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

(11) EP 2 604 863 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
19.06.2013 Bulletin 2013/25

(51) Int Cl.:
F04D 23/00 *(2006.01)* ***F04D 25/02*** *(2006.01)*

(21) Application number: **11009817.5**

(22) Date of filing: **13.12.2011**

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

(71) Applicant: **EagleBurgmann Germany GmbH & Co. KG**
82515 Wolfratshausen (DE)

(72) Inventors:
- **Sanford, Timothy D.**
Fall River Ns, B2T 1L2 (CA)
- **Landry, Garrett**
Dartmouth, NS B3A 2Z1 (CA)
- **MCCURDY, Stephen**
Dartmouth NS, B2W 4P4 (CA)
- **MCCULLOCH, Ron**
Kennetcook NS B0N 1P0 (CA)

(74) Representative: **Schaeberle, Steffen**
Hoefer & Partner
Patentanwälte
Pilgersheimer Strasse 20
81543 München (DE)

(54) **Rotary compessor**

(57) The present invention concerns a rotary compressor for compressing a gaseous medium, comprising an impeller (2), a drive unit (3) and a magnetic coupling (4) comprising a rotating inner rotor (41), a rotating outer rotor (42) and a can (40), wherein the inner rotor (41) is connected to the impeller (2), wherein the impeller (2) comprises a continuous solid portion (25), wherein a first row (21) and a second row (22) of blades (23) are provided at the outer circumference of the solid portion (25) of the impeller, the first and second row of blades being separated by a circumferential middle wall (20), and wherein the blades (23) of the first row (21) are offset in circumferential direction relative to the blades (23) of the second row (22).

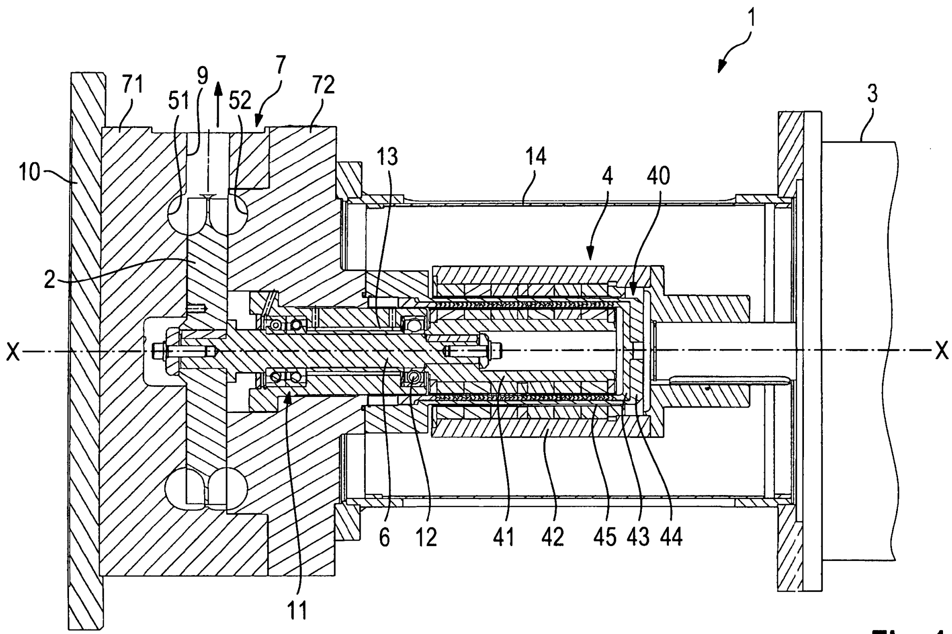

Fig. 1

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present invention relates to a rotary compressor for compressing a gaseous medium and a gas lubricated mechanical seal arrangement comprising such a rotary compressor as an auxiliary compressor.

[0002] The reliability of gas lubricated mechanical seal arrangements is largely depending on having a continuous supply of clean and dry flushing gas. Flushing gas prevents entry of contaminated process gas into the seal arrangement. Flushing gas is usually tapped from the compressor while in operation. In idle or standstill conditions of the main compressor, flushing gas is supplied by an auxiliary compressor. Auxiliary compressors are reciprocating, piston-type design. Piston compressors are prone to leakage and failure due to high wear, blocking of the piston on start-up, producing heat. Also, the piston compressor provides a pulsating gas flow which usually requires a pulsation damper. Further, WO 97/01053 A discloses a seal gas pressure booster system comprising a turbo machine as a booster compressor. However, no exact design for such a turbo machine is disclosed.

[0003] It is therefore an object of the present invention to provide a rotary compressor and a gas lubricated mechanical seal arrangement, which can secure a leakage-free, reliable supply of a flushing gas to a gas lubricated mechanical seal.

[0004] This object is solved by a rotary compressor having the features of claim 1 and a gas lubricated mechanical seal arrangement having the features of claim 13. The sub-claims contain advantageous embodiments of the invention.

[0005] The inventive rotary compressor having the features of claim 1 has an enhanced flow rate and enhanced pressure boosting. A rotary compressor comprises an impeller, a drive unit and a magnetic coupling for connecting the impeller with the drive unit. The impeller is designed as a solid, deflection-free disc. At the outer circumference, the impeller comprises a first row and a second row of blades, wherein the blades are separated by a circumferential middle wall. The blades of the first row are thereby offset in circumferential direction relative to the blades of the second row. Thus, according to the inventive rotary compressor, a continuous flow of the gaseous medium can be provided, so that flushing gas can be supplied to a gas lubricated mechanical seal. Further, the inventive rotary compressor provides a flushing gas flow after start up in case the main compressor is non-operative. Furthermore, since the magnetic coupling comprises a rotating inner rotor, a rotating outer rotor and a can, a hermetical sealing is provided and leakage of process gas towards the environment is excluded. The drive unit is preferably an electric drive unit or a hydraulic drive unit or a pneumatic drive unit. Preferably, the rotary compressor comprises a housing having an inlet, an outlet and a flow path located at the outer circumference of the impeller. The flow path connects the inlet with the outlet and preferably comprises two tube-like, ring-shaped path elements. The cross section of the path elements in the housing is preferably a semi-circle. Further, the flow path is provided around at least 300°, preferably 315°, of the outer circumference of the impeller.

[0006] According to another preferred embodiment of the invention, the flow path and/or the inlet and/or the outlet have a surface with a plurality of dimples. The dimples induce micro-turbulences, which enhance the flow characteristic. Preferably, the dimples have a ring-like outer circumference and are designed as circular pits with approx 0,1 - 0,5 mm diameter and a depth of 25-30% of the diameter. Further, a uniform distribution of the dimples on the flow path and in- and outlet ports is preferred.

[0007] Preferably, the joint between inlet and/or outlet port and the flow path is shaped as a fillet, minimizing obstructions.

[0008] In a preferred embodiment, the number of blades of the first row and the second row is identical. This supports a constant flow of the gaseous medium.

[0009] Preferably, the first and second row of blades are offset in circumferential direction by half of a length of one spacing between two neighbouring blades. Preferably, the offset resembles an arc length of 4°.

[0010] To further enhance the efficiency of the impeller, the blades are straight radial blades being slightly tapered in radial direction.

[0011] According to a further preferred embodiment of the invention, the barrier can of the magnetic coupling comprises an inner barrier and an outer barrier, wherein an electrostatic insulation layer is arranged between the inner and outer barrier in order to prevent electrostatically induced arcing. Preferably, the electrostatic insulation layer is made of a synthetic material, preferably polyimide. The inner barrier consists preferably of an alternating stack of metal rings and PTFE insulation foil. The outer barrier can comprises longitudinal slots. The arrangement of inner- and outer barrier can reduce magnetic eddy currents, providing low energy consumption and a highly efficient magnetic coupling. Heat generation is reduced.

[0012] Further preferred, the rotary compressor comprises a bearing unit. The bearing unit comprises an upper and lower bearing. Preferably, the lower bearing is a double bearing whereas the upper is a single bearing. Preferably, the bearings are angular contact ball bearings, so that a precise axial positioning of the impeller shaft and the impeller can be provided.

[0013] Preferably, a circumferential distance between neighbouring blades of the impeller is 10° arc length or less.

[0014] Further preferred, a thickness of the middle wall of the impeller is the same as a thickness of the blades at an outermost portion of the blades.

[0015] Furthermore, the present invention relates to a gas lubricated mechanical seal arrangement comprising a rotating ring and a stationary ring defining a sealing gap therebetween. Further, a gas supply unit is provided, comprising a main compressor and an auxiliary compressor, wherein the auxiliary compressor is a rotary compressor according to the invention.

[0016] Thus, the inventive gas lubricated mechanical seal arrangement is operable under special conditions like stopping of the main gas supply system or working under low system pressure conditions. Due to the use of the inventive rotary compressor-long maintaining intervals and a reliable, leakage-free operation and a non-leakage can be achieved. As further advantage standard electric motors can be used to drive the impeller.

[0017] In the following, a preferred embodiment of the invention is described with regard to the accompanying drawings as follows:

Fig. 1 is a cross section of a rotary compressor according to one embodiment of the invention,

Fig. 2 to 4 different elevations of the impeller,

Fig. 5 a total view of the rotary compressor including a motor,

Fig. 6 an illustration showing the flow path in the housing and

Fig. 7 a schematical view of the arrangement of the rotary compressor in a gas lubricated mechanical seal.

[0018] As shown in Fig. 1, the rotary compressor 1 according to a preferred embodiment of the invention comprises an impeller 2, an electric motor 3 and a magnetic coupling 4. The magnetic coupling 4 connects the electric motor 3 with the impeller 2.

[0019] The magnetic coupling 4 comprises a can 40, an inner rotor 41 and an outer rotor 42. The outer rotor 42 is connected with the electric motor 3 and the inner rotor 41 is connected via an impeller shaft 6 with the impeller 2. The impeller 2 comprises a central opening 26 (see Fig. 4) to accommodate an end of the impeller shaft 6. The magnetic coupling 4 is protected by a cover 14.

[0020] The can 40 comprises an inner barrier 43, an outer barrier 44 and an electrostatic insulation layer 45. The electrostatic insulation layer 45 is arranged between the inner and outer barrier in order to prevent electric arcing. The electrostatic insulation layer 45 is, for example, made of polyimide.

[0021] The rotary compressor 1 further comprises a housing 7 with a first housing part 71 and a second housing part 72. The can 40 is fixed to the second housing part 72, e.g. by means of bolts. The housing 7 accommodates a flow path 5, with a ring-like path surrounding the impeller 2 partly. As shown in Fig. 6, the flow path 5 is defined between an inlet 8 and an outlet 9 and covers approximately 315°. That is, an angle α between the inlet and the outlet is approximately 45°. As shown in Fig. 1, the flow path 5 comprises a first portion 51 and a second portion 52. Thereby, in cross section, the first and second portion have the shape of semi-circles with equal radii. As shown in Fig. 1, the radii of the first and second portion 51, 52 and the contour of the spacings 24 provided between neighbouring blades 23 of the impeller 2 merge into a closed volute channel.

[0022] The housing 7 is attached to a base plate 10 by means of which the rotary compressor 1 can be fixed to any structural part.

[0023] The impeller shaft 6 is supported by a first bearing 11 and a second bearing 12. The first bearing 11 is a double bearing provided by angular contact ball bearings. Thereby, the first bearing 11 is the bearing being located closer to the impeller 2 in an axial direction X-X (see Fig. 1). Furthermore, pressure balancing bores 13 are provided in order to achieve a pressure equilibrium between bearing unit inside and outside.

[0024] The impeller 2 is shown in detail in Figs. 2 to 4. As can be seen in Fig. 3, the impeller 2 comprises a first row 21 of blades and a second row 22 of blades. The first row and the second row of blades have the same number of blades 23. Neighbouring blades are separated by spacings 24, respectively. As shown in Fig. 3, the first row 21 of blades is offset in circumferential direction with regard to the second row 22 of blades. In this embodiment, the two rows of blades are offset by half of an arc length of one spacing 24, i.e. 4°. The first row 21 and the second row 22 of blades 23 are separated in axial direction by means of a middle wall 20. A thickness at the outer circumferential portion of the middle wall 20 is thereby the same as a thickness of the blades 23 at the outermost end of the blades 23. The impeller 2 further comprises a solid portion 25 which connects the central opening 26 and the two rows of blades. Thus, the impeller has a deflection-free disc.

[0025] The impeller shaft 6 is connected with the impeller 2 by means of a key and slot arrangement.

[0026] Further, dimples may be provided on the first and second portion 51, 52 of the flow path 5. The dimples enhance the flow characteristic and thereby can improve a the flow rate provided by the rotary compressor 1 and, thus, improve the pressure boosting. Further, also a coating, like PTFE, of the flow path 5 can further enhance the flow rate. Furthermore, at the transition between the flow path 5 with the inlet 8 and the outlet 9 features a smooth transition to minimize obstructions in the gas flow path in the housing 7.

[0027] Fig. 7 shows a preferred use of the inventive rotary compressor 1 in a gas lubricated mechanical seal arrangement 100. The arrangement 100 comprises a mechanical seal having a rotating seal ring 101 connected to a shaft 115 and a stationary seal ring 102 connected to a stationary element. A sealing gap 103 is formed between the two sealing rings 101, 102. The mechanical seal separates a product side 113 from an atmosphere side 114 by means of a gaseous medium provided by a main compressor 105 via a seal gas supply 106. In the seal gas supply 106 there are provided a filter 110, a stop valve 108, an orifice 111 and a check valve 112. Further, there is provided a bypass 107, which comprises a stop valve 109 and a rotary compressor 1 according to the invention. The bypass 107 bypasses thereby the stop valve 108, the orifice 111 and the check valve 112 (see Fig. 7). Furthermore, there is provided a labyrinth seal 104 neighbouring the rotating seal ring 101 in order to keep supplied gaseous medium 116 close to the sealing gap 103.

[0028] In a case, when the main compressor 105 is inoperative or in idle mode, the inventive rotary compressor 1 is activated as an auxiliary compressor in order to maintain the supply of gaseous medium 116 to the mechanical seal. Thereby, the stop valve 108 is closed and the stop valve 109 is opened so that the gaseous medium is sucked through the bypass 107.

[0029] The inventive rotary compressor 1 has a very short start-up time and can provide a nonpulsating gas flow to the mechanical seal. Due to the inventive configuration of the impeller 2, the flow path 5 and the magnetic coupling 4, a very efficient gas supply can be provided in a continuous matter and without gas leakage to the atmosphere. Thus, a contamination of the sealing gap 103 between the seal rings 101, 102 can be avoided. Thereby, the inventive rotary compressor 1 can be run over a long time, since there is no friction and the danger of building up heat at the impeller 2. Furthermore, there is no risk of mechanical failure as it was the case when piston compressors were used.

Claims

1. Rotary compressor for compressing a gaseous medium, comprising

    - an impeller (2),
    - a drive unit (3) and
    - a magnetic coupling (4) comprising a rotating inner rotor (41), a rotating outer rotor (42) and a can (43),
    - wherein the inner rotor (41) is connected to the impeller (2),
    - wherein the impeller (2) comprises a continuous solid portion (25),
    - wherein a first row (21) and a second row (22) of blades (23) are provided at the outer circumference of the solid portion (25) of the impeller, the first and second row of blades being separated by a circumferential middle wall (20), and
    - wherein the blades (23) of the first row (21) are offset in circumferential direction relative to the blades (23) of the second row (22).

2. Rotary compressor according to claim 1 further comprising a housing (7) having an inlet (8), an outlet (9) and a flow path (5), wherein the flow path (5) connects the inlet (8) with the outlet (9) and is provided in an arc shape of at least 300°, preferably 315°, of the outer circumference of the impeller (2).

3. Rotary compressor according to claim 2, **characterized in that** the flow path (5) and/or the inlet and/or the outlet comprise a surface having a plurality of dimples.

4. Rotary compressor according to claim 2 or 3, **characterized in that** the flow path (5) has a surface coating, preferably a PTFE-coating.

5. Rotary compressor according to any of claims 2 to 4, **characterized in that** a connecting portion between the inlet (8) and/or outlet (9) with the flow path (5) is edge-free.

6. Rotary compressor according to any of the preceding claims, **characterized in that** the number of blades (23) of the first row and the second row is identical.

7. Rotary compressor according to any of the preceding claims, **characterized in that** the first row (21) and the second row (22) of blades are offset in circumferential direction by half of a length of one spacing (24) provided between two neighbouring blades (23), and preferably offset by an arc length of 4°.

8. Rotary compressor according to any of the preceding claims, **characterized in that** the blades (23) are straight radial blades being tapered in radial outer direction.

9. Rotary compressor according to any of the preceding claims, **characterized in that** the can (40) comprises an inner barrier (43) and an outer barrier (44), wherein an electrostatic insulation layer (45) is arranged between the inner and outer barrier.

10. Rotary compressor according to any of the preceding claims, further comprising an impeller shaft (6) supported by a first bearing (11) and a second bearing (12), wherein the first bearing (11) is a double bearing.

11. Rotary compressor according to any of the preceding claims, **characterized in that** a distance between neighbouring blades in circumferential direction has an arc length of 10° or less.

12. Rotary compressor according to any of the preceding claims, **characterized in that** a thickness of the middle wall (20) of the impeller (2) is the same as a thickness of the blades (23) at an outermost portion of the blades.

13. Gas lubricated mechanical seal arrangement comprising

- a rotating ring (101),
- a stationary ring (102) and
- a gas supply unit comprising an main compressor (105) and an auxiliary compressor (1),
- wherein the auxiliary compressor (1) is a compressor according to any of the preceding claims.

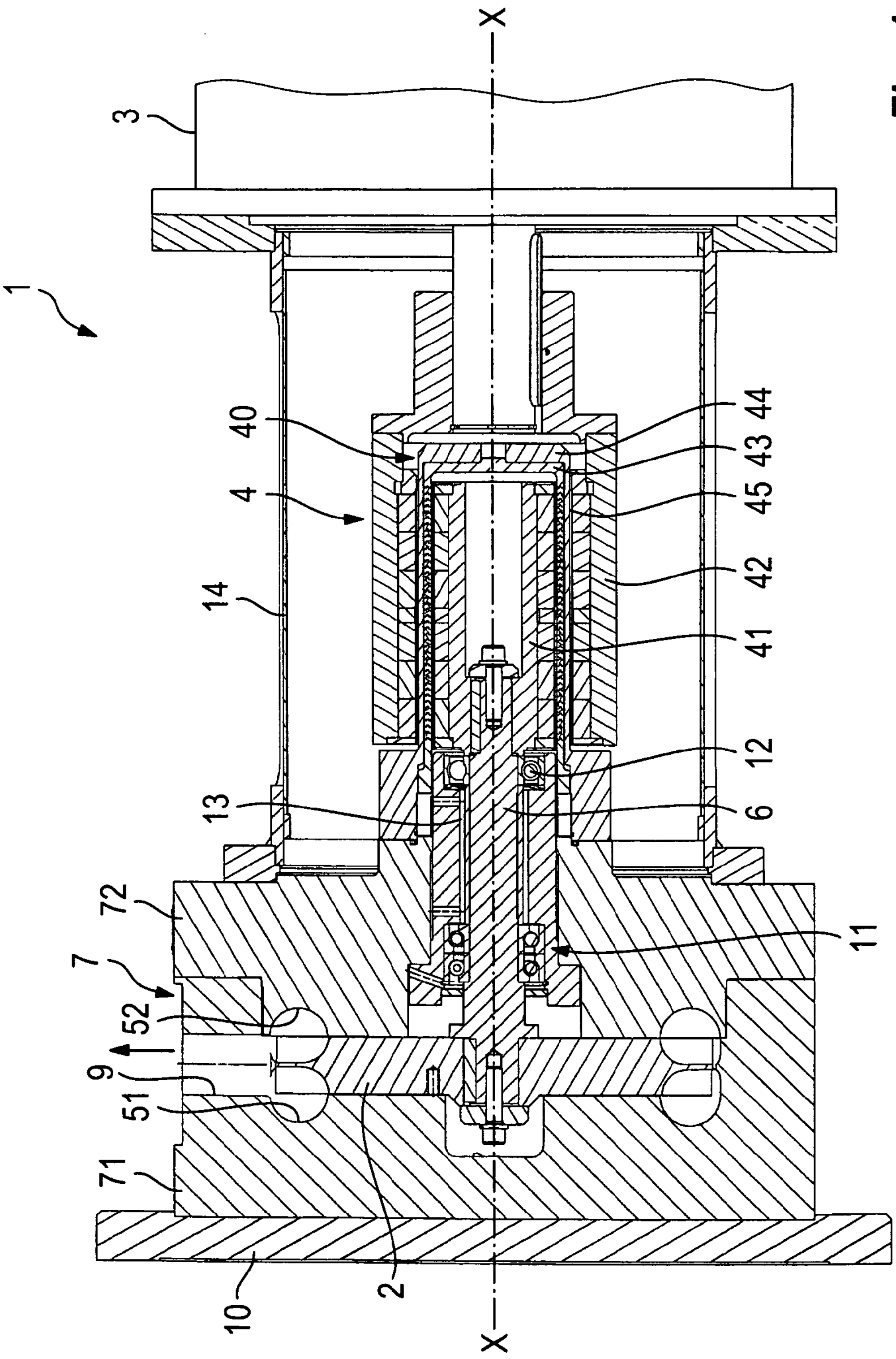

Fig. 1

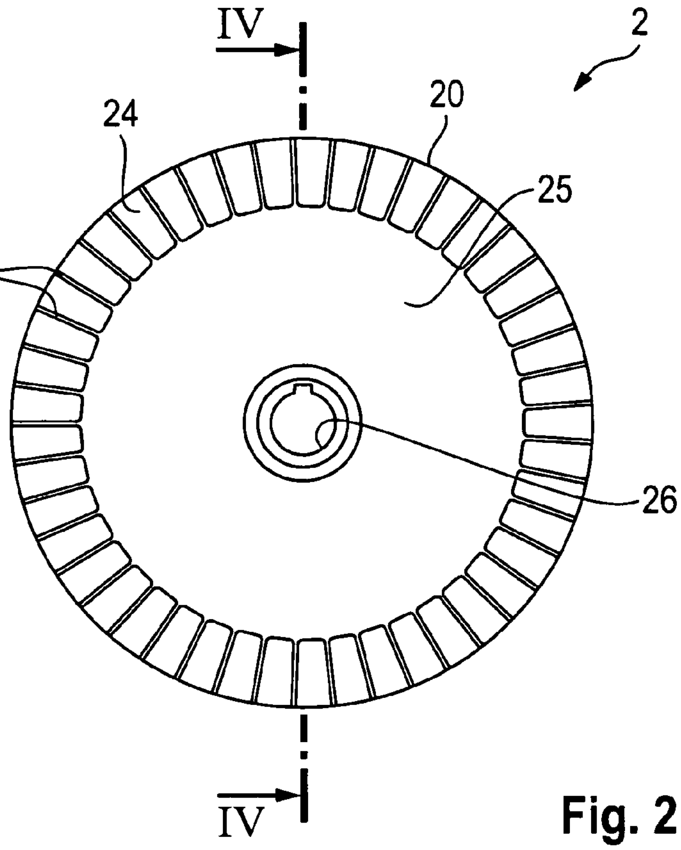

Fig. 2

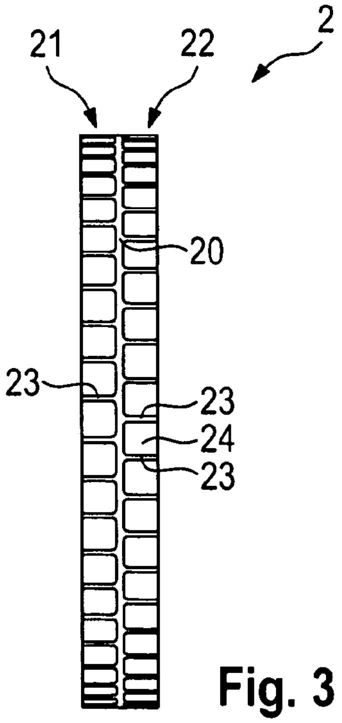

Fig. 3

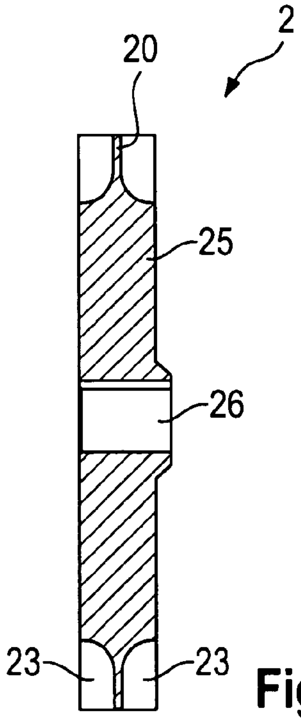

Fig. 4

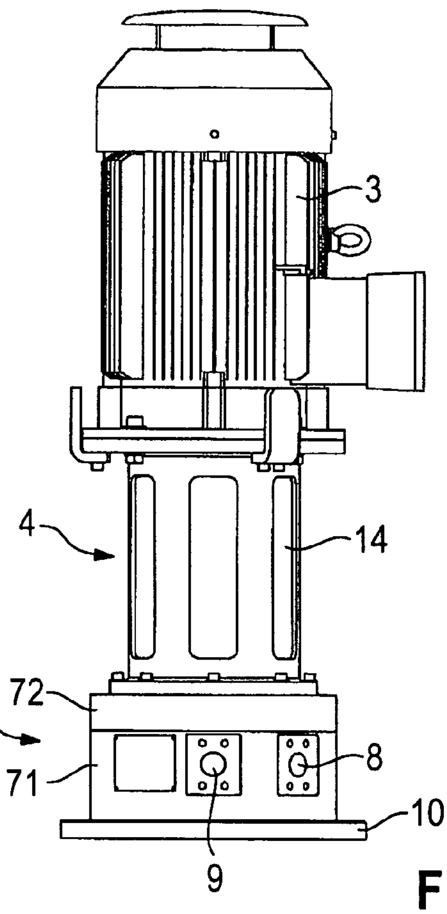

Fig. 5

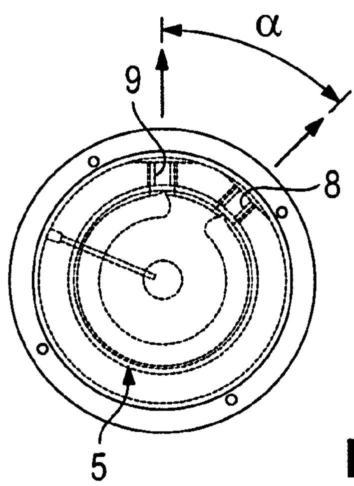

Fig. 6

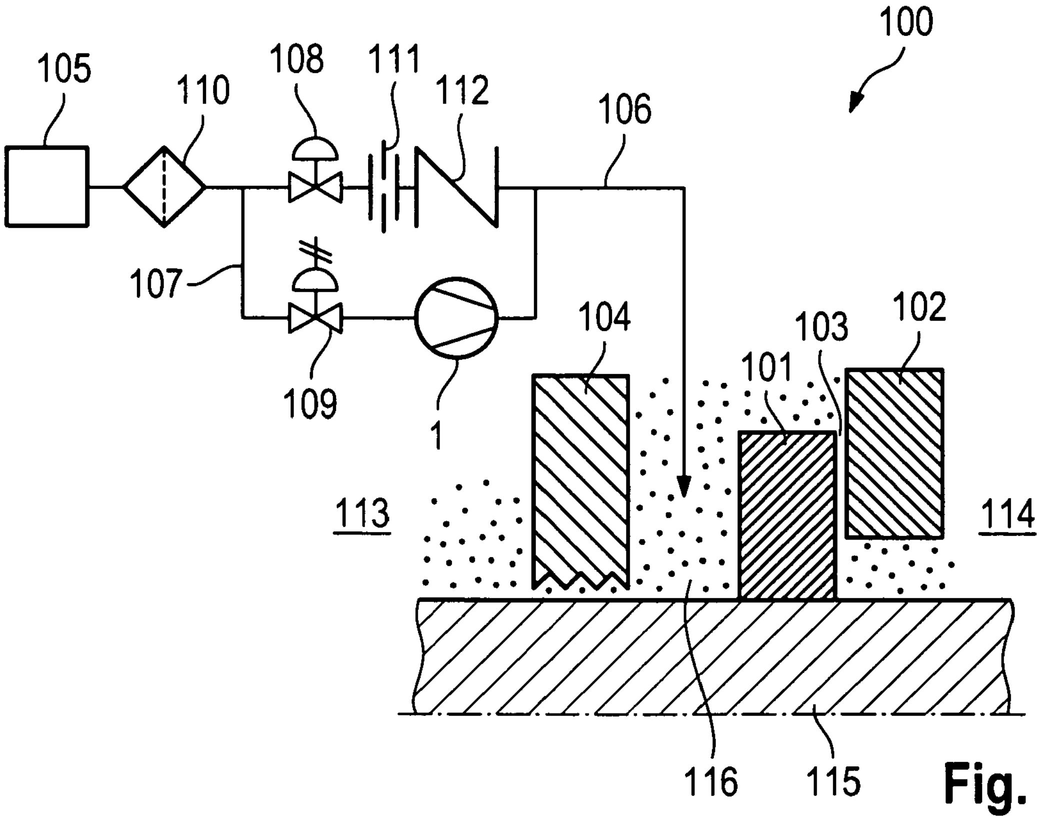
100
105
110
108
111
112
106
107
109
1
104
103
102
101
113
114
116
115

Fig. 7

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 11 00 9817

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 2 313 158 A (TOTTON PUMPS LTD [GB]) 19 November 1997 (1997-11-19) * page 1, lines 16-17; figures 2,3 * -----	1-13	INV. F04D23/00 F04D25/02
A	JP 58 091393 A (NISHIGAKI PUMP SEIZO KK) 31 May 1983 (1983-05-31) * abstract; figures 1-4 * -----	1	
A	JP 61 014495 A (SHIBAURA ENG WORKS CO LTD) 22 January 1986 (1986-01-22) * abstract; figure 1 * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)

F04D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	15 May 2012	de Martino, Marcello

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
....
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 00 9817

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

15-05-2012

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2313158 A	19-11-1997	NONE	
JP 58091393 A	31-05-1983	NONE	
JP 61014495 A	22-01-1986	NONE	

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 9701053 A **[0002]**