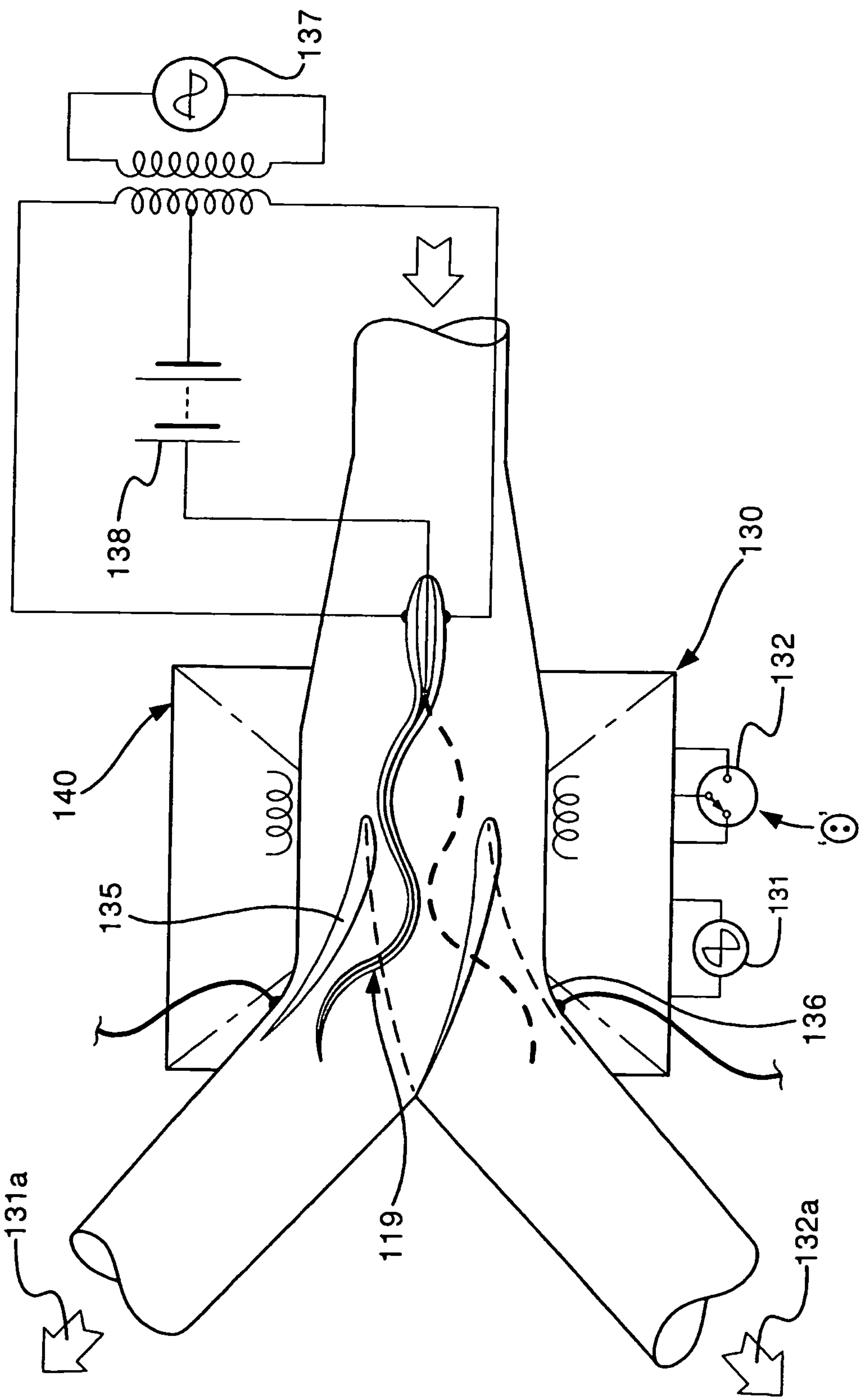


Fig.9

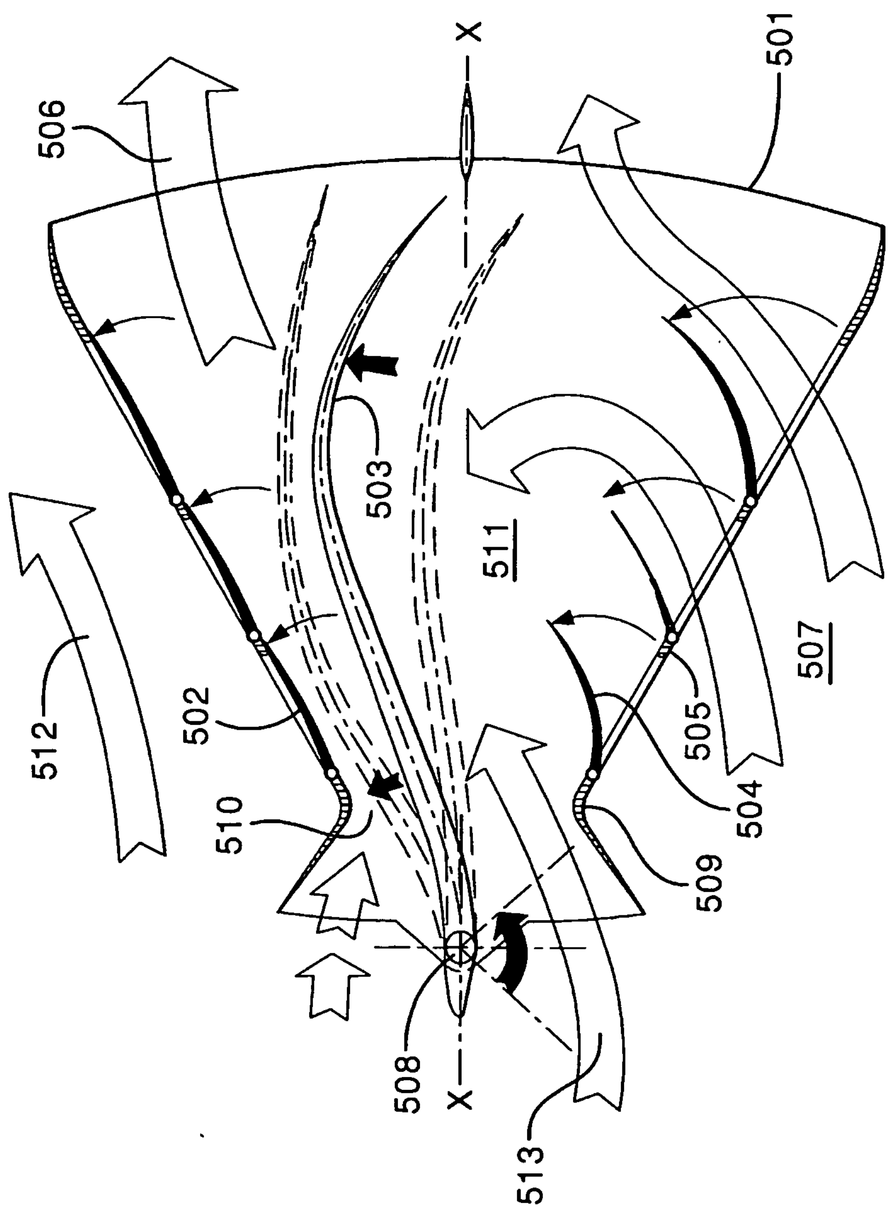


Fig. 10

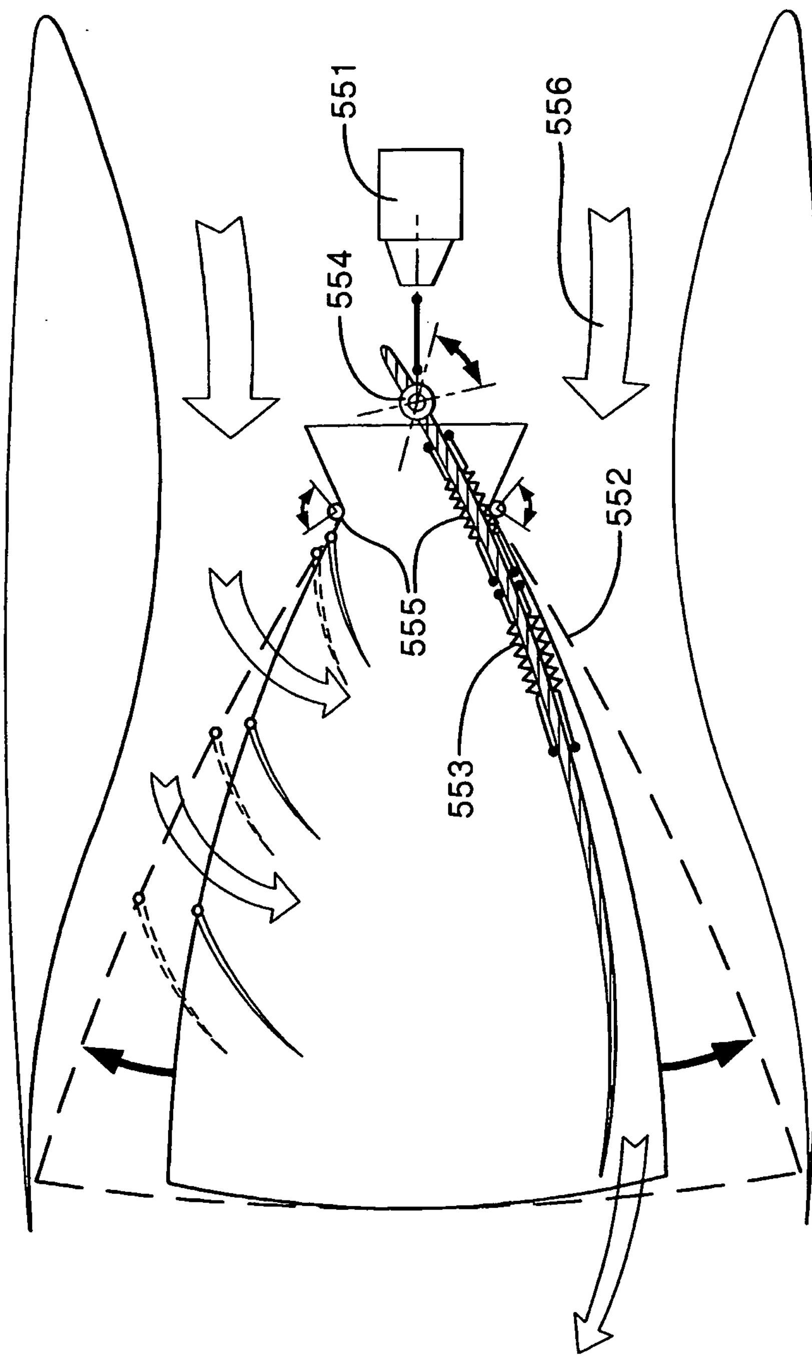
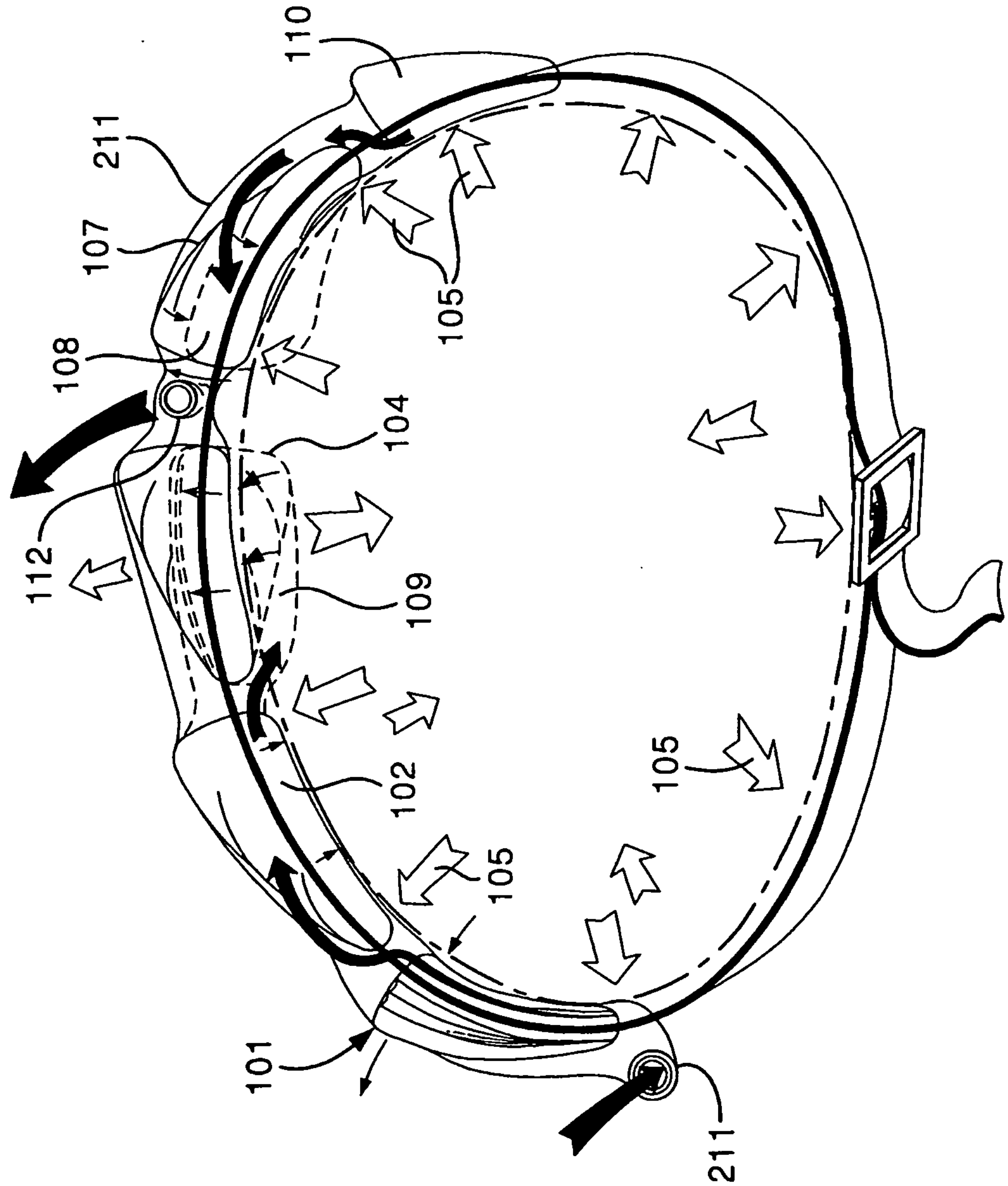


Fig.11



INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 03/02837

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F02K7/00 F02K7/02 F02K7/06

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)
IPC 7 F02B F02D F02K F04D F04F F04B

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	DE 12 62 076 B (ERICH TAUSEND) 29 February 1968 (1968-02-29) column 2, line 50 - column 4, line 4 column 4, line 57 - column 5, line 55 column 8, line 40 - line 63 claim 1; figures	1-5,10, 11,20 6,7,21, 61
X	GB 784 089 A (WESTLAND AIRCRAFT LTD) 2 October 1957 (1957-10-02) page 2, line 17 - line 77 figures	1-5,10, 11,20,61
X	US 4 102 293 A (DE LA ROCHE KERANDRAON OLIVIER) 25 July 1978 (1978-07-25) column 3, line 16 - line 65 abstract; figures	1,17

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 March 2004	01 06. 2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	O'Shea, G

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 03/02837

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-27, 61-63

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-27,61-63

   A jet engine comprising a flipper, one end of which is pivotally mounted within an inner manifold and an intermediate part of which is pivotally mounted within the manifold, the pivots lying centrally with respect to the manifold.

   ---

2. claims: 28-42,63

   A turbojet compressor and an internal combustion engine, the turbojet compressor comprising a flipper, one end of which is pivotally mounted within an inner manifold and an intermediate part of which is pivotally mounted within the manifold, the pivots lying centrally with respect to the manifold.

   ---

3. claims: 43-47,63

   An engine comprising a manifold and a flipper pivotally mounted within the manifold and means for moving the flipper from a first to a second position, the sidewalls of the manifold including at least one one-way valve.

   ---

4. claims: 48-60

   A pump with a channel having a flipper mounted therein, the flipper including a fixed end and a free tail extending downstream and means to move the tail.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 03/02837

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
DE 1262076	B	29-02-1968	NONE			
GB 784089	A	02-10-1957	NONE			
US 4102293	A	25-07-1978	FR	2359744	A1	24-02-1978
			AU	511644	B2	28-08-1980
			AU	2640977	A	04-01-1979
			BE	857247	A1	14-11-1977
			BR	7704820	A	02-05-1978
			CA	1083432	A1	12-08-1980
			DD	132960	A5	22-11-1978
			DE	2727042	A1	02-02-1978
			DK	340777	A ,B,	30-01-1978
			ES	460201	A1	01-04-1978
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			PT	66734	A ,B	01-07-1977
			SU	707514	A3	30-12-1979
			ZA	7703615	A	30-05-1978

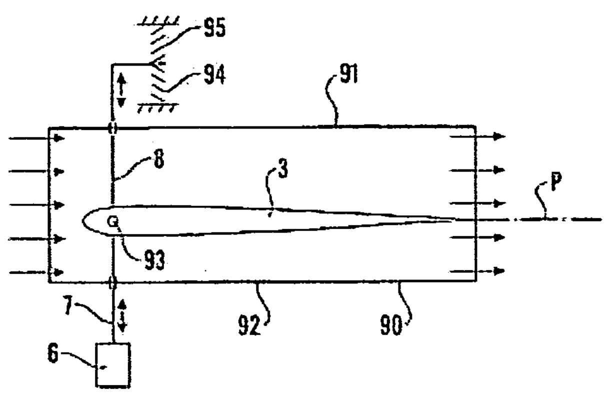
Espacenet

Bibliographic data: WO2006038808 (A1) — 2006-04-13

DEVICE FOR MOVING AN OBJECT IN RELATION TO A FLUID

Inventor(s):	SAGOV MAGOMET S [NO] +	
Applicant(s):	CLAVIS BIOPROPULSION AS [NO]; SAGOV MAGOMET S [NO] +	
Classification:	**- international:**	(IPC1-7): B63H1/36; F03B17/06; F04D33/00
	- European:	B63H1/36; F04D33/00; Y02E10/28
Application number:	WO2004NO00296 20041005	
Priority number(s):	WO2004NO00296 20041005	
Also published as:	US2009023349 (A1) US7874882 (B2) JP2008515712 (A) EP1814780 (A1) EP1814780 (B1) CN101072708 (A) CN101072708 (B) CA2624600 (A1) CA2624600 (C) AT507141 (T) less	

Abstract of WO2006038808 (A1)



The device comprises at least one flap member (3) having a rear flap portion that runs in a plate plane, and a forward portion, as seen in the direction of motion (F). The forward portion (8) is connected to the object (2) in such manner that the flap portion (17) can be moved in the fluid transverse to the plate plane and between two positions which are on their respective sides of a neutral place (P). Furthermore, the device comprises an actuating means (8, 9) which allows a freely oscillating motion of the flap member (3; 61, 62), and a drive unit (6) for actuating the flap member (3; 61, 62) when the valve of an oscillation amplitude of the flap member (3; 61, 62) is less than a predetermined threshold value.

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

(19) World Intellectual Property Organization
International Bureau

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(43) International Publication Date
13 April 2006 (13.04.2006)

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WO 2006/038808 A1

(51) International Patent Classification[7]: B63H 1/36 // F03B 17/06, F04D 33/00

(21) International Application Number: PCT/NO2004/000296

(22) International Filing Date: 5 October 2004 (05.10.2004)

(25) Filing Language: Norwegian

(26) Publication Language: English

(71) Applicant *(for all designated States except US)*: **CLAVIS BIOPROPULSION AS** [NO/NO]; P.O. Box 77, N-3301 Hokksund (NO).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **SAGOV, Magomet, S.** [RU/NO]; Elvebakken 3, N-3320 Vestfossen (NO).

(74) Agents: **ONSAGERS AS** et al.; P.O. Box 6963 St. Olavs plass, N-0130 Oslo (NO).

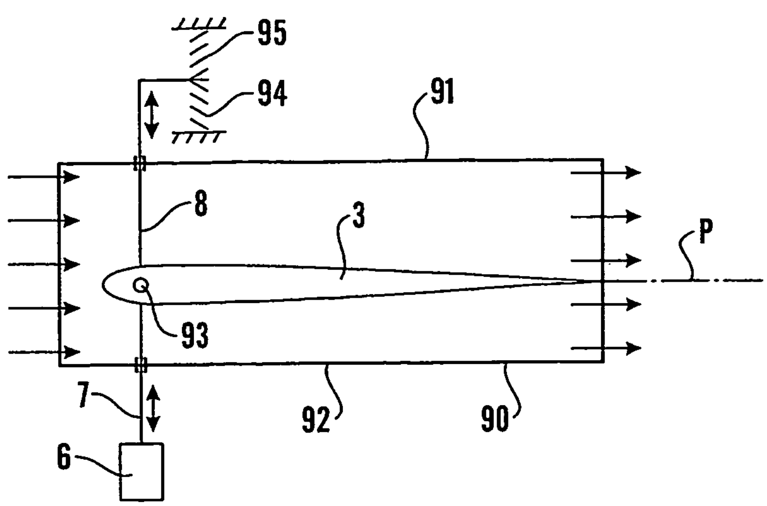
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: DEVICE FOR MOVING AN OBJECT IN RELATION TO A FLUID



(57) Abstract: The device comprises at least one flap member (3) having a rear flap portion that runs in a plate plane, and a forward portion, as seen in the direction of motion (F). The forward portion (8) is connected to the object (2) in such manner that the flap portion (17) can be moved in the fluid transverse to the plate plane and between two positions which are on their respective sides of a neutral place (P). Furthermore, the device comprises an actuating means (8, 9) which allows a freely oscillating motion of the flap member (3; 61, 62), and a drive unit (6) for actuating the flap member (3; 61, 62) when the valve of an oscillation amplitude of the flap member (3; 61, 62) is less than a predetermined threshold value.

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Device for moving an object in relation to a fluid

The invention relates to a device for moving an object in a direction of motion relative to a fluid.

A piston engine comprises components which for each stroke have to be accelerated, decelerated and re-accelerated. These accelerations and decelerations form a sequence which is not advantageous per se, but must be accepted as they are an integral part of the mode of operation of this engine. In, e.g., rotating engines (Wankel engines) these sequences are avoided.

NO 310401 discloses a propulsion device for ships where the components of a drive unit or engine are arranged to oscillate at a resonant frequency. Also in this oscillating drive unit, mass is accelerated and decelerated, but this mass represents alternately an accumulator and a source of energy, which is a prerequisite for the actual oscillation and does not cause any energy loss. This drive unit is thus well suited to an operation of drive elements which are driven back and forth, and which can easily be connected to the oscillating drive unit.

From NO 310401 it is also known that the drive unit is arranged to move a plate-like member, which can be moved in the ship's direction of motion, and whose plate plane runs transverse to the ship's direction of travel. This member provides an intermittent movement of water behind the ship.

To obtain a sufficiently large propulsion force, there is therefore a need for the object to have a large extent in the transverse direction of the ship, which may be a disadvantage if it is desirable that the ship's cross-section under water should be small.

Furthermore, it is already known, e.g., that swimmers can use flap-like elements, so-called flippers, which are fastened to each foot. By moving the flipper transverse to the swimming direction and optionally at the same time oscillating the flipper about the ankle joint, the swimmer can obtain a substantial speed using relatively little energy. However, at the end of each movement of the foot in one direction, the swimmer must use energy to brake this movement and to accelerate the foot in the opposite direction, and this requires a great deal of energy.

From US 5 370 561 it is known that the stern of a boat can support two tiltable arms that extend backwards from the boat and into the water. A flap is pivotally connected to the rear ends of the arms and when the arms are tilted alternately in one direction and the other, a forward water force is exerted against the flap for forward movement of the boat. In this arrangement, the arms are operated continuously by an engine, and by means of a control system comprising a toothed belt that is connected to the flap, a sensor that determines the position of the flap, a control circuit and a torque motor, an attempt is made to tilt the flap towards a neutral position and against a torque which is produced by the water force. If the continuously operated engine is a piston engine, it will have a relatively large fuel consumption. The control system must constantly be in operation and this will further increase the fuel consumption. Moreover, the control system is complex, bulky and maintenance-intensive, and, hence, expensive.

US 1 245 540 describes a pump with a housing in which a tiltable flap is located which is arranged to alternately draw fluid into the pump housing and to force fluid out of the housing. A drive unit for the flap is not discussed in any detail.

With a device having a combination of the known per se oscillating drive unit for operation of the known per se plate-like member for moving a fluid, where the member is arranged to be moved substantially transverse to the direction of a flow of a fluid in relation to the object, the result is a very simple and inexpensive device which in operation uses little energy. In this case, the object may be, e.g., a vessel such as a ship, and the member may be arranged in the water behind the ship in order to move it forwards. The object may instead be, e.g., a pipe for the transport of a fluid, and the member may be located in the fluid for pumping the fluid in relation to the pipe.

The object of the invention is to provide a device of the aforementioned type which does not have the aforementioned disadvantages.

The characteristic aspects of the device according to the invention are apparent from the characteristic features disclosed in the claims.

In the following, the invention will be described in more detail with reference to the drawings, which schematically show embodiments of the invention, the member for the sake of simplicity being called hereafter "flap".

Fig. 1 is a side view of a first embodiment of a device according to the invention, wherein an inflexible member, hereafter called "flap", at its forward end is pivotally supported in a hull of a vessel such as a ship.

Fig. 1a is an illustration showing the section that is indicated by the letter B in Fig. 1.

Fig. 2 is a side view of a second embodiment of a device according to the invention, comprising a flap whose forward end portion is flexibly connected to a supporting rod which in turn is pivotally supported in the hull at its forward end.

Fig. 3 is a top view of the device in Fig. 2.

Fig. 4 is an enlarged side view of the flap according to Fig. 2, where a centre position of the supporting rod and the flap is indicated in a solid line, and other positions thereof are indicated in broken lines.

Fig. 5 is a side view of another embodiment of the device according to the invention, where an inflexible flap is supported in the hull so that the flap can be tilted and at the same time be displaced in its transverse direction.

Fig. 6 is a side view of another embodiment of the device according to the invention, comprising an inflexible flap resembling the flap shown in Fig.1, but arranged to be moved between two walls.

Fig. 7 is a side view of another embodiment of the device according to the invention, with a flap resembling the flap shown in Fig. 1, but where at each side of the flap there is arranged a wall that is stationary relative to the hull, and which is provided with check valves.

Fig. 8 is a side view of another embodiment of a device according to the invention, comprising two flaps that are tiltable about the same axis, and which can be moved in opposite phase between two walls that are provided with valves.

Fig. 9 is a side view of another embodiment of a device according to the invention, comprising a flap which at its forward end is pivotally supported in. e.g., a hull of a vessel, the flap being made of a resilient, flexible material with decreasing rigidity from the forward end of the flap to its rear end.

Figs. 10-13 are side views of another embodiment of a device according to the invention, comprising a flap like the flap shown in Fig. 9, but where on each side of the flap there is arranged a side wall provided with check valves like that shown in Fig. 7, the figures showing respective, different stages of the flap during a tilting of the flap.

Fig. 14 is a side view of another embodiment of a device according to the invention, comprising a flap whose forward end portion is flexibly connected to a rod that is connected to a drive unit

Fig. 15 is a side view of another embodiment according to the invention, comprising a flap that is tiltably connected to a part of the exterior of the hull, and which can be tilted towards or away from this part, and which is provided with check valves.

Fig. 16 is a side view of another embodiment of a device according to the invention, comprising tiltable flaps of the type shown in Fig. 15, and which are arranged on their respective sides of a plane portion of the hull.

Fig. 17 is a side view of another embodiment of a device according to the invention, comprising two flaps that are moved in opposite phase, the flaps being provided with check valves.

Fig. 18 is a side view of a device with two flaps of the type shown in Fig. 6.

Fig. 19 is a side view of another embodiment of a device according to the invention, comprising three flaps of the type shown in Fig. 7.

Fig. 20 is a top view of a pipeline or conduit with a device according to the invention, wherein a flap and a pair of walls with check valves as shown Fig. 7 are arranged in the pipeline, and a top cover of the pipeline has been removed.

Fig. 21 is a side view of the pipeline shown in Fig. 20, wherein a side cover of the pipeline has been removed.

Fig. 22 shows a section of an area of Fig. 21 as indicated by the letter A.

Fig. 23 shows a section taken along the line X-X through the pipeline shown in Fig. 21.

Fig. 24 is a side view of a device with three flaps of the type shown in Fig. 14.

Fig. 25 is a side view of a device with five flaps of the type shown in Fig. 8 or 16, where the drive unit is shown further schematised.

Fig. 26 is a view of an assembly comprising a row of devices according to the invention.

Fig. 27 is a side view of a further embodiment of a device according to the invention, comprising three flaps.

The terms "to the right" and "up" in the following should be understood to mean respectively the direction towards the right end of the drawing sheet and the end of the drawing sheet facing away from the reader.

Corresponding components are indicated by the same reference numerals in the figures.

As shown in Fig. 1, located in water 1 is a hull 2 of a vessel such as a ship that is moving towards the left at a speed F relative to the water. A substantially streamlined and plate-like flap or flap member 3 has a plate plane which in the figure runs horizontally and in the longitudinal direction of the vessel. As can be seen from Fig. 1a, the flap 3 has a flap portion 17 and a forward portion 18. The forward portion of the flap has a pivot axle 4 whereby it is supported in the hull so that the flap 3 can tilt about a horizontal axis of rotation 5. The pivot axle 4 and its support in the hull thus form a hinge and a first connecting means 121.

A drive unit 6 has a driving rod 7 which can be moved back and forth in its longitudinal direction, and which can actuate an arm 8 which in turn is connected to the pivot axle 4. When the drive unit 6 via the driving rod 7 exerts a force to the right against the arm 8, the flap is tilted or swung clockwise.

One of the ends of a spring 9, such as a helical torsion spring, is fastened to the hull 2 and the other end of the torsion spring is fastened to the pivot axle 4. The torsion spring 9 tries to hold the flap 3 in such manner that the plate plane of the flap runs in a neutral plane P, e.g., a horizontal plane, when it is not loaded. The components that are moved together with the flap 3 have corresponding, respective neutral positions. The spring 9 is thus gradually put under more tension in opposite directions when the flap is moved away from its neutral position in respectively a clockwise and anticlockwise direction, and the spring 9 tries constantly to bring the flap 3 back to the neutral position.

In the illustrated embodiment the flap 3, the pivot axle 4, the arm 8 and optionally an additional component form a unified mass. Together, the torsion spring 9 and this mass form a spring/mass arrangement or an actuating means which can oscillate at a resonant frequency that is determined by fixed values for the stiffness of the spring, the mass of the said components and the damping of the oscillating motion.

The figures are schematic and do not include components which simply serve to increase the complexity of the figures. Thus, for instance sealing means that prevent inflow of water into the hull through openings between the components of the device and the hull etc. have not been included in the drawing as an arrangement of such means will be obvious to the skilled person.

The mode of operation of the device will be described below, based on the assumption that the components of the device are in the position indicated in solid lines in Fig. 1.

Initially, the drive unit 6 exerts a transitory, almost shock-like driving force towards the right against the arm 8 via the driving rod 7, whereby the arm 8 and the flap 3 are moved clockwise. These components thus receive a certain amount of energy of which a first portion is transferred to the water surrounding the flap. This energy portion is converted into kinetic energy in that the water is set in motion essentially in the direction at right angles to the neutral plane P. The other, remaining energy portion is, during the movement of the flap towards the position N in Fig. 1, converted into potential energy in the spring 9. When the flap has reached the position N, all the energy that has been supplied by the drive unit has been converted into kinetic energy for the water and potential energy in the spring 9, whereby the speed of the flap is zero. The force exerted by the spring 9 against the flap 3 is now a maximum force.

When the flap thus has reached the position N, the spring 9 causes a movement of the flap 3 in the opposite direction, i.e., back towards the neutral plane P and in an anticlockwise direction, during which the potential energy of the spring is converted to kinetic energy for the water, the flap 3 and the components that are moved together therewith. At this time, the flap 3 runs at an angle relative to the direction of motion F. When the flap 3 has reached the neutral plane P, all potential energy of the spring 9 has been converted into kinetic energy for the flap 3 and the water, so that the speed of motion of the water has a backward component. Consequently, a reaction force is exerted against the flap and thus the hull in the direction of motion F. Conversion of a portion of the kinetic energy into potential energy in the spring 9 then takes place again, whereupon the flap 3 is stopped in the position indicated by the letter O in Fig. 1. The flap is then accelerated in the clockwise direction and the aforementioned movement pattern is repeated, the flap and the components that have been set in motion therewith and the spring forming a freely oscillating or swinging structure. For each swing of the flap 3 between the extreme positions N and O of the flap, water is pushed backwards, i.e., to the right, whilst against the hull, a reaction force is exerted towards the left, i.e., forwards in the direction F. It will be understood that it is the flap portion 17 of the flap that provides the motion of the water. The forward portion contributes very little to this motion.

The device according to the invention also comprises an arrangement (not shown) whereby the oscillation amplitude can be monitored. This arrangement may, e.g., comprise sensors that determine the angular position and movement of the flap, and a computer that is connected to the sensors. When the oscillation amplitude has been reduced so that it falls below a predetermined threshold value, and it has been determined that the arm 8 has started a movement away from the drive unit 6, a control signal is sent from the computer to the drive unit 6 for the exertion of a possibly transitory force against the arm 8 as described above, so that the oscillating structure is supplied with such a large amount of energy that compensation for the amplitude reduction or decrement will be obtained. The drive unit 6 may therefore be small, and it will be used only when there is a need for a fresh supply of energy to the oscillating structure.

The drive unit may comprise, e.g., a combustion chamber into which at a desired time there may be introduced a combustible material such as combustible gas material or a material in solid form that is combusted rapidly and actuates a piston or a diaphragm that is connected to the driving rod 7.

Fig. 2 shows a device resembling that shown in Fig. 1, but where an inflexible flap member or flap 3 comprises a inflexible, almost plate-like flap portion 17 and the forward portion of the flap member is made of a rigid rod or supporting rod 10. Here, it has been taken into account that it is the flap portion which provides the motion of the water, whilst the forward portion only contributes slightly to this motion. The distance between the tilting axis 5 and the flap portion 17 has therefore been increased. When the flap 3 is in a neutral position, the plate plane of the flap portion runs in a neutral plane P.

The forward end of the supporting rod is connected to the hull so that it can tilt about a tilting axis 5.

The rear end of the supporting rod is via suitable means (not shown) flexibly connected to a forward portion of the flap portion 17 at a point of connection 75. This connection forms a second connecting means 122 which may also be a hinge device.

These means seek in a elastically resilient manner to bring the supporting rod 10 and the flap portion 17 into a mutually aligned position in which the supporting rod 10 runs in the plate plane. At the forward end of the supporting rod there may e.g., be arranged a torsion spring 9 which tries to hold the supporting rod 10 in a neutral position as shown in Fig. 2 in a solid line.

As can be seen from Fig. 3, the flap portion 17 in top view is essentially triangular, in that it may have the shape of a fish tail where a portion 76 at the forward, outer area of the flap portion that is ineffective as regards propulsion, and which would have given the flap portion an almost rectangular form, has been omitted. The flap portion 17 may however have another shape. For example, it may advantageously be elliptical.

In Fig. 4 different positions of the supporting rod 10 and the flap portion 17 relative to each other are shown in broken lines, where the supporting rod 10 has also been tilted away from its neutral position.

Thus, the supporting rod 10 and the flap portion 17 are shown in a first position S1 and K1, respectively, wherein the supporting rod has been moved a small distance anticlockwise away from its neutral position. Because of the flexible point of connection 75 and because of the inertia and water drag of the flap portion, the flap portion 17 has however been swung a small distance in the clockwise direction to a position K1 relative to the supporting rod 10.

When the supporting rod has been tilted into its upper extreme position S2, the flap portion 17 then runs almost horizontally in the position K2.

However, on an immediately subsequent movement of the supporting rod 10 towards the neutral position and in the clockwise direction to the position S3 (which for the sake of simplicity corresponds to the position S1 of the supporting rod), the flap portion 17 is, for the same reasons as mentioned above, tilted a small distance in the anticlockwise direction to a position K3 relative to the supporting rod. On further movement of the supporting rod 10 in the clockwise direction past the neutral position, it reaches an intermediate position S4 and then a lower extreme position S5, the position of the flap portion 17 and the supporting rod 10 relative to each other changing only slightly.

Subsequently, the supporting rod can be moved from the lower extreme position towards the neutral position, thereby obtaining a movement pattern of the supporting rod and the flap portion 17 corresponding to the aforementioned movement pattern from the upper extreme position towards the neutral position.

Instead of the supporting rod 10 and the flap portion 17 being inflexible, one of them or both of them may be elastically flexible. Although it is advantageous that resilient means are arranged at the point 75, the connection between the supporting rod and the flap may however be inflexible. Such means may be a torsion spring one end of which is connected to the supporting rod 10 and the other end of which is connected to the flap portion 17. Alternatively, the connection may be formed by a material that is elastically flexible and which is connected to the supporting rod 10 and the flap portion 17.

Fig. 5 shows another embodiment of the invention, where the hull 1 supports a flap member or flap 3 that resembles the flap shown in Fig. 1. However, the flap 3 is via a first spring 11 connected to a slide block 12 which is run in a rail 13 that is secured to the hull and runs transverse to the direction of motion F and the plate plane of the flap. The flap 3 is thus arranged for translational movement transverse to the neutral plane P.

The first spring 11 tries to hold the flap 3 in such manner that the plate plane of the flap runs in the direction of motion F, i.e., in a neutral position relative to the slide block 12, but it allows the flap 3 to be resiliently angularly displaced an angular distance in opposite directions about an axis of oscillation 5 which is close to the forward end of the flap.

The upper end portion of the slide block 12 may be connected to one end of a combined pressure and tension spring or other spring 14. The other end of the spring 14 is connected to the hull 1.

The second end portion of the slide block 12 may be actuated by a compressive force that is exerted by a drive unit 6 via a rod 7. When the drive unit 6 does not exert any pressure on the slide block and the flap 3 is stationary, the springs 11, 14 cause the flap 3 to be in the position shown in a solid line in Fig. 5, i.e., a position in which the flap runs in a neutral plane P and is in its neutral position relative to the rail 13.

If the flap 3 is stationary and is in the position shown in the solid line in Fig. 5, and an upward force is exerted by the drive unit 6 on the slide block 12, the slide block 12 will initially be accelerated upwards whilst the flap 3, because of its inertia and water drag, is swung in a clockwise direction a small angular distance depending on the spring characteristics of the first spring 11, the second spring 14 at this time being compressed. When the energy that has been supplied by the drive unit 6 to the movable structure comprising the slide block, the spring 11 and the flap 3, has been converted into kinetic energy of the water surrounding the flap 3 and potential energy in the first and the second spring 11, 14, the slide block 12 has an upper position (not shown) where the flap is in the position indicated by the reference letter C in Fig. 5.

The first spring 11 then causes a turning of the flap 3 into a position D whilst the second spring 14 causes a downward acceleration of the slide block 12.

When the slide block 12 and the flap 13 pass the neutral plane P, all potential energy in the springs 11, 14 has been converted into kinetic energy, whereupon the springs 11, 14 are re-tensioned in a manner similar to that described above. Thus, a repeated oscillation of the flap with gradually decreasing amplitude is also obtained. When the amplitude falls below a predetermined threshold value, the drive unit is reactivated so that it exerts an impact force against the slide block and compensation for the reduction in amplitude is obtained.

Thus, it will be understood that the flap 3 during each stroke of the tilting motion runs obliquely relative to the neutral plane, e.g., so that there is obtained an effective backward movement of the water with the aid of the flap, and a correspondingly large reaction force against the hull, and that the flap is then moved into a position corresponding to the position D at the upper part of the tilt stroke. Furthermore, it will be understood that the flap 3 according to Fig. 5 is moved a large distance transverse to the neutral plane, which is also the case with the flap shown in Fig. 2. Thus, an efficient device is obtained.

Instead of the device comprising a first spring 11, the flap 3 may be made of an elastic material and be fastened directly to the slide block 12. Thus, the flap 3 during its oscillation may be bent transverse to its plate plane into positions like the positions C and D, whilst potential energy also in this case is stored in or released from the flap. Since the flap 3 is tapered backwards, when viewed from the side, it is possible to ensure it has decreasing rigidity in this direction. Alternatively, the device may both comprise the spring 11 and in addition be made of an elastic material.

Fig. 6 shows a flap of the type shown in Fig. 1, where the flap may be actuated by a drive unit 83, and the torsion spring 11 has been replaced by a similarly functioning device comprising two coil springs 80, 81 which actuate an arm 82 that is fixedly connected to the flap 3. The flap 3 is arranged between two walls, e.g., of a conduit or pipeline 84 having a square cross-section and can thus function as a pump. The function of this device corresponds to the function of the device in Fig. 1, but in this case cooperation is obtained between the flaps 3 and the walls of the conduit 84 so that the effect is better.

Fig. 7 is a view of a device according to the invention that resembles the device shown in Fig. 1. However, in connection with this device there is arranged above and below the flap 3 a stationary plate or wall 31 and 32, respectively. The distance between the walls 31, 32 increases in the direction from the forward end of the walls to the rear end of the walls. Each of the walls 31, 32 is provided with two check valves 34, 35. It will be understood that more or fewer than two valves could be provided. These check valves 34, 35 are arranged to allow a flow from the outside of the walls, i.e., from the space which is on the side of the walls facing away from the flap 3, to the space between the walls, as is shown by arrows. At or in front of the forward end of the flap 3 there may be provided a transverse wall 36 which prevents water from flowing forwards from the space between the walls 31, 32. If the whole flap 3 is located in the water behind the ship, the forward wall may, for example, comprise at least one check valve that allows water to flow into the space between the walls 31, 32.

During oscillation of the flap 3, water is drawn in through the valves 34, 35 of the plate 31, 32 which the flap is momentarily moved away from, whilst the valves of the opposite plate remain closed. As shown in Fig. 7, where the flap 3 is momentarily moved, for example, in the clockwise direction, water that is between the flap 3 and the plate 32 towards which the flap 3 momentarily moves, is forced backwards, whereby the valves 35 remain closed, whilst the valves 34 of the upper plate 31 are opened so that water, via the valves 34, flows from above into the space between the flap 3 and the plate 31 which the flap 3 moves away from. It is thus ensured that the device has a high rate of efficiency during oscillation of the flap.

Fig. 8 shows another embodiment of a device according to the invention, comprising two flaps 37, 38 which can be moved in opposite phase between two walls that are provided with check valves. When the flaps 37, 38 are moved towards each other, the water between the flaps is forced backwards. When the flaps are moved away from each other, water flows through the valves of both walls.

Fig. 9 is a view of a device according to the invention that resembles the device shown in Fig. 1, but where the flap 3 is made of an elastic material so that it is bendable in its transverse direction.

Figs. 10-13 show a device with a flap resembling that shown in Fig. 6, but where the flap 3 is made of a elastomeric material, and where above and below the flap and symmetrically about the neutral plane P there is arranged a plate or wall 51, 52, the walls being arranged symmetrically about the neutral plane P and the distance between the walls increasing in the direction towards the right. Check valves 53 are provided in the walls as described in connection with Fig. 7. Via the check valves, water can flow into the spaces between the flap 3 and the respective walls 51, 52 during oscillation of the flap. In front of the forward part of the flap 3 the walls 51, 52 are connected to each other via a transverse wall 54, through which an arm 8 is sealingly passed. The arm 8 can be actuated by a drive unit 6 as mentioned above.

In Fig. 10 the flap is stationary and runs in the neutral plane P. To start the device when the flap is in this position, the drive unit 6 is activated and it then briefly exerts a force against the arm 8, so that the flap 3 is initially tilted about the tilting axis 5 in an anticlockwise direction into the position shown in Fig. 11. In this way successive portions of the flap portion, as seen from the front backwards, come consecutively to rest against the upper wall 51, and water is thus drawn in between the flap and the lower wall 52 via the check valves in this wall. At the same time, water between the upper wall 51 and the rear portion of the flap 3 is forced essentially backwards. To prevent water at the same time being forced sideways, the device may advantageously comprise vertical plates or walls (not shown) which are arranged between the upper wall 51 and the lower wall 52 and close to the lateral edges of the flap. If the flap 3 can bear sealingly against these vertical walls, the space between the plates 51 and 52 can be sealed off sideways. In the position of the flap 3 as shown in Fig. 11, the space between the flap 3 and the upper wall 51 is thus only open backwards.

The oscillating unit subsequently causes a swinging of the flap 3 downwards so that a flap form as shown in Fig.12 is obtained. At this time, water between the flap 3 and the lower wall 52 is forced backwards, whilst in the space between the flap 3 and the upper wall 51 water is drawn in via the check valves 53.

When the flap 3 is thus swung further in a clockwise direction to close to the lower wall 52, a flap form as shown in Fig. 13 is obtained, which resembles that shown in Fig. 11. The angle α represents the angle between the neutral plane and the plate plane of the flap at the forward end of the flap. This movement is optionally terminated with the flap 3 resting against the lower wall along its entire length.

The device shown in Figs. 10-13 is thus very simple and efficient, and if in addition it comprises vertical side walls or plates, its efficiency can be increased further. At the forward portion of the flap there may be provided a torsion spring or the flexure of the flap portion 17 can be provided by the forward portion being elastically deformable so that the desired oscillation effect is obtained.

Fig. 14 shows a device whose function is similar to the function of the device shown in Fig. 5, but which is arranged in a conduit or pipeline 90 having an upper wall 91 and a lower wall 92. Through openings in the walls 91, 92 there is sealingly and slidably passed an element in the form of an arm or rod 8 which is connected to a driving rod 7 of a drive unit 6, the rod 8 being arranged to be moved back and forth in its longitudinal direction. The end of the upper portion of the rod 8 projects from the upper wall 91 and is acted on by two springs 94, 95 which try to hold the rod 8 in a neutral position, but which allow the arm to be moved resiliently away therefrom.

At a point of connection 93 at a central portion of the rod 8, the rod is connected to a forward end portion of a flap 3, the connection being elastic and allowing the flap 3 to be tilted about the point of connection 93.

Fig. 15 shows a device that comprises a flap 100 which is arranged to tilt about a tilting axis 5 that is close to a portion of a wall 102. The flap 100 comprises check valves 103 which allow water to flow into the space that is defined by the flap 100 and the wall portion 102 as is shown by arrows. A forward portion of the flap 3 is connected to a spring such as a torsion spring 9, and a drive unit 6 is arranged for exertion of a transitory force against an arm 8 that is connected to the flap 100.

For example, the wall portion may be a portion of the skin or the planking of a ship. An oscillating tilting of the flap towards and away from the wall portion 102, results in a backward movement of water and thus a movement of the ship as described above.

Fig. 16 shows an assembly comprising two flaps 100 of the type shown in Fig. 15. The flaps 100 can be moved independent of each other or dependent on each other, e.g., in opposite phase. Disposed between the flaps 3 is a plate 105 that is fixedly connected to the ship.

Fig. 17 is a side view of an embodiment of the invention, wherein the invention comprises two flaps 61, 62 which can be moved in opposite phase.

Each flap 3 has an arm 64, 65, and the arms 64, 65 are articulated to each other via a connecting rod means 66 which in turn is connected to a drive unit 6. Each of the flaps 61, 62 is connected to a helical torsion spring 69, 70.

Each flap 3 has at least one valve 67, 68 which resembles that shown in Fig. 16, these valves being arranged to allow water to flow into a space between the flaps 61, 62, but not in the opposite direction.

In this device, the flaps 61, 62 are arranged to oscillate towards each other or away from each other in opposite phase between the extreme position shown in solid lines and the extreme position shown in broken lines about respective neutral positions. When the flaps 61, 62 are not actuated by the drive unit 6 and the springs 69, 70, and are stationary, they are in their respective neutral positions or neutral plane between the illustrated positions.

During a movement of the flaps 61, 62 towards each other, water between them can be forced out backwards from the space between the flaps 61, 62, whilst the valves 67, 68 are kept closed. When the flaps 61, 62 are moved away from each other, water can flow into this space via the valves 67, 68. Thus, a highly efficient device according to the invention can be obtained.

To increase the thrust or pumping action of the aforementioned devices, a plurality thereof can be put together in an assembly.

Fig. 18 shows a device with two flaps 3 of the type shown in Fig. 6. The flaps are arranged between two outer walls 21, 22 of a conduit. A streamlined, central guide plate 20 is disposed between the flaps 3. Instead of a helical torsion spring according to Fig. 1, there is provided, as in Fig. 6, a pair of pressure springs 23, 24 which actuate respective sides of an arm 8, which is connected to a pivot axle 4 of the flap 3. The flaps 3 are connected to respective pivot arms 25, 26 which are interconnected via an articulated arm 27. A drive unit 6 is arranged to actuate the articulated arm 27 in the manner described above. Instead of the device having just two flaps, a row of flaps can be arranged side by side in the same way.

Fig. 19 shows an arrangement where a row of devices of a type similar to that shown in Fig. 7 may be arranged side by side and transverse to the direction of motion F.

Figs. 20-22 are views of a device resembling that shown in Fig. 7, but where the device is arranged in a portion 42 of a pipeline 41 to pump a fluid through the pipeline, the portion 42 having a rectangular cross-section. The pipeline 41 thus forms an object past which the fluid flows during operation of the device.

In Fig. 20, which shows the device from above, an upper cover 45 (Fig. 21) has been removed. It is thus possible to see a flap 3 which via a pivot axle 4 is pivotally supported in opposite side walls or covers 43, 44 of the pipeline portion 42.

Fig, 21 is a side view of the pipeline 41, where a side cover 44 has been removed. Above and below the flap 3 there are provided respective plates or walls 46, 47, and in each of these plates 46, 47 a number of valves of the type shown in Fig. 7 are mounted. Furthermore, the forward portion of the plates 46, 47 are interconnected via a front plate 48. In addition, a number of check valves 50 are provided between the rear ends of the plates to prevent a flow of fluid forwards in the pipeline during portions of the oscillation of the flap 3.

Fig. 22 shows an enlarged section A in Fig. 21, where the arrangement of a check valve 49 is shown more clearly.

Fig. 23 shows a section through the pipeline 41 taken along the line X-X in Fig. 21. This line runs between flanges that connect portions of the pipeline together.

Fig. 24 shows a device having three flaps 3 of the type shown in Fig. 14, springs and a drive unit having been omitted. Through the arrangement of an arm or rod 8 which is connected flexibly to all the flaps 3, and the springs and the drive unit, a very simple device is obtained which can be used in a pipeline for pumping a fluid, or as a ship drive unit like a water jet device. Optionally, the flaps may be located in the water by the ship, the arm 8 being supported in a support that projects from the hull.

Fig. 25 shows an assembly with five devices of the type shown in Fig. 16, wherein it is shown schematically that springs, drive unit and flaps can be connected √together via rods.

Fig. 26 is a schematic view showing an assembly of, e.g., 16 devices comprising flaps of the type shown in Figs. 1-17, seen from behind. For example, the assembly comprises four rows of devices, wherein each row comprises four devices, the devices being spaced apart. The assembly may, for example, be placed in a pipeline 107 for pumping a fluid, or located in the water at the stern of a ship for the propulsion thereof. The devices may, for example, be controlled and operated individually, e.g., for manoeuvring the ship. Alternatively or additionally, they may be arranged so that they can be swung about common or individual vertical axes of oscillation.

Lastly, Fig. 27 shows an assembly resembling that shown in Fig. 24, wherein at each side in a pipeline 110 there is arranged a vertical arm 8 which runs transversely through the pipeline 110 and sealingly through an upper and a lower portion thereof. Behind each arm 8 there is provided a support 111 in which there is formed a series of recesses 112 that are spaced apart in the vertical direction. Three stay bars 113 run between the arms 8 with corresponding vertical spacing.

Three flaps 114 are also arranged in the conduit. In the forward portion of each flap there is formed a through hole that runs in the transverse direction of the flap. The holes are elongate in the longitudinal direction of the flap and a stay bar 113 runs through each hole. The rear end portion of the flaps is inserted into the respective recesses 112.

On movement of the rod 8 alternately up and down, a movement of a fluid in the pipeline can be obtained in the direction indicated by arrows.

It will be understood that many features of the described and illustrated embodiments can be combined. For instance, the flaps may be inflexible or made of an elastic material, and plates or walls may be provided that run above and/or below the flaps and/or at the sides thereof. If flaps and walls are provided, valves may be provided in the flaps or the walls.

Although in the above it is indicated that the plate plane of the flaps may run horizontally, it will be understood that the plate plane may run vertically or obliquely.

All embodiments of the device according to the invention can be used for propulsion of vessels or for pumping a fluid in a pipeline or in another manner for obtaining a movement of the fluid and the device relative to each other.

For the sake of clarity, as simple means as possible have been used for the illustrated exemplary embodiments. For example, as a spring element that tries to hold the flap in a neutral position, a helical torsion spring or a coil spring has been used. However, a person skilled in the art will understand that any other means could be used, e.g., pneumatic means, in order to obtain the same effects.

Although in the above it has been stated that the drive unit is of the intermittent type for operation of the flaps, drive means for continuous operation may be used.

PATENT CLAIMS

1. A device for movement of an object in a direction of motion (F) relative to a fluid,
c h a r a c t e r i s e d b y the combination of the known per se features that the device comprises
- at least one flap member (3; 61, 62) having a flap portion (17) that runs in a plate plane, and a forward portion (18), as seen in the direction of motion (F);
- a first connecting means (121) via which the forward portion (18) is connected to the object (2), and which allows the flap portion (17) to be moved in the fluid transverse to the plate plane between two positions which are on their respective sides of a neutral plane (P);
- an actuating means (8, 9) which together with the flap member (3; 61, 62) forms a mechanical oscillatory arrangement and is arranged to allow a freely oscillating motion of the flap member (3; 61, 62); and
- a drive unit (6) for intermittent actuation of the flap member (3; 61, 62) for starting the movement thereof and increasing the movement when the value of an oscillation amplitude of the flap member (3; 61, 62) is less than a predetermined threshold value.

2. The device according to claim 1,
c h a r a c t e r i s e d i n that the first connecting means (121) comprises a hinge device which allows a tilting motion of the flap member (3; 61, 62) relative to the object.

3. The device according to claim 1 or 2,
c h a r a c t e r i s e d i n that the forward portion (18) is a rod (10).

4. The device according to claim 3,
c h a r a c t e r i s e d i n that the rod (10) is connected to the flap portion (17) via a second connecting means (122).

5. The device according to claim 4,
c h a r a c t e r i s e d i n that the second connecting means (122) is a hinge device.

6. The device according to claim 5,
c h a r a c t e r i s e d i n that the second connecting means (122) comprises a flexible portion of the forward portion (18) or the flap portion (17).

7. The device according to one of claims 4 - 6,

c h a r a c t e r i s e d i n that the second connecting means (122) comprises means which in an elastically resilient manner try to hold the flap portion (17) and the forward portion (18) in a predetermined position relative to each other.

8. The device according to one of the preceding claims,
c h a r a c t e r i s e d i n that the first connecting means (121) comprises a means (10; 12, 13) for movement of the forward portion transverse to the neutral plane.

9. The device according to claim 8,
c h a r a c t e r i s e d i n that the means for translational movement of the forward portion comprises an element (12) that supports the forward portion (18), and which is supported in the object and is arranged to be moved in a path that runs transverse to the neutral plane (P).

10. The device according to claim 9,
c h a r a c t e r i s e d i n that the element is a slide block (12) that is supported in a rail (13) which runs transverse to the neutral plane (P).

11. The device according to claim 8,
c h a r a c t e r i s e d i n that the element is a rod (8), where at least one end portion of the rod (8) is supported in the object (2).

12. The device according to one of the preceding claims,
c h a r a c t e r i s e d i n that on at least one side of the flap member (3) there is provided a wall (21, 22; 31, 32; 46, 47; 51, 52; 84; 91, 92; 100; 102;110) that is stationary in relation to the object.

13. The device according to claim 12,
c h a r a c t e r i s e d i n that one of the flap member (61, 62) and the wall (31, 32) is provided with at least one check valve which opens in the direction of the space defined by the flap member and the wall.

14. The device according to claim 13,
c h a r a c t e r i s e d i n that there is provided one wall (102) and one flap member (100), and that the space between the flap member and the wall is extended backwards, as seen in the direction of travel (F) of the object, apart from when the plate plane of the flap runs close to the wall.

15. The device according to claim 13,
c h a r a c t e r i s e d i n that there is provided two walls (31, 32) and that the space between them is extended backwards, as seen in the direction of travel (F) of the object (2).

16. The device according to one of the preceding claims, c h a r a c t e r i s e d i n that there is provided two flap members (37, 38; 61, 62) having a coincident tilting axis or respective tilting axes that run close to each other, the flap members being movable in opposite phase.

17. The device according to one of the preceding claims, c h a r a c t e r i s e d i n that the flap portion (17) of the flap member (3) and/or the forward portion (18) of the flap member (3) are elastically flexible.

18. The device according to claims 12 and 17, c h a r a c t e r i s e d i n that successive portions of the flap portion, as seen from the front and backwards, are arranged to consecutively come to bear against the wall (51; 52).

19. The device according to one of the preceding claims, c h a r a c t e r i s e d i n that the flap portion (17), when viewed in the direction of its plate plane, is almost triangular like a fish tail, an apex of the triangle facing forwards.

20. The device according to one of the preceding claims, c h a r a c t e r i s e d i n that the device is located in a conduit or pipeline (42; 107) and is arranged to pump the fluid therethrough.

21. An arrangement comprising a plurality of devices according to claims 1-17, c h a r a c t e r i s e d i n that the devices are arranged in at least two rows that run at an angle to each other.

22. An arrangement according to claim 21, c h a r a c t e r i s e d i n that the drive units (6) of the devices are individually controllable.

23. A device according to one of the preceding claims, c h a r a c t e r i s e d i n that the forward portion (18) comprises a rod (10) which runs in the direction of motion (F), and whose rear portion is connected to the flap portion (17) via rigid or elastic means (122), which try to hold the flap portion (17) and the rod (10) in a predetermined position relative to each other, and the flap portion (10) of the flap member (3) and/or the rod (10) are elastically flexible.

24. A device according to one of the preceding claims, c h a r a c t e r i s e d i n that the flap portion (17), when viewed looking away from its plate plane, is almost triangular like a fish tail, wherein an apex of the triangle faces forwards and is connected to a rear end portion of the rod (10).

25. A pump,
c h a r a c t e r i s e d i n that it comprises at least one device according to one of the preceding claims, wherein the device is located in a conduit of the pump.

26. A pump according to claim 25,
c h a r a c t e r i s e d i n that it comprises a plurality of devices according to one claims 1-24, wherein the drive units (6) of the devices are individually controllable.

27. A vessel,
c h a r a c t e r i s e d i n that as propulsion means it comprises at least one device according to one of the preceding claims.

28. A vessel according to claim 27,
c h a r a c t e r i s e d i n that it comprises a plurality of devices according to one of claims 1-24, wherein the drive units (6) of the device are individually controllable.

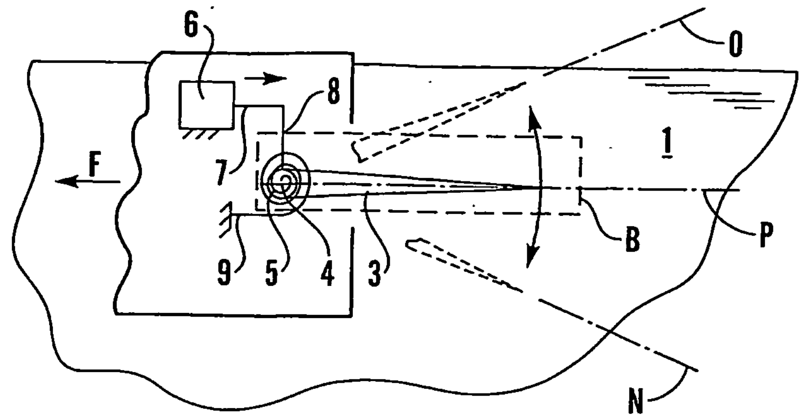

Fig. 1

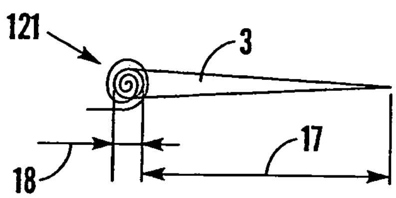

Fig. 1a

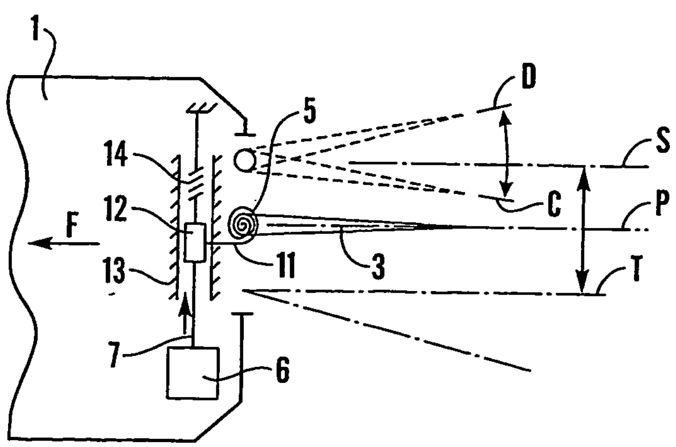

Fig.5

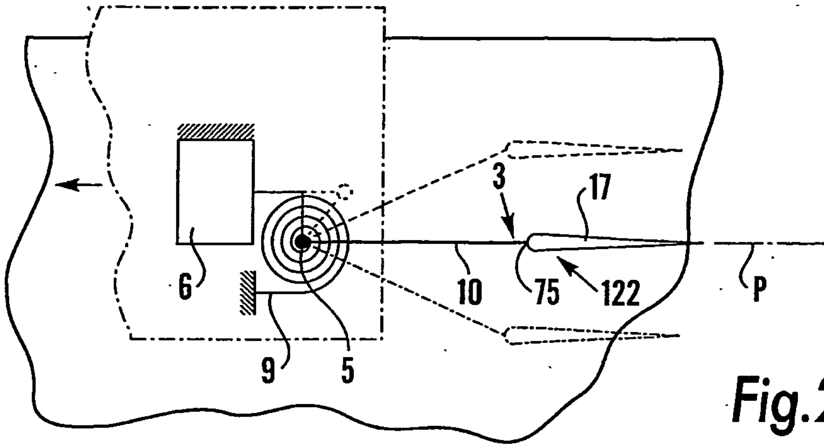

Fig.2

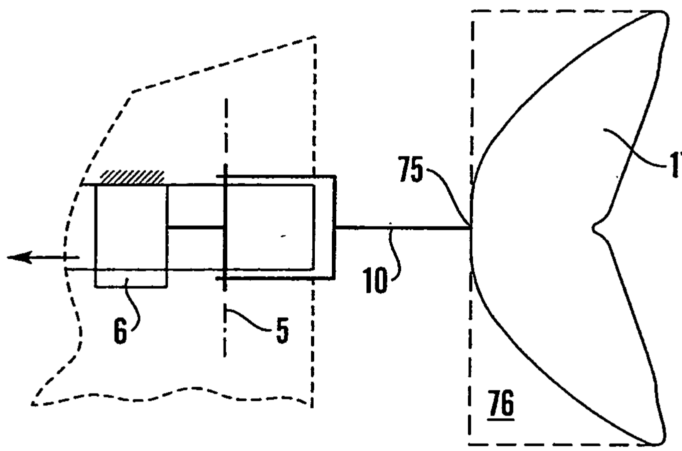

Fig.3

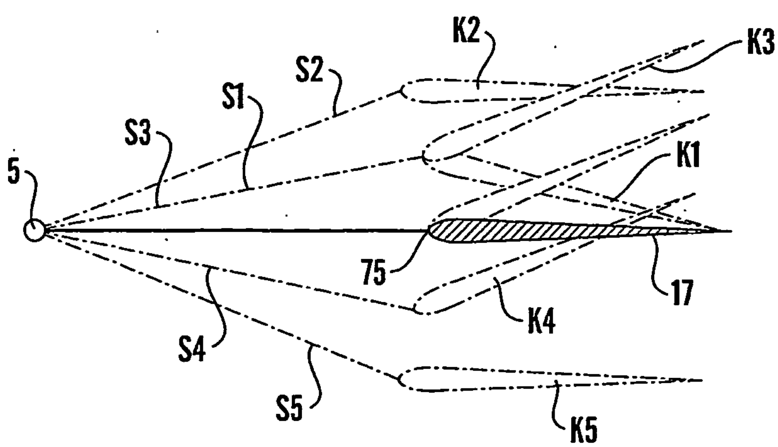

Fig.4

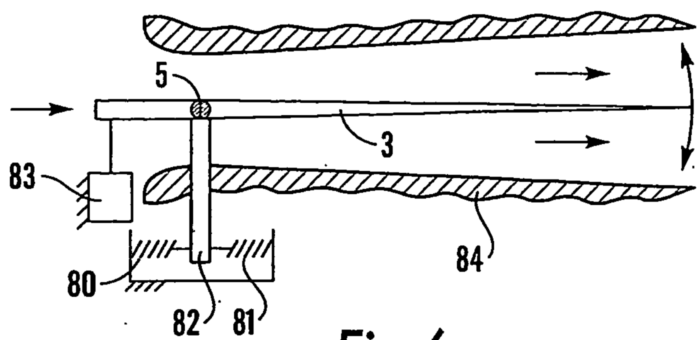

Fig.6

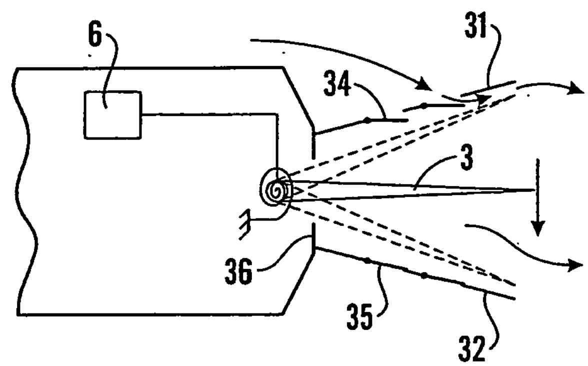

Fig.7

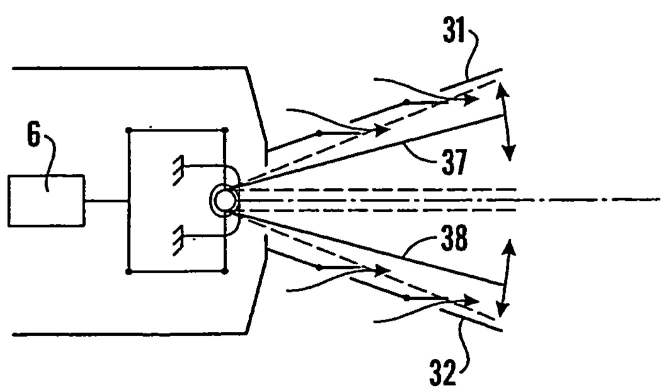

Fig.8

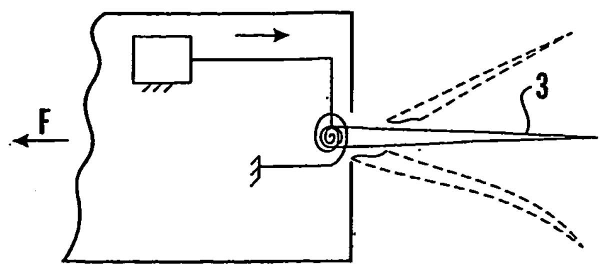

Fig.9

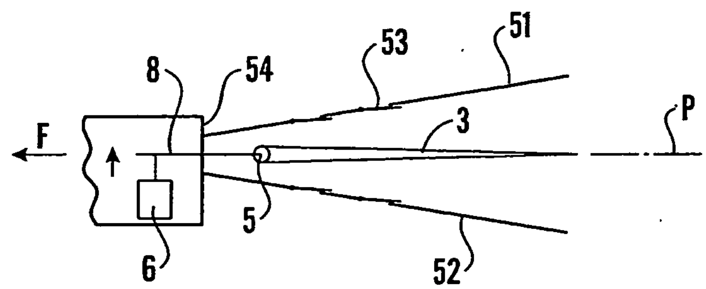

Fig.10

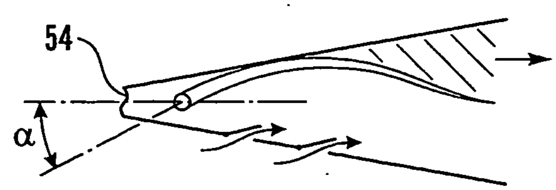

Fig.11

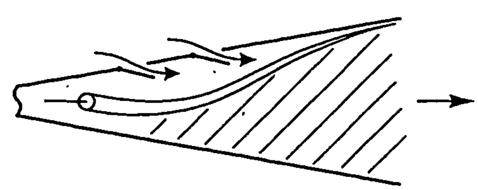

Fig.12

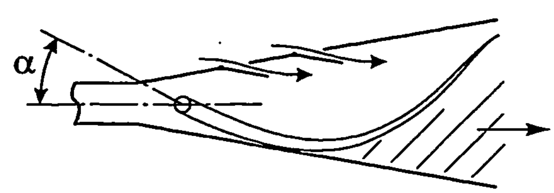

Fig.13

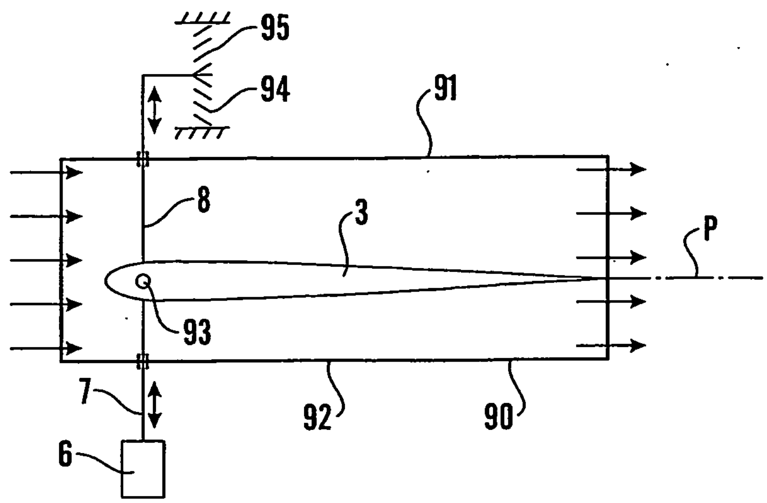

Fig. 14

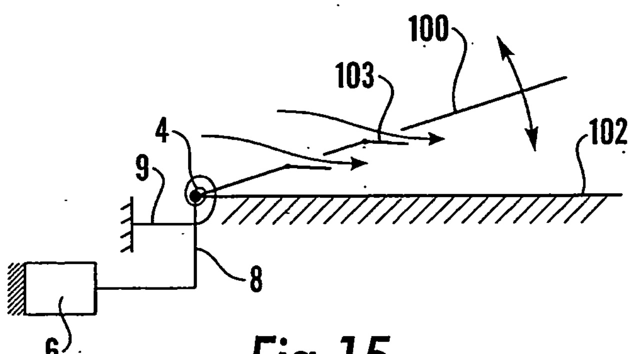

Fig. 15

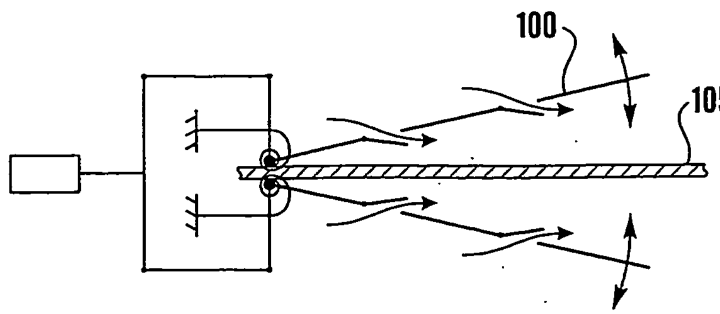

Fig. 16

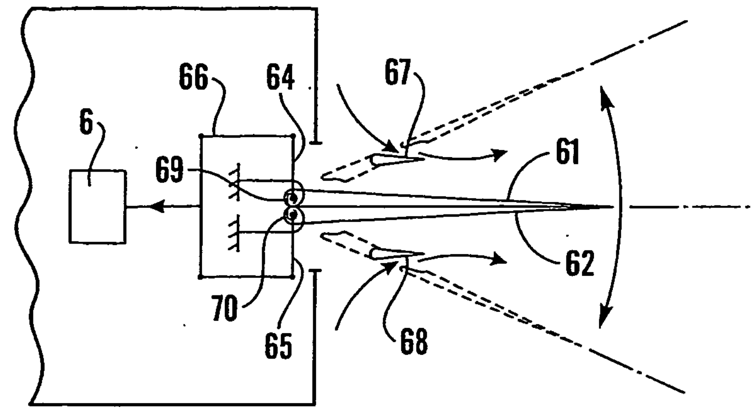

Fig. 17

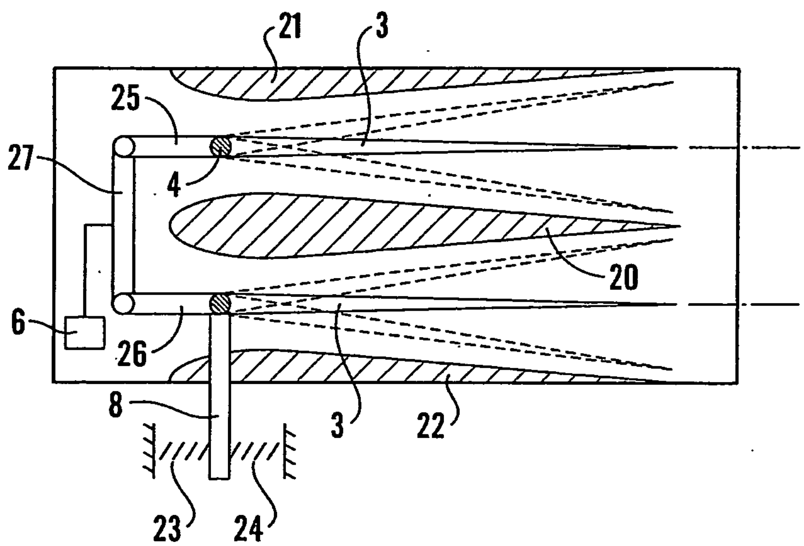

Fig. 18

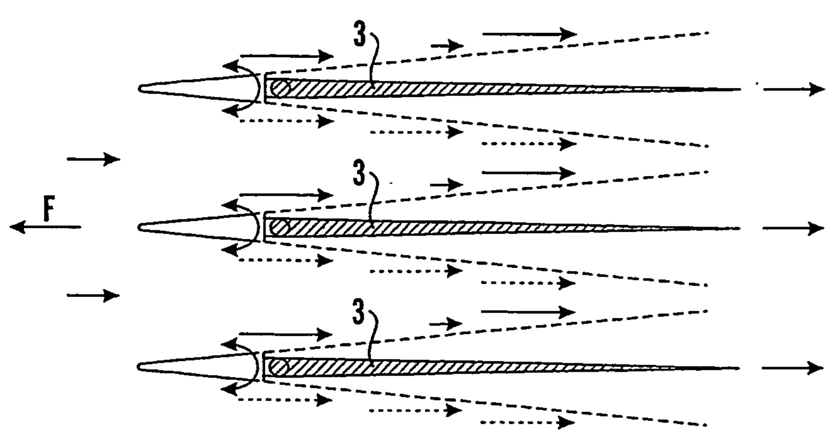

Fig. 19

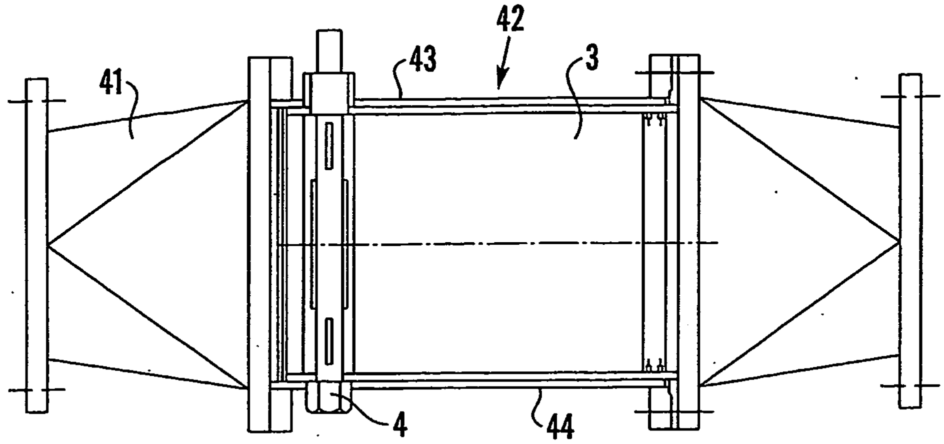

Fig.20

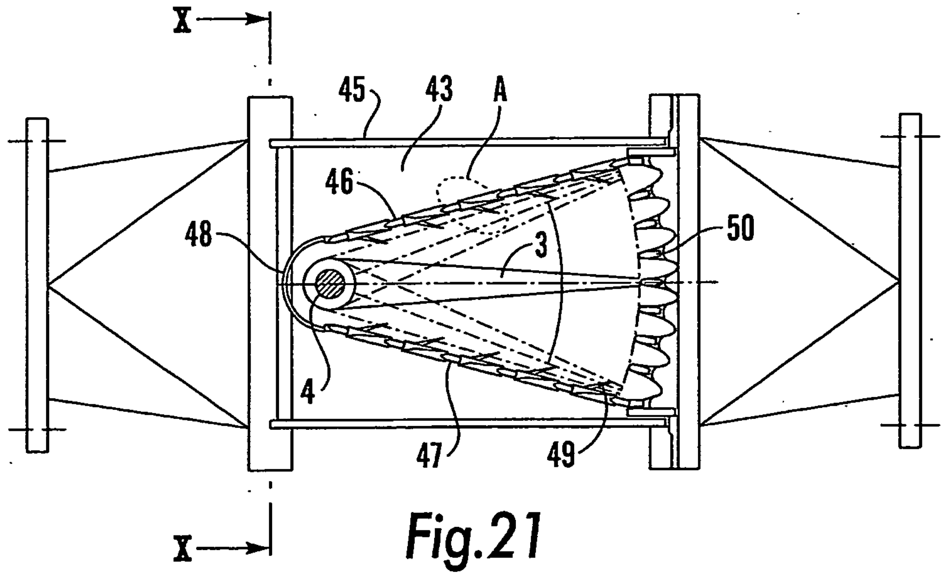

Fig.21

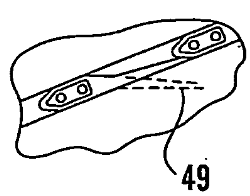

Fig.22

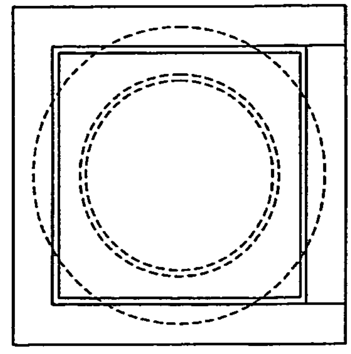

Fig.23

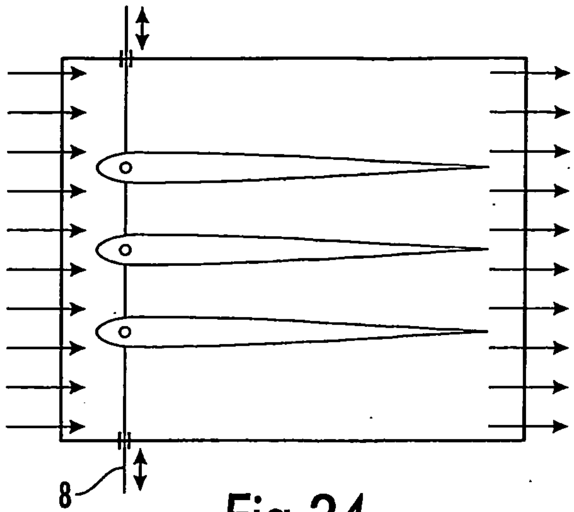

Fig.24

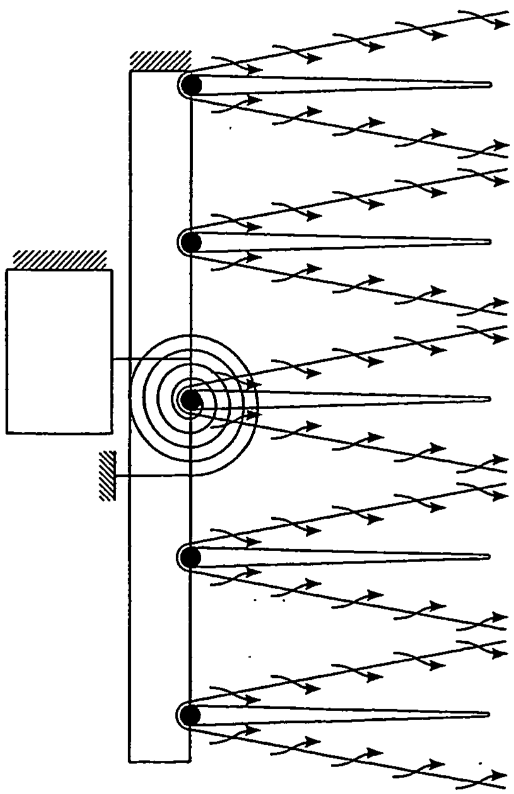

Fig.25

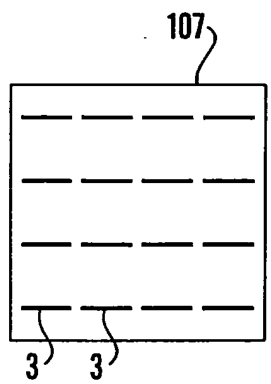

Fig.26

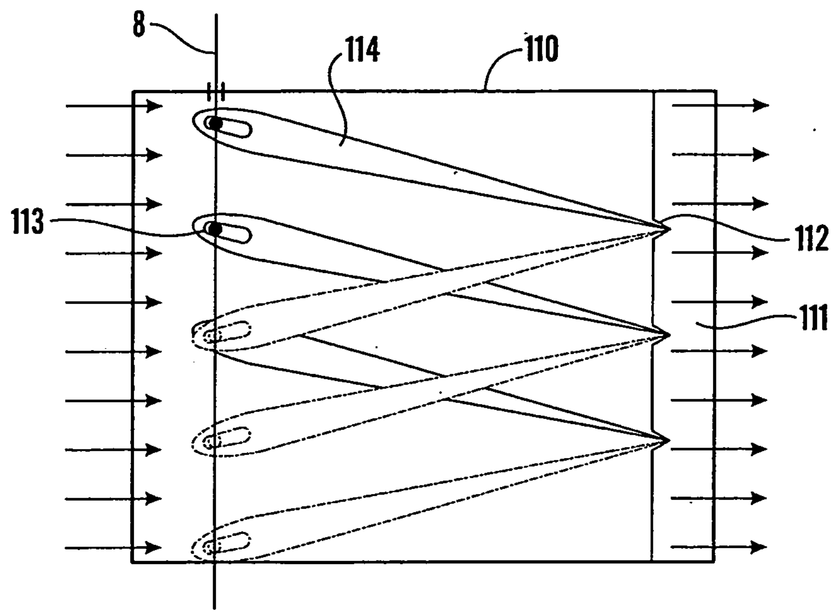

Fig.27

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 2004/000296

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B63H 1/36 // F03B 17/06, F04D 33/00
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)

IPC7: B63H, F03B, F04D

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

SE,DK,FI,NO classes as above

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

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3765175 A (OHNAKA), 16 October 1973 (16.10.1973) --	
A	US 4490119 A (YOUNG), 25 December 1984 (25.12.1984) --	
A	US 5370561 A (JAKOBSEN), 6 December 1994 (06.12.1994) --	
A	WO 9748599 A1 (HORRIGAN, DAVID, J, P), 24 December 1997 (24.12.1997) -- --------	

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

* Special categories of cited documents:
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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
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"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 May 2005	11-05-2005

Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Sune Söderling / JA A Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

01/04/2005

International application No.
PCT/NO 2004/000296

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WO	9748599	A1	24/12/1997	AU	3390997	A	07/01/1998

Espacenet

Bibliographic data: WO2009157840 (A1) — 2009-12-30

CATHETER PUMP FOR CIRCULATORY SUPPORT

Inventor(s):	REITAN OEYVIND [SE]; EPPLE KLAUS [DE] +	
Applicant(s):	CARDIOBRIDGE GMBH [GE]; REITAN OEYVIND [SE]; EPPLE KLAUS [DE] +	
Classification:	**- international:**	***A61M1/12***
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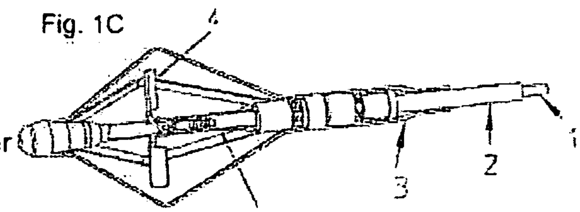
Application number:	WO2009SE00318 20090622	
Priority number(s):	SE20080001459 20080623; SE20080001460 20080623	
Also published as:	WO2009157840 (A8) US2011282128 (A1) US2011034874 (A1) JP2011525385 (A) EP2308422 (A1) EP2288392 (A1) DE202009018145 (U1) CN102065924 (A) less	

Abstract of WO2009157840 (A1)

Fig. 1C



A catheter pump intended to be inserted in the circulatory system of a mammal, for example for assisting the heart. The catheter pump comprises: a hollow catheter (2); a drive cable (1) arranged in a lumen (6) of the catheter (2); a sheath (3) surrounding the hollow catheter (2); a drive shaft (5) connected to a distal end of the drive cable (1) to be rotated by the drive cable; a propeller (4) arranged at the drive shaft; and a cage (11) surrounding the propeller. The propeller and the cage are moveable from a folded position, wherein the catheter pump has a small cross-sectional dimension of about 3.3 mm to an unfolded position wherein the unfolded cage surrounds the unfolded propeller and the size of the cage is about 19.5 mm. The drive shaft comprises a distal bearing (24) and a proximal bearing (25).; A purge system is arranged for passing fluid in a lumen (7) along the hollow catheter to the proximal bearing, for purging and lubrication of the proximal bearing. The fluid is returned outside the drive wire. A portion of the fluid is passed into channels (22) for passing fluid from the proximal bearing to the distal bearing, for purging and lubrication of the distal bearing.

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(71) Applicant *(for all designated States except US)*: **CARDIOBRIDGE GMBH** [GE/GE]; Lotzenäcker 3, D-72379 Hechingen (GE).

(72) **Inventors; and**

(75) **Inventors/Applicants** *(for US only)*: **REITAN, Öyvind** [SE/SE]; Villebrådsvägen 10, S-226 53 Lund (SE). **EPPLE, Klaus** [DE/DE]; Waldstrasse 7, 72414 Rangendingen (DE).

(74) Agent: **ASKETORP. Göran**; Asketorp Patent & Juridik AB, Råbygatan 14B, S-223 61 Lund (SE).

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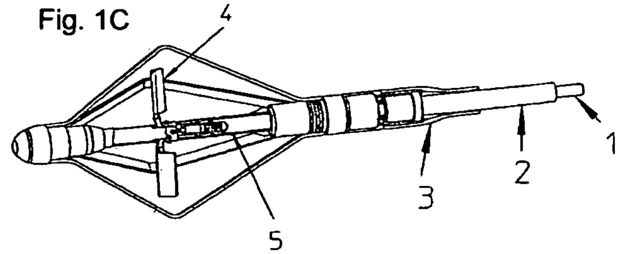
(54) **Title**: CATHETER PUMP FOR CIRCULATORY SUPPORT

Fig. 1C



(57) **Abstract**: A catheter pump intended to be inserted in the circulatory system of a mammal, for example for assisting the heart. The catheter pump comprises: a hollow catheter (2); a drive cable (1) arranged in a lumen (6) of the catheter (2); a sheath (3) surrounding the hollow catheter (2); a drive shaft (5) connected to a distal end of the drive cable (1) to be rotated by the drive cable; a propeller (4) arranged at the drive shaft; and a cage (11) surrounding the propeller. The propeller and the cage are moveable from a folded position, wherein the catheter pump has a small cross-sectional dimension of about 3.3 mm to an unfolded position wherein the unfolded cage surrounds the unfolded propeller and the size of the cage is about 19.5 mm. The drive shaft comprises a distal bearing (24) and a proximal bearing (25). A purge system is arranged for passing fluid in a lumen (7) along the hollow catheter to the proximal bearing, for purging and lubrication of the proximal bearing. The fluid is returned outside the drive wire. A portion of the fluid is passed into channels (22) for passing fluid from the proximal bearing to the distal bearing, for purging and lubrication of the distal bearing.

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CATHETER PUMP FOR CIRCULATORY SUPPORT

AREA OF INVENTION

The invention relates to a catheter pump intended to be introduced into the body of a mammal, for example via the femoral artery and placed in for example the aorta for circulatory support of the heart. The catheter pump may be arranged after the left ventricular valve in the aorta or after the right ventricular valve in the pulmonary artery.

BACKGROUND OF INVENTION

A previous device for circulatory support is known from US 5,749,855, having the same inventor as the present invention. The device comprises a drive cable, with one end of the drive cable being connectable to a drive source and a collapsible drive propeller at the other end of the drive cable. The collapsible drive propeller is adjustable between a closed configuration in which the collapsible drive propeller is collapsed on the drive cable and an open configuration in which the collapsible drive propeller is expanded so as to be operative as an impeller. A sleeve extends between one side of the collapsible drive propeller and the other side of the collapsible drive propeller with the sleeve being movable between configurations in which the collapsible drive propeller is in the open and closed configuration. A lattice cage is arranged surrounding the propeller and is folded out at the same time as the propeller.

This device operates very well in many circumstances. However, there is still room for improvements. For example, it would be safer if the lattice cage is folded out before the propeller is folded out. In addition, the shaft supporting the propeller needs to be journalled with bearings, and such bearings need to be lubricated.

Thus, there is a need in the art for a device addressing such needs.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to mitigate, alleviate or eliminate one or more of the above-identified deficiencies and disadvantages singly or in any combination.

According to an aspect of the invention, there is provided a catheter pump intended to be inserted in the circulatory system of a mammal, for example for assisting the heart, comprising: a hollow catheter; a drive cable arranged in a lumen of said hollow catheter; a drive shaft connected to a distal end of the drive cable to be rotated by the drive cable; and a propeller arranged at the drive shaft; characterized by a distal bearing and a proximal bearing arranged at the distal end and proximal end of the drive shaft; a purge system for passing fluid along the hollow catheter to said proximal bearing, for purging and lubrication of said proximal bearing; and channel means for passing fluid from said proximal bearing to said distal bearing, for purging and lubrication of said distal bearing.

In an embodiment, the channel means may be arranged in said drive shaft. The drive shaft may be surrounded by a sleeve and said channel means may be arranged between said drive shaft and said sleeve, in the nature of grooves in the shaft and/or sleeve. The purge system may comprise a dedicated hole in said hollow catheter, which hole is used solely for the purpose of passing said fluid from the proximal end of the hollow catheter to the distal end thereof. The distal bearing may be connected to the surrounding space via a lip seal. The fluid may pass outside the drive wire in the said lumen in the direction from the distal end to the proximal end.

In another embodiment, there is a sheath circumventing said hollow catheter and being moveable in the axial direction for unfolding a cage comprised of several filaments and propeller blades from a folded position close to said drive shaft and to an unfolded position. The propeller may be circumvented by a girdle. The girdle may comprise an inflateable ring. The sheath may be moveable a first distance for unfolding said cage and a second distance for unfolding said propeller blades.

In another aspect, there is provided a catheter pump intended to be inserted in the circulatory system of a mammal, for example for assisting the heart, comprising: a hollow catheter; a sheath surrounding said hollow catheter and being axially moveable in relation to the hollow catheter; a drive cable arranged in a lumen of said catheter; a drive shaft connected to a distal end of the drive cable to be rotated by the drive cable; a propeller arranged at the drive shaft; a proximal housing and a distal housing arranged at the proximal and distal ends of the drive shaft; and several filaments extending between the proximal housing and the distal housing; characterized in that the proximal housing is connected to the hollow catheter and the distal housing is connected to the distal housing, whereby axial movement of the sheath in relation to the hollow catheter results in that the distal housing is brought closer to the proximal housing resulting in that said filaments are unfolded to form a cage; and the drive shaft comprises a propeller pin arranged so that said propeller is pivotable between a first folded position, in which the propeller is parallel with the drive shaft and an unfolded position in which the propeller is perpendicular to the drive shaft.

According to an embodiment, the axial movement of the sheath may in a first movement unfold the cage and may in a second subsequent movement unfold the propeller. The drive shaft may be surrounded by a sleeve, said sleeve comprising actuation pins, which may be moveable in the axial direction for cooperation with a cam surface of said propeller for unfolding the propeller. A spring-loaded bolt may be arranged for cooperation with cam surfaces of said propeller.

In an embodiment, there may be arranged a purge fluid system comprising an axial lumen in said hollow catheter for providing fluid to a proximal bearing at the proximal side of the drive shaft; channels in said drive shaft for providing fluid to a distal bearing at the distal side of the drive shaft; and a lip seal for passing the fluid from the distal bearing and out to the surroundings.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects, features and advantages of the invention will become apparent from the following detailed description of embodiments of the invention with reference to the drawings, in which:

Fig. 1A is a schematic view in perspective of a system according to an embodiment of the invention.

Figs. 1B and 1C are cross-sectional views showing the pump head according to an embodiment of the invention. Fig. 1B shows the folded pump head during insertion and Fig. 1C shows the pump head in an unfolded or deployed position.

Fig. 1D is a cross-sectional view taken line D-D in Fig. 1B.

Fig. 2A is a perspective view, partly broken, and shows the deployed distal part of the catheter pump head.

Fig. 2B is a magnified view of the central part of Fig. 2A encircled by the circle 2B.

Fig 3A and 3B are cross-sectional views showing the housing of and the tip and body bearings of the propeller shaft.

Fig. 3C is a partially broken view of a portion of Fig. 3A.

Fig. 4 is a partially broken perspective view showing the propeller shaft with parts of the sliding outer sleeve removed for illustrating longitudinal channels on the outer surface of the propeller shaft.

Figs. 5A to 5D are perspective views showing how the propeller blades are deployed from the folded position to the unfolded position.

Figs. 6A to 6C are partial views showing the unfolding mechanism in an enlarged scale of the propeller shown in Figs. 5A to 5D.

Figs. 7 to 12 are perspective and end views showing how the catheter pump can be used in combination with other treatment devices and/or diagnostic tools.

DETAILED DESCRIPTION OF EMBODIMENTS

Below, several embodiments of the invention will be described with references to the drawings. These embodiments are described in illustrating purpose in order to enable a skilled person to carry out the invention and to disclose the best mode. However, such embodiments do not limit the invention. Moreover, other combinations of the different features are possible within the scope of the invention.

"The Reitan Catheter Pump System" is a temporary circulatory support system based on the concept of a foldable propeller at the tip of a flexible catheter according to an embodiment. The system is used in patients with heart failure when the native heart is unable to support the body with sufficient oxygenated blood. The basic principles of the system corresponds to that described in US 5,749,855 mentioned above.

There are several blood pumps on the market, but most of them require major surgery to be implanted. The use of a foldable propeller has therefore the advantage that while folded during the insertion it makes it possible to introduce a large dual-winged propeller with high-flow capacity into the body without the need of surgery. The propeller is arranged at the distal end of the catheter in the pump head. In addition to the propeller, the pump head also comprises a cage made of six filaments surrounding the propeller in order to protect the aorta against the propeller.

The insertion is accomplished percutaneously via a puncture in the femoral artery in the groin through an introducer sheath and the pump is advanced into the thoracic aorta with the pump head placed approximately 5 to 10 centimeters below the left subclavian artery. Once in position, the propeller and its protective cage are deployed or unfolded. The pump is then ready for operation. The rotation of the propeller creates a pressure gradient inside the aorta. The blood pressure decrease created in the upper part of the aorta facilitates the ejection of blood from the left ventricle. The increased pressure in the lower part of the aorta facilitates the perfusion of the internal organs, especially the kidneys.

The pump is mounted on a flexible catheter with an inner rotating wire which is connected to a DC motor at the proximal end. The motor is operated with adjustable rotational speed, monitored by a specially designed console.

The pump has a purge system with two small channels, which transport a 20 % glucose solution to the proximal bearing of the propeller shaft for lubrication an dpurging. Two thirds of this fluid enters the patient's circulation, and one third of the fluid is returned to a waste bag. The return fluid passes along the drive wire, which receives lubrication.

The advantage of making the system foldable is to be able to introduce a large propeller into the body without any large surgery. The size of the folded pump head and the flexible catheter is approximately 10 French (3.3mm) in diameter.

The system comprises four main components:

1. The catheter pump head,
2. The drive unit,
3. The console,
4. The purge set.

The catheter has been designed such that it will be advanced through the femoral artery into the aorta, so that the pump resides 5 to 10 cm below the subclavian artery in the descending aorta.

The catheter pump head comprises a flexible outer catheter or sheath and an inner, hollow catheter, which slide against one another to deploy the protective cage and unfold the propeller within the cage. There is a flexible drive wire running through the central lumen of the inner catheter. The inner catheter also has two small channels for transporting 20% glucose solution to the pump head for lubrication and purging. One-third of the fluid is returned via the internal drive shaft lumen, and two-thirds of the fluid is added to the blood pool.

The pump head is mounted at the distal end of the flexible catheter. Filaments surrounding the propeller are foldable, forming a protective cage around the propeller when the propeller/cage system is unfolded. The folded pump head during insertion measures 3.3 mm (10 French), whereas the deployed pump head measures approximately 19.5 mm. The rotation of the propeller is transmitted via the flexible drive wire placed in the central lumen of the inner catheter.

The proximal end of the catheter (the drive coupling) is connected via a magnetic field to a DC motor, which is placed in a Drive Unit. The speed of the DC motor, rotating wire and propeller is adjustable and is monitored by a console. The speed can be adjusted between 1,000 and 15,000 rpm.

The drive unit has been designed such that it may be positioned at the bedside of the patient and has a magnetic coupling for connection to the catheter pump at one end. The other end of the drive unit is connected to the console via an electric cable.

The primary functions of the console are to monitor and control the speed of the catheter pump and a peristaltic pump for the purge fluid. All controls and monitoring parameters for the system are displayed on a touch screen. The console also comprises batteri or electric power for the Drive Unit.

The purge system is constructed to lubricate and to prevent entrance of blood into the rotating parts of the pump. The rotation of the propeller is transmitted from the external DC motor via magnetic coupling and a flexible wire in the center of the catheter.

The purge system consists of small channels inside the catheter to transport a 20% sterile glucose solution to lubricate the internal components. Heparin may be added to the purge fluid. One-third of the fluid is transported back through the inner lumen and lubricates the rotating wire. Two-thirds of the glucose solution enters the circulation of the patient and seals off the drive shaft. The total amount of purge fluid may be set to 600 ml per 24 hours (about 0.4 ml per minute) and is transported via a peristaltic pump. The console controls the speed of the peristaltic pump.

Fig. 1 discloses an overview of a system according to an embodiment. The system comprises a catheter A intended to be introduced into the body of a mammal, such as a human, via the femoral artery and placed in the aorta for circulatory support of the heart. The catheter is relatively long so that it can extend from the percutaneous introduction site into for example the femoral artery in the groin and up to the aortic arc.

The catheter comprises a pump head with a propeller enclosed within a cage as described in more details below. The pump head may be placed in the intra-aortic balloon position in the thoracic aorta. Other positions may be used as well.

The other end of the catheter extends at the proximal end out of the mammal and is connected to a drive unit B, which also will be further described below. The drive unit B is connected to and controlled by a control console C, which may comprise batteries, touch-screen displays and a computer system.

The distal portion of the catheter, i.e. the pump head, is shown in Figs. 1B and 1C. The catheter comprises a drive wire 1 which is flexible and can transmit torque although it can be bent to some extent. The drive wire 1 is enclosed in an inner, hollow catheter 2, which in turn is enclosed in an outer catheter or sheath 3.

In the present specification, the expression “distal” has the meaning of facing away from the percutaneous introduction site and “proximal” has the meaning of being closer to the percutaneous introduction site than the “distal”.

The drive wire 1, the hollow catheter 2 and the sheath 3 extend along the entire catheter pump, as shown by the cut lines in Figs. 1B and 1C.

The drive wire 1 is at its distal end connected to a drive shaft 5. A foldable propeller 4 is attached to the shaft in a folded position shown in Fig. 1B.

As shown in the cross-sectional view of Fig. 1D, the inner catheter 2 comprises a cylinder having a central lumen 6, in which the drive wire 1 is arranged. In addition, the inner catheter 2 comprises two axial holes 7, as will be further described below. The inner catheter is relatively rigid in the longitudinal direction and is flexible in the cross-direction. Thus, the catheter has a sufficient rigidity to be inserted into the vascular system and moved to a desired position by itself. The catheter has also a sufficient flexibility to follow the curvature of the vascular system.

If a guide wire is used for inserting the catheter pump, the guide wire may extend inside one of the holes 7.

The drive wire 1 fits into the central lumen 6 with a small clearance as shown in Fig. 1D. The clearance may comprise a lubricant so that the drive wire 1 may rotate freely in the catheter 2, which is non-rotating. The sheath 3 surrounds the inner catheter 2 with a clearance. The sheath 3 is moveable in the axial direction in relation to the inner catheter 2 as will be described below.

In the pump head, the distal end of the drive wire 1 is attached to a nipple 5a arranged at the proximal end of the drive shaft as shown in Fig. 1B. The drive shaft is journalled in distal bearings 24 and proximal bearings 25 as shown in Figs. 1B, 3A and 3B.

A proximal housing 9 and a distal housing 10 are arranged adjacent the distal and proximal ends of the drive shaft 5. Several filaments 11 are arranged between the housing 9 and the housing 10. In the folded position, the filaments 11 are parallel with the drive shaft 5 and extend close to the drive shaft as shown in Figs. 1B and 3C.

The drive shaft 5 is covered by a sleeve 8, which is moveable in the axial direction on the drive shaft 5. In the folded position, the sleeve 8 extends from the proximal housing 9 and ends a short distance 27 before the distal housing as shown in Fig. 3C.

The distal housing 10 is attached to the inner catheter 2 and the drive wire 1 via the drive shaft 5. The proximal housing 9 is attached to the outer catheter or sheath 3 as appears from Fig. 2A. The outer catheter 3 is moveable in the axial direction in relation to the inner catheter 2. When the outer catheter 3 is moved in the direction downward in Fig. 2A, the proximal housing 9 is advanced towards the distal housing 10 resulting in the fact that the filaments 11 are bent outward in order to form a cage, as shown in Fig. 2A. Such bending of the filaments 11 may be facilitated by weakening lines 26, see Fig. 4, arranged at the inside of the filaments 11, close to the middle thereof.

When the cage has been initially formed, continued movement of the outer catheter 3 and the proximal housing 9 towards the distal housing 10 results in that the folded propeller is unfolded to the position shown in Fig. 2A, as further described below in connection with Figs. 5A to 5D.

The cage thus formed, protects the inner walls of a blood vessel 20 from the propeller. Since the cage is unfolded before the propeller is unfolded and by the same movement as the unfolding of the propeller, it is assured that the cage is formed before the propeller is unfolded. Thus, the blood vessels are protected from the propeller also during the unfolding of the propeller, which is an advantage.

As shown in Fig. 2B, the propeller 4 comprises two blades 4 which are journalled by a propeller pin 13 extending through the drive shaft 5. Moreover, each propeller blade comprises a cam surface 12 for cooperation with a spring bolt 14 and an actuation pin 15 attached to the sleeve 8.

The complete movement of the outer catheter 3 and the proximal housing 9 towards the distal housing 10 corresponds to the short distance 27 shown in Fig. 3C and mentioned above.

As shown in Fig. 3B, the outer surface of the drive shaft is provided with several channels 22 extending along the entire drive shaft inside the sleeve 8.

A lubricant and purge fluid is introduced into one or both of the holes 7, see Fig. 1D, at the end of the inner catheter 2 extending out of the body at the percutaneous site. The fluid exits the hole 7 adjacent the nipple 5a, as shown in Fig. 3B. The fluid, shown by line 28, encircles the nipple 5a and lubricates the proximal bearing 25 and passes out to the blood outside the bearing in order to purge the bearing and prevent blood from entering the bearing in the opposite direction.

In addition, the fluid enters the channels 22 and passes towards the distal housing.

Moreover, a portion of the fluid is diverted into the clearance between the inner catheter 2 and the flexible drive wire 1 inside the central lumen 6, as shown in Fig. 1D. This fluid will lubricate the drive wire and ensure that the drive wire will operate smoothly. This fluid will return to the percutaneous site and be collected. The portion of the fluid returning this way is approximately one third of the total flow.

The fluid entering the channels 22 at the proximal housing 9 will exit the channels 22 at the distal housing 10 as indicated by line 29 in Fig. 3A. The fluid will encircle the distal bearing 24 and lubricate the bearing. The fluid will pass outside the sleeve 8 and beyond a lip seal 23 arranged surrounding the sleeve 8. The sleeve 8 is moveable in relation to the lip seal 23 between the position shown in Fig. 3C, when the filaments and the propeller are folded, and the position shown in Fig. 3A, when the propeller and the cage are unfolded. The fluid finally enters inside the blood vessel via the lip seal 23 and prevents blood from passing in the opposite direction.

Thus, by this arrangement, both the proximal bearing 25 and the distal bearing 24 are lubricated by the fluid and the fluid purges the inside of the proximal housing 9 and the distal housing 10 so that no blood can enter inside the housings.

As shown in Fig. 3C, the channels 22 are open to the interior of the distal housing also in the folded position of the cage and propeller. Thus, purge fluid can be provided before unfolding the cage and propeller and before starting any propelling action, which is an advantage.

Alternatively or additionally, the channels 22 can be placed on the inner surface of the outer sliding sleeve 8 or arranged as axial holes in the center of the drive shaft. Both the drive shaft 5 and the sleeve 8 are rotating in common.

With reference now to Figs. 5A to 5D, the unfolding of the propeller will be described. The unfolded cage with the filaments 11 is not shown so that the other details will be clearly visible.

As appears from Figs. 5A and 6B, in the folded position of the propeller blades 4, a spring bolt 14 engages a cam surface 12a of the propeller blade and keeps the propeller blade in the folded position. The spring bolt 14 is biased by a spring 16, see Fig. 6B.

Two actuation pins 15 are arranged at the sleeve 8. When the sleeve 8 is advanced in the downward direction in order to unfold the cage, the actuation pins 15 are moved to the position shown in Figs. 5B, acting upon a second cam surface 12b of the propeller blade.

Further movement of the sleeve 8 downward will move the cam surface 12b downward, thereby pivoting the propeller blade around the propeller pin 13, as shown in Figs.

5C and 6A. This action is counteracted by the spring bolt 14. The spring bolt is forced to pass over a cam shoulder 12c as shown in Figs. 5C, 5D and 6A.

Further movement of the sleeve 8 downward will unfold the propeller to the position shown in Fig. 2B. The opposite actuation pin 15 prevents the propeller blade 4 from moving over the 90 degree position.

When the propeller is fully unfolded, the spring bolt 14 has lost its contact with the cam surface of the propeller blade, as appears from Fig. 2B. In this position, the propeller blade is locked by the actuation pin 15.

The propeller blade will be retracted to the folded position at the opposite movement of the actuation pin 15. Then, the cage will be collapsed to the folded position.

Thus, it appears that the cage is unfolded or deployed before the propeller is unfolded. The propeller is unfolded in a partly or completely deployed cage. This prevents the walls of the blood vessel from possible sharp edges during the unfolding of the propeller blades.

Fig. 7 shows another embodiment of the catheter pump, wherein the cage is provided with a girdle 17 surrounding the filaments at the outer positions thereof. This arrangement enables the addition of a guide wire 18, which may pass the catheter pump without influencing upon the operation or the pump or contacting the propeller blades during rotation thereof.

Alternatively or additionally, a guide tube 19 may be inserted in a blood vessel 20 and passing the pump head. A treatment device 21 can be inserted by means of the guide wire 18 and/or the guide tube 19. The treatment device 21 may be a coronary vessel dilation and stenting device, an ultrasound coronary artery device, a drug delivery device, a left ventricular pressure measurement device, a conductance catheter for pressure volume loops, a catheter for electro-physiology of the left ventricle, a micro camera, a video camera, a balloon catheter, coronary angioplasty catheter, etc.

Fig. 8 is an end view showing the arrangement according to Fig. 7.

As shown in Fig. 9, the girdle 17 may be arranged as an inflatable ring. In this manner, back-flow of blood may be reduces along the wall of the vessel 20. The flow pattern of the back flow without such a ring is further illustrated in Fig. 10.

Fig. 11 shows a catheter pump inserted into the aorta in a position near the heart. The guide tube 19 extends outside the catheter pump. The guide tube 19 is inserted with help of the guide wire 18. The insertion of at least the guide wire 18 may be accomplished before the insertion of the catheter pump and deployment of the cage 11. The girdle 17 prevents both the guide wire 18 as well as the guide tube 19 from coming in contact with the propeller 4.

Outside the body, the catheter device A is connected to a drive unit B as shown in Fig. 1. The drive unit comprises an electric motor having a radial disk arranged at its shaft. The disk comprises several permanent magnets attached to the surface of the disk. The flexible drive wire 1 ends with a similar disk provided with permanent magnets. The disks of the motor and the disk of the drive wire are brought into close distance from each other. Then, the magnets will attract and connect the two disks together. In this manner, torque from the motor can be transmitted to the drive wire. If the drive wire is prevented from rotating, for example by the fact that the propeller is blocked, the magnets of the drive disks will separate. Then, substantially no torque is transmitted from the motor, until the motor has been stopped and the magnets of the disks have been aligned and attract. This is a safety measure.

The drive unit B further comprises a peristaltic pump, which drives the purge fluid into the holes 7 in the inner catheter 2. The fact that the purge fluid is passing inside a separate channel to the proximal housing 9 and further to the distal housing 10 is an advantage. If instead the purge fluid would pass outside the drive wire, there is a risk that small particles in the drive wire may come lose and contaminate the bearings.

The purge fluid passes inside channels 22 arranged in the drive shaft 5. Thus, no separate member is required between the proximal housing and the distal housing. The purge fluid has no other way to escape from the distal housing but via the lip seal 23.

The catheter pump may be arranged after the left ventricular valve in the aorta or after the right ventricular valve in the pulmonary artery. The catheter pump may be arranged adjacent the heart valves or further down the aorta or artery in any suitable position.

The catheter pump may be driven with a constant speed, which is adjusted to the needs of the patient. If required, the catheter pump may be driven with a pulsative or partially pulsative flow, for example substantially synchronously with the heart.

The catheter pump is intended for assisting the beating heart. However, the catheter pump may also be used also during heart surgery when the heart is non-beating.

Although the present invention has been described above with reference to specific embodiment, it is not intended to be limited to the specific form set forth herein. Rather, the invention is limited only by the accompanying claims and other embodiments than those specifically described above are equally possible within the scope of these appended claims.

In the claims, the term "comprises/comprising" does not exclude the presence of other elements or steps. Furthermore, although individually listed, a plurality of means, elements or method steps may be implemented by e.g. a single unit or process. Additionally, although individual features may be included in different claims, these may possibly advantageously be combined, and the inclusion in different claims does not imply that a combination of features is not feasible and/or advantageous. In addition, singular references do not exclude a plurality. The terms "a", "an", “first”, “second” etc do not preclude a plurality. Reference signs in the claims are provided merely as a clarifying example and shall not be construed as limiting the scope of the claims in any way.

CLAIMS

1. A catheter pump intended to be inserted in the circulatory system of a mammal, for example for assisting the heart, comprising:

a hollow catheter (2);

a drive cable (1) arranged in a lumen (6) of said hollow catheter (2);

a drive shaft (5) connected to a distal end of the drive cable (1) to be rotated by the drive cable; and

a propeller (4) arranged at the drive shaft;

characterized by

a distal bearing (24) and a proximal bearing (25) arranged at the distal end and proximal end of the drive shaft;

a purge system for passing fluid along the hollow catheter (2) to said proximal bearing (25), for purging and lubrication of said proximal bearing; and

channel means (22) for passing fluid from said proximal bearing to said distal bearing (24), for purging and lubrication of said distal bearing.

2. The catheter pump according to claim 1, characterized in that said channel means (22) are arranged in said drive shaft (5).

3. The catheter pump according to claim 1 or 2, characterized in that said drive shaft (5) is surrounded by a sleeve (8) and said channel means being arranged between said drive shaft and said sleeve, in the nature of grooves in the shaft and/or sleeve.

4. The catheter pump according to any one of the previous claims, characterized in that said purge system comprises a dedicated hole (7) in said hollow catheter, which hole is used solely for the purpose of passing said fluid from the proximal end of the hollow catheter to the distal end thereof.

5. The catheter pump according to any one of the previous claims, characterized in that said distal bearing is connected to the surrounding space via a lip seal (23).

6. The catheter pump according to any one of the previous claims, characterized in that said fluid is passing outside the drive wire in the said lumen (6) in the direction from the distal end to the proximal end.

7. The catheter pump according to any one of the previous claims, characterized by a sheath (3) circumventing said hollow catheter (2) and being moveable in the axial direction for

unfolding a cage comprised of several filaments (11) and propeller blades (4) from a folded position close to said drive shaft and to an unfolded position.

8. The catheter pump according to any one of the previous claims, characterized in that the propeller is circumvented by a girdle (17).

9. The catheter pump according to claim 8, characterized in that said girdle comprises an inflateable ring.

10. The catheter pump according to claim 9, characterized by the fact that said sheath (3) is moveable a first distance for unfolding said cage and a second distance for unfolding said propeller blades (4).

11. A catheter pump intended to be inserted in the circulatory system of a mammal, for example for assisting the heart, comprising:

a hollow catheter (2);

a sheath (3) surrounding said hollow catheter (2) and being axially moveable in relation to the hollow catheter (2);

a drive cable (1) arranged in a lumen (6) of said catheter (2);

a drive shaft (5) connected to a distal end of the drive cable (1) to be rotated by the drive cable;

a propeller (4) arranged at the drive shaft;

a proximal housing (9) and a distal housing (10) arranged at the proximal and distal ends of the drive shaft (5); and

several filaments (11) extending between the proximal housing and the distal housing;

characterized in that

the proximal housing (9) is connected to the hollow catheter (2) and the distal housing is connected to the distal housing (10), whereby axial movement of the sheath (3) in relation to the hollow catheter (2) results in that the distal housing is brought closer to the proximal housing resulting in that said filaments are unfolded to form a cage; and

the drive shaft comprises a propeller pin (13) arranged so that said propeller is pivotable between a first folded position, in which the propeller is parallel with the drive shaft and an unfolded position in which the propeller is perpendicular to the drive shaft.

12. The catheter pump according to claim 11, characterized in that said axial movement of the sheath (3) in a first movement unfolds the cage and in a second subsequent movement unfolds the propeller (4).

13. The catheter pump according to claim 11 or 12, characterized in that said drive shaft (5) is surrounded by a sleeve (8), said sleeve comprising actuation pins (15) which are moveable in the axial direction for cooperation with a cam surface (12b) of said propeller for unfolding the propeller.

14. The catheter pump according to any one of claims 11 to 13, characterized by a spring-loaded bolt (14) arranged for cooperation with cam surfaces (12a, 12c) of said propeller (4).

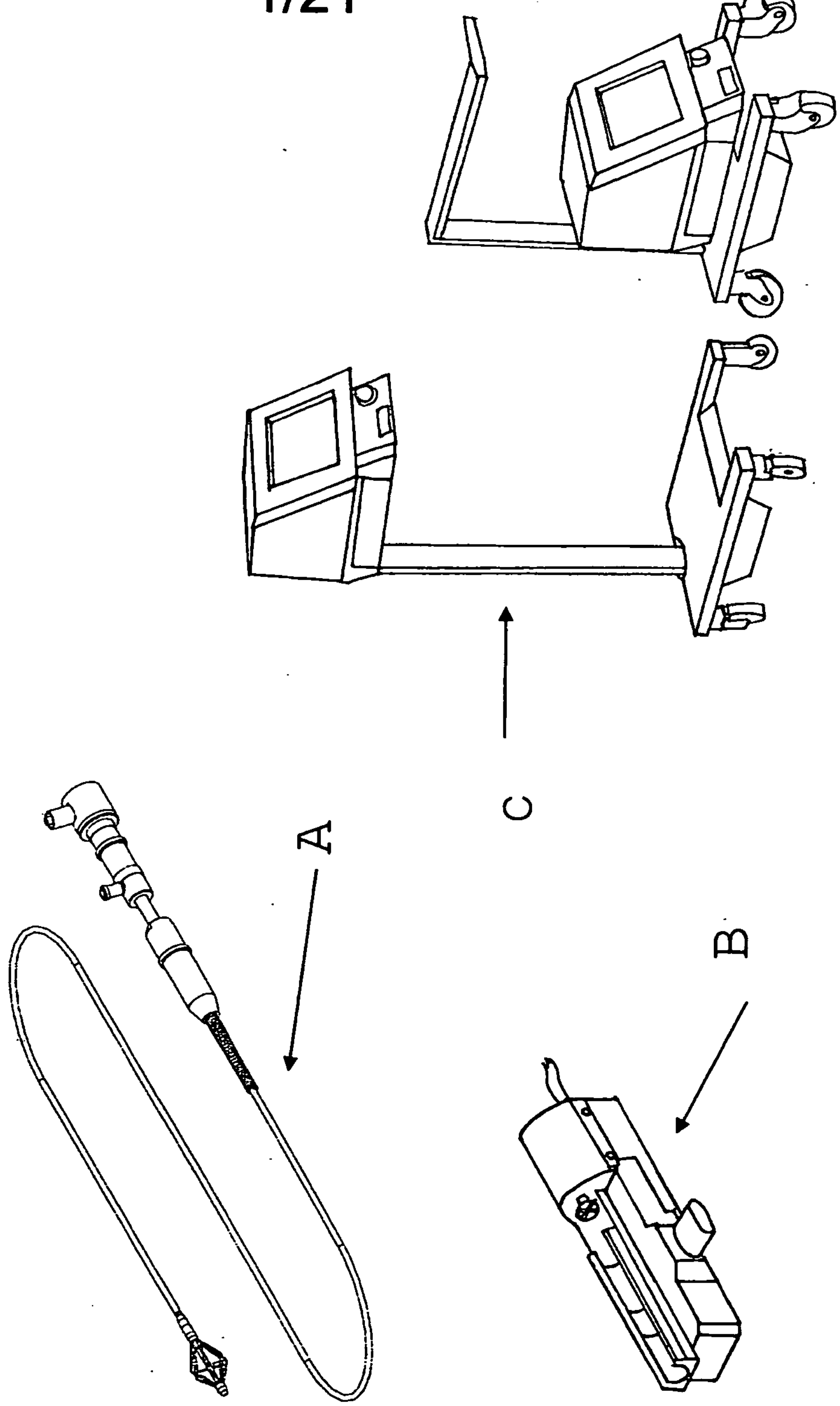
15. The catheter pump according to any one of claims 11 to 14, characterized by a purge fluid system comprising

an axial lumen (7) in said hollow catheter (2) for providing fluid to a proximal bearing at the proximal side of the drive shaft (5);

channels (22) in said drive shaft for providing fluid to a distal bearing at the distal side of the drive shaft; and

a lip seal (23) for passing the fluid from the distal bearing and out to the surroundings.

Fig. 1A



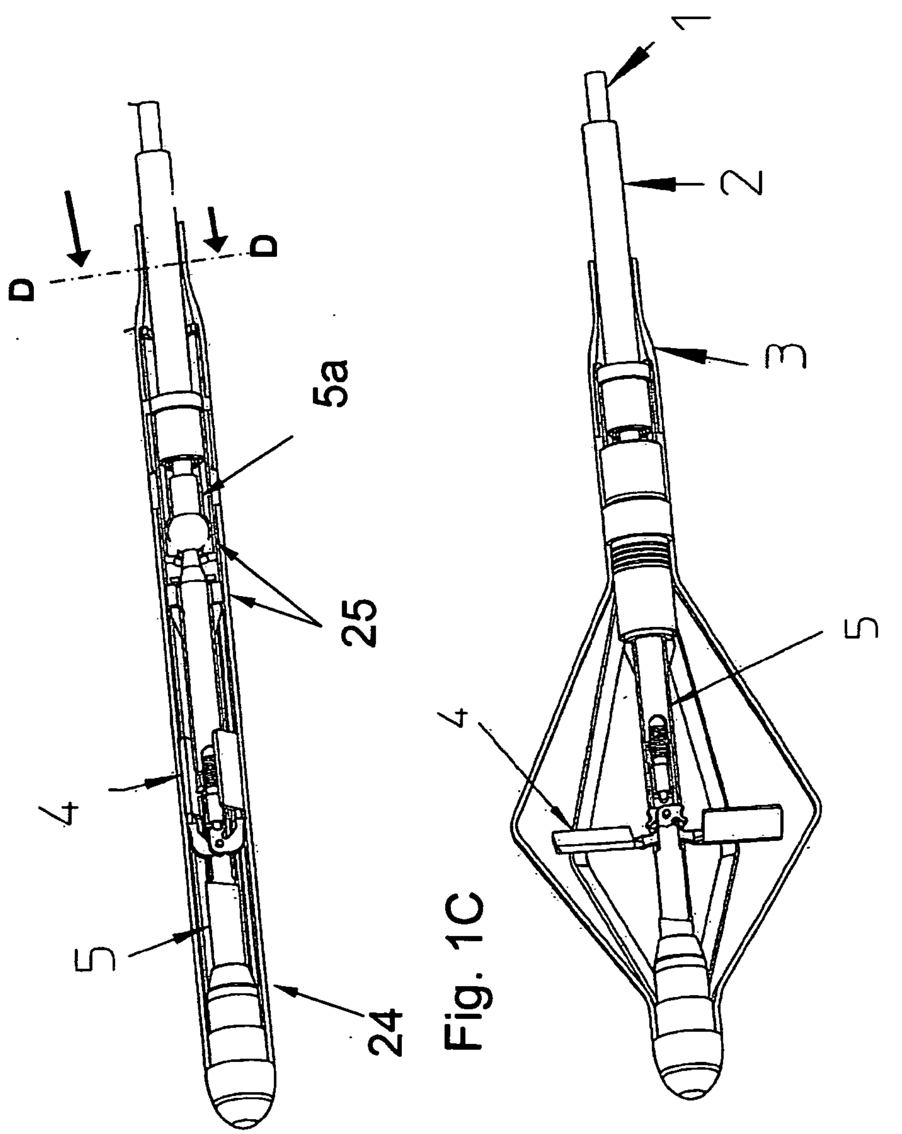


Fig. 1B

Fig. 1C

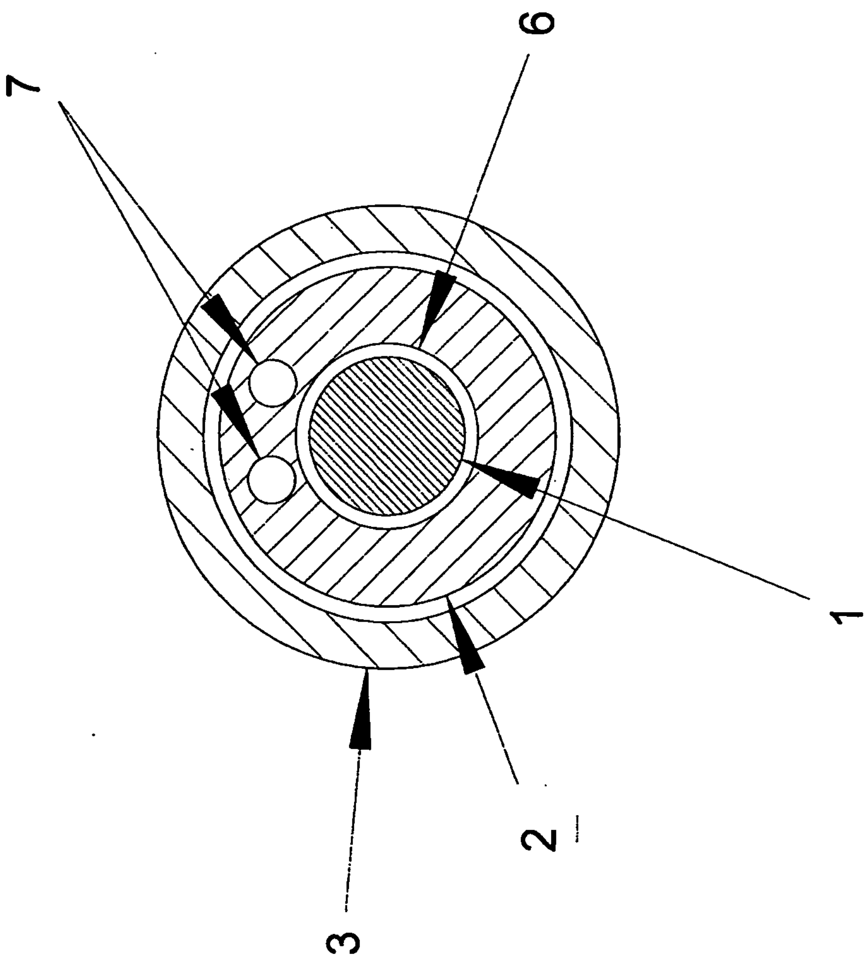


Fig. 1D

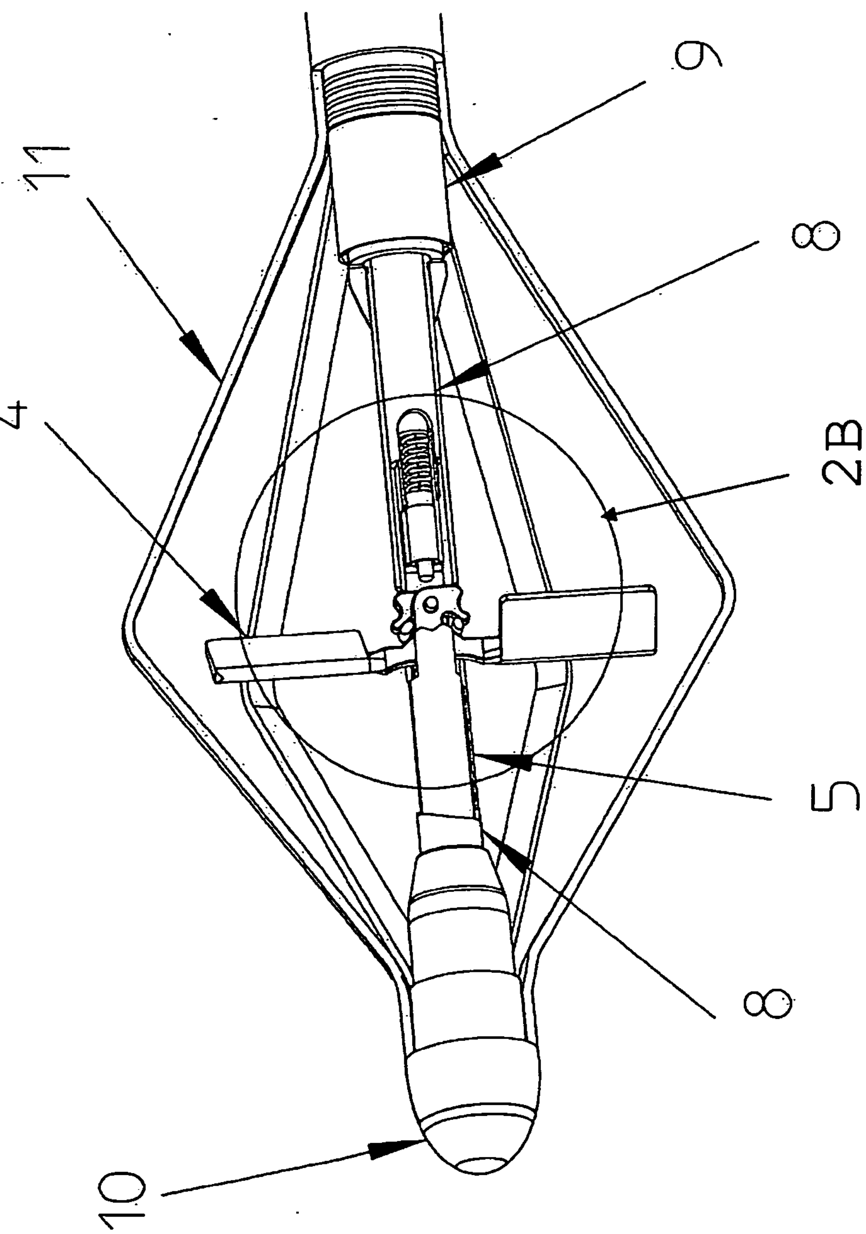


Fig 2A

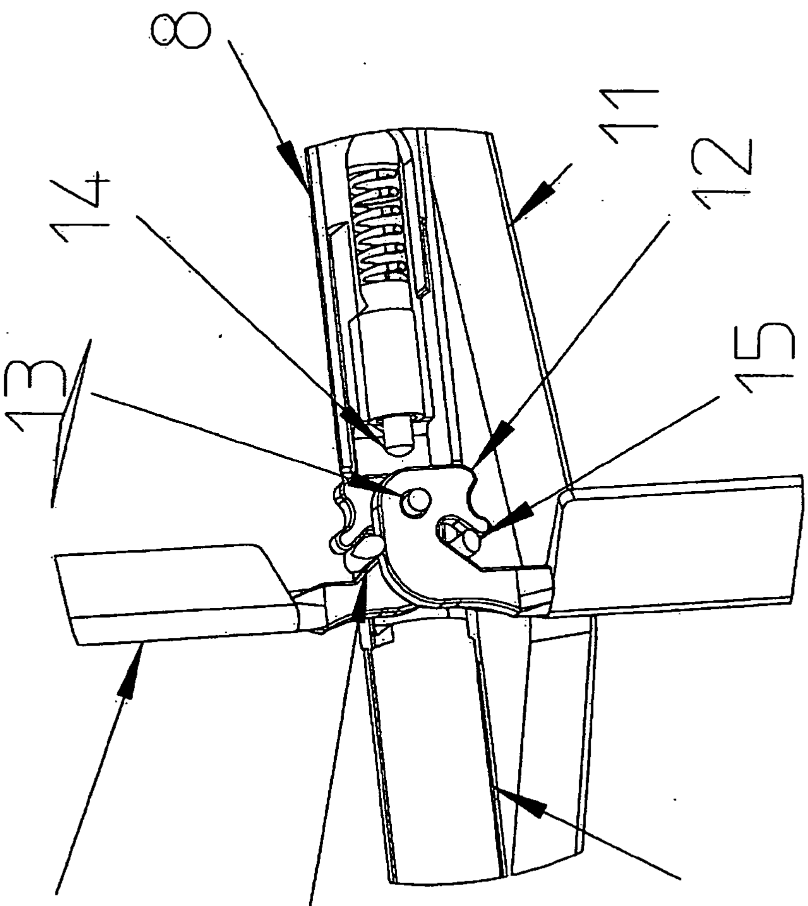


Fig 2B

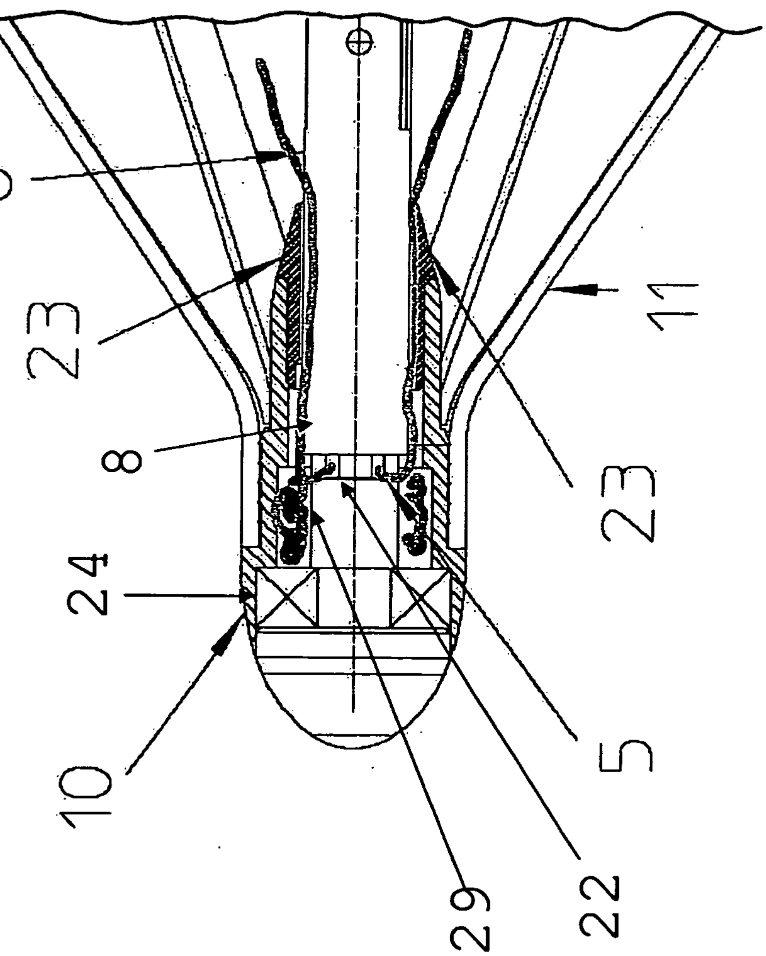


Fig 3A

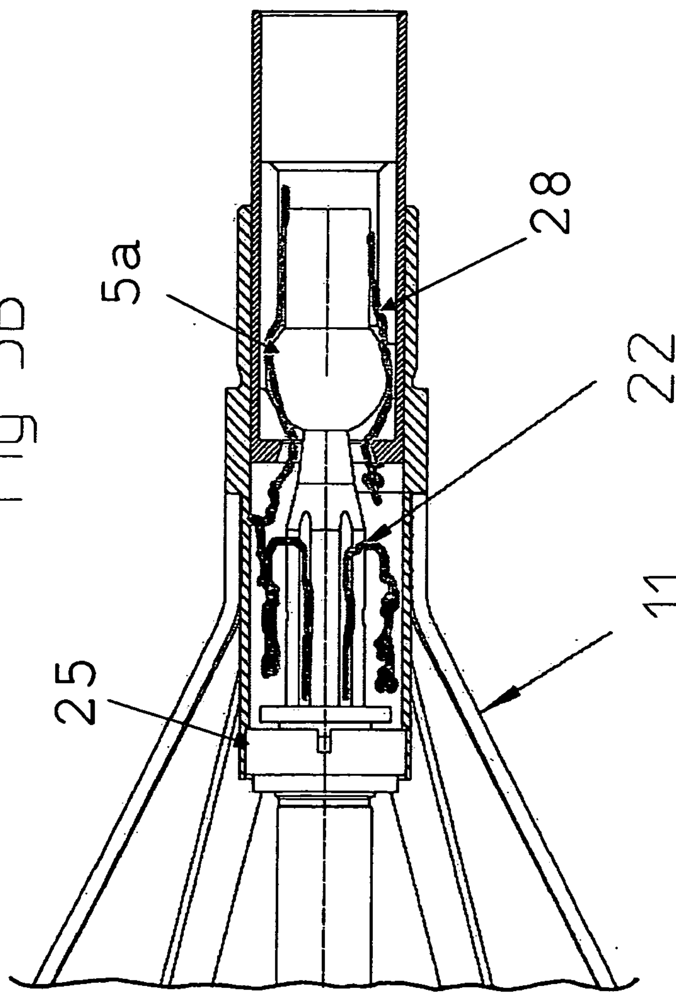


Fig 3B

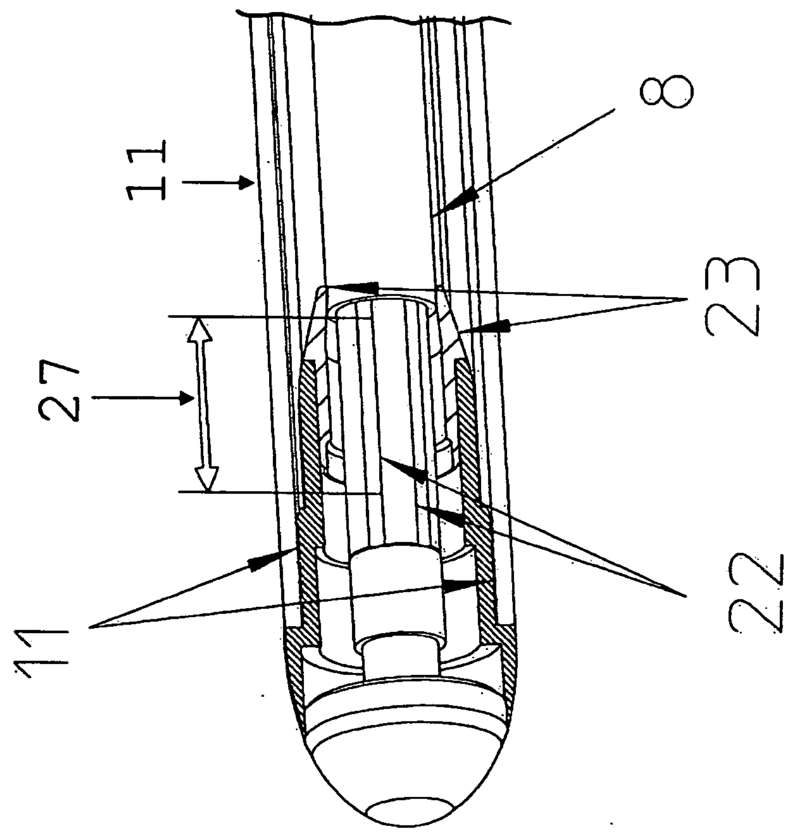


Fig 3C

9 / 21

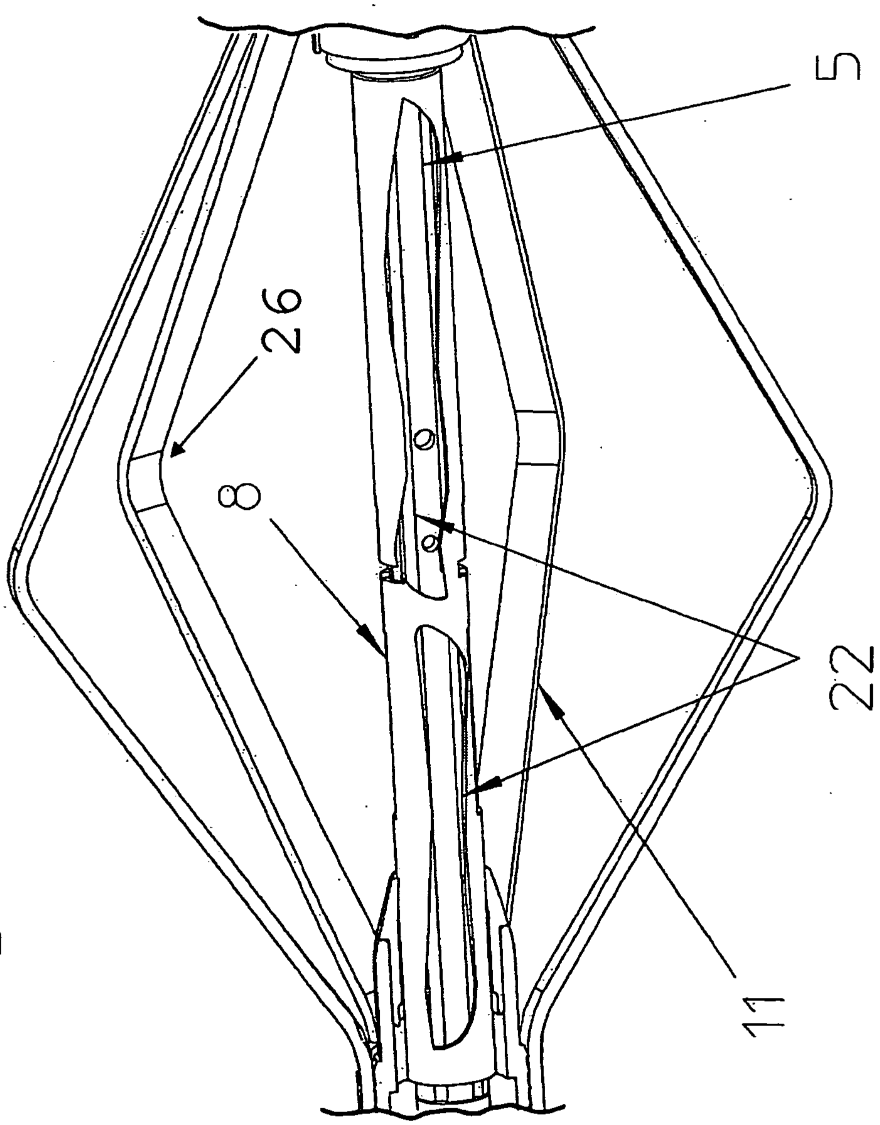


Fig 4

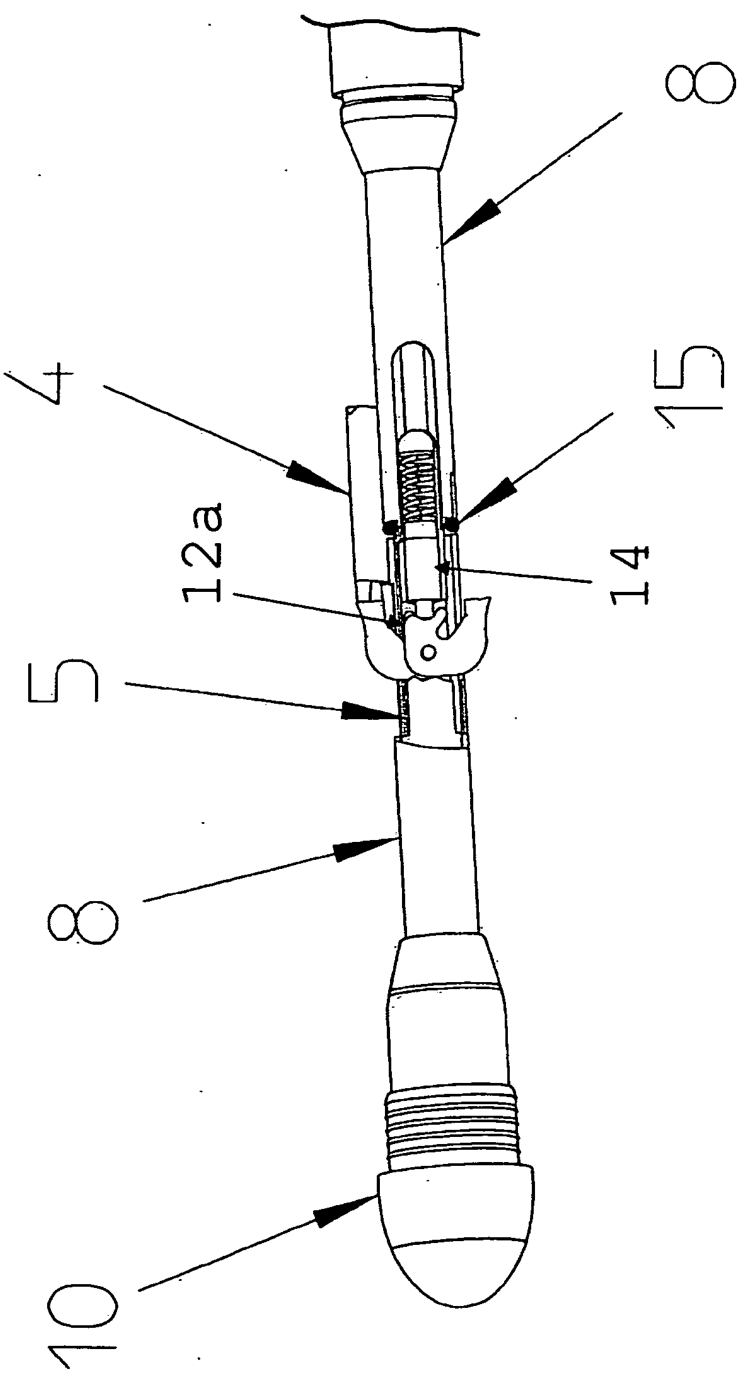


Fig 5A

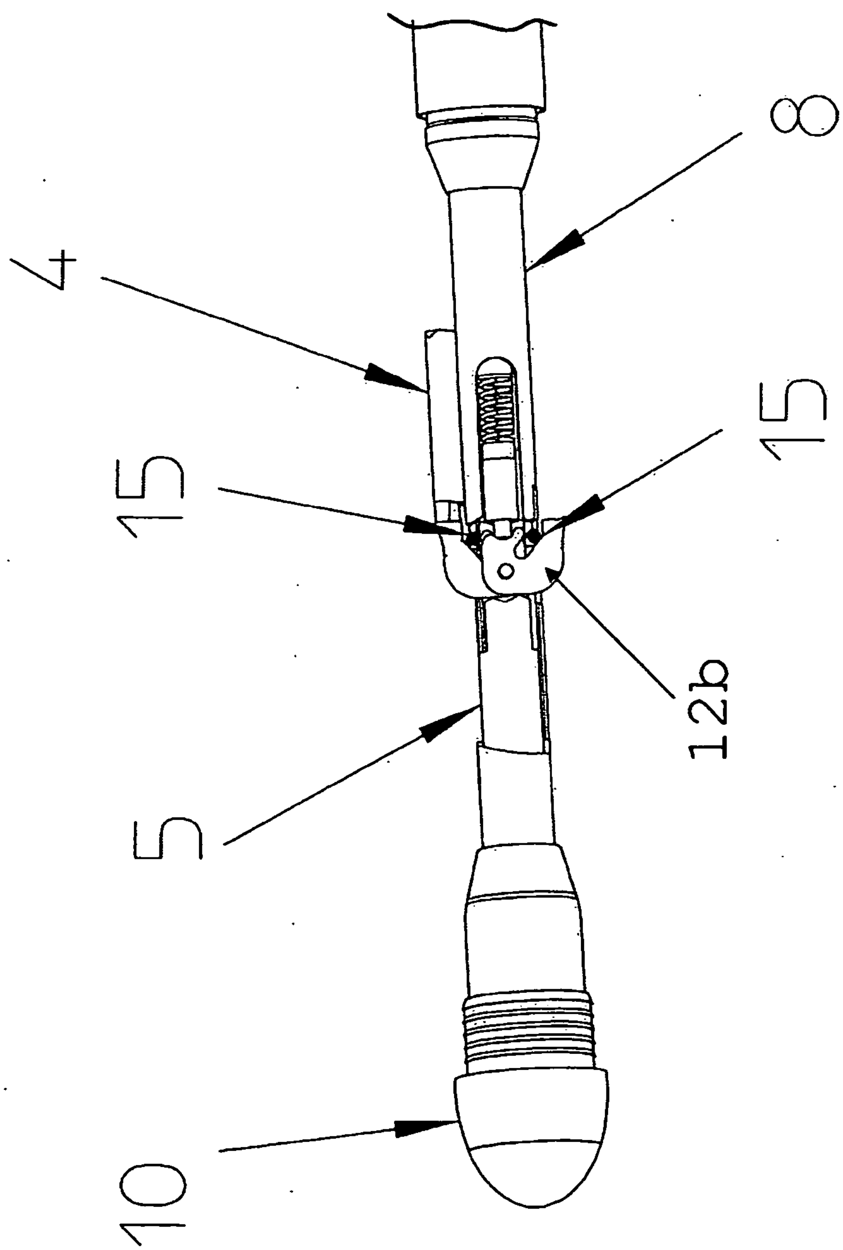


Fig 5B

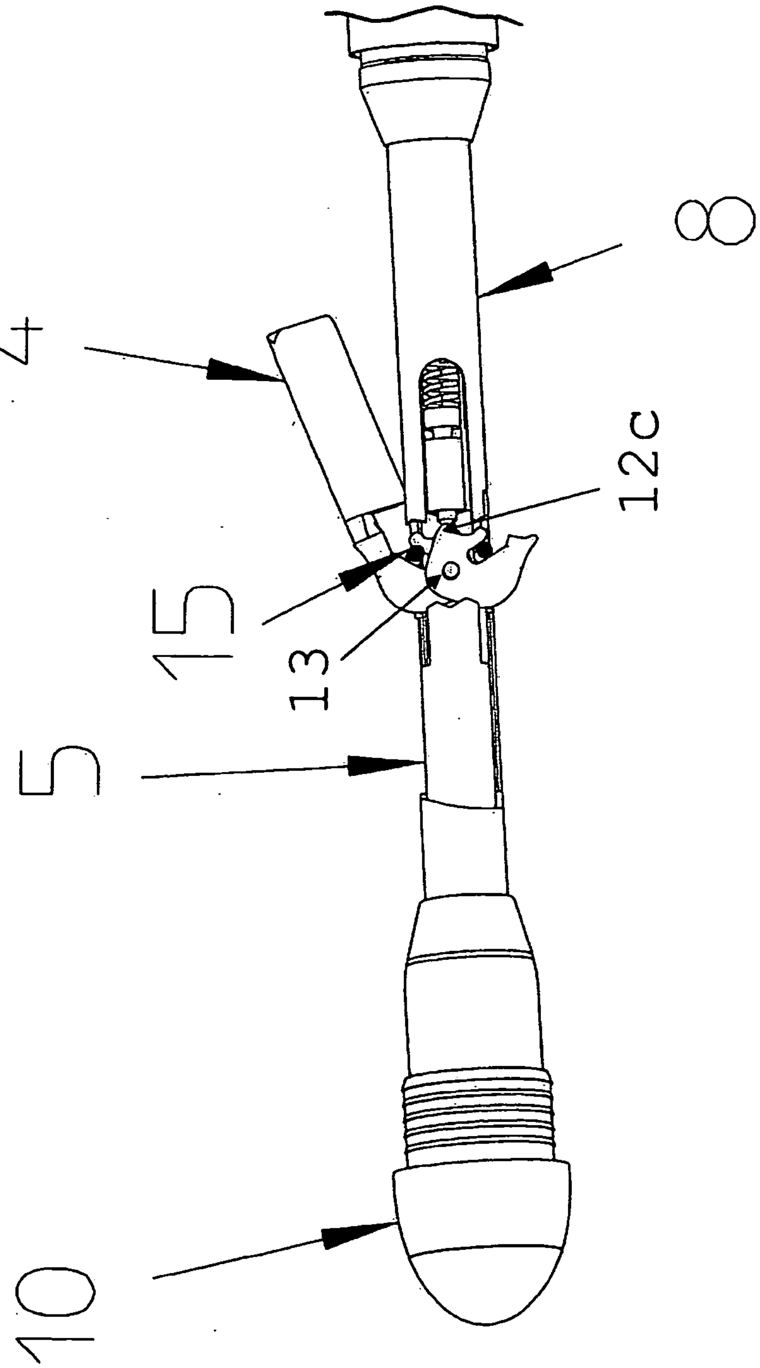


Fig 5C

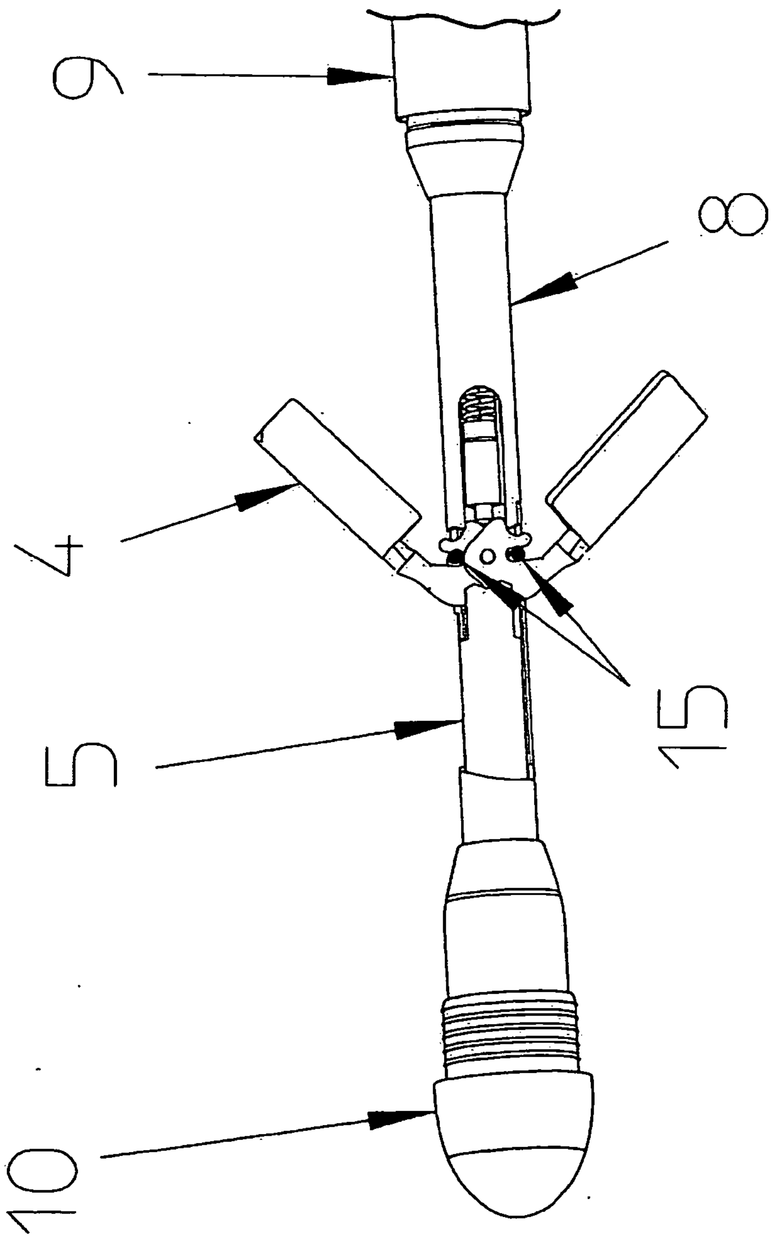


Fig 5D

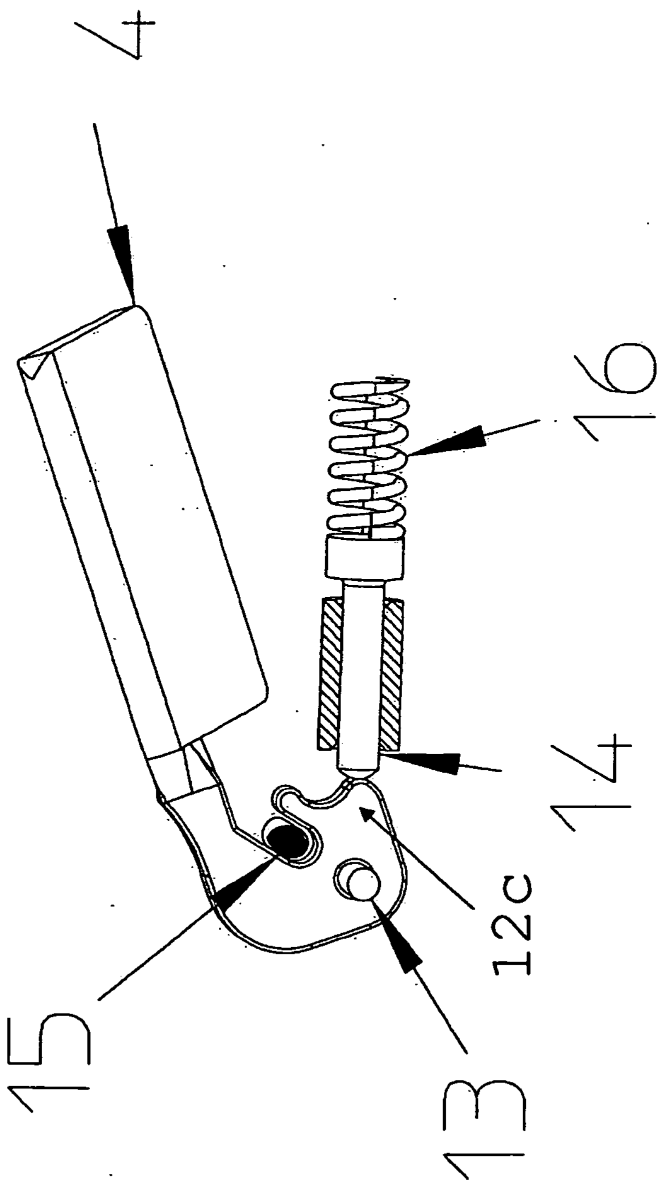


Fig 6A

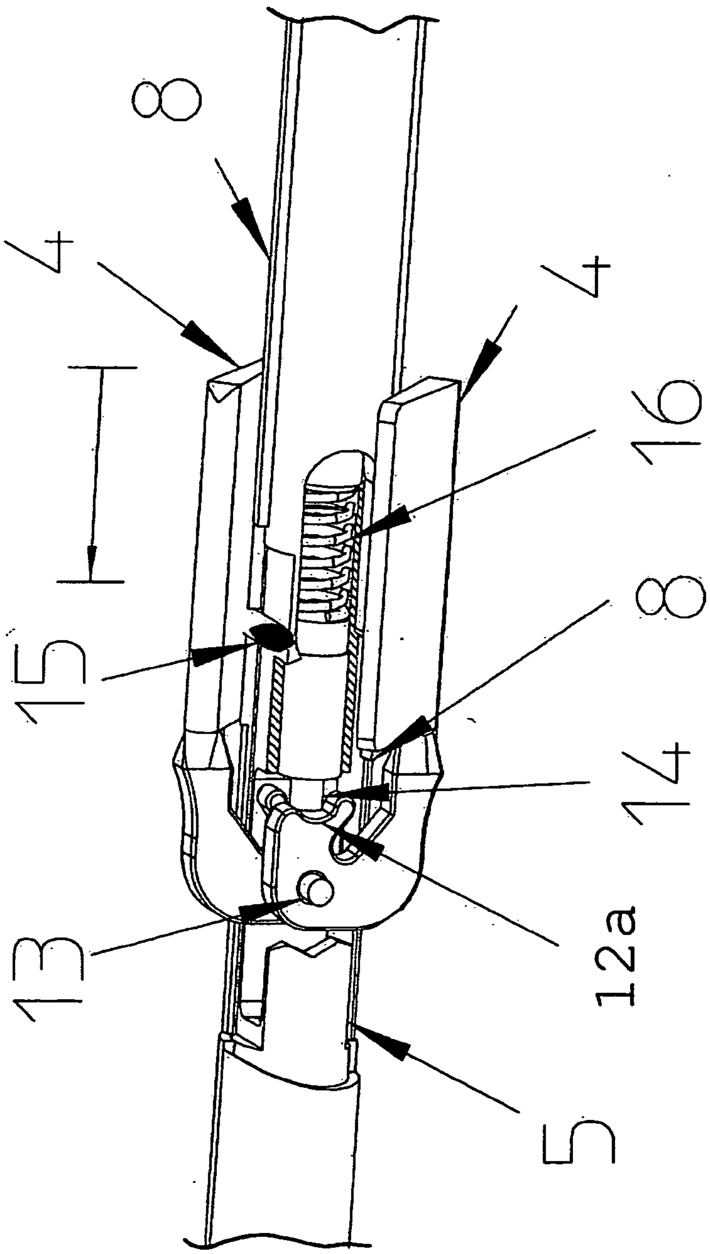


Fig 6B

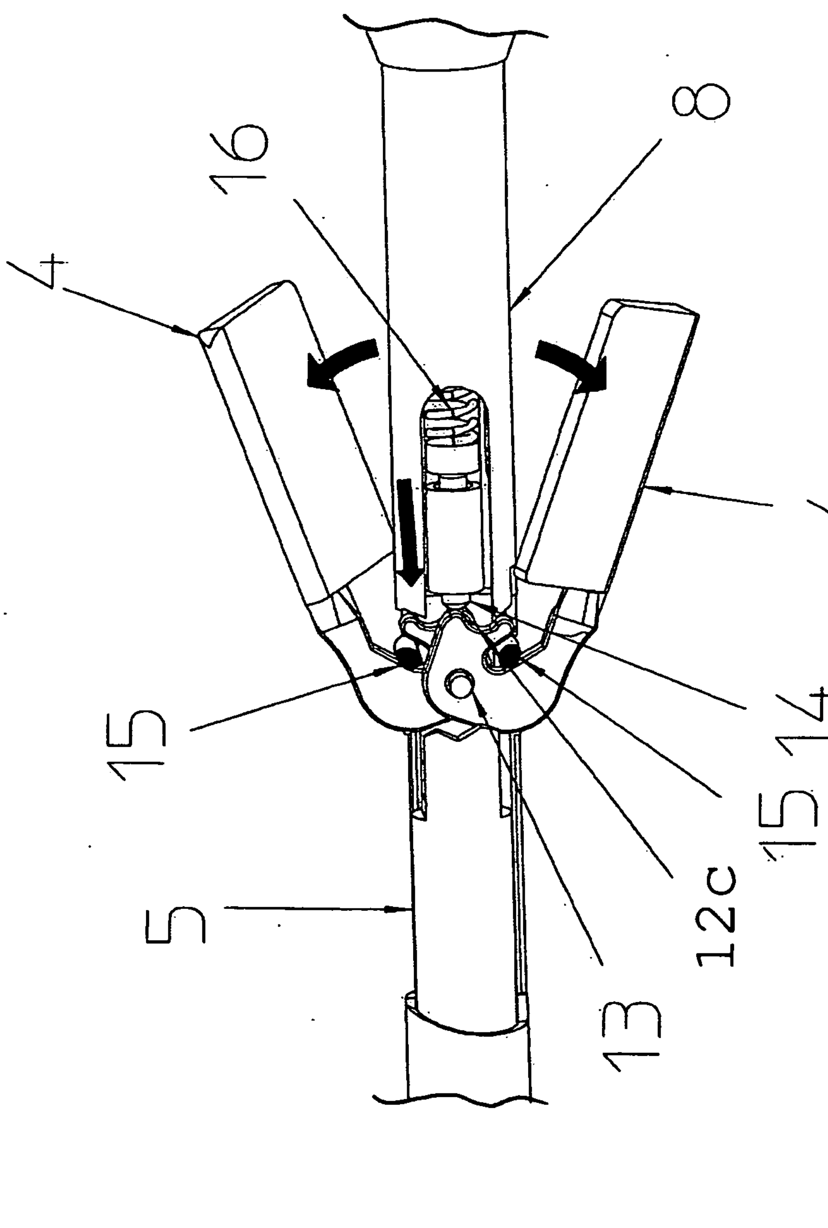


Fig 6C

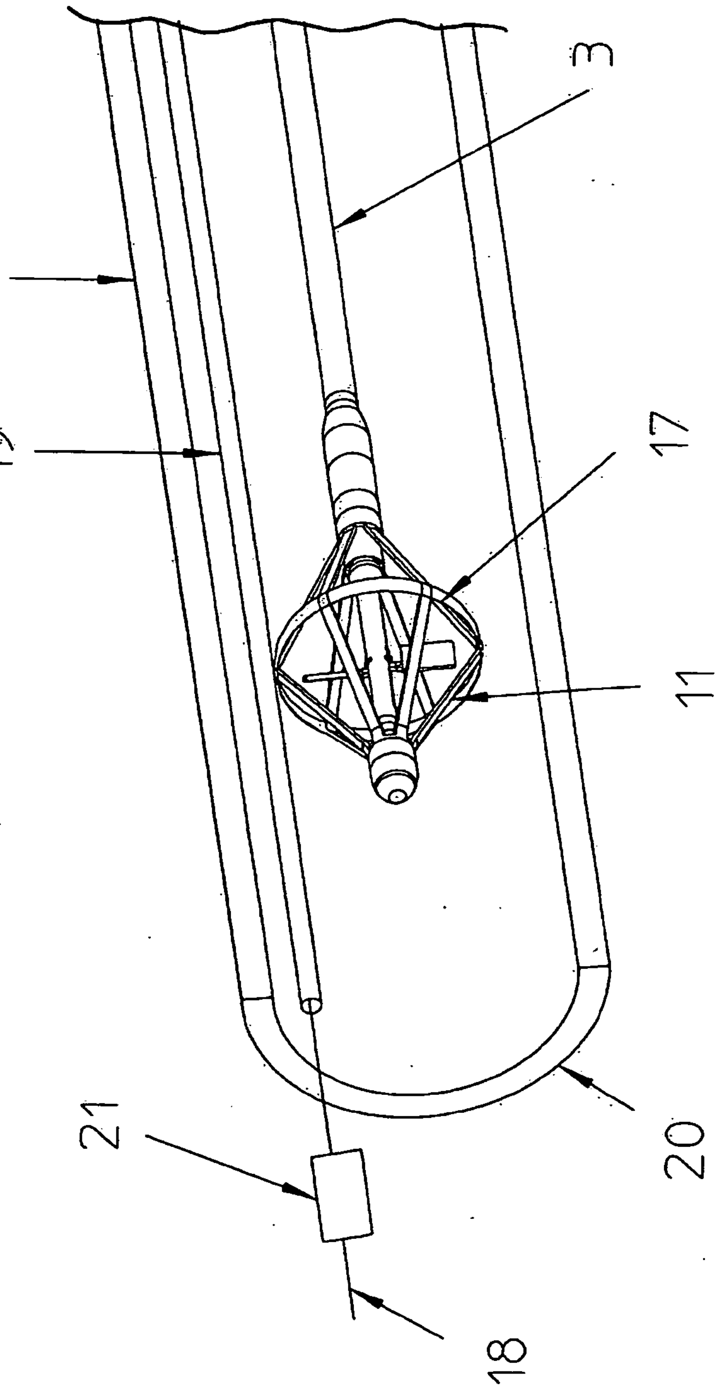


Fig 7

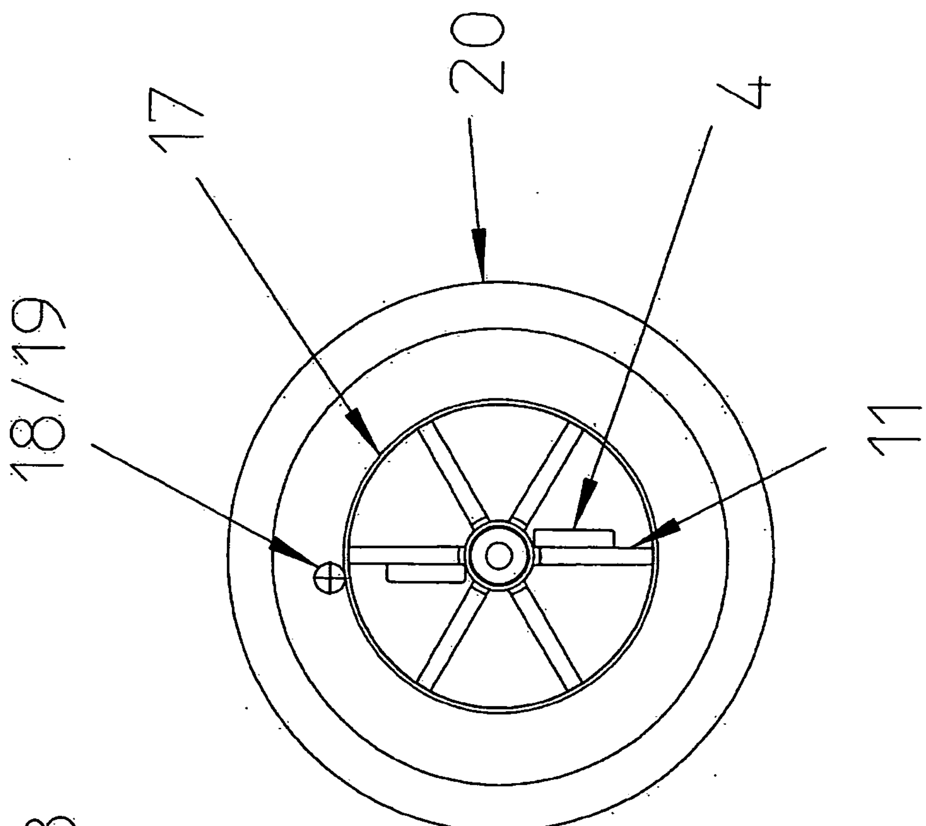


Fig 8

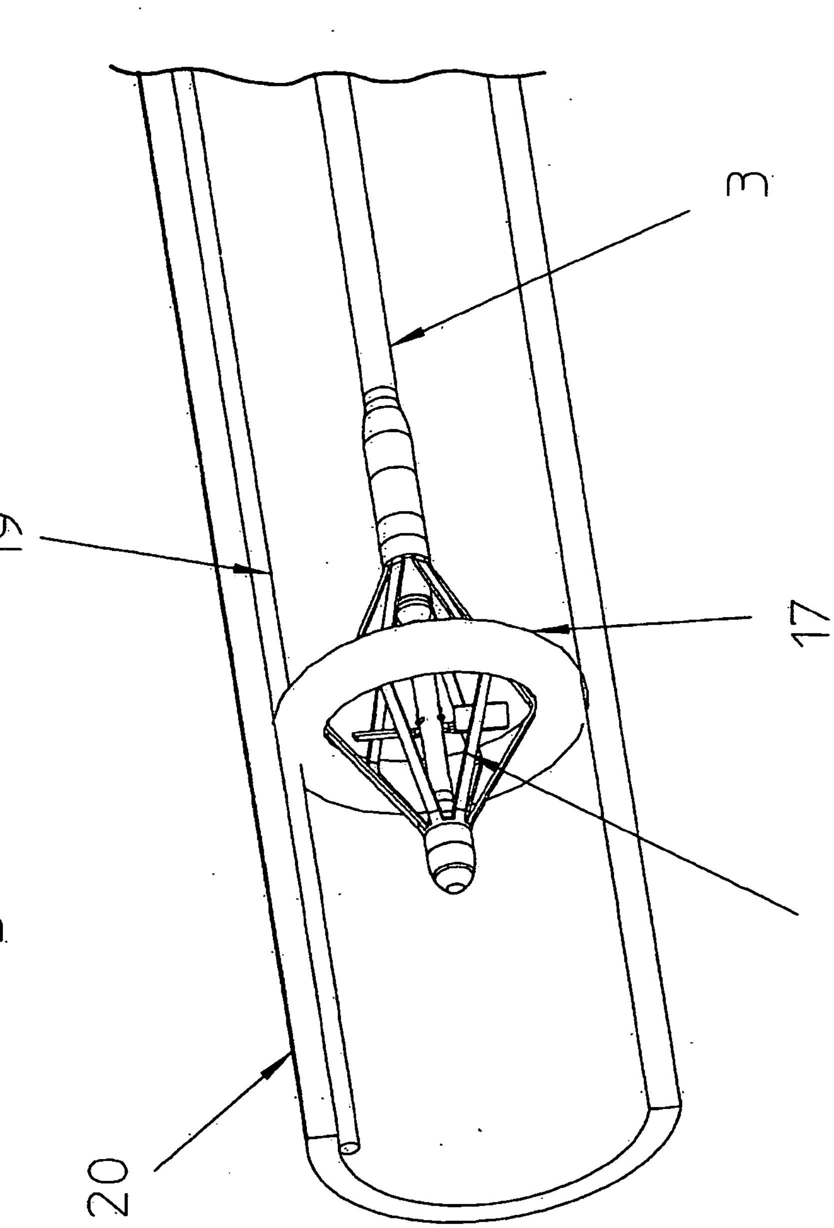


Fig 9

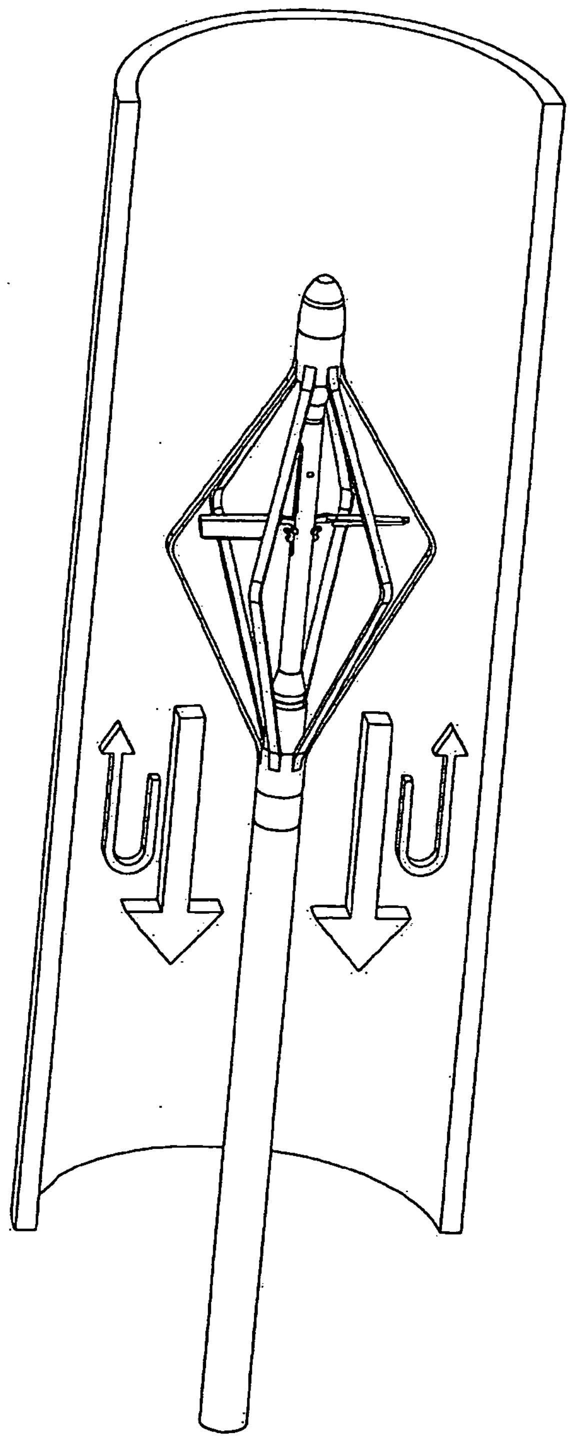


Fig. 10

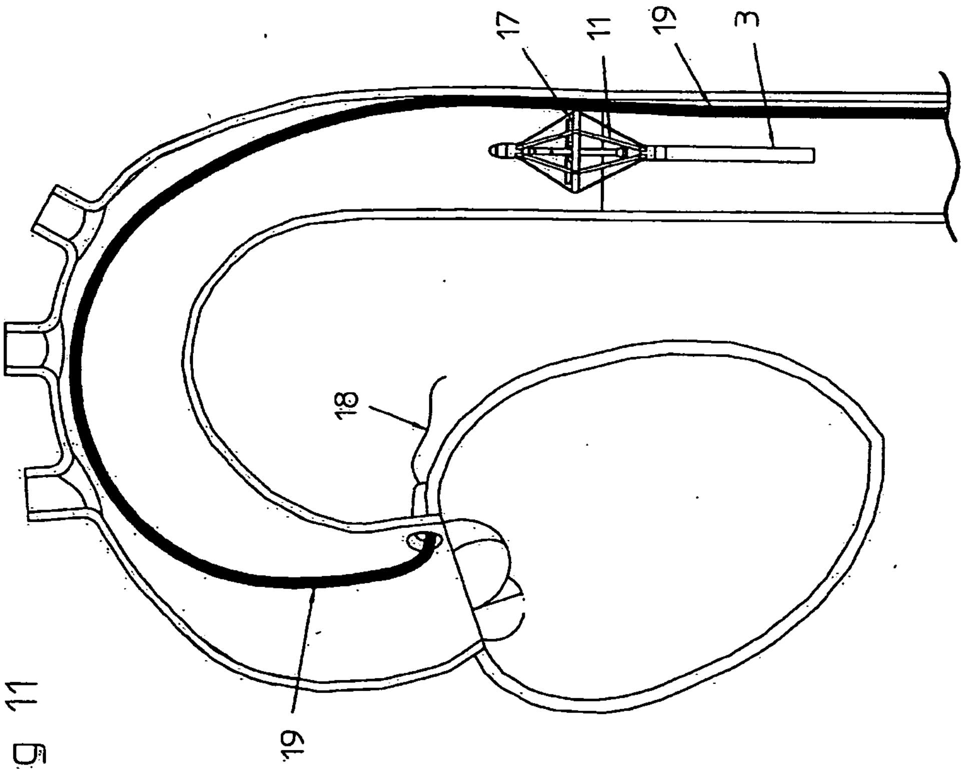


Fig 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2009/000318

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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)

IPC: A61M

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

SE,DK,FI,NO classes as above

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

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20080114339 A1 (M.W. MCBRIDE ET AL), 15 May 2008 (15.05.2008), whole document --	1-15
X	US 20080132748 A1 (J. SHIFFLETTE), 5 June 2008 (05.06.2008), whole document --	1-15
X	WO 03103745 A2 (ABOUL-HOSN, W.), 18 December 2003 (18.12.2003), whole document --	1-15
X	WO 8501436 A1 (NIMBUS, INC.), 11 April 1985 (11.04.1985), whole document --	1-6

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"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

"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
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 October 2009	21-10-2009

Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Daniel Dartis / MRo Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2009/000318

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5749855 A (O. REITAN), 12 May 1998 (12.05.1998), whole document --	1-15
A	US 20030135086 A1 (K. KHAW ET AL), 17 July 2003 (17.07.2003), whole document -- --------	1-15

International patent classification (IPC)

A61M 1/12 (2006.01)

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Use the application number as username. The password is **YACUTROLAV**.

Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85).

Cited literature, if any, will be enclosed in paper form.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SE2009/000318

US	20080114339	A1	15/05/2008	NONE			
US	20080132748	A1	05/06/2008	NONE			
WO	03103745	A2	18/12/2003	AU	2003236497	A	22/12/2003
WO	8501436	A1	11/04/1985	BR	8407085	A	13/08/1985
				CA	1222355	A	02/06/1987
				DE	3485662	D	21/05/1992
				EP	0157859	A,B	15/04/1992
				SE	0157859	T3	
				JP	4072551	B	18/11/1992
				JP	61500058	T	16/01/1986
				US	4704121	A	03/11/1987
US	5749855	A	12/05/1998	AT	214294	T	15/03/2002
				DE	69331713	D,T	28/11/2002
				DK	768900	T	08/07/2002
				EP	0768900	A,B	13/03/2002
				ES	2170071	T	01/08/2002
				JP	3278160	B	30/04/2002
				JP	8500512	T	23/01/1996
				SE	501215	C	12/12/1994
				SE	9202517	A,L	03/03/1994
				WO	9405347	A	17/03/1994
US	20030135086	A1	17/07/2003	NONE			

PATENT APPLICATION SERIAL NO.________________________

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

07/16/2012 TLUU11 00000006 13261361

01 FC:2631	190.00 OP
02 FC:2633	125.00 OP
03 FC:2642	245.00 OP
04 FC:2615	120.00 OP

PTO-1556
(5/87)

*U.S. Government Printing Office: 2002- 489-267/69033

13/261361

IAP01Rec'd PCT 13 JUL 2012

CERTIFICATE UNDER 37 CFR 1.10 OF MAILING BY "EXPRESS MAIL"

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Kathleen J. Moore

Signature of person mailing correspondence

Kathleen J. Moore

Typed name of person mailing correspondence

FILING UNDER 35 USC 371 IN THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)

International Appln. No. PCT/EP2010/000439 filed 27 January 2011

Earliest Claimed Priority: 27 January 2010 (27.01.2010)

Title: CONVEYING DEVICE FOR A FLUID

Inventor: Reiner LIEBING

Assignee: ECP Entwicklungsgesellshaft mbH

Attorneys: Marshall & Melhorn, LLC
Customer Number 00001678

Attorney Docket No: 1-21942

Enclosures

Transmittal Letter PTO-1390 Concerning Submission/Filing under 35 USC 371 (3 pgs) with copy of same (3 pgs)
Application Data Sheet 37 CFR 1.76 (SB14) (3 pgs)
Combined Declaration and Power of Attorney (2 pgs)
Preliminary Amendment (8 pgs)
IB/304 Notification Concerning Transmittal of Priority Document to WIPO (1 pg);
IB/308 (Second and Supplementary Notice) Concerning Transmittal of the International Application to the Designated Offices (1pg)
ISA/210 International Search Report with Written Opinion in English (15 pgs)
Copy of the Published International Application (44 pgs)
Information Disclosure Statement (3 pgs) with IDS Forms SB/08A (2 pg); cover page of the earliest claimed EP priority with detailed citation listing and European Search Report (5 pgs); the International Search Report with Written Opinion (15 pgs), and copies of the cited foreign documents
Check

PATENT COOPERATION TREATY PCT/EP2011/000439

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION, OBTENTION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

PFENNING, MEINIG & PARTNER GBR
Joachimstaler Strasse 12
10719 Berlin
ALLEMAGNE

Date of mailing *(day/month/year)* 11 March 2011 (11.03.2011)	
Applicant's or agent's file reference 107PCT 2211	**IMPORTANT NOTIFICATION**
International application No. PCT/EP2011/000439	International filing date *(day/month/year)* 27 January 2011 (27.01.2011)
International publication date *(day/month/year)* **Not yet published**	Priority date *(day/month/year)* 27 January 2010 (27.01.2010)
Applicant ECP ENTWICKLUNGSGESELLSCHAFT MBH et al	

The applicant is hereby notified of the date of receipt (or of obtaining by the International Bureau) of the priority document(s) relating to all earlier application(s) whose priority is claimed. Unless otherwise indicated by the letters "NR", in the right-hand column or by an asterisk appearing next to the date of receipt, **the priority document concerned was submitted or transmitted to or obtained by the International Bureau in compliance with Rule 17.1(a), (b) or (b-*bis*)**. This Form replaces any previously issued notification concerning submission, transmittal or obtaining of priority documents.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
27 January 2010 (27.01.2010)	10075043.9	EP	28 February 2011 (28.02.2011)
27 January 2010 (27.01.2010)	61/298,581	US	21 February 2011 (21.02.2011)

The letters "NR" denote a priority document which, on the date of mailing of this Form, had not yet been received or obtained by the International Bureau in compliance with Rule 17.1(a), (b) or (b-*bis*). Where the applicant has failed to either submit, request to prepare and transmit or obtain and transmit, or to request the International Bureau to obtain the priority document within the applicable time limit under that Rule, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

An asterisk "*" next to a date of receipt, denotes a priority document submitted or transmitted to or obtained by the International Bureau but not in compliance with Rule 17.1(a), (b) or (b-*bis*) (the priority document was received after the time limit prescribed in Rule 17.1(a); the request to prepare and transmit the priority document was submitted to the receiving Office after the applicable time limit under Rule 17.1(b) or the request to the receiving Office or the International Bureau to obtain the priority document was made after the applicable time limit under Rule 17.1(b-*bis*)). Even though the priority document was not furnished in compliance with Rule 17.1(a), (b) or (b-*bis*), the International Bureau will nevertheless transmit a copy of the document to the designated Offices, for their consideration. In case such a copy is not accepted by the designated Office as the priority document, Rule 17.1(c) provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Yolaine Cussac
Facsimile No. +41 22 338 89 75	e-mail pt05.pct@wipo.int Telephone No. +41 22 338 74 05

PATENT COOPERATION TREATY

WO 2011/092034
PCT/EP2011/000439

From the INTERNATIONAL BUREAU

PCT

SECOND AND SUPPLEMENTARY NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION (TO DESIGNATED OFFICES WHICH APPLY THE 30 MONTH TIME LIMIT UNDER ARTICLE 22(1))

(PCT Rule 47.1(c))

To:

PFENNING, MEINIG & PARTNER GBR
Joachimstaler Strasse 12
10719 Berlin
ALLEMAGNE

Date of mailing *(day/month/year)* 31 May 2012 (31.05.2012)		
Applicant's or agent's file reference 107PCT 2211	**IMPORTANT NOTICE**	
International application No. PCT/EP2011/000439	International filing date *(day/month/year)* 27 January 2011 (27.01.2011)	Priority date *(day/month/year)* 27 January 2010 (27.01.2010)
Applicant ECP ENTWICKLUNGSGESELLSCHAFT MBH et al		

1. **ATTENTION**: For any designated Office(s), for which the time limit under Article 22(1), as in force from 1 April 2002 (30 months from the priority date), **does not apply**, please see Form PCT/IB/308(First Notice) issued previously.

2. Notice is hereby given that the following designated Office(s), for which the time limit under Article 22(1), as in force from 1 April 2002, **does apply**, has/have requested that the communication of the international application, as provided for in Article 20, be effected under Rule 93*bis*.1. The International Bureau has effected that communication on the date indicated below:
04 August 2011 (04.08.2011)

   AU, AZ, BY, CN, CO, DZ, EP, HU, KG, KP, KR, MD, MK, MY, MZ, NA, NG, PG, RU, SY, TM, US

   In accordance with Rule 47.1(c-*bis*)(i), those Offices will accept the present notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

3. The following designated Offices, for which the time limit under Article 22(1), as in force from 1 April 2002, **does apply**, have not requested, as at the time of mailing of the present notice, that the communication of the international application be effected under Rule 93*bis*.1 :

   AE, AG, AL, AM, AO, AP, AT, BA, BB, BG, BH, BR, BW, BZ, CA, CH, CL, CR, CU, CZ, DE, DK, DM, DO, EA, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, ID, IL, IN, IS, JP, KE, KM, KN, KZ, LA, LC, LK, LR, LS, LT, LY, MA, ME, MG, MN, MW, MX, NI, NO, NZ, OA, OM, PE, PH, PL, PT, RO, RS, SC, SD, SE, SG, SK, SL, SM, ST, SV, TH, TJ, TN, TR, TT, UA, UZ, VC, VN, ZA, ZM, ZW

   In accordance with Rule 47.1(c-*bis*)(ii), those Offices accept the present notice as conclusive evidence that the Contracting State for which that Office acts as a designated Office does not require the furnishing, under Article 22, by the applicant of a copy of the international application.

4. **TIME LIMITS for entry into the national phase**

   For the designated or elected Office(s) listed above, the applicable time limit for entering the national phase will, **subject to what is said in the following paragraph, be 30 MONTHS** from the priority date.

   In practice, **time limits other than the 30-month time limit** will continue to apply, for various periods of time, in respect of certain of the designated or elected Office(s) listed above. For **regular updates on the applicable time limits** (30 or 31 months, or other time limit), Office by Office, refer to the *PCT Gazette*, the *PCT Newsletter* and the *PCT Applicant's Guide*, Volume II, National Chapters, all available from WIPO's Internet site, at http://www.wipo.int/pct/en/index.html.

   It is the applicant's **sole responsibility** to monitor all these time limits.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Yolaine Cussac e-mail: pt05.pct@wipo.int

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

To:
Pfenning, Meinig & Partner GbR
Joachimstaler Strasse 12
10719 Berlin
ALLEMAGNE

EINGEGANGEN
- 8. Juni 2011
Frist

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

	Date of mailing *(day/month/year)* 8 June 2011 (08-06-2011)
Applicant's or agent's file reference 107PCT 2211	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/EP2011/000439	International filing date *(day/month/year)* 27 January 2011 (27-01-2011)
Applicant ECP ENTWICKLUNGSGESELLSCHAFT MBH	

1. [X] The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the International Search Report.

   Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Fascimile No.: (41-22) 338.82.70

   For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 - 9.011.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. [ ] **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

   [ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

   [ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. Following the expiration of 30 months from the priority date, these comments will also be made available to the public.

   Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

   Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

   In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months.

   For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide*, National Chapters.

Name and mailing address of the International Searching Authority	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040 Fax: (+31-70) 340-3016	RASMUSSEN, Sine Tel: +31 (0)70 340-4595

Form PCT/ISA/220 (July 2010)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 107PCT 2211	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/EP2011/000439	International filing date *(day/month/year)* 27/01/2011	(Earliest) Priority Date *(day/month/year)* 27/01/2010
Applicant ECP ENTWICKLUNGSGESELLSCHAFT MBH		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 6 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      [X] the international application in the language in which it was filed
      [ ] a translation of the international application into ______________, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. [ ] This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. [ ] **Certain claims were found unsearchable** (See Box No. II)
3. [ ] **Unity of invention is lacking** (see Box No III)
4. With regard to the **title**,
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established by this Authority to read as follows:
5. With regard to the **abstract**,
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority
6. With regard to the **drawings**,
   a. the figure of the **drawings** to be published with the abstract is Figure No. 3
      [X] as suggested by the applicant
      [ ] as selected by this Authority, because the applicant failed to suggest a figure
      [ ] as selected by this Authority, because this figure better characterizes the invention
   b. [ ] none of the figures is to be published with the abstract

INTERNATIONAL SEARCH REPORT

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/000439

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61M1/10 F04D33/00
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)
A61M F04D B63H

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 practical, 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 √√	WO 98/18508 A1 (DOBAK JOHN D III [US]; GHAERZADEH KAMBIZ [US]) 7 May 1998 (1998-05-07) page 9, line 2 - page 11, line 23 figures 1-2	1,8-10, 12-19,22
X √	WO 2009/157840 A1 (CARDIOBRIDGE GMBH [GE]; REITAN OEYVIND [SE]; EPPLE KLAUS [DE] CARDIOBR) 30 December 2009 (2009-12-30) page 5, line 7 - page 7, line 31 figures 1, 1b, 1c	1,2,8,9, 11,18,22
X,P √	EP 2 194 278 A1 (ECP ENTWICKLUNGSGMBH [DE]) 9 June 2010 (2010-06-09) paragraphs [0033] - [0066] figures 1-4, 10, 11	1,2, 8-10,12, 13, 18-20,22

-/--

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"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

"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
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search: 30 May 2011

Date of mailing of the international search report: 08/06/2011

Name and mailing address of the ISA/
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer
Schlaug, Martin

1

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/000439

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 1 218 663 A (KUETTNER HUGO) 12 May 1960 (1960-05-12) page 1, right-hand column, line 7 - page 2, left-hand column, line 4 figure 1	1,3,7
A	DE 103 37 804 A1 (WILO AG [DE]) 24 March 2005 (2005-03-24) paragraphs [0023] - [0036] figures 1-3	1,3,7
A	WO 2006/038808 A1 (CLAVIS BIOPROPULSION AS [NO]; SAGOV MAGOMET S [NO]) 13 April 2006 (2006-04-13) page 7, lines 3-10 page 10, line 5 - page 12, line 10 figures 6-13	1,3,7
A	WO 2005/003545 A1 (ROBINSON NICHOLAS PAUL [GB]) 13 January 2005 (2005-01-13) page 19, line 23 - page 20, line 14 figure 8	1,3,7

1

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/000439

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 9818508	A1	07-05-1998	AU 5000597	A	22-05-1998
			EP 1017430	A1	12-07-2000
WO 2009157840	A1	30-12-2009	CN 102065924	A	18-05-2011
			DE 202009018145	U1	05-05-2011
			EP 2288392	A1	02-03-2011
			EP 2308422	A1	13-04-2011
			US 2011034874	A1	10-02-2011
EP 2194278	A1	09-06-2010	WO 2010063494	A1	10-06-2010
FR 1218663	A	12-05-1960	NONE		
DE 10337804	A1	24-03-2005	NONE		
WO 2006038808	A1	13-04-2006	AT 507141	T	15-05-2011
			CA 2624600	A1	13-04-2006
			CN 101072708	A	14-11-2007
			EP 1814780	A1	08-08-2007
			JP 2008515712	T	15-05-2008
			US 2009023349	A1	22-01-2009
WO 2005003545	A1	13-01-2005	AU 2003304285	A1	21-01-2005

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1, 2(completely); 6, 8-22(partially)

   A conveying device for conveying a fluid with a drive body, that can be driven in an oscillating manner transversely to the conveying direction
   with further features relating to the drive body being compressible together with a housing surrounding it;

1.1. claims: 3-5(completely); 6, 8-22(partially)

   A conveying device for conveying a fluid with a drive body, that can be driven in an oscillating manner transversely to the conveying direction
   with further features relating to blocks which are laterally fastened to at least one drive body and which form a barrier between different conveying surfaces of a drive body;

1.2. claims: 7(completely); 8-22(partially)

   A conveying device for conveying a fluid with a drive body, that can be driven in an oscillating manner transversely to the conveying direction
   with further features relating the drive bodies being pivotable in an oscillating manner about an axis extending in the conveying direction.

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
see form PCT/ISA/220

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)* see form PCT/ISA/210 (second sheet)	
Applicant's or agent's file reference: see form PCT/ISA/220	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP2011/000439	27.01.2011	27.01.2010

International Patent Classification (IPC) or both national classification and IPC
INV. A61M1/10 F04D33/00

Applicant
ECP ENTWICKLUNGSGESELLSCHAFT MBH

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☒ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☒ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notifed the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA:	Date of completion of this opinion	Authorized Officer
European Patent Office P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Fax: +31 70 340 - 3016	see form PCT/ISA/210	Schlaug, Martin Telephone No. +31 70 340-2504

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/EP2011/000439

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing filed or furnished:

   a. (means)

   ☐ on paper

   ☐ in electronic form

   b. (time)

   ☐ in the international application as filed

   ☐ together with the international application in electronic form

   ☐ subsequently to this Authority for the purposes of search

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/EP2011/000439

Box No. IV Lack of unity of invention

1. ☐ In response to the invitation (Form PCT/ISA/206) to pay additional fees, the applicant has, within the applicable time limit:

   ☐ paid additional fees

   ☐ paid additional fees under protest and, where applicable, the protest fee

   ☐ paid additional fees under protest but the applicable protest fee was not paid

   ☐ not paid additional fees

2. ☒ This Authority found that the requirement of unity of invention is not complied with and chose not to invite the applicant to pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rule 13.1, 13.2 and 13.3 is

   ☐ complied with

   ☒ not complied with for the following reasons:

   see separate sheet

4. Consequently, this report has been established in respect of the following parts of the international application:

   ☒ all parts.

   ☐ the parts relating to claims Nos. 1-22

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	3-7, 13, 15, 20, 21
	No:	Claims	1, 2, 8-12, 14, 16-19, 22
Inventive step (IS)	Yes:	Claims	3-7, 20, 21
	No:	Claims	1, 2, 8-19, 22
Industrial applicability (IA)	Yes:	Claims	1-22
	No:	Claims	

2. Citations and explanations

   see separate sheet

Box No. VI Certain documents cited

1. Certain published documents (Rules 43*bis*.1 and 70.10)

   and / or

2. Non-written disclosures (Rules 43*bis*.1 and 70.9)

   see form 210

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Re Item IV.

1 The application does not meet the requirements of unity of invention as defined in Rules 13.1 and 13.2 PCT.

1.1 The document WO 2006/038808 discloses a conveying device having at least one drive body, which can be driven by means of a drive system and which has a conveying surface and wherein the drive body can be driven in an oscillating manner transversely to the conveying direction and therefore all common features of independent claims 1, 3 and 7.

1.2 Therefore the Authority considers the following groups of claims:

<u>I. group: claims 1, 2 and 6, 8-22 partial:</u>

A conveying device for conveying a fluid with a drive body with further features as potential special technical features within the meaning of Rule 13.2 PCT relating to the drive body being compressible together with a housing surrounding it and solving the following technical problem:

"provide a pump that can be introduced through a blood vessel (see page 2, lines 19-20 of the application)";

<u>II. group: claims 3-5 and 6, 8-22 partial:</u>

A conveying device for conveying a fluid with a drive body with further features as potential special technical features within the meaning of Rule 13.2 PCT relating to blocks which are laterally fastened to at least one drive body and which form a barrier between different conveying surfaces of a drive body and solving the following technical problem:

"reduce pressure equalization between the high pressure and low pressure side of each drive body (see page 20, line 33 - page 21, line 2 of the application)"

<u>III. group: claims 7 and 8-22 partial:</u>

A conveying device for conveying a fluid with a drive body with further features as potential special technical features within the meaning of Rule 13.2 PCT relating to the drive bodies being pivotable in an oscillating manner about an axis extending in the conveying direction and solving the following technical problem:

"provide an alternative drive principle (see page 18, line 31 of the application)"

1.3 The three groups of claims defined above forming the 3 potential inventions are not so linked as to form a single general inventive concept, as required by Rule 13.1 PCT, because all common technical features, that could be considered to be unifying, are fully disclosed in combination together with their technical effects in the document WO2006/038808. The inventions do consequently not have a common special technical feature either. Although all groups of claims are related to a conveying device, they solve different and unrelated problems and are thus lacking a single general inventive concept.

Consequently, neither the objective problem underlying the subjects of the claimed inventions, nor their solutions defined by the special technical features allow for a relationship to be established between the said potential inventions, which involves a single general inventive concept.

1.4 In conclusion, the groups of claims are not linked by common or corresponding special technical features and define three different potential inventions not linked by a single general inventive concept. The application hence does not meet the requirements of unity of invention as defined in Rules 13.1 and 13.2 PCT.

1.5 The invention I together with both sub-inventions I-1 and I-2 have been searched (sub-inventions I-1 and I-2 were already searched in the frame of EP-application EP10075043, see also search report).

Re Item V.

2 Reference is made to the following documents:

D1 WO 98/18508 A1 (DOBAK JOHN D III [US]; GHAERZADEH KAMBIZ [US]) 7 May 1998 (1998-05-07)

D2 WO 2009/157840 A1 (CARDIOBRIDGE GMBH [GE]; REITAN OEYVIND [SE]; EPPLE KLAUS [DE] CARDIOBR) 30 December 2009 (2009-12-30)

3 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of independent claim 1 is not new in the sense of Article 33(2) PCT.

3.1 The document D1 discloses (see page 9, line 2 - page 11, line 23; figures 1-2, the references in parentheses applying to this document):

A conveying device (10) for the conveying of a fluid in a conveying direction having at least one drive body (14) which can be driven by means of a drive system and which has a conveying surface (inner or outer side of membrane, see also page 9, lines 6-10), wherein the drive body (14) can be driven in an oscillating manner transversely to the conveying direction (see page 11, lines 10-23) and is flowed around on a plurality of sides by the fluid to be conveyed (e.g. all inner sides of the membrane enclosing the fluid to be conveyed), and wherein the drive body can be compressed together with a housing surrounding it (see page 9, lines 17-31).

The subject matter of claim 1 is therefore not new (Article 33(2) PCT).

3.2 The technical features of claim 1 are also fully disclosed in combination in document D2 (see page 5, line 7 - page 7, line 31; figures 1, 1b, 1c) and this claim therefore lacks novelty also in view of this document (Article 33(2) PCT).

3.3 Comment: Claim 1 does not establish a causal relationship between the oscillatory movement of the drive body and the actual conveying action / direction. It only reads, that "the drive body can be driven in an oscillating manner ...". This is possible with numerous pumping devices.

4 The dependent claims 1, 2, 8-19, 22 do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step, the reasons being as follows:

4.1 ad claim 2: see D2, page 6, line 10-13 (Article 33(2) PCT);

4.2 ad claims 8, 9: see D1, page 11, lines 10-23 and figure 1 (Article 33(2) PCT);

4.3 ad claim 10: see D1, fig1 (Article 33(2) PCT);

4.4 ad claim 11: see D2, figure 1c (implicitly disclosed) (Article 33(2) PCT);

4.5 ad claim 12: see D1, figure 1 (Article 33(2) PCT);

4.6 ad claim 13: the application does not disclose a technical problem solved by the microgrooves, claim 13 is therefore not considered inventive (Article 33 (3) PCT);

4.7 ad claim 14: see D1, figure 1 (Article 33(2) PCT);

4.8 ad claim 15: the use of foam or polyurethane is a standard design choice for e.g. blood pumps (Article 33(3) PCT);

4.9 ad claims 16, 17: see D1, page 9, lines 6-10 (Article 33(2) PCT);

4.10 ad claim 18: see D2, page 5, lines 14-17 (Article 33(2) PCT);

4.11 ad claim 19: see D1, page 11, lines 10-23 (Article 33(2) PCT);

4.12 ad claim 22: see D1, page 9, line 11 (Article 33(2) PCT);

5 The devices described in claims 1-22 are industrially applicable. Therefore the requirements of Article 33(4) PCT are met.

Re Item VI.

6 Certain documents cited:

Publication No	Publication date *(day/month/year)*	Filing date *(day/month/year)*	Priority date *(valid claim)* *(day/month/year)*
EP2194278	09/06/2010	05/12/2008	05/12/2008

Re Item VII.

7 The independent claims 1 and 7 are not in the two-part form in accordance with Rule 6.3(b) PCT, which in the present case would be appropriate, with those features known in combination from the prior art being placed in the preamble (Rule 6.3(b)(i) PCT) and with the remaining features being included in the characterising part (Rule 6.3(b)(ii) PCT).

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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 August 2011 (04.08.2011)

PCT

(10) International Publication Number
WO 2011/092034 A1

(51) International Patent Classification:
A61M 1/10 (2006.01) *F04D 33/00* (2006.01)

(21) International Application Number:
PCT/EP2011/000439

(22) International Filing Date:
27 January 2011 (27.01.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/298,581 27 January 2010 (27.01.2010) US
10075043.9 27 January 2010 (27.01.2010) EP

(71) Applicant *(for all designated States except US)*: **ECP ENTWICKLUNGSGESELLSCHAFT MBH** [DE/DE]; Wiesenweg 10, 12247 Berlin (DE).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **LIEBING, Reiner** [DE/DE]; Schmiedegasse 43, 14469 Potsdam (DE).

(74) Agent: **PFENNING, MEINIG & PARTNER GBR**; Joachimstaler Strasse 12, 10719 Berlin (DE).

(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, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, 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, ML, MR, NE, SN, TD, TG).

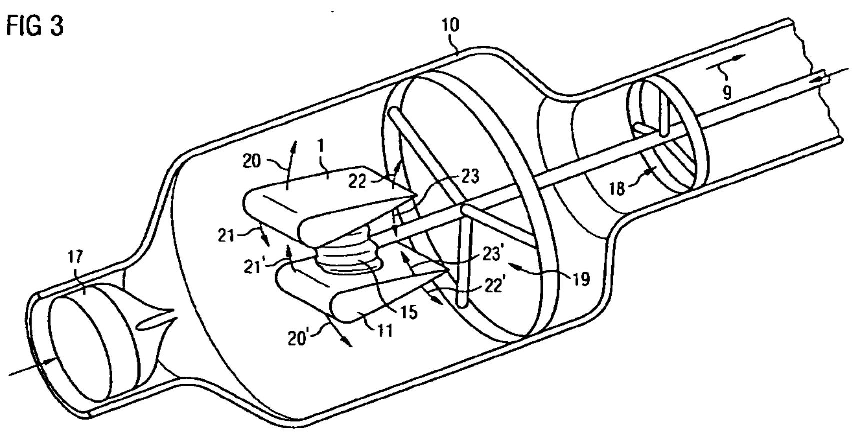
Published:

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

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: CONVEYING DEVICE FOR A FLUID

FIG 3



(57) Abstract: The invention relates to a conveying device for conveying a fluid in a conveying direction (9) having one or more drive bodies (1, 1', 1'', 1''', 11, 11', 11'', 11''') which can be driven in an oscillating manner by means of a drive system (15, 15') transversely to the conveying direction. An acceleration of the fluid is achieved by a corresponding movement in translation or by a partially pivoting movement of the drive bodies in the manner of the fin principle known from biology (e.g. aerodynamics and hydrodynamics).

WO 2011/092034 A1

IAP01Rec'd PCT 13 JUL 2012 13/261361

Conveying device for a fluid

The invention is in the field of mechanical engineering and relates to conveying devices for fluids, in particular for liquids.

Such conveying devices have become known in the form of different kinds of pumps in the most varied of embodiments. Pumps are of particular interest at this point which can be manufactured in such constructions that they can be used for more sensitive fluids, in particular fluids having macromolecules. A specific group among such pumps is represented by the fluid pumps which can be used for medical application purposes and which can be manufactured in small constructions. Such pumps can also be used in micro constructions, for example, for conveying the body's own fluids, or biocompatible fluids, for example as heart pumps for conveying blood.

In the conveying of such sensitive fluids such as blood which have large and sensitive molecules, for example, which satisfy biological functions and which therefore also may not be damaged at the microscopic level, care must be taken that the mechanical effect on the fluid by pressure maxima, shear forces and accelerations is limited as much as possible.

Axial flow pumps have in particular become known in this connection, for example, for the conveying of blood which have a rotor which rotates about a longitudinal axis, which has impeller blades and which continuously conveys blood in the axial direction.

Since a specific problem for the use of such pumps in the inside of the body comprises the fact of providing them, on the one hand, with sufficient conveying capacity, and, on the other hand, however, of configuring the construction size so that they can be introduced through a blood vessel, some of the challenges for such pumps comprise the fact of configuring them from a construction aspect so that they are radially compressible and expandable again for operation in the body.

A compressible rotor of this kind is known, for example, from US 6,860,713. Another rotor is known from US 7,393,181 B2. In the known solutions, the rotors are compressible and expandable either due to the elasticity and deformability of the material or on the basis of mechanically movable constructions.

It is unavoidable in this respect that a certain construction effort is exerted to ensure the compressibility of such a pump despite a

corresponding reliability and conveying capacity. It must moreover be ensured that large shear forces which can damage sensitive fluids do not arise due to too high a rotational speed of the rotor or due to unfavorable geometrical shapes of impeller blades. In addition, care must be taken that pressure differences within the geometry of such a conveying device, on the one hand, and over the course of time, on the other hand, are kept within tight limits.

Under these conditions and against the background of the prior art, it is the underlying object of the present invention to provide a conveying device which can be manufactured with means which are simple from a construction aspect and which reliably and gently allow the conveying of a fluid.

The object is achieved in accordance with the invention by the features of claim 1, alternatively by the features of claim 3 or claim 7.

The conveying device in accordance with the invention, which serves to move a fluid in a conveying direction, for this purpose has a drive body which can be driven by means of a drive system and which can be driven in an oscillating manner transversely to the conveying direction.

The drive body is arranged in a channel or in a space in which the fluid should be conveyed in a preset conveying direction.

Known conveying mechanisms such as centrifugal pumps or the above-named axial flow pumps make use of rotating conveying elements for moving or accelerating a fluid. The likewise known piston pumps respectively have at least one piston which is substantially movable in translation and which conveys the medium in its direction of movement on its movement.

In contrast to this, in accordance with the present invention, the drive body is moved transversely to the conveying direction in the manner of a fin of a fish which is used in nature as a rule to generate a relative movement between the fin and a fluid. In the present invention, the fin-like element, the drive body, is in this respect substantially fixed in the conveying direction so that the relative movement results in a conveying movement of the fluid.

The movement of the drive body transversely to the conveying direction in this respect, for example, means that at least one part of the drive body is moved in translation or along a less curved path substantially perpendicular to the conveying direction and/or associated with a pivot movement about an axis which is substantially perpendicular to the conveying direction. In this respect, the deviation of the direction of extent of the axis to the perpendicular of the conveying direction should amount to a maximum of 45°. In this respect, movement patterns of fin-like bodies in fish and other creatures known from bionics should be reproduced.

The corresponding drive bodies can be adapted in shape and size to the available space. The relative movement of the drive body or of different parts of said drive body with respect to the fluid to be driven can be kept in a range with respect to the speed which prevents the creation of unpermitted shear forces. In this respect, the relative speed is to be coordinated with the viscosity of the medium to be conveyed and accordingly with possibly present compressibilities. The conveying principle described can be used particularly efficiently with substantially non-compressible and slightly liquid media such as blood. Corresponding drive movements can also be transmitted easily to a drive body to be moved in an oscillating manner. A rotatable journalling of a rotor does not necessarily have to be provided.

The drive body or bodies are flowed around by the fluid to be conveyed at multiple sides, in particular at all sides. In particular when two mutually opposite conveying surfaces are provided, they are each both in contact with the fluid to be conveyed.

The drive body or bodies are compressible together with a housing surrounding them in the radial direction with respect to the conveying direction. For this purpose, the drive bodies can be configured as foldable, as elastically compressible as foam or as inflatable. The housing can likewise be foldable and can comprise a membrane spanned over a support frame. The support frame can comprise a plastic or a metallic memory alloy, for example Nitinol or another superelastic material. The housing can also be configured as inflatable, in particular as a double-wall balloon body.

Since a certain periodicity of pressure fluctuations is to be expected due to the oscillatory movement of the drive body, with an occasional reversal of the flow direction not always being able to be precluded on such pressure fluctuations, the arrangement of a control valve for the flow to be generated in the conveying channel or in the space in which the drive body is located can also advantageously be considered. In this respect, the valve can either be controlled by an intelligent control synchronously with the movement of the drive body or it can be configured as an automatically acting check valve.

The conveying surface or a conveying surface of the drive body is advantageously aligned so that a partial force acts on the fluid in the conveying direction on a movement of the drive body. For this purpose, the direction of movement of the drive body and the direction of extent of the surfaces of the drive body at which a pressure increase arises are to be correspondingly coordinated with one another.

In this connection, at least two conveying surfaces can be provided, for example at a single drive body, which are aligned so that they each effect a conveying of the fluid in at least one of the directions of movement of the drive body. A conveying of the fluid in both drive movement directions or in a plurality of drive movement directions thus becomes possible. Two conveying surfaces can be provided at two different, mutually opposite outer surfaces of a drive body.

Provision can moreover advantageously be made that at least one drive body tapers in the conveying direction in the cross-section disposed parallel to its movement plane.

The drive body can, for example, be configured in the manner of a fin as a wedge-shaped body whose thickened end is arranged upstream with respect to the flow to be produced and whose tapered end is arranged downstream. The tapered end can converge acutely in the form of a blade edge, with the blade edge being able to extend perpendicular to the drive direction of the drive body. The drive body can also be widened toward its tapered end in the direction of extent of the cutting blade.

The conveying surfaces at both sides of such a wedge-shaped fin body can be either planar or convex or concave, viewed in the direction perpendicular to the movement plane or to the drive direction of the drive body.

The drive body can be stiff in one type of embodiment of the invention. In this case, the drive body can be pivotable about an axis which lies in the region of its thickened end. In addition, a superimposed movement in translation of the thickened end can be provided, for example in a straight manner or along a gate path. The movement portion in translation takes place in the same plane as the pivot movement in this respect.

Alternatively to this, provision can also be made that the drive body is so elastic that it can also be bent in operation in its end region by the fluid counterpressure by at least 5°, in particular also by at least 20°, with respect to the undistorted state.

The drive can in this case be configured in the same manner as with a stiff drive body, but the alignment of the conveying surfaces relative to the fluid to be conveyed in the respective phase of the drive movement can already be optimized and thus the efficiency of the drive increased by the elasticity and deformability of the drive body per se.

Such a drive body, whether stiff or elastic, can either be configured as symmetrically wedge-shaped, with planar, concave or convex conveying surfaces in the cross-section viewed perpendicular to the plane of the drive movement or a shape asymmetrical in the named cross-section can also be provided, for example with elements of an airfoil wing, to utilize additional flow effects. Such an airfoil section, for example, provides a convex shape on one side of the drive body and a convex or straight shape of the conveying surface on the opposite side.

On the use of such an asymmetrical design of a drive body, a further drive body can additionally be provided which is shaped and arranged in mirror form with respect to the first drive body and which is movably in synchronization with it in the same or opposite sense.

Provision can moreover be made to increase the efficiency of the drive that the drive body, in particular in the region of a conveying surface, has optimized surface structures.

In an advantageous embodiment of the invention, provision can moreover be made that the drive body has at least one hollow space. The provision of a hollow space reduces the mass of the drive body and thus the energy to be expended for its acceleration. In addition, the drive body can be configured as at least partially inflatable so that its outer dimensions in the non-inflated state can be smaller than in the inflated state. Such a drive body can then be brought more easily to its deployment site in the non-inflated state and inflated to the operating dimensions there. This is in particular advantageous when the conveying device should be manufactured in very small dimensions and moved within blood vessels.

The drive body can moreover advantageously comprise a foam, in particular polyurethane. The drive body can thus be manufactured as elastically deformable and as very light. The drive body can also comprise a hardenable material or generally a material whose deformability can be directly changed by physical influence, e.g. by irradiation, temperature change or by chemical reactions.

Provision can be made in the conveying device in accordance with the invention by providing a corresponding drive system that the drive body can be driven by means of a hydraulic or pneumatic device, in particular by means of a balloon body, but also by means of an electric and/or magnetic device.

Although one or more drive bodies in accordance with the invention can be moved simply by means of levers or similar mechanical devices, the drive movement can particularly easily be conducted to the conveying device by a hydraulic or pneumatic drive device. Corresponding pneumatic or hydraulic lines can be laid, for example, in the form of a hollow catheter or also within a hollow catheter, at the distal end of which the conveying device is provided, and can either act directly on a piston, bellows or balloon-like drive body in the region of the conveying device or can be converted into a lever movement there.

Possible drive movements of the drive body or bodies in this respect provide that at least one drive body is pivotable in an oscillating manner about an axis extending transversely to the conveying direction; and/or that one or more drive bodies are pivotable in an oscillating manner about an axis extending in the conveying direction, in particular outside the conveying bodies.

It is special about such an oscillatory movement that the pivot movement has a relatively small stroke so that a full rotation of the drive body does not take place in any case.

A rotation about larger angles can, however, also be provided on the rotation about an axis extending in the conveying direction.

To reduce unwanted pressure compensation procedures at the drive bodies, blocking bodies can be arranged on them between their conveying surfaces. Said blocking bodies should be flexible and can in this respect be configured as pliable or stiff, but bendable. The blocking bodies can also connect two respective blocking bodies to one another or one blocking body to a housing wall.

Provision can also be made that the driving force is transmitted to a drive body by means of a blocking body.

The described fin-like drive principle for fluids is novel in connection with the conveying of liquids and thus allows the realization of conveying characteristics which cannot be achieved with the already known conveying devices.

The invention will be shown and subsequently described in the following with reference to an embodiment in a drawing.
There are shown

Fig. 1 a drive body in three positions in cross-section;

Fig. 2 a conveying system for fluids having two drive bodies in a longitudinal section;

Fig. 3 a conveying system having two drive bodies in a three-dimensional view;

Fig. 4 two drive bodies in a first position with a drive system;

Fig. 5 the drive bodies from Fig. 4 in a second position;

Fig. 6 the drive bodies from Figs. 4 and 5 in a third position;

Fig. 7 a drive system in a three-dimensional representation having a conveying space quadrangular in cross-section;

Fig. 8 two drive bodies which are rotated in an oscillating manner about an axis extending in the conveying direction;

Fig. 9 a drive system in a three-dimensional view having two partly cylindrical drive bodies;

Fig. 10 a section through the drive system of Fig. 9;

Fig. 11 an embodiment as in Fig. 3 with additional blocking bodies;

Fig. 12 an embodiment similar to that of Fig. 7 with blocking bodies;

Fig. 13 a representation of two drive bodies which are connected by means of blocking bodies;

Fig. 14 the embodiment of Fig. 13 in a front view;

Fig. 15 a view of the embodiment of Fig. 13, with the effect of a driving force on the blocking bodies being indicated;

Fig. 16 an arrangement in which the blocking bodies have a stiff, but bendable ring-strip shape;

Fig. 17 a drive body having fin-rays in the neutral state; and

Fig. 18 a drive body as in Fig. 17 in the loaded state.

Fig. 1 shows in the middle part a drive body 1 in section which substantially has a wedge shape which is modeled on the shape of a fin occurring in biology. The drive body 1 extends perpendicular to the plane of the drawing with an unchanging section, but can also widen perpendicular to the plane of the drawing toward its tapered end.

The drive body 1 can be moved in an oscillating manner along the dotted line 2 in the directions indicated by the arrows 3, 4. The region about the point of attack of the driving force is in this respect shown as a circle and is marked by 5. The driving force engages at this point such that the drive body is moved substantially in translation along the line 2 and is thus not pivotable in a first variant to avoid an active fluid counterpressure.

A fluid counterpressure then results in operation, for example on the movement of the drive body within a liquid, on the side of the respectively acting conveying surface 6, 7, said fluid counterpressure resulting in a deformation of the end 8 of the drive body 1 remote from the drive, i.e. the tapered end, when this drive body is configured as elastic as in the example shown. A particularly efficient advance of the driven fluid in the conveying direction 9 results by this effect.

Alternatively, the drive of the drive body 1 can also be configured so that it is not driven strictly in translation in the sense of the directions 3, 4, but rather in a superimposed movement in translation and in a pivot movement. In this respect, for example simultaneously with the movement in the direction of the arrow 3, a pivoting of the drive body takes place about the point of attack 5 clockwise about a specific angle, for example 10°, so that the drive body inclines at the end of the movement in a similar manner as under the effect of a fluid counter-pressure. Optionally, the direction of rotation of the pivot movement can be reversed at the end of the movement in translation to beat with the fin. This driving principle can be combined both with stiff drive bodies and with flexible drive bodies.

A specific lever drive or a gate drive of the drive body can be provided for this purpose or it is conceivable to transmit the driving forces by means of a hydraulic or pneumatic apparatus.

Fig. 2 shows in a side view a housing 10 in which a conveying device in accordance with the invention having two drive bodies 1, 11 is arranged. The housing 10 is set up rotationally symmetrically or elliptically in cross-section about the drive bodies 1, 11 and has an inflow channel 12 as well as an outflow channel 13. A fluid line 14 which is part of the drive system and which is connected to a drive bellows 15 projects through the outflow channel 13. The drive bellows 15 can be connected via a pressure control device, not shown, via the fluid line 14 to an overpressure or to an underpressure so that said drive bellows can be inflated or deflated by the inflow of a fluid or the removal of the fluid.

One respective drive body 1, 11 is fastened to the two ends 15a, 15b of the drive bellows 15 and runs through a drive movement in the direction of the arrows 3, 4 by the volume changes of the drive bellows. The drive movement in translation of the drive bellows 15 can be translated into a more complex movement path of the drive bodies 1, 11, which can correspond to a superimposition of the movement in translation with a pivot movement, by a corresponding elastic configuration of the drive bellows 15 or by additional levers which connect the bellows to the drive bodies 1, 11 or the drive bodies to a fixed point of the housing 10.

Provision can, however, also be made that the movement of the drive bodies 1, 11 substantially takes place in translation and said drive bodies are configured as elastic to carry out the elastically fin-like overall movement shown with reference to Fig. 1.

If the pressure in the drive bellows 15 is changed periodically via the control of the fluid pressure in the fluid line 14, for example several times per second, this is translated into an oscillatory movement of the drive bodies 1, 11. This results in an acceleration of the fluid located in the housing 10 in the direction of the arrow 16 which designates the conveying direction of the fluid. Since pressure fluctuations occur due to the periodicity of the movement, it may be meaningful to provide a check valve 17 in the inflow channel 12 which blocks the inflow channel 12 for the case that an overpressure arises within the housing 10 in front of the valve and closes it again as soon as an underpressure is generated there.

The fluid line 14 can be configured as a flexible hose line provided that the drive bellows 15 is held otherwise in the housing 10. The drive line 14 can, however, also be configured as a rigid line in the form of a pipe in order simultaneously to conduct the fluid and to fix the drive bellows and the drive bodies 1, 11. The fluid line 14 can in every case be held and fixed in a holding star 18 or at a holding arm within the outflow channel 13.

In the Figure, three positions are shown for each drive body 1, 11, with a middle neutral position being shown by solid lines and the extreme positions on the movement path of each individual drive body 1, 11 being shown by broken lines.

Fig. 3 shows a similar arrangement to Fig. 2, but in a three-dimensional view, with a second holding star 19 being provided in addition to the first holding star 18 in direct vicinity of the drive bellows 15 and of the drive bodies 1, 11.

Arrows 20, 21 and 20', 21' are drawn in which indicate the directions of movement of the respective thickened ends of the drive bodies 1, 11 as are arrows 22, 23 and 22', 23' which indicate the movement of the tapered ends of the drive bodies 1, 11. The different lengths of the arrows shown should indicate that the thickened ends of the drive bodies 1, 11 facing the one-way valve 17 carry out a pivot movement whose amplitude is substantially larger than the movement of the tapered ends of the drive bodies. This is made possible, as will be shown in more detail with reference to Figs. 4, 5 and 6, by a special construction of the drive bellows 15.

Fig. 4 shows in a side view in the upper part the two drive bodies 1, 11 as well as the drive bellows 15 in the deflated, i.e. compressed, form. The arrow 24 indicates that an underpressure is present in the fluid line 14 in this state to compress the drive bellows 15.

The drive bellows 15 itself has an asymmetrical structure, as can be seen more clearly from the lower part of Fig. 4. A cross-section through the drive bellows 15 along the dashed line A is shown there which makes clear that the drive bellows has a smaller wall thickness in its region facing the one-way valve 17 than in the outflow channel 13.

It is thereby achieved that the movement amplitude is larger in the front region facing the inflow channel 12 than in the rear region of the drive bellows facing the outflow channel 13. A pivot movement of the drive bodies 1, 11 therefore results on a pressure change in the drive bellows 15.

In Fig. 5, the arrangement of Fig. 4 with the drive bodies 1, 11 and a drive bellows 15 inflated further with respect to Fig. 4 is shown. The drive bodies are approximately in the straight position shown in Fig. 2.

Fig. 6 finally shows the state of the drive bodies 1, 11 in the fully inflated state of the drive bellows 15, with it also becoming clear that the thickened ends of the drive bodies 1, 11 have passed through a larger movement amplitude than the tapered ends so that a pivot movement of the drive bodies has taken place in addition to a movement in translation.

Fig. 7 shows in a three-dimensional view from a different perspective two drive bodies 1', 11' which are configured as asymmetrical in the manner of an aerodynamic airfoil section, but which may additionally also be configured as flexible and which can be driven by means of a drive bellows 15. The inflow channel 12 is shown in the foreground of the figure, the outflow channel 13 in the background. In contrast to the cylindrical housing 10 of the arrangement shown in Fig. 3, the housing 10' shown in Fig. 7 has a parallelepiped structure with a rectangular cross-section to implement the non-cylindrically symmetrical structure of the drive arrangement and of the drive bodies as efficiently as possible. Unlike the specific representation of Fig. 7, the transition from the housing 10' to the inflow and outflow channels 12, 13 can take place with conical or oblique transitions. Provision can advantageously be made that the drive bodies 1', 11' extend perpendicular to the plane of the drive movement up to as close as possible to the side walls 25, 26 of the housing 10'. Turbulence at the side surfaces of the drive bodies 1', 11' is thereby reduced.

The drive bodies 1', 11' can, just like the drive bodies 1, 11 shown further above, comprise a foam, in particular polyurethane, and can be inflatable. For this purpose, the bodies can have large and/or a plurality of small hollow spaces which can, for example, be inflated by the drive fluid via the fluid line 14 and which have check valves to be stabilized in the inflated state.

A good compressibility in the non-inflated state is hereby made possible so that the drive bodies can be radially compressed for transport to a deployment site together with the housing 10, 10' and can be expanded on site before they are put into operation.

Fig. 8 shows an arrangement in comparison with the Figures described further above having two drive bodies 1", 11" with another drive principle in which the drive bodies are connected via connection webs 28, 29 to a drive shaft 27 which extends in the conveying direction 30.

The drive shaft 27 can be rotated in an oscillating manner about the conveying direction 30, and indeed in each case, for example, at least by an amount of 5°, 10° or at least by 20° or 30°, in each direction, as indicated by the arrows 33, 34.

The longitudinal axes of the drive bodies 1" and 11" are aligned parallel to the shaft and undergo a movement quasi in translation in the peripheral direction of the shaft in the directions which are indicated by the arrows 31, 32 within the framework of this rotary movement, provided that the length of the connection webs 28, 29 is sufficient. In this manner, a corresponding approximately linear movement in translation of the drive bodies can be realized in a very simple manner by means of the drive shaft 27. In Figure 8, a plurality of parallel microgrooves 41 are also shown by way of example at the lower drive body 11".

In Fig. 9, an arrangement is shown in a three-dimensional view which is as largely cylindrically symmetrical as possible of two drive bodies 1''' and 11''' which are connected by a drive bellows 15' and which can be moved substantially in the direction of the arrows 35, 36 in the radial direction with respect to the cylinder axis. The drive bellows 15' is connected to a pressure generation system by means of a fluid line 14. It is also conceivable to divide the cylindrically symmetrical arrangement into a higher number of cylinder segments, for example 4 or 8 or more and to move them radially in each case, with a movement pattern resulting which is similar to the manner of propagation of jellyfish.

A section through the arrangement of Fig. 9 is shown in Fig. 10 which makes the function clear. The drive body 1''' is shown by way of example with a hollow space 37, the drive body 11''' with a hollow space 38, with the hollow spaces only being indicated schematically.

Fluid is exchanged via the fluid line 14 with the interior of the drive bellows 15 and is pumped from there into the hollow spaces 37, 38, with the hollow spaces 37, 38 of the drive bodies 1''' and 11''' being connected to the hollow space of the drive bellows 15' by means of one-way valves 39, 40 so that the drive bodies are only inflated once and then thereafter maintain the increased fluid pressure to be stabilized in shape. Only the interior of the drive bellows 15' is inflated and deflated thereafter. The drive bodies 1''', 11''' thereby alternately move apart in the direction of the arrows 35, 36 and move together in the opposite direction, whereby a corresponding drive movement is realized.

The efficiency of the conveying device with respect to the non-cylindrically symmetrical arrangements which are shown in the aforesaid Figures is increased by the cylindrically symmetrical or approximately cylindrically symmetrical arrangement of the drive bodies.

Fig. 11 shows a cylindrical arrangement of a housing 10 having two drive bodies 11 which are each laterally provided with blocking bodies 50, 51, 52, 52 which are flexible and may also be connected to the wall of the housing 10 and which prevent or reduce a pressure equalization between the lower side and upper side or the high pressure side and low

pressure side of each drive body during the drive movement.

Fig. 12 shows corresponding blocking bodies 53, 54 for a housing 10' with flattened side walls.

Fig. 13 shows two blocking bodies in the form of wide, flexible bands 55, 56 which connect two drive bodies to one another at both sides. This constellation is shown in a front view in Fig. 14.

Fig. 15 shows two blocking bodies 55, 56, as in Fig. 13, which connect two fin-like drive bodies to one another and act as an equalization block. The blocking bodies are configured as strips and can be configured as flexible or stiff and elastically pliable. In the latter case, a drive movement can be directly applied to the drive bodies by direct application of a mechanically, magnetically, pneumatically hydraulically or electrically generated driving force onto the blocking bodies from the outside, indicated by the arrows F_1 and F_1' or from the inside from the intermediate space of the drive bodies, indicated by the double arrow F_2.

Instead of the blocking bodies, similarly positioned coupling bodies in the form of a scaffold or frame can be provided to couple the drive movement into the sections.

The principle of the drive via the blocking bodies is additionally illustrated by way of example by Fig. 16. Two drive bodies 57, 58 are connected to one another there by two ring segments 59, 60 of a ring strip in the form of a circular ring. The cylinders 61, 62 symbolically indicate outwardly engaging

driving forces which can apply a traction force or a compression force to the ring segments from the outside. Corresponding inwardly engaging forces are symbolically designated by 63, 64. A deformation of the ring segments effects a drive movement of the drive bodies 57, 58. They can be controlled in a suitable manner by a profiling of the ring segments 59, 60 or by cut-outs in the ring segments.

In Figs. 17 and 18, a drive body is shown in a schematic plan view having so-called fin-rays 65 which have an influence on the flow of the fluid on the surface as web-like, groove-like or fin-like structures. They can be shaped and configured by their inner structure such that they effect a concave deformation and thus an increase in pressure on the pressure side on a movement of the drive body. This deformation against the pressure takes place automatically without any additional external energy supply and thus substantially differs from the deformation of customary beam structures which usually yield to a pressure increase on one side and evade the higher pressure.

The inner structure is formed by struts which preferably extend in the interior of a drive body from a drive surface to an oppositely disposed drive surface. The struts can in this respect be made as bars or also as plates, ribs or equivalent structures.

The conveying device for fluids in accordance with the invention allows an efficient configuration thanks to the use of an oscillatory movement transversely to the conveying direction of drive bodies, with the disadvantages of only rotating drive devices being avoided.

Claims

1. A conveying device for the conveying of a fluid in a conveying direction having at least one drive body (1, 1', 1'', 1''', 11, 11', 11'', 11''') which can be driven by means of a drive system and which has a conveying surface (6, 7), wherein the drive body can be driven in an oscillating manner transversely to the conveying direction (9) and is flowed around on a plurality of sides by the fluid to be conveyed, and wherein the drive body can be compressed together with a housing surrounding it.

2. A conveying device in accordance with claim 1, characterized in that the drive body/bodies can be driven by means of a rotatable shaft.

3. A conveying device for the conveying of a fluid in a conveying direction having at least one drive body (1, 1', 1'', 1''', 11, 11', 11'', 11''') which can be driven by means of a drive system and which has a conveying surface (6, 7), wherein the drive body can be driven in an oscillating manner transversely to the conveying direction (9), characterized by blocks which are laterally fastened to at least one drive body and which form a barrier between different conveying surfaces of a drive body.

4. A conveying device in accordance with claim 3, characterized in that at least one block is connected either to two drive bodies or to one

drive body and a housing of the conveying device.

5. A conveying device in accordance with either of claims 3 or 4, characterized in that the driving force is applied to the drive bodies by means of the blocking body/bodies.

6. A conveying device in accordance with claim 1 or one of the following claims, characterized in that at least one drive body (1, 1', 1'', 1''', 11, 11', 11'', 11''') is pivotable in an oscillating manner about an axis extending transversely to the conveying direction (9).

7. A conveying device for the conveying of a fluid in a conveying direction having at least one drive body (1, 1', 1'', 1''', 11, 11', 11'', 11''') which can be driven by means of a drive system and which has a conveying surface (6, 7), wherein the drive body can be driven in an oscillating manner transversely to the conveying direction (9), characterized in that the drive body/bodies (1'', 11'') is/are pivotable in an oscillating manner about an axis extending in the conveying direction (9), in particular outside the drive body/bodies.

8. A conveying device in accordance with claim 1 or one of the following claims, characterized in that at least one conveying surface (6, 7) of at least one drive body (1, 1', 1'', 1''', 11, 11', 11'', 11''') is aligned such that a partial force acts on the fluid in the conveying direction (9) on a movement of the drive body.

9. A conveying device in accordance with claim 8, characterized in that two conveying surfaces (6, 7) are aligned such that they effect a conveying of fluid in a respective at least one movement direction (3, 4) of a drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′).

10. A conveying device in accordance with claim 1 or one of the following claims, characterized in that at least one drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) tapers in the conveying direction (9) in the cross-section disposed parallel to its movement plane.

11. A conveying device in accordance with claim 1 or one of the following claims, characterized in that the at least one drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) is configured as stiff.

12. A conveying device in accordance with one of the claims 1 to 4, characterized in that the drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) is configured as elastic such that it is bendable in its end region by the fluid counterpressure in operation by at least 5° with respect to the non-deformed state.

13. A conveying device in accordance with one of the claims 1 to 12, characterized in that the drive body has microgrooves (41) extending in the conveying direction (9).

14. A conveying device in accordance with claim 1 or one of the following claims, characterized in that the drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) has at least one hollow space (37, 38).

15. A conveying device in accordance with claim 1 or one of the following claims, characterized in that the drive body (1, 1', 1'', 1''', 11, 11', 11'', 11''') comprises a foam, in particular polyurethane.

16. A conveying device in accordance with either of claims 14 or 15, characterized in that the drive body (1, 1', 1'', 1''', 11, 11', 11'', 11''') is at least partly inflatable.

17. A conveying device in accordance with claim 1 or one of the following claims, characterized in that the drive body can be driven by means of a hydraulic or pneumatic device (15, 15'), in particular by means of a balloon body.

18. A conveying device in accordance with one of the claims 1 to 10, characterized in that the drive body can be driven by means of an electric and/or magnetic device.

19. A conveying device in accordance with claim 1 or one of the following claims, characterized in that the drive body or bodies is/are deformed in operation against the fluid pressure on the respective pressure side.

20. A conveying device in accordance with claim 19, characterized in that the deformation of the pressure side takes place by inner struts of the drive body without any additional external energy supply.

21. A conveying device in accordance with either of claims 19 or 20, characterized in that the deformation of the pressure side takes place by the so-called fin-ray effect.

22. A conveying device in accordance with claim 1 or one of the following claims, characterized in that it is a blood conveying device.

FIG 1

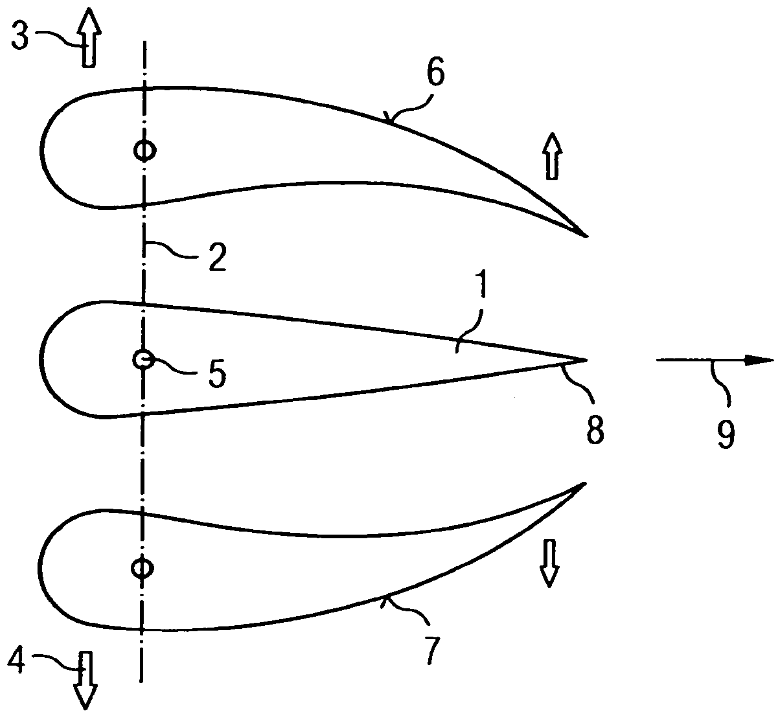
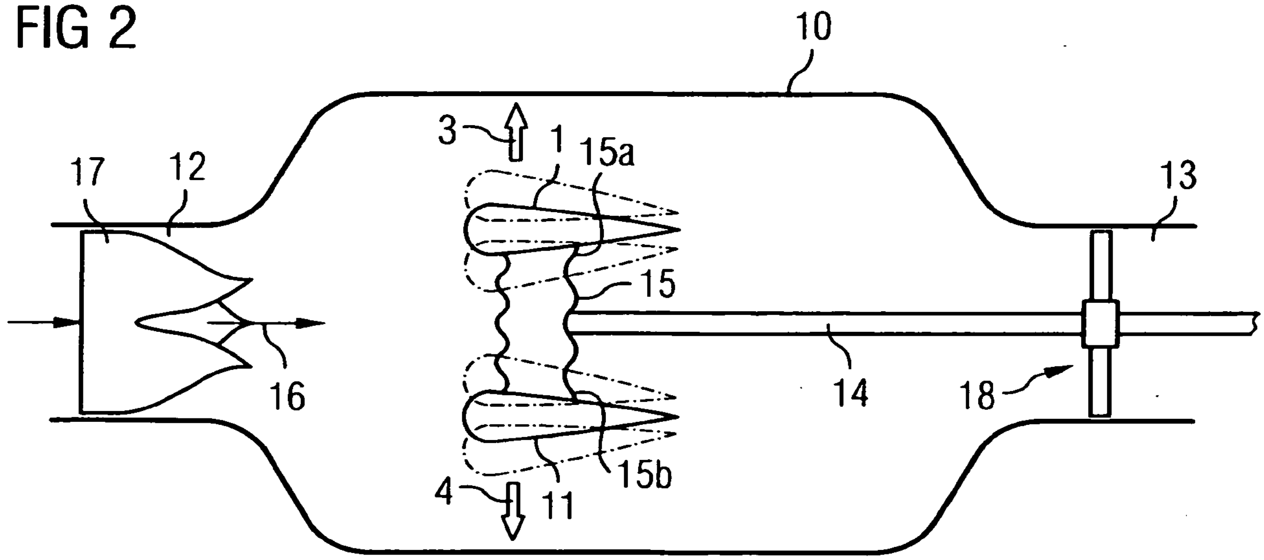


FIG 2



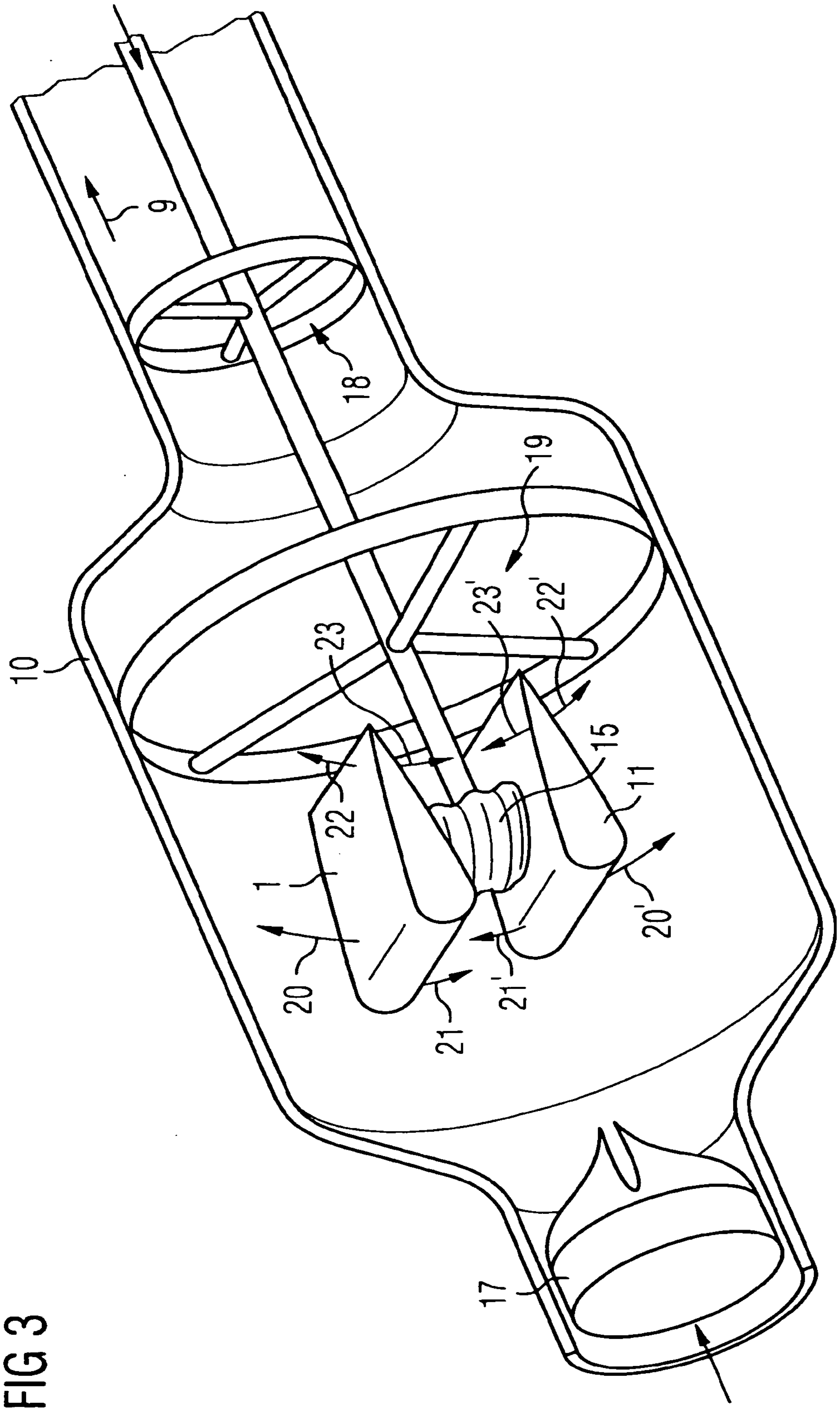


FIG 3

FIG 6

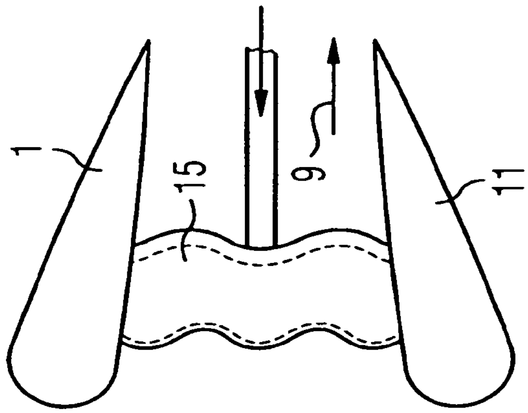


FIG 5

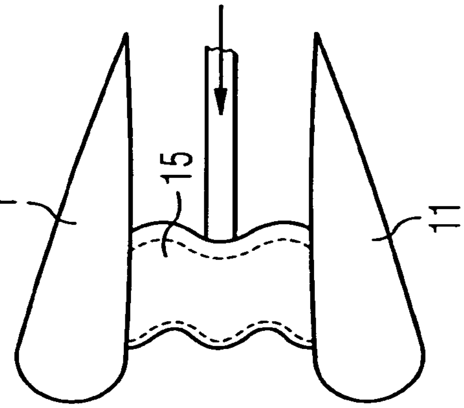


FIG 4

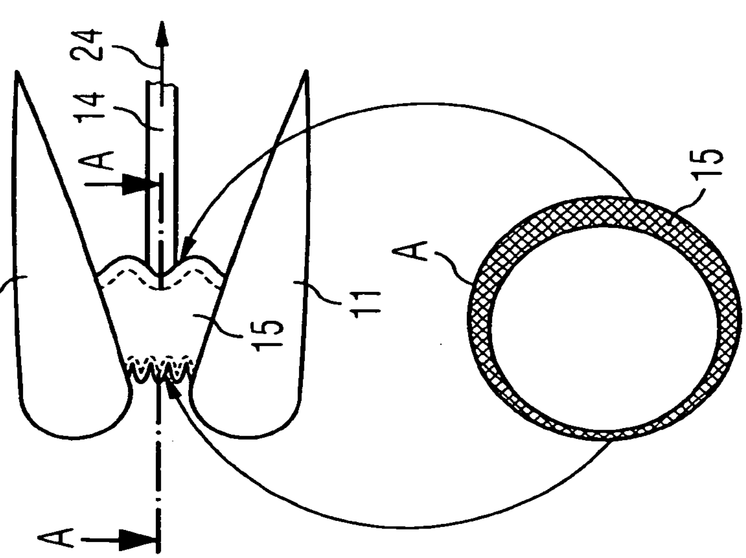


FIG 7

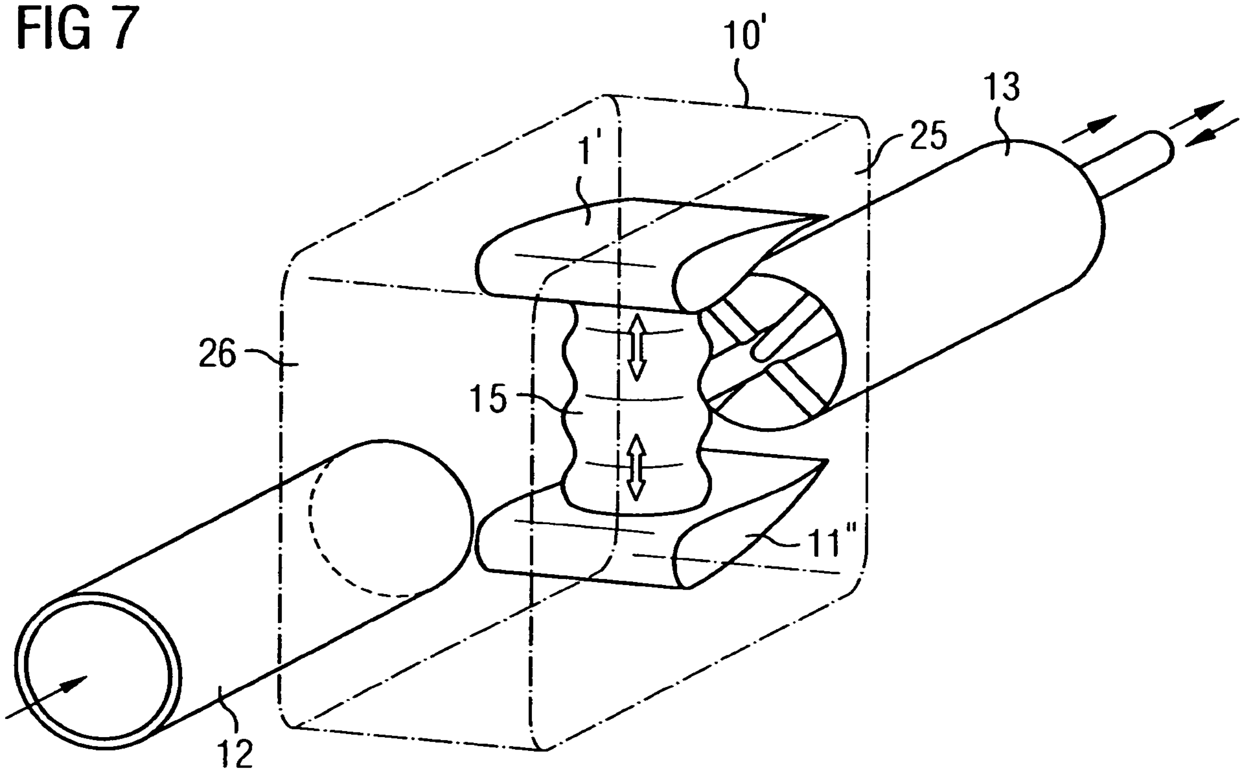


FIG 8

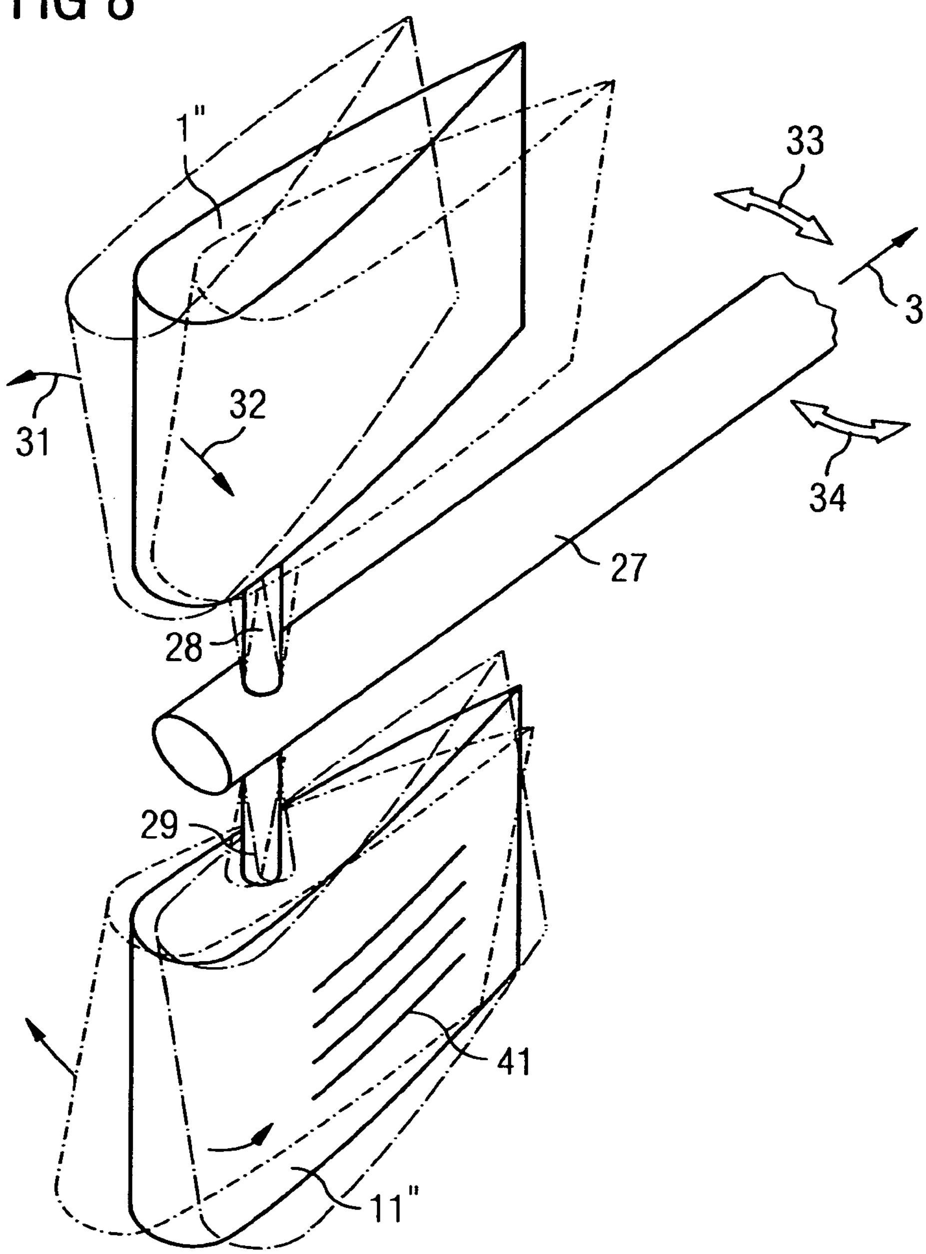


FIG 9

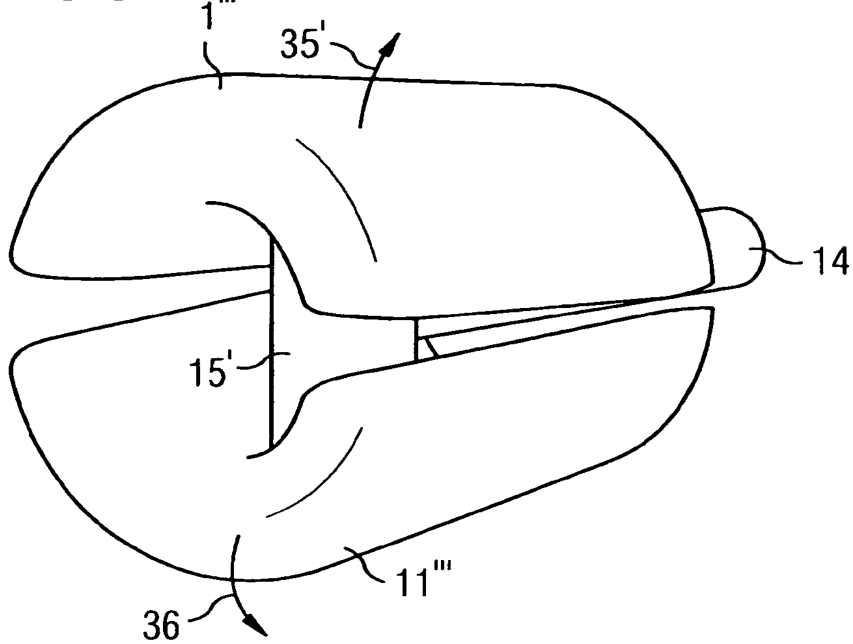
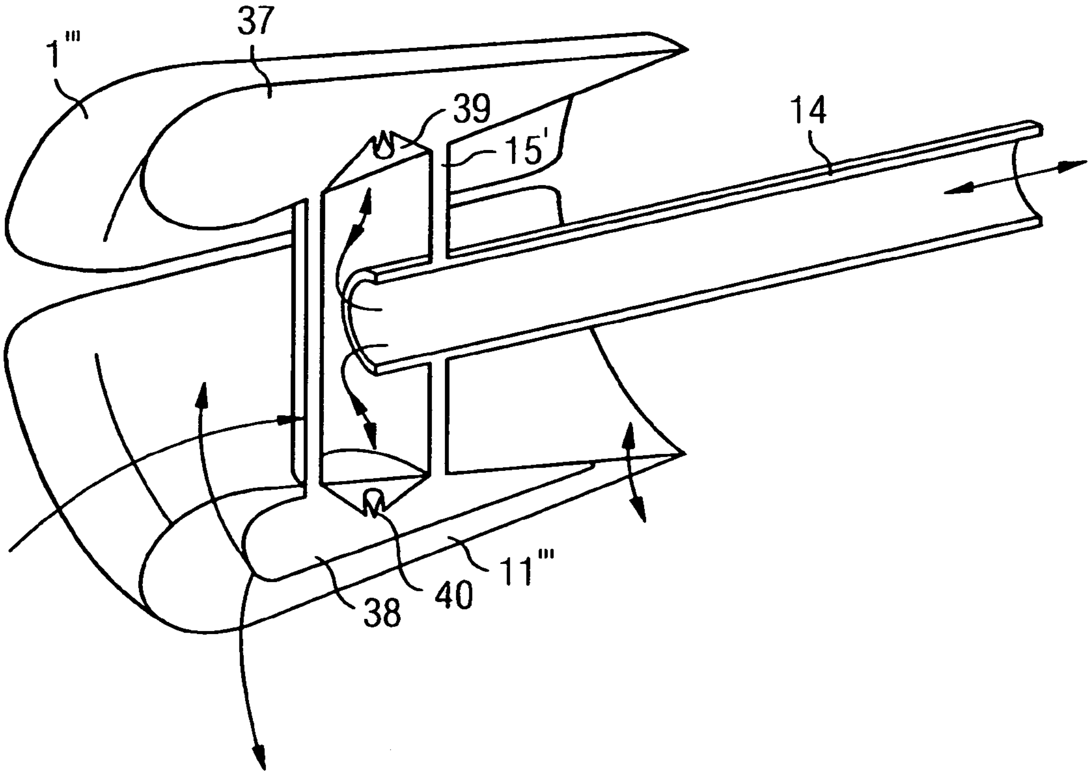


FIG 10



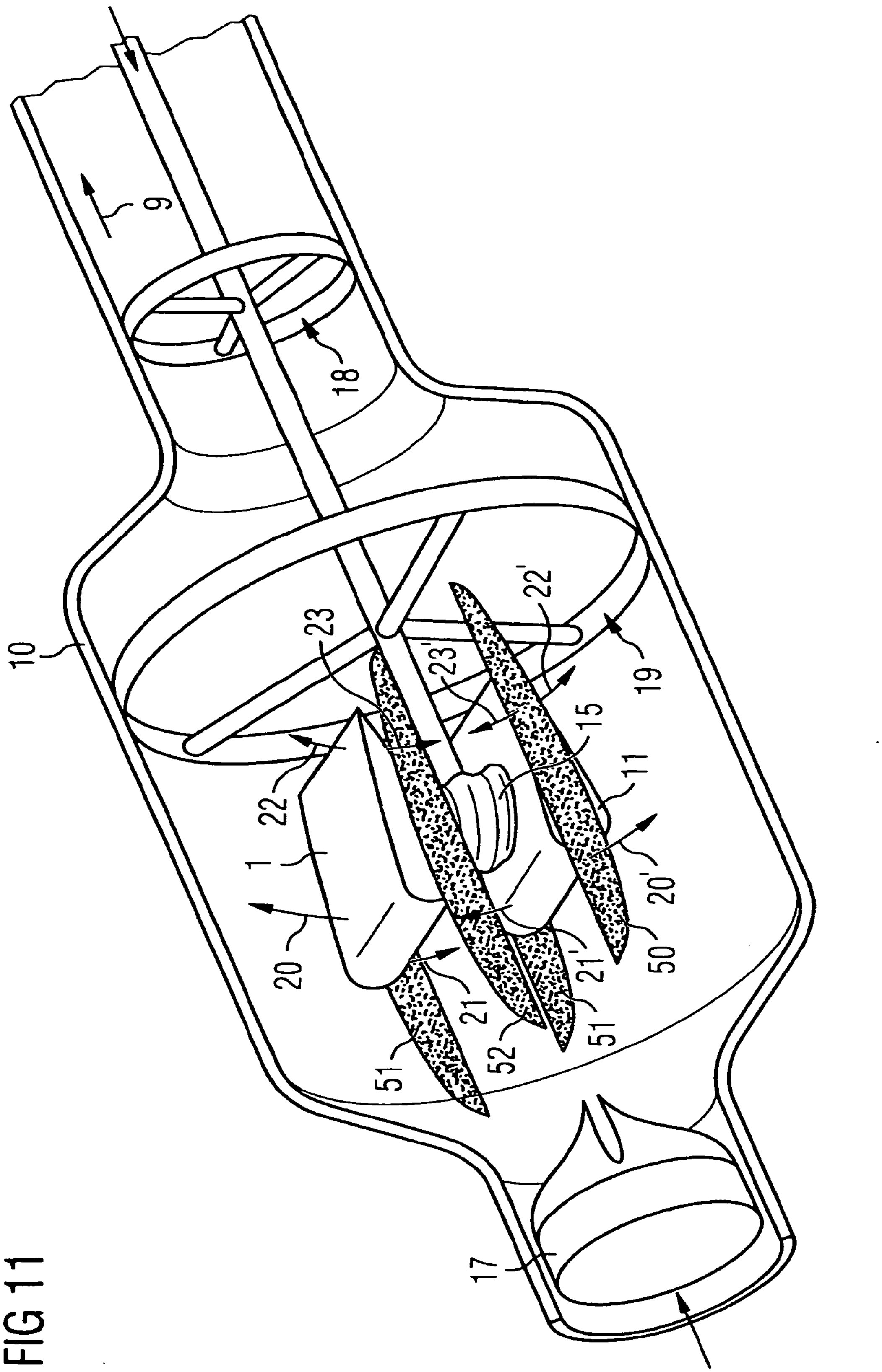


FIG 11

FIG 12

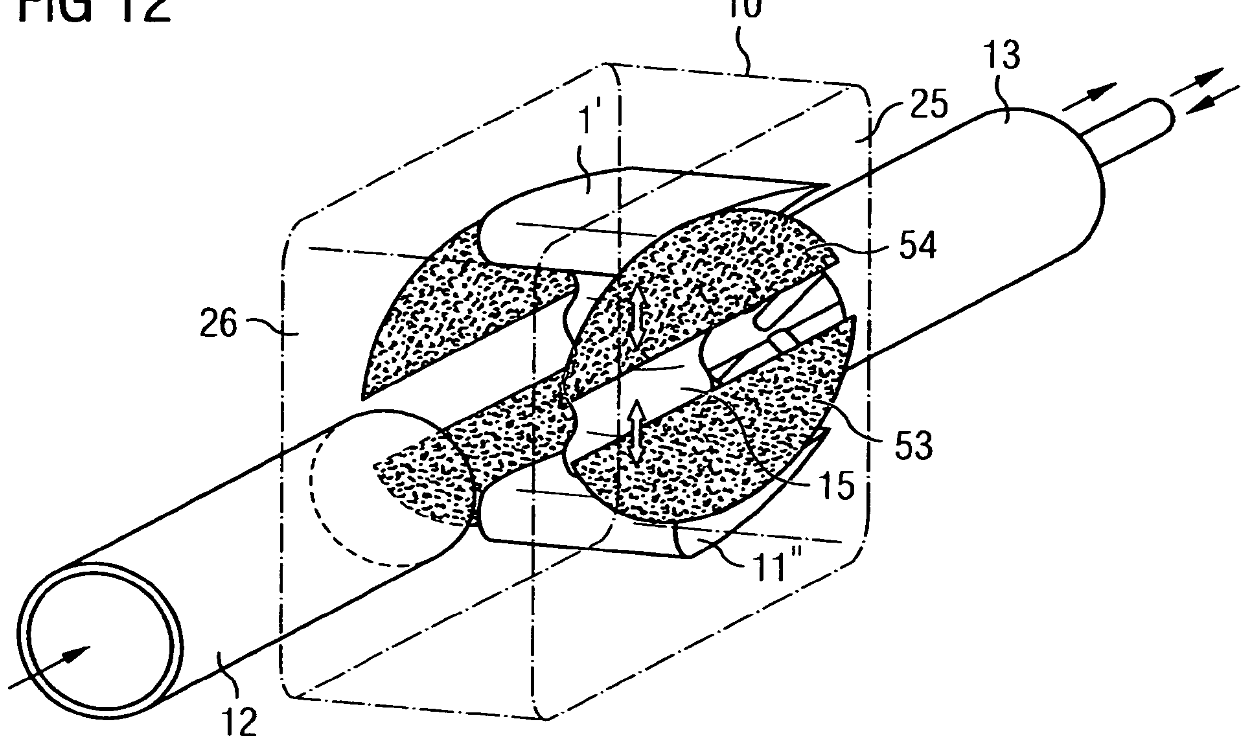


FIG 13

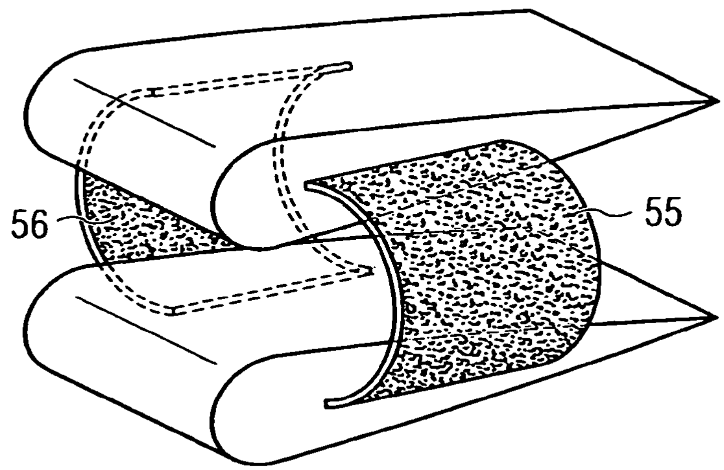


FIG 14

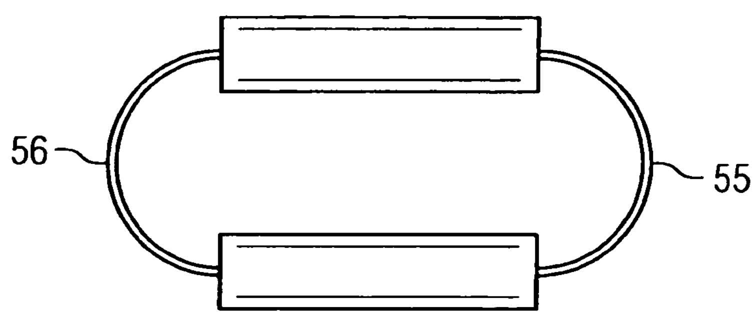


FIG 15

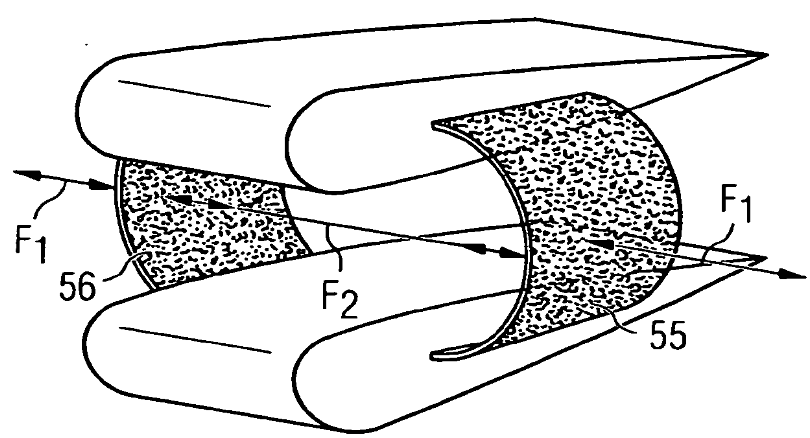


FIG 16

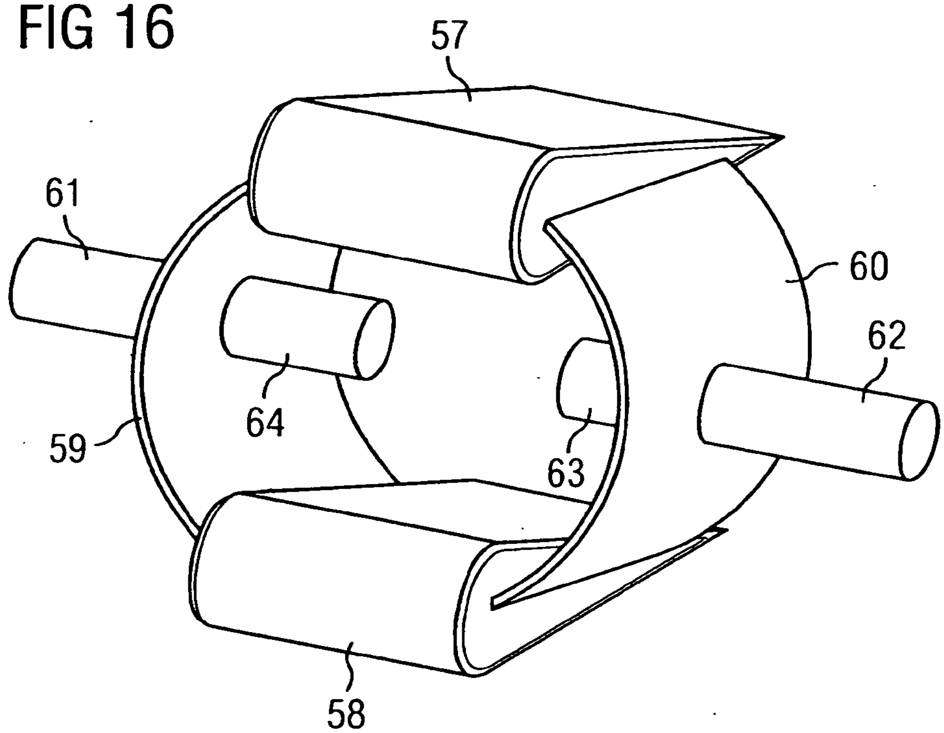


FIG 17

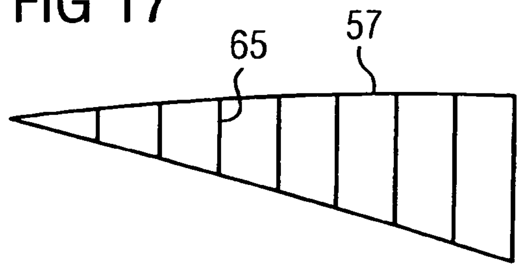
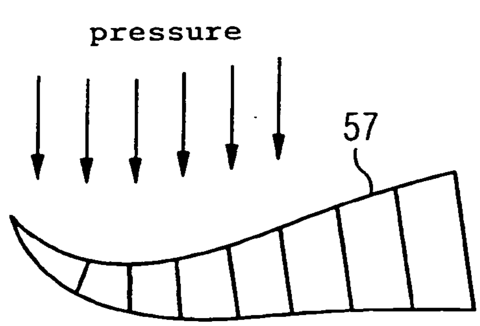


FIG 18



13/261361

IAP01Rec'd PCT 13 JUL 2012

Docket No. 1-21942

COMBINED DECLARATION AND POWER OF ATTORNEY
IN ORIGINAL APPLICATION
(CONCERNING A FILING UNDER 35 USC 371)

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name,

I believe that I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled ______ CONVEYING DEVICE FOR A FLUID ______

the specification of which

_X_ is a filing under 35 USC 371 of PCT International Application No. PCT/EP2011/000439 filed 27 January 2011 (27.01.2011); and

_X_ is attached hereto;

____ was filed on ______ under 35 USC 371, assigned U.S. Application Number ______ and was amended on ______.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information, which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56,

_X_ and which is material to the examination of this application, namely, information where there is a substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent;

____ if this is a continuation-in-part application, information that occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application, in accordance with 37 CFR 1.63(e);

_X_ in compliance with this duty, there is attached an information disclosure statement, in accordance with 37 CFR 1.98.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-art applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent, inventor's or plant breeder's certificate(s), or any PCT international application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application

			Priority Claimed	
10 075 043.9	Europe	27 January 2010	X	
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith with full power of substitution and revocation: Stephen P. Evans, Reg. No. 47,281; Donald A. Schurr, Reg. No. 34,247; Mark A. Hixon, Reg. No. 44,766; Mark M. Hamilton, Reg. No. 56,903; D. Edward Dolgorukov, Reg. No. 26,266; Stephen G. Kimmet, Reg. No. 52,488; Kristene M. Ragan, Reg. No. 48,611; and Jeanette M. Kuhn, Reg. No. 66,111. Address all telephone calls to Stephen P. Evans at telephone number 419-249-7138. Address all correspondence to Customer Number 001678: MARSHALL & MELHORN, LLC, Four Seagate - 8th Floor, Toledo, Ohio 43604, Attention: Stephen P. Evans.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor Reiner LIEBING

Inventor's signature ____________________ Date __________

Residence Schmiedegasse 43, 14469 Potsdam, Germany

Citizenship Germany Post Office Address Same as above

13/261361

IAP01Rec'd PCT 13 JUL 2012

"Express Mail" Label Number EM 576466895 US

I hereby certify that this correspondence is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on July 13, 2012 and is addressed to Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Kathleen J. Moore
(Signature of person mailing correspondence)
Kathleen J. Moore
(Typed name of person mailing correspondence)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: REINER LIEBING	Group Art Unit:
Filing Under 35 USC 371 in DO/EO/ US of PCT/EP2011/000439 filed 27 January 2011	Examiner:
For: CONVEYING DEVICE FOR A FLUID	Attorney Docket 1-21942

July 13, 2012

Mail Stop PCT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PRELIMINARY AMENDMENT

Honorable Sir:

Prior to the first Office Action and before examination, please amend the application being filed concurrently herewith under 35 U.S.C. 371 as follows:

A listing of changes to the specification and Abstract begins on page 2.

A listing of claims begins on page 4.

Remarks begin on page 8.

In the Specification:

On page 1, line 2, between the title and the first paragraph, insert the following heading:

--BACKGROUND OF THE INVENTION--.

On page 3, line 10, insert the following heading:

--BRIEF SUMMARY OF THE INVENTION--.

On page 11, above the first paragraph, insert the following heading:

--BRIEF DESCRIPTION OF THE DRAWINGS--.

On page 10, line 12, line 28, above the last paragraph, insert the following heading:

--DETAILED DESCRIPTION OF THE INVENTION--.

In the Abstract

Please replace the Abstract presently on file with the following:

The invention relates to a conveying device for conveying a fluid in a conveying direction having one or more drive bodies which can be driven in an oscillating manner by means of a drive system transversely to the conveying direction. An acceleration of the fluid is achieved by a corresponding movement in translation or by a partially pivoting movement of the drive bodies in the manner of the fin principle known from biology (e.g. aerodynamics and hydrodynamics).

In the Claims:

Claims 1-22 (canceled).

23. (new) A conveying device for the conveying of a fluid in a conveying direction having at least one drive body which can be driven by means of a drive system and which has a conveying surface, wherein the drive body can be driven in an oscillating manner transversely to the conveying direction and is flowed around on a plurality of sides by the fluid to be conveyed, and wherein the drive body can be compressed together with a housing surrounding it.

24. (new) The conveying device in accordance with claim 23, wherein the drive body/bodies can be driven by means of a rotatable shaft.

25. (new) The conveying device for the conveying of a fluid in a conveying direction having at least one drive body which can be driven by means of a drive system and which has a conveying surface, wherein the drive body can be driven in an oscillating manner transversely to the conveying direction, characterized by blocks which are laterally fastened to at least one drive body and which form a barrier between different conveying surfaces of a drive body.

26. (new) The conveying device in accordance with claim 25, wherein at least one block is connected either to two drive bodies or to one drive body and a housing of the conveying device.

27. (new) The conveying device in accordance with claim 26, wherein a driving force is applied to the drive bodies by means of the blocking body/bodies.

28. (new) The conveying device in accordance with claim 23, wherein at least one drive body is pivotable in an oscillating manner about an axis extending transversely to the conveying direction.

29. (new) A conveying device for the conveying of a fluid in a conveying direction having at least one drive body which can be driven by means of a drive system and which has a conveying surface, wherein the drive body can be driven in an oscillating manner transversely to the conveying direction, wherein the drive body/bodies is/are pivotable in an oscillating manner about an axis extending in the conveying direction, in particular outside the drive body/bodies.

30. (new) The conveying device in accordance with claim 23, wherein at least one conveying surface of at least one drive body is aligned such that a partial force acts on the fluid in the conveying direction on a movement of the drive body.

31. (new) The conveying device in accordance with claim 30, wherein two conveying surfaces are aligned such that they effect a conveying of fluid in a respective at least one movement direction of a drive body.

32. (new) The conveying device in accordance with claim 23, wherein the at least one drive body tapers in the conveying direction in the cross-section disposed parallel to its movement plane.

33. (new) The conveying device in accordance with claim 23, wherein the at least one drive body is configured as stiff.

34. (new) The conveying device in accordance with claim 23, wherein the drive body is configured as elastic such that it is bendable in its end region by the fluid counterpressure in operation by at least 5° with respect to the non-deformed state.

35. (new) The conveying device in accordance with claim 34, wherein the drive body has microgrooves extending in the conveying direction.

36. (new) The conveying device in accordance with claim 23, wherein the at least one drive body has at least one hollow space.

37. (new) The conveying device in accordance with claim 23, wherein the at least one drive body comprises a foam.

38. (new) The conveying device in accordance with claim 37, wherein the at least one drive body is at least partly inflatable.

39. (new) The conveying device in accordance with claim 23, wherein the drive body can be driven by means of a hydraulic or pneumatic device.

40. (new) The conveying device in accordance with claim 23, wherein the drive body can be driven by means of an electric and/or magnetic device.

41. (new) The conveying device in accordance with claim 23, wherein the drive body or bodies is/are deformed in operation against the fluid pressure on the respective pressure side.

42. (new) The conveying device in accordance with claim 41, wherein the deformation of the pressure side takes place by inner struts of the drive body without any additional external energy supply.

43. (new) The conveying device in accordance with claim 20, wherein the deformation of the pressure side takes place by the so-called fin-ray effect.

44. (new) The conveying device in accordance with claim 23, wherein it is a blood conveying device.

45. (new) The conveying device in accordance with claim 37, wherein the at least one drive body comprises polyurethane.

46. (new) The conveying device in accordance with claim 39, wherein the at least one drive body can be driven by a balloon body.

REMARKS

Applicants have amended the specification, abstract and claims to eliminate multiple dependencies and adapt the subject specification to U.S. patent practice.

Claims 1-22 were canceled. New claims 23 - 46 were added. Claims 23 - 46 are currently pending in the subject application. No new matter has been added by these amendments.

Favorable consideration of the application as amended is respectfully requested.

Respectfully submitted,

Stephen Evans

Stephen P. Evans
Registration No. 47,281

ATTORNEYS
Customer Number 00001678
MARSHALL & MELHORN, LLC
Four SeaGate - 8th Floor
Toledo, Ohio 43604

Phone: (419) 249-7138
Fax: (419) 249-7151
Email: evans@marshall-melhorn.com

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

To:
Pfenning, Meinig & Partner GbR
Joachimstaler Strasse 12
10719 Berlin
ALLEMAGNE

EINGEGANGEN
- 8. Juni 2011
Frist

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

	Date of mailing *(day/month/year)* 8 June 2011 (08-06-2011)
Applicant's or agent's file reference 107PCT 2211	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/EP2011/000439	International filing date *(day/month/year)* 27 January 2011 (27-01-2011)
Applicant ECP ENTWICKLUNGSGESELLSCHAFT MBH	

1. [X] The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the International Search Report.

   Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Fascimile No.: (41-22) 338.82.70

   For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 - 9.011.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. [ ] **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

   [ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

   [ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. Following the expiration of 30 months from the priority date, these comments will also be made available to the public.

   Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

   Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

   In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months.

   For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide*, National Chapters.

Name and mailing address of the International Searching Authority	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040 Fax: (+31-70) 340-3016	RASMUSSEN, Sine Tel: +31 (0)70 340-4595

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 107PCT 2211	**FOR FURTHER ACTION** see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
International application No. PCT/EP2011/000439	International filing date *(day/month/year)* 27/01/2011	(Earliest) Priority Date *(day/month/year)* 27/01/2010
Applicant ECP ENTWICKLUNGSGESELLSCHAFT MBH		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 6 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      [X] the international application in the language in which it was filed
      [ ] a translation of the international application into ____________, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. [ ] This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. [ ] **Certain claims were found unsearchable** (See Box No. II)

3. [ ] **Unity of invention is lacking** (see Box No III)

4. With regard to the **title**,
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings**,
   a. the figure of the **drawings** to be published with the abstract is Figure No. 3
      [X] as suggested by the applicant
      [ ] as selected by this Authority, because the applicant failed to suggest a figure
      [ ] as selected by this Authority, because this figure better characterizes the invention
   b. [ ] none of the figures is to be published with the abstract

International application No.
PCT/EP2011/000439

INTERNATIONAL SEARCH REPORT

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/000439

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61M1/10 F04D33/00
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)
A61M F04D B63H

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 practical, 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 √√	WO 98/18508 A1 (DOBAK JOHN D III [US]; GHAERZADEH KAMBIZ [US]) 7 May 1998 (1998-05-07) page 9, line 2 - page 11, line 23 figures 1-2	1,8-10, 12-19,22
X √	WO 2009/157840 A1 (CARDIOBRIDGE GMBH [GE]; REITAN OEYVIND [SE]; EPPLE KLAUS [DE] CARDIOBR) 30 December 2009 (2009-12-30) page 5, line 7 - page 7, line 31 figures 1, 1b, 1c	1,2,8,9, 11,18,22
X,P √	EP 2 194 278 A1 (ECP ENTWICKLUNGSGMBH [DE]) 9 June 2010 (2010-06-09) paragraphs [0033] - [0066] figures 1-4, 10, 11	1,2, 8-10,12, 13, 18-20,22

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 May 2011	08/06/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Schlaug, Martin

1

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 1 218 663 A (KUETTNER HUGO) 12 May 1960 (1960-05-12) page 1, right-hand column, line 7 - page 2, left-hand column, line 4 figure 1	1,3,7
A	DE 103 37 804 A1 (WILO AG [DE]) 24 March 2005 (2005-03-24) paragraphs [0023] - [0036] figures 1-3	1,3,7
A	WO 2006/038808 A1 (CLAVIS BIOPROPULSION AS [NO]; SAGOV MAGOMET S [NO]) 13 April 2006 (2006-04-13) page 7, lines 3-10 page 10, line 5 - page 12, line 10 figures 6-13	1,3,7
A	WO 2005/003545 A1 (ROBINSON NICHOLAS PAUL [GB]) 13 January 2005 (2005-01-13) page 19, line 23 - page 20, line 14 figure 8	1,3,7

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/000439

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
WO 9818508	A1	07-05-1998	AU	5000597	A	22-05-1998
			EP	1017430	A1	12-07-2000
WO 2009157840	A1	30-12-2009	CN	102065924	A	18-05-2011
			DE	202009018145	U1	05-05-2011
			EP	2288392	A1	02-03-2011
			EP	2308422	A1	13-04-2011
			US	2011034874	A1	10-02-2011
EP 2194278	A1	09-06-2010	WO	2010063494	A1	10-06-2010
FR 1218663	A	12-05-1960	NONE			
DE 10337804	A1	24-03-2005	NONE			
WO 2006038808	A1	13-04-2006	AT	507141	T	15-05-2011
			CA	2624600	A1	13-04-2006
			CN	101072708	A	14-11-2007
			EP	1814780	A1	08-08-2007
			JP	2008515712	T	15-05-2008
			US	2009023349	A1	22-01-2009
WO 2005003545	A1	13-01-2005	AU	2003304285	A1	21-01-2005

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1, 2(completely); 6, 8-22(partially)

   A conveying device for conveying a fluid with a drive body, that can be driven in an oscillating manner transversely to the conveying direction
   with further features relating to the drive body being compressible together with a housing surrounding it;

1.1. claims: 3-5(completely); 6, 8-22(partially)

   A conveying device for conveying a fluid with a drive body, that can be driven in an oscillating manner transversely to the conveying direction
   with further features relating to blocks which are laterally fastened to at least one drive body and which form a barrier between different conveying surfaces of a drive body;

1.2. claims: 7(completely); 8-22(partially)

   A conveying device for conveying a fluid with a drive body, that can be driven in an oscillating manner transversely to the conveying direction
   with further features relating the drive bodies being pivotable in an oscillating manner about an axis extending in the conveying direction.

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:

see form PCT/ISA/220

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY
(PCT Rule 43*bis*.1)

Date of mailing (*day/month/year*) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date (*day/month/year*)	Priority date (*day/month/year*)
PCT/EP2011/000439	27.01.2011	27.01.2010

International Patent Classification (IPC) or both national classification and IPC
INV. A61M1/10 F04D33/00

Applicant
ECP ENTWICKLUNGSGESELLSCHAFT MBH

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☒ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☒ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notifed the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA:	Date of completion of this opinion	Authorized Officer
European Patent Office P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Fax: +31 70 340 - 3016	see form PCT/ISA/210	Schlaug, Martin Telephone No. +31 70 340-2504

13/261361
IAP01Rec'd PCT 13 JUL 2012

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/EP2011/000439

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing filed or furnished:

   a. (means)

      ☐ on paper

      ☐ in electronic form

   b. (time)

      ☐ in the international application as filed

      ☐ together with the international application in electronic form

      ☐ subsequently to this Authority for the purposes of search

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

Box No. IV Lack of unity of invention

1. ☐ In response to the invitation (Form PCT/ISA/206) to pay additional fees, the applicant has, within the applicable time limit:

   ☐ paid additional fees

   ☐ paid additional fees under protest and, where applicable, the protest fee

   ☐ paid additional fees under protest but the applicable protest fee was not paid

   ☐ not paid additional fees

2. ☒ This Authority found that the requirement of unity of invention is not complied with and chose not to invite the applicant to pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rule 13.1, 13.2 and 13.3 is

   ☐ complied with

   ☒ not complied with for the following reasons:

   see separate sheet

4. Consequently, this report has been established in respect of the following parts of the international application:

   ☒ all parts.

   ☐ the parts relating to claims Nos. 1-22

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	3-7, 13, 15, 20, 21
	No:	Claims	1, 2, 8-12, 14, 16-19, 22
Inventive step (IS)	Yes:	Claims	3-7, 20, 21
	No:	Claims	1, 2, 8-19, 22
Industrial applicability (IA)	Yes:	Claims	1-22
	No:	Claims	

2. Citations and explanations

   see separate sheet

Box No. VI Certain documents cited

1. Certain published documents (Rules 43*bis*.1 and 70.10)

   and / or

2. Non-written disclosures (Rules 43*bis*.1 and 70.9)

   see form 210

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Re Item IV.

1 The application does not meet the requirements of unity of invention as defined in Rules 13.1 and 13.2 PCT.

1.1 The document WO 2006/038808 discloses a conveying device having at least one drive body, which can be driven by means of a drive system and which has a conveying surface and wherein the drive body can be driven in an oscillating manner transversely to the conveying direction and therefore all common features of independent claims 1, 3 and 7.

1.2 Therefore the Authority considers the following groups of claims:

I. group: claims 1, 2 and 6, 8-22 partial:

A conveying device for conveying a fluid with a drive body with further features as potential special technical features within the meaning of Rule 13.2 PCT relating to the drive body being compressible together with a housing surrounding it and solving the following technical problem:

"provide a pump that can be introduced through a blood vessel (see page 2, lines 19-20 of the application)";

II. group: claims 3-5 and 6, 8-22 partial:

A conveying device for conveying a fluid with a drive body with further features as potential special technical features within the meaning of Rule 13.2 PCT relating to blocks which are laterally fastened to at least one drive body and which form a barrier between different conveying surfaces of a drive body and solving the following technical problem:

"reduce pressure equalization between the high pressure and low pressure side of each drive body (see page 20, line 33 - page 21, line 2 of the application)"

III. group: claims 7 and 8-22 partial:

A conveying device for conveying a fluid with a drive body with further features as potential special technical features within the meaning of Rule 13.2 PCT relating to the drive bodies being pivotable in an oscillating manner about an axis extending in the conveying direction and solving the following technical problem:

"provide an alternative drive principle (see page 18, line 31 of the application)"

1.3 The three groups of claims defined above forming the 3 potential inventions are not so linked as to form a single general inventive concept, as required by Rule 13.1 PCT, because all common technical features, that could be considered to be unifying, are fully disclosed in combination together with their technical effects in the document WO2006/038808. The inventions do consequently not have a common special technical feature either. Although all groups of claims are related to a conveying device, they solve different and unrelated problems and are thus lacking a single general inventive concept.

Consequently, neither the objective problem underlying the subjects of the claimed inventions, nor their solutions defined by the special technical features allow for a relationship to be established between the said potential inventions, which involves a single general inventive concept.

1.4 In conclusion, the groups of claims are not linked by common or corresponding special technical features and define three different potential inventions not linked by a single general inventive concept. The application hence does not meet the requirements of unity of invention as defined in Rules 13.1 and 13.2 PCT.

1.5 The invention I together with both sub-inventions I-1 and I-2 have been searched (sub-inventions I-1 and I-2 were already searched in the frame of EP-application EP10075043, see also search report).

Re Item V.

2 Reference is made to the following documents:

D1 WO 98/18508 A1 (DOBAK JOHN D III [US]; GHAERZADEH KAMBIZ [US]) 7 May 1998 (1998-05-07)

D2 WO 2009/157840 A1 (CARDIOBRIDGE GMBH [GE]; REITAN OEYVIND [SE]; EPPLE KLAUS [DE] CARDIOBR) 30 December 2009 (2009-12-30)

3 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of independent claim 1 is not new in the sense of Article 33(2) PCT.

3.1 The document D1 discloses (see page 9, line 2 - page 11, line 23; figures 1-2, the references in parentheses applying to this document):

A conveying device (10) for the conveying of a fluid in a conveying direction having at least one drive body (14) which can be driven by means of a drive system and which has a conveying surface (inner or outer side of membrane, see also page 9, lines 6-10), wherein the drive body (14) can be driven in an oscillating manner transversely to the conveying direction (see page 11, lines 10-23) and is flowed around on a plurality of sides by the fluid to be conveyed (e.g. all inner sides of the membrane enclosing the fluid to be conveyed), and wherein the drive body can be compressed together with a housing surrounding it (see page 9, lines 17-31).

The subject matter of claim 1 is therefore not new (Article 33(2) PCT).

3.2 The technical features of claim 1 are also fully disclosed in combination in document D2 (see page 5, line 7 - page 7, line 31; figures 1, 1b, 1c) and this claim therefore lacks novelty also in view of this document (Article 33(2) PCT).

3.3 Comment: Claim 1 does not establish a causal relationship between the oscillatory movement of the drive body and the actual conveying action / direction. It only reads, that "the drive body can be driven in an oscillating manner ...". This is possible with numerous pumping devices.

4 The dependent claims 1, 2, 8-19, 22 do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step, the reasons being as follows:

4.1 ad claim 2: see D2, page 6, line 10-13 (Article 33(2) PCT);

4.2 ad claims 8, 9: see D1, page 11, lines 10-23 and figure 1 (Article 33(2) PCT);

4.3 ad claim 10: see D1, fig1 (Article 33(2) PCT);

4.4 ad claim 11: see D2, figure 1c (implicitly disclosed) (Article 33(2) PCT);

4.5 ad claim 12: see D1, figure 1 (Article 33(2) PCT);

4.6 ad claim 13: the application does not disclose a technical problem solved by the microgrooves, claim 13 is therefore not considered inventive (Article 33 (3) PCT);

4.7 ad claim 14: see D1, figure 1 (Article 33(2) PCT);

4.8 ad claim 15: the use of foam or polyurethane is a standard design choice for e.g. blood pumps (Article 33(3) PCT);

4.9 ad claims 16, 17: see D1, page 9, lines 6-10 (Article 33(2) PCT);

4.10 ad claim 18: see D2, page 5, lines 14-17 (Article 33(2) PCT);

4.11 ad claim 19: see D1, page 11, lines 10-23 (Article 33(2) PCT);

4.12 ad claim 22: see D1, page 9, line 11 (Article 33(2) PCT);

5 The devices described in claims 1-22 are industrially applicable. Therefore the requirements of Article 33(4) PCT are met.

Re Item VI.

6 Certain documents cited:

Publication No	Publication date *(day/month/year)*	Filing date *(day/month/year)*	Priority date *(valid claim)* *(day/month/year)*
EP2194278	09/06/2010	05/12/2008	05/12/2008

Re Item VII.

7 The independent claims 1 and 7 are not in the two-part form in accordance with Rule 6.3(b) PCT, which in the present case would be appropriate, with those features known in combination from the prior art being placed in the preamble (Rule 6.3(b)(i) PCT) and with the remaining features being included in the characterising part (Rule 6.3(b)(ii) PCT).

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/261,361	Filing Date 10/03/2012	☐ To be Mailed

APPLICATION AS FILED – PART I

SMALL ENTITY ☒ OR OTHER THAN SMALL ENTITY

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY RATE ($)	SMALL ENTITY FEE ($)		OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
			TOTAL			TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED – PART II

SMALL ENTITY OR OTHER THAN SMALL ENTITY

AMENDMENT	07/13/2012	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 24	Minus	** 24	= 0	X $30 =	0	OR	X $ =	
	Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $125 =	0	OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE	**0**	OR	TOTAL ADD'L FEE	

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/MARGARET BYARS/

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(71) Applicant *(for all designated States except US)*: **ECP ENTWICKLUNGSGESELLSCHAFT MBH** [DE/DE]; Wiesenweg 10, 12247 Berlin (DE).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **LIEBING, Reiner** [DE/DE]; Schmiedegasse 43, 14469 Potsdam (DE).

(74) Agent: **PFENNING, MEINIG & PARTNER GBR**; Joachimstaler Strasse 12, 10719 Berlin (DE).

(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, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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.

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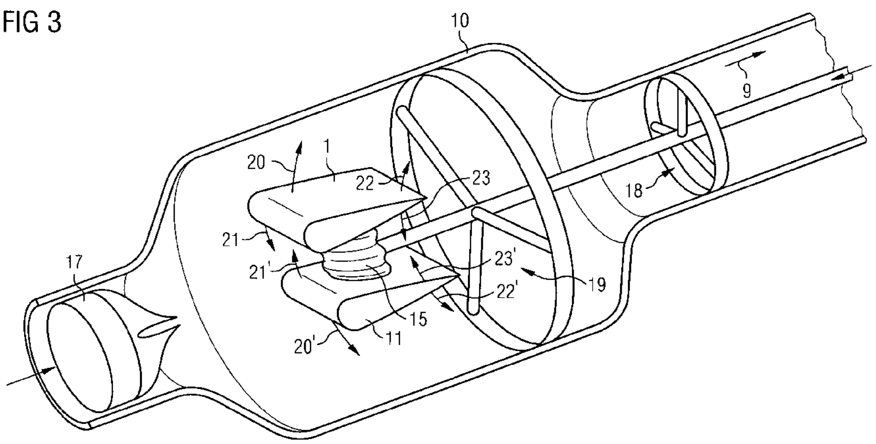
Published:
— *with international search report (Art. 21(3))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

WO 2011/092034 A1

(54) Title: CONVEYING DEVICE FOR A FLUID

FIG 3



(57) Abstract: The invention relates to a conveying device for conveying a fluid in a conveying direction (9) having one or more drive bodies (1, 1', 1'', 1''', 11, 11', 11'', 11''') which can be driven in an oscillating manner by means of a drive system (15, 15') transversely to the conveying direction. An acceleration of the fluid is achieved by a corresponding movement in translation or by a partially pivoting movement of the drive bodies in the manner of the fin principle known from biology (e.g. aerodynamics and hydrodynamics).

Conveying device for a fluid

The invention is in the field of mechanical engineering and relates to conveying devices for fluids, in particular for liquids.

Such conveying devices have become known in the form of different kinds of pumps in the most varied of embodiments. Pumps are of particular interest at this point which can be manufactured in such constructions that they can be used for more sensitive fluids, in particular fluids having macromolecules. A specific group among such pumps is represented by the fluid pumps which can be used for medical application purposes and which can be manufactured in small constructions. Such pumps can also be used in micro constructions, for example, for conveying the body's own fluids, or biocompatible fluids, for example as heart pumps for conveying blood.

In the conveying of such sensitive fluids such as blood which have large and sensitive molecules, for example, which satisfy biological functions and which therefore also may not be damaged at the microscopic level, care must be taken that the mechanical effect on the fluid by pressure maxima, shear forces and accelerations is limited as much as possible.

Axial flow pumps have in particular become known in this connection, for example, for the conveying of blood which have a rotor which rotates about a longitudinal axis, which has impeller blades and which continuously conveys blood in the axial direction.

Since a specific problem for the use of such pumps in the inside of the body comprises the fact of providing them, on the one hand, with sufficient conveying capacity, and, on the other hand, however, of configuring the construction size so that they can be introduced through a blood vessel, some of the challenges for such pumps comprise the fact of configuring them from a construction aspect so that they are radially compressible and expandable again for operation in the body.

A compressible rotor of this kind is known, for example, from US 6,860,713. Another rotor is known from US 7,393,181 B2. In the known solutions, the rotors are compressible and expandable either due to the elasticity and deformability of the material or on the basis of mechanically movable constructions.

It is unavoidable in this respect that a certain construction effort is exerted to ensure the compressibility of such a pump despite a

corresponding reliability and conveying capacity. It must moreover be ensured that large shear forces which can damage sensitive fluids do not arise due to too high a rotational speed of the rotor or due to unfavorable geometrical shapes of impeller blades. In addition, care must be taken that pressure differences within the geometry of such a conveying device, on the one hand, and over the course of time, on the other hand, are kept within tight limits.

Under these conditions and against the background of the prior art, it is the underlying object of the present invention to provide a conveying device which can be manufactured with means which are simple from a construction aspect and which reliably and gently allow the conveying of a fluid.

The object is achieved in accordance with the invention by the features of claim 1, alternatively by the features of claim 3 or claim 7.

The conveying device in accordance with the invention, which serves to move a fluid in a conveying direction, for this purpose has a drive body which can be driven by means of a drive system and which can be driven in an oscillating manner transversely to the conveying direction.

The drive body is arranged in a channel or in a space in which the fluid should be conveyed in a preset conveying direction.

Known conveying mechanisms such as centrifugal pumps or the above-named axial flow pumps make use of rotating conveying elements for moving or accelerating a fluid. The likewise known piston pumps respectively have at least one piston which is substantially movable in translation and which conveys the medium in its direction of movement on its movement.

In contrast to this, in accordance with the present invention, the drive body is moved transversely to the conveying direction in the manner of a fin of a fish which is used in nature as a rule to generate a relative movement between the fin and a fluid. In the present invention, the fin-like element, the drive body, is in this respect substantially fixed in the conveying direction so that the relative movement results in a conveying movement of the fluid.

The movement of the drive body transversely to the conveying direction in this respect, for example, means that at least one part of the drive body is moved in translation or along a less curved path substantially perpendicular to the conveying direction and/or associated with a pivot movement about an axis which is substantially perpendicular to the conveying direction. In this respect, the deviation of the direction of extent of the axis to the perpendicular of the conveying direction should amount to a maximum of 45°. In this respect, movement patterns of fin-like bodies in fish and other creatures known from bionics should be reproduced.

The corresponding drive bodies can be adapted in shape and size to the available space. The relative movement of the drive body or of different parts of said drive body with respect to the fluid to be driven can be kept in a range with respect to the speed which prevents the creation of unpermitted shear forces. In this respect, the relative speed is to be coordinated with the viscosity of the medium to be conveyed and accordingly with possibly present compressibilities. The conveying principle described can be used particularly efficiently with substantially non-compressible and slightly liquid media such as blood. Corresponding drive movements can also be transmitted easily to a drive body to be moved in an oscillating manner. A rotatable journalling of a rotor does not necessarily have to be provided.

The drive body or bodies are flowed around by the fluid to be conveyed at multiple sides, in particular at all sides. In particular when two mutually opposite conveying surfaces are provided, they are each both in contact with the fluid to be conveyed.

The drive body or bodies are compressible together with a housing surrounding them in the radial direction with respect to the conveying direction. For this purpose, the drive bodies can be configured as foldable, as elastically compressible as foam or as inflatable. The housing can likewise be foldable and can comprise a membrane spanned over a support frame. The support frame can comprise a plastic or a metallic memory alloy, for example Nitinol or another superelastic material. The housing can also be configured as inflatable, in particular as a double-wall balloon body.

Since a certain periodicity of pressure fluctuations is to be expected due to the oscillatory movement of the drive body, with an occasional reversal of the flow direction not always being able to be precluded on such pressure fluctuations, the arrangement of a control valve for the flow to be generated in the conveying channel or in the space in which the drive body is located can also advantageously be considered. In this respect, the valve can either be controlled by an intelligent control synchronously with the movement of the drive body or it can be configured as an automatically acting check valve.

The conveying surface or a conveying surface of the drive body is advantageously aligned so that a partial force acts on the fluid in the conveying direction on a movement of the drive body. For this purpose, the direction of movement of the drive body and the direction of extent of the surfaces of the drive body at which a pressure increase arises are to be correspondingly coordinated with one another.

In this connection, at least two conveying surfaces can be provided, for example at a single drive body, which are aligned so that they each effect a conveying of the fluid in at least one of the directions of movement of the drive body. A conveying of the fluid in both drive movement directions or in a plurality of drive movement directions thus becomes possible. Two conveying surfaces can be provided at two different, mutually opposite outer surfaces of a drive body.

Provision can moreover advantageously be made that at least one drive body tapers in the conveying direction in the cross-section disposed parallel to its movement plane.

The drive body can, for example, be configured in the manner of a fin as a wedge-shaped body whose thickened end is arranged upstream with respect to the flow to be produced and whose tapered end is arranged downstream. The tapered end can converge acutely in the form of a blade edge, with the blade edge being able to extend perpendicular to the drive direction of the drive body. The drive body can also be widened toward its tapered end in the direction of extent of the cutting blade.

The conveying surfaces at both sides of such a wedge-shaped fin body can be either planar or convex or concave, viewed in the direction perpendicular to the movement plane or to the drive direction of the drive body.

The drive body can be stiff in one type of embodiment of the invention. In this case, the drive body can be pivotable about an axis which lies in the region of its thickened end. In addition, a superimposed movement in translation of the thickened end can be provided, for example in a straight manner or along a gate path. The movement portion in translation takes place in the same plane as the pivot movement in this respect.

Alternatively to this, provision can also be made that the drive body is so elastic that it can also be bent in operation in its end region by the fluid counterpressure by at least 5°, in particular also by at least 20°, with respect to the undistorted state.

The drive can in this case be configured in the same manner as with a stiff drive body, but the alignment of the conveying surfaces relative to the fluid to be conveyed in the respective phase of the drive movement can already be optimized and thus the efficiency of the drive increased by the elasticity and deformability of the drive body per se.

Such a drive body, whether stiff or elastic, can either be configured as symmetrically wedge-shaped, with planar, concave or convex conveying surfaces in the cross-section viewed perpendicular to the plane of the drive movement or a shape asymmetrical in the named cross-section can also be provided, for example with elements of an airfoil wing, to utilize additional flow effects. Such an airfoil section, for example, provides a convex shape on one side of the drive body and a convex or straight shape of the conveying surface on the opposite side.

On the use of such an asymmetrical design of a drive body, a further drive body can additionally be provided which is shaped and arranged in mirror form with respect to the first drive body and which is movably in synchronization with it in the same or opposite sense.

Provision can moreover be made to increase the efficiency of the drive that the drive body, in particular in the region of a conveying surface, has optimized surface structures.

In an advantageous embodiment of the invention, provision can moreover be made that the drive body has at least one hollow space. The provision of a hollow space reduces the mass of the drive body and thus the energy to be expended for its acceleration. In addition, the drive body can be configured as at least partially inflatable so that its outer dimensions in the non-inflated state can be smaller than in the inflated state. Such a drive body can then be brought more easily to its deployment site in the non-inflated state and inflated to the operating dimensions there. This is in particular advantageous when the conveying device should be manufactured in very small dimensions and moved within blood vessels.

The drive body can moreover advantageously comprise a foam, in particular polyurethane. The drive body can thus be manufactured as elastically deformable and as very light. The drive body can also comprise a hardenable material or generally a material whose deformability can be directly changed by physical influence, e.g. by irradiation, temperature change or by chemical reactions.

Provision can be made in the conveying device in accordance with the invention by providing a corresponding drive system that the drive body can be driven by means of a hydraulic or pneumatic device, in particular by means of a balloon body, but also by means of an electric and/or magnetic device.

Although one or more drive bodies in accordance with the invention can be moved simply by means of levers or similar mechanical devices, the drive movement can particularly easily be conducted to the conveying device by a hydraulic or pneumatic drive device. Corresponding pneumatic or hydraulic lines can be laid, for example, in the form of a hollow catheter or also within a hollow catheter, at the distal end of which the conveying device is provided, and can either act directly on a piston, bellows or balloon-like drive body in the region of the conveying device or can be converted into a lever movement there.

Possible drive movements of the drive body or bodies in this respect provide that at least one drive body is pivotable in an oscillating manner about an axis extending transversely to the conveying direction; and/or that one or more drive bodies are pivotable in an oscillating manner about an axis extending in the conveying direction, in particular outside the conveying bodies.

It is special about such an oscillatory movement that the pivot movement has a relatively small stroke so that a full rotation of the drive body does not take place in any case.

A rotation about larger angles can, however, also be provided on the rotation about an axis extending in the conveying direction.

To reduce unwanted pressure compensation procedures at the drive bodies, blocking bodies can be arranged on them between their conveying surfaces. Said blocking bodies should be flexible and can in this respect be configured as pliable or stiff, but bendable. The blocking bodies can also connect two respective blocking bodies to one another or one blocking body to a housing wall.

Provision can also be made that the driving force is transmitted to a drive body by means of a blocking body.

The described fin-like drive principle for fluids is novel in connection with the conveying of liquids and thus allows the realization of conveying characteristics which cannot be achieved with the already known conveying devices.

The invention will be shown and subsequently described in the following with reference to an embodiment in a drawing.
There are shown

Fig. 1 a drive body in three positions in cross-section;

Fig. 2 a conveying system for fluids having two drive bodies in a longitudinal section;

Fig. 3 a conveying system having two drive bodies in a three-dimensional view;

Fig. 4 two drive bodies in a first position with a drive system;

Fig. 5 the drive bodies from Fig. 4 in a second position;

Fig. 6 the drive bodies from Figs. 4 and 5 in a third position;

Fig. 7 a drive system in a three-dimensional representation having a conveying space quadrangular in cross-section;

Fig. 8 two drive bodies which are rotated in an oscillating manner about an axis extending in the conveying direction;

Fig. 9 a drive system in a three-dimensional view having two partly cylindrical drive bodies;

Fig. 10 a section through the drive system of Fig. 9;

Fig. 11 an embodiment as in Fig. 3 with additional blocking bodies;

Fig. 12 an embodiment similar to that of Fig. 7 with blocking bodies;

Fig. 13 a representation of two drive bodies which are connected by means of blocking bodies;

Fig. 14 the embodiment of Fig. 13 in a front view;

Fig. 15 a view of the embodiment of Fig. 13, with the effect of a driving force on the blocking bodies being indicated;

Fig. 16 an arrangement in which the blocking bodies have a stiff, but bendable ring-strip shape;

Fig. 17 a drive body having fin-rays in the neutral state; and

Fig. 18 a drive body as in Fig. 17 in the loaded state.

Fig. 1 shows in the middle part a drive body 1 in section which substantially has a wedge shape which is modeled on the shape of a fin occurring in biology. The drive body 1 extends perpendicular to the plane of the drawing with an unchanging section, but can also widen perpendicular to the plane of the drawing toward its tapered end.

The drive body 1 can be moved in an oscillating manner along the dotted line 2 in the directions indicated by the arrows 3, 4. The region about the point of attack of the driving force is in this respect shown as a circle and is marked by 5. The driving force engages at this point such that the drive body is moved substantially in translation along the line 2 and is thus not pivotable in a first variant to avoid an active fluid counterpressure.

A fluid counterpressure then results in operation, for example on the movement of the drive body within a liquid, on the side of the respectively acting conveying surface 6, 7, said fluid counterpressure resulting in a deformation of the end 8 of the drive body 1 remote from the drive, i.e. the tapered end, when this drive body is configured as elastic as in the example shown. A particularly efficient advance of the driven fluid in the conveying direction 9 results by this effect.

Alternatively, the drive of the drive body 1 can also be configured so that it is not driven strictly in translation in the sense of the directions 3, 4, but rather in a superimposed movement in translation and in a pivot movement. In this respect, for example simultaneously with the movement in the direction of the arrow 3, a pivoting of the drive body takes place about the point of attack 5 clockwise about a specific angle, for example 10°, so that the drive body inclines at the end of the movement in a similar manner as under the effect of a fluid counter-pressure. Optionally, the direction of rotation of the pivot movement can be reversed at the end of the movement in translation to beat with the fin. This driving principle can be combined both with stiff drive bodies and with flexible drive bodies.

A specific lever drive or a gate drive of the drive body can be provided for this purpose or it is conceivable to transmit the driving forces by means of a hydraulic or pneumatic apparatus.

Fig. 2 shows in a side view a housing 10 in which a conveying device in accordance with the invention having two drive bodies 1, 11 is arranged. The housing 10 is set up rotationally symmetrically or elliptically in cross-section about the drive bodies 1, 11 and has an inflow channel 12 as well as an outflow channel 13. A fluid line 14 which is part of the drive system and which is connected to a drive bellows 15 projects through the outflow channel 13. The drive bellows 15 can be connected via a pressure control device, not shown, via the fluid line 14 to an overpressure or to an underpressure so that said drive bellows can be inflated or deflated by the inflow of a fluid or the removal of the fluid.

One respective drive body 1, 11 is fastened to the two ends 15a, 15b of the drive bellows 15 and runs through a drive movement in the direction of the arrows 3, 4 by the volume changes of the drive bellows. The drive movement in translation of the drive bellows 15 can be translated into a more complex movement path of the drive bodies 1, 11, which can correspond to a superimposition of the movement in translation with a pivot movement, by a corresponding elastic configuration of the drive bellows 15 or by additional levers which connect the bellows to the drive bodies 1, 11 or the drive bodies to a fixed point of the housing 10.

Provision can, however, also be made that the movement of the drive bodies 1, 11 substantially takes place in translation and said drive bodies are configured as elastic to carry out the elastically fin-like overall movement shown with reference to Fig. 1.

If the pressure in the drive bellows 15 is changed periodically via the control of the fluid pressure in the fluid line 14, for example several times per second, this is translated into an oscillatory movement of the drive bodies 1, 11. This results in an acceleration of the fluid located in the housing 10 in the direction of the arrow 16 which designates the conveying direction of the fluid. Since pressure fluctuations occur due to the periodicity of the movement, it may be meaningful to provide a check valve 17 in the inflow channel 12 which blocks the inflow channel 12 for the case that an overpressure arises within the housing 10 in front of the valve and closes it again as soon as an underpressure is generated there.

The fluid line 14 can be configured as a flexible hose line provided that the drive bellows 15 is held otherwise in the housing 10. The drive line 14 can, however, also be configured as a rigid line in the form of a pipe in order simultaneously to conduct the fluid and to fix the drive bellows and the drive bodies 1, 11. The fluid line 14 can in every case be held and fixed in a holding star 18 or at a holding arm within the outflow channel 13.

In the Figure, three positions are shown for each drive body 1, 11, with a middle neutral position being shown by solid lines and the extreme positions on the movement path of each individual drive body 1, 11 being shown by broken lines.

Fig. 3 shows a similar arrangement to Fig. 2, but in a three-dimensional view, with a second holding star 19 being provided in addition to the first holding star 18 in direct vicinity of the drive bellows 15 and of the drive bodies 1, 11.

Arrows 20, 21 and 20', 21' are drawn in which indicate the directions of movement of the respective thickened ends of the drive bodies 1, 11 as are arrows 22, 23 and 22', 23' which indicate the movement of the tapered ends of the drive bodies 1, 11. The different lengths of the arrows shown should indicate that the thickened ends of the drive bodies 1, 11 facing the one-way valve 17 carry out a pivot movement whose amplitude is substantially larger than the movement of the tapered ends of the drive bodies. This is made possible, as will be shown in more detail with reference to Figs. 4, 5 and 6, by a special construction of the drive bellows 15.

Fig. 4 shows in a side view in the upper part the two drive bodies 1, 11 as well as the drive bellows 15 in the deflated, i.e. compressed, form. The arrow 24 indicates that an underpressure is present in the fluid line 14 in this state to compress the drive bellows 15.

The drive bellows 15 itself has an asymmetrical structure, as can be seen more clearly from the lower part of Fig. 4. A cross-section through the drive bellows 15 along the dashed line A is shown there which makes clear that the drive bellows has a smaller wall thickness in its region facing the one-way valve 17 than in the outflow channel 13.

It is thereby achieved that the movement amplitude is larger in the front region facing the inflow channel 12 than in the rear region of the drive bellows facing the outflow channel 13. A pivot movement of the drive bodies 1, 11 therefore results on a pressure change in the drive bellows 15.

In Fig. 5, the arrangement of Fig. 4 with the drive bodies 1, 11 and a drive bellows 15 inflated further with respect to Fig. 4 is shown. The drive bodies are approximately in the straight position shown in Fig. 2.

Fig. 6 finally shows the state of the drive bodies 1, 11 in the fully inflated state of the drive bellows 15, with it also becoming clear that the thickened ends of the drive bodies 1, 11 have passed through a larger movement amplitude than the tapered ends so that a pivot movement of the drive bodies has taken place in addition to a movement in translation.

Fig. 7 shows in a three-dimensional view from a different perspective two drive bodies 1', 11' which are configured as asymmetrical in the manner of an aerodynamic airfoil section, but which may additionally also be configured as flexible and which can be driven by means of a drive bellows 15. The inflow channel 12 is shown in the foreground of the figure, the outflow channel 13 in the background. In contrast to the cylindrical housing 10 of the arrangement shown in Fig. 3, the housing 10' shown in Fig. 7 has a parallelepiped structure with a rectangular cross-section to implement the non-cylindrically symmetrical structure of the drive arrangement and of the drive bodies as efficiently as possible. Unlike the specific representation of Fig. 7, the transition from the housing 10' to the inflow and outflow channels 12, 13 can take place with conical or oblique transitions. Provision can advantageously be made that the drive bodies 1', 11' extend perpendicular to the plane of the drive movement up to as close as possible to the side walls 25, 26 of the housing 10'. Turbulence at the side surfaces of the drive bodies 1', 11' is thereby reduced.

The drive bodies 1', 11' can, just like the drive bodies 1, 11 shown further above, comprise a foam, in particular polyurethane, and can be inflatable. For this purpose, the bodies can have large and/or a plurality of small hollow spaces which can, for example, be inflated by the drive fluid via the fluid line 14 and which have check valves to be stabilized in the inflated state.

A good compressibility in the non-inflated state is hereby made possible so that the drive bodies can be radially compressed for transport to a deployment site together with the housing 10, 10' and can be expanded on site before they are put into operation.

Fig. 8 shows an arrangement in comparison with the Figures described further above having two drive bodies 1", 11" with another drive principle in which the drive bodies are connected via connection webs 28, 29 to a drive shaft 27 which extends in the conveying direction 30.

The drive shaft 27 can be rotated in an oscillating manner about the conveying direction 30, and indeed in each case, for example, at least by an amount of 5°, 10° or at least by 20° or 30°, in each direction, as indicated by the arrows 33, 34.

The longitudinal axes of the drive bodies 1" and 11" are aligned parallel to the shaft and undergo a movement quasi in translation in the peripheral direction of the shaft in the directions which are indicated by the arrows 31, 32 within the framework of this rotary movement, provided that the length of the connection webs 28, 29 is sufficient. In this manner, a corresponding approximately linear movement in translation of the drive bodies can be realized in a very simple manner by means of the drive shaft 27. In Figure 8, a plurality of parallel microgrooves 41 are also shown by way of example at the lower drive body 11".

In Fig. 9, an arrangement is shown in a three-dimensional view which is as largely cylindrically symmetrical as possible of two drive bodies 1''' and 11''' which are connected by a drive bellows 15' and which can be moved substantially in the direction of the arrows 35, 36 in the radial direction with respect to the cylinder axis. The drive bellows 15' is connected to a pressure generation system by means of a fluid line 14. It is also conceivable to divide the cylindrically symmetrical arrangement into a higher number of cylinder segments, for example 4 or 8 or more and to move them radially in each case, with a movement pattern resulting which is similar to the manner of propagation of jellyfish.

A section through the arrangement of Fig. 9 is shown in Fig. 10 which makes the function clear. The drive body 1''' is shown by way of example with a hollow space 37, the drive body 11''' with a hollow space 38, with the hollow spaces only being indicated schematically.

Fluid is exchanged via the fluid line 14 with the interior of the drive bellows 15 and is pumped from there into the hollow spaces 37, 38, with the hollow spaces 37, 38 of the drive bodies 1''' and 11''' being connected to the hollow space of the drive bellows 15' by means of one-way valves 39, 40 so that the drive bodies are only inflated once and then thereafter maintain the increased fluid pressure to be stabilized in shape. Only the interior of the drive bellows 15' is inflated and deflated thereafter. The drive bodies 1''', 11''' thereby alternately move apart in the direction of the arrows 35, 36 and move together in the opposite direction, whereby a corresponding drive movement is realized.

The efficiency of the conveying device with respect to the non-cylindrically symmetrical arrangements which are shown in the aforesaid Figures is increased by the cylindrically symmetrical or approximately cylindrically symmetrical arrangement of the drive bodies.

Fig. 11 shows a cylindrical arrangement of a housing 10 having two drive bodies 11 which are each laterally provided with blocking bodies 50, 51, 52, 52 which are flexible and may also be connected to the wall of the housing 10 and which prevent or reduce a pressure equalization between the lower side and upper side or the high pressure side and low

pressure side of each drive body during the drive movement.

Fig. 12 shows corresponding blocking bodies 53, 54 for a housing 10' with flattened side walls.

Fig. 13 shows two blocking bodies in the form of wide, flexible bands 55, 56 which connect two drive bodies to one another at both sides. This constellation is shown in a front view in Fig. 14.

Fig. 15 shows two blocking bodies 55, 56, as in Fig. 13, which connect two fin-like drive bodies to one another and act as an equalization block. The blocking bodies are configured as strips and can be configured as flexible or stiff and elastically pliable. In the latter case, a drive movement can be directly applied to the drive bodies by direct application of a mechanically, magnetically, pneumatically hydraulically or electrically generated driving force onto the blocking bodies from the outside, indicated by the arrows F_1 and F_1' or from the inside from the intermediate space of the drive bodies, indicated by the double arrow F_2.

Instead of the blocking bodies, similarly positioned coupling bodies in the form of a scaffold or frame can be provided to couple the drive movement into the sections.

The principle of the drive via the blocking bodies is additionally illustrated by way of example by Fig. 16. Two drive bodies 57, 58 are connected to one another there by two ring segments 59, 60 of a ring strip in the form of a circular ring. The cylinders 61, 62 symbolically indicate outwardly engaging

driving forces which can apply a traction force or a compression force to the ring segments from the outside. Corresponding inwardly engaging forces are symbolically designated by 63, 64. A deformation of the ring segments effects a drive movement of the drive bodies 57, 58. They can be controlled in a suitable manner by a profiling of the ring segments 59, 60 or by cut-outs in the ring segments.

In Figs. 17 and 18, a drive body is shown in a schematic plan view having so-called fin-rays 65 which have an influence on the flow of the fluid on the surface as web-like, groove-like or fin-like structures. They can be shaped and configured by their inner structure such that they effect a concave deformation and thus an increase in pressure on the pressure side on a movement of the drive body. This deformation against the pressure takes place automatically without any additional external energy supply and thus substantially differs from the deformation of customary beam structures which usually yield to a pressure increase on one side and evade the higher pressure.

The inner structure is formed by struts which preferably extend in the interior of a drive body from a drive surface to an oppositely disposed drive surface. The struts can in this respect be made as bars or also as plates, ribs or equivalent structures.

The conveying device for fluids in accordance with the invention allows an efficient configuration thanks to the use of an oscillatory movement transversely to the conveying direction of drive bodies, with the disadvantages of only rotating drive devices being avoided.

Claims

1. A conveying device for the conveying of a fluid in a conveying direction having at least one drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) which can be driven by means of a drive system and which has a conveying surface (6, 7), wherein the drive body can be driven in an oscillating manner transversely to the conveying direction (9) and is flowed around on a plurality of sides by the fluid to be conveyed, and wherein the drive body can be compressed together with a housing surrounding it.

2. A conveying device in accordance with claim 1, characterized in that the drive body/bodies can be driven by means of a rotatable shaft.

3. A conveying device for the conveying of a fluid in a conveying direction having at least one drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) which can be driven by means of a drive system and which has a conveying surface (6, 7), wherein the drive body can be driven in an oscillating manner transversely to the conveying direction (9), characterized by blocks which are laterally fastened to at least one drive body and which form a barrier between different conveying surfaces of a drive body.

4. A conveying device in accordance with claim 3, characterized in that at least one block is connected either to two drive bodies or to one

drive body and a housing of the conveying device.

5. A conveying device in accordance with either of claims 3 or 4, characterized in that the driving force is applied to the drive bodies by means of the blocking body/bodies.

6. A conveying device in accordance with claim 1 or one of the following claims, characterized in that at least one drive body (1, 1', 1'', 1''', 11, 11', 11'', 11''') is pivotable in an oscillating manner about an axis extending transversely to the conveying direction (9).

7. A conveying device for the conveying of a fluid in a conveying direction having at least one drive body (1, 1', 1'', 1''', 11, 11', 11'', 11''') which can be driven by means of a drive system and which has a conveying surface (6, 7), wherein the drive body can be driven in an oscillating manner transversely to the conveying direction (9), characterized in that the drive body/bodies (1'', 11'') is/are pivotable in an oscillating manner about an axis extending in the conveying direction (9), in particular outside the drive body/bodies.

8. A conveying device in accordance with claim 1 or one of the following claims, characterized in that at least one conveying surface (6, 7) of at least one drive body (1, 1', 1'', 1''', 11, 11', 11'', 11''') is aligned such that a partial force acts on the fluid in the conveying direction (9) on a movement of the drive body.

9. A conveying device in accordance with claim 8, characterized in that two conveying surfaces (6, 7) are aligned such that they effect a conveying of fluid in a respective at least one movement direction (3, 4) of a drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′).

10. A conveying device in accordance with claim 1 or one of the following claims, characterized in that at least one drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) tapers in the conveying direction (9) in the cross-section disposed parallel to its movement plane.

11. A conveying device in accordance with claim 1 or one of the following claims, characterized in that the at least one drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) is configured as stiff.

12. A conveying device in accordance with one of the claims 1 to 4, characterized in that the drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) is configured as elastic such that it is bendable in its end region by the fluid counterpressure in operation by at least 5° with respect to the non-deformed state.

13. A conveying device in accordance with one of the claims 1 to 12, characterized in that the drive body has microgrooves (41) extending in the conveying direction (9).

14. A conveying device in accordance with claim 1 or one of the following claims, characterized in that the drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) has at least one hollow space (37, 38).

15. A conveying device in accordance with claim 1 or one of the following claims, characterized in that the drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) comprises a foam, in particular polyurethane.

16. A conveying device in accordance with either of claims 14 or 15, characterized in that the drive body (1, 1′, 1′′, 1′′′, 11, 11′, 11′′, 11′′′) is at least partly inflatable.

17. A conveying device in accordance with claim 1 or one of the following claims, characterized in that the drive body can be driven by means of a hydraulic or pneumatic device (15, 15'), in particular by means of a balloon body.

18. A conveying device in accordance with one of the claims 1 to 10, characterized in that the drive body can be driven by means of an electric and/or magnetic device.

19. A conveying device in accordance with claim 1 or one of the following claims, characterized in that the drive body or bodies is/are deformed in operation against the fluid pressure on the respective pressure side.

20. A conveying device in accordance with claim 19, characterized in that the deformation of the pressure side takes place by inner struts of the drive body without any additional external energy supply.

21. A conveying device in accordance with either of claims 19 or 20, characterized in that the deformation of the pressure side takes place by the so-called fin-ray effect.

22. A conveying device in accordance with claim 1 or one of the following claims, characterized in that it is a blood conveying device.

FIG 1

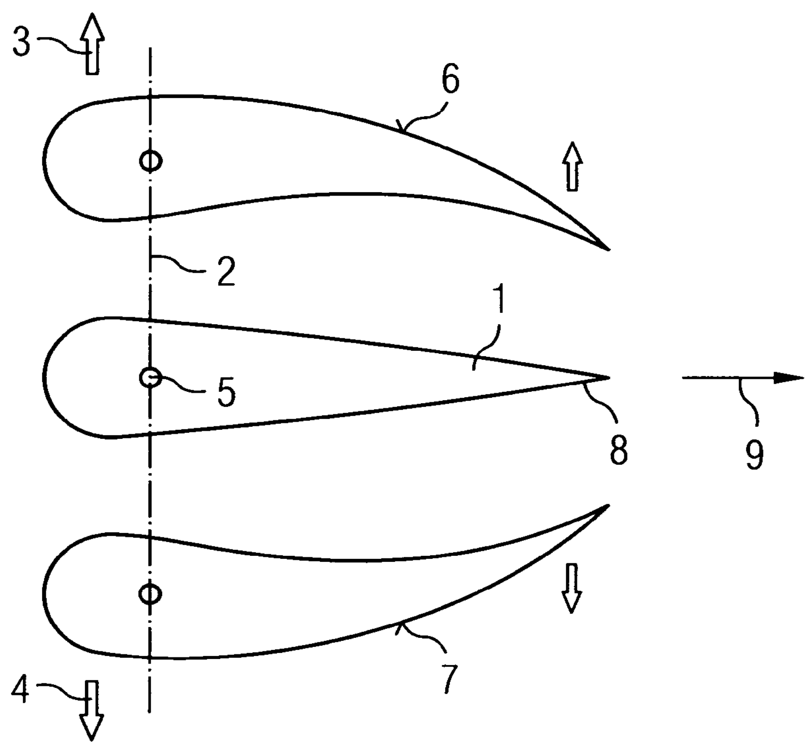


FIG 2

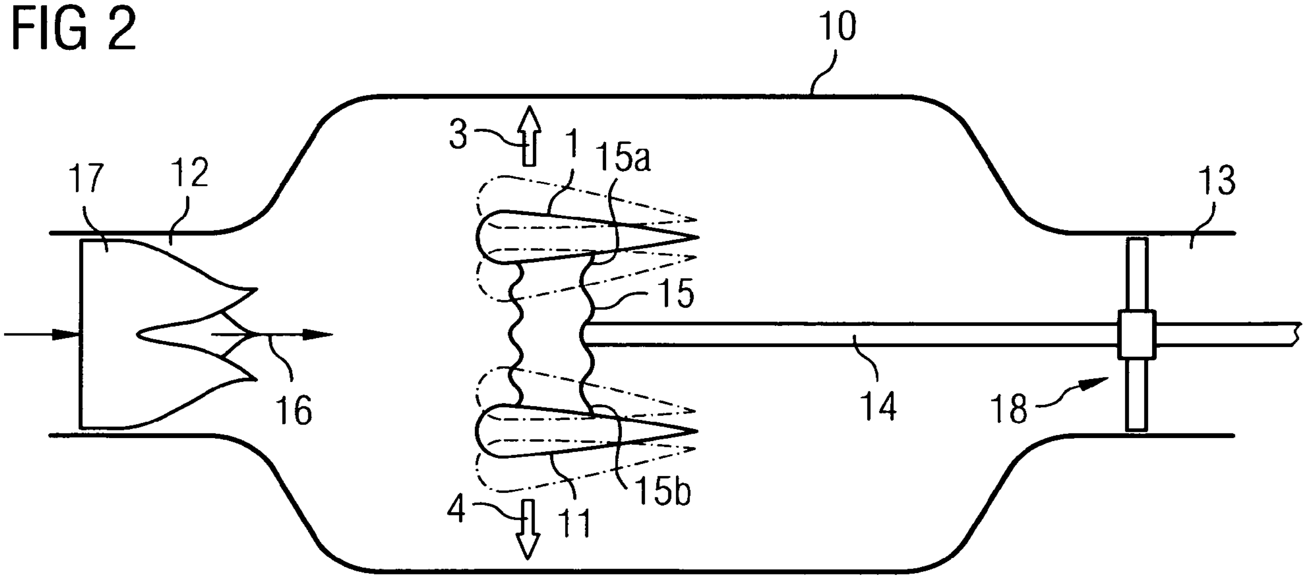


FIG 3

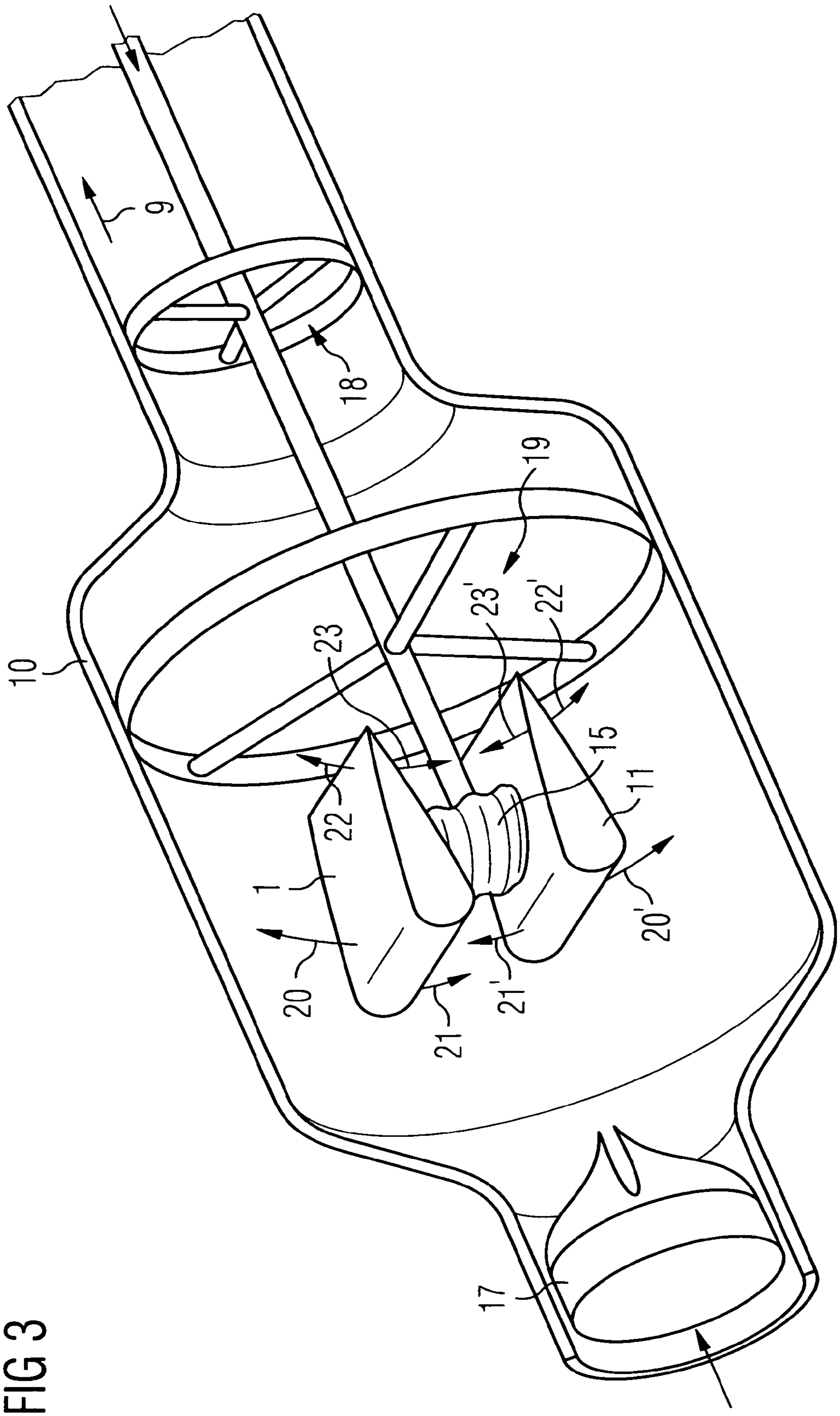


FIG 6

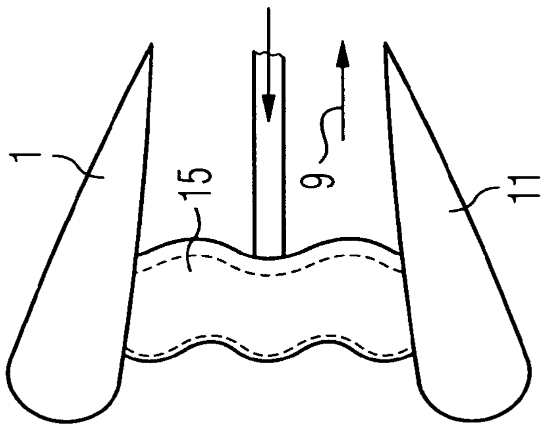


FIG 5

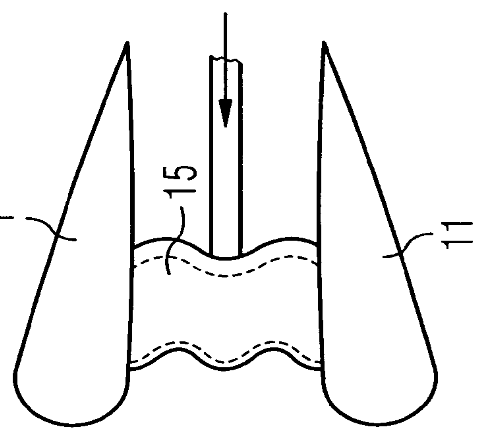


FIG 4

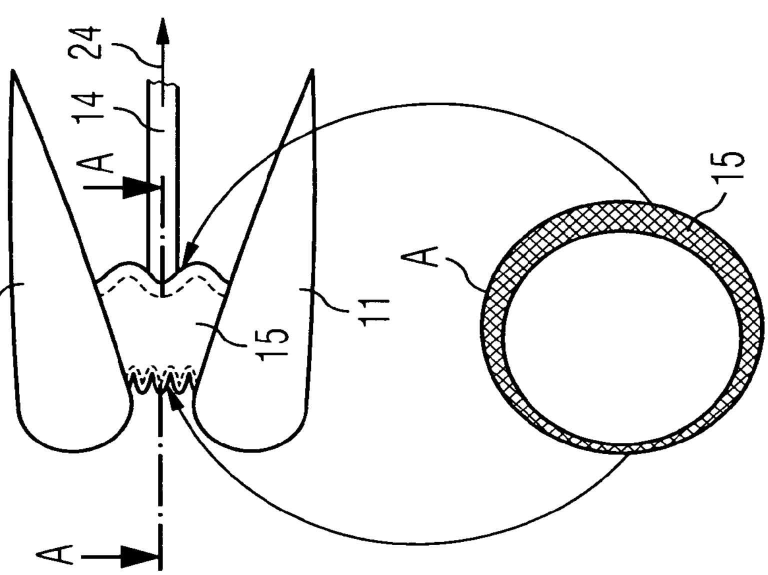


FIG 7

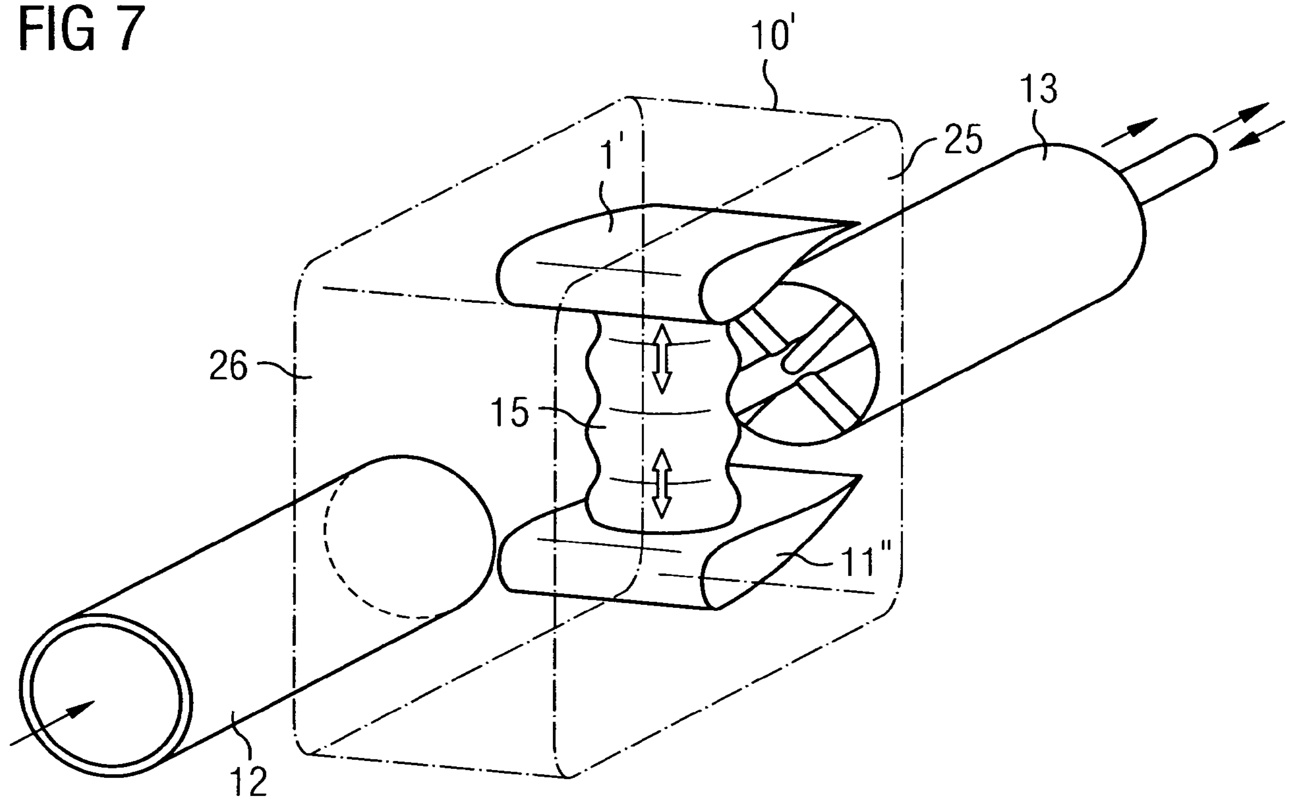


FIG 8

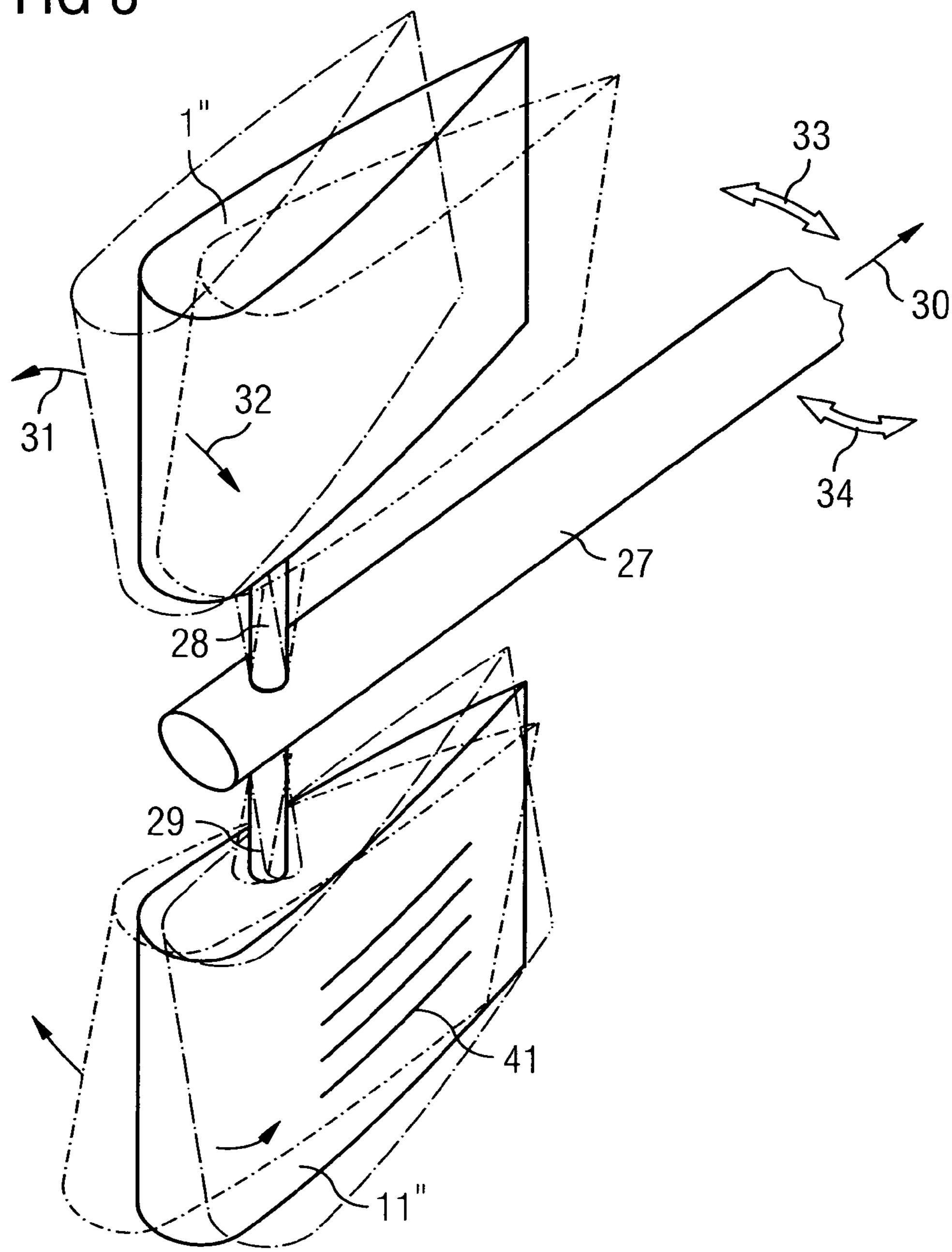


FIG 9

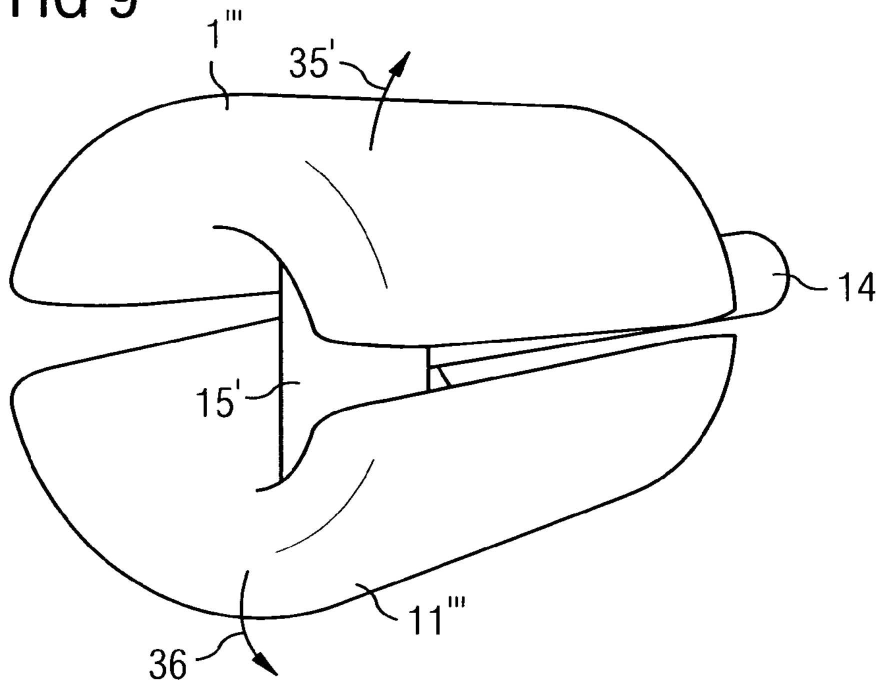
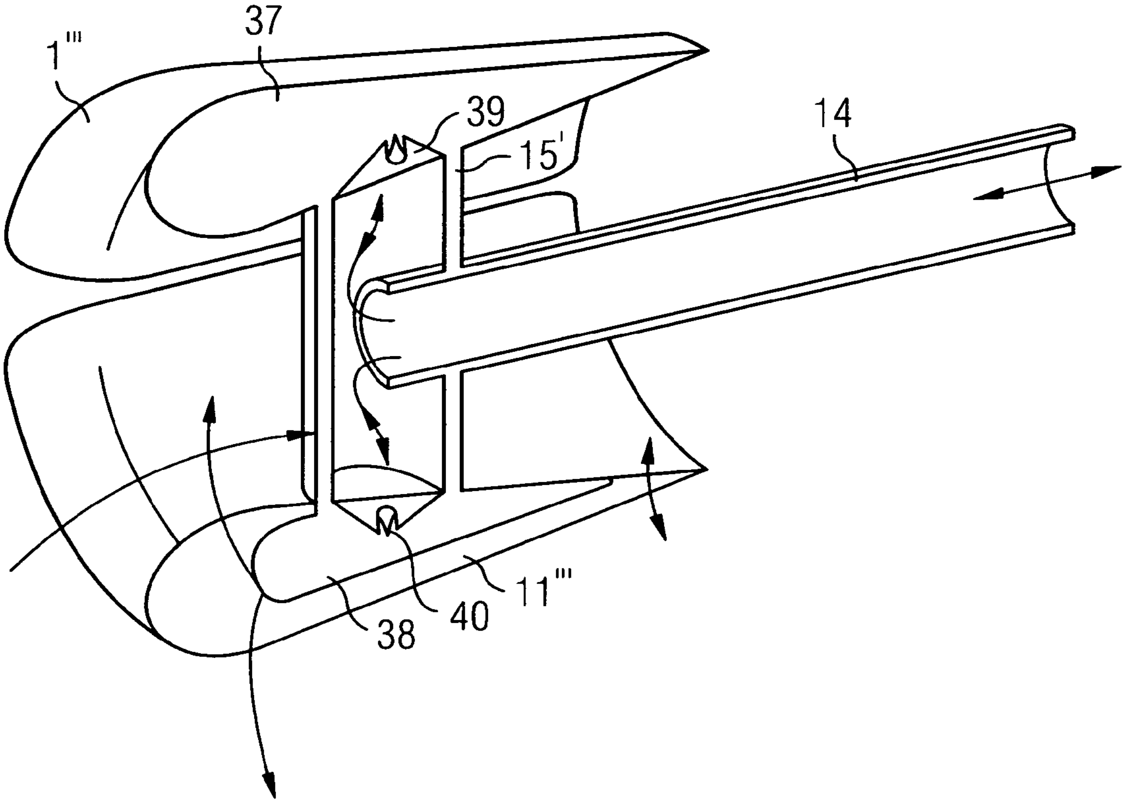


FIG 10



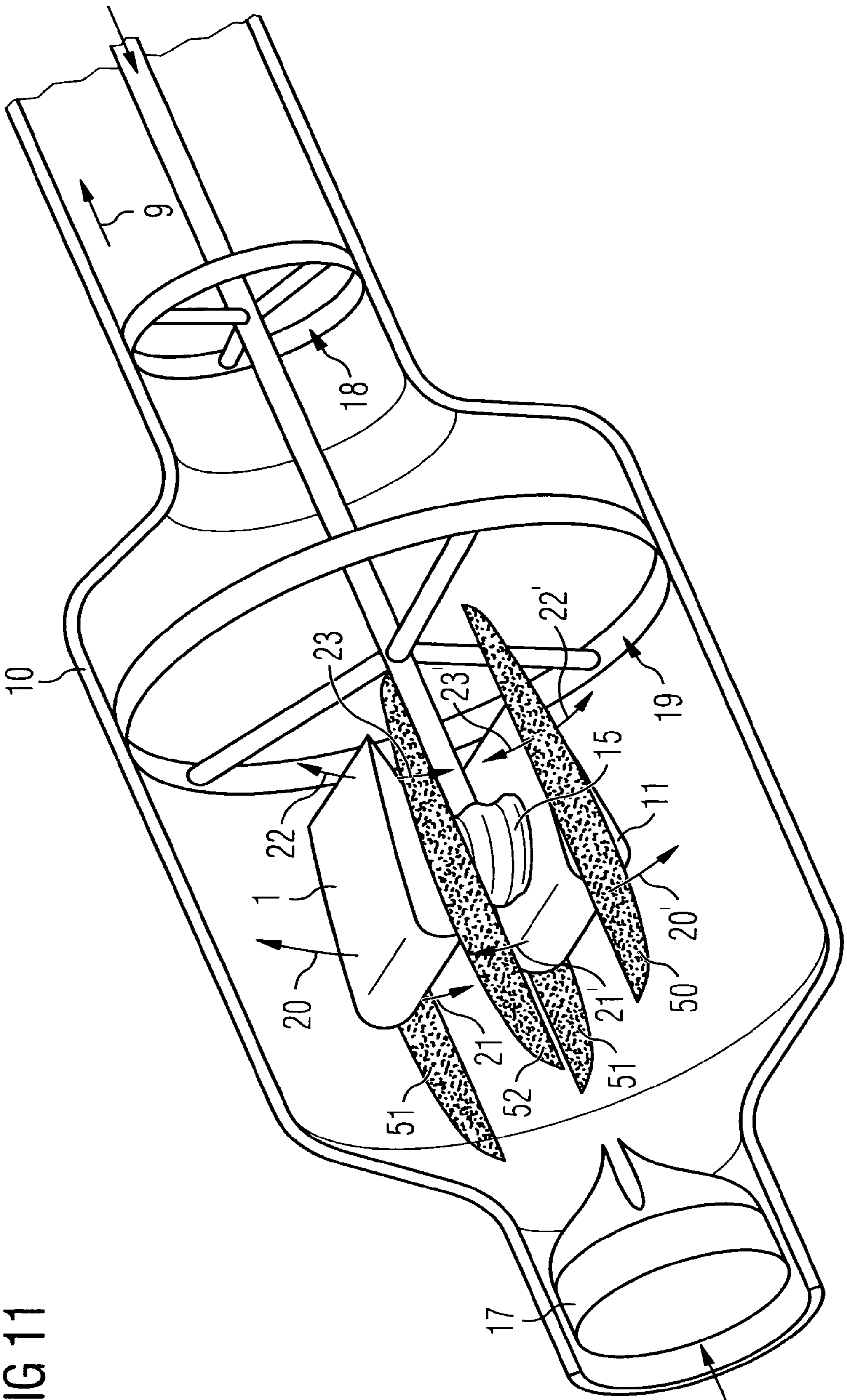


FIG 11

FIG 12

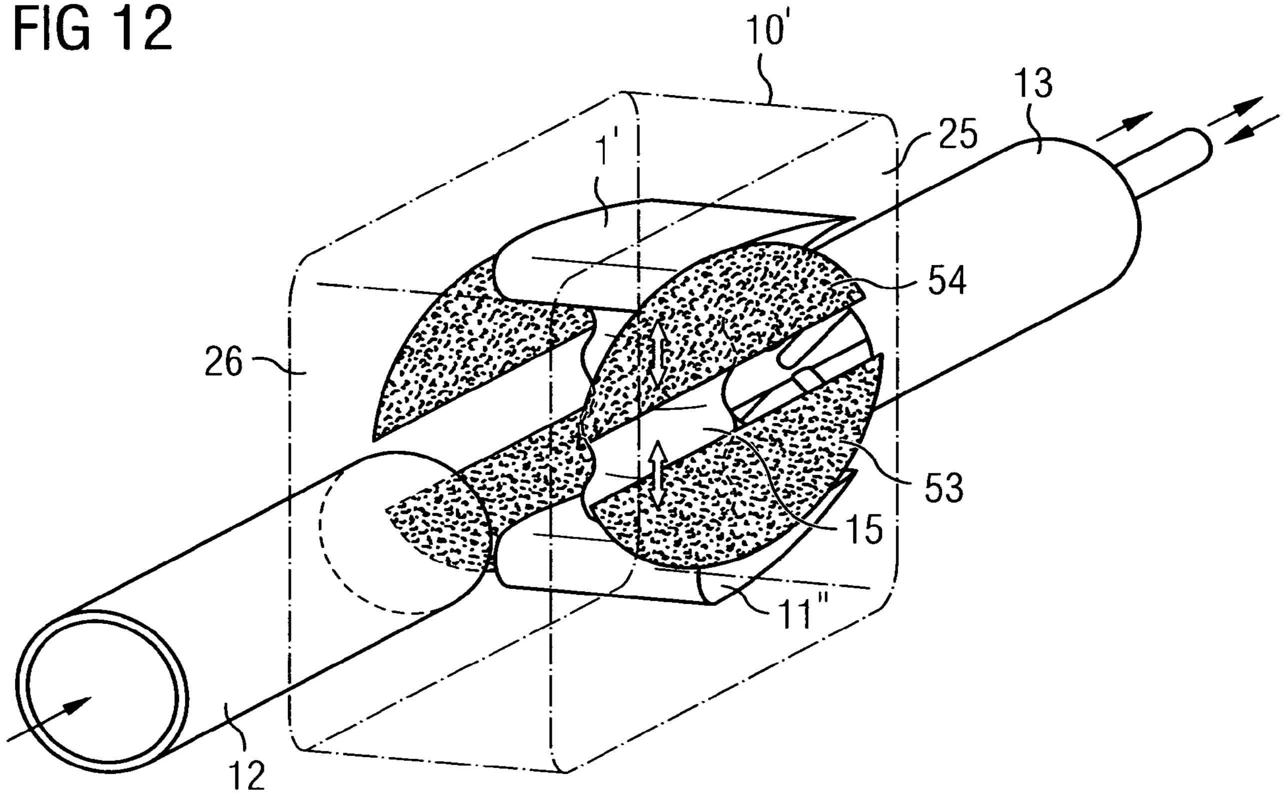


FIG 13

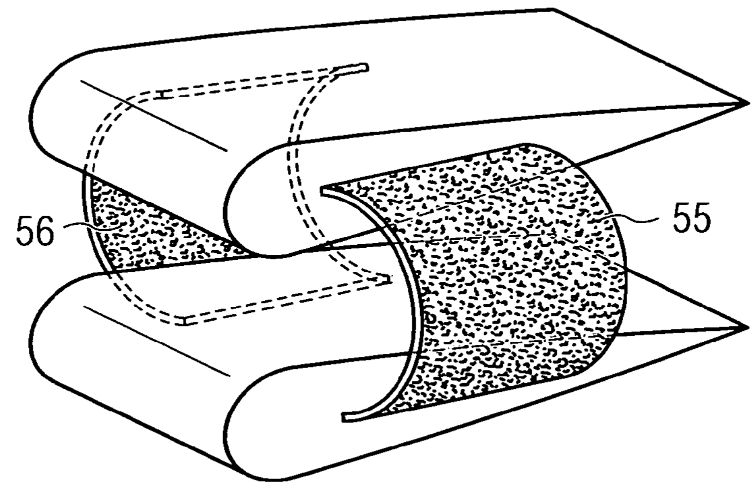


FIG 14

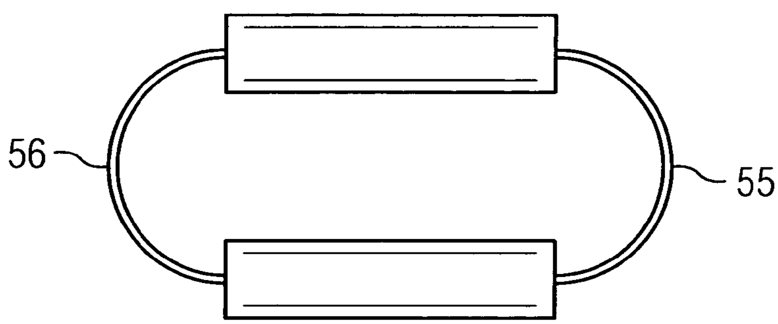


FIG 15

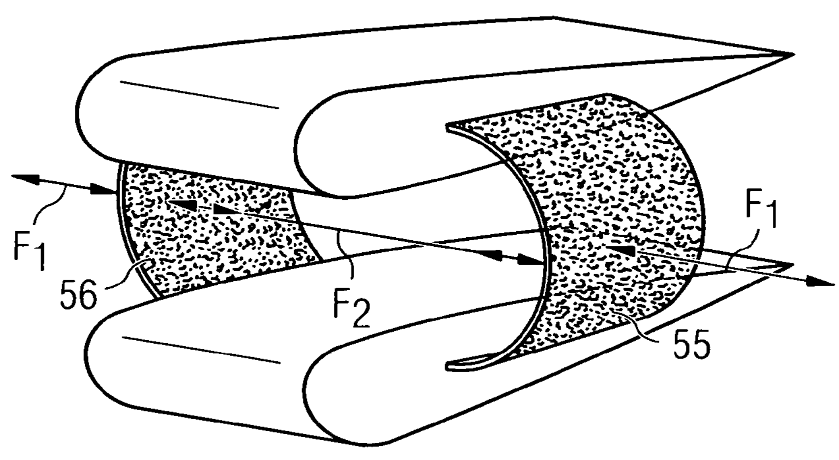


FIG 16

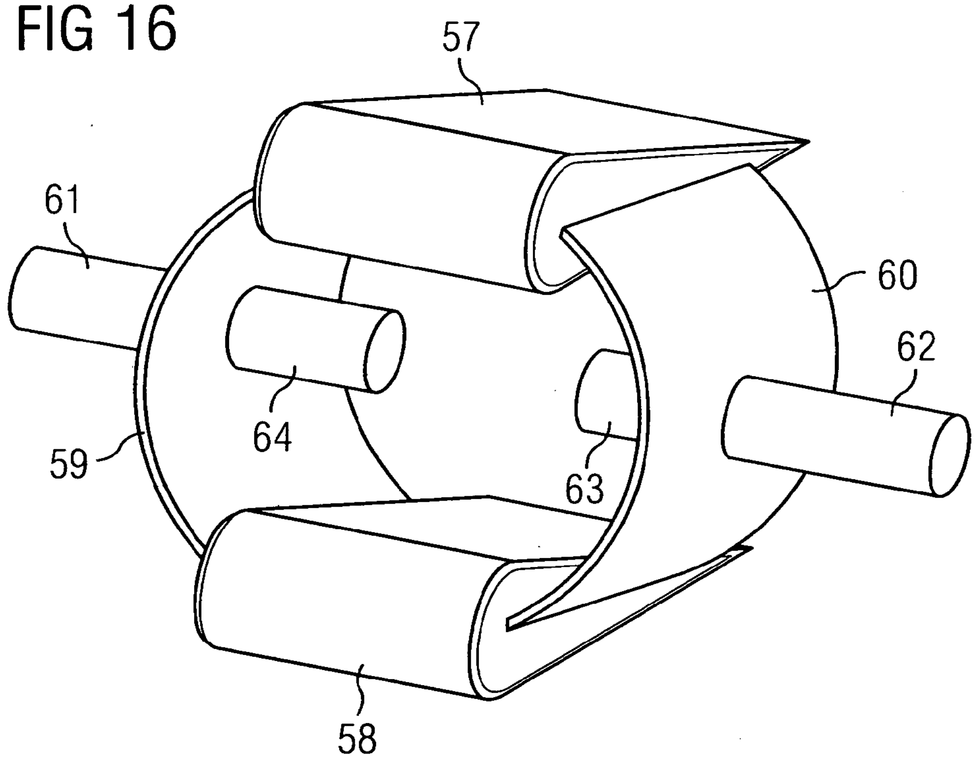


FIG 17

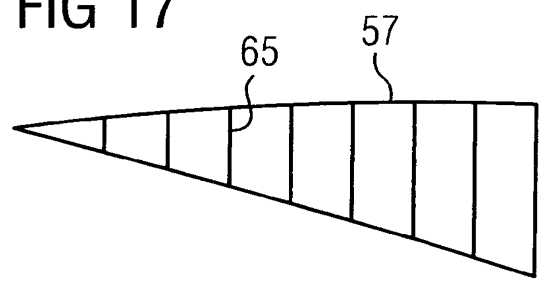


FIG 18